Appendix C Sample Cruise Report —.DOC Text File

An overview of the cruise information needed by the WHPO to perform the requisite data quality evaluation and to subsequently prepare data reports is given in Table 3.4, “Outline of a cruise report (—.DOC file),” on page 28. The outline is intended to cover the minimum amount of information required for the data quality evaluation (DQE) process. We ask that format be followed as closely as possible in the interests of making the information for the many WOCE cruises as accessible as possible. While the primary responsibility for preparing and submitting the cruise report, as well as the assembled data, lies with the **chief scientist**, it is expected that the PIs for the various measurements will write the individual sections required. A standard reporting protocol is given in Appendix D.

It is particularly important that replicate data and calibration, reagent, and blank information be provided for the various measurements. A standard reporting protocol is given in Appendix D and its use is recommended for all measurements and is required for nonstandard parameters. Additional information is certainly welcome and will often be requested by the DQEs during the data evaluation process.

The following sample cruise report for a one-time survey is not intended to be definitive. Cruise reports for repeat hydrography sections will usually be somewhat less extensive simply because fewer parameters are measured on such cruises. Also, if a repeat section or time series station is repeatedly occupied during the course of a year only one cruise report covering all the cruises made during the year need be submitted.

We hope the example given here is of some help and would welcome suggestions for improving it. We emphasize that it is necessary to report and describe *all* measurements made on the cruise and the WOCE units defined in this manual must be used consistently.

Note that we would prefer to receive any figures either incorporated in the —.DOC file or separately in one of the electronic formats given in Appendix E. Figures are needed by the WHPO in order to print and distribute the cruise data reports. If paper copies of figures are sent they must be either the original line drawings or high quality glossy photos of the *original* drawings. Photocopies (xerox) or photos of xerox copies do not reproduce well due to moiré effects.

C.1 Cruise Narrative (9 Feb '93)

C.1.1 Highlights

WOCE A11, RRS Discovery Cruise 199 in the South Atlantic

Expedition Designation (EXPOCODE): 74DI199/1

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Ship: RRS Discovery, newly lengthened to 90.2m

Ports of Call: Punta Arenas, Chile to Cape Town, South Africa

Cruise Dates: December 22, 1992 to February 1, 1993

C.1.2 Cruise Summary

Cruise Track

The cruise track and station locations are shown in Figure C.1: only small volume samples were taken.

Number of Stations

A total of 91 CTD/rosette stations were occupied using a General Oceanics 24 bottle rosette equipped with 24 10–liter Niskin water sample bottles, and a NBIS Mk IIIa CTD equipped with a SensorMedic oxygen sensor, Sea Tech Inc. 1 m path transmissometer, Simrad altimeter model 807–200m, and IOS DL 10 kHz pinger.

Sampling

The following water sample measurements were made: salinity, oxygen, total nitrate, phosphate, silicate and CFCs 11,12 and 113, the chlorofluorocarbons on alternate stations. CTD salinity and oxygen were also measured. The depths in m sampled were: 5(10), 50, 100, 150, 200, 250, 350, 500, 750, 1000, 1250, 1500, 1750, 2000, 2500, 3000, 3500, 4000, 4500, 5000, 5500, 6000.

Floats, Drifters, and Moorings

No floats, drifters, or moorings were deployed on this cruise.

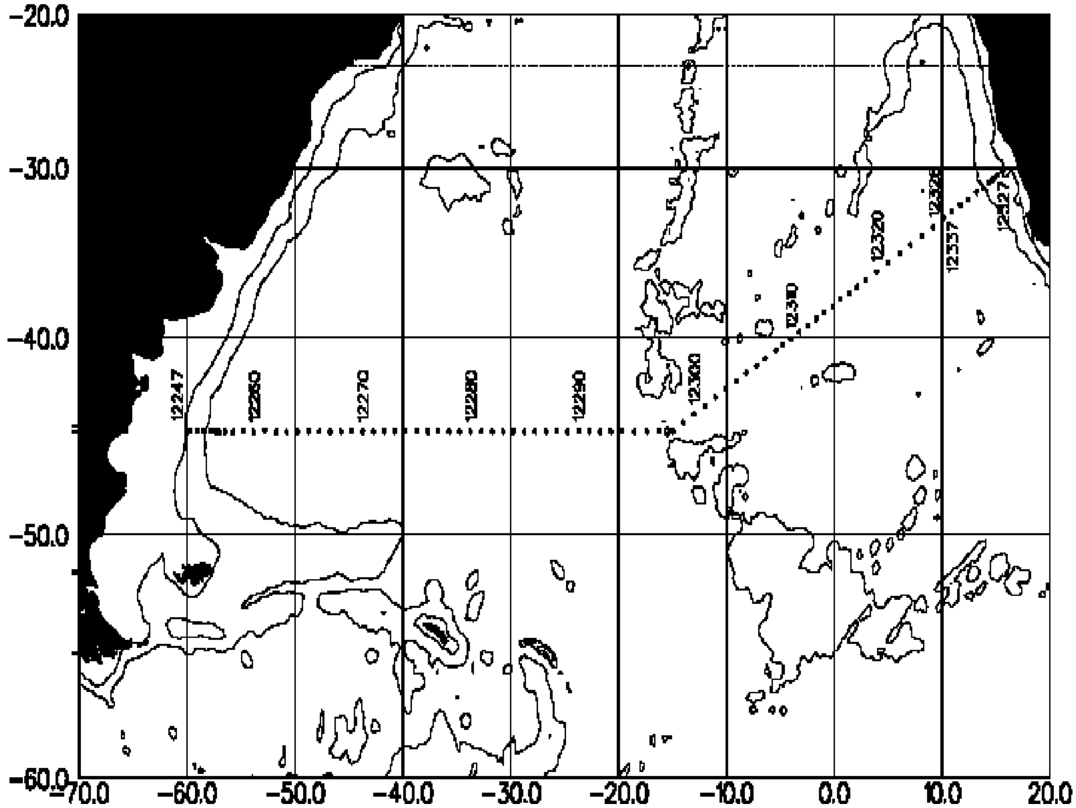

FIGURE C.1: The A11 cruise track defined by CTD/rosette stations.

C.1.3 List of Principal Investigators

The principal investigators responsible for the major parameters measured on the cruise are listed in Table C.1. The responsibility for all tasks undertaken on the cruise will be found inSection C.1.7 on page 100 (Table C.2).

C.1.4 Scientific Programme and Methods

The principal objectives of the cruise were:

- To estimate the exchange of heat, freshwater, nutrients and CFCs across the section, i.e., between the Southern Ocean and the South Atlantic.
- To determine the water mass characteristics on the section and to determine whether and where secular changes are found.
- To submit to the WHPO a data set, a fit companion to other WHP one time survey cruises, and thereby contribute to the global measurements necessary to meet the objectives of WOCE.

The principal instruments employed in the measurement programme consisted of a NBIS Mk IIIa CTD and General Oceanics rosette mounted within a tubular aluminium frame of

TABLE C.1: Principal investigators

Name	Responsibility	Affiliation
B.King	CTD	IOS DL
S.Bacon	Salinity	JRC
D.Hydes	Nutrients	IOS DL
P.Chapman	Oxygen and iodine	Texas A&M
D.Smythe-Wright	CFCs	JRC
P.Saunders	ADCP and bathymetry	IOS DL
P. Smith	Meteorology	IOS DL
S. Thompson	XBTs	IOS DL
M. Meredith	Satellite imagery (MACSAT) and thermosalinograph	UEA

dimensions 1.8 m height x 1.5 m diameter. The package was weighted to give a free fall speed in excess of 2 m/s. Subsidiary instrumentation consisted of a 1 m transmissometer, altimeter (with 200 m range for bottom finding) and 10 kHz location pinger. Four of the rosette bottles were fitted with SIS digital reversing thermometers (6) and pressure meters (2). The wire was a single conductor 10 mm steel rope manufactured by Rochester Cables, and the winch was of traction winch design built by Kley France. A complex folding gantry of RVS Barry design ensured the virtually automatic launching and recovery of the CTD/rosette package in all conditions within which the ship could be safely operated.

After a cast the rosette was placed on deck and secured, the rosette pylon was drenched in fresh water and the CTD sensors covered with protective housings. Subsequently digital instrumentation was read and CFC samples were drawn followed, in order, by samples for oxygen, nutrient and salinity analysis. The rosette was stored on deck throughout the cruise and all sampling was performed there. In moderate weather the rosette would be pushed forward on a railway about 3 m to obtain further shelter. In rain umbrellas could be clamped to the rosette frame in order to protect the samples and in rough seas the ship remained on station until sampling was completed.

Other and, in some cases, crucial additional measurements were made throughout the cruise. XBTs were launched between CTD stations and more frequently in the slope regions at each end of the cruise section. Acoustic Doppler Current Profiler (ADCP) measurements were made continuously employing a hull mounted 150 kHz unit manufactured by RDI. In support of the ADCP measurements a GPS 3DF receiver manufactured by Ashtech, Inc. provided heading information superior to that of the ship’s gyro. Underway measurements of surface temperature and salinity were made by a FSI thermosalinograph and Simrad 500 Echosounder provided continuous water depth measurements. Other navigation information was supplied by a Trimble GPS receiver and all data was logged by networked SUN workstations with terminals widely available in the main and computer labs.

A description of the methods of measurement, calibration and analysis of the data received from these various sources will be found in Section C.3 of this report.

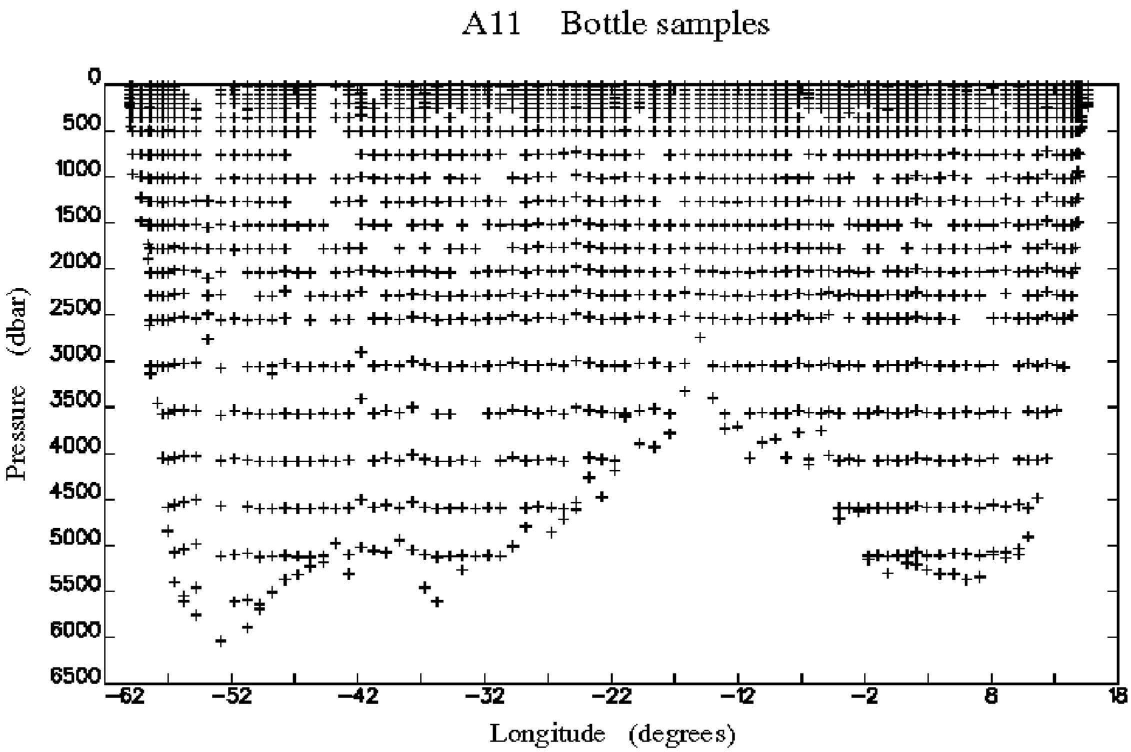

FIGURE C.2: Location of 10 liter water samples collected on A11.

Preliminary Results

Figure C.2 shows the distribution of sample observations made on the A11 section. Since data from the South Atlantic Ventilation Experiment (SAVE) were available on the ship (thanks to WHPO), we were able to compare A11 and SAVE sample data. The property distributions were very similar, but small differences were noted in the deep water which became evident with potential temperature <1.0°C or salinity in the range 34.66 – 34.72. A11 salinity measurements agreed well with the SAVE 5 leg data, but were more saline by 0.002 than adjacent SAVE 4 data: the differences amongst the SAVE data were not previously known to us. Nitrates showed agreement with both SAVE 4 and 5 measurements, but at the deepest levels silicates and oxygens were slightly lower by 2.5 µmol/kg (Figure C.3) and 2.5 µmol/kg (Figure C.4) respectively; phosphates were lower by about 0.08 µmol/kg. These preliminary results, whose magnitude but not sign depends on which historic set is compared, apply principally within the Argentine Basin, and possible causes of the differences are under investigation.A more unexpected result, which owed nothing to the accuracy of the measurements, was the extreme northern position of the Subtropical Convergence on the NE leg of the track (Figure C.1). Although the water became progressively warmer along this leg, the surface salinity remained below 35 until a ring was encountered centered on 36°20′S 4°E. The ring had a thermostad of temperature 13.5°C, salinity 35.2 and a maximum depth of 600 m. An anticyclonic circulation of 30 cm/s was observed by the ADCP. It may have been an Agulhas ring that had over–wintered south of the convergence, or a Brazil Current ring shed in the WBC retroflexion zone that had migrated eastward. Opinions in the scientific party were split about equally, but a closer post–cruise examination of the data may well resolve the question. Beyond its NE edge, near 35°40′S and 5°E we encountered the subtropical gyre, with

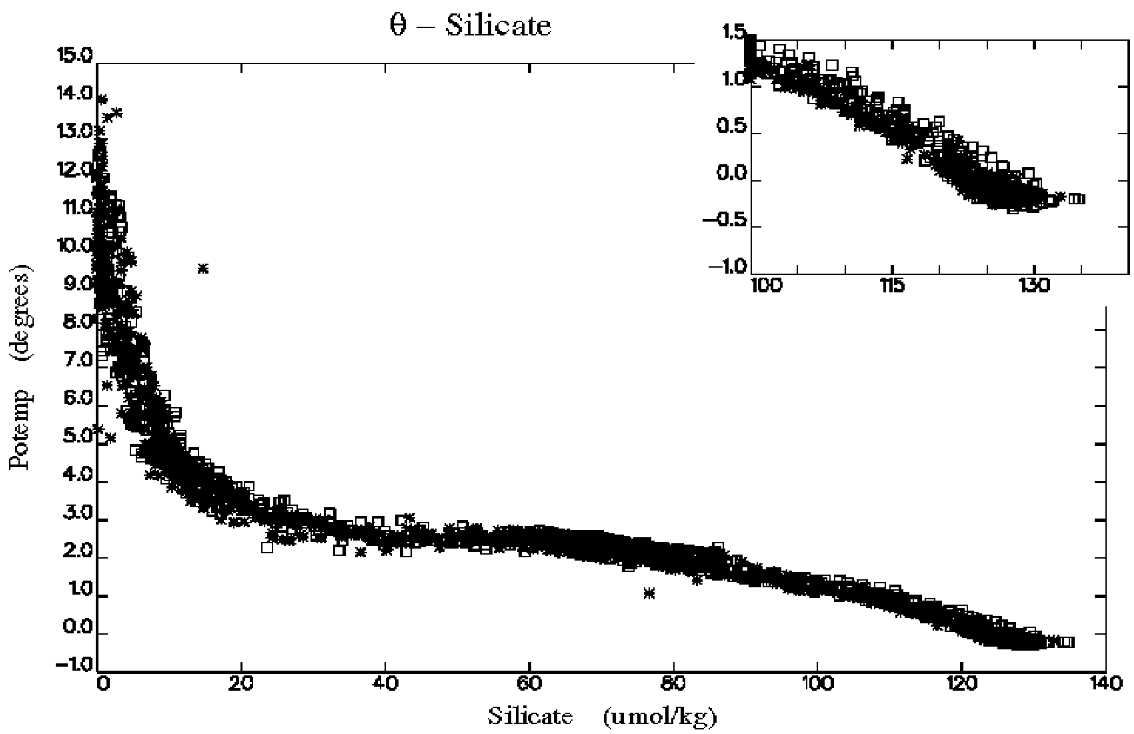

FIGURE C.3: Silicate concentration vs. potential temperature for A11 (*) and SAVE 4 data: both are in the Argentine Basin and for the whole water column. The inset, for the deepest levels, shows the small discrepancy between the data sets.

a surface salinity exceeding 36 and temperature of 20 °C. This observation appears to confirm Deacon's (1937) assertion of the northward migration of the convergence in summer in this region.

Within the subtropical gyre a second hydrographic feature was encountered. This was defined by two hydrographic casts and 5 XBTs and was centered at 33°30′S, 9°45′E and extended for 300 km along the track. Within it, the 15°C isotherm plunged to a depth of 250 m, while outside it the same isotherm was nearer a depth of 100 m. An anticyclonic circulation was measured by the ADCP with currents approaching 75 cm/s. This was undoubtedly a recent Agulhas ring.

The ADCP instrumentation furnished, we believe, important new data on the cruise: it functioned incomparably better than when installed on the previous 10 m–shorter version of the ship. The most important results derived from it were found in the western boundary region. On the Argentine Slope, on two crossings of the Falklands Current, large and persistent northward velocities were found at 100 m depth (30 – 50 cm/s). These were considerably in excess of those predicted by the geostrophic shear (relative to the bottom), and consequently bottom velocities of 15–30 cm/s are inferred. The consequences for transport in the WBC and exchange across the section are considerable. On the South African slope, along–slope velocities were also observed on a crossing of the Benguela Current. However these were quite small and variable in direction and a preliminary analysis suggested they were dominated by transient (tidal or inertial) components.

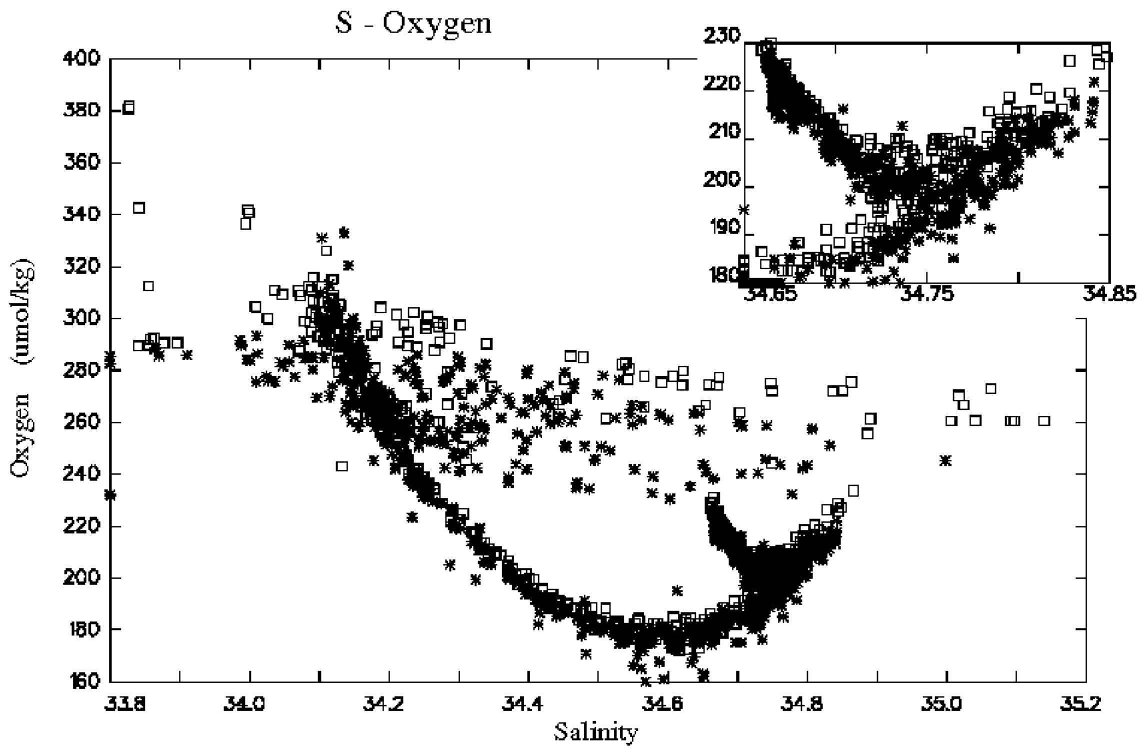

FIGURE C.4: Dissolved oxygen concentration vs. salinity for A11 (*) and SAVE 4 data: both are in the Argentine Basin and for the whole water column. The inset, where the deepest levels form the left branch of the Y, shows the small discrepancy between the data sets.

Also of note were ADCP observations made in a storm near 45°S 21°W: winds approached 30 m/s for a brief period, and striking inertial oscillations (circa 40 cm/s) were recorded. Since meteorological measurements were made aboard the ship, it is hoped that given the high quality of the ADCP data, it may prove possible to deduce the integrated Ekman drift on this cruise.

C.1.5 Major Problems Encountered on the Cruise

Two GO rosettes were available and both were utilized. Misfiring and double tripping were initially widespread, but when their sensitivity to the lanyard tension was recognized it became possible to reduce them to acceptable levels. Nevertheless a post–cruise review estimates the overall number of double trips as nearly 10% of the total number of samples. Thus a larger than expected number of duplicate samples was achieved. It is our recommendation and intention for the future that lanyard tensions be measured, monitored and set to a value which allows a properly reliable operation of the unit.

As mentioned in Section C.3.6, the winch was of complex traction design; it was put to use only on the previous cruise and because of its newness, inevitably there were difficulties. On the 1st of January at 0600, control failure occurred: it was approximately 36 hours before the fault was identified, the electronic component replaced and control settings optimized to allow station work to proceed. The efforts of all involved deserve recognition and thanks. Although we believe this was a unique situation, a different problem occurred twice and was potentially liable to occur anytime there was a large swell. Because the CTD/rosette takes time to shed air from all its component parts, very close to the surface it is vulnerable to heavy swell: it may ‘float’. In such circumstances the wire goes slack, and on both occasions the wire jumped out of a sheave pair at the foot of the gantry (where the wire direction changed from horizontal to vertical). Even in the short term this is probably a rectifiable fault, but on the cruise it cost us 4 hours both times it occurred.

Concerning the instrumentation for analysis, two problems were noted. Early on, the SIS unit for determination of oxygen concentration became unreliable: the photometric end point detection system was no longer stable. Fortunately a backup amperometric system, the Metrohm 686 titroprocessor, was available, and this was used for the bulk of the cruise measurements.

The CFC measurements also experienced difficulties which led to the loss of some data. Shortly after the start of the cruise the CFC– 12 measurements exhibited severe contamination which was believed to be due to the accidental release of oil from the ship and its capture in the non–toxic seawater system used to store the sample syringes. To bypass this problem, syringes were stored in surplus sample water, a practice however, which did not eliminate the contamination. Early CFC–12 measurements may be expected to be of lower quality than expected on the cruise, but the CFC–11 and CFC– 113 measurements should be unaffected.

C.1.6 Other Observations of Note

On the 16th January, a large iceberg was sighted: its location was determined as 44°50′S 14°22′W. In view of a much more southerly position and crossing of the Falkland Current three weeks earlier in the cruise, this was an odd location to observe one for the first time.

On the 19th January in about 3700 m of water, RRS Discovery passed over a flat–topped seamount near 40°48′S 5°40′W: it is not recorded on the GEBCO chart and its minimum depth was near 750 m. We propose the name New Discovery Seamount for this 3000 m high feature.

C.1.7 List of Cruise Participants

The members of the scientific party are listed in Table C.2, along with their responsibilities.

C.2 Underway Measurements

C.2.1 Navigation

GPS–Trimble

by P.M. Saunders and M.G. Beney (9 Feb ‘93)

Navigation, i.e., ship position and velocity over the ground, was provided throughout the cruise by a Trimble GPS receiver. No rubidium clock was available so at least 3 satellites were required for a fix. The observations are interfaced via a level A microprocessor (see Section C.3.9 on computing) into the SUN acquisition system. In order to prevent hanging or

TABLE C.2: Cruise participants

Name	Responsibilities	Affiliation
S.Bacon	Salinity	JRC
M.Beney	Data acquisition	RVS
S.Boswell	CFCs	JRC
P.Chapman	Oxygens, nutrients, iodine	Texas A & M
V.Cornell	Data archiving, MACSAT	JRC
N.Crisp	CTD operations	IOS DL
S.Cunningham	CTD/sample analysis	JRC
P.Gwilliam	CTD operations (IC)	IOS DL
V.Gouretski	ADCP/historical hydrography	UEA
K.Heywood	CTD/sample analysis	UEA
S.Holley	Oxygens, nutrients	JRC
D.Hydes	Nutrients, oxygens	IOS DL
S.Jordan	Mech. Eng. (IC)	RVS
B.King	CTD/sample analysis	IOS DL
R.Marsh	ADCP	JRC
M.Meredith	Thermosalinograph, MACSAT	UEA
D.Price	CFCs	JRC
R.Phipps	Mech. Engineer	RVS
P.Saunders	Chief scientist, ADCP	IOS DL
P.Smith	CTD operations, Met	IOS DL
D.Smythe-Wright	CFCs (IC)	JRC
A.Taylor	Elec. Engineer	RVS
S.Thompson	GPS, XBTs	IOS DL
S.Whittle	Mech. Engineer	RVS

Abbreviations

IOS DL Institute of Oceanographic Sciences, Deacon Laboratory – Wormley

JRC James Rennell Centre – Southampton

RVS Research Vessel Services – Barry UEA University of East Anglia – Norwich

IC In charge of

crashing of the level A, which was of new design, the sample rate was set to 0 and data was logged at approximately 1 Hz. Editing of this data was carried out to exclude a small but tiresome number of zero times, zero latitudes, zero longitudes, northern hemisphere positions (!) or otherwise suspect data and subsampled at 30 second intervals. This data known as ‘gps’ was archived and provided coverage for approximately 95% of the cruise.

In order to complete the navigation data set for 100% of the time, during periods of absent or inaccurate GPS fixes the ship’s gyro and Emlog data were combined to give a dead reckoning position. Such data is flagged and the data is known as ‘bestnav’. Transit satellite data were not used on the cruise.

Positions were logged in port at the start of the cruise and a rms position error of approximately 30 m was found. Evidently selective availability was in operation at this time. Underway errors are known to be larger.

Electromagnetic log and gyrocompass

by A.J. Taylor (1 Feb ‘93)

Ship speed is determined by a Chernikeeff log with sensor head approximately 0.25 m beyond the hull of the ship. Because of a sensor failure on the previous cruise a new unit was installed in Punta Arenas and zeroed whilst at the dock. Initially when underway a nominal calibration was applied, but at 11.0 knot smg as determined by a navigation unit (Decca Mk 52), the indicated speed was 12.24 knots, so a scaling was introduced to bring the two into agreement. The same adjustment was made to the port/starboard component.

On January 8 the sensor head was rotated approximately 5 degrees anticlockwise to reduce a spurious athwartship drift of about 1.3 knots at full speed. Improved log calibrations will be obtained by comparison with ADCP data (including the zig–zags) but because this will have a minor impact on ‘bestnav’ calculations we do not anticipate recalculating navigation for this reason.

Two S.G.Brown gyrocompass units (SGB1000) are installed on the Bridge. Because of a long lag noted with unit 1 on the previous cruise, unit 2 was employed for primary navigation throughout cruise 199. The output was logged via a level A microprocessor at 1 Hz and was free of gaps. The accuracy of heading is discussed in the following section.

Ashtech GPS 3DF Instrument

by S.R.Thompson (9 Feb ‘93)

This instrument, newly acquired for the cruise, measures not only the position but also the three dimensional attitude of the ship from the GPS system, i.e., ship’s roll, pitch and, most significantly for the ADCP work, heading. The determination of attitude is performed by an array of four antennas approximately in the form of a square of side 8m. Data was logged in the deck unit of the receiver at 0.2 Hz frequency (because the level A failed to work reliably) and down loaded to the SUN workstations twice per day.

King and Cooper (1993) have described details of the instrument, its installation and preliminary results on a 7 day trial cruise of RRS Discovery. They demonstrated that the gyro error is a function of ship’s heading and also that it changes with time after a ship manoeuvre: in port they confirm the accuracy claimed by the manufacturer of 0.05°. On cruise 199 we elected to use the second of the two ship’s Gyro compass units, (i.e., a different one from King and Cooper), and our preliminary results show that this instrument also experiences gyro error related to the ship's heading and time-dependent errors after maneuvering. Also long term drift of the gyro is apparent. For both instruments, these variations are of the order of 1°.

Data quality control was implemented in the manner described by King and Cooper (loc cit). For reasons not currently understood only approximately one third of one minute averages of the difference between Ashtech and gyro headings contain data, far less than they encountered at the same latitude in the N. Atlantic. Ten minute average differences have also been constructed and assembled in 5 day summaries. These will be used in post processing of the ADCP data and are expected to bring significant changes especially for underway estimates of currents.

References

King, B.A. and E.B. Cooper, 1993, Comparison of ship's heading determined from an array of GPS antennas with heading from conventional gyrocompass measurements. Submitted to Deep–Sea Research.

C.2.2 Echosounding

by A.J.Taylor (1 Feb '93)

Equipment

The bathymetry equipment installed on RRS Discovery consists of:

- Hull mounted transducer,
- Precision Echosounding (PES) 'fish' transducer, and
- Simrad EA500 Hydrographic Echosounder.

Operation

The Simrad Echosounder was used during the cruise for bottom detection and determining the height of the CTD off the bottom during casts. While in bottom detection mode the depth values were passed via a RVS level A interface to the level C system for processing. Data was logged at a 30 second interval.

The transducers were connected to the Simrad equipment via an external switch. A uniform sound velocity in water of 1500 m/s was used during the cruise.

A visual display of the return echo was displayed on the Simrad VDU. Hardcopy output was produced on a color inkjet printer and a Waverley thermal linescan recorder.

Performance

While on station and steaming during the initial few weeks of the cruise, the PES fish transducer was used. This gave good return signals on station and adequate return signals whilst steaming at 10 knots. After the second week the return signal when steaming deteriorated rapidly and the hull transducer was used whilst underway. Upon recovery of the fish on day 025 prior to steaming for Capetown, it was found that the lowest section of fairing was split in two. This was probably hitting the fish and the cause of noise whilst steaming. The fairing was replaced before being redeployed on day 028, and a good signals were obtained whilst underway for the remainder of the cruise.

When coming on station the PES fish sank considerably from its steaming depth: this resulted in a 17 m offset between the PES fish and the hull transducer on the graphic display. The fish returned a lower depth than the hull transducer. The amount of cable submerged whilst on station was measured to be approximately 22 m thereby accounting for the offset.

The Hewlett Packard inkjet printer developed a fault after one week and was replaced by the Waverley linescan recorder. This was quite unreliable and was itself replaced, when a new inkjet printer was delivered by the Capetown pilot on 27 January.

As is well known the automatic depth finder performance is adversely affected when the signal to noise ratio is small. In these circumstances the digitally recorded data is frequently unreliable. Given strip–chart records the situation can be recognized and rectified. Except for the first few and the last few days, such records are unavailable on cruise 199. Consequently the overall quality of the depth measurements is very disappointing. (Note added by P.M.Saunders, 9 Feb ‘93).

C.2.3 Acoustic Doppler Current Profiler (ADCP)

by P.M.Saunders and R.Marsh (1 Feb ‘93)

The instrument used was an RDI 150 kHz unit, hull–mounted approximately 2 m to port of the keel of the ship and approximately 33 m aft of the bow at the waterline. On this cruise the firmware version was 17.10 and the data acquisition software was 2.48. For most of its operation the instrument was used in the water tracking mode, recording 2 minute averaged data in 64x8 m bins from 8 m to 512 m. On the shelf at the start and end of the cruise, the instrument was put into a mode in which both water and the bottom are tracked. Here 2 minute averaged data was collected in 50x4 m bins from 6 m to 200 m depth.

The performance of the instrument was excellent throughout the cruise: on station, profiles were almost always recorded to 300 m depth, and whilst steaming, except in the heaviest weather, profiles in excess of 200 m were the norm. Data were passed in real time from the deck unit to a SUN workstation acquisition area: once a day, 24 hours of the data were read into the processing area.

Our processing has much in common with that of Griffiths (1992) except in one or two important respects, but for completeness will be outlined here. Stage 0 was to capture the 24 hours of data and write it into an appropriate format. Stage 1 consisted of correcting the time base for instrument clock drift and changing the time stamp from end of data period to centre of data period. Stage 2 consisted of applying misalignment corrections (to be described below), averaging data into 10 minute periods, merging with the ship’s motion over the earth from GPS navigation and thereby deriving, by algebraic addition, current components averaged over the same interval. At this stage error velocities were displayed as time series to identify both depths of good data and periods of poor data: there were remarkably few of the latter.

Stages 3 and 4 of the processing were novel: average profiles were constructed in approximate 4 hour chunks whose boundaries were selected by inspection and corresponded to ‘on station’ and ‘steaming’ activities. Data for maneuvering periods were excluded. The average profiles were identified by the station number, with the addition of the letter A to indicate the steaming period after the station. A cruise data set was constructed by appending the files together and we expect to employ this modest body of data in a combined analysis with the hydrographic data. For more detailed studies of the Ekman layer, for example, and the response of the upper ocean to storm force winds, the 10 minute data set will be utilized.

As is well known, a key element in the determination of currents (water motion over the Earth's surface) from the ADCP is the ship's gyro. This allows the fore and aft and athwartships components of flow determined from the RDI instrument to be resolved into east and north components and so added to the ship's motion determined by navigation (GPS). The results are sensitive to gyro error, gyro drift, and the alignment of the transducers on the hull. In order to evaluate these errors, zigzag calibration exercises (Pollard and Read, 1989) were carried out on 4 occasions: 24 December (courses 0°, 090°), 8 January (courses 045°, 135°), 21 January (courses 015°, 105°), and 31 January (courses 015°, 105°). The results from the first 3 calibration exercises showed a small increase in the misalignment angle from 0.5° to 1.0° to the right of the apparent gyro direction. On board the initial value of 0.55° was used in the preliminary analysis of the data. Ashore considerable post processing will be undertaken to correct for both directional and gyro errors (see the section 2.9c).

References

Griffiths, G., 1992, Handbook for VM–ADCP–PSTAR system as used on RRS Charles Darwin and RRS Discovery. Internal document No.4, James Rennell Centre, Southampton, 24pp.

Pollard, R.T. and J.F. Read, 1989, A method for calibrating ship–mounted acoustic Doppler profiles and the limitation of gyro compasses. Journal of Atmospheric and Oceanic technology, 6, 859–865

C.2.4 Thermosalinograph measurements

by S.Cunningham (1 Feb '93)

Instrument and Technique

Continuous underway measurements of surface salinity and temperature were made with a Falmouth Scientific Inc. (FSI) shipboard mounted thermosalinograph (TSG). Salinity samples were drawn from the uncontaminated sea water supply at four hourly intervals, and used to calibrate conductivities obtained from the TSG. The instrument was run continuously throughout the cruise.

The TSG comprises of two FSI sensor 'modules', an Ocean Conductivity Module (OCM) and an Ocean Temperature Module (OTM) both fitted within the same laboratory housing. Sea surface temperature is measured by a second OTM situated on the suction side of the uncontaminated seawater supply in the forward hold. The uncontaminated seawater intake is 5 m below the sea surface.

Data from the OCM and OTM modules are passed to a personal computer (PC). The PC imitates the traditional Level A system, passing it to Level B at 30 second intervals.

Sensor Calibrations

The temperature modules are installed pre-calibrated to a laboratory standard and laboratory calibration data are used to obtain four polynomial coefficients. A similar procedure is employed for the conductivity module.

Underway Salinity Sampling

Salinity samples were drawn from the uncontaminated seawater supply at four hourly intervals. These samples were then analyzed on a Guildline 8400 using standard sea water batch P120.

Calibration of TSG Salinities against Underway Salinity Samples

TSG conductivity measurements at 30 second interval were median despiked, discarding data more than 0.01 mmho/cm from a mean computed over 5 adjacent data values. Conductivity of the bottle samples was calculated at a pressure of 0 dbar and at the temperatures of the TSG OTM. The TSG data were merged onto the bottle data and the conductivity difference between the bottles and TSG calculated. After excluding outliers, a linear regression between the conductivities was determined and applied to the TSG values. TSG salinities were computed along with the difference from the bottle salinities. This difference was filtered with a Gaussian filter of half width 12 hours and normalized peak height of 0.38. TSG salinities were then corrected by adding the filtered difference. A plot of the corrected salinity and temperature at the surface for the entire cruise is shown in Figure C.5.

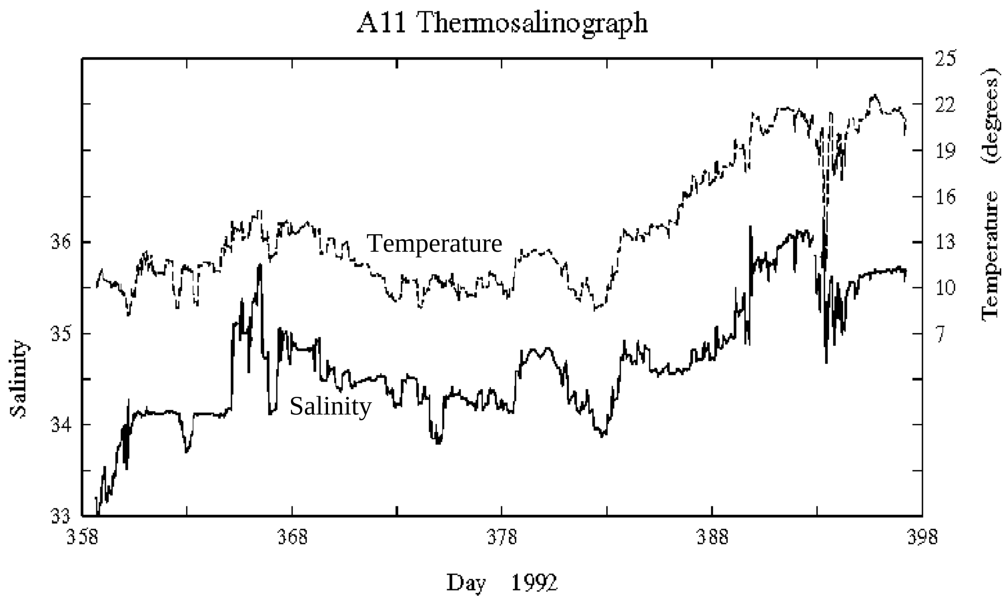

FIGURE C.5: Surface salinity and temperature on cruise A11. The cruise begins on the Argentine Shelf, passes through the Falkland Current (day 363), the Brazil Current retroflection (day 365), traverses the Subantarctic Zone until somewhere between data 386 and 390 it enters the subtropical gyre. The cruise ends in South Africa.

Estimate of the TSG accuracy and salinity residuals

Due to particular difficulties with the instrument, the estimate of salinity residuals has been split into two portions. For the period day of year=359 to day=23 (389) the mean difference between the bottle and TSG salinities was –0.0009 with a standard deviation of 0.0145. For the period day=23 to day=32 the mean salinity difference was 0.0005 with a standard deviation of 0.02.

Over the period from 23 0000Z to 27 0825Z the housing temperature sensor produced unreliable results. A current leakage was found between the platinum resistance thermometer and the surrounding seawater. This caused the probe to oxidize and eventually fail. At about the same time the pumps for the uncontaminated seawater supply failed and an alternative set were switched on. This caused a decrease in the flow rate and a corresponding increase in lag time for water from the uncontaminated seawater intake to reach the TSG, from approximately 5 to 10 minutes. Degradation of the conductivity results is likely. On day=26 at 0555Z the housing OTM was replaced. For the period 23 0000Z to 26 0555Z a reconstructed housing temperature was derived from the remote temperatures. Given the uncertainties in lag time and the alternative heating and cooling of the uncontaminated seawater supply through the ship (during this period for surface temperatures less than 20.2°C the supply is warmed and above that cooled) the reconstructed temperatures are not likely to be better than 0.2°. The uncertainty probably accounts for most of the spread in the salinity residuals over this latter period.

C.2.5 XBTs

by S.R.Thompson (1 Feb '93)

XBT profiles during Discovery cruise 199 were collected using the Bathy Systems Inc. XBT program version 1.1 and SA–810 XBT controller, with the probes launched from a Sippican Corporation hand–held launcher. The inflection points calculated by the program were transmitted to the GTS network after each launch via the GOES satellite. ASCII versions of the raw data were transferred to the RVS level A using a diskette.

An intercomparison was carried out by comparing profiles made in a marked mixed layer with the surface temperature measured on the thermosalinograph in regions of low horizontal temperature gradient. Linear regression of TSG onto XBT temperature gave a slope of 0.99 and an uncertainty of 0.01, with an offset of 0.2 degrees at 10 °C.

Launch 107 was a calibration run using the test probe. This yielded 14.85 degrees for a resistor chosen to give a value of 15.0.

Two problems were noted with the software:

1) The bucket temperature information in the header does not appear to be saved. This means that if a file is not transmitted to the satellite immediately after the launch then the temperature must be reentered in the header.

2) The column indicating whether the file has been transmitted sometimes fails to show a 'Y' after transmission.

Information concerning all the successful launches is shown in the accompanying XBT station list (omitted from this example for the sake of brevity). All launches were T7 probes unless marked otherwise and breaks in the launch numbers indicate probe failures, of which there were nine (eight T7 and one T5). Launches 101 to 125 did not form part of the A11 section

C.2.6 Meteorological Measurements

by K.J.Heywood and P.K.Smith (1 Feb '93)

The meteorological monitoring system used on RRS Discovery comprises the following instruments:

- an R.M. Young Instruments Type 05103 wind velocity propeller – vane sensor, located on the foremast to port.

- two Vector Instruments psychrometers, located on the foremast to starboard (serial numbers 1072 and 1073). (1073 was replaced by 1071 during the cruise).
- two Didcot cosine collector PAR sensors (spectral range 400– 700 nm) located port and starboard on the foremast (serial numbers 0150 and 0151 respectively).
- two Kipp and Zonen total irradiance sensors located on the foremast to port and starboard (serial numbers 92015 and 92016 respectively).
- an Eppley longwave pyrogeometer located on the foremast top pole (serial number 26207F3).
- a hull–mounted RVS/RS Components platinum resistance thermometer, recording sea surface temperatures.
- a Vaisala DPA21 aneroid barometer, located in the main lab.
- a Gill sonic anemometer located on the foremast to starboard.
- a shipborne wave recorder.

Unlike most shipboard instruments that have a dedicated Level A interface, the metlogger PC emulates a standard Level A interface and transmits the data directly to the Level B in Ship Message Protocol (SMP). The data are transferred to the Level C and then reformatted from Level C to PSTAR format to allow processing under UNIX, using a series of pexec scripts based on the set of scripts used for the IOS DL Multimet system. Data were recorded as 1 minute averages.

Processing

The UNIX shell script metexec0 was used to retrieve data from the Level C and convert them into PSTAR format. Metexec1 was used to calibrate all instruments apart from the aneroid barometer and wind direction output from the wind velocity sensor. Ship's navigation data including gyro heading (bestnav, derived from GPS and dead–reckoning) were merged with the met file by metexec2. Metexec3 and metexec4 were not normally used for this cruise. A combination of the ship's velocity components and heading was used in metexec5 for the conversion from relative to absolute wind velocities. Metexec6, an appending script was used to generate a full time series from the individual files, metexecp was used to produce plots, and the Pstar program metflx was used to derive wind stress and heat fluxes.

Calibration

With the exception of the aneroid barometer and wind direction output from the wind velocity sensor where any conversion or calibration is performed by the metlogger PC and were therefore logged through to the Level B as calibrated output, all instruments were calibrated during PSTAR processing of the meteorological data. The calibration algorithms applied were derived either from manufacturers calibration certificates or from calibrations undertaken by RVS and IOS DL prior to the cruise. Details are given in Table C.3.

Problems encountered

Air temperatures

The RVS PC display system showed slightly higher readings than expected. This was due to the calibration coefficients being only nominal values. Also the calibration file used a 2 order formula, whereas the IOS calibration uses a 3 order formula. Using the calibration data for

TABLE C.3: Calibration coefficients for the meteorological sensors

Measurement	Calibration coefficients y=*a*+*b*x+*c*xx+*d*xxx				Source if not IOS DL
	a	***b***	***c***	***d***	
Wind speed	0	0.1	0	0	mfr
Wind direction	0	1.0	0		mfr
swet	–21.63646	2.580562E–3	7.893778E–6	0.660868E–9	
sdry	–20.18834	9.733870E–4	7.835114E–6	0.525038E–9	
up to day 364					
pwet	–23.71101	6.848060E–3	5.626587E–6	1.077627E–9	
pdry	–23.84735	5.788879E–3	5.648462E–6	0.907665E–9	
after day 364					
pwet	–24.38268	6.720888E–3	5.840227E–6	0.969597E–9	
pdry	–23.36777	5.245053E–3	5.784058E–6	0.882978E–9	
sea	0.26705	0.99189	2.9755E–4	0	RVS
longwave	0	0.23364486	0	0	
y=x/(ab)					
pPAR	5	12.86E–6			
sPAR	5	12.87E–6			
pirr	2	48.49E–3			
sirr	2	43.63E–3			

each psychrometer, new values were calculated and entered into the calibration file. These gave good readings on the display. The correct 3 order coefficients were in the Pstar calibration file.

On December 29, 1992 (day 364) the port psychrometer data became very noisy. It was replaced and new calibration coefficients entered into the calibration file (/pstar/src/extras/cal/met 199.cal). There is a gap in the port data between 1600 hours and 1845 hours. No further problems occurred during the cruise.

Long Wave Radiometer

This gave good readings at the start of the cruise, but began giving some low readings during 1st January (day 367). The signal slowly deteriorated becoming more erratic. This could not be due to dirty lens or cloud cover. The battery was replaced on 16 January (day 382) and good readings were obtained for the rest of the cruise.

Sonic Anemometer

The Asymmetric Sonic Anemometer was mounted on the foremast with North facing forward. The system gave good readings. The system stores processed data on both hard disk and floppy disk. To store the raw data an optical disk was installed with a capacity of 20 days' data. There was some difficulty in setting up the software but eventually the optical disk recorded raw data. There was some complex interaction between the system clock and the optical disk software. As the software needs the time and date information in the data files and in naming the files, the software halts if the internal clock is in error. This error occurred between once in 3 days to 3 times in a day. Re-booting and resetting the time and date resumed normal operation.

Ship Borne Wave Recorder

The computer and associated software worked well during the cruise with very few errors. The signal amplification/conditioning unit showed a large DC offset and low amplitude signal for the Port Pressure Transducer. This transducer was flushed, which considerably reduced the DC offset and increased the signal amplitude. Further flushing produced a further improvement but there was still a small DC offset and the amplitude remained slightly smaller than the starboard pressure transducer. The last calibration was at the refit and a DC offset was noted then.

Meteorological Observations During the cruise

Weather conditions during the cruise were remarkably clement, with the exception of a storm in mid-January. The maximum sustained wind speed observed was 28 m/s on 13th January, producing the largest wave heights.

C.3 Hydrographic Measurement Techniques and Calibrations

C.3.1 Sample Salinity Measurements.

by: S. Bacon (1 Feb ‘93)

On RRS Discovery cruise 199 the salinity analysis of samples was carried out exclusively on the IOS DL Guildline Autosal salinometer model 8400, modified by addition of an Ocean Scientific International peristaltic–type sample intake pump. The instrument was operated in the ship’s constant temperature laboratory at a bath temperature of 24°C with the laboratory set to 20.5°C. This difference in temperature was larger than normally employed and only arose through a misunderstanding, but was allowed to remain rather than disturb the salinometer again when it became clear that the machine was quite ‘happy’ operating thus. Standardization was effected by use of IAPSO Standard Seawater batch P120, of which 110 ampoules were consumed. Two of these were imperfectly sealed, and were discarded; two were evidently of incorrect (too high) salinity, and one more was thought dubious. These latter three were not used as standards. The standardization history of the salinometer has been constructed, in which standardization drift is represented as equivalent salinity (ES) change referenced to the first standard measurement of the cruise. The instrument was remarkably stable, not changing from its initial standardization by more than 0.001 ES until the last ten days of the cruise, when the seas generally were calmer and the outside temperature increased, although it is difficult to associate such changes in external conditions with the observed behavior of the salinometer, unless the ship’s power supply is implicated in some way. Excluding the two bad standards, the mean standardization drift was 0.0007 ES, with a standard deviation of 0.0007 ES, for 108 standards.

There were 46 pairs of replicate (i.e., from the same rosette bottle) samples drawn; and 210 pairs of duplicate (i.e.,from different rosette bottles fired at the same depth) samples. Of the duplicate pairs, 87 were from below 3000m. The standard deviations of the three groups of sample pairs are given in Table C.4 below.

TABLE C.4: Salinity replicate and duplicate statistics

Quantity	Standard deviation	Number of pairs
Duplicates	0.0019	208
Duplicates	0.0009	87
from >3000 m		
Replicates	0.0008	46
See text above table for the distinction between replicates and duplicates.		

C.3.2 Sample Oxygen Measurements

by P.Chapman, S.E.Holley and D.J.Hydes (9 Feb ‘93)

Equipment and techniques

Bottle oxygen samples were taken in calibrated clear glass bottles immediately following the drawing of samples for CFCs. The temperature of the water at the time of chemical fixation was measured to allow corrections to be made for the change in density of the sample between the closure of the rosette bottle and the fixing of the dissolved oxygen. Analysis followed the Winkler whole bottle method. The thiosulfate titration was carried out in a controlled environment laboratory maintained at temperatures between 21° and 22 °C. Thiosulfate normality was determined on a daily basis and whenever new reagents were made up. Duplicate samples were taken on every cast; usually these were from the deepest four bottles.

For the early stations, the end point was determined by an automatic photometric method manufactured by SIS (Germany). After station 12253, however, the instrument began giving erroneous endpoint readings since a distinct yellow color was sometimes still visible in the titration flasks. The error was not consistent, and some analyses within each run appeared to titrate correctly; however, all samples from stations 12253, 12254, 12255, and 12257 have been flagged as suspect. For stations 12258 to 12337, i.e., the bulk of the cruise, an “amperometric titration to a dead stop” following the method of Culberson and Huang (1987) was used. A Metrohm Titrator and a Dosimat 665 (10 ml) automatic burette was employed. Titration volumes in deep waters were approximately 5 ml and the smallest increment from the burette was 2 microliters.

The volume of oxygen dissolved in the water was converted to mass fraction by use of the factor 44.66 and an appropriate value of the density; corrections for the volume of oxygen added with the reagents and for impurities in the manganese chloride were also made as described in the WOCE Manual of Operations and Methods (Culberson, 1991, WHPO 91-1).

Reproducibility of measurements

Approximately 1900 samples were taken during the cruise; in addition, a large number of duplicates were analyzed. Statistics on the duplicates are given in Table C.5. These include both duplicates taken from the same bottle (replicates) and those taken from different bottles fired at the same depth and invariably unknown to the analysts.

TABLE C.5: Statistics of duplicates and replicates obtained by both the photometric and amperometric methods. Sample depths are given where appropriate.

Station(s)	Number	Depth(s) m	Oxygen concentration µmol/kg		
			mean (diff.)	Std. dev.	%mean
Photometric method					
12240	22	2500	208.5	0.63	0.3
12250–56	12	all	1.2	1.29	0.56
Amperometric method					
12277	13	5234	230.1	0.35	0.15
12258–337	223	all	0.64	0.85	0.40
12258–337	166	all	0.57	0.65	0.30

While the photometric method was being used, 22 samples were taken from separate bottles all fired at a depth of 2500 m at station 12240 (Table C.5). The data gave a standard deviation of 0.63 µmol, or 0.3%. However, 12 pairs of duplicates taken from the same bottle for stations 12250–12256 gave a mean difference of 1.2 µmol with a standard deviation of 1.29 µmol (approximately 0.56%, Table C.5). Duplicates from 223 pairs of samples taken from the same bottle later in the cruise while the amperometric method was in use had a mean difference of 0.64 µmol, and standard deviation of 0.85 µmol, while 13 samples from 5455 m from station 12277 gave a standard deviation of 0.35 µmol (0.15%, Table C.5).

A further series of multiple samples was taken from different bottles fired at the same depth as a result of doubletrips by the rosette. The results of these are also given in Table C.5. The mean difference for 166 sets taken over all depths and analyzed by the amperometric method was 0.57 µmol; the standard deviation of the differences was 0.65 µmol. These figures are not significantly different from duplicates taken from the same bottle (replicates).

Comparisons with historical data

Data taken at on this cruise on stations 12271–12274, 12282–12286, and 12296–12299 were compared with SAVE stations 289–293, 260–264, and 200–203 respectively. Additionally, stations 12313–12316 were compared with data obtained at AJAX stations 46 and 47 near the Greenwich Meridian. Some of this is shown in Figure C.3 and Figure C.4. Apart from differences in the near surface data resulting from changes in water masses in the area, there is a large measure of agreement. However, at the deepest levels the present cruise data at a given potential temperature (or salinity) shows an offset of between 2 and 6 µmol kg^{-1}, in all cases less than the historic data. We are currently investigating the cause of these offsets.

References

Culberson, C.H. and S.Huang, 1987. Automated amperometric oxygen titration. Deep–Sea Research, 34, 875–880.

Culberson,C.H. 1991. 15 pp in the WOCE Operations Manual (WHP Operations and Methods) WHPO 91/1, Woods Hole.

C.3.3 Nutrients

by D.J.Hydes, P.Chapman and S.E.Holley (9 Feb '93)

Equipment and techniques

The nutrient analyses were performed on an Alpkem Corporation Rapid Flow Analyzer, Model RFA–300.

The methods used were:

Silicate: the standard AAII molybdate-ascorbic acid method with the addition of a 37°C heating bath (Hydes, 1984) to reduce the reproducibility problems encountered when analyzing samples of different temperatures, noted on an earlier cruise when the standard Alpkem method was used (Saunders et al., 1991, c.f. Joyce et al., 1991).

Phosphate used the standard (Murphy and Riley, 1962) reagents and reagent to sea water ratios but with separate additions of ascorbic acid and mixed molybdate–sulfuric acid–tartrate to overcome the problem of the instability of a mixed reagent including ascorbic acid.

Nitrate was determined using the standard Alpkem method.

Previous experience has shown that better reproducibility is achieved when the instrument is run in a laboratory with a stable temperature. The Alpkem was located in the new constant temperature laboratory on Discovery. The temperature was maintained between 21° and 22°C. A drawback of this location was that the large air circulation in the laboratory leads to enhanced evaporation of samples in the open cups sitting in the analyzer tray, and possibly to some contamination due to dust circulating in the airstream. This was ameliorated by fitting a cardboard skirt round the sample tray lid.

Sampling Procedures

Sampling of nutrients followed that for trace gases (CFCs on this cruise) and oxygen. Samples were drawn into virgin polystyrene 30 ml Coulter Counter Vials (ElKay). These were rinsed three times before filling. Samples were then analyzed as rapidly as possible after collection to avoid build up of a sample back log. Samples cups of 2.0 ml capacity were used. These were rinsed once by filling completely before filling with analyte. Tests carried out on the cruise showed that samples from all depths stored for a week in a refrigerator at 4 °C were not significantly effected by storage.

Calibration and Standards

The calibrations of all the volumetric flasks used on the cruise were checked before packing and these were recalibrated if necessary.

Calibrations of the three Finnpipettes used on the cruise were checked before packing. The six Eppendorf fixed volume pipettes were delivered too late to be calibrated before the cruise.

However in use no difference was detectable between the results achieved with the Finnpipettes and Eppendorfs.

Nutrient standards

Nutrient primary standards were prepared from salts dried at 110 °C for two hours and cooled over silica gel in a desiccator before weighing. Precision of weighing was to better than 1 part per thousand. For *nitrate*, 0.510 g of potassium nitrate was dissolved in 500 ml of distilled water in a calibrated volumetric PP flask at a temperature of 21°–22°C. For *nitrite*, 0.345 g of sodium nitrite was dissolved in 500 ml of distilled water in a calibrated volumetric PP flask at a temperature of 21–22°C. For *phosphate*, 0.681 g of potassium dihydrogen phosphate was dissolved in 500 ml of distilled water in a calibrated volumetric PP flask at a temperature of 21–22°C. Working standards were prepared from a secondary standard made by diluting 5.00 ml of the primary standard measured using a Finnpipette Digital 1.00 to 5.00 ml adjustable volume, in a 100 ml calibrated glass volumetric flask. For silicate, 0.960 g of sodium silica fluoride was dissolved in 500 ml of distilled water in a calibrated volumetric PP flask at a temperature of 21–22°C. Dissolution was started by grinding the fluoride powder to a paste with a few drops of water in 30 ml polythene beaker using a plastic rod for three to four minutes.

Secondary calibration standards.

A uniform set of six mixed secondary standards were prepared in artificial seawater, Concentrations (µmol) were: nitrate 40, 30, 20, 10, and 0; phosphate 2.5, 2.0, 1.5, 1.0, 0.5 and 0; silicate 150, 100, 75, 50, 25 and 0 up to station 12288, and 150, 120, 90, 60, 30 and 0 thereafter.

The artificial seawater was a 40 ppt solution of Analar grade sodium chloride. Nutrients were undetectable in these solutions relative to Ocean Science International (OSI) Low Nutrient Sea Water which contains 0.7 µmol Si, 0.0 µmol NO_3 and 0.0 µmol PO_4. On one occasion the solution was found to contain 0.6 µmol PO_4 and consequently was not used.

Establishment of a Quality Control (QC) Sample

At a test station 12240 occupied on 26 December a large volume of deep water was collected with the idea of using this as a quality control standard when its stability had been verified. Samples of this water where run at intervals over the next two weeks.

From station 12291 onwards a sample of 12240 water was measured as a “QC” sample on each analyzer run. The scatter of the data are shown in Figure C.6. Silicate returned a consistent result with occasional flyers. The phosphate results suggest that the first (up to 12301) and second (up to 12319) one liter subsample were unstable but the third sample was stable. This may be due to the surface of the polythene bottle storage equilibrating with the sample. The sharp shift in the apparent nitrate concentration in the QC between stations 12311 and 12312 is currently inexplicable. It does not correspond to a change in primary standard concentration. It was difficult to detect in the contour plots, but does appear to be present when concentrations were compared along isopycnal surfaces.

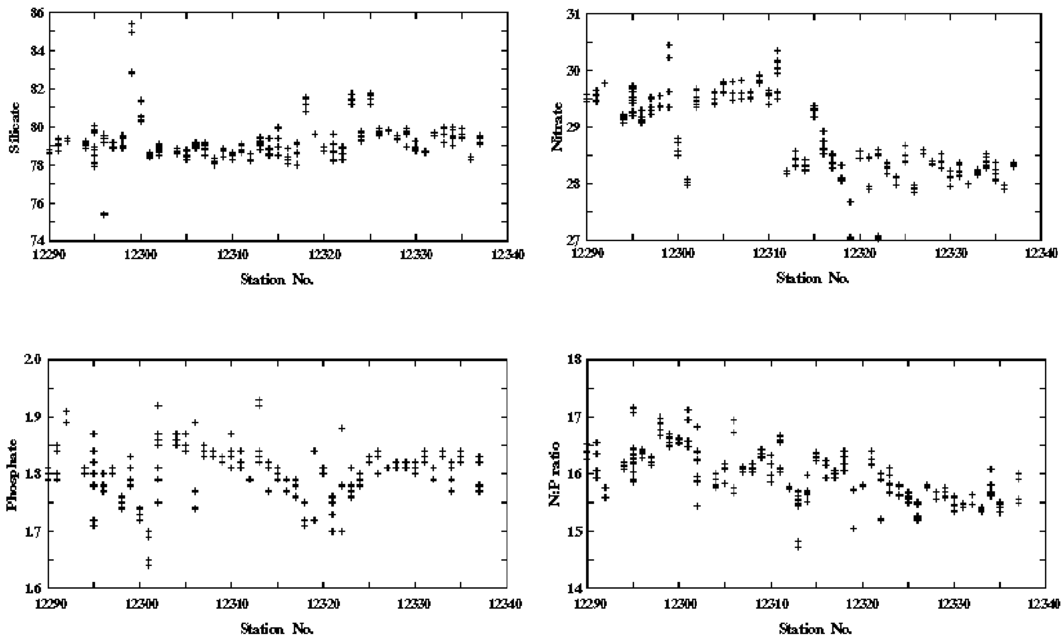

FIGURE C.6: Deep water collected on station 12240 from 2500 m was used as quality control for the nutrient measurements: results are shown for the last 50 stations of the cruise.

Reproducibility

For the QC standard 189 measurements were made. The means were: silicate 78.85, nitrate 28.85, phosphate 1.79. Percent standard deviations: silicate 1.05, nitrate 2.45, phosphate 2.35.

For 10 replicates of the top standard run after station 12337 the percent standard deviations were: silicate 0.22, nitrate 0.25, phosphate 1.1.

References

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C.3.4 CFC–11, CFC–12, and CFC–113

by D.Smythe-Wright, S.M.Boswell and D.Price (1 Feb ‘93)

Sample collection

All samples were collected from depth using 10 liter Niskin bottles. These had been cleaned prior to the cruise using a high pressure water jet. All ‘O’ rings, seals and taps were removed, washed in deacon solution and propan–2–ol then baked in a vacuum oven for 24 hours. Cleaning and reassembling of the bottles was carried out at the commencement of the cruise to minimize contamination due to long storage. Of the 24 bottles initially assembled three had to be replaced due to leakage. None of the 27 working bottles showed a CFC contamination problem during the entire cruise. All bottles in use remained outside on deck throughout the cruise, those not in use were stored in aluminium boxes inside the hanger where there was a free flow of air to minimize contamination.

Equipment and technique

Chlorofluorocarbons CFC–11, CFC–12 and CFC–113 were measured on a total of 46 stations. The analytical measuring technique was a modification of that described in Smythe-Wright (1991a & b). In the modified system trapping was achieved using a 10 cm Poracil B trap cooled to below –45 °C. Subsequent desorption was by means of a water bath at 100 °C. The trap was positioned on the exterior of the GC oven and not on the extraction board as in the original system. Valves V6 and V7 were replaced respectively with automated 8 port and 6 port Valco valves sited inside the GC oven to give better chromatographic resolution. Gases were forward flushed off the trap into a 3 m precolumn and subsequently chromatographically separated using a 75 m long DB 624 megabore column. The precolumn was of the same material as the main column. Samples for analysis were drawn first from the Niskin bottles and stored under clean sea water. The analysis was completed mostly within 12 hours of the samples coming on board. Duplicate samples were run on most but not all casts due to the long analytical turn over time. Air samples were run daily from an air intake high up on the foremast. Air was pumped from this location through a single length of Dekoron tubing using a metal bellow pump.

Calibration

All CFC–11 and CFC–12 analyses were calibrated using 12 point calibration curves constructed from a gas standard calibrated by Weiss at SIO. This standard was contained in an Airco spectra seal cylinder as recommended in WHPO 91-1. CFC–113 analyses were calibrated in a similar fashion using a compressed air standard prepared at the JRC and calibrated by Haine at PML.

Contamination

Because of a delay in customs clearance of the air freight, the CFC equipment was delivered to the ship less than 24 hours before departure. This delay had a knock on effect and compounded a number of teething problems, mainly due to two blocked valves and a contamination problem which masked the CFC–12 chromatographic peak. This resulted in the loss of data from a number of stations at the beginning of the cruise. The nature and source of the contamination problems was never totally discovered. It seemed to be related to the aquarium baths and the uncontaminated seawater supply used for storing the syringes prior to analysis. The problem appeared some days after sailing and was overcome chromatographically by reducing the carrier gas flow and thereby separating the contamination from the CFC–12 peak. This meant that the overall analysis time was lengthened to 25 minutes and consequently restricted CFC analysis to every other CTD cast.

Comparison with historical data

Data accuracy was checked by comparison with Save leg 4 and 5 data and with data from the AJAX experiment. Some comparisons are given in Figure C.7. Since four years has elapsed

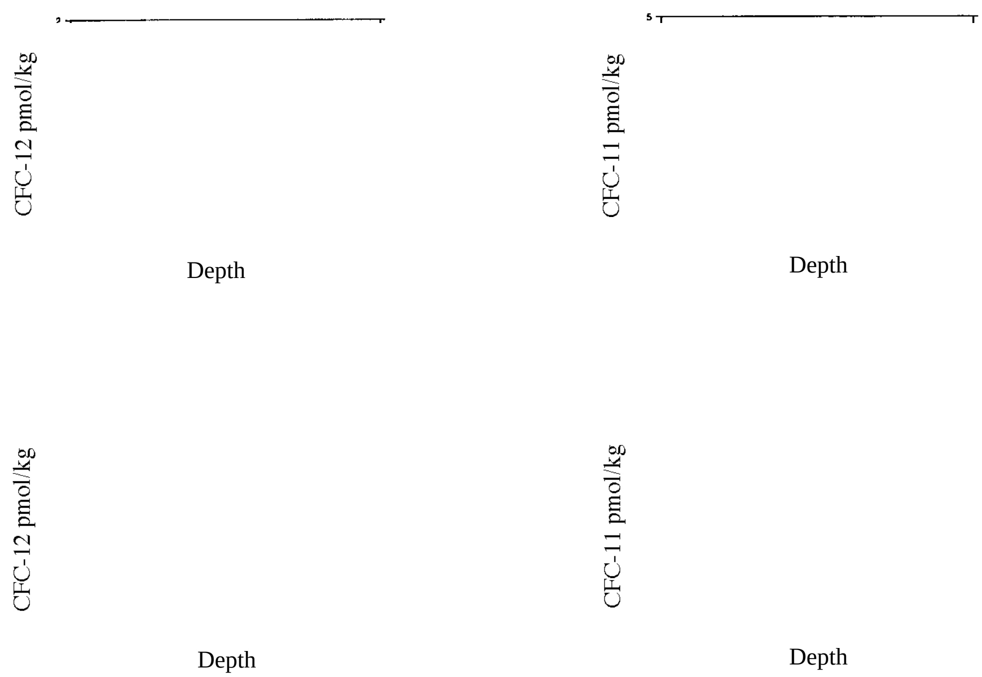

FIGURE C.7: A comparison of CFC-11 and CFC-12 data from (a) SAVE station 291 and A11 station 12273 and (b) SAVE station 200 and A11 station 12295.

since these programmes some deviation in the data was expected particularly in the surface and deepest waters. In all cases deviations were consistent with the increase in atmospheric concentrations over the four year period.

References

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C.3.5 Samples Taken for Other Chemical Measurements

Oxygen and Hydrogen Isotope Ratios

by S. M. Boswell (1 Feb ‘93)

A total of 241 samples were collected from 12 stations for isotope analysis by UEA. These included 18 duplicate samples from station 12333. Samples were collected directly into 50 ml glass vials following an initial rinse and two filling/emptying method. The caps were then sealed using parafilm and stored in the refrigerator. A total of 8 samples from the first three stations were lost when the refrigerator opened in rough weather. Samples thereafter were stored in the cold store.

Iodine

by P. Chapman (1 Feb ‘93)

A total of 78 samples were collected from full water depth casts at Stations 12255, 12288, 12305 and 12335. These will be analyzed by Dr. G. Luther, University of Delaware, USA.

C.3.6 CTD Measurements

Gantry and Winch Arrangements

by S. Jordan, R. Phipps, S. Whittle (1 Feb ‘93)

Midships Gantry

This gantry is of a novel design, and basically acts in the manner of a parallelogram lifting table. While the gantry is moving from the inboard to outboard positions, the block from which the package is suspended describes an arc of a circle; due to the lifting action of the gantry, no winch movement is normally necessary while the package is being lifted outboard. Various loads, in our case the CTD package, can be safely deployed in virtually any sea state in which the ship can keep station. The performance of the gantry surpassed expectations. One reservation of note concerns the leading of the wire around a number of sheaves required to make the wire follow the parallelogram shape of the gantry. On two occasions, during deployment and with the CTD package at the sea surface, sufficient slack occurred in the wire for it to jump off one of the sheaves.

10 Ton Traction Winch

The CTD package was deployed using the 10T Traction Winch. The maximum descent/ascent rate required was 60 m/min, therefore only one boost and two main pumps were required for successful operation (two boost and four main pumps being available). The following problems were noted: a) A bearing on the scrolling gear was found to be excessively worn. This was replaced with a minimal loss of scientific cruise time (Feb. 12, ‘92). Inspection of the bearing showed it to be incorrectly designed or assembled. b) The 37 kW storage system hydraulic power packs failed to provide power, a fault which persisted after various valves were stripped, cleaned and reassembled (Jan. 1, ‘93). The fault was eventually traced to an erratically operating potentiometer (by P. Gwilliam and A. Taylor). Approximately 36 hours of scientific time were lost. c) Inboard compensator and back tension adjustments were needed more or less continuously. Although these were carried out with no loss of scientific time, a satisfactory solution was not found on the cruise.

With known limitations the winch worked reasonably well and appears to have future expansion potential. It must be noted that the manufacturers intend to modify some of this system during the next ship refit, which should eliminate the problems encountered. The mechanical technicians are gaining more knowledge and confidence of the traction winch system and are especially pleased to have managed to repair/maintain the system with minimal down time.

Equipment, calibrations and standards

by T. J. P. Gwilliam (1 Mar ‘93)

The CTD equipment used on this cruise was the property of IOS. The following equipment was deployed on the CTD/multisampler underwater frame:

1. Neil Brown MK. 3 CTD complete with SensorMedic oxygen cell. IOS identification: DEEP01

2. Sea Tech. 100 cm folded path transmissometer. Serial No.: 35.

3. General Oceanics 10 liter 24 bottle rosette. Model 1015. IOS identification: 01.

4. Seven SIS (Sensoren Instrumente Systeme) digital reversing thermometers and two SIS digital reversing pressure meters. Serial numbers are detailed elsewhere in the report.

5. Simrad Altimeter, Model 807–200M

6. IOS DL 10 kHz pinger.

Backup equipment consisted of spare CTD, transmissometer, rosette, Niskin bottles, pinger and underwater frame.

The shipboard equipment consisted of two complete integral systems for demodulating and displaying the CTD data as well as controlling the rosette multisampler. Each system included the following major units:

1. EG&G demodulator. Model 1401.

2. IBM PS2 PC system with 80 Mbyte tape system for archiving the data.

3. EG&G non data interrupt rosette firing module.

Calibration of the Mk III CTD temperature and pressure sensors was carried out at the IOS DL calibration facility. Conductivity and oxygen cell calibration was carried out at sea by reconciliation with sample values. Reversing thermometers were also calibrated in the lab, three at IOS DL, and four at the Research Vessel Base.

CTD temperature calibration – IOS DL DEEP01 – 19 June 92 CTD temperature was calibrated in degrees Centigrade in the ITS_{90} scale at six temperatures ranging from 0.19 to 25.3 degrees. The transfer standard had been calibrated on 25 March 92 at the triple points of mercury and water, and at the melting point of gallium. The following linear fit for CTD temperature was found, with a rms error of 0.4 millidegrees.

$T = 0.9986622 \times T_{raw} - 0.01282084$

No post–cruise laboratory calibration is available at present (March 1993). The CTD equipment is required on Discovery for two subsequent cruises, and will not be returned to IOS

DL until at least June, 1993. Stability of temperature calibration during the cruise was monitored by comparison with reversing thermometers, and this is discussed in the description of reversing thermometer data.

CTD pressure calibration – IOS DL DEEP01 – 24 June 92 CTD pressure was calibrated by comparison with a Paroscientific Digiquartz model 240 portable transfer standard, in series with a deadweight tester; the Digiquartz was used as the pressure standard. The following quadratic fit for CTD pressure was found at an ambient temperature of 20 degrees, with a rms error of 1.8 dbar.

$P = 3.066286E{-}07 \times P_{raw}{**}2 + 0.9978454 \times P_{raw} - 12.6$

Further corrections were applied during data processing for variation of offset with temperature, and up/down hysteresis.

Equipment performance

General

With deployments at approximately four hourly intervals, power to the CTD was maintained throughout the cruise to minimize interruption problems. For satisfactory operation the optimum sea cable input voltage and current levels were 80 volts at 640 milliamps. Power distribution for the CTD, rosette and altimeter was controlled by a simple circuit in a separate 6 inch diameter pressure case mounted on the frame. The sea cable was terminated before sailing and a further three times during the cruise when cable damage occurred on deployment in heavy swell conditions. In two of the instances, the slack was sufficient to bounce the cable from the winch gantry pulleys, resulting in the instrument package free falling through the water for several meters. Approximately 30/40 meters of cable had to be discarded when this occurred.

CTD

As usual at the start of a cruise, the oxygen sensor was renewed before installing the system into the underwater frame. The first cast, to test the winch and CTD system, highlighted a wiring fault with the conductivity electronics which was quickly identified and corrected. Before station 12287 (near mid–cruise) the conductivity cell was flushed out with 10% hydrochloric acid as data from the previous two stations had indicated contamination.

24–Bottle Rosette System.

It was this system that gave the most problems, non-closing of bottles and double bottle closing producing a lack of operational confidence. Cures seemed, at times, to be the result of a “black art” rather than engineering expertise. The pylon was washed down immediately after each recovery with hot fresh water and the mechanical switching mechanism lubricated with silicon oil before the next deployment. Several times during the cruise the operational rosette pylon (01) was serviced on the frame and also interchanged with the backup unit (IOS identification 02) for a more detailed mechanical inspection and overhaul.

The present system of codes, indicating bottle firing information, is not satisfactory. Misfire codes transmitted when one or more bottles had in fact closed, multiple trips that could not be identified, and a lack of cam position information are just a few of the problems that need to be resolved.

In one instance seawater ingress via the camshaft, on pylon 01, caused corrosion damage to the 24-position rotary code switch, which had to be replaced. Perhaps there would have been greater protection had the switch been mounted on the shaft beneath the motor.

Prior to the cruise the springs in all the bottles had been changed for ones of a different type at the request of the CFC analysts: these alternative springs had a different length and tension from the originals. Unfortunately, during the cruise the spring fastenings on the bottle end caps were mechanically breaking down to such an extent that the original springs were restored. During the cruise, three bottles were changed as suspected “leakers”.

Transmissometer.

The transmissometer worked well throughout most of the cruise, but there were times when noise on the data, although not at an unacceptable level, proved difficult to trace and eliminate. The voltage in air was 4.310 volts, and the blackout offset was 16 millivolts. Towards the end of the cruise a slight leak in the prism pressure balancing mechanism was observed, which will require attention back at the laboratory.

SIS Thermometers and Pressure Meters.

Apart from routine battery replacements, one unit, T228, was removed after station 12248; the temperature readings were found to be in error by several hundred millidegrees. Comparison studies with the CTD data to check stability and accuracy were carried out and the results are shown elsewhere in this report.

Altimeter and 10 kHz Pinger.

This was the first IOS DL cruise where “depth off bottom” information was included into the CTD data stream and digitally displayed on the CTD monitor: the results were very satisfactory. The unit invariably locked onto the bottom from a range of 200 meters and tracked to the depth required with no problems. The 10 kHz pinger, working in conjunction with the ship’s Echosounder had in the past been the only way of obtaining this information. As the cruise progressed, and confidence increased with the altimeter, the 10 kHz system was used more in a backup role. Apart from requiring battery changes the pingers themselves were totally reliable.

Shipboard Equipment

Overall the deck equipment worked satisfactorily with only one minor problem on one of the 1401 deck units. The acquisition software worked well and 12 tapes of 80 Mbytes of backup CTD data were archived.

C.3.7 CTD Data Collection and Processing

by B. A. King (1 Mar ‘93)

Data Capture and Reporting

CTD data are passed from the CTD Deck Unit to a small dedicated microcomputer (‘Level A’) where one-second averages of all the raw values are assembled. This process includes checking for pressure jumps exceeding 100 raw units (10 dbar for the pressure transducer on the CTD) and discarding of spikes detected by a median–sorting routine. The rate of change of temperature is also estimated. A fuller account of this procedure is given by Pollard et al. (1987). The one-second data are passed to a SUN workstation and archived. Calibration algorithms are then applied (as will be described) along with further editing procedures. Partially processed data are archived after various stages of processing. CTD salinity and dissolved oxygen concentrations are reconciled with sample values, and any necessary adjustments made. CTD temperatures and pressures are compared with reversing measurements. The downcast data are extracted, sorted on pressure and averaged to 2 dbar intervals: any gaps in the averaged data are filled by linear interpolation. Information concerning all the CTD stations is shown in the accompanying station list (either at the end of this report or in the accompanying —.SUM file).

Temperature calibration

The following calibration was applied to the CTD temperature data:

$T = T_{raw} \times 0.998662 - 0.01282$

This calibration was in °C on the ITS_{90} scale, which was used for all temperature data reported from this cruise. For the purpose of computing derived oceanographic variables, temperatures were converted to the 1968 scale, using $T_{68} = 1.00024\ T_{90}$ as suggested by Saunders (1990).

In order to allow for the mismatch between the time constants of the temperature and conductivity sensors, the temperatures were corrected according to the procedure described in the SCOR WG 51 report (Crease et al., 1988). The time constant used was 0.20 seconds. Thus a time rate of change of temperature (called deltaT) was computed, from 16 Hz data in the levelA, for each one-second data ensemble. Temperature T was then replaced by T + 0.2 x deltaT.

Pressure calibration

The following calibration was applied to the CTD pressure data:

$P = P_{raw}\ {**}2 \times 3.066286\times10^{-7} + P_{raw} \times 0.997845 - 9.0$

The calibration applied to the data included an offset different from that found in the lab calibration and given in Section C.3.6. The chosen offset gave correct pressures on deck and over the top few meters of the cast. A further correction was made for the effect of temperature on the CTD pressure offset:

$P_{new} = P_{old} - 0.4\ (T_{lag} - 20)$.

Here T_{lag} is a lagged temperature, in °C, constructed from the CTD temperatures. The time constant for the lagged temperature was 400 seconds. Lagged temperature is updated in the following manner. If T is the CTD temperature, t_{del} the time interval in seconds over which T_{lag} is being updated, and t_{const} the time constant, then

$W = \exp\ (-\ t_{del}/t_{const})$

$T_{lag}(t=t_0+t_{del}) = W \times T_{lag}(t=t_0) + (1 - W) \times T(t=t_0+t_{del})$.

The values of 400 seconds for t_{const} and the sensitivity of 0.4 dbar per dbar are based on laboratory tests. During the cruise, the variation of deck pressure value with ambient temperature was monitored. A least squares linear fit to the set of 73 deck pressure/temperature pairs collected had a slope of 0.49 and an offset of 5.4 dbar at 10 degrees: this agrees with the applied correction to within 1.5 dbar over the range 0 to 20 °C.

A final adjustment to pressure is to make a correction to upcast pressures for hysteresis in the sensor. This is calculated on the basis of laboratory measurements of the hysteresis. The hysteresis after a cast to 5500 m (denoted by dp5500(p)) is given in Table C.6afor pressures at

TABLE C.6: (a) Laboratory measurements of hysteresis in pressure sensor dp5500(p) = (upcast – downcast) pressure at various pressures, p, in a simulated 5500 m cast. (b) revised form of hysteresis used for stations 12303–12337

p (dbar)	(a) dp5500(p) (dbar)	(b) dp5500(p) (dbar)
5500	0.0	0.0
5000	1.0	0.0
4500	1.2	1.2
4000	1.8	2.8
3500	2.4	4.4
3000	3.0	6.0
2500	3.4	6.8
2000	4.8	6.6
1500	5.6	6.5
1000	6.0	6.4
500	6.3	6.3
0	0.0	0.0

500 dbar intervals. Intermediate values are found by linear interpolation. If the observed pressure lies outside the range defined by the table, dp5500(p) is set to zero. For a cast in which the maximum pressure reached is p_{max} dbar, the correction applied to the upcast CTD pressure (p_{in}) is

$$p_{out} = p_{in} - (dp5500(p_{in}) - ((p_{in}/p_{max}) * dp5500(p_{max})))$$

Two thirds of the way through the cruise, at station 12303, a slight hysteresis between the up and down theta–S relationship was noted. On the upcast salinity was lower than on the down. The size of the difference was small near the bottom of the cast, growing to a maximum of about 0.002 at about 3000 m. At shallower depths the shape of the theta–S curve made it impossible to determine differences to the required accuracy. After some consideration, it was felt that the most likely cause of this was the CTD pressure (after the above correction for hysteresis) still reading slightly too high on the upcast. Accordingly the size of the hysteresis correction was increased, so that upcast pressures read slightly lower, and Table C.6b was used.

Salinity calibration

Salinity was calibrated during the course of the cruise, by comparison with sample salinities. This was done on a station by station basis. A cell conductivity ratio of 0.996683 was estimated from early stations, and this was applied to all station data as an initial calibration. The initial calibration was followed by the correction to conductivity ratio

$C_{new} = C_{old}$ x (1 – 6.5E–6 x (T–15) + 1.5E–8 x P).

After reconciliation with sample salinities, vertical profiles of residuals showed a systematic depth dependence. A final salinity calibration on a station by station basis was made by fitting the residuals with the form

a + b * T + c * P.

The need for this procedure is not understood. The offset at the bottom of each station introduced by the expression above, which may be used as a description of the drift of the cell, was monitored and varied between –0.006 and +0.004 (but not monotonically). A full list of the coefficients will be submitted with the CTD station data in due course.

Oxygen calibration

CTD oxygens were calibrated by fitting to sample values using the following formula:

O_2 = oxsat(T,S) x rho x oxyc x exp (ax(Wx ctdT + (1–W) x oxyT) + bxP)

where the coefficients rho, a, b were chosen on a station by station basis to minimize the rms residual.

The weight W was not fitted for each station, but rather was chosen in order to give the best overall fit of groups of stations. The fitting of oxygen data achieved at sea was not entirely satisfactory, rms errors were about 3–4 µmol/kg Also there was a tendency for the calibrated CTD data to produce the wrong oxygen gradient in the deep water. Introducing the time rate of change of oxyc had little effect but, in contrast, an offset in oxyc (of the order of –0.07 µA) produced a significant improvement. This will be fully discussed when the CTD data are reported. IOS DL has not previously found it necessary to introduce an offset in oxyc in order to achieve satisfactory oxygen fits, and the value required is rather greater than suggested in the WHP operations manual (WHPO 91-1).

SIS thermometer data, and the stability of the CTD temperature sensor

Six SIS digital temperature meters and two digital pressure meters were used throughout the cruise. These, along with salinity and chemical data from the rosette water samples, were used to determine the depth of bottle firings.

Digital Reversing Temperature Meters (RTM)

The digital temperature meters were calibrated using the linear fits given in Table C.7. In addition to these another sensor, T228, was discarded after the first station of the A11 cruise.

A comparison of CTD and RTM temperatures is given in Table C.8 below. The table has four parts. Parts (a) and (b) present data from the entire section, with part (b) for temperature colder than 2 degrees; as expected, the latter have generally smaller standard deviations. Parts (c) and (d) show the data colder than 2 degrees further subdivided about station 12293, which is one of the stations over the mid–Atlantic Ridge. Three numbers of observations are given in each part, corresponding to the number of differences greater than 10 millidegrees, considered as outliers and discarded, the number less than 10 millidegrees, from which mean and standard deviation are calculated, and the number within two standard deviations of the mean.

The most significant feature of these tables is the change in mean value of ctd–T399 and ctd–T400 between the two halves of the cruise, the mean difference changing by 1.3 millidegrees. This is rather more than the standard deviation of the measurement, and much more than the standard error of the estimate of the mean for each group. Although this might be

TABLE C.7: Digital RTM calibrations. $T_{cal} = b \times T_{raw} + a$.

Position on rosette	Thermometer	b	a	Date of calibration	Source
1	T399	1.00031	–0.00331	20/7/92	IOS DL
1	T400	1.00006	0.00146	20/7/92	IOS DL
4	T401	1.00016	–0.01002	20/7/92	IOS DL
4	T219	0.99992	–0.01250	18/8/92	RVS
8	T238	0.99992	0.00175	18/8/92	RVS
12	T220	0.99999	–0.00570	18/8/92	RVS

TABLE C.8: Summary of RTM data

(a)							(b)				
All Data							T < 2 degrees				
Pair	n	n	n	mean	SD		n	n	n	mean	s.d.
	>10 m°C	<10 m°C	<2s.d.	m°C	m°C		>10	<10	<2sd	m°C	m°C
ctd–T399	1	92	90	1.0	1.6		0	75	72	1.1	1.5
ctd–T400	2	91	88	0.8	1.3		1	74	70	0.9	1.1
ctd–T401	3	90	84	2.1	2.2		2	60	56	2.0	1.7
ctd–T219	5	82	76	–6.7	2.3			2	56	52	–6.8
ctd–T238	9	80	75	1.6	2.5		0	17	16	0.7	3.0
ctd–T220	9	69	65	2.0	2.6		0	11	1.9	—	
T400–T399	0	93	89	0.4	0.9		0	75	72	0.4	0.9
T401–T219	4	82	79	–8.7	1.8		2	56	55	–8.6	1.4

(c)							(d)					
STNNBR < 12293							STNNBR > 12293					
Pair	n	n	n	mean	s.d.	mean	n	n	n	mean	s.d.	mean
	>10 m°C	<10 m°C	<2s.d.	m°C	m°C	temp.°C	>10	<10	<2s.d.	m°C	m°C	temp.
ctd–T399	0	38	36	0.6	0.9	0.33	0	36	35	1.9	0.8	1.19
ctd–T400	0	38	37	0.3	1.0	0.33	0	36	35	1.6	0.9	1.19
ctd–T401	1	39	37	2.0	1.5	0.60	1	20	19	2.2	1.8	1.46
ctd–T219	0	36	34	–6.8	1.7	0.48	2	19	18	–6.6	1.5	1.46
T400–T399	0	38	36	0.3	0.9	0.33	0	36	34	0.3	0.5	1.19
T401–T219	0	36	35	–8.9	1.5	0.48	2	19	18	–8.9	1.1	1.46

thought to indicate an offset in CTD temperature calibration (there being no change in the T400–T399 difference), there is no evidence for this in the ctd–T401 and ctd–T219 pairs. Our tentative conclusion is that the difference arises because the temperature observed at rosette position 1 is generally warmer in the eastern basin than in the western basin. Note the mean temperature of the observations, which is shown in the last column of Table C.8 (c) and (d). We suppose that nonlinearity in the response of either CTD or RTM temperature near zero may be the cause of the change in CTD–RTM difference. If it is the behavior of the RTM thermometers that is nonlinear, then it must be very similar in the two thermometers; this is not unreasonable for two instruments of the same type. On the other hand, we do not exclude the possibility of nonlinear behavior in the CTD temperature. When the CTD is recalibrated on return to IOS DL, careful attention will be paid to establishing the linearity or otherwise of the calibration near zero. In any case the overall consistency of the CTD and RTM comparisons and the magnitude of the change in differences amongst them strongly imply that there was no significant change in the CTD calibration between the start and the end of the cruise.

Digital Reversing Pressure Meters (RPM)

Two reversing pressure meters were used:

Rosette position	Pressure meter
1	P6132H
8	P6075S

Despite the shortcomings in the RPM performances, which are described below, their data were very useful in confirming or identifying the depth of bottle closures.

Calibration of P6075S were carried out by the manufacturer on both 13.2.88 and 27 3 90 the latter at temperatures of both 3° and 20°C. These indicated that corrections of between –7 and +3 dbar were required over the range 0 to 5400 dbar. However residuals between the calibrated RPM and the CTD were found on cruise 199 to exceed 30 dbar at pressures greater than 3000 dbar.

P6132H was calibrated by the manufacturer on Feb. 22,’90. Linear interpolation was used to correct the RPM between the following calibration values in dbars: (P6132H pressure, correction applied), (0006,–6), (0975,+6), (1949,+12), (2930,+12), (3915,+8), (4907,–4), (5405,–11), (6022,–22). The last pair was not supplied by the manufacturer, but was an extrapolation of the manufacturer’s information. In general, after applying the above calibration, P6132H shows a consistent offset compared with the CTD of about 14 dbars over the range 1800 – 6000 dbar.

Discrepancies of similar magnitude between RPM and CTD pressures have been noted on a number of previous IOS cruises, see for example the CONVEX cruise report (Gould et al., 1992). On cruise 199 the CTD bottom pressures were converted to depth and were compared with corrected Echosounder depths minus depth of CTD off bottom: the differences had a mean value of 3 meters and 75 percent were smaller than 12 meters. On the CONVEX cruise an even smaller mean for nearly 100 stations was found. We are therefore quite confident of the CTD pressure calibration and in the near future plan to carry out calibration and other tests of the RPM instruments at IOS DL.

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C.3.8 Satellite Image Acquisition and Processing

by M. P. Meredith and V. C. Cornell (1 Feb '93)

Equipment and function

On this cruise equipment was installed for the capture, display and processing of polar–orbiting weather satellite imagery. This consisted of an omnidirectional VHF antenna mounted on the main mast, a preamplifier to compensate for feeder cable losses of up to 10 db, a Dartcom system II receiver, an 8–bit 15 MHz microcontrolled interface to control the frequency and mode of the receiver, and an Apple Macintosh IIsi computer with the MACSAT 2.1 software supplied jointly by Dartcom and Newcastle Computer Services.

The equipment was used to receive data sent from the NOAA satellites 10, 11 and 12 via the Automatic Picture Transmission (APT) system at 137.50 and 137.62 MHz. Although the software allows the capture of geostationary weather satellite images, the hardware necessary for this was not present. No attempt was made to capture images from polar–orbiting satellites other than the NOAA series.

The data collected were from the Advanced Very High Resolution Radiometer (AVHRR), a five-channel radiometer featuring one visible, two near–infra red and two thermal infra–red channels, though the APT system only allows for the visible channel plus one infra–red channel to be received. The APT system also reduces the spatial resolution of the data from its maximum of 1.1 km^2 at nadir to approximately 4 km^2. Data from almost all the radiometers' swath width is captured with MACSAT; an 800 x 800 pixel image covers approximately 3000 km^2, and has a maximum of 256 digitization levels per pixel.

Procedure

During the cruise, most of the longer satellite passes (>12 minutes) were captured. Shorter passes generally did not contain enough noise-free data to warrant their capture. The vast majority of images were from the infra–red channel, since the previous cruise experienced serial error problems with the Auto Save function (the function enabling both channels to be acquired simultaneously), which led to the loss of the images. Thus, only one of the two channels was available, and the infrared data were deemed more useful than the visible for our purposes.

Once captured, the time/date, ship's position, and whether the satellite was in an ascending or descending pass was recorded, and a geographical overlay created for the image. This shows lines of latitude and longitude, ship's position at time of acquisition, and, if relevant, a coarse coastline. Three standard color palettes were created to enable depiction of sea brightness temperature. One would not suffice since the manual contrast stretch facilities of MACSAT (adjusting the RGB response curves for the image) were found to be very cumbersome, and the Auto Contrast function is only useful for grey scale images.

Color hardcopies were produced for each image by using the Mac’s screen dump tool. This creates a TeachText picture of the screen, which can then be printed to a postscript file, transferred to the Sun workstations using ftp, converted to a PCL file and outputted to the HP Paintjet printer. This was considered a better procedure than using MACSAT's print option, since not only can the whole image be displayed on one A4 sheet, but the geographical overlay can be also be printed on the image.

Some images were transferred to more sophisticated image processing software on the Suns; this, along with the image file format and file archiving, is discussed elsewhere.

Problems

Difficulties encountered on the previous cruise concerning the gross inaccuracy of the geographical overlay were to a large extent resolved. Updated files containing the Keplerian orbital elements for the satellites were obtained by fax from Newcastle Computer Services on two occasions as a matter of course, and on a third (1st Jan), when an error in the orbital element calculations became apparent. Also, the Mac’s internal clock was corrected each day, since it gains approximately one second per day on GMT. Such an error is not insignificant for satellites travelling at 27,000 km/h, and would greatly affect the positioning of the overlay if left unaltered for a number of days. However, even with these measures being taken, the overlay could still be as much as a degree or two out, and the uncertainty should be borne in mind when considering images without coastline in them.

Noise contamination of images was a frequent problem, and although MACSAT has a noise reduction filter, this is of use only for presentation purposes and obviously cannot replace missing data values. Whether the problem was caused by atmospheric conditions, insufficient signal amplification or faulty hardware remains unknown.

A further unsolved problem is the overlay tool’s failure to plot lines of latitude for descending satellite passes. We think this can only be attributable to a bug in the program.

Initially, difficulties were encountered with the loss of images due to serial errors during acquisition. This was caused by a slowing of the Mac to the point where it could not keep up with the incoming data stream, and was solved by ensuring that there were no telnet connections active, no print jobs queued and no Appleshare volumes present on the work space at the time of capturing an image.

Observations

Several significant oceanographic features were observed in the satellite imagery captured during the course of the cruise. The retroflexion of the Falkland Current at the Brazil Current was clearly visible, and when the thermosalinograph (TSG) showed an increase in temperature, the MACSAT image revealed a warm ring shed from the conflict of the two currents. Many of the images showed the position of the Subtropical Front to the north of the cruise track, and, towards the end of the cruise, the coastal upwelling region associated with the Benguela Current is clearly visible. An Agulhas ring was possibly observed, but not certainly, since cloud contamination partially obscures the feature. The cloud images also proved illuminating, especially during the severe storm encountered on the 13/14th January 1993.

C.3.9 Shipboard Computing

by M. G. Beney and V. C. Cornell (1 Feb ‘93)

RVS Logging System ‘ABC’

The RVS logging system comprises of 3 distinguishable parts or levels. Each level is referred to by one of the following letters A, B or C, and the whole system is called the ‘ABC’ system.

A Level A consists of a microprocessor based intelligent interface with firmware which collects data from a piece of scientific equipment, checks and filters it, and outputs it as SMP (ship message protocol) formatted messages.

There are two versions of dedicated Level A’s, a Mk I based on a 8085 processor using CEXEC as the operating system, and a Mk II based on a 68000 processor running OS 9 as the operating system. In addition there are pseudo Level A’s which are PC’s around which a piece of equipment it based, which are also capable of generating SMP messages.

The Level B collects each of the Level A SMP messages and writes them to disk and backup cartridge tape. The Level B monitors the frequency of these messages, and besides providing a central display for the data messages also warns the operator when messages fail to appear. The Level B, which is based on a 68030 processor using OS 9 as the operating system, collates the data and outputs it to the network.

The Level C, which is a SUN IPC (4/40), takes this data and parses it into RVS data files. These data files are constructed on a RVS styled database for speed of access.

The following list shows the instrument Level A’s and the variables which were logged by the Level C. The first column shows the name used by the Level A. Brackets after the Level A name indicate whether it was a Mk I (1), Mk II (2) or IBM compatible PC (PC), based Level A. The “ADCP” data was collected directly by the Level C through one of its serial ports (ttya). The data was written to the data file named in column 2 with the variable names shown in column 3.

Level A	Data File	Variables
BOTTLES(1)	bottles	code
CTD_17C(2)	ctd_17	press temp cond trans alt oxyc oxyt temp2 cond2 deltat nframs
GPS_ATT(2)	gps_att	hdg pitch roll mrms brms attf sec
GPS_TRIM(2)	gps_trim	lat lon pdop hdg svc s1–s5
GYRO_RV	S(2) gyro_rvs	heading
LOG_CHF(2)	log_chf	speedfa speedps
METLOGGR(PC)	metloggr	winspd windir pwettemp pdrytemp swettemp sdrytemp seatemp ppar ptir spar stir lwave baro
MX1107(1)	mx1107	lat lon slt sln el it ct dist dir sat r status
SIM500(2)	sim500	uncdepth rpow angfa angps
SURFLOG(PC)	surflog	temp_h temp_m cond
WAVE(1)	wave	height
WINCH(PC)	winch	cabltype cablout rate tension btension comp angle

The following list shows data files that contained data directly collected by the Level C.

adcp_raw	rawampl beamno bindepth
adcp	bindepth heading velew velns velvert velerr ampl good bottomew bottomns depth
xbt	depth temp

The following data files were archived:

relmov	gps	mx1107
bestnav	bestdrf	winch
wave	metloggr	surflog
adcp	adcp_raw	ctd and xbt.

These RVS archives have only limited life and are only intended as (fall–) backups.

Processing of Data

Virtually all of the data processing was performed using the interactive “pstar” suite of about 300 documented programs (Alderson et al., 1991). This continuously updated system is installed on RVS ships as well as at labs ashore. RVS data files were converted to “pstar” data files using the program ‘datapup’.

Archiving of pstar files

Archiving took place on a daily basis. Copies were made of all processed files on Sony erasable magneto–optical disks. These were mounted as standard UNIX file systems. In addition files were copied to Quarter Inch Cartridge (QIC) tape in both raw sequential and UNIX tar format. Six sides of optical disk data were taken ashore at the end of the cruise, totalling about 1.5 Gigabytes.

Computer Equipment Available on Cruise 199:

Personal Computers (Operating under Apple system 7.0.1)

- 3 Apple Macintosh Classics (40 Mb Hard Disc, 4 Mb RAM), 1 Apple Macintosh Classic II (40 Mb Hard Disc, 4 Mb RAM), 1 Apple Macintosh IIsi (80 Mb Hard Disc, 5 Mb RAM). The last was connected to a Dartcom System II satellite image receiver.

Sun Workstations (Operating under Sunsoft’s version 4.1.1)

Nodename	Type	Ram (Mb)	Hard Disc (Mb)	Peripherals (Mb)
discovery1	IPC	12	2x327	Exabyte drive
			1x207	QIC 150 tape
discovery2	IPC	12	1x207	Magneto/optic
			1x1200	QIC 150 tape
discovery3	Sparc stn	8	2x327	
discovery4	Sparc stn	8	2x237	

Output devices:

- Apple LaserWriter II (Mono Laser Printer). Hewlett Packard Paintjet XL (InkJet Color Plotter). Tektronix 4693 RGB (Thermal transfer plotter). Hewlett Packard LaserJet III (Mono Laser Printer). NEC Pinwriter P5 (Dot Matrix line printer). Bruning Drum–type Pen Plotter.

Networking

All PCs, workstations and a number of output devices were connected to a thin Ethernet (10Base2) local area network. The Sun workstations have integral Ethernet interfaces, the Apple Macintoshes were connected via external SCSI Ethernet interfaces.

References

Alderson, S.G., Griffiths, M.J., Read, J.F., and R.T. Pollard, 1991, PEXEC PROCESSING SYSTEM, Internal document, IOS DL, about 450 pp.