MINISTRY OF AGRICULTURE FISHERIES AND FOOD
DIRECTORATE OF FISHERIES RESEARCH

RRS DISCOVERY CRUISE 207

19 FEBRUARY-31 MARCH 1994

Circulation and structure in the Southern Ocean between 20°E and 90°E and 20°S and 65°S. Part of the World Ocean Circulation Experiment

Lowestoft
1995

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Moss, S.A.	Chief Engineer
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Vrettos, C.	Seaman 1a
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Staite, E.	Ship's Catering Manager
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SCIENTIFIC OBJECTIVES

Together with *DISCOVERY 200*, the main scientific objectives and activities of *DISCOVERY 207* form part of a wider international investigation into the rates and pathways of the global abyssal circulation as a component of the World Ocean Circulation Experiment (WOCE) and are intended to co-ordinate with other research programmes being undertaken in the Southern Ocean as part of the UK WOCE effort.

The principal objectives were as follows:

1. To make measurements of the flow of deep and bottom waters passing eastwards from the Weddell-Enderby Abyssal Plain to the Southern Indian Ocean via deep topographic gaps to the northeast and southeast of the Kerguelen Plateau. Specifically, to recover the two main current meter arrays deployed during *DISCOVERY 200* — an array of 10 moorings (42 current meters) and 2 bottom pressure gauges in the main gap between Crozet and Kerguelen, supplemented with a mooring in the deep cleft immediately west of Crozet Island, and a further 5 moorings (13 current meters) set in the Princess Elizabeth Trough between the Kerguelen Plateau and Antarctica.

2. To use a range of tracers, including the CFCs 10, 11, 12, 113, inorganic nutrients, dissolved oxygen and both oxygen and hydrogen isotopes (indicating meltwater content) to assist in partitioning the deep throughflow into its constituent watermasses, and to track the onward incursion of the AABW plume into the Indian Ocean.

3. To make discrete measurements of CO_2 partial pressure in seawater (pCO_2), total seawater CO_2 content (TCO_2) and appropriate measures of biological activity throughout the cruise-track as a BOFS/PRIME component of the BAS Antarctic Special Topic, and as a necessary determinand of WOCE.

4. To monitor a suite of discontinuous and continuous environmental variables throughout the cruise, including bathymetry from PES, XBT, ADCP, multimet, wave recorder, and thermosalinograph, and where possible to locate the major ocean frontal zones in this sector of the Southern Ocean.

5. To use a range of satellite-derived ice and weather intelligence where possible and appropriate.

6. To obtain water samples for heavy-metal analysis by Dr Frew (UEA)

All these objectives were met in full or part. The exceptions were

- One full-depth mooring, one upper-bottom type mooring and one bottom pressure gauge were lost when their releases failed to respond to interrogation or cut commands. Thus 16 of 18 current meter moorings were recovered and 1 of 2 BPGs

- Of the current meters recovered, one had flooded, three produced little or no record due to faulty meshing between the encoder pin and star-wheel, and a range of other instruments produced partial records of greater or lesser length due to a range of problems, (cold-effect on encoders, faulty battery connection, and the effect on certain compasses of the proximity of the Earth's South Magnetic Pole).

- Overheating on the pre-cruise leg from Gibraltar to Cape Town caused loss of some standards for the TCO_2 work and probably caused damage to the resident memory of the computer used to control the system. The first problem reduced the number of calibration runs and the replacement computer imposed certain restrictions on the type and number of measurements.

NARRATIVE (Figures 1(a)-(c))

Though the bulk of Scientific Staff flew in and embarked around midday on 16 February, the planned sailing am 18 February was delayed through failure of the Magnavox satellite receiver. This had proved invaluable the previous year not only for communications but for the transfer of computer software to the vessel at sea. After a delay of 1.5 days in which the MacSat computer used for ice-intelligence was repaired and the vessel was cleared of aerosols and other potential sources of CFC contamination, a replacement Magnavox power unit was flown in; *RRS DISCOVERY* sailed from Cape Town 1430h local/1245z, on Saturday 19 February/Day 50, and proceeded southeastwards to her first main working area between Conrad Rise and Crozet. (GMT and day numbers will be used throughout the remainder of this narrative). Watches began with the streaming of the PDR fish at 1815z and, apart from the more intensive periods of station and mooring-recovery work when personnel were deployed to other duties, were to continue for the remainder of the cruise, providing continuous monitoring of a broad suite of underway environmental parameters— bathymetry, ADCP/Ashtec, Multimet, thermosalinograph and (after a slow start due to malfunction of its control PC), four-hourly XBT.

During this first steaming leg, the pCO_2/TCO_2 system was set up and worked thereafter on passage throughout the cruise. Overheating on the pre-cruise leg from Gibraltar to Cape Town had caused loss of some standards for the TCO_2 work and also some damage to the resident memory of the computer used to control the system. The first problem was to reduce the number of calibration runs, while the replacement computer imposed certain restrictions on the the type and number of measurements. This passage leg was also used to set up and cleanse the CFC line, run in the nutrients line and test the assembled CTD Multisampler. With preparatory work completed, an easing of heavy weather conditions in the early hours of Day 53 permitted these systems to be tested, with a first CTD trial to 2200 m on the eastern flanks of Agulhas Bank providing a CFC error determination by triggering the full 24-bottle rosette at the same depth within the deep CFC minimum of the North Atlantic Deep water layer. Later that day, a zigzag course was run for the calibration of the ADCP between 1030 and 1330z.

From arrival 1548z, Day 55 until 0549z, Day 57 and in unpleasantly marginal sea conditions, *DISCOVERY* worked a first short CTD-tracer section across the channel which separates Conrad Rise from the Crozet Plateau. Several problems were encountered.The CTD wire jumped its sheeve when the rosette kited on a swell and twice had to be stoppered-off and re-terminated, a few bottles leaked or hung up, uncharted topographic spikes forced unhelpful changes in planned station-spacing, and we began to find the first evidence of firing ambiguities in the CTD sampling record which were to get worse in succeeding days.

On the early hours of Day 58, and in fine weather conditions, the first of the 18 current meter moorings was recovered undamaged from the deep cleft west of Crozet and *DISCOVERY* then continued to conduct a second, zonal CTD section across the west wall of Crozet Basin along 43°S, designed to intercept the AABW plume where it passes northward from the Crozet-Kerguelen Gap. Throughout this section however, a growing number of misfires caused increasing ambiguity in the depths sampled by the Multisampler, with considerable loss of resolution and some time lost through re-working of stations. By station 12639, 1141-1449z on Day 60, and despite changing pylons and stripping down the sea-unit between stations, these malfunctions had proceeded to the point where all 23 samplings showed misfire lights and only 8 bottles closed. Accordingly *DISCOVERY* turned south towards her third and main working area in the Crozet-Kerguelen Gap, making urgent modifications to the Multisampler en route. By improving the silicon-oil circulation within the sea-unit, and by recutting an ineffective O-seal bed around the camshaft which triggers the bottles, these modifications were to prove highly effective, with no further leaks, misfires or ambiguities in sampling-depth for the remainder of the voyage.

From her arrival 0900z Day 61 to her departure for the South in storm force winds late pm on Day 67, *DISCOVERY* completed the most intensive work-schedule of the cruise, recovering current-meter moorings by day and working CTD/chemistry by night across the Crozet-Kerguelen Gap, almost always in unpleasantly marginal conditions of wind and swell, yet with only one full day (Day 65) plus a few hours of Day 63 lost through dodging. By completion, a total of 8 out of 11 moorings of the Northern Array and one tide-gauge had been recovered, and the hydrographic section worked across the Gap in spring 1993 during ADOX-1 had been largely repeated with a total of 7 full-depth CTD stations.

Of the unsuccessful recoveries, one full-depth mooring (Mooring C or 93-14) gave a return signal (if it was a signal at all, which is by no means certain) which was too weak to be distinguished against the acoustically-noisy (instrument and weather) conditions which prevailed, and which was lost in all attempts to manoevre the vessel towards it. Despite an extensive search pattern throughout Day 61 and into the following morning, later repeated more briefly on re-passing the site during Days 63 and 81, we never regained any trace of an acoustic response despite interrogating at both the call-up and cut frequencies of its two releases at a succession of ranges and bearings. It was tentatively concluded that if present at all, the mooring was most probably collapsed and lying on the bottom in 4000 m depth following detachment of its upper buoyancy, with its acoustic releases pointing horizontally or buried in ooze where they could neither hear our commands to cut or provide an unambiguous response. The mooring was therefore abandoned as lost. Our second full-depth mooring (mooring F or 93-11) was clearly present, standing upright and responded strongly to interrogation on Day 64, but refused to cut, presumably through leakages in the firing circuits of both releases. After switching these off and observing them timing-out, this mooring was temporarily abandoned but would be cut free and recovered later in the cruise. The second current meter mooring to be lost was the 'upper-bottom' type mooring I or 93-08, — the only mooring that had failed to respond to routine interrogation after being laid the previous year and which was presumed to have been damaged on launch. It was abandoned after 2.7 hours of continuous but fruitless pinging. The third and final item of moored gear to be lost was the P.O.L Bottom Pressure Gauge from the eastern end of the Crozet-Kerguelen Section. This unit, which was fitted with two different and independent release-systems, never responded to either one despite the working of an extensive search-and-interrogation grid (pinging both when stopped and when underway at 5 knots), about the nominal position of the mooring from 0805 to 1300z, Day 67. At that time, with winds of over 50 knots providing slow headway and very poor acoustic conditions for further search, the BPG was abandoned as lost (presumably self-released during its one-year deployment), and *DISCOVERY* turned south in a strong wind and a heavy quartering swell towards her fourth main working area in the Princess Elizabeth Trough off Antarctica. Watches were resumed as before en route, but with more-intensive XBT work where necessary to define the position and structure of the Polar Front (encountered at 58°S) and the Southern Polar Front (64°S).

From arrival 0430z Day 72 to completion 0334z Day 74, the vessel carried out her intensive work schedule in the South without loss or incident, and in much-improved calm but cold weather conditions. All five of the southern moorings were recovered intact, a new 'fish'-mounted MORS acoustic release command system was tested, advantage was taken of the prevailing light ice-conditions to extend the 1993 ADOX-1 line of CTD/tracer stations south towards the ice-edge, and bulk samples of sea-ice were recovered as a calibration for the oxygen isotope chemistry. The sole problem was with the freezing of water samples for CFC analysis as they were drawn-off by syringe, but this was eventually overcome also.

DISCOVERY then returned slowly north through increasingly heavy weather with winds gusting to 60 knots, but was hove-to only briefly early on Day 78 when the Starboard lifeboat slipped off its chocks. From arrival in the early hours of Day 79, the vessel then proceeded to complete a variety of unfinished business on the Crozet-Kerguelen Line. A further attempt was made (Day 79) to interrogate the lost BPG from 3 miles out to the position of the waypoint, but without result; two supplementary CTD/Tracer stations were worked; and after a whole day of painstaking and precise work towing a double grapnel and chain from *DISCOVERY*'s 20-tonne gear close to the seabed around the position of Mooring F, and using its acoustic-release signal as a position-reference, the mooring was successfully cut free only 250 m from the seabed in 4240 m water-depth. After a brief chase in gathering darkness and a full gale of wind, a total of 7 out of 8 instruments were recovered undamaged by 1621z (2021 local). A final interrogation at the site of the lost full-depth mooring C (93-14) on Day 81 brought no response however, and with no acoustic signal to aim for with her dragging gear, *DISCOVERY* left the area.

Between 1449z Day 82 to 1640z, Day 83 the vessel re-occupied the zonal Crozet Basin section along 43°S to re-work the CTD stations lost earlier through the malfunctioning of the Multisampler, and to extend these stations east into the water depths of up to 4500 m where the deep CFC plume from the Crozet-Kerguelen Gap was expected to lie as it passed north. This work was completed without any malfunction of the Multisampler and with a clearly-defined deep CFC core where predicted. On the closing stages of station 12652 however, the CTD cable jumped into a gap which had opened between the main outboard sheeve and its cheek-plate, thus threatening further CTD operations on this cruise. In the event, it proved possible in the calm conditions, and with great care in working the ship to the wire by Bridge staff, to work the final three stations of the Section, and thus to close-off the CFC plume to the eastward.

With the work on this line complete but with little time remaining, *DISCOVERY* steamed north towards her final planned working area while the faulty CTD sheeve was lowered for examination and repair by RVS staff. After stopping a.m. Day 85 to test the repaired sheeve under load to 500 m without problem, *DISCOVERY* continued to the central Madagascar Basin where between 1640z Day 86, and 0913z Day 88, the final six-station CTD Section was worked, successfully intercepting the deep CFC plume where it issued through the Atlantis II and Melville Fracture Zones to pass northwestward across the basin towards Madagascar.

Completion of this section brought the planned work of the cruise to an end. Accordingly, *DISCOVERY* sailed for Mauritius, docking Port Louis 0830 h local, Day 90 after a total cruise-length of some 8220 nautical miles.

The completion of almost all of our complex list of scientific objectives to the most exacting standards and under some of the most challenging conditions on Earth, is once again evidence of the high capabilities of *RRS DISCOVERY* and her Staff. The astonishingly high quality of catering and its effect in maintaining a high morale among the Scientific Staff was referred-to last year and was maintained in this; the ingenuity and resource of technical staff both from RVS and IOSDL in quickly overcoming a succession of cruise-threatening equipment problems, remote from land-support and the skill, flexibility and drive of the Ship's Compliment in meeting the heavy demands of our work programme are all gratefully acknowledged. Together, they made for a most memorable and enjoyable Cruise, and a most worthwhile British contribution to the World Ocean Circulation Experiment.

RRD, PSO
RRS DISCOVERY
March 1994

INDIVIDUAL PROJECT REPORTS

CTD

CTD operations.

The CTD/multisampler package consisted of the IOSDL NBIS Mk IIIB with Beckman oxygen sensor. The CTD lay horizontally with the axis of the conductivity sensor vertical and alongside the SeaTech 1 m folded-path transmissometer. These were located beneath the General Oceanics 24 × 10 l multisampler and all enclosed within a weighted protective frame. The package was also fitted with a Simrad 200 kHz altimeter which measured height above the sea bed when within the lock out range of 204.8 m.

For stations 12629 - 12632 inclusive, problems were experienced in the upper few hundred metres of the cast as the rosette became weightless in large swell and tension came off the CTD wire. On 12629 the wire jumped the sheave during deployment, requiring 50 m to be discarded and the wire to be re-terminated. After 12631 the wire was 'birdcaged' and again required re-termination. To alleviate the problem, from 12633 onwards the transmissometer, pinger and up to 6 bottles were removed and extra lead added. Though not ideal, this strategy proved workable for the remainder of the cruise. Additionally, to avoid keeping the CTD near the sea surface at the start of each cast, data logging was started with the CTD on deck and lowering was continuous once the CTD had entered the water. Lowering rates were low (30 m min^{-1} or less) in the upper 1000 m or so of each cast, depending on sea state, and increased to 50 - 60 m min^{-1} at deeper levels. Typically, the CTD was lowered to within 20 m of the sea bed and bottles fired on the up cast. Hauling rates ranged from 40-60 m min^{-1}. Toward the end of the cruise (station 12652) the wire slipped from the outside block. Fortunately the sea state was slight and the package was retrieved by crane. Subsequently, the wire was re-terminated and the remaining three stations on the section completed after a wire test with dummy weight and by limiting the lowering/hauling rate to a maximum of 45 m min^{-1}. On passage to the northern most CTD line the block was overhauled.

On recovery, the deck values of CTD pressure and temperature were again noted, bottles checked for leaking taps and end caps and the digital temperature and pressure meters on bottles 1, 4, 8 and 23 recorded.

Sampling from the rosette bottles was in the following sequence

CFCs
Oxygen
Salinity
Nutrients
Oxygen/hydrogen isotope ratio
Trace metals from Go Flo at position 24

Information on individual stations is given in Table 1.

JB, JS, FSJW, PDC

Rosette multisamplers

The GO Rosette unit No. 1 was fitted to the Multisampler/CTD frame at the beginning of the cruise. Initially, this unit appeared to perform correctly with no misfires. After a few casts misfires (long, usually meaning that the unit fired but did not indicate so) began to occur. Close inspection of the salinity, silicate and oxygen values etc., obtained from the samples indicated that a bottle would fail to close on the fire command and would then trip together with the next one at the second attempt.

After 10 stations had been occupied it was decided to change over to Rosette unit No. 2. This unit in fact closed the bottles correctly but indicated 15 misfires (long) and leaked sea water into the pressure balanced silicone oil filled compartment. Unit No. 1 was serviced and re-fitted although it had shown no obvious reasons for its failure. At the next cast only one bottle indicated that it had tripped properly with the rest being a mixture of short (real) and long misfires. On retrieval of the package, 8 of the 24 bottles had tripped. Unit No. 2 was then completely overhauled. The pressure balance diaphragm and 24 way position indicator switch were replaced. The ingress of sea water was due to a faulty 'O' seal groove on the drive/camshaft. This had been machined eccentrically to the shaft axis, allowing a proper contact of the seal over only a part of its area. The groove was recut by R. Phipps and a new larger seal fitted. The actuator mechanism was also modified by drilling 6 x 1/8 inch holes in its base, to allow air out and oil in. The unit was filled with new silicone oil, set up, and remounted in the frame. For the rest of the cruise it worked extremely well with bottles tripping correctly without doubles and only the occasional short misfire. As before the salinity, oxygen and silicate values etc., were used to check the bottle depths. The EG&G Rosette electronics fitted to both units had been modified prior to the cruise to provide a drive pulse of higher power to the actuator.

JS

CTD data processing (Figure 2)

The CTD processing scheme is now well documented; see the cruise reports for *DISCOVERY 200* and *DISCOVERY 199* for details of the processing path. The *DISCOVERY 189* Cruise report is also a useful reference.

Data was logged from the ctdr17d1 stream (press, temp, cond, trans, alt, fluor, oxyc, oxyt, deltat, nframes). alt and nframes were both left uncalibrated. After station 12632, the fluorometer was removed (to reduce drag); the variable was kept in the data files to maintain consistency with previous data, and just in case the unit was put back on later (it wasn't).

Data for two stations were not logged directly by the level B, and had to be 'played back' after the cast was completed. These were at stations 12631 and 12633. In the first case, bottle firing times were reconstructed 'by hand', using pressure to identify stops in the upcast. For 12633 the bottle firing times were logged. In both cases we are confident that we have matched the CTD pressure with the bottle firings, although times may not necessarily be correct.

Following on from last year, the downcast oxygen data were calibrated, although it was noted that the upcast data looked good, and was as spike-free as the downcasts.

MJG, NPH, PDC

Reconciliation of bottle and CTD data and CTD calibrations

Owing to uncertainty in the depths at which the multisampler closed it was first necessary to confirm firing depths. The performance of the multisampler was problematical up to and including station 12639, when repairs were effected. From this point, confirmation of sample depths indicated few problems. Three information sources were available:-

1. SIS Digital pressure/temperature meters.
2. Bottle salinities.
3. Nutrient values.

Digital P/T meters were only used at 4 bottles, therefore they could not define all levels. Nutrient values, principally silicate, could identify where bottles had fired in pairs, but provided no information on the firing level. Bottle salinities were compared with those values (calibrated using a nominal initial calibration) in the firing file. The firing file is generated by the CTD and data averaged 5 seconds either side of the bottle firing command. Experience showed that the CTD-bottle differences changed smoothly throughout the depth range of the cast. In all but the regions of weakest gradient the salinity information supported by the other data allowed an unambiguous sequence of bottle firing depths to be established for each station (Table 2). Corrections for station 12637 were particularly convoluted and could only be resolved by comparison with the silicate depth profiles at the preceding and succeeding stations.

The discrete bottle oxygen and salinity values were then used to calibrate each individual station, using the series of PSTAR executives detailed in the CTD processing section.

Although the CTD profiles were calibrated individually, the residuals between the calibrated CTD and the bottle salinities are shown in Figure 3 (standard deviation ± 0.0012).

The behaviour of the oxygen sensor is such that the recorded values are dependent on flow rate past the sensor. To reduce this effect, the discrete samples taken on the up cast were used to calibrate the CTD oxygens from the down cast. Matching was done on the basis of pressure. The up cast CTD oxygens were discarded. Algorithms used were those used for *DISCOVERY 200* and developed by B. King. The residuals between the calibrated and discrete oxygen values are given in Figure 4 (standard deviation ± 3.384 μmol l^{-1}).

Two other comparisons can be made that shed light on the data quality.

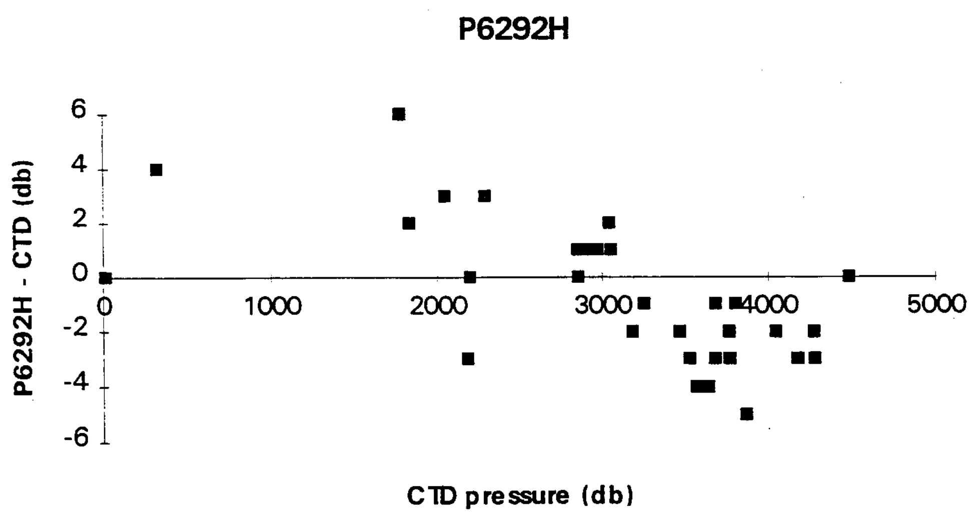
Paired digital temperature meters can be compared with each other and in every case with the CTD temperatures from the firing files. In the following calibrated temperatures are used.

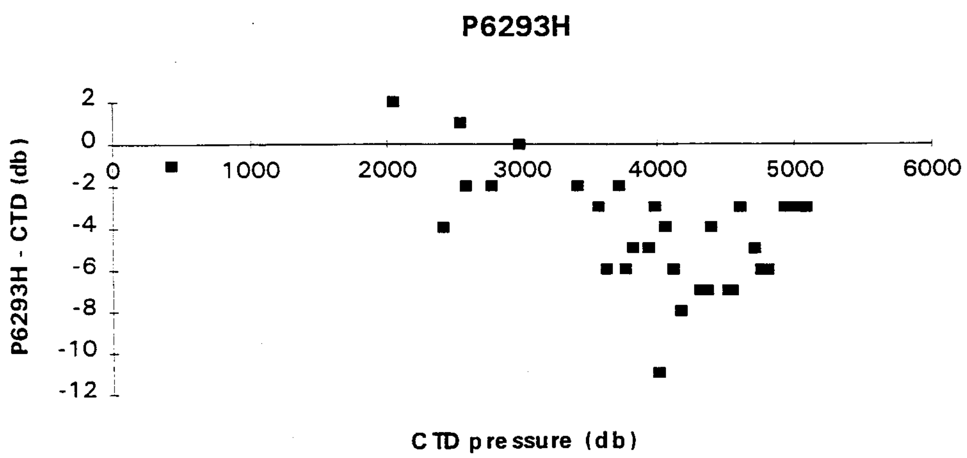
Thermometer No.	CTD - Therm (Mean±SD) m°C	Number of Observations
238	1.3 ± 2.9	31
401	1.1 ± 3.2	28
746	-0.5 ± 2.9	30
228	-5.0 ± 1.9	24
743	5.9 ± 2.4	32
714	3.8 ± 2.4	31
219	-1.0 ± 20.6	32
220	-0.4 ± 13.4	32
790	-0.7 ± 11.6	32

Results of comparisons of paired thermometers are

401 - 746	-1.5 ± 2.1	29
401 - 228	-6.2 ± 1.5	26
746 - 228	-4.7 ± 2.3	27
743 - 714	-2.0 ± 1.1	32
219 - 220	-2.7 ± 8.2	32
219 - 790	-2.5 ± 5.0	32
220 - 790	-0.2 ± 8.7	32

Similar comparisons can be made between the CTD pressures and those recorded on the digital pressure meters. Measurements were made over a considerable range of pressures and the pressure dependence is shown in following two plots (calibrations applied).





JB, MJG, NPH, PDC

Bottle salinities

Bottle salinities were collected for calibration of the CTD and thermosalinograph (TSG). Samples were contained in glass bottles sealed with push in polyurethane inserts and secured with a screw cap.

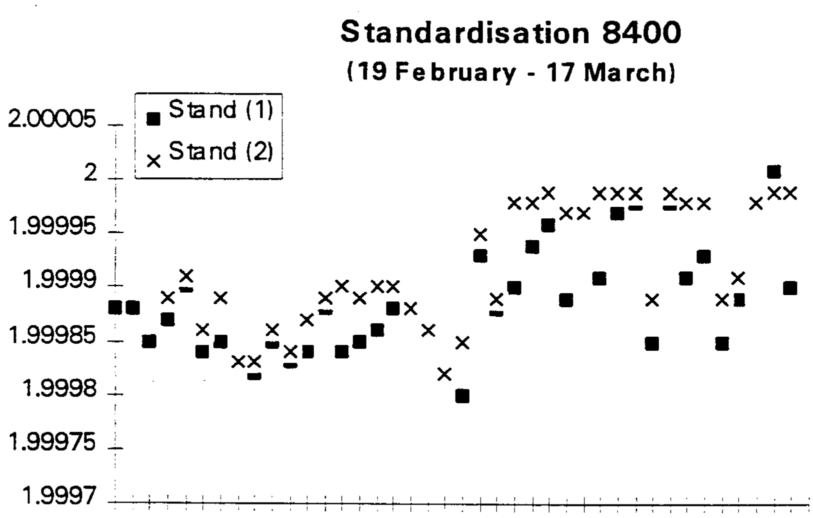
Sampling in every case involved emptying the old sample, rinsing three times with the new sample and finally filling to the shoulder of the bottle, drying the neck with a tissue and sealing the bottle. In the case of the multisampler all external water droplets were removed from the area around the tap before sampling began.

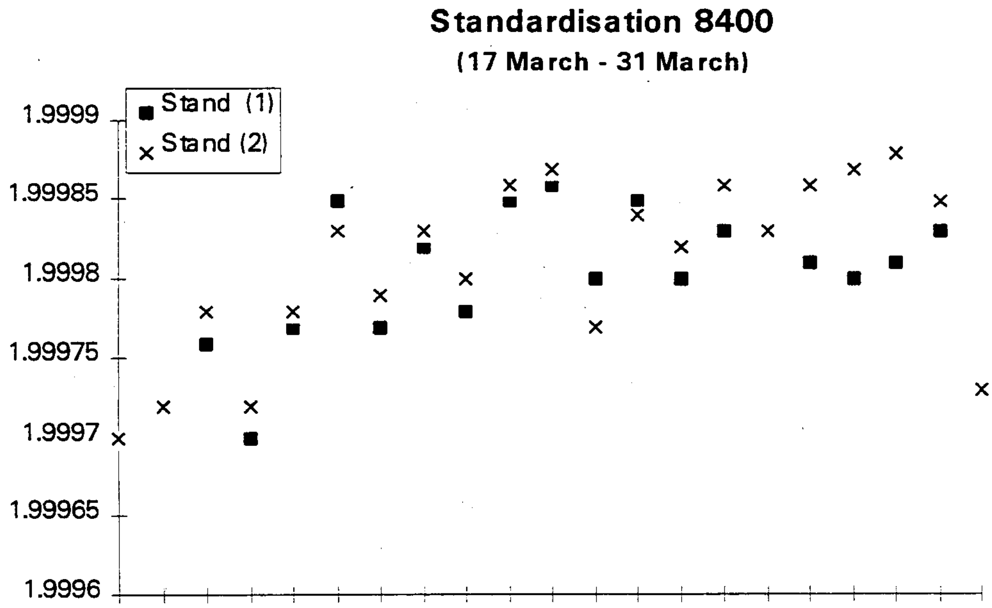
The bottles were in crates of 26. TSG samples were taken hourly, and on occasion it was up to 3 days between sampling and analysis on the salinometer. For the CTD samples this delay was never more than 36 hours. Sample crates were kept in the salinometer lab for the sample temperature to equilibrate before analysis.

The salinometers used were the MAFF Guildline Autosal model 8400A and the IOSDL Guildline Autosal model 8400A, with an Ocean Scientific International peristaltic pump. The units were housed in the constant temperature laboratory. The laboratory temperature was set at 21°C and the bath temperature at 24°C. The salinometer was powered from the clean supply.

The salinometer was standardised with ampoules of P120 and P123 IAPSO Standard Sea water. The method adopted was to standardise with a new ampoule at the start of each box, to seal the ampoule with 'Blu Tac' and then to use the remainder of the ampoule to restandardise at the end of each box.

Problems were encountered with the operation of both salinometers. Pump failure on the MAFF salinometer, caused the cell flush mechanism to break down. The pump was replaced and normal operation resumed with only one sample lost. 10 days into the cruise there was a large drift in standardisation, the conductivity became completely unstable and operations were moved over to the IOSDL salinometer. Its standardisation remained very steady, however problems were encountered with cell fouling throughout the trip. Flushing the cell with Decon helped to clean the cell and improve the speed at which it filled. This did not cure a recurring problem in which water enters one of the small tubes attached to the cell flush mechanism causing one of the arms in the conductivity cell not to flush. Several times operations were suspended and the blockage cleared successfully with the loss of only a few samples.





The data shows that there was a steady trend in the values that amounted to a shift of 0.0003 during the cruise.

Duplicate salinities were taken from rosette bottles 12 and 24. Bottle 2 was in all cases closed at the same depth as bottle 1. An analysis of the differences shows the following:

Bottle 1 - Bottle 2	0.0001±0.0021
Bottle 12 - duplicate	0.0000±0.0007
Bottle 24 - duplicate	0.0001±0.0005

AR

Chemistry

Nutrients

A total of 682 samples of sea water were analysed for nitrate, phosphate and silicate using MAFF's SKALAR SA4000 segmented-flow analyser. Of these, 650 came from 31 CTD stations, the remainder were surface samples taken from the ship's non-toxic supply and analysed in support of pCO_2 measurements.

The SA4000 system gave no problems, and the reliability of the silicate determination proved particularly useful in resolving questions of bottle-firing depths at times when the rosette sampler was suffering from intermittent faults.

Procedures

Samples were drawn from the CTD rosette bottles directly into 1-litre polyethylene bottles and were analysed without filtration, generally within one or two hours. On the few occasions when it was necessary to store samples pending later analysis, storage conditions were darkness at 10 ± 2 °C for a maximum of 6 hours. (Repeat analyses of typical samples showed no detectable differences over this time interval.)

The 8 ml sample cups used on the SA4000 carousel were new and not subjected to any cleaning procedure before use other than three or four rinses with sample. The same forty cups were re-used repeatedly throughout the cruise. As a protection against contamination, this regime has proved as good as any, and better than some.

Results were obtained by a single analysis of each sample unless there was any evidence of oceanographic inconsistency, in which case repeats were undertaken, within the same batch or in the one immediately following. (These were rare events, i.e. two occasions when slightly high phosphate concentrations were attributable to random contamination from handling.)

The analytical methods used are fully described and discussed in the SKALAR Seawater Methods booklet. These gave highly satisfactory results (laboratory number 117) in the most recent ICES Intercomparison Exercise, NUTS I/C 5.

Quality Control

On 22 February (day 053), a 'bottle cleaning' CTD station (12628) was worked at 29° 43.6′S, 42° 00.6′ E in a water depth of 4886 m. Twenty-three bottles were closed at 2000 m, the 24th at the surface. Sub-samples were drawn from each for the determination of nitrate, phosphate and silicate. This station was intended primarily for CFC purposes, but nutrients, salinity and CFC determinations, together, unambiguously confirmed and identified one leaky and one contaminated bottle, both of which were replaced.

Mean concentrations (μmol l^{-1}) and relative standard deviations (%) for sub-samples from the 21 consistent bottles are as follows -

nitrate 28.20 (0.64) phosphate 1.92 (2.60) silicate 59.96 (1.80)

These concentrations (and temperature and salinity data) are consistent with the assigned identity of the water mass at this depth and position as North Atlantic Deep Water.

A bulk Quality Control (QC) sample was obtained by draining approximately two litres from each of the first 12 of these consistent bottles into a 25 l polyethylene carboy which was stored in darkness under refrigeration for the remainder of the cruise. Two aliquots of this QC sample were analysed among the samples from each of the subsequent 30 CTD stations. These aliquots were withdrawn as required, immediately before their analysis, by Eppendorf-type pipette from the 25 l carboy which was assumed to be subject to adequate mixing from the ship's motion. No intermediate storage vessel was used; i.e. the aliquots were pipetted directly from the carboy into auto-analyser sample cups and these were spaced well apart from each other on the carousel, interspersed with each station's samples.

Mean concentrations (μmol l^{-1}) and relative standard deviations (%) for these 60 analyses of the QC sample are as follows -

nitrate 28.197 (0.938) phosphate 1.929 (1.981) silicate 61.19 (0.847)

Individual results are shown plotted against time in Figure 5.

Oxygen

A total of 622 oxygen determinations were made on samples from 31 CTD stations.

Once more the photometric end-point detector developed and manufactured by UCNW Menai Bridge failed to perform to expectations. After its total failure on *DISCOVERY 200* it spent several months in UCNW's workshop but in mid-December 1993 it was reported to be ready for use. Soon afterwards, its performance was seen to be satisfactory in the laboratory at MAFF Lowestoft before shipment to Gibraltar. It also appeared to be satisfactory on board *DISCOVERY* during a brief test while berthed in Cape Town, but once at sea, all was not well.

Essentially, towards the end of a titration, as the liberated iodine is consumed by the reaction with thiosulphate, the instrument's output signal approaches 100% transmission, and the end-point detection is on a 'no further change in transmission' basis. In principle, the transmission can only increase (never decrease) on the way to the end-point, but in practice, this instrument, when nearing the end-point produced both increases and decreases sufficiently large to exceed the default tolerance threshold level. This resulted in the end-point identification procedure becoming ineffective; i.e. the instrument appears to be close to detecting the genuine end-point then an unacceptably high change in transmission (+ve or -ve) upsets the detection sequence and the search for an end-point begins anew. The instrument can throw itself in and out of this search mode several times before it finally finds a (spurious) end-point. On advice from Jane Robertson who had experience of an earlier similar instrument, two parameters were manipulated in order to de-sensitise the instrument and thereby overcome the problem, but it persisted despite all efforts. On occasions, perhaps once in every five or six titrations, a genuine end-point might be found, but if the instrument's opinion were to have been accepted uncritically for every titration, serious overshoots would have been the norm.

The stability of the mains supply, to the instrument and thence to the filament bulb which provides the light source, was prime suspect as a possible cause of the problem, but after thorough testing with the aid of an oscilloscope over several days, the ship's (clean) supply, and that to the bulb, were reckoned to be satisfactory by those aboard with expertise in these matters. For want of something else to try, the bulb was replaced in turn by two new spares, but neither produced an improvement. (One produced an output greater than the measurement system could cope with, and the applied voltage required adjustment to compensate.)

In the latter part of the cruise, the instrument was tested in very light seas but the problem persisted suggesting that ship's motion *per se* may not be the only important factor. Whatever the problem may be with this particular instrument, there is no alternative but to conclude that it is presently not robust enough for its intended task.

Procedures

Reagent formulation was as documented in L. I. Gordon's draft WOCE protocol (Sept. 1993).

Sample temperatures were measured in the Winkler bottles with a hand-held digital thermometer immediately before reagent addition. After initial mixing, samples were allowed to stand at least 2 hours before a second thorough shaking, followed by at least a further 2 hours settling before acidification/titration.

In view of the problems associated with the photometric end-point detection equipment, titrations were undertaken with the Metrohm 665 Dosimat under manual control which allows a readability of ±0.001 ml for a typical titre of 0.7 ml. The end-point was visualised with a starch-based iodine indicator, BDH product no. 20054 3P.

Quality Control

The primary standard iodate solution used for initial standardisation of the thiosulphate titrant (and thence the secondary standard iodate), was supplied by WAKO Chemicals GmbH, Neuss, Germany, and is guaranteed by the Sagami Chemical Research Centre (Lot no. TWP8499). (On *DISCOVERY 200* the same solution was used).

Thiosulphate concentration was checked on each day of use using the secondary standard iodate solution prepared from potassium iodate, 'UNIVAR' product no. 504 48 00 batch 27986, SAARCHEM (pty) Ltd.

Figure 5 illustrates the differences between Winkler oxygens and CTD oxygens as a function of depth.

DSK, AR

CFCs

CFC measurements (CFCs 11, 12, 113 and CCl4) were made using the PML CFC instrument as described in the *DISCOVERY 200* cruise report. The only significant difference between the techniques used on *DISCOVERY 200* and *DISCOVERY 207* concerned the standard gas. On *DISCOVERY 207* two new gaseous standards were used with regulators to provide calibration aliquots for all four compounds of interest. During the cruise the CCl4 concentration of the *DISCOVERY 207* standard was poorly established, and routine measurements of the marine atmosphere provided the effective primary standard for that compound. The GC system was set up in Gibraltar, two weeks before the *DISCOVERY* arrived in Cape Town for cruise 207. The carrier and make-up lines were left running, with the ECD and column just above operating temperature. No problems were experienced, and valuable time waiting for the ECD sensitivity to stabilise was saved as a result.

Shortly after setting sail from Cape Town a cast was hauled where all 23 bottles on the rosette used for CFC samples were closed at the same depth (Niskin 24 was a Go-Flow type, and not used for CFC samples). A comparison of the replicate chromatograms of samples taken from this station clearly revealed two contaminated Niskins. These were replaced with other bottles and apart from minor incidents no further episodes of contamination occurred. There were two periods when sampling was difficult however. The first occurred on the southernmost station on the Antarctic continental shelf. Sea water in the syringes, taps and water bottles froze within minutes of arriving on the deck, presumably due to high wind chill. The second period of problematic sampling happened on the northern-most section when the temperature difference between the bottom samples and the surface was sufficient (>20° Celsius) to cause outgassing of the sample in the syringes (and possibly in the Niskins too, on occasion). This difficulty was almost entirely solved by using chilled and frozen de-airated surface sea water as the bath in the syringe bucket.

Thirty-one stations were occupied in all, and CFC samples were drawn from each of these. Almost without exception every Niskin bottle was sampled, with 5-6 duplicate syringes on a typical cast. In addition, three experiments with surface water were carried out. These involved comparison of water from Niskin bottles, the ship's non-toxic seawater supply and water sampled using a stainless steel bucket thrown over the ship's rail. There was no systematic difference in CFC concentration between these sources of surface water, apart from a slight tendency for the non-toxic supply to be lower in concentration. This trend is consistent with a small amount of sparging of the non-toxic supply. The final, and most ambitious, part of this exercise involved a 36 hour continuous surface survey, during which samples of sea water from the non-toxic supply were drawn every 20 or 30 minutes and analysed almost immediately in order to measure the variability in surface saturations.

Typical seawater precisions were of order 1-2% for CFC-11 and CFC-12, and 2-3% for CFC-113 and CCl_4. Replicate precisions for gas aliquots were initially about twice these figures, but considerable improvement was achieved by closing the laboratory door in order to stabilise the air temperature. Calibration exercises with 8-9 aliquot volumes were run approximately every other station, including marine air samples. The chromatogram checking and calibration was carried out on board and typical precisions for curve fits was of order 0.5%. Detection limits were typically of order 5 fMol l^{-1} (5×10^{-15}), although there were some problems with the CFC-12 blanks towards the end of the cruise which reduced this figure to around 10 fMol l^{-1} for this compound.

Bottom enhancement in CFCs was evident in many of the stations occupied. The re-occupation of the Crozet-Kerguelen Gap line confirmed the measurements made on *DISCOVERY 200*, including subtleties in the field which reinforce our faith in the quality of the observations. The two sections transecting the abyssal flow downstream of Crozet revealed the plume of Antarctic Bottom Water; distinctly traced by CFC maxima which reveal the stain of atmospheric contact. In these lines the invaluable utility of CCl_4 as a tracer was further confirmed; as the signal in CFCs 11 and 12 petered out the bottom maxima in CCl_4 continued to delicately mark the Antarctic plume. Figure 6 shows profiles from stations typical of the five areas worked (preliminary calibration scale only).

This cruise was notable because four volunteer assistants helped TWNH and MIL to make the CFC determinations. Despite their inexperience, the enthusiasm, care and willingness of Elaine, Rebecca, Monica and Tony meant that they learned at such a rate as to be quickly relied upon. The quality and volume of the CFC measurements made on *DISCOVERY 207* are witness to their skill and hard work in conditions that were never easy (freezing winds, storm force seas with only occasional sunshine!). Many thanks to them, and also to the rest of the ship's company for their consideration of the probable and possible detrimental effects of using aerosols.

TWNH, MIL, ELM, RAW, MFC, ARC

Stable isotope and trace metals

Approximately 750 samples were collected for analysis of stable oxygen and hydrogen isotope ratios. By combining stable isotope ratios with salinity measurements it is possible to distinguish water masses that have had their salinity changed by evaporation or precipitation from those that have been altered by freezing or melting.

Three types of sampling bottle were used : 250 ml salinity bottles with plastic neck inserts, 250 ml salinity bottles of the older metal screw top type and 150 ml bottles also with metal screw tops. The latter two types of bottles were sealed with paraffin wax after filling.

Trace metal samples were also collected from each CTD station. These were taken from a 10 l GOFLO bottle placed on the CTD rosette in position 24. A total of 39 samples were collected, including several duplicates. Two samples from the Princess Elizabeth Trough were taken from bottle 23 as the GOFLO failed to fire. GOFLO leakage was also a problem on four of the early stations (see Table 1), though this was not encountered in later sections. These samples will be analysed primarily for Cd to compare the Cd/P relationship through the different water masses sampled. Other biologically important trace metals (Ni, Cu) will be determined depending on the extent of contamination from the rosette and Niskins.

A large ice sample was captured at 62° 02′ S 84° 33′ E. Inner sections of the ice were removed, from the 'upper' and 'lower' parts of the sample and allowed to melt slowly in the cold store. The sample was then separated into 250 ml salinity bottles and several duplicates taken. These will be analysed for stable oxygen and hydrogen isotope ratios.

All samples will be analysed by Dr Frew at the University of East Anglia.

MDS

On-passage chemistry

During this cruise the measurement of pCO_2 and TCO_2 was carried out on passage along with ancillary measurements for chlorophyll and stable isotopes.

pCO_2

During the cruise pCO_2 was measured using a gas chromatograph and showerhead equilibrator. Air was supplied by a compressor and hydrogen fed in using copper pipes from the gas bottle store. The same procedure used on *DISCOVERY 200* was followed with the equilibrator placed in the water bottle annexe close to the de-bubbled non-toxic supply. The auxiliary heating was switched off in the annexe enabling the temperature in the equilibrator to be kept as close as possible to the *in situ* temperature. Measurements of pCO_2 (Figure 7) were taken twice in each 14 minute cycle, bracketed by both standard and measurements of marine air. The system worked well with two motor failures during the six weeks. The main source of concern was related to fluctuations in the temperature of the deck lab. due to cold air entering from the doorway connecting the decklab. and hangar. These temperature changes caused some variation in the reproducibility of the standard and certain periods have had to be edited out of the data set.

TCO_2

During the cruise TCO_2 was measured using an extractor unit combined with coulometric analysis of the carbonate content in a sample of sea water. Unfortunately a couple of major problems occurred prior to the cruise start that severely affected the quantity and perhaps quality of the data, although this will not be known until the data is calibrated.

The computer used to control the system was left in the container on deck during the passage down from Gibraltar to Cape town. The computer suffered damage to resident memory most probably as a result of the heat. An alternative computer was supplied by RVS Engineering Dept. that was adapted by RVS computing support. Without this support and expertise the system would not have functioned at all and two thirds of the planned science for the cruise would have been lost. Their interest, advice and expertise is gratefully acknowledged. The computer supplied was faster than the original leading to occasional communication problems between computer and valve controller. This could not be overcome during the cruise and so handicapped the type and number of measurements. All samples had to be watched as the programme occasionally hung and had to be restarted manually.

The other problem was a lack of standards as one box of WOCE TCO_2 standards was left inside the container during the run down. One box (half used) was placed inside the main lab., unfortunately the full box was left in the container. These seawater standards had warmed up and some evidence of de-gassing was observed. The limited number of standards remaining meant that the number of calibrations carried out were severely reduced. During the first few runs one solenoid valve failed on the extractor system and was replaced with the help of the RVS electronic support and this worked well during the rest of the cruise.

Despite the above handicaps a number of measurements were carried out in conjunction with the sampling schedule for stable isotopes.

Stable Isotopes

Surface water was sampled during the cruise, typically twice a day, the filters and water samples to be returned to the UK for analysis of the following:

13C-POC, 13C-DIC, POC/PON ratios, Opal concentration, 15N-PON, 15N-DIN

I wish to thank Don Kirkwood who measured surface nutrient concentrations from samples taken in conjunction with the sampling for stable isotopes.

Chlorophyll

Chlorophyll samples were taken roughly hourly between 0800 and 2200 h and frozen. These samples will be taken back to the UK and analysed to provide a calibration for the underway fluorometer onboard.

JER

Current meters and moorings

Moorings (Figure 1(c))

Of the 16 moorings laid on *DISCOVERY 200*, 13 were recovered without problem using the IOSDL double barrelled capstan and spooling winches. Initially the rope was hauled through a block mounted on the aft gantry, but later, the use of a block hung from the starboard crane allowed greater flexibility in the angle of the recovered mooring rope. All recovered rope was spooled directly onto wooden storage drums, and both full drums and recovered glass spheres were stored in a 20 ft cargo container mounted on the after deck.

The 13 moorings were recovered intact and there was no sign of any damage or excessive wear in any component other than an imploded sphere on mooring 9313, whose raft of spheres also broke into two sections at the surface, fortunately leaving enough to support the mooring whilst it was recovered. All shackles other than those securing the anchor and swivels were seized with cable ties rather than wire, and all appeared satisfactory on recovery except for some holding the rafts of spheres together.

Mooring 9311 was recovered by dragging and two moorings, 9314 and 9308 were lost.

Mooring 9311 - Recovery by dragging

1. Dragging

A dragline operation was initiated for recovery of mooring 9311 determined to be in an upright position in 4240 metres water depth but unable to release the anchor.

Co-ordination and navigation was from the ship's bridge with monitoring of mooring and dragline acoustics from the main laboratory.

The ships 20 tonne Cley-France winch system with trawl warp was operated from the winch control cab. Communications were by UHF radio throughout.

A dragline had been prepared at IOSDL for this cruise. The assembly is shown Figure 8(a). The object of the dragline was to deploy the line along the seabed with the leading grapnel just on the seabed.

Navigation during this operation was by the Captain and 2nd Officer using the bridge Racal Decca CVP3500 interlinked with the Mk 53G Navigator operating on GPS. Positions of mooring deployment and re-navigated closest approaches were plotted on the system and the plotter operated at 1:35000 scale.

The dragline was deployed from the DBC using both storage winches. An RVS 10 Khz pinger was clamped to the ship's trawl warp to give height off bottom, to prevent the trawl wire being dragged across the bottom.

With 3000 metres of main warp deployed the ship manoeuvred into position for the first approach at the mooring. The dragline was then clear of the sea floor. With the ship positioned for the first approach the main warp was deployed at 64 m min^{-1} as the ship came up to 2 knots dragging speed. This laid the dragline onto the seabed as the ship approached the mooring.

The mooring's relative position was monitored from the CR200 displayed on the waterfall display. This gave information of approaching the mooring and beam-on positions.

The 10 Khz pinger was monitored on the ship's SIMRAD EA500, giving height of pinger off-bottom. Height off-bottom varied from 500 m when towing in a straight course to 150 m off-bottom when sweeping the line across as the ship turned.

Several sweeps were made through the mooring positions with the vessel turning across the swell to starboard. During these turns the after gantry main warp sheave was tilted to its stop to starboard. To alleviate this some warp was deployed to ease the tension in the line.

As the final sweep was concluding the main warp was hauled at 30 m min^{-1}, increasing to 60 m min^{-1} at 3000 m, i.e. with the dragline off bottom.

It was during this hauling that the CR200 indicated mooring approach and successful cutting of the mooring above the release and below the back-up buoyancy as the release signal jumped on the trace and was seen to rapidly descend to the seabed with reducing bottom echo separation.

With daylight fading it was decided to cut away the dragline below the top grapnel in order that the ship could manoeuvre to recover the mooring.

It was felt that there was no hazard to the mooring in doing this, as should the grapnel still be entangled with the mooring the weight of the remaining grapnel and line could not sink the mooring.

On recovery of the grapnel rig it was found that the leading weight had come off, probably by jerking of the Boss hook with which it was attached. The 10 mm wire and leading grapnel did not appear to have been on the seabed as there were no signs of abrasion. The remainder of the rig was not recovered and no inspection could be made.

2. Recovery

The steel sphere was sighted 100 m ahead of the ship and was floating at the equatorial weld, as the back up buoyancy surfaced the sphere was seen to float slightly higher in the water. The back up buoyancy surfaced approximately 200 m upwind of the sphere and was seen to be streamed correctly.

Recovery of the sphere was initiated by grappling from amidships and passing the sphere astern using a 5 tonne BL floating rope to the DBC. The sphere was towed astern for several minutes to allow the ship to manoeuvre upwind of the back-up buoyancy which passed 100 m off the starboard side.

The steel sphere was then hauled aboard by DBC and recovery operations commenced with the steel wire being hauled onto a steel storage drum, hauling onto a wooden drum was believed to be inadequate given the loads expected and the back tension required at the storage winch.

The stainless swivel at the joint between the steel wire and polyester line was entangled and freeing the unit was achieved with some difficulty.

The back up buoyancy appeared entangled as it was hauled to the stern with the deeper MAFF buoyancy being recovered first. The mooring lines were twisted together and four lines were hauled aboard together through the DBC.

The MAFF current meter was recovered by stopping off and the tangled lines rejoined with polypropylene rope. This procedure was repeated for the IOSDL current meter with the buoyancy being hauled aboard suspended from two twisted lines.

The two entangled lines were hauled through the DBC until the final twisted pair was onboard and hauling was recommenced on the single kevlar mooring line. The mooring line was then transferred onto the second storage winch fitted with a wooden drum and the mooring recovered as normal. The final length hauled aboard had been parted at 354 m length by the dragline. The line appeared to have failed due to excess loading probably caused by the grapnel entangling and attempting to drag the 1600 kg deadweight anchor and 35 kg Bruce embedment anchor across the sea floor.

3. Inspection of mooring hardware

The mooring hardware was thoroughly inspected and all appeared in excellent condition with negligible corrosion. The fibre lines showed no signs of wear and all splices were tight with no signs of slippage. There were no signs of the dragline having touched these lines. The wire swages on the top 30 m length of coated wire were cut open and inspected for signs of water ingress. The outer swage sleeve appeared to have had some water penetration but this had not penetrated to the wire core. The swage was machined open on board to inspect the internal condition of the wire and was found to be undamaged.

One of the MAFF RCM-8 gimbal outer pivot bolts had suffered crevice corrosion on one side only.

The top four IOSDL RCMs all showed signs of the gimbal casting having come up against the angle stops during deployment.

4. Mooring stretch rework figures

These calculations have been re-worked following the apparent upward drift of the pressure values recorded by meter 10865 at the top of this mooring. (See Current meters, below)

Component	Length	
Jacket wire	630 m	
Polyester	121 m	Stretch measure
Kevlar KT3	2033 m	Stretch measure
Chain	11 m	
Glass sphere assy.	10 m	
Current meters '1' to '4'	9 m	
Fittings	5 m	
ACM MAFF strops	7 m	

In line loading 'Top' section		
Buoyancy 1.3 m sphere		634 kg
Load Current meters		82 kg
	Wire	73 kg
	Polyester	25.75 kg
	Fittings/chain	15 kg
Total load		195 kg
Buoyancy/tension in line top of spheres		438 kg
Maximum tension in polyester		520 kg

Stretch figures achieved by pre-stretching lines overside with 600 kg weight.

Nominal length	Stretched length	% stretch
46 m	50 m	9%
184 m	205 m	10.3%
368 m	418 m	13.5%
460 m	522 m	13.5%

'Lower' section		
Buoyancy 'Top' section		438 kg
Buoyancy Glass spheres		450 kg
Load	Current meters '4' to '8'	91 kg
	Acoustic Releases	22 kg
	KT3	48 kg
	Fittings/chain	42.7 kg
Total load		195 kg

Buoyancy/tension in line at spheres	888 kg
Maximum tension in KT3 at RCM '5'	887 kg
at RCM '6'	848 kg
at RCM '7'	806 kg
at RCM '8'	771 kg
at anchor	684 kg

The error/stretch of the KT3 from MAFF shoreside measurements compared to the onboard stretch measurements was 5% . All the KT3 was measured overside with 600 kg weight.

From Marlow load extension graph we see the following stretch figures:

Material	Min.strength	Load applied	% of Ms	Graph stretch
Marlowbraid 10mm	2720 kg	520 kg	19%	4%
Marlow KT3 10mm	3670 kg	887 kg	24%	1.5%

Note: Marlow stretch figures are obtained from lengths preloaded to 50% of breaking load 6 times and allowing 24 hours for recovery. For guidance only.

What we therefore are seeing in our stretch operation is Elastic stretch and non-recoverable stretch ie the rope bedding in as the construction tightens with also an element of recoverable stretch.

Marlow Ropes also estimate a further long-term 1-year creep given our loadings of:

Marlow braid 10 mm	1.2%
Marlow KT3 10 mm	0.3%

From M. Hartman IOSDL, 25th March, following his communication with Marlow Ropes made in response to a query from the ship:

> "Therefore if we assume that our ropes are fully stretched and add in the one year creep we see that the lines will extend:
>
> | | | | |
> |---|---|---|---|
> | Marlow braid | 10 mm | Ship measure 1215 m | Creep 14 .58 m |
> | Marlow KT3 | 10 mm | Ship measure 2033 m | Creep 6.099 m |
>
> To get the buoy to rise from 309 metres (nom.) to 80 metres we need to see an increase of 229 metres in the stretchable mooring components ie the polyester and KT3.
>
> To get this overall stretch we would see that from the new untensioned line lengths the polyester would need to extend 20% and the KT3 12% or the polyester would stretch more and the KT3 less. This hardly seems feasible given the comparatively light loadings applied.
>
> From these figures it would seem doubtful that line stretch could be the cause for the apparent rise of the subsurface sphere through the deployment period."

Current meters (Figures 8(b-d))

1. General comments

The 16 moorings supported a total of 57 Aanderaa Recording Current meters of all four types. Of the 46 units recovered, 32 were RCM5, 10 RCM8, 3 RCM7 and 1 RCM4. Meter performance reflected generally the age of the instruments with the solid state versions producing 100% data return, only the data from a 3239D pressure transducer fitted in 10856, detailed below being suspect. Figure 8(b) shows the general mooring layout, whilst Figures 8(c) and 8(d) show the two arrays of moorings and the lost meters.

2. Individual Malfunction Notes.

073
This instrument suffered from a channel starwheel switch fault, that progressed from perfect operation to continuous encoder running in 40 hours, whilst cased but still in the lab awaiting deployment. The fault appears to be caused by marginal contact between the operating pin in the encoder cap and the starwheel causing the switch to be left in a midway position and the bridge not connected. This causes the encoder to record 1023 and increases the likelihood of further problems. Eventually, after several near misses the tips of the starwheel become worn, the encoder never succeeds in switching to the stop segment and continuous running results.

768
As 73 above except fault occurs immediately on entering the sea.

825
As above except runs for 24 hrs after entering sea.

The following 6 meters worked satisfactorily for a number of days before being terminated because of increasing signs of encoder 'noise' (16, 32, 64 and 512 bits appearing) causing data to be contaminated:

278	163 days	331	238 days	607	314 days
696	159 days	703	101 days	924	26 days

933
This meter recorded correctly for 261 days but then a fault that looked like the classic encoder fault developed with only single bit values being recorded (16,32,64,128) but only in the speed channel. This could be caused by the battery becoming exhausted and beginning to drop in voltage after 5 channels of operation, but the meter continues to record 5 channels perfectly for a further 107 days. It is therefore likely that the cause is a faulty rotor counter.

109
This instrument was recovered with only 15 signals recorded and the battery disconnected. The terminal is not faulty so it can only be assumed that it was not fully pushed on when originally fitted.

128
Meter leaked very shortly after deployment, and internal pressure blew out the bottom end cap during recovery ascent. 12hrs data in sea only.

10856 (serial)
This RCM7 was recovered from the top of mooring 9311, nominally 300 m from the surface. The pressure readings from the 3239D sensor showed an uneven but steady drift in indicated depth

from the 'correct' value of 300 m at the start to 80 m at the end. All other recorded parameters indicate that one unlikely possibility of severe mooring stretch can be discounted, the only other cause is drift in the pressure sensor itself. A crude test of its output was carried out after the processing, by lowering it 500 m on the ship's CTD wire, but it was found to have the same calibration as when laid. The sensor will be subjected to steady long-term pressure under laboratory conditions to confirm our suspicion that long-term drift occurs, that is reset on returning to atmospheric pressure. (See also Mooring 9311 above).

3. Compass problems in areas of severe South Pole dip angle (Figure 8(e))

Most of the meters in the Princess Elizabeth Trough array (all RCM5) and some RCM5s mainly at the eastern end of the Kerguelen-Crozet array were affected in varying degrees to a 'faulty' direction/speed scatter plot. Depending on severity an area of 90-150 degrees was partially or wholly devoid of readings with the centre of the 'blind' sector pointing towards the Magnetic South Pole. It would appear that the design of the Aanderaa compass, with its north pole fitted reading pointer, could be more easily jammed by large magnetic dip angles in the southern hemisphere than in the north, however the large spread geographically, with some very mild affects at 64°S, 85°E and severe affects at 48°S, 61°E, and the fact that no RCM8s (fitted with identical compasses) in the northern array were affected means that further investigation is needed.

Acoustic release operations

1. Deck systems

The moorings deployed used sea units of CR200 and MORS RT661 types. The deck command units were supplied by both IOSDL and MAFF, the principal relocation display being an IOSDL Waterfall display fitted to a PC with suitable interfacing for both the CR200 Mk3 deck units and the modified IOSDL MORS TT301 deck unit. The PC supplied for the Waterfall display failed to boot up its hard disk on setting up in port and a spare unit was fitted with the Waterfall card and the software installed.

To test reception of the deck units an IOSDL 10 Khz precision pinger was lowered on a CTD dip to 3500 m and signals observed using the echo sounder fish as the receiver transducer in both single and 8 element modes. Good signals were observed on both the Mk3 and MORS systems. The EA500 SIMRAD ship's echo sounder was also tested in the Passive mode as a back up system using 8 elements. The ship's hull transducer was connected to the Mk3 deck unit, but reception was found to be poor at 3000 m range.

The system evolved for relocation and releasing CR200 moorings was to transmit and receive on one Mk3 deck unit with a second Mk3 providing the time base for the waterfall display. This prevented disruption of the time base when acoustic transmissions were taking place. Both single and 8 elements of the echo sounder fish were used dependent on reception conditions and ranges.

The MORS releases were commanded by the MAFF deck unit and overside transducer lowered amidships and pinger signals monitored on the IOSDL MORS unit using the echo sounder fish. The principal relocation and mooring rise was made using the sea unit 10 Khz pinger signal as onboard reception from the overside transducer was poor and transponder replies were often lost in the sea noise.

Both the MAFF and IOSDL TT301 deck units suffered casing damage in heavy weather due to their light plastic construction.

RVS had a MORS system type TT201 onboard with a towed Endeco V-Fin fish which was tested on two occasions. In a moderate sea state mooring 9304 was relocated and good slant ranges obtained to 3600 m at a ship's speed of 4 knots with subsequent command to release being successful. However mooring 9305 could not be relocated in a moderate sea state, ship's speed 4 to 6 knots. The release was subsequently relocated using the TT301 with overside transducer. This could have been due to high sea noise levels or possibly to the MORS sea unit operating at reduced power output as observed on the Waterfall display.

Recommendations

The MORS RT300 in standard form is not adequate for observing the transponder and pinger functions and is inadequately mechanically housed. A towed fish suitably interfaced may reduce the sea noise and improve transducer stability, because even with moderate ship motion the transducer streams at various angles not suited to reliable communication.

The modified IOSDL MORS RT301 with integral Waterfall board is awkward to use having switches inside which can be required during an operation. It would be desirable to rebuild the units into a more robust housing having all the connectors and switches on a front panel.

It is felt that the waterfall display when used with the MORS pinger gives the most reliable indicator of unit operation at this time and it would be essential that whenever the sea units are deployed a waterfall display is available.

MAFF will need to invest in a waterfall display unit and suitable towed body if further use is to be made of the MORS releases

2. Sea units

CR200

The CR200 releases were used in the Crozet-Kerguelen array and operations are summarised by mooring number.

Mooring 9309 - CR200 serial no. 267.
Water depth 4393 metres. 7 March (day 066).
Responded to one tx of 320 Hz released with nine tx of 299 Hz.
On release the unit malfunctioned in that it switched from the double ping mode to the single, command mode and could not be commanded again. The unit could not be switched off acoustically in the laboratory and was powered down internally to stop the pinger. Both pyros fired.

Mooring 9310 - CR200 serial no. 2187.
Water depth 4478 metres. 7 March (day 066).
Responded to one tx of 320 Hz but would not release after indication of correct firing was observed after 10 transmissions. The release procedure was repeated four times with each successive firing giving poorer indications. The unit was then reset to single ping and allowed to time out. Transmission of the release frequency was then restarted and after 24 transmissions the release was observed to be rising through the water column although no indication of firing was seen on the Waterfall display. On recovery one pyro had not fired and the electrical lead was flooded whilst the other had fired and the lead was also flooded.

Mooring 9311 - Tandem CR200 units Serial nos. 2345 and 2402.
Water depth 4240 metres.
The release units were arranged on a single bar with each unit firing one pyro. On arrival at the site on 5 March (day 064) both units were turned on with one tx of 320 Hz and a good 50 m bottom echo observed off each identifying the mooring as upright. However on attempting release both units indicated correct firing but the mooring remained firmly anchored. Each unit was cycled through six times with the same result. The units were then switched to single ping and observed to time out correctly. Further attempts were postponed and the mooring left on position until a further attempt could be made on the 21 March (day 080).

On arrival at the site CR 2345 was switched on but CR 2402 failed to respond. Release transmissions were made and all the indications were that the unit was performing correctly but would not drop the anchor. The unit was then switched to time out and further release transmissions made with no anchor drop being observed. The unit was then switched to the release mode such that it would act as a continuous navigation beacon whilst a drag line was towed around the position. On hauling the drag line the pinger trace jumped across the Waterfall display and was seen to sink to the seabed indicating that the mooring was cut free above the release. The mooring was recovered with the CR200s lost on the seabed.

Mooring 9312 - CR200 Serial no. 2180.
Water depth 4427 metres. 5 March (day 064).
Responded to two tx of 320 Hz and released after 8 tx of 240 Hz.
On recovery both pyros had fired correctly .

Mooring 9313 - Tandem CR200 Serial nos. 2184 and 2400.
Water depth 4141 metres. 4 March (day 063).
Both units responded to one tx of 320 Hz and with twelve tx of 339 Hz
2184 released. 2400 was fired as the mooring rose. On recovery 2400 had not fired its pyro and water was observed in the electrical lead at the pressure case connector. 2184 had successfully fired its pyro but the electrical lead was flooded and green corrosion products were observed within the pyro end connector. The mushroom transducer was also corroding through the protective anodising.

Mooring 9314 - Tandem CR200 Serial nos. 2348 and 2401.
Water depth 3996 metres 2 March (day 061).
On arrival at the site transmissions were made to the releases and an apparent signal observed with a weak signal strength barely visible in the sea noise. A strong signal was observed but this was subsequently traced to the sync pulse being generated to drive the Waterfall display. Courses were steamed to see if the mooring had surfaced and drifted, however no visual contact was made in good visibility. The ship then hove to at the site and an apparent signal was detected, again very weak. The 'pinger' was set to time out and with a CTD overnight the deck unit reception was checked using a 10 Khz pinger on the CTD and was correct giving strong signals to 3700 m. The ship returned to the site on 3, 4 and 22 March (days 062, 063 and 081) but was unable to make any contact with the releases and the mooring was abandoned. On comparing all the recovered CR200 signal strengths and traces it would seem highly unlikely that the poor signal detected was a pinger and that it was most likely a short period of correlated noise.

Mooring 9315. Tandem CR200 - Serial nos. 2333 and 2347.
Water depth 3809 metres. 3 March (day 062).
Both CRs responded to one tx of 320 Hz and correctly fired to release anchor. On recovery 2333 had traces of water in the electrical lead to the pyro.

Mooring 9317. CR200 Serial no. 2344.
Water depth 3345 metres. 4 March (day 063).
Responded to one tx of 320 Hz and fired with 13 tx of 440 Hz. On recovery it was found that the unit had only fired one pyro. Investigation showed that the unfired pyro had completely corroded away its connecting pins and the electrical lead was flooded. The other pyro lead was also found to be wet within the pyro connector. The mushroom transducer was also severely corroding particularly around the circumference adjoining the pressure casing.

CR200 recommendations

The CR200 units recovered suffered with a preponderance of pyro leads flooding. It is suggested that there is a mismatch between the leads and the new pyro connectors. The leads all need replacing before any further use, with a type compatible to the current pyro connector, this will also probably require the bulkhead connectors on the pressure casing being replaced.

MORS RT661 transponder releases

The MORS releases were all new instruments on deployment and as such had not been previously used by MAFF or IOSDL as long-term mooring releases. They were used as single units for all five PET moorings, 9301-9305, on mooring 9318 west of Crozet and 9308 and 9306 in the Crozet - Kerguelen array.

Of the eight units deployed all but 9308 were successfully recovered and performed to specification. 9308 was suspect on deployment as no contact was established as the mooring sank onto position, no contact was established on returning to the site on 7 March (day 066).

The recovered units all gave good bottom echoes on position and pinger signal strength was good. Control commands were received by the sea units with reliability and dependent on sea state/noise could be received on the MORS TT301 with dunking transducer but not consistently enough to observe any mooring rising. When examined in the laboratory the hardware was in good condition, only minor 'corrosion' was observed on the cage bars around the acoustic transducer. This appeared to be crevice type although not significant in its extent and being on only the four non-load-bearing bars which tends to suggest that they are of a different material to the two load bearers which were unaffected. The units were not opened on recovery and further inspection would be desirable to examine sealing faces and grooves and the release drive shaft which actuates the release mechanism.

MORS recommendations

The MORS system as used functions well enough to give confidence in the long term ability of these units. Further investigation into corrosion is required at the transducer cage and as suggested above the units require disassembly and checking before next use.

Portable IOSDL double barrel mooring winch

The winch system was fitted in Gibraltar and required final connections and checking in Cape Town before sailing. It was found that the siting of the storage winches was incorrect as the hydraulic hoses did not connect to the power pack. This was easily rectified using the ship's crane to move them on the deck matrix.

The winch was fitted out for this cold climate voyage with thick thermal insulation around the hydraulic oil reservoir and has a thermostatically controlled heater fitted within this reservoir to keep the oil temperature above 20°C. This was to prevent the high starting currents required with cold thick oil.

The 240 volts AC supply required by the heater was routed overhead to the hangar where it was supplied from the 'dirty' ship's supply. Other than one occasion when the heater was inadvertently switched off, this system functioned well and no starting problems were encountered.

Further trials were carried out on passage to Mauritius to investigate the winch performance in this form with higher air temperatures of 22°C and with the winch exposed to direct sunlight. By running the winch with rotating barrels for 1 hour with no cooling, the hydraulic oil was heated to 56°C. Cooling is achieved using an oil cooler on the motor return line, supplied with sea water from the non toxic supply. With this turned on for 15 minutes the oil temperature was reduced to 35°C and maintained this temperature for a further hour when the test was concluded satisfactorily.

A new design of drive shaft was produced at IOSDL which enabled wooden mooring line drums to be fitted into the auxiliary winches when recovering moorings. Two of these shafts were used and the time saved by not having to transfer from the steel drums as on previous cruises was significant. Care is required that the back tension is not set too high as damage can be done to the centres of the drums with overtight lines.

Recommendations

Overall the winch system performed well and the recent modifications have improved its performance and made for a more flexible system.

However the supply to the heater needs to be connected from the three phase main supply as the routing of 240 volt unarmoured cable along overhead lines is not advised, particularly as the route is over the main hatch which could restrict crane operations.

Changing over storage winches involves disconnecting hoses which can be pressurised and small quantities of oil inevitably drip on the deck. It would be better to fit a simple manifold with valves such that the pipes can remain connected.

The hydraulic hoses to the storage winches are not long enough to allow the winches to be best sited. Longer hoses with adequate protective deck channel are required.

The davit supplied for the storage winches will only fit onto one unit, this needs to be re-engineered such that cranes are not required to lift out the drums.

Equipment Losses

MOORING 9308	MAFF	RCM5: 397 and 743 RCM8: 980	RT661 71
MOORING 9314	MAFF	RCM5: 611 and 234 RCM8: 436	CR200 2348
	IOSDL	RCM7/8: 9969, 10113, 10854 and 10855	CR200 2401
MOORING 9311	MAFF	RCM8: 942	CR200 2345
	IOSDL		CR200 2402

JWR, IW

Current meter results

Processing of results

All the meters recovered on this cruise were processed on board using software developed from that in use on the VAX Mini Computer at MAFF, Fisheries Laboratory, Lowestoft. The software was specifically designed to run on Apricot PCs.

The data were processed through various stages to give a clean and corrected version in what is referred to as the CM4 file. This contains u and v values and other parameters — usually temperature, and occasionally pressure or conductivity. Beyond the CM4 stage data were run through a filter program HILOW to remove the tidal component from the data. A file of the filtered results was created.

The data in the CM4 file were then processed through program QMSY which produces a numerical matrix of speed vs. direction and tabulates the data from additional sensors. This is useful in detecting spurious data points so that they can be corrected by interpolation The computer file from this programme contains u, v, speed, direction together with data from additional sensors.

Finally the data were plotted as a series of standard A4 plots showing histograms, time-series, progressive vector diagrams and spectral energy plots, for both filtered and unfiltered data.

Not all the records were the full expected length and a few (seven) were shortened because of poor data quality, usually during the second half of the record. On return to the UK these records will be closely examined to see if a greater length of good data may be obtained — perhaps by processing in two or more parts — if the bad data does not extend to the end of the record.

Data Processing Comments

In the CM3 module second stage the following was found :

> The 'AMEND' command is case dependant, i.e. 'amend' is OK but not 'AMEND'
>
> 'amend n1 to nz' deletes lines n1 to the one before nz but not line nz which is what seems to be implied in the instructions.
>
> The editing facility did not work, or the instructions are not clear. We edited the CM3 file using Norton Editor after running QMSY to identify any spurious values. Norton Editor seemed deficient since it was not apparently possible to search by columns.

In the VECPLOT module we noted the following:

> \currents\hilow\stick - despite communication with MAFF the option to plot stick plots of filtered data could not be made to work. This will have to be followed up on return to the UK.
>
> Sometimes when plotting the unfiltered data the automatically set axis values would default to the same as the minimum value of the data. This resulted in the plot file not being created. We learned to cope with this by checking as we went along. Some work needs to be done to remedy this.

In the final plotted histograms we noted:

that for RCM7 and 8 meters there was a noticeable dip in the plot at around 12 cm s^{-1}. It was more pronounced in some records than others, but was always present to some extent. Enquiries made of Lowestoft revealed that this feature was already known and was a function of the binning which means that a few 'bins' have only one bit value allocated to them. The dip which we noticed was one of these 'bins'. Discussions will take place, at a later date, to see whether a smoother binning arrangement might be appropriate for future processing.

Data Return (provisonal)

The Table below shows the overall rate of good data return for the two arrays — Crozet to Kerguelen (including one station west of Crozet) and the Princess Elizabeth Trough.

CROZET Is. to KERGUELEN

Meters deployed = 44 recovered = 33

Days good data expected = 15922 days actual good data = 10010

% return of good data = 63%

PRINCESS ELIZABETH TROUGH

Meters deployed = 13 recovered = 13

Days good data expected = 4960 days actual good data = 3715

% return of good data = 75%

Table 3 gives details of each mooring deployed and shows the provisional data return from each of the meters used.

Taking both arrays together the overall provisional good data return is 66%

SRJ, JC

Bottom pressure recorders

Recovery of the two bottom pressure recorders (BPRs) which had been deployed at either end of the Crozet-Kerguelen section was attempted during *DISCOVERY 207*. The positions of the BPRs were chosen to monitor variations in the baratropic transport through the section and to compare with values derived from the MAFF current meter array and similar measurements made by satellite altimeters. The locations are illustrated in Figure 8(c) and designated mooring positions 9307 and 9316 respectively.

The instruments are self contained units which measure pressure at the seabed induced by changes in surface level. Recovery is achieved by transmitting an acoustic command which initiates the release of a ballast frame allowing the positively buoyant main unit to rise to the surface. One of our aims was to test newly acquired Benthos acoustics to determine their suitability for this work. Each instrument was fitted with a well proven CR200 release as backup. The mechanical and electronic details of the instruments are outlined in the report 'RRS Discovery Cruise 200' and therefore not repeated here.

Acoustic Recovery Equipment

The Benthos acoustic system is a transponding release designed to give a slant range between the ship and the seabed XT6000 acoustic module. The information derived can therefore provide a heading for the ship during recovery. The Nagrafax tracking display can be connected to the Benthos deck unit to enable monitoring of the BPR as it rises to the surface. The XT6000 is not fitted with a repetitive pinger but this effect may be simulated by transponding at a fixed interval.

The CR200 operates a repetitive pinger which can be monitored on the Simrad EA500 echo sounder and on the IOS Waterfall display. The use of this method is particularly beneficial as an aid to recovery since it can be plainly seen when a mooring has released due to the sloping nature of the display.

BPR recovery at Mooring 9316

The ship hove-to at 1212Z on 3 March (day 062) and the Benthos overside transducer was deployed. Exploratory transmissions were made to establish contact and a series of reasonable slant ranges appeared in response.

At 1214Z, the release command was activated and the deck unit was set to transpond at ten second intervals. The Nagrafax display and the slant range display were both monitored for signs of the BPR being released. This was soon confirmed with a sloping trace display and a decreasing slant range.

With the knowledge that the Benthos release had fired first time, the CR200 pinger was activated to fire the secondary pyro-release. Activating the CR200 also enabled the Simrad and Waterfall display to be used to determine when the instrument had reached the surface.

The BPR was spotted on the surface at 1328Z and was recovered using the CTD A frame and the Rexroth winch. The rig was stored in the water bottle annex for dismantling.

BPR recovery attempt at Mooring 9307

An attempt was made to recover this mooring after arriving on station at 0805Z 8 March (day 067). Initial acoustic interrogation of the rig took place using the Benthos acoustic release system, but this failed to produce a sensible value for slant range. With this lack of success, the CR200 system was employed.

When repeated transmission attempts to the CR200 pinger failed to produce any sort of response, it was decided to begin a search pattern. Waypoints for the search were chosen 1 mile north, east, south and west of the deployment site using the GPS navigation system. At these positions the ship hove-to and both the CR200 and Benthos systems were tried.

After two hours of searching and repetitive transmissions to both types of acoustic releases, the ship headed east towards mooring 9306. All along the track to mooring 9306, transmissions were made to the CR200 release but no response was received.

Once the recovery of mooring 9306 had been successfully completed, the ship steamed west and passed over the site of mooring 9307 on its way to a CTD station. Continuous transmission attempts were maintained using the CR200 system, but again no response was obtained. Eventually the transmissions were halted at 1300Z.

A second attempt was made to recover the BPR at mooring 9307 on the northward bound leg of the cruise at 0821Z on 20 March (day 079). The ship slowed to four knots a few miles from the mooring and a signal was transmitted to the CR200.

Transmissions were made to release the instrument and not to activate the repetitive pinger. It was hoped that if the pinger battery was discharged, the main unit would still activate the release mechanism.

At 0855Z the ship hove-to at the waypoint for the mooring and preparations were made to perform a CTD. Alternate release transmissions were made to the CR200 and the Benthos system during the entire CTD deployment. There was no response. At 1126Z, acoustic transmission ceased and a visual search was initiated around the waypoint. This did not prove fruitful, and the BPR was assumed lost due to an unexplained failure.

IMV, GWH

Bottom pressure recorder data

Of the two instruments deployed during *DISCOVERY 200* across the Crozet-Kerguelen section only Instrument No. 2 from the West side was recovered. Instrument No. 1 was not located.

INSTRUMENT No. 2 : Data Processing

Raw data from RDC logger was transferred via floppy disk to Discovery Unix system

Calibrations were applied to convert the raw data into temperatures (degrees C) and pressures (mBar). Subsequently data sample rate was reduced to hourly and instrumental drift removed.

Tidal analyses were performed on the hourly data and the non-tidal residuals formed.

Low frequency signals were generated with a filter whose pass band was below the diurnal tides.

Spectral analyses were performed on the hourly series and the low frequency series.

FILES:

All files have the prefix /nerc/packages/pstar/users/imv/bprdata/

ck293raw.dat	Raw data from RDC logger
ck293rawc.dat	Reformatted raw data
ck293p4h.dat	Data in deg C and mBar. 15 minute samples Begins 1993 Day 68 18.375Z Ends 1994 Day 62 12.125Z
ck293ph.dat	Data sample rate reduced to hourly values
ck293df.dat	Data with instrumental drift removed.
ck293lf.dat	Low frequency data with a pass band below 1 cpd. Sampling interval 1 hour
ck293lf2.dat	Low frequency data as above but sampled at 12 hourly intervals.
ck293r8.dat	Non-tidal residuals as a result of tidal analyses
ck293r10.dat	

PROGRAMS:

refrdclogger.f	Reformats raw RDC logger data
ptrtgp.f	Applies calibration data to raw data. Calibrations are in the file croker293.ctl
filt5.f	Filter program. Control data in filt5.ctl Filter flp03b used for sample rate reduction of 15 minute to hourly data. flp20 used to generate low frequency time series cut-off frequency at 1cpd.
zfilth.f	Drift removal program
tira.f	Tidal analysis program
spectrad.f	Spectral analysis program.

IMV

ADCP

The ADCP was a RDI 150 kHz unit, hull-mounted approximately 2 m to port of the keel of the ship and 33 m aft of the bow at the waterline. For most of the cruise the instrument was used in water tracking mode, recording 2 minute averaged data in 64 x 8 m bins down to 512 m. Several hours after departing Cape Town the ADCP was calibrated whilst within bottom track range. In this mode the data was collected in 50 x 4 m bins down to 200 m, with both the water motion and sea bottom being tracked. To determine the error introduced into the data from the ship's gyro a zigzag calibration run was carried out on 22 February day 53 on the southward leg whilst sea conditions were favourable.

The underway processing of the data was carried out in five stages. In summary, the first stage was to read in a certain time period of data and convert it to the appropriate format. The second corrected for the error introduced by the PC clock drift. The third performed editing and nominal calibration on the data. The fourth plotted out the velocity relative to a reference layer (in this case bins 20 - 30), compared the ADCP and navigation velocities and gave a pseudo vector plot of error and vertical velocities. Finally, the data was merged with smoothed navigation and absolute velocities derived.

A new processing protocol was adhered to on this cruise — separating the 'on station' and 'underway' data at an early stage. From this (as would be expected) the data could be seen to be of a higher standard whilst on station. The quality of the data for most of the cruise was good, with penetration as deep as 450 m the norm. The exception, as per the deployment cruise (*DISCOVERY 200*), was along the Kerguelen plateau, especially on the northward leg in heavy weather.

Before a complete assessment of the data can be made gyro offset errors derived from the Ashtec system need to be applied and the data thoroughly screened.

MDS, JB

Support services and routine environmental monitoring

Expendable Bathythermographs (XBTs) (Figure 9)

XBTs for the cruise were supplied by the Hydrographic Department, Ministry of Defence and MAFF, Directorate of Fisheries Research. A total of 16 boxes of T7s (750 m) and 7 boxes of T5s (1830 m) were available for use. The Hydrographic Department supplied the Bathy Systems SA810 controller and deck unit which were already on board located in the plot room. The SA810 was installed with the Bathy Systems XBT Program version 1.1. The probes were deployed from the RVS Sippican hand launcher from the port or starboard stern, or outside the Bosun's workshop on the port side if the weather conditions were bad. On several occasions, deployment of XBTs was suspended when weather conditions made venturing out onto the afterdeck too dangerous.

Several problems were encountered as the PC unit for the SA810 gradually failed. Before sailing, the lithium back-up battery in the PC failed so the setup configuration for the PC was lost. While waiting to receive the relevant information from Taunton via RVS, the 'A' drive of the PC failed so data which were to be recorded on the hard disk would not be retrievable. A replacement PC was found and the Bathy System program installed from a diskette. The replacement PC had earlier trouble with its hard disk, so the data were written to the 'A' drive. Mid-way through the cruise, the original Zenith PC monitor began to deteriorate rapidly and a replacement monitor was fitted.

Boxes of XBTs were stored in the hold but brought up to the water bottle annex one box at a time to allow the probes to cool prior to launching. This prevented failure due to thermal shock, which occurs if warm probes are launched into very cold water. The hand launcher is connected to the deck unit via a wire which runs onto the deck from the Bosun's workshop. The launcher was left in a plastic bag in the covered area of the afterdeck between launches.

Once the deck unit was functional XBTs were deployed every 4 hours after leaving the continental shelf. The ship was slowed to half speed (7 knots) for the deployment of T5s to allow sufficient wire to spool from the cannister to reach the 1830 m depth. All the deployment times and corrected GPS positions are given in Table 4.

After each XBT launch the profile was used to generate an IGOSS format BATHY message consisting of some header information and a list of inflection points. The software generates an incorrect bottom temperature-depth pair with a temperature of zero, so these were edited out before transmission. The messages were transmitted to Bracknell via the GOES satellite and inserted onto the Global Telecommunications System (GTS). RVS informed us the messages were not being transmitted properly; even after the correct ending to the call sign (GLNE=) was typed in, many remained garbled. For a short period 12-16 March (Day 71-75) the buffer was permanently full, preventing transmission of data. It is possible the position of the ship was outside the footprint of GOES. The PC clock slowly lost time so both the PC clock and the transmitter clock were re-set daily.

A total of 160 XBTs were deployed resulting in 143 good profiles. Of the probes that failed, most (11) gave traces that began at a spuriously low temperature (usually less that 0°C). Some of the T5s gave very spikey profiles, with the profile not recovering below large spikes. On one occasion a petrel flew into the spooling wire, but both the bird and the profile were unharmed.

The data were extracted from the PC daily and read onto the RVS Level A. Each profile was converted to Pstar format and edited to remove spikes and spurious top and bottom data. Profile plots and contoured sections were generated. All the data were mailed in the original format with accompanying documentation to the Hydrographic Office in Taunton.

T5 XBTs were deployed every half a degree of latitude south along the Kerguelen Plateau to the Princess Elizabeth Trough. The profiles were gridded and a contoured section of temperature generated. Geostrophic transport was calculated using the Pstar program 'pgeost' and an assumed constant salinity value of 34. The resulting geostrophic velocities were contoured and fronts at

64°S and 58°S were clearly visible; these are thought to be the South Polar Front and Polar Front respectively. The use of constant salinity in the calculations means the velocities and total transport values are not reliable, but it allowed us to identify where to deploy further T5s on the northward leg to improve the dataset which will be used for more accurate analysis of these fronts.

NPH, MDS

Thermosalinograph (TSG)

Surface salinity and temperature were continuously measured by a Falmouth Scientific shipboard mounted TSG located in the hangar. Bottle samples for salinity calibration were taken from an outflow pipe from the TSG every hour by the watchkeepers. The TSG records the temperature and conductivity of the non-toxic seawater supply which is drawn in 5 m below the surface and piped up to a header tank located opposite the winch control room at the hangar deck-head level. The header tank was maintained at a constant level by adjustable intake and outflow taps and provided an even flow for the TSG. The watchkeepers checked the header tank at regular intervals.

The TSG has an Ocean Conductivity Module (OCM) and two Ocean Temperature Modules (OTM); one fitted within the flow-through sensor holder (housing temperature) and another on the suction side of the non-toxic intake (remote temperature). The housing temperature is used in the determination of salinity. Data are passed from the OCM and OTMs via an RS-485 data interface to a Viglen 386sx 25 MHz personal computer where they are formatted and passed to Level B at 5 Hz. The program used is 'surflog' and the output to the screen (the last 3.27 hours of data as line graphs) was monitored by the watchkeepers in case of interruptions in the logging of data. Data were converted into Pstar format daily and an averaged file generated and merged with bestnav data. Plots of uncalibrated temperature and salinity against latitude were generated and provided a good indication of the position of fronts.

At 1100Z on 24 February (Day 055) the OCM was replaced by a spare sensor because the readings were very noisy due to a loose sensor head. The new OCM had less noise but immediately began logging conductivity which gave a salinity of around 6 units below the true value. This offset was eliminated in the final data by the calibration described below. Even with the calibration, the data from the new sensor for the first day or so may be somewhat unreliable during a settling in period.

To calibrate the TSG salinity, the bottle salinities were merged with the TSG 2 minute averaged data and the bottle samples' conductivities recalculated using the housing temperature. A linear least squares fit regression produced A1 and B1 coefficients for the equation

$$\text{botcond} = \text{A1} + \text{B1tsgcond}$$

The TSG conductivities were corrected with the coefficients, the TSG salinities recalculated, and the difference between the calibrated salinities and the bottles salinities calculated. The data for JDays 50-55, while the first sensor was in place, were calibrated separately. The mean difference after calibration was 0.000246 and the standard deviation **0.0217**. For the remaining days the mean difference after calibration was -0.00496 and the standard deviation **0.0242**.

The remote temperature was calibrated using temperature data from the CTD casts (2 db files). The TSG 2 minute averaged data were merged with the CTD temperature at 5 db and a linear least squares fit regression produced A1 and B1 coefficients for the equation

$$\text{CTDtemp} = \text{A1} + \text{B1tsgtemp\_m}$$

The TSG temperatures were corrected with the coefficients and the difference between the calibrated temperature and the CTD temperatures calculated. The mean difference was 0.198 degrees C and the standard deviation was 0.0094.

NPH, AR, SFJW

Satellite imagery and sea ice intelligence

Satellite imagery

(a) Equipment and purpose
Real time satellite imagery of the sea surface was provided on *DISCOVERY 207* by a Dartcom Macsat receiver and antenna, together with Macsat software installed on a Macintosh IIcx PC. Macsat is a commercially available package distributed by Newcastle Computer Services. This equipment was used to receive images from the NOAA series of satellites (NOAA 10, 11 and 12) which transmit on 137.50 and 137.62 MHz.

The Macsat antenna and pre-amp were mounted on the starboard side of the bridge top on a stainless steel tube (16 swg wall thickness, 1.5 inch outside diameter) clamped to the bridge railings, in a site chosen for the clearest view of the sky possible given restrictions offered by existing bridge top fittings. Consideration also had to be given to possible interference from a number of ship's radio aerials. Cabling on the bridge top was secured to the rails and routed to the junction box above the bridge.

This was the first occasion on which we have used the new marine version of the Macsat antenna at sea (a helical antenna enclosed in a fibre glass radome). Initial concern that extra windage presented by the radome might cause problems in high winds proved unfounded. Although the dome was seen to vibrate considerably under moderate to high wind conditions, the mounting proved adequate for the job. Without a direct intercomparison it is difficult to assess how the reception performance of this antenna compares with that of its predecessor, but our initial impressions are that it shows an improvement.

The receiver, controller and associated Macintosh PC were located in the scientific plot, with cabling routed through the junction box in the main lab. Because of software problems (see later) the PC was not networked to the RVS system.

(b) Results
Infra-red and visual images were routinely received and stored 2-3 times per day, and subsequently geolocated and analysed. In the area in which the large part of the cruise was carried out, cloudy conditions predominated making it difficult to receive clear images of the sea surface. Although we received few images exhibiting clear sea surface temperature fronts, a number of clear images of the ice edge in the vicinity of the Princess Elizabeth Trough were acquired. We were thus able to confirm that there was no significant ice coverage in our working areas. Good images (all infra-red) were stored on the PC hard disk and backed up onto floppy disks.

(c) Problems
On arrival at Cape Town we encountered severe problems with the Macintosh PC, which began to crash out of applications. Fortunately we were able to call in an Apple Macintosh computer technician to deal with the fault, which appeared to be a combination of old system software and a dirty disk drive. Although the problem was in part solved, the Macintosh could not be subsequently

networked, and any hardcopy, or transfer of images to the RVS computer system had to be made through floppy disk.

Initial reception problems were also experienced through poor terminations on the cabling. These were corrected in Cape Town with the help of the Radio Officer, David Stewart. We also encountered subsequent intermittent trouble with local interference at 137.62 MHz only. We were unable to locate the cause of the noise, but after a bridge top survey, carried out with the less cumbersome radial antenna, a lower noise site was identified. Unfortunately, relocation to this site did not completely solve the problem, which continued intermittently throughout the cruise. It would be helpful in future if it were possible to carry out a proper survey and identify the true cause of such interference.

The Macsat software package is on the whole easy to install and use with adequate image processing capabilties. There are, however, a number of improvements that we recommend be made to the software. The geolocation and fixing software suffers from two defects. Firstly the land outline that may be used to accurately fix an image is of too coarse a resolution to be of much use. On a number of occasions we were presented with a coastline overlayed on an image that had as few as two or three turning points, and exhibited only vague resemblance to the actual coastline. In addition the coastal outline is only drawn to the last turning point within the displayed image, so that it does not continue up to the edges of the image. A second and fundamental fault is that the overlay facility draws lines of latitude on ascending passes only.

A useful added option would be the ability to store received images in postscipt format.

Sea Ice

Sea ice information was required for two purposes:

> To enable an early and continued assessment of the possible impact of sea-ice conditions on the mooring recovery operations in the Princess Elizabeth Trough,
>
> and to provide the Master with all available sea ice intelligence whilst the *DISCOVERY* was travelling at high latitudes within the Southern Ocean.

The three sources used (in addition to Macsat) are briefly described below.

US Navy/NOAA Joint Ice Centre (Washington, USA)
The US Navy/NOAA Joint Ice Center routinely prepare two summary charts of sea-ice conditions per week, plus an ice edge forecast. This information is compiled mostly from infra-red, visual, and passive microwave satellite data, and is available on fax through an autopolling facility. These charts were acquired twice weekly by colleagues at the James Rennell Centre in Southampton and forwarded to the *DISCOVERY*. Though of a fairly low resolution, the information from this source is reliable and authoritative.

European Systems (ESYS) and Mullard Space Science Laboratories (MSSL)
In a trial project ESYS/MSSL provided us with sea ice information for 30-90°E, 60-70°S, compiled twice weekly from passive microwave (SSM/I) and ERS-1 altimeter data. These data were provided to us free of charge on the understanding a full assessment of their product would be provided at the end of the cruise — a report will be written seperately to this brief note. Their information proved consistent with and complementary to that acquired from US Navy/NOAA. They could

perhaps gain an advantage over the US Navy/NOAA information by providing data at a higher resolution over a more limited area. Their stated intention to provide iceberg information would certainly be of great benefit to those navigating in the Southern Ocean.

Australian Bureau of Meteorology

At the Antarctic research station Casey, the Australian of Bureau of Meteorlogy operate a ground station which is capable of receiving HRPT (High Resolution Picture Transmissions) images transmitted by the NOAA satellites. They were therefore contacted before the beginning of the cruise to establish whether they would be able to provide us with high resolution ice data, and they kindly agreed to help us. We were thus provided with early detailed information on conditions in the Princess Elizabeth Trough and off the West Ice Shelf, and this information enabled us to be confident that all the mooring sites were free of ice. Unfortunately, due to cloudy conditions in that area during the cruise they were subsequently only able to update their information on a few occasions. Nonetheless their data were of great value. The help of Neil Adams and colleagues from the Australian Bureau of Meteorology is gratefully acknowledged.

Summary

Icebergs were first sited on 25 February (day 056) at 48.1°S, 43.5°E, and subsequently on the 27th (day 058) at 44.1°S, 49.5°E. Little further ice was seen once the *DISCOVERY* had moved further to the east, until we moved into the Princess Elizabeth Trough region. The edge of loose pack was encountered on 12 March (day 071) at 66° 02.5S, 84° 73.5 E. The last iceberg was sighted on 15 March (day 074) at 62.3°S, 81.0°E.

Together with data from Macsat the above sources of information provided us with the best possible sea-ice intelligence, and we would recommend the use of all these forms of data. I would like to acknowledge the help of Carl Davies and Helen Snaith at the James Rennell Centre, Southampton, for forwarding ice information to the *DISCOVERY*.

PDC

Meteorological Measurements

Equipment

The meteorological monitoring system on *RRS DISCOVERY* for cruise 207 comprised the following instruments:

Wind Speed and Direction:

1 RM Young Instruments Type 05103 wind velocity propellor vane sensor, located on the port side of the foremast. Serial number 11277 (replaced by 11276 during the cruise) (RVS)

1 Gill sonic anemometer (serial number 0038) located on the starboard side of the foremast. Data from this instrument was logged and processed on a dedicated NEC PC in the main lab (IOSDL).

Wet and Dry Bulb Temperatures:

2 vector instrument psychrometers, located to starboard on the foremast. Serial numbers 1072 and 1060, (1072 was replaced by 1065 during the cruise) (IOSDL)

Radiation Sensors:

2 Didcot cosine collector PAR sensors, located port and starboard on the foremast. Serial numbers DRP-1G 0151 and DRP-1G 0150, (RVS)

2 Kipp and Zonen Total Irradiance sensors, located port and starboard on the foremast. Serial number 920215 and 920216 (RVS)
1 Eppley Longwave pyrogeometer located on the foremast top pole. Serial number EP26207F3 (IOSDL)

Sea Temperature:
1 hull mounted platinum resistance thermometer (RVS)

Atmospheric Pressure:
1 Vaisala DPA21 aneroid barometer (RVS).

Significant Wave Height:
1 Mark 2 Ship Borne Wave Recorder (IOSDL). After initial processing on the electronics unit in the main lab, data was logged directly to a NEC PC.

Data Processing
With the exception of the Ship Borne Wave Recorder (SBWR) and the sonic anemometer, data from all instruments were logged through the metlogger PC and then transmitted to the ship system's level B. Data were transferred daily to level C, and then worked up using a suite of pexec scripts to provide a final set of calibrated data. The SBWR and sonic anemometer data were processed on two dedicated NEC PCs in the main lab. Data from these instruments were regularly backed up onto a tape device and optical disk respectively.

Logging of Multimet data commenced shortly after departure from Cape Town (05:19 on day 51), and ceased on the day before arrival in Port Louis, Mauritius (24:00 on day 88). On the whole the weather was remarkably kind, with wind speeds topping 20 m s^{-1} on only a few occasions. Maximum (20 minute average) significant wave heights of 8.4 m were recorded. Air and sea temperatures ranged from below 0°C to 24°C (note that the sea surface temperature thermometer is only calibrated between +5 and +25°C).

It is worth noting that the bridge officers often recorded higher wind speeds than were seen in the calibrated multimet data (by up to 10 knots). This is probably a consequence of the different locations of the bridge and multimet anemometers. The Young anemometer is located high on the foremast, and should therefore be minimally influenced by the ship's structure (unless the wind is blowing from aft). However, the bridge anemometer is placed on the forward bridge top rail and must be considerably affected by turbulence generated as airflow is deflected over the superstructure

Problems

Data Processing
It became apparent on the first day at sea, 20 February (day 051), that the RVS metloggr data file did not contain the appropriate variables for the instrumentation now fitted. This fault was rectified as soon as it was noticed.

Young Anemometer
Intermittent gaps in data from this instrument recurred throughout the cruise, culminating in a near three day loss of data on 25-27 March (days 084-086). The fault was an elusive one and has still not

been tracked down satisfactorily. Attempts to cure it involved replacement of the wind vane and propellor, and replacement of the wiring between the anemometer and the foremast electronics unit. No wind speed calibrations were available for the replacement anemometer, so we continued to apply the original calibrations.

Starboard psychrometer
This instrument began to display noisy dry bulb temperatures during the cruise, and was replaced by the spare on 14 March (day 073).

On 22 March (day 081) the protective 'top hat' of this instrument, together with its mounting, was blown off onto the boat deck. This top hat is mounted on top of an assembly which is in turn fastened to the psychrometer body by three small grub screws. Whilst replacing this mounting, it was clear that the threads on the psychrometer that accept the grub screws had been completely stripped. Without recourse to more secure fittings the screws were inserted into the (now bare) holes and self amalgamating tape was employed to provide some protection. Somewhat surprisingly this fix held out until the end of the cruise.

Ship Borne Wave Recorder
Documentation from RVS indicated that the outgoing connections on the back of the SBWR electronics unit were incorrect, leading to only the ship 'heave' being recorded. After consultation with IOSDL it was decided to remake the connection on 27 February (day 058). Subsequent analysis of data indicated that the original connections were indeed incorrect, and that the correct data were now being recorded.

PDC, SFJW

Navigation

GPS Trimble, GPS Ashtech, Ship's Gyro, bestnav

gps_trim (lat, lon, hdg, hvel, pop, svc, s1, s2, s3, s4, s5)
gps_ash (sec, lat, lon, hdg, pitch, roll, mrms, brms, attf)
gyro (heading)
bestnav (lat, lon, vn, ve, cmg, smg, dist_run, heading)

gps_trim data were read in 10 second intervals; gps_ash and gyro were copied in 10 second intervals; bestnav was copied in the 30 second intervals. At the end of the cruise 1 second data for Ashtech and gyro were read but not processed. GPS coverage from satellites was good, with data for around 85% of the cruise.

Ashtech level B errors

Some errors displayed on the level B terminal during logging were common (a few times every day), but caused no problems:
Reset with errno=221 on process (0)
Value 666 of HDG greater than limit 360
Value X of HDG has not changed for 20 seconds
One error stopped the level B logging, resulting in 6 hours loss of data
Reset with errno=3 on process (0)

Ashtech processing

Ashtech data were merged with the gyro each day. We used the following limits for good data:

- merge with gyro data
- calculate difference between Ashtech and gyro headings (a-ghdg)
- pick out bad data; good data qualified as:
  hdg 0 - 360
  pitch -3 3
  roll -5 5
  attf -0.5 0.5
  mrms 0.00001 0.01
  brms 0.00001 0.001
  a-ghdg -5 5
- median despike, with changes in pitch +-20, roll +-12 and a-ghdg +-6 discarded
- take 2 minute time average
- calculate speed and direction from position

Additionally, data were sorted by heading and averaged into 10 degree cells.

File System	kBytes	Mounted on
discovery2:/nerc/packages/pstar	225888	/nerc/packages/pstar
discovery2:/nerc/packages/pstar/data	829843	/nerc/packages/pstar/data
discovery2:/nerc/packages/pstar/users	169999	/nerc/packages/pstar/users
discovery2:/nerc/packages/pstar/archive	340015	/nerc/packages/pstar/archive
discovery3:/data3	316693	/data3
discovery3:/data4	317469	/data4
discovery4:/data	316693	/data5

Data Processing

Discovery1 (Level C)
Sun SPARCstation IPC
Hard Disks:
200Mb Internal
2800Mb HAMCOM External
Floppy disk: 3.5" 1.44Mb/720K PC or Unix format.
Tape Units:
150Mb Sun Quarter Inch Cartridge (QIC) drive
Resolv Exabyte 8mm drive
Sun CD-ROM drive.

Discovery2
Sun SPARCstation IPC
Hard Disks:
200Mb Internal
311Mb External
1340Mb External
Floppy disk: 3.5" 1.44Mb/720K PC or Unix format.

Tape Unit:
    150Mb Sun Quarter Inch Cartridge (QIC) drive
Single-sided magneto-optical disk drive.

Discovery3
Sun SPARCstation 1
Hard Disks:
    317Mb External
    317Mb External
Floppy disk: 3.5" 1.44Mb/720K PC or Unix format.

Discovery4
Sun SPARCstation 1
Hard Disks:
    317Mb External
No floppy disk.

Total Hard disk space on network: 5.8Gb

Output Devices (permanently on ship)
NEC Pinwriter P5 (Wide carriage dot matrix printer)
Hewlett-Packard Laserjet III with Turboscript Postscript cartridge
Tektronix 4693RGB Wax Transfer Screen Dump Plotter
Nicolet-Zeta A0 Drum plotter
Advance-Bryans Colourwriter A3/A4 HPGL flat-bed plotter

Level B - Custom built fault-tolerant data logger, comprising:
Philips PG2111 Single board computer featuring:
    68030 25Mhz CPU with 68882 Floating-point Co-processor
    4Mb RAM
    1Mb ROM
    4 Serial ports
    1 Parrallel port
    SCSI port
Mirrored 150Mb SCSI Hard disks
150Mb Viper QIC tape drives x 2
Radstone PME-SIO4 Intelligent Serial Cards x 2 featuring:
    68020 12.5Mhz CPU
    1Mb RAM
    128K ROM
    8 x 68681 DUART giving a total of 16 serial ports per card.
Thus up to thirty-two Level A's can be connected to a single Level B.

Level A computers.
There were three types of Level A used during cruise 207.
Mk 1 Level A based on an RVS designed board utilising an Intel 8085 processor.

WAVE	Wave height recorder
MX1107	Magnavox MX1107 transit sattelite navigator
BOTTLES	CTD Bottle firing time logger

Mk II Level A based on the Syntel CP-68 board using a Motorola 68000 processor.

GYRO_RVS	Ships gyro
GPS_TRIM	Trimble GPS Surveyor
LOG_CHF	Chernikeeff log
SIM500	Simrad EA-500 Hydrographic Echosounder
GPS_ASH	Ashtek Differential GPS Receiver
GASANY	PCO2 logger

PC Based Level A's

SURFLOG	Thermosalinograph, fluorometer, transmissometer
METLOGGR	Wind speed/direction, wet/dry temperature, barometric pressure, long wave radiation, port/starboard light sensors.
WINCH	Seametrix winch monitoring system.

MK II CTD Level A based on a Level B processor board

CTDR17D1	IOS 17byte CTD

RVS computing system

1. Level A computers

Currently there are four different types of Level A computer in service on RRS Discovery.

The Mk I Level A which contains RVS designed circuit boards and uses an Intel 8085 processor. These systems use the C-EXEC operating system.

The Mk II Level A which contains a *Syntel CP-68* single board computer using a Motorola 68000 processor. The Mk II Level A software runs under the *Microware OS-9/68K* operating system.

The MK II CTD Level A which contains an *MVME-147S* single board computer using a Motorola 68030 processor, with a 68882 floating point coprocessor. The software on this system is virtually identical to that of the standard Mk II Level A.

IBM PC based Level As are becoming more common. The only requirement for their software, is that it send out SMP (Ship Message Protocol) over a serial or ethernet link, and if possible it should keep its clock synchronised to the main Radiocode clock.

2. The Level B computer

This computer can be connected to up to thirty-two Level A computers via RS-232 links, and more if ethernet based Level A computers are used. It forms the first backup in the system, since all data is written to RAM disk, then to both of the 150Mb hard disks, then, if one is available, a 150Mb tape cartridge. The standard procedure is that there is a cartridge in both tape drives, so that if a problem occurs with one tape drive, writing can continue on the other. Tapes have to contain a special pattern of characters before the Level B will write to them, this is to guard against the accidental overwriting of data from the current cruise. If no valid tape is found, data is backed up on the Level B until it recognises a valid drive. During this cruise 15 tapes were used.

All data is passed on via ethernet to the Level C system. A similar backup system is used for the ethernet link. If the Level C system crashes for some reason, data is stored on the Level B for transmission once the Level C is operating again.

The Level B also acts as a warning system, with a terminal in both the computer room and the main lab which shows which instruments are currently sending data, and will flag in red instruments that have recently stopped sending data, or which have generated alarms. The terminals also display information about the health of the Level B, its disks, tapes and whether the ethernet link is running or not, together with the size of any data backed up for transmission or writing to tape.

3. Level C Computers

There is a network of four *Sun SPARCstation* computers (two *SPARCstation IPC* and two *SPARCstation 1* machines). The *discovery1* machine actually receives the data from the Level B and ADCP machines, parses it, and stores it on a local hard disc, but the data is available to each of the four machines on the network.

In the same way as the data is available to each machine over the network, so are the various output devices (with the exception of the wax transfer printer). Theses device comprise the *NEC Pinwriter P5* (wide carriage dot matrix printer), the *Hewlett Packard LaserJet III*, the *Advance-Bryans Colourwriter* (A3/A4 flatbed plotter), and the *Nicolet-Zeta 836* (A0 8 colour drum plotter).

The *Tektronix 4693 RGB* wax transfer screen dump plotter is connected to *discovery1* and *discovery3* by fibre optic link. A box near each of the computers intercepts the red, green, blue, and sync signals going to the monitor, and when required sends this data to the printer to produce an exact copy of what is on the screen.

Processing

The Mk II GPS Level A regularly sent data with either backwards going times, or duplicate times. One day it sent eleven successive records with the same time. The *gps_av* and *bestnav* programs which are used to process this data either hang or crash when they encounter these bad times, so much work was done to manually patch the times so that they looked a little more correct. Once this was done for a section of data, this section could be processed.

Once the navigation was processed, depth data from the *Simrad EA-500* echo sounder could be corrected for Carter area.

Approximately 160 XBT profiles were transferred from the XBT P.C. to the Level C (bypassing the Level B). No further processing was performed on these, since they were then copied to PSTAR files.

Thirty-three CTD dips were logged by the system, and the data processed into real units.

Thermosalinograph data logged and sent to the Level B by the *METLOGGR* PC based Level A was processed into real units, and salinity derived from temperature and conductivity.

Miscellaneous

A memory fault was diagnosed on the TCO_2 PC. The fault lay in one of the two SIMMs (Single In-line Memory Modules), and unfortunately no spares could be obtained. The Engineering Division's office PC was used instead, with the application specific boards being transferred from the deceased PC. This system seemed to work well, after a few problems caused by the new PC being too fast were ironed out.

The big Nicolet-Zeta 836 drum plotter started reporting errors one day, and all of a sudden it couldn't put the pen down or select a new pen. The initial suspicion was that the solenoid that controls both these functions had burnt out. So with the help of Colin Day, a spare pen carriage assembly was fitted. The plotter was tested, and things were exactly the same as before. It was then decided to change the driver PCB which takes signals from the microprocessor board, and converts them into signals that the motors and solenoids in the plotter use. This was successful and the problems were cured.

Several Transverse Mercator track plots of scale 1:5000000 were produced during the cruise to be attached to the weekly newsletter being sent back to IOS.

Combined listings of PCO_2 and surface sampling data were supplied to Jane Robertson for use in *Microsoft Excel.*

During the cruise, the ship exchanges E-mail with the research vessel base at Barry by means of a MODEM, and a package called *Blast*. At present *DISCOVERY*'s system uses an old *Thorn* 2400 baud MODEM, but there is a new *GPT 9600* baud modem on board. If this MODEM could be setup, the communications cost of E-mail would be less. Instructions were received from the Base on how to set up *Blast* to use the new MODEM, and several tests were run, but the best result we were able to obtain with the new MODEM, was a partial transfer.

At 2245 on 4th March, *discovery1* was observed to have crashed and was rebooted. Later the following morning an 11Mb backlog of data to be transferred to the Level C was showing on the Level B. After re-booting the system, it became apparent that it had crashed about two-three hours after the previous reboot. The only data that had been lost was ADCP, data since that bypasses the Level B. All through the day the system failed with increasing frequency, and eventually the big data disk from *discovery1* was swapped to *discovery2*. All the machines on the network had to be re-configured slightly. The Exabyte tape backup unit that had been connected to *discovery1* was transferred to *discovery3.*

A few days later *discovery1* was booted with no external SCSI peripherals, it crashed once, and then behaved. Gradually all the SCSI devices that had previously been attached to the machine were re-attached, starting with the quarter inch cartridge tape, and CD-ROM. After about a week, the big data disk was re-attached, and the network re-configured to its original state. Its possible that the crashes may have been caused by a bad SCSI connection. The new style compact Sun SCSI connectors are extremely fragile, and in my view are a step backwards.

The IOS magneto-optical disk drive connected to *discovery2* started producing lots of read and write errors. It is still not clear why these occur, but the drive may require cleaning, and the necessary cleaning cartridges are not on board. However I managed to devise a procedure for ensuring that data was written correctly to the disks using the Unix tar program.

Two programs were written during the cruise. *tspot* takes times and labels, and outputs a file containing positions and labels, which can then be used by the existing program *fspot*, to plot the positions of XBTs and CTDs on a grid. *grabgrid* takes a *MacSat* file and separates out the original satellite image, and the overlay file containing latitude and longitude lines, and the ship's position. The output files from this program can then be processed by the ALV image processing software.

PD

Simrad EA500 Echo Sounder

The Simrad EA500 was used routinely for echo sounding and pinger work. The fish transducer was used throughout apart from a short period while in icy waters and when the fairing needed to be repaired. A Hewlett Packard printer was used to produce a real time hard copy output. A uniform sound velocity of 1500 m s^{-1} was used and it was noted that the fish depth was approx. 20 m while stationary and decreased by several metres when steaming at 13 Knots. The data was also sent to the level B at 30 second intervals.

PD

PEXEC and PSTAR

PEXEC is the name of the suite of programs developed by staff at the Institute of Oceanographic Sciences (IOS) to process hydrographic data, both at sea and in the lab. The range of programs covers all aspects of data processing, including calibration of data, arithmetic operations, derivation of oceanographic parameters and graphical display of data. The programs use a binary data format called PSTAR, which is compatible with the RVS data format. All PSTAR data files incorporate a header at the start of the file, which contains details of variables stored, number of data cycles and so on. Each file has an associated data name and a version code, and after each operation, the version code is incremented. Logsheets are maintained (by hand) to record each operation and version code, which is tedious, but does provide an accurate history of each data set.

Source code and executables were owned by the id pexec. Data was processed by the id pstar.

Problems

Each instrument was allocated a directory under the pstar home directory, and all programs and C-shell scripts for an instrument were run from its directory. Some scripts used to check at the start which is the current directory and whether that is the same as the required directory. In fact, the code to do this was taken out at the start of this cruise to simplify code and on the assumption that it would cause confusion — processed files would not be in the current directory when the script finishes. This was a mistake. We recommend that a check is made at the start of script and if the directory is not correct, exit with message.

MJG,PDC,NPH,MS

Archiving and backups

Archiving in this section refers to PSTAR data only. Backups are for PSTAR only too.

A separate partition was available as a temporary store before writing data to the archive media.

The original basis for archiving was a Sony erasable optical disk — once mounted, each disk is considered a standard UNIX file system and can store up to approximately 260 Mbytes. One copy of each data file was to be put on 150 Mbyte Quarter Inch Cartridge (QIC) tape using the UNIX binary storage command 'dd'.

Archiving didn't go according to plan. Very soon into the cruise, the optical disk failed with the following errors:

Running fsck revealed a large number of errors in the file system, which ultimately could not be resolved, even by reformatting. From several weeks experimenting we found the most reliable way to store data to disk was to write one large UNIX tar file. We ran fsck on the raw device (/dev/rsk0c) both before and after archiving. As soon as the disk was complete, the disk was write protected. We used the spare partitions on discovery3 and discovery4 to store about 260 Mbytes of data before 'taring' to optical.

Despite this achievement, we trusted the optical disks not, and made copies of each data file on two 150 Mbyte Quarter Inch Cartridge (QIC) tape using the UNIX binary storage command 'dd' tapes. We originally planned to make only one backup archive copy to tape so this procedure quickly consumed the small supply of tapes.

We recommend the optical disk drive be serviced before taken to sea. If necessary, a head cleaning kit should be available on ship.

The pstar data and archive directories were backed up each alternate night to 2 Gbyte Exabyte tapes, using the UNIX 'bar' command. Only two tapes were used.

MJG,PD

RVS Engineering Division

Use of engineering division scientific equipment was in the following areas;

1. Starboard Gantry
2. 10T traction system
3. 20T traction system
4. Aft Gantry
5. Ships cranes
6. Compressors
7. Non toxic water system
8. Gas distribution system
9. IOS CTD

1. Starboard gantry

CTD head sheave

During a CTD deployment the wire jumped out of the gantry head sheave and located around the sheave pin boss. The CTD was duly recovered with the 130 TM crane, and the wire cropped and re-terminated. The cause of the fault was found to be excessive play in the sheave bearing assembly, allowing the sheave to wobble about its axis. The movement was sufficient to allow a gap between the sheave OD and the keep plates wide enough to allow the cable to be pulled between the sheave and cheek plates when slack was generated over the sheave. The sheave/swivel assembly was removed, and the sheave bearing assembly stripped down for examination. It was found that either a design or manufacturing error had resulted in the aftermost roller bearing inner race being able to float within the bearing housing, eventually resulting in 10mm play in the aftermost bearing.

The bearing inner race should locate upon a set of inner spring retainers which are located in a recess centrally positioned in the bearing housing. The retainers ID should be proud of the inner housing diameter, thus creating a shoulder on which the bearing inner races locate. It was found during examination that when the spring locating pieces were fitted they did not provide the required locating shoulder, thus allowing the bearings to float over them when an external side load was exerted on the sheave.

To resolve the situation an inner spacing bush was made to locate inside the retainer ring recess. The retainer rings were straightened, repaired and refitted now showing approximately 1.8 mm proud of the bearing housing ID. The bearings were refitted, the assembly re-installed on the gantry and a test using weights successfully carried out. The manufacturer's drawings should be studied and a permanent solution affected for the other sheaves working in the system of the same design. Either the appropriate dimensioned retainer rings fitted or the recess diameter reduced (new sheave).

On further examination of the sheaves operation during the test deployment, it was observed that with only a 10 to 20 degree wire angle, at the exit point of the wire off the sheave the wire fouls and runs over the sheave keep plates quite badly, this is the result of:

a) the keep plates running too far out-board around the sheave.
b) the inability of the sheave to swivel under light loads due to its own weight.

It is not necessary to have the keep plates so far out-board and it is a simple operation to trim them back. The swivel mechanism is free and swivels on its bearings satisfactorily but the torque required for rotation is in excess of the torque generated by low out-board tensions and small wire angles. A means to increase the swivel torque on the sheave at low wire tension and the trimming of the sheave keep plates would be useful modifications for this piece of equipment.

Roller/pendulum/winch check valve
A check valve has been fitted in the roller extension flow-splitter drain line. This will check any drain of oil via this route but will not check any drain between:

a) Cylinder and power pack on the 'roller down' pressure line
b) Valve 14d and the powerpack on the 'roller up' pressure line (the delay in operation occurs primarily when lowering the roller indicating the roller down pressure line is most important).

The gantry winches show the same delay in operation as the roller after a period of non-use. According to the schematic it appears that, when in neutral the return line is connected to the tank via the proportional control valve. This will allow the oil to drain back to the tank during periods of non-use. If this is the case the insertion of a low pressure check valve mounted at the power pack may be required, or investigation into the changing of the valve spool.

Gantry roller
During CTD operations it was noted that the aft roller bearing was noisy and showing signs of wear. It is assumed that this wear so soon after the bearing has been changed, is due to the misalignment caused by the dropping of the roller under its own weight when not in use. Solution of this problem is already in hand.

Hanger top sheaves
During a CTD deployment the wire jumped off the hangar deck vertical diverter sheave and caught on the sheave boss. The CTD was recovered and the wire re-terminated. The fault area in the sheave was subsequently identified and a wire keep roller manufactured and fitted. During the remainder of the cruise operations were carried out under varying conditions of package weight, seastate, etc. and the situation did not recur.

It was noted that the wire was not jumping out of the sheave as slack wire is fed back over the gantry (due to the 'floating' of the IOS CTD), but was in fact being pushed off the sheave by the wire delivery from the cable hauler. This was a result of the outboard wire speed being reduced by the 'floating' of the CTD package.

It should be recognised that by solving this problem locally, i.e. at the vertical diverter sheave, the problem does not go away. When slack is now generated it tends to gather between the hauler and the vertical sheave. When wire is paid out faster than the outboard wire speed, slack will be generated somewhere in the system, whether this is in the wire run shipside or outboard of the gantry headsheave depends on the amount of wire out and the dynamic characteristics of the package being deployed.

2. 10T traction system

The winch system was used extensively for CTD operations and tide gauge recovery. The winch power packs were set up at the beginning of the cruise and required only minimum adjustment during the cruise. It is assumed the sequence braking mechanism has been disabled on a previous cruise and left so. It is important that all modifications to this equipment are documented or that personnel joining the vessel are informed.

3. 20T traction system

This system was used for dragging for moorings in 4200 m of water. Although there are some areas for concern with this system, the operation was carried out with no undue problems. The grommet fitted around the traction winch was not found to be required whilst veering out wire on deck or overboard at low tensions. The 37 KW power pack was run in manual with very low back tensions until sufficient outboard load was generated to put the winch into fully automatic mode.

4. Aft gantry

All gantry systems functioning satisfactorily. During the cruise the 24V DC supply was lost to the control potentiometers and the gantry had to be stowed using the hydraulic valves on the cubicle. The fault was traced to the 240V ac/24V dc transformer in the power pack room. It was fortunately repairable as it appears that the ship carries no spare. This item was duplicated on the starboard gantry also.

5. Ship's cranes

Problems occurred early on in the cruise with the forward 30TM crane. The proximity switch has failed and is now bridged out awaiting a spare. A proportional control valve solenoid also failed and was changed, and several persistent oil leaks have been cured, but with one still to go! During operation the winch wire became trapped between the winch cheek plate and the winch mounting, crushing the wire. It was felt necessary to change the wire for the spare, and therefore a new wire must be ordered for spare.

The other cranes all operated satisfactorily other than their regular bouts of tripping on overload due to high oil pressure (this was never addressed by ACTA). At some stage this could cause concern if it occurs at a critical point.

6. Compressors

The compressors were run on load, the whole system as far as the deck valves was pressurised to 150 bar and any leaks dealt with. No. 1 compressor could not be started, it registers HAP alarm which cannot be reset in the normal manner. No further investigation was carried out.

Setting the deck pressure setting valves was considered, but at the time it required the fitting of a gauge to the deck delivery valve as no gauge is fitted in the compressor room. As time did not permit, the pressure setting valves operation was tested by setting to 'max' pressure, then the valve was set to 'zero bar' ready to be set during the *DISCOVERY 208* trials.

7. Non-toxic water system

This system was run continually and gave no problems. Both the de-aerated and on line systems were used for 24 hour continuous sampling throughout the cruise.

8. Gas Distribution System

As on previous cruises this system was by-passed due to its unreliability, and other means were affected to transport gas to the deck and chemistry labs. The alarm system remains disabled. These systems when fully operational will provide an effective service for gas transport and monitoring throughout the ships working areas.

9. IOS CTD

Due to its dynamic characteristics, the 24 bottle package has proved to be potentially difficult to operate under certain conditions. Whether or not to deploy this package in moderate to heavy seas has to be carefully assessed due to the packages tendency to be lifted by swells during the critical deployment period (0 - 40 m depth).

Prior to sailing on *DISCOVERY 207*, from previous experience it was anticipated that problems may occur. Consequently 200 kg of lead was purchased in Cape Town and later fitted to the CTD frame in a manner which permitted the quick removal and fitting to respond to the varying depths and conditions. In addition to the lead ballast, up to six bottles were removed to reduce drag on the package.

The problem manifests itself in two distinct ways:

a) during the initial deployment phase, i.e. 0-40 m.
b) during the paying out period up to 700 m.

During the initial deployment phase as the package is lowered into the water, a rising swell tends to lift the CTD package due to its large surface area to weight ratio. As the wire is continually being paid out, the swell recedes and the package, not yet submerged, drops under its own weight (in air) and snatches on the slack wire creating high shock loads on the system. During this period slack wire can also be generated shipside with potentially damaging results, demonstrated by the wire jumping off the vertical diverter sheave as previously described. If the wire speed is increased to accommodate the falling swell the problem is magnified on the next upswell.

A further occurrence which identified the excessive drag problem is, during the paying out period (up to 700 m dependant on sea conditions), the outboard load can be seen to reduce to 'zero package weight', i.e. the monitored outboard load reads wire weight only. At this point the package effectively floats. This occurs even at speeds as low as 15 - 20 m min^{-1} and as stated can occur up to a depth of 700 m (dependant on sea conditions).

As the ship rolls with the swell the package will lift on the up swell inducing high loads on the cable and then begin to sink at a slow rate as the ship rolls back on the down swell and effectively float for a period. As the ship's movement and the package movement become out of phase the snatch loads have been recorded between 0.2 t to 1.6 t. This induces great stress on the package, the wire and the system in general.

This is not a situation specific to the winch system utilised by *DISCOVERY*, this problem can be as acute on any of the NERC vessels whether traction or dead drum winches are in operation.

On previous *DISCOVERY* cruises the standard 12 bottle CTD rosette has been used in comparable conditions. It demonstrated the fact that with this package operations can be carried out faster and with less potential for equipment damage. The limiting factor for CTD deployments was the ability to keep the ship on station. The 12 bottle CTD weighs less than a third of the 24 bottle system. This allows for an extra 1000 m of wire to be deployed prior to reaching the wire SWL. In addition it has a significantly lower drag factor thereby increasing its operational speed through the water column.

The above factors must of course be balanced against the scientific need for 24 bottle samplers. If future requirements dictate the need for larger and heavier packages then considerable investigation should be directed towards the packages design and operational characteristics. As the requirement for this type of scientific equipment increases, these problems highlight the necessity to constantly address the ongoing and future development of overside equipment and deployment systems.

CTD malfunction and repair

During operations a fault occurred with the CTD unit which was identified as an ingress of water via the CTD bottle firing mechanism O-ring seal. The component was removed and the problem identified as corrosion and eccentricity on the O-ring seat. The component was removed and the problem identified as corrosion and eccentricity on the O-ring seat. It was machined and a larger section O-ring fitted which prevented any further occurrence of the problem during the cruise.

CD, RAP

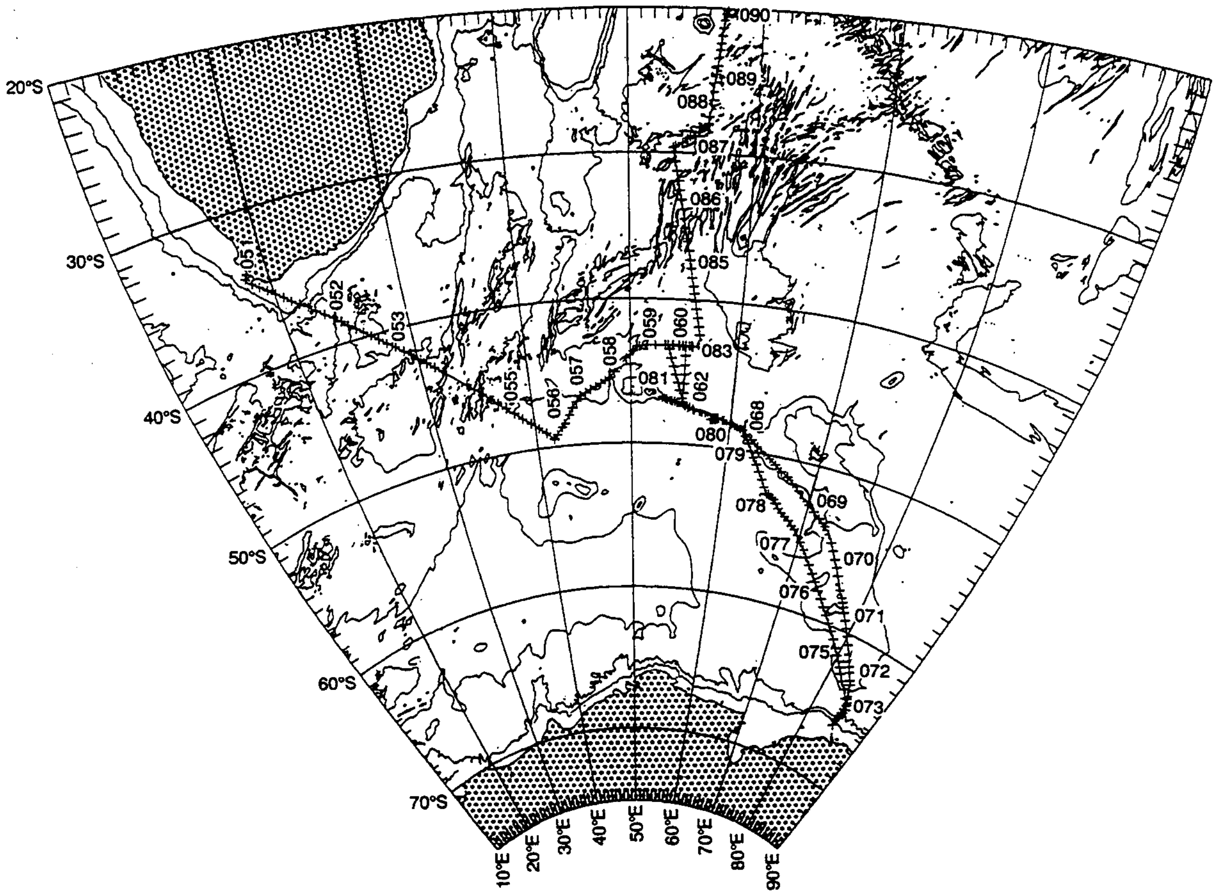


Figure 1(a). Track chart

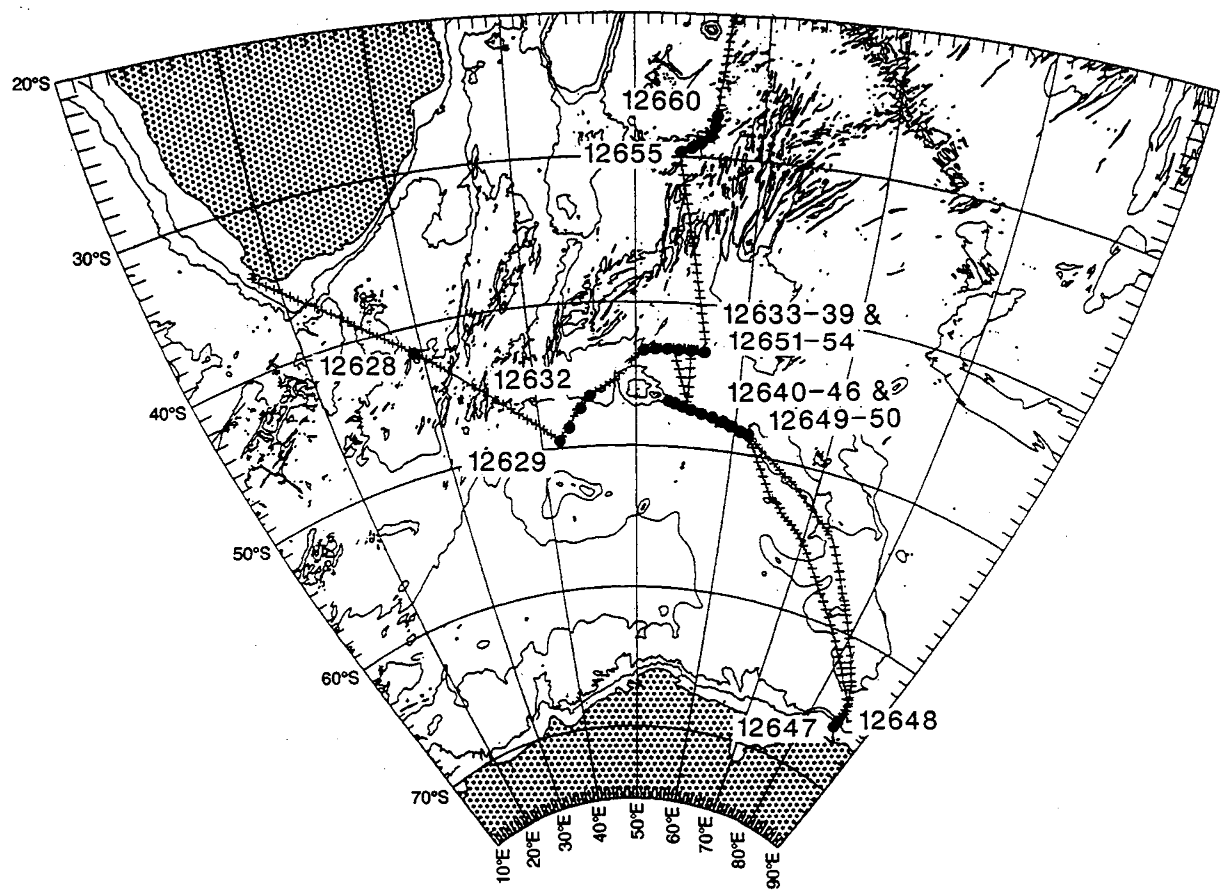


Figure 1(b). Chart showing CTD station positions

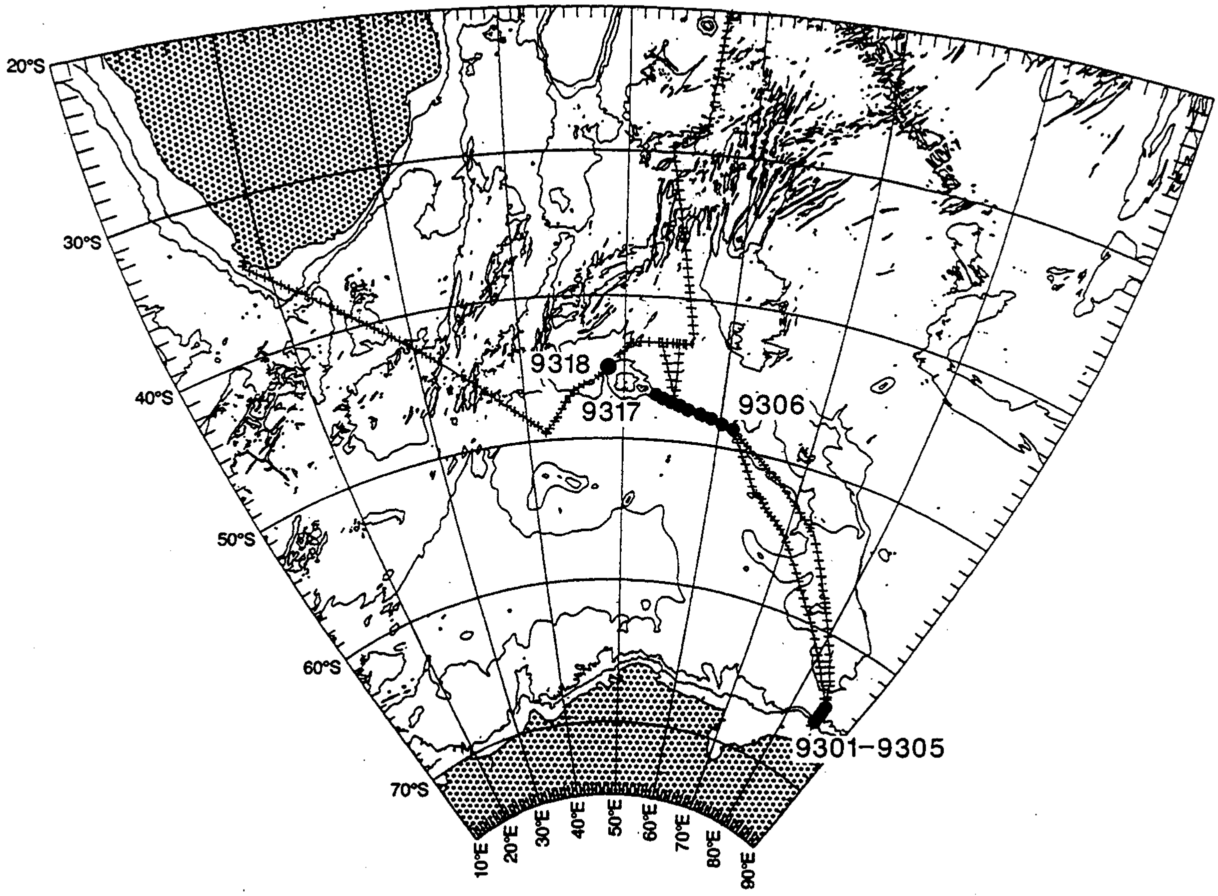


Figure 1(c). Chart showing current meter mooring positions

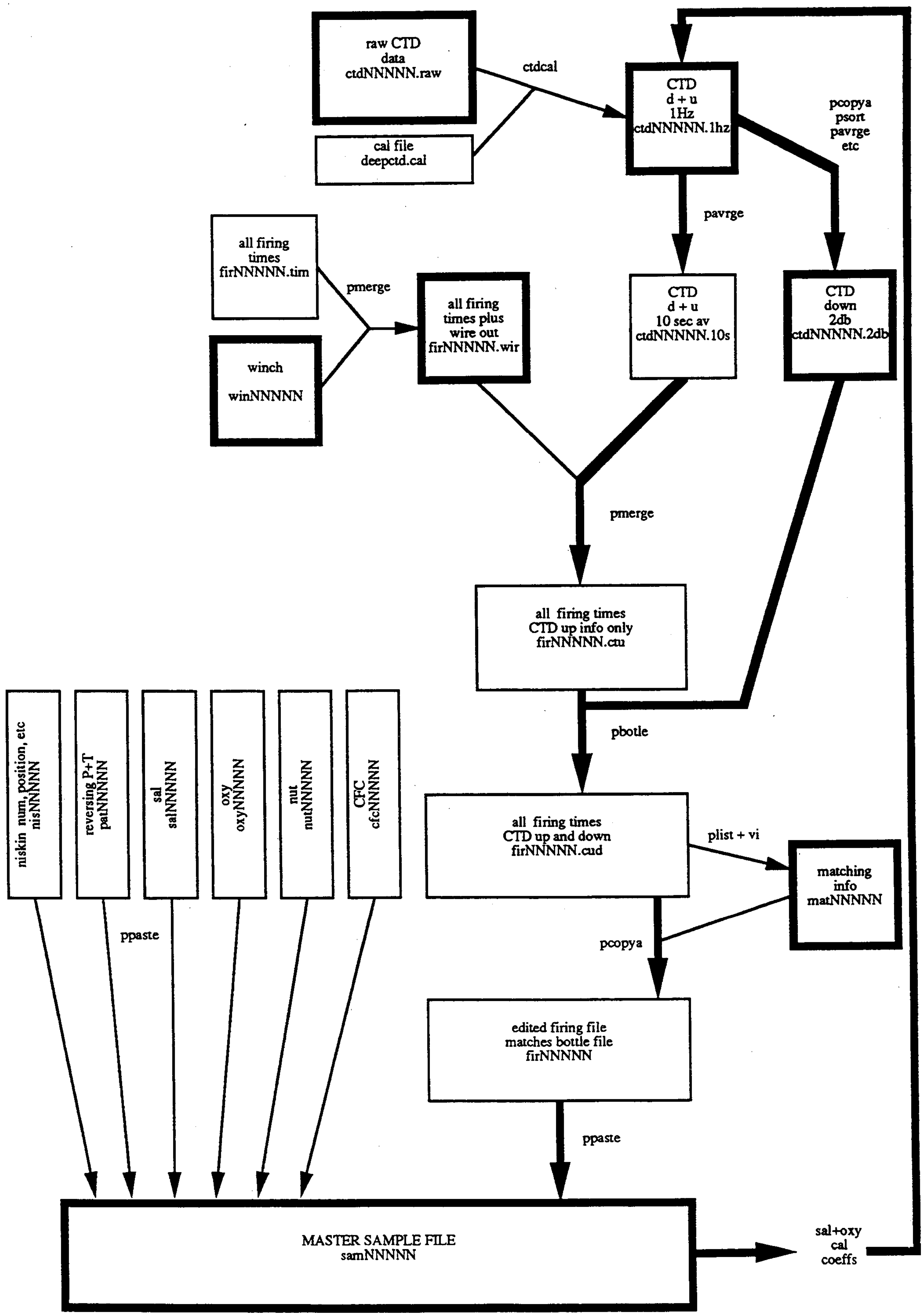


Figure 2. ***Cruise 207 data processing path***

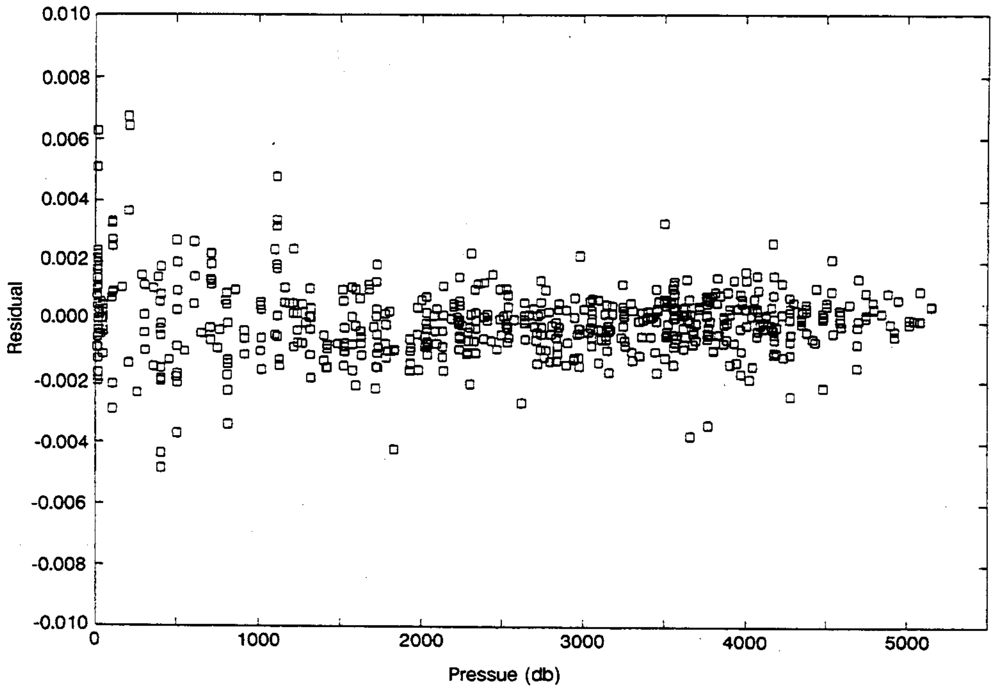


Figure 3. Residuals between calibrated CTD and bottle salinities

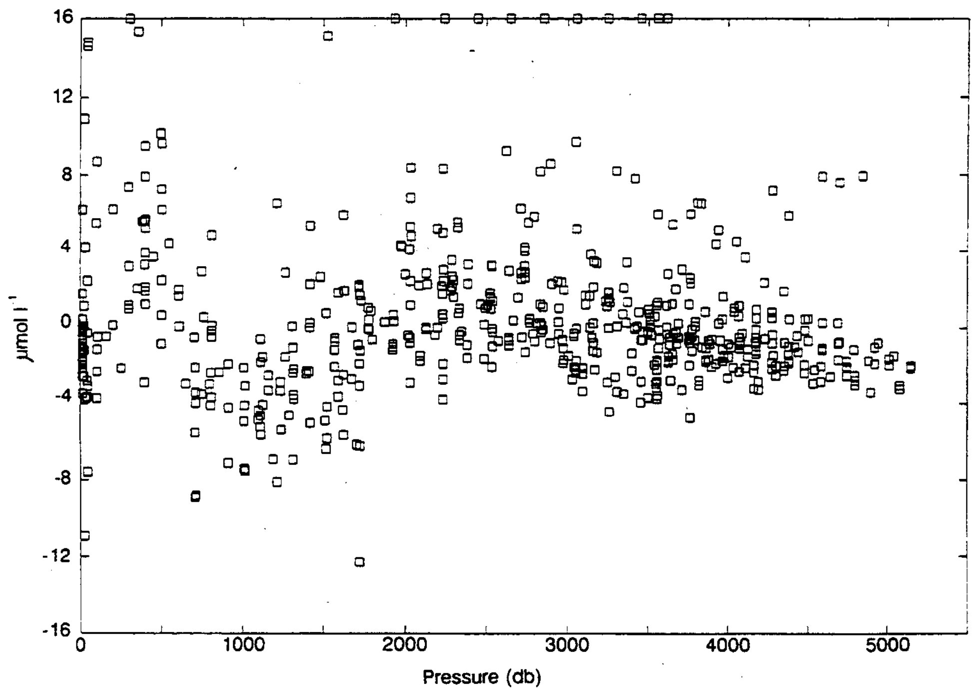


Figure 4. CTD and bottle oxygen comparison against depth

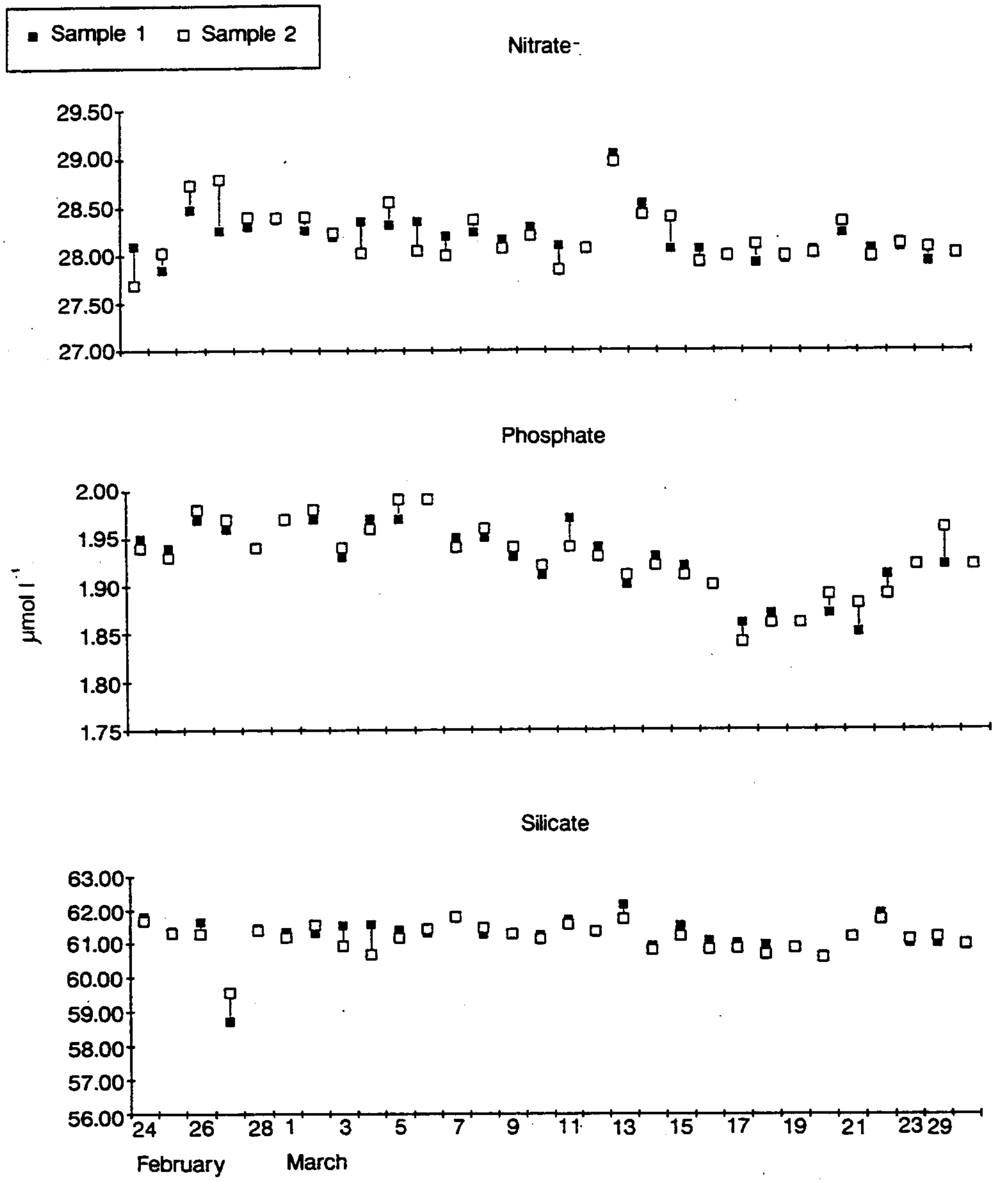


Figure 5. Results of nutrient Quality Control analysis

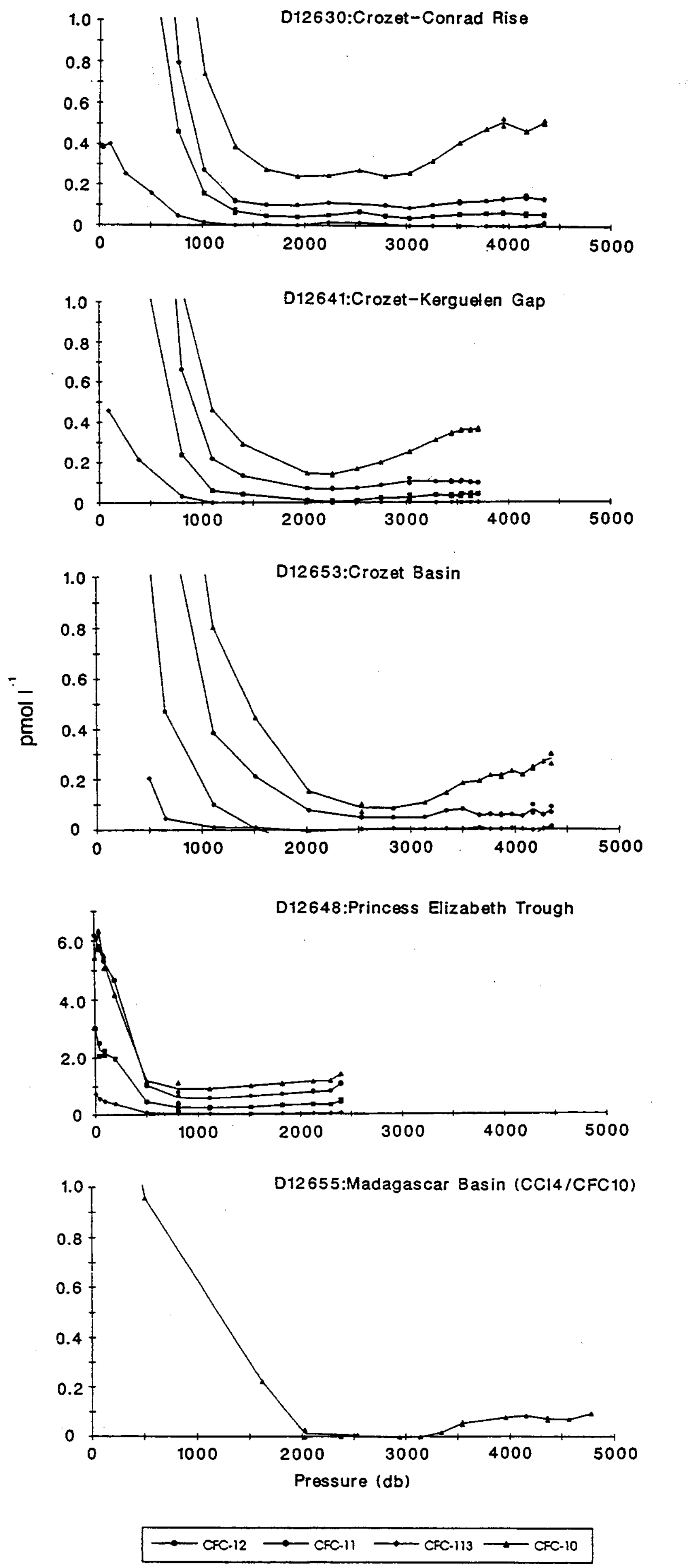


Figure 6. ***Preliminary CFC concentration profiles in five areas***

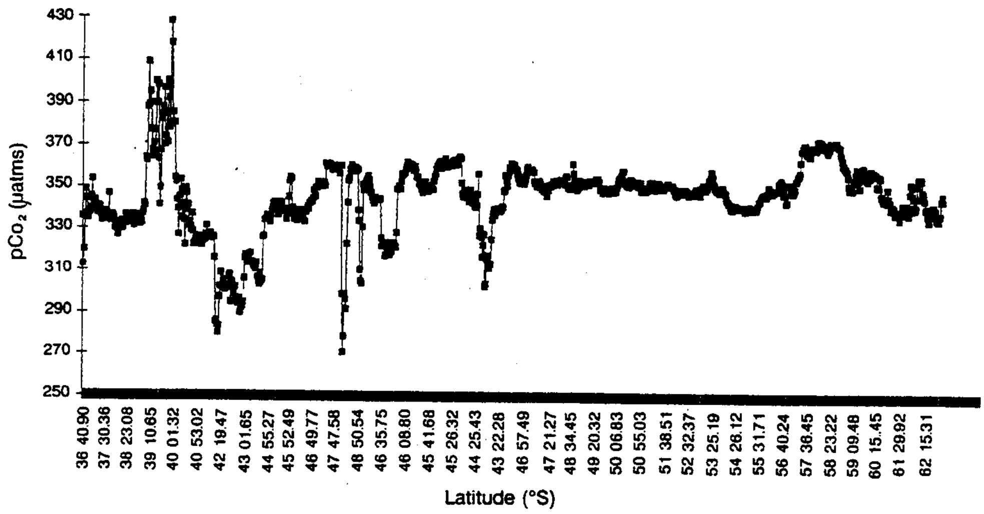


Figure 7. *Underway* pCO_2 *values against latitude*

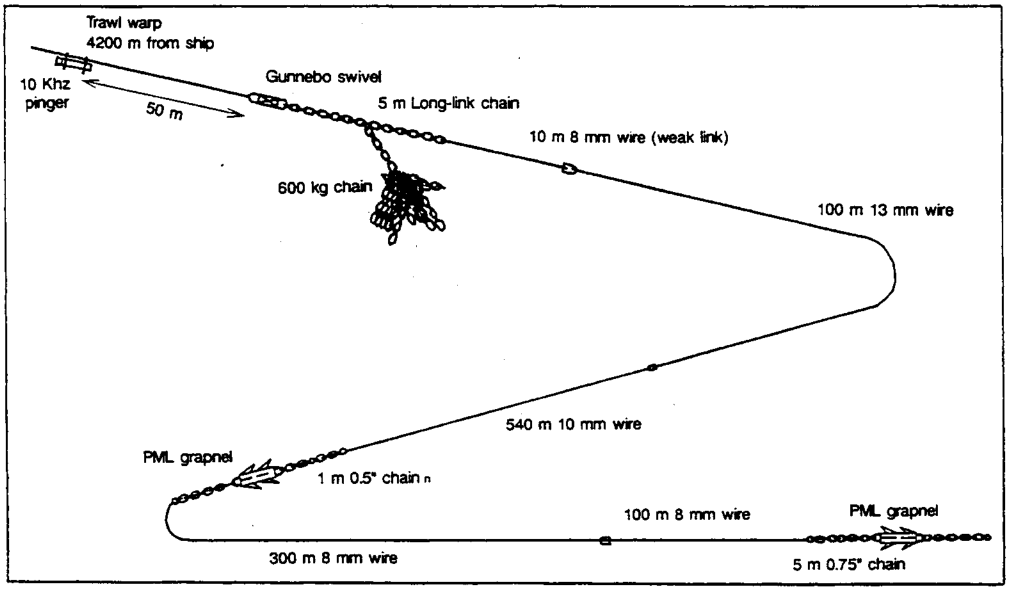


Figure 8(a). Dragline scheme

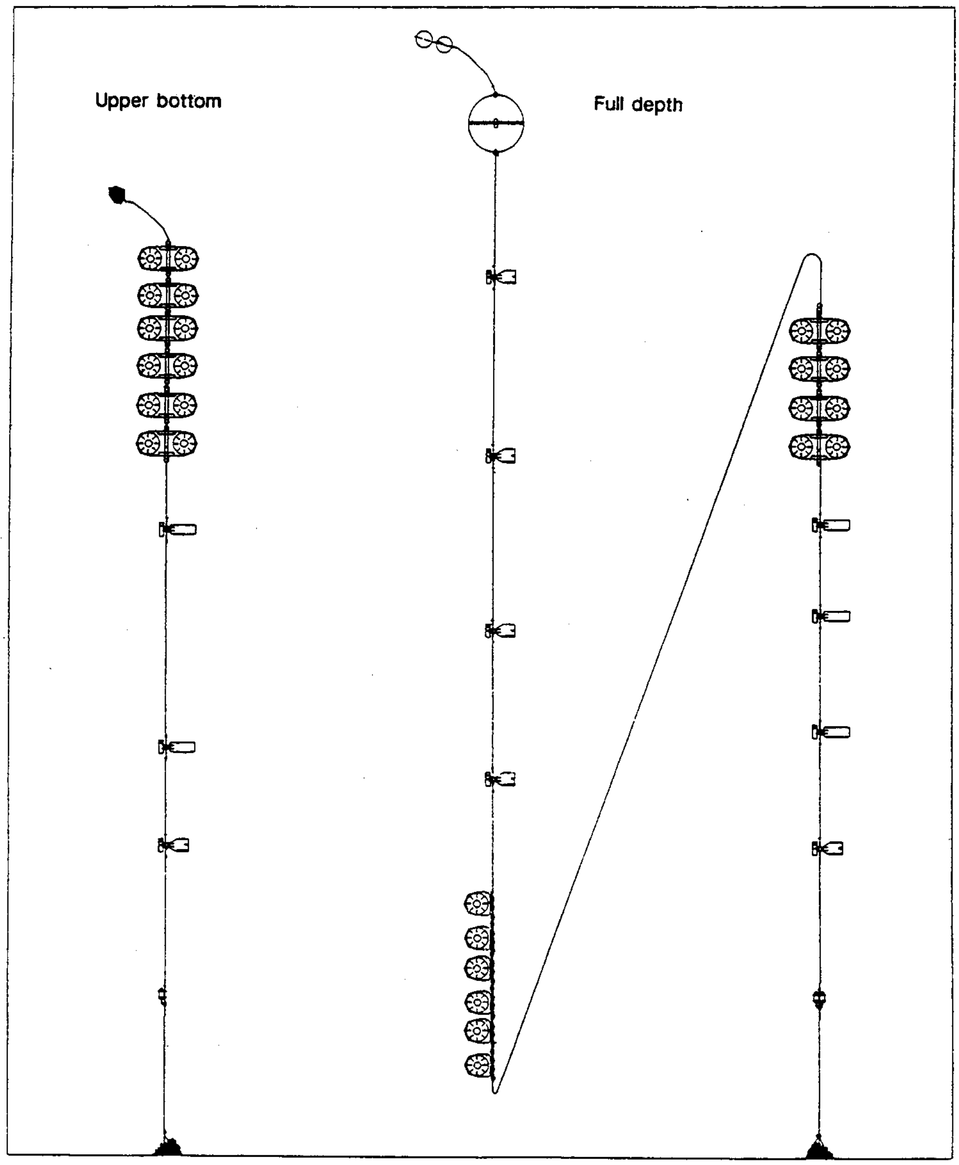


Figure 8(b). General mooring layout

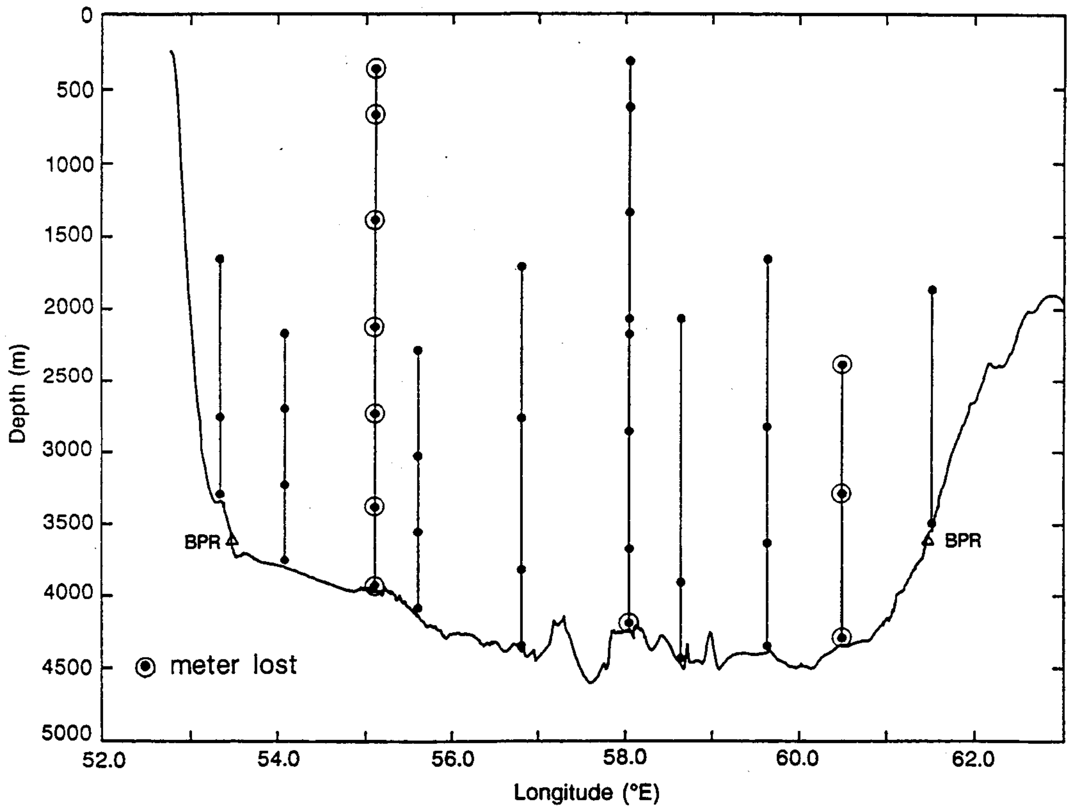


Figure 8(c). Moorings on the Crozet - Kerguelen section

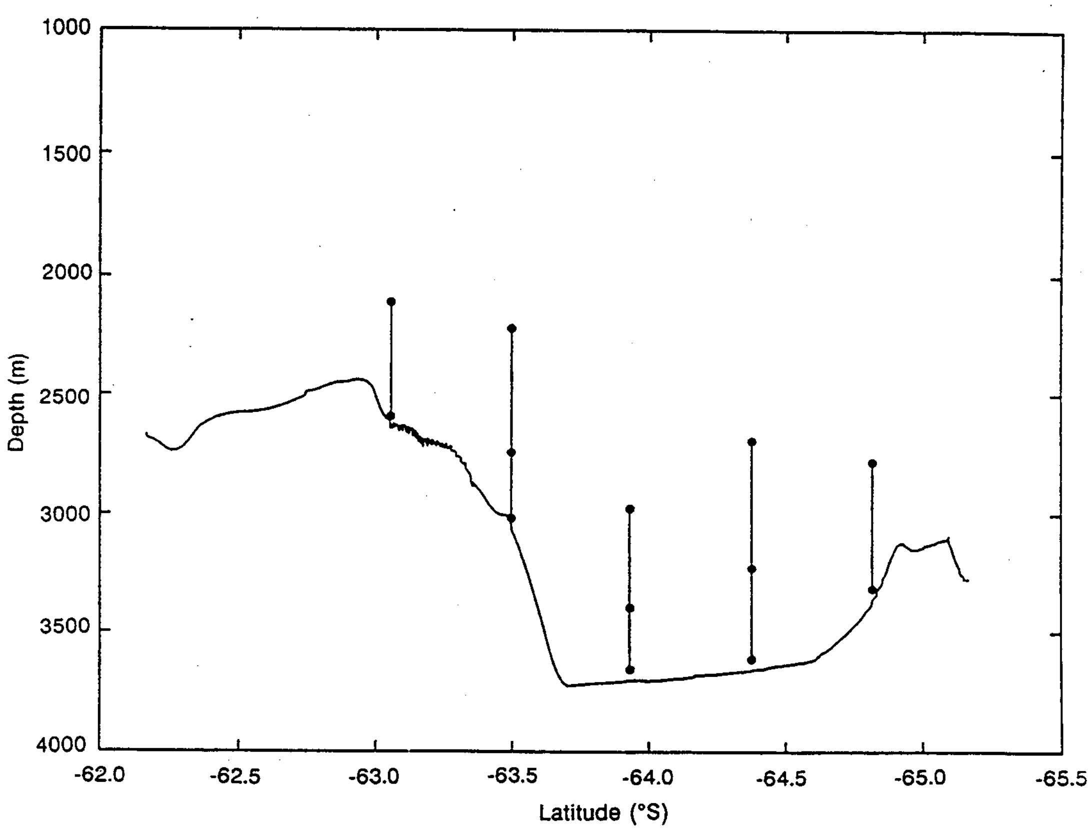


Figure 8(d). Moorings in the Princess Elizabeth Trough

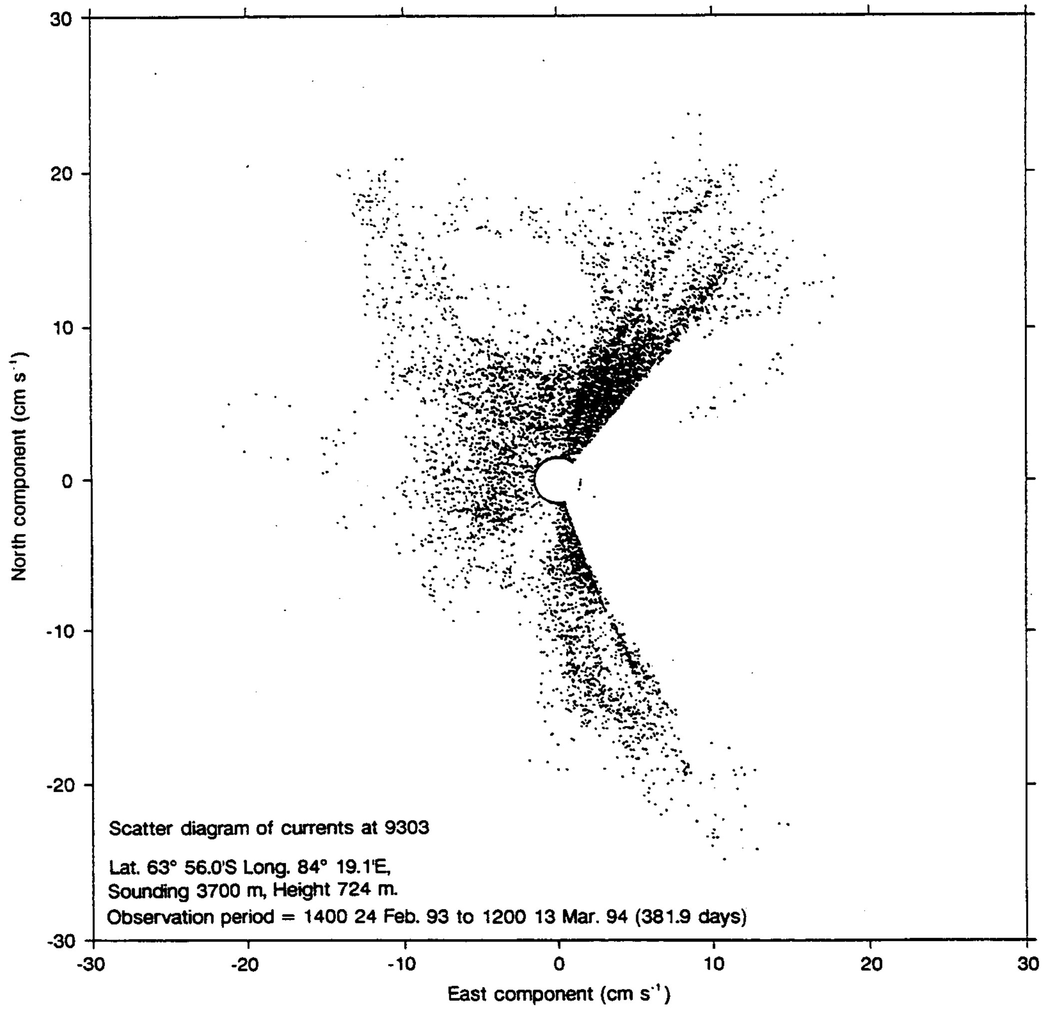


Figure 8(e). Illustration of compass problems caused by proximity of the South pole

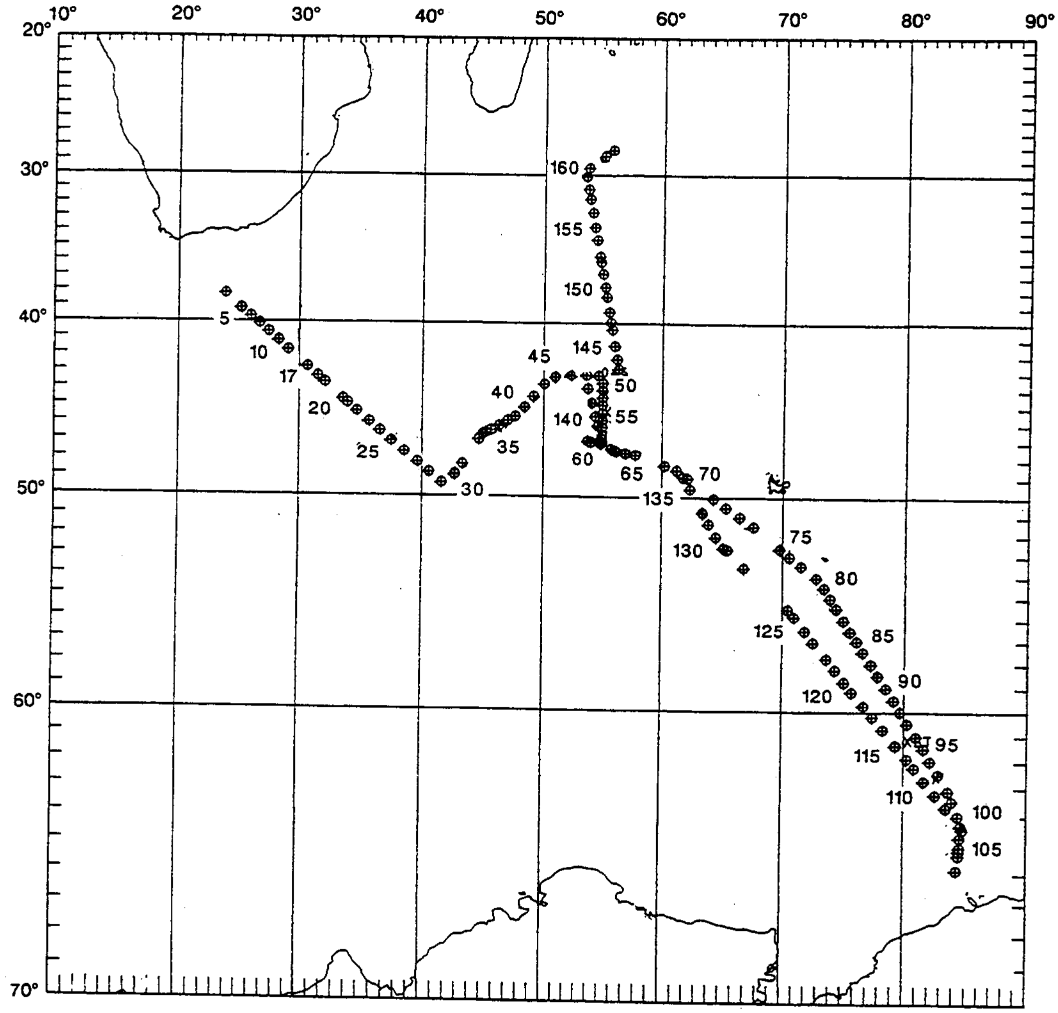


Figure 9. Location of XBT stations

Table 1. CTD station list

Station No.	Date (Day)	Time (UT)	Lat. (S)	Long. (E)	Depth (m)	Bottom Pressure	Height off	Levels sampled	Comments
12628	22/2(53)	0623	41 59.89	29 31.31	4913	2046		2	CFC calibration;
		0710	42 0.05	29 31.43					23 bottles at 2046 db
		0755	42 0.17	29 31.74					
12629	24/2(55)	1757	49 29.70	41 57.43	4160	4163	28.0	15	First attempt aborted;
		1953	49 29.94	41 56.00					wire trapped in sheave.
		2125	49 30.06	41 55.63					Bottles 4 & 21 open; 24 leaking.
12630	25/2(56)	0443	48 29.31	43 05.34	4281	4351	30.8	19	
		0626	48 28.80	43 06.97					
		0805	48 28.61	43 07.85					
12631	25/2(56)	1441	47 26.71	44 07.22	3373	3402	30.0	16	
		1615	47 27.10	44 06.65					
		1737	47 25.45	44 08.28					
12632	26/2(57)	0305	46 37.54	44 59.06	2559	2579	22.5	18	
		0438	46 38.24	44 59.22					
		0549	46 38.45	44 59.84					
12633	27/2(58)	1731	43 16.02	50 37.53	2960	2979	26.0	13	
		1858	43 16.82	50 36.96					
		2005	43 17.81	50 36.60					
12634	28/2(59)	0018	43 12.71	51 33.31	3517	3560	24.0	12	
		0153	43 12.89	51 33.33					
		0313	43 13.09	51 33.35					
12635	28/2(59)	0904	43 09.23	53 11.99	3737	3757	22.0	12	
		1012	43 09.31	53 12.65					
		1143	43 09.57	53 13.92					
12636	28/2(59)	1500	43 09.15	53 57.96	4022	4055	23.3	16	
		1631	43 09.49	53 59.34					
		1807	43 09.84	54 01.56					
12637	28-29/2	2352	43 09.57	54 35.80	4153	3812	19.0	11	At surface 7 positions
	(59-60)	0123	43 09.62	54 34.11					unfired. Subsequently
		0253	43 09.89	54 32.15					fired.
12638	1/3(60)	0559	43 11.29	54 29.21	4085	4110	25.7	8	Rosette IOSDL2 now
		0716	43 11.73	54 29.12					fitted.
		0904	43 11.34	54 30.84					
12639	1/3(60)	1142	43 09.96	55 09.99	4242	2544	18.0	5	Rosette IOSDL1 on.
		1303	43 10.62	55 09.21					Only 9 bottles closed.
		1449	43 11.21	55 07.90					
12640	2/3(61)	1742	47 07.10	54 32.89	3886	3929	19.0	16	Rosette IOSDL2
		1901	47 07.23	54 32.54					refitted.
		2044	47 07.37	54 32.35					
12641	2/3(62)	1452	46 54.89	53 37.62	3676	3714	21.0	17	
		1615	46 55.24	53 36.40					
		1748	46 55.50	53 36.65					

Table 1. continued

Station No.	Date (Day)	Time (UT)	Lat. (S)	Long. (E)	Depth (m)	Bottom Pressure	Height off	Levels sampled	Comments
12642	2/3(62)	2141 2256 0006	46 45.64 46 44.94 46 44.63	53 06.10 53 05.81 53 06.18	2787	2771	20.0	15	GO FLO at position 24 leaking as CTD came on deck.
12643	3/3(63)	1725 1922 2055	47 17.59 47 18.82 47 19.07	55 17.62 55 15.74 55 16.11	3952	4006	25.0	15	GO FLO at position 24 leaking as CTD came on deck.
12644	4/3(64)	1412 1556 1751	47 40.10 47 40.61 47 41.59	57 35.74 57 35.00 57 35.44	4539	4594	23.8	14	GO FLO at position 24 leaking as CTD came on deck.
12645	7/3(66)	0739 0932 1137	48 05.25 48 05.28 48 05.48	59 08.92 59 08.31 59 08.29	4449	4504	27.0	13	
12646	7/3(66)	1717 1912 2040	48 16.26 48 16.89 48 17.75	60 01.44 60 01.46 59 59.47	4476	4536	17.0	14	
12647	14/3(73)	0913 0928 0953	66 02.24 66 02.34 66 02.47	84 32.98 84 33.14 84 33.22	454	432	9.2	12	Bottle 21 & Go Flo empty. Water freezing when sampling. No sal., O_2 or nutrients.
12648	14/3(73)	1257 1342 1437	65 32.19 65 31.97 65 31.51	84 37.14 84 37.94 84 38.52	2377	2411	18.0	12	Bottle 21 not closed.
12649	20/3(79)	0911 1024 1152	48 34.77 48 34.64 48 34.51	61 27.72 61 26.82 61 26.40	3562	3617	22.0	14	
12650	22/3(81)	0404 0530 0709	47 30.88 47 31.28 47 32.08	56 12.34 56 11.96 56 12.03	4326	4383	18.1	19	
12651	23/3(82)	1054 1207 1309	43 09.49 43 09.80 43 09.82	53 31.84 53 33.79 53 35.97	3949	3980	25.0	19	Break in altimeter signal near surface on up cast.
12652	23/3(82)	2152 2328 0112	43 10.91 43 11.05 43 11.29	54 51.95 54 53.73 54 55.46	4259	4302	19.7	19	First attempt aborted as wire in sheave.
12653	24/3(83)	0442 0620 0824	43 10.43 43 11.11 43 11.78	55 40.83 55 41.42 55 41.11	4309	4356	23.6	19	
12654	24/3(83)	1238 1427 1642	43 09.85 43 09.92 43 10.20	56 31.69 56 33.01 56 33.68	4627	4700	14.6	19	
12655	27/3(86)	1640 1820 2002	29 40.35 29 39.67 29 39.18	53 29.08 53 28.94 53 28.97	4748	4799	24.1	17	

Table 1. continued

Station No.	Date (Day)	Time (UT)	Lat. (S)	Long. (E)	Depth (m)	Bottom Pressure	Height off	Levels sampled	Comments
12656	28/3(87)	0010	29 20.14	54 09.96	4705	4747	27.0	19	
		0148	29 19.64	54 10.84					
		0344	29 18.97	54 11.59					
12657	28/3(87)	0706	28 55.22	54 44.27	4960	5018	22.2	18	
		0838	28 54.64	54 45.04					
		1037	28 53.35	54 46.02					
12658	28/3(87)	1522	28 30.69	55 29.39	4864	4925	16.4	18	
		1656	28 31.28	55 29.25					
		1847	28 31.30	55 29.44					
12659	28-29/3	2308	28 04.97	56 05.27	5003	5083	19.7	18	
	(87 - 88)	0047	28 04.93	56 05.19					
		0228	28 04.69	56 05.30					
12660	29/3(88)	0533	27 31.04	56 08.16	5124	5152	18.0	18	
		0708	27 30.52	56 08.64					
		0913	27 29.94	56 09.13					

Notes:

Times are:	*First*	*Start down*
	Second	*At Bottom*
	Third	*On deck*

Positions are given in degrees and decimal minutes and were taken from abnav2072.av at times stated

Depth is recorded by Simrad PES (assuming 1500 m s^{-1} with 17 m added to account for sinking of the PES fish on station. Carters Tables corrections have been applied)

Wire out indicates the value at the bottom of the cast

Bottom pressure indicates the pressure measure at the CTD at the bottom of the cast

Height Off is the height above the seabed at the closest approach as measured by the altimeter

Levels sampled is the number of depths sampled and defined in Table 2

Table 2. ***Bottle firing depths (db)***

Bottle Number	Station Number 12628	12629	12630	12631	12632	12633	12634	12635	12636	12637	12638
1	2046	4163	4351	3402	2579	2979	3560	3757	4055	3812	4110
2	2046	4163	4351	3402	2387	2979	3560	3757	3842	3657	4110
3	2046	4163	4171	3160	2387	2979	3058	3655	3630	3503	4006
4	2046	Empty	3943	3160	2232	2835	3058	3558	3630	3298	4006
5	2046	3767	3943	3160	2232	2671	3058	3558	3630	3097	3902
6	2046	3513	3779	3009	2077	2513	2803	3558	3375	3097	3902
7	2046	3257	3525	2853	1928	2352	2293	3250	3172	3097	3902
8	2046	3257	3525	2853	1777	2200	2293	3046	2973	2897	3800
9	2046	2949	3261	2700	1777	—	—	2844	2973	2897	3800
10	2046	2644	3034	2546	1624	—	—	—	2725	2290	3692
11	2046	2339	2792	2393	1315	—	—	—	2227	—	—
12	2046	2339	2540	2239	1165	2200	2038	2844	1980	1594	3692
13	2046	2028	2237	2239	1165	2002	1834	2233	1733	1594	3619
14	2046	1726	1930	2086	1012	1802	1630	2233	1733	799	3619
15	2046	1423	1628	1934	1012	1572	1324	1927	1487	799	3619
16	2046	1423	1320	1781	860	1572	1324	1927	1241	401	3619
17	2046	1131	1320	1528	706	1244	1020	1522	1241	401	3517
18	2046	1131	1018	1528	553	478	613	713	750	14	3517
19	2046	809	764	1272	404	456	360	713	750	14	3517
20	2046	505	508	Leak	304	—	—	308	306	14	3517
21	2046	Empty	258	714	205	—	—	—	306	14	3517
22	2046	105	106	361	104	—	—	—	107	—	—
23	2046	45	36	109	43	48	17	16	16	14	16
24	8.0	45**	36	109	43	48	17	16	16	14	16

** *Go Flo leaking as CTD came on deck*

Bottle Number	Station Number 12639	12640	12641	12642	12643	12644	12645	12646	12647	12648	12649
1	2544	3929	3714	2771	4002	4594	4504	4536	432	2411	3617
2	1721	3929	3714	2771	4006	4594	4504	4536	432	2411	3617
3	915	3823	3643	2644	3763	4421	4286	4351	406	2309	3559
4	507	3823	3554	2644	3544	4229	4080	4194	406	2309	3454
5	15	3563	3554	2492	3544	4229	4080	4194	366	2136	3454
6	15	3563	3461	2492	3370	4091	3826	4037	366	2136	3249
7	15	3309	3304	2338	3182	3889	3568	3882	326	1830	3054
8	15	3056	3043	2185	3185	3681	3568	3676	326	1830	2852
9	—	3056	3043	2032	2979	—	—	—	286	1525	—
10	—	2798	2763	—	—	—	—	—	286	1525	—
11	—	—	—	—	—	—	—	—	245	1119	—
12	—	2544	2529	1879*	2719	3422	3310	3420	245	1119	2648
13	—	2290	2282	1728	2436	3115	3054	3166	205	813	2444
14	—	2035	2034	1575	2137	2705	2745	3166	205	813	2239
15	—	2035	1715	1575	1831	2301	2339	2714	164	507	1933
16	—	1781	1403	1421	1424	2301	2339	2252	164	507	1933
17	—	1322	1403	1270	1424	1706	1727	1794	124	205	1524
18	—	915	1103	1015	1018	1214	1221	1295	124	205	713
19	—	407	806	711	407	610	611	709	84	104	308
20	—	289	390	406	106	—	—	—	84	104	—
21	—	165	100	—	—	—	—	—	Empty	Empty	—
22	—	—	—	—	—	—	—	—	44	54	—
23	—	15	25	45	25	27	26	33	7	14	46
24	—	15	25	45**	25**	27**	26	33	Empty	14	46

* *Probable leak;* ** *Go Flo leaking as CTD came on deck; Depths for 12647 not verified other than by reversing thermometers and pressure gauges (no salinities or nutrients). For 12648, bottles 1-8 inseperable in salinity and nutrients, but thermometers and pressure gauges indicate correct firing*

Table 2. continued

Bottle Number	Station Number										
	12650	12651	12652	12653	12654	12655	12656	12657	12658	12659	12660
1	4383	3980	4302	4356	4700	4799	4747	5018	4925	5083	5152
2	4383	3980	4302	4356	4700	4799	4747	5018	4925	5083	5152
3	4277	3883	4176	4280	4585	4583	4645	4885	4797	4900	5047
4	4127	3779	4072	4177	4482	4380	4544	4791	4693	4746	4949
5	4127	3779	4072	4177	4482	4380	4443	4693	4591	4591	4846
6	3955	3678	3970	4074	4381	4174	4236	4487	4385	4436	4690
7	3795	3575	3867	3970	4279	3968	4043	4277	4180	4281	4484
8	3637	3470	3764	3865	4177	3761	4043	4277	4180	4281	4484
9	3637	3470	3764	3865	4177	—	—	—	—	—	—
10	3436	3367	3661	3763	4023	3556	3835	4070	3973	4075	4279
11	3239	3264	3506	3660	3767	3556	3626	3862	3769	3768	4071
12	2906	3163	3352	3503	3502	3352	3418	3654	3564	3460	3766
13	2626	2967	3146	3346	3248	3150	3114	3447	3256	3154	3458
14	2326	2721	2942	3140	2982	2947	2810	3142	2950	2847	3149
15	2326	2471	2740	2835	2742	2744	2499	2838	2644	2541	2741
16	2022	2222	2537	2531	2390	2540	2095	2534	2236	2236	2741
17	1721	1975	2537	2531	2034	2031	2095	2129	2236	2236	2333
18	1418	1975	2130	2021	2034	2031	1595	2129	1676	1725	1722
19	1012	1678	1724	1515	1627	1622	1102	1521	1118	1118	1218
20	709	1193	1319	1114	1218	1117	806	1116	813	811	811
21	407	702	914	653	812	505	406	507	404	407	407
22	206	210	508	500	407	—	—	—	—	—	—
23	15	11	15	14	15	14	14	13	15	15	14
24	15	11	15	14	15	14	14	13	15	15	14

Table 3. ***Preliminary data return from current meters***

Rig No.	Position	Sounding (m)	Meter No.	Meter Type	Meter depth (m)	Ht. above bed (m)	Start time Final time	Good data Days	Good data Hr.	Timing Error (min.)
West of Crozet										
9318-1	46 26.23 S 47 59.67 E	3057	128	RCM5	2276	781	1530 11-3-93 0330 12-3-93	0	11	0
-2			192	RCM5	3011	46	1530 11-3-93 0230 27-2-94	352	10	-60
Crozet- Kerguelen										
9317-1	46 50.52 S 53 20.27 E	3345	213	RCM7	1664	1681	1330 10-3-93 0138 04-3-94	358	12	-8
-2			825	RCM5	2764	581	1330 10-3-93 1230 12-3-93	1	23	0
-3			146	RCM8	3299	46	1330 10-3-93 0246 04-3-94	358	11	-16
9315-1	47 01.24 S 53 05.31 E	3809	553	RCM7	2179	1630	1330 09-3-93 0646 03-3-94	358	17	-16
-2			523	RCM5	2707	1102	1530 09-3-93 0538 03-3-94	358	15	+52
-3			442	RCM5	3235	574	1530 09-3-93 0520 03-3-94	358	15	+70
-4			279	RCM7	3763	46	1330 09-3-93 0636 03-3-94	358	17	-6
9313-1	47 24.96 S 55 36.55 E	4141	555	RCM7	2294	1847	1630 08-3-93 1214 04-3-94	360	19	-44
-2			606	RCM5	3039	1102	1730 08-3-93 1234 04-3-94	360	19	-4
-3			278	RCM5	3567	574	1730 08-3-93 1430 19-8-93	163	21	0
-4			546	RCM7	4095	46	1730 08-3-93 1245 04-3-94	360	19	-15
9312-1	47 36.95 S 56 48.36 E	4427	178	RCM5	1747	2680	1330 07-3-93 0135 05-3-94	362	12	-5
-2			607	RCM5	2800	1627	1130 07-3-93 0930 16-1-93	314	22	0
-3			703	RCM5	3853	574	1130 07-3-93 1530 16-6-93	101	4	0
-4			638	RCM8	4381	46	1130 07-3-93 0142 05-3-94	362	14	-12
9311-1	47 45.28 S 58 02.80 E	4240	10856	RCM7	325	3915	1830 06-3-93 1037 21-3-94	379	16	-7
-2			10862	RCM7	626	3614	1730 06-3-93 1040 21-3-94	379	17	-10
-3			9967	RCM8	1345	2895	1630 06-3-93 1040 21-3-94	379	18	-10
-4			9968	RCM8	2073	2167	1630 06-3-93 1039 21-3-94	379	18	-9
-5			238	RCM8	2176	2064	1630 06-3-93 1043 21-3-94	379	18	-13
-6			652	RCM5	2862	1378	1830 06-3-93 1023 21-3-94	379	17	+67
-7			331	RCM5	3678	562	1830 06-3-93 1130 31-10-93	238	17	0
-8			942	RCM8	4194	46		Meter lost		

Table 3. continued

Rig No.	Position	Sounding (m)	Meter No.	Meter Type	Meter depth (m)	Ht. above bed (m)	Start time Final time	Good data Days	Good data Hr.	Timing Error (min.)
Crozet-Kerguelen (cont.)										
9310-1	48 00.13 S 58 38.16 E	4478	855	RCM5	2065	2413	0930 06-3-93 0230 07-3-94	365	17	0
-2			644	RCM5	3905	573	0930 06-3-93 0215 07-3-94	365	16	+15
-3			965	RCM8	4432	46	0830 06-3-93 0240 07-3-94	365	18	-10
9309-1	48 11.91 S 59 37.65 E	4393	155	RCM4	1655	2738	1430 05-3-93 1236 07-3-94	366	22	-6
-2			696	RCM5	2823	1570	1630 05-3-93 2235 11-8-94	159	6	-5
-3			109	RCM5	3630	763		No data		
-4			981	RCM8	4347	46	1330 05-3-93 1243 07-3-94	366	23	-13
9306-1	48 34.77 S 61 30.77 E	3565	801	RCM5	1890	1675	1430 04-3-93 0036 08-3-94	368	17	-66
-2			933	RCM5	3519	46	1430 07-3-93 0530 21-11-93	261	15	0
Princess Elizabeth Trough										
9305-1	64 22.65 S 84 41.64 E	3654	490	RCM5	2692	962	1730 25-2-93 0630 13-3-94	380	13	0
-2			879	RCM5	3223	431	1830 25-2-93 0134 15-3-94	382	7	-4
-3			924	RCM5	3608	46	1830 25-2-93 0130 24-3-93	26	7	0
9304-1	64 49.23 S 85 07.82 E	3367	562	RCM5	2790	577	1230 25-2-93 1230 28-11-93	276	0	0
-2			768	RCM5	3321	46		No data		
9303-1	63 56.01 S 84 19.12 E	3700	2	RCM5	2976	724	1430 24-2-93 1139 13-3-94	381	21	-9
-2			46	RCM5	3395	305	1430 24-2-93 1126 13-3-94	381	21	4
-3			73	RCM5	3654	46		No data		
9302-1	63 29.82 S 83 57.19 E	3048	124	RCM5	2204	844	1030 24-2-93 0833 13-3-94	381	21	-63
-2			373	RCM5	2732	316	1130 24-2-93 0656 13-3-94	381	20	+34
-3			898	RCM5	3002	46	1130 24-2-93 1030 21-2-94	361	23	0
9301-1	63 03.21 S 83 35.41 E	2636	37	RCM5	2103	533	0730 24-2-93 0336 13-3-94	381	20	-6
-2			476	RCM5	2590	46	0630 24-2-93 0314 13-3-94	381	20	-54

Moorings 9308 and 9314 were lost
Moorings 9307 and 9316 were bottom pressure gauges only

Table 4. XBT drop list

Drop	Date (Day)	Time (GMT)	Lat. (S)	Long. (E)	Type	Xmitted	Comments
1	20-II (51)	20 16	37 45.77	023 08.11	T7	No	No profile recorded
2	20-II (51)	20 30	37 47.72	023 10.58	T7	No	No profile recorded
3	21-II (52)	00 01	38 14.67	023 53.27	T7	Yes	
5	21-II (52)	04 02	38 44.49	024 33.62	T7	Yes	
6	21-II (52)	08 04	39 12.38	025 13.36	T7	Yes	
7	21-II (52)	12 03	39 41.55	025 58.41	T7	Yes	
8	21-II (52)	16 00	40 09.40	026 42.19	T7	Yes	
9	21-II (52)	20 02	40 40.55	027 27.26	T7	Yes	
10	21-II (52)	23 51	41 10.62	028 15.50	T7	No	Failed; initial temp too low
11	21-II (52)	23 58	41 11.49	028 17.04	T7	Yes	
12	22-II (53)	03 58	41 44.91	029 07.21	T7	Yes	
13	22-II (53)	08 50	42 06.08	029 41.90	T7	No	Failed; thermal shock
14	22-II (53)	10 50	42 20.00	030 06.93	T7	No	Profile not saved
15	22-II (53)				Test	No	
16	22-II (53)				Test	No	
17	22-II (53)	15 11	42 44.66	030 43.57	T7	Yes	
18	22-II (53)	19 10	43 17.82	031 34.88	T7	Yes	
19	22-II (53)	21 54	43 40.89	032 10.55	T7	Yes	
20	23-II (54)	02 00	44 15.00	033 04.90	T7	Yes	
21	23-II (54)	06 13	44 50.96	033 59.54	T7	Yes	
22	23-II (54)	09 51	45 19.99	034 47.05	T7	Yes	
23	23-II (54)	14 09	45 56.12	035 45.05	T7	Yes	
24	23-II (54)	17 55	46 27.51	036 36.71	T7	Yes	
25	23-II (54)	21 51	47 00.98	037 30.58	T7	Yes	
26	24-II (55)	02 01	47 36.70	038 33.57	T7	Yes	
27	24-II (55)	06 04	48 11.80	039 37.95	T7	Yes	
28	24-II (55)	09 50	48 43.56	040 35.15	T7	Yes	
29	24-II (55)	14 01	49 17.92	041 37.69	T7	Yes	
30	25-II (56)	02 03	48 51.77	042 41.24	T7	No	Failed
31	25-II (56)	02 16	48 49.60	042 43.92	T7	Yes	
32	25-II (56)	09 48	48 16.90	043 20.69	T7	Yes	
33	25-II (56)	21 46	46 53.37	044 41.57	T7	Yes	
34	26-II (57)	02 11	46 36.16	044 59.93	T7	Yes	
35	26-II (57)	07 23	46 31.92	045 14.85	T5	Yes	
36	26-II (57)	09 53	46 22.41	045 39.67	T7	Yes	
37	26-II (57)	13 54	46 06.71	046 20.97	T7	Yes	
38	26-II (57)	18 04	45 49.15	047 02.30	T7	Yes	
39	26-II (57)	21 51	45 34.83	047 37.76	T7	Yes	
40	27-II (58)	05 55	45 03.16	048 24.89	T7	No	Failed
41	27-II (58)	06 00	45 02.40	048 25.94	T7	Yes	
42	27-II (58)	09 52	44 25.98	049 10.27	T7	Yes	
43	27-II (58)	14 24	43 42.65	050 03.69	T7	Yes	
44	27-II (58)	21 49	43 16.16	051 00.79	T7	No	Failed; initial temp too low
45	27-II (58)	21 54	43 16.02	051 02.06	T7	Yes	
46	28-II (59)	06 26	43 09.91	052 26.87	T7	Yes	
47	28-II (59)	14 00	43 09.11	053 45.60	T7	Yes	
48	01-III (60)	10 07	43 10.92	054 46.00	T7	Yes	
49	01-III (60)	17 01	43 38.50	055 08.03	T7	No	Failed; initial temp too low
50	01-III (60)	17 05	43 39.33	055 08.03	T7	Yes	
51	01-III (60)	19 04	44 04.69	055 08.70	T7	Yes	
52	01-III (60)	20 58	44 29.03	055 08.05	T7	Yes	
53	01-III (60)	22 58	44 54.94	055 08.04	T7	Yes	
	02-III (61)	01 11	45 23.34	055 07.46	T7	No	Failed
54	02-III (61)	01 18	45 24.85	055 07.41	T7	Yes	
55	02-III (61)	03 02	45 47.53	055 08.26	T7	Yes	
56	02-III (61)	05 00	46 12.87	055 05.98	T7	Yes	
57	02-III (61)	06 57	46 38.02	055 06.79	T7	Yes	
58	02-III (61)	08 51	47 02.46	055 06.84	T7	Yes	
59	03-III (62)	01 05	47 06.49	055 01.99	T7	No	
60	03-III (62)	10 12	46 58.23	053 52.65	T7	Yes	

Table 4. continued

Drop	Date (Day)	Time (GMT)	Lat. (S)	Long. (E)	Type	Xmitted	Comments
61	04-III (63)	06 47	47 01.43	054 06.24	T7	No	Failed
62	04-III (63)	06 56	47 02.02	054 08.84	T7	Yes	
63	04-III (63)	09 38	47 06.52	054 57.40	T7	Yes	
64	05-III (64)	00 56	47 32.00	056 20.56	T7	Yes	
65	05-III (64)	06 11	47 38.91	057 04.86	T7	No	Failed
66	05-III (64)	06 15	47 39.01	057 06.06	T7	Yes	
67	05-III (64)	12 05	47 43.46	057 53.48	T7	Yes	
68	05-III (64)	21 41	47 51.13	058 13.47	T7	Yes	
69	08-III (67)	15 13	48 32.33	061 11.88	T7	Yes	
70	08-III (67)	19 25	48 59.85	062 10.99	T5	No	Very spikey profile
71	09-III (68)	04 19	50 03.17	064 21.74	T5	Yes	
72	09-III (68)	08 39	50 32.78	065 24.74	T5	Yes	
73	09-III (68)	13 12	51 01.68	066 33.26	T5	Yes	Unreliable (T too low)
74	09-III (68)	17 37	51 31.13	067 39.20	T5	No	PC screen died
75	10-III (69)	02 17	52 38.54	069 49.12	T5	No	Failure
76	10-III (69)	02 20	52 38.74	069 49.66	T5	No	Wire ran out 1700m
77	10-III (69)	05 27	53 01.78	070 38.67	T5	No	
78	10-III (69)	09 09	53 28.92	071 37.51	T5	Yes	
79	10-III (69)	13 41	54 02.62	072 51.04	T5	No	
80	10-III (69)	16 39	54 31.50	073 29.10	T5	Yes	Large spike at 350m
81	10-III (69)	19 35	55 01.42	073 59.54	T5	Yes	Large spike at 170m
82	10-III (69)	22 35	55 29.43	074 29.13	T5	No	Large spike at 120m
83	11-III (70)	01 43	56 01.76	075 03.49	T5	Yes	
84	11-III (70)	04 49	56 33.17	075 37.39	T5	No	
85	11-III (70)	07 53	56 59.70	076 09.08	T5	Yes	Wire blown across deck
86	11-III (70)	11 29	57 28.60	076 38.27	T5	Yes	
87	11-III (70)	15 18	58 00.23	077 17.89	T5	No	Failure
88	11-III (70)	15 26	58 00.80	077 18.74	T5	No	Large spike at 450m
89	11-III (70)	20 41	58 29.71	077 52.06	T5	Yes	
90	12-III (71)	01 27	59 01.03	078 32.00	T7	No	
91	12-III (71)	04 44	59 31.38	079 08.42	T5	Yes	
92	12-III (71)	07 38	60 00.77	079 40.53	T5	Yes	
93	12-III (71)	10 32	60 29.75	080 16.27	T5	No	Bird hit wire
94	12-III (71)	13 39	61 01.38	080 59.66	T5	No	Transmitter buffer is
95	12-III (71)	16 47	61 31.02	081 37.51	T5	No	permanently full
96	12-III (71)	21 08	61 59.67	082 10.67	T5	No	
97	13-III (72)	01 13	62 29.98	082 51.05	T5	No	
98	13-III (72)	06 51	63 08.12	083 38.51	T5	No	
99	13-III (72)	08 55	63 29.86	083 57.95	T5	No	
100	13-III (72)	15 41	64 02.61	084 26.91	T5	No	
101	13-III (72)	21 58	64 30.24	084 50.71	T7	No	
102	14-III (73)	05 22	65 24.72	084 31.44	T5	No	Water depth 390m
103	14-III (73)	07 48	65 53.73	084 20.70	T7	No	
104	14-III (73)	18 27	65 13.58	084 34.90	T5	No	
105	14-III (73)	19 50	65 06.55	084 36.14	T5	No	
106	14-III (73)	23 31	64 46.31	084 38.50	T5	No	
107	15-III (74)	03 37	64 22.98	084 43.57	T5	No	Spike 870m, fail at 1400m
108	15-III (74)	07 45	63 43.02	083 29.05	T5	No	
109	15-III (74)	10 42	63 16.07	082 37.50	T5	No	
110	15-III (74)	14 22	62 44.79	081 40.97	T5	No	Failed; no trace on screen
111	15-III (74)	14 26	62 44.36	081 40.49	T5	No	
112	15-III (74)	18 46	62 13.96	080 51.66	T5	No	
113	15-III (74)	21 58	61 53.33	080 17.44	T7	No	
114	16-III (75)	02 09	61 22.67	079 22.45	T7	No	Failed; no trace on screen
115	16-III (75)	02 21	61 20.86	079 19.54	T7	No	
116	16-III (75)	06 31	60 42.72	078 17.95	T7	Yes	Transmitter buffer emptied
117	16-III (75)	09 58	60 11.61	077 27.41	T7	Yes	
118	16-III (75)	13 03	59 44.16	076 44.32	T5	No	Water depth 1240m
119	16-III (75)	16 55	59 09.74	075 46.12	T5	No	Water depth 1300m
120	16-III (75)	19 42	58 44.43	075 08.70	T5	No	Water depth 1400m

Table 4. continued

Drop	Date (Day)	Time (GMT)	Lat. (S)	Long. (E)	Type	Xmitted	Comments
121	16-III (75)	22 56	58 14.32	074 24.60	T5	Yes	
122	17-III (76)	02 03	57 45.32	073 41.69	T5	No	
123	17-III (76)	06 41	57 01.40	072 35.60	T7	Yes	
124	17-III (76)	09 55	56 30.67	071 53.86	T7	Yes	
125	17-III (76)	14 24	55 51.32	071 01.28	T7	Yes	
126	17-III (76)	16 46	55 30.78	070 29.49	T7	Yes	
127	18-III (77)	14 18	53 33.44	066 51.37	T7	Yes	
128	19-III (78)	02 09	52 41.55	065 31.15	T7	Yes	
129	19-III (78)	05 51	52 36.54	065 11.72	T7	Yes	
130	19-III (78)	10 06	52 02.03	064 33.12	T7	Yes	
131	19-III (78)	14 15	51 22.54	063 56.62	T7	Yes	
132	19-III (78)	17 55	50 49.54	063 27.09	T7	No	Failed
133	19-III (78)	18 18	50 46.26	063 23.73	T7	Yes	
134	20-III (79)	02 07	49 34.28	062 20.68	T7	Yes	
135	20-III (79)	06 29	48 55.51	061 44.27	T7	Yes	
136	22-III (81)	07 36	47 30.82	056 07.26	T7	Yes	
137	22-III (81)	08 52	47 24.13	055 49.54	T7	No	
138	22-III (81)	15 05	46 49.51	054 59.40	T5	No	Spikey at 950m
139	22-III (81)	18 52	46 07.23	054 41.75	T5	Yes	
140	22-III (81)	22 00	45 34.53	054 28.83	T5	No	Spikes at 400m, 1300m
141	23-III (82)	02 08	44 47.79	054 09.33	T5	Yes	
142	23-III (82)	06 30	43 57.22	053 49.30	T5	Yes	Spikes below 1500m
143	24-III (83)	19 06	42 45.20	056 25.07	T5	Yes	
144	24-III (83)	22 09	42 11.48	056 17.15	T5	No	Spike at 1650m
145	25-III (84)	02 02	41 25.22	056 05.41	T5	No	Spikey around 300m
146	25-III (84)	06 56	40 25.36	055 51.59	T5	Yes	
147	25-III (84)	09 56	39 57.34	055 44.68	T5	No	
148	25-III (84)	13 37	39 18.74	055 35.14	T5	No	
149	25-III (84)	18 33	38 21.05	055 22.51	T5	Yes	Spike at 1700m
150	25-III (84)	21 53	37 41.75	055 13.87	T5	No	
151	26-III (85)	02 14	36 49.26	055 02.48	T5	No	
152	26-III (85)	06 03	36 02.91	054 51.41	T7	Yes	
153	26-III (85)	09 52	35 40.58	054 46.55	T7	No	
154	26-III (85)	17 49	34 33.18	054 32.51	T7	Yes	
155	26-III (85)	21 48	33 41.63	054 19.80	T7	Yes	Spike at 350m
156	27-III (86)	02 34	32 40.44	054 08.04	T5	No	
157	27-III (86)	06 55	31 42.22	053 54.46	T7	Yes	
158	27-III (86)	09 53	31 02.87	053 46.20	T7	Yes	
159	27-III (86)	14 13	38 08.25	053 34.78	T7	No	
160	27-III (86)	21 49	29 30.58	053 47.98	T7	Yes	
161	28-III (87)	13 04	28 41.75	055 08.42	T7	Yes	
162	28-III (87)	21 21	28 15.18	055 51.25	T7	Yes	