# RRS CHARLES DARWIN CRUISE 78
## 22/04/1993 — 24/05/1993

# THE NORTH ATLANTIC TRACER RELEASE EXPERIMENT (NATRE): FINAL SAMPLING LEG

**Principal Scientist: A. J. Watson**
**Co-Principal Investigator: J. R. Ledwell**

Report prepared by: A. J. Watson, K. Van Scoy, J. R. Ledwell, C. S. Law,
D. Jones, C. Marquette, T. Donaghue, S. Watts, M. I. Liddicoat, C. Fernandez,
J. Bouthilette, D. Ciochetto, J. Donoghue, S. T. Bolmer,
K. Tedesco, K. Smith and J. Scott

*We are pleased to acknowledge the assistance of the staff of the RRS Charles Darwin under*
*Captain R. Bourne. Their hard work and professional skills helped ensure that this was a successful and enjoyable cruise.*

*Funding for NATRE is provided by the Natural Environment Research Council in the UK and the National Science Foundation in the USA.*

**PERSONNEL LIST**

| | |
|---|---|
| R. A. Bourne | Master |
| C. M. Leathe | C/O |
| P. Newton | 2/O |
| R. A. Warner | 2/O |
| J. G. Baker | R/O |
| I. R. Bennet | C/E |
| D. E. Anderson | 2/E |
| V. E. Lovell | 3/E |
| S. F. Dean | 3/E |
| M. Trevaskis | CPO |
| T. G. Lewis | PO |
| A. Marren | SG. 1A |
| S. Jones | SG. 1A |
| K. R. Luckhurst | SG. 1A |
| J. Miller | SG. 1B |
| C. Hubbard | S.C.M |
| K. Peters | COOK |
| R. Edes | STWD |
| A. P. Lee | STWD |
| J. P. Taylor | STWD |
| I. M. Slater | MM. 1A |
| A. J. Watson | Chief Scientist |
| C. S. Law | Scientist |
| M. I. Liddicoa | Scientist |
| K. Van Scoy | Scientist |
| S. T. Bolmer | Scientist |
| J. Bouthilette | Scientist |
| J. Donoghue | Scientist |
| T. Donoghue | Scientist |
| C. Fernande | Scientist |
| C. Marquette | Scientist |
| K. Tedesco | Scientist |
| D. Ciochetto | Scientist |
| J. Scott | Scientist |
| W. K. Smith | Scientist |
| D. A. Jones | Scientist |
| S. F. Watts | Scientist |
| J. R. Ledwell | Scientist |

## INTRODUCTION AND CRUISE OBJECTIVES

This cruise was the third and last scheduled tracer documentation cruise associated with the North Atlantic Tracer Release Experiment (NATRE). The experiment is a major international exercise under the auspices of the World Ocean Circulation Experiment, Core 3 programme, in which UK, US and Canadian scientists and ships are participating. Its object is to study the rates of both vertical and horizontal mixing in the main pycnocline of the Northeast Atlantic subtropical gyre, using a release of sulphur hexafluoride ($SF_6$) tracer, marked by neutrally buoyant floats, and accompanied by an extensive suite of measurements of micro- and fine-structure of the kind more conventionally used to infer rates of vertical mixing. By these means the existing techniques will be validated against a direct and accurate measurement of mixing processes associated with the tracer experiment. The experiment was initiated in April/May 1992 in a two-ship exercise in which the Woods Hole vessel R/V Oceanus released 139kg of tracer and the neutrally buoyant floats, while the Charles Darwin documented the distribution of the tracer in the first month after release (Cruise CD68). Subsequently, at six months after release, the Oceanus returned to the area and documented the distribution of about 25-33% of the tracer during October and November 1992, finding two lengthy streaks extending to about 600km in length and typically 3km wide by 18m thick. An accurate measure of the vertical mixing rate during the April-October period was obtained by comparison of the CD68 data with these Oceanus observations.

The task of the present cruise was to document the distribution of the tracer one year after release. In this we were assisted by the Canadian research vessel CSS Hudson, currently in the area conducting microstructure measurements as part of the overall experiment. Dr. James Ledwell, the Principal Scientist on the US component of the experiments, was aboard the Hudson and made some tracer measurements in advance of our cruise, so that we had information on the location of at least some of the tracer before we left port.

## NARRATIVE

Figure 1 shows the overall cruise track, from Ponta Delgada in the Azores to Lisbon. We sailed from Ponta Delgada at 0810 on 22nd April 1993, and made course 204°T for a previously agreed rendezvous with the CSS Hudson, at 26° 50'N, 31° 20'W. Hudson had to make an unscheduled journey to Las Palmas, due to a medical emergency, which set back their programme considerably. The original reason for the early rendezvous was to transfer analytical equipment to speed sample analysis. Dr. James Ledwell, at this time aboard the Hudson, was scheduled to transfer to Darwin but not before about 10th May when the Hudson would leave the NATRE site.

We kept a regular radio schedule with the Hudson throughout the period that the two ships were working. We were told that they had succeeded in locating some of the neutrally buoyant SOFAR floats originally released with the tracer, i.e. float 55 at 23°

50'N, 30° 20'W, and float 58 at 21° 20'N, 30° 30'W, in what might be the SE corner of the tracer patch. One float, to which was attached a Richardson Number (RiNo) neutrally buoyant float, appeared at that time to be at about 30°N, 37°W, in what might demarcate a NW corner. This position later proved to be incorrect, but nevertheless the assumption that the tracer lay mostly east and south of there was verified.

We arrived at the rendezvous in the early hours of 25th April, but continued past the Hudson, having elected to postpone transfer of equipment for a time. After crossing 29°N, we began exploratory casts through the target surface, spacing these approximately 50 miles apart. No tracer was found on the first three casts, but we encountered it on the fourth, which was at the original rendezvous point.

It was soon apparent that the tracer had spread into an enormous area of ocean: the concentrations we observed averaged about 25fM, with column integrals averaging around $2 \times 10^{-9}$ moles/m$^2$, and given the initial amount released of approximately 1000 moles this indicates a patch ~700km on a side. However the shape was not regular or simple, and the concentration varied widely even on the 10-20km scale. Given that we had very little information at the beginning of the cruise as to where this patch might be centred or what its shape might be, it was thought that it would not be possible to comprehensively document the entire patch. Instead we aimed to get a sufficient number of profiles, from many different areas of the patch, to be confident of a statistically valid description of properties such as the vertical thickness and streakiness. In the event however, we did end by accounting for more than 90% of the tracer.

Having approached the region on a course of 204°T we saw no reason to deviate after passing the Hudson, so continued on this heading for the better part of a week, finally running out of the patch at 21° 20'N latitude. We then executed a series of east-west sections spaced approximately 1 apart in latitude, heading northwards, (see cruise track for the working area, Figure 2). This pattern was designed to be complemented by the tracer measurements performed from the Hudson (see Figure 29 for a map of Hudson stations). The pattern was broken at about the time of our RiNo hunt (see below), to make a number of tows using a high-resolution sampling system, and towards the end of the cruise when we filled in corners in the north-west and south-east. We finished science at 1200 on 19th May and set course for Lisbon, docking there at 1700 on 24th May.

**Sampling Casts**

These were to 500m: on the downcast, the depth of the target isopycnal (actually at $\sigma_{0.3}$ = 28.050, though we used the previous year s calibration of the BBC microcomputer which gave $\sigma_{0.3}$ = 28.0395), was noted — it was generally between 300 and 400m depth. On the upcast, bottles were triggered at 10m intervals, starting 120m below the depth of the target surface and ending 120m above it. We found that the time taken for each cast was roughly an hour, which meant that at a spacing of 10 miles or more between casts, the limiting factor on the rate at which we could proceed was not the rate of processing samples in the laboratory, but the wire time and steam time. Stations were spaced initially at 10 mile intervals, but the standard spacing was increased to 15 miles after station 22 (Table 1). Stations were grouped into geographical working areas (Figure 3). Tracer and salt samples only were taken from the Niskin bottles, and the work continued 24 hours a day. We found that we could progress about 130 miles per day in this mode, with the ship on station and wire out for about half the time, and steaming at 10kt the other half of the time.

**Rendezvous with CSS Hudson**

On 6th May we broke off sampling to rendezvous with the Hudson, chiefly for the purpose of transferring Dr. Ledwell from the Hudson to the Darwin. Hudson at this time was continuing her programme of CTD and Epsonde microstructure casts for the overall experiment under the direction of Chief Scientist Neil Oakey of Bedford Institute of Oceanography. The rendezvous was at 1000, at 24° 58'N, 31° 6'W. The Master of the Hudson invited members of the Darwin s company over for lunch which was taken up by nine scientists and ships personnel including the PSO. We extended a reciprocal invitation, which was taken up by Dr. Oakey and several members of the science party aboard Hudson. Gifts were exchanged between the two ships companies. Dr. Ledwell transferred, and we took the opportunity to transfer a $SF_6$ gas standard from the Hudson to the Darwin to cross calibrate our measurements with theirs. We were finished with the transfer and pleasantries at about 1430 and departed to continue our programme.

**Hunt for the RiNo**

One of the aims of Hudson was to locate and recover the Richardson Number (RiNo) float deployed by Oceanus at the time of the tracer injection. RiNo is tracked by SOFAR signal, and at close range by means of a 10kHz beacon. We determined last year during cruise CD68 that the Simrad EA500 precision echo-sounder aboard the Darwin was an efficient instrument for sensing these beacons.

The task of recovering the RiNo was greatly hampered by what appears to have been a malfunction of the clock on the SOFAR beacon, which initially led the team aboard the Hudson to believe that the float was situated well to the west at about 36°W. Latterly, the best guess for the position of the float was thought to be near 26° 15'N, 29° 30'W. We offered to assist the Hudson in the search they were to undertake for this float after leaving our rendezvous, since the Simrad was thought to have a better range for the 10kHz beacon than the equipment aboard the Hudson. We agreed to search two lines out of a grid of 5 lines, covering a region about 8-18 miles NW of the most likely position of the float.

The search began at 1600 on 7th May and lasted until about 1300 the following day. The actual lines originally agreed with Hudson took only 8 hours. These are shown in Figure 4. However, as we were ending this pattern we saw a trace on the Simrad, lasting about 20 minutes, which looked characteristic of a beacon behind the ship. The trace was very faint, appearing and then disappearing without obvious cause. We therefore re-traced and re-retraced our course, running over the section on which the signal had appeared a total of four times, but without seeing it again. We then began a box-search pattern (Figure 5) centred on the location where we considered the source most likely to be, and continued this for 8 hours further, without at any time again seeing the signal. We remain unsure about the source of this signal, but we know of no phenomenon other than a regularly repeating beacon which could give rise to such a trace. Therefore we believe that we must have heard the float we were searching for, but perhaps due to freak acoustic conditions, at a distance very much greater than the normal range of the apparatus.

### Sled Tows using High-Resolution Carousel Sampler

Casts 220 through 223 were tows in which the CTD was mounted on a sled with sequentially filling syringe samplers. 50 samples were collected on each tow, but the distance covered varied from 8 to 65km (Table 2). The package was lowered on the CTD wire from the starboard A frame, and flown on the target surface by automated control of the winch, using the control system developed by R. Powell of RVS for cruise CD68. The longest tow entailed steaming at approximately 2kt, at which speed the wire angle was considerable (60-70° from the vertical). The tracks towed along are shown in Figure 6 and the along-track concentrations are shown in Figure 7: they reveal a pattern of plates of relatively constant concentrations of dimension ~10km, separated by rather sharp boundaries.

## CTD DATA

### Calibration

Hydrographic data were gathered with an EG&G MkIII CTD, equipped with PRT thermometers and a single conductivity probe. A laboratory temperature calibration performed just prior to the cruise indicated that the primary PRT was within 0.0005°C of the bath standard. No adjustment was made for a temperature offset.

Salinity samples taken on each cast showed the salinity reading from the system to be low by 0.028-0.029psu throughout the cruise. The constants in the acquisition system had already been set to compensate for a raw salinity that was low by 0.018psu. Thus, another 0.011psu were added to the salinity calculated using these constants.

The pressure sensor read high by 4.7db at the surface, and this amount was subtracted from all pressures throughout the cruise.

A sample profile and a $\theta$/S plot are shown in Figures 8 and 10, respectively.

### Data Reduction

The descent for each cast was selected from the CTD data stream, and made into a separate file named cd780xxx.dat , where xxx represents the number of the cast, from 001 to 241. These raw data were then interpolated to a 1db pressure grid and stored in files called cd780xxxpi.dat . At the same time the potential temperature $\theta_{0.3}$, and potential density $\sigma_{0.3}$, both referenced to 300db, were added to the files, in the 4th and 5th columns, respectively. A sixth column reports the number of scans skipped during the original file because the pressure was decreasing. Seldom was this number different from 0, since the weather was light, and the payout rate of the CTD wire was typically 60m/min.

The target $\sigma_{0.3}$ for the tracer release was 28.05kg/m$^3$. Hydrographic properties at this surface were estimated from the CTD data for each cast (Table 3), and vertical gradients in the properties were estimated for casts that went more than 50m below the target surface, as follows.

First, the nearest pressure to the target density surface was found, and a window spanning –50db about this pressure was selected. A quadratic fit of $\theta_{0.3}$ versus $\sigma_{0.3}$ in this window was performed, and the value of $\theta_{0.3}$ at the target surface was determined from the resulting polynomial. This procedure reduces the uncertainty in finding the target surface created by noise in salinity which propagates to potential density. The salinity at the target density was then found from the potential temperature, using the equation of state. Also, an accurate pressure at the target surface was found by interpolation.

Gradients of *in situ* temperature, dT/dP, and salinity, dS/dP, at the target surface were then determined by making quadratic fits of T(P) and S(P) in the –50db window about the target surface. The coefficient of thermal expansion, $\alpha$, the change of density with salinity, $\beta$, and the adiabatic lapse rate, $\Gamma$, were determined at the target surface. Then, a density gradient, $d\sigma/dp$, the density ratio, $R_\rho$, and the buoyancy frequency, N, were calculated from the following equations:

$\rho_0 = 1000 + \sigma_0$ $\qquad\qquad$ $\rho = 1000 + \sigma_3$

$$d\sigma/dP = \rho_0 \,[\alpha \{ -dT/dP + \Gamma \} + \beta \, dS/dP ]$$

$$R_\rho = \alpha \{ -dT/dP + \Gamma \} / \{ -\beta \, dS/dP \}$$

$$N = \mathrm{sqrt} \{ g \, (d\sigma/dP) / \rho \}$$

The values for P, $\theta_{0.3}$, S, -dT/dP, -dS/dP, $d\sigma/dP$, $R_\rho$, and N at the target density surface are given for each cast in Table 4.

The CTD casts were sorted into the same groups as the tracer data (Table 5). The data from each group were averaged, and the average data were treated the same way as above to give the properties and gradients for each group (Table 4).

The last entry in Table 4 gives the properties and gradients calculated from the average of the deep CTD profiles that went at least 50db deeper than the target surface for the whole cruise. This average CTD profile is tabulated every 10db in Table 3, and is plotted in Figure 9. A typical θ/S relation is plotted in Figure 10 and the mean θ/S relation is plotted in Figure 11.

## $SF_6$ DATA

### $SF_6$ Analysis

Water samples were analysed using two identical systems (A and B), each of which consisted of a vacuum-sparge front end in which the $SF_6$ was stripped from the water and trapped on Porapak Q at —70°C, followed by chromatographic separation and detection by an Electron Capture Detector (Shimadzu GC8-AIE). Both systems were fully automated requiring minimal input from the operator, and so reducing any errors arising from sample handling and manual valve-switching. Water from the Niskin bottles were sub-sampled into 500ml glass bottles which were flushed three times, and then transferred to the laboratory where they were stored underwater. The $SF_6$ concentration at the target density was obtained within 10 minutes of the CTD landing on deck, allowing alterations in the cruise track to be made relatively rapidly. A volume of 350ml was required for analysis of profile samples, although GC-B was adjusted to facilitate analysis of 50ml samples obtained from the carousel sampler for a period of 4 days towards the end of the cruise. A typical profile cast consisted of 25 samples, which at a rate of 6.75 minutes per sample resulted in a cast analysis time of 90 minutes; in total, 5000 water samples and 500 standards were run by a pool of 10 analysts.

The sensitivity of GC-A and B were 0.05 and 0.03fmol/l, respectively, although the background concentration was higher than these values. Samples from each profile were artificially divided, with the  tails  of the profile analysed on the more sensitive GC, and the middle of the profile on the less sensitive system. Duplicate samples from the target density were run on both instruments at the start of each cast analysis to determine an average reproducibility of 3.6% between the two instruments. This reproducibility is a reflection of the difference in calibration between the two instruments as opposed to variability in the efficiency of the analysis. The reproducibility within both GC s was 0.6% (A) and 0.88% (B) for duplicate samples (including background samples).

Calibration of each system took approximately 75 minutes every 36-48 hours, requiring certain casts to be run entirely on one system while the other was calibrated. The response of both instruments remained relatively constant (Table 6), except for the initial recovery of GC-A in the first 3 days from a previous contamination event on a recent cruise. Despite continuous analysis for 30 days, both instruments performed extremely well with virtually no down-time and minimal sample back-up. A valve driver board had to be replaced at the start of the cruise when a motor burnt out during start up on GC-A, and occasional maintenance was required to clean up salt crystal deposit in valves and solenoids on both systems. The gland in the 29.4ppt standard cylinder failed, although the calibration fitting programme was able to compensate for the absence of standards in this range.

### $SF_6$ Data Reduction

The $SF_6$ data were calibrated using a linear fit for samples less than 1.3 x $10^{-14}$ moles (300ppt in 1ml gas standard), smoothly joined to a cubic fit for higher values: previous work at PML has shown this to be the best polynomial type of fit to cover the range 0 to 5 x $10^{-13}$ moles. Calibrated data, identified by Niskin bottle number, were merged on the RVS computer with CTD data from the last frame before the bottle was closed. For each cast, a file was made tabulating pressure, temperature, salinity, $\sigma_{0.3}$, and $SF_6$ for each bottle. These files constitute a basic data output from the cruise.

For further analysis, the $SF_6$ profiles were interpolated onto a regular density grid (27.8 to 28.2 x 0.01) and averaged by regional group (Figure 3) to give statistics on mean concentration, depth and rms width. To obtain meaningful widths in depth (actually pressure) space, correctly referenced to the target surface, the mean pressure versus density profile of the initial sampling cruise CD68 was used to map $SF_6$ from density space into pressure. Individual profiles versus $\sigma_{0.3}$, these mean profiles versus CD68 depth, and the statistics of mean depth and rms width relative to the centre of mass are plotted in Figures 12-24. The interpolation could profitably have been continued to 28.3 as data from the lower tail were sometimes missed out of the interpolation.

The entire cruise average of casts interpolated from 27.8 to 28.3 is plotted in Figure 26. The centre of mass is at 28.058, 0.008 units lower than the original injection, and the rms width relative to the centre of mass is 31.14m in CD68 depth space. The width indicates a vertical mixing rate, $K_z$ in the range 0.17 to 0.2cm$^2$/s since the October-November period when the tracer was last sampled. This is significantly larger than the value of 0.11cm$^2$/s for the first 6 months of the experiment, presumably due to larger forcing energy during the winter months. The actual value of $K_z$ will be defined to better accuracy after post-cruise analysis. The average profile is almost a perfect gaussian (see Figure 27).

The lateral dispersion of the tracer, expressed as column integral in nmol/m$^2$, is shown in Figure 30 after gridding and contouring the data, using a 0.75 degree radius of integration. The tracer was spread over about 5-6 degrees of latitude and 9-10 degrees of longitude — an area in excess of 150000 square miles. Though still highly variable in space, there were few points within this region that had no tracer at all — in other words, the tracer streaks had combined to paint in this area. Integrating under the contours gives a total amount of 937 moles, which is less than 2% different from the 950 moles which were released. Ana alternative way of integrating the tracer, by obtaining an average concentration along the cruise track and multiplying by the overall area covered, gave essentially the same value. However, the margin of error is undoubtedly larger than these figures suggest. Provisionally we estimate that we accounted for 99–10%.

**TABLE 1: STATION LIST**

Notes:

1) Full casts were 24 bottle casts with approx 10m spacing centred on the target surface.
2) Short casts: one or two bottles were fired at the target surface only.
3) Background casts (2-4) were used as representative background measurements, the average of which was subtracted from the remainder in all calculations.
4) Sled casts (218-223) were tows along the target surface of the WHOI sled with carousel samplers.
5) The $SF_6$ column integral, background subtracted, is in nanomoles per square metre. est indicates it was estimated from the concentration at the target surface.
6) Casts 38-65 are numbered differently in the original cast sheets: original numbering is in brackets under cast type .

| Cast | Date | Time GMT | Latitude | Longitude | Cast type | $SF_6$ Column Integral |
|---|---|---|---|---|---|---|
| 1 | 22/04/93 | 19:23 | 35 55.76N | 26 38.05W | background | 0.00 |
| 2 | 24/04/93 | 13:36 | 29 0.32N | 30 14.82W | background | 0.00 |
| 3 | 24/04/93 | 19:14 | 28 17.12N | 30 36.97W | background | 0.00 |
| 4 | 25/04/93 | 00:44 | 27 33.24N | 30 58.01W | background | 0.00 |
| 5 | 25/04/93 | 06:26 | 26 49.86N | 31 20.12W | full | 2.69 |
| 6 | 25/04/93 | 09:27 | 26 32.01N | 31 27.75W | full | 3.92 |
| 7 | 25/04/93 | 11:49 | 26 22.21N | 31 32.92W | full | 2.04 |
| 8 | 25/04/93 | 14:00 | 26 13.14N | 31 37.98W | full | 1.28 |
| 9 | 25/04/93 | 16:00 | 26 4.20N | 31 42.89W | full | 0.86 |
| 10 | 25/04/93 | 18:16 | 25 54.99N | 31 47.06W | full | 1.72 |
| 11 | 25/04/93 | 20:42 | 25 45.90N | 31 51.47W | full | 2.01 |
| 12 | 25/04/93 | 23:00 | 25 35.82N | 31 56.38W | full | 2.75 |
| 13 | 26/04/93 | 01:02 | 25 26.93N | 32 0.83W | full | 1.19 |
| 14 | 26/04/93 | 03:07 | 25 18.23N | 32 4.88W | full | 1.50 |
| 15 | 26/04/93 | 05:31 | 25 8.85N | 32 9.92W | full | 0.52 |
| 16 | 26/04/93 | 08:02 | 24 59.63N | 32 14.25W | full | 2.59 |
| 17 | 26/04/93 | 10:48 | 24 50.34N | 32 18.02W | full | 6.03 |
| 18 | 26/04/93 | 13:04 | 24 41.23N | 32 22.68W | full | 4.42 |
| 19 | 26/04/93 | 15:25 | 24 32.11N | 32 27.71W | full | 6.23 |
| 20 | 26/04/93 | 17:39 | 24 23.11N | 32 32.14W | full | 2.86 |
| 21 | 26/04/93 | 19:52 | 24 13.65N | 32 36.36W | full | 0.59 |
| 22 | 26/04/93 | 22:22 | 24 4.95N | 32 40.88W | full | 0.87 |
| 23 | 27/04/93 | 01:03 | 23 50.89N | 32 47.14W | full | 1.06 |
| 24 | 27/04/93 | 03:41 | 23 37.28N | 32 53.94W | full | 0.39 |
| 25 | 27/04/93 | 06:24 | 23 23.11N | 32 59.93W | full | 2.74 |
| 26 | 27/04/93 | 09:08 | 23 9.27N | 33 6.79W | full | 3.12 |
| 27 | 27/04/93 | 11:55 | 22 55.06N | 33 13.27W | full | 0.76 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 28 | 27/04/93 | 14:32 | 22 41.09N | 33 19.71W | full | 1.22 |
| 29 | 27/04/93 | 17:05 | 22 28.21N | 33 25.99W | full | 1.89 |
| 30 | 27/04/93 | 19:50 | 22 14.43N | 33 32.51W | full | 2.76 |
| 31 | 27/04/93 | 22:30 | 22 0.48N | 33 39.01W | full | 0.82 |
| 32 | 28/04/93 | 01:08 | 21 46.66N | 33 45.25W | full | 0.40 |
| 33 | 28/04/93 | 04:15 | 21 32.12N | 33 51.87W | full | 0.05 |
| 34 | 28/04/93 | 06:53 | 21 19.02N | 33 58.91W | short | 0.00 |
| 35 | 28/04/93 | 10:43 | 21 19.29N | 33 26.90W | short | 0.00 |
| 36 | 28/04/93 | 14:09 | 21 18.94N | 32 54.44W | short | 0.00 |
| 37 | 28/04/93 | 17:40 | 21 19.02N | 32 22.36W | short | ? |
| 38 | 28/04/93 | 18:18 | 21 19.47N | 32 22.33W | full (37i) | 0.39 |
| 39 | 28/04/93 | 22:04 | 21 18.96N | 31 50.27W | short (38) | ? |
| 40 | 28/04/93 | 22:42 | 21 19.15N | 31 50.21W | full (38i) | 0.31 |
| 41 | 29/04/93 | 01:48 | 21 42.17N | 31 49.96W | full (39) | 0.42 |
| 42 | 29/04/93 | 05:04 | 22 6.08N | 31 50.24W | full (40) | 0.08 |
| 43 | 29/04/93 | 08:23 | 22 29.97N | 31 50.41W | full (41) | 0.49 |
| 44 | 29/04/93 | 10:46 | 22 29.94N | 32 4.29W | full (42) | 0.45 |
| 45 | 29/04/93 | 13:17 | 22 30.19N | 32 20.10W | full (43) | 0.82 |
| 46 | 29/04/93 | 15:53 | 22 29.95N | 32 36.18W | full (44) | 0.87 |
| 47 | 29/04/93 | 18:30 | 22 29.98N | 32 52.04W | full (45) | 0.36 |
| 48 | 29/04/93 | 21:24 | 22 30.00N | 33 7.87W | full (46) | 0.91 |
| 49 | 30/04/93 | 01:17 | 22 30.15N | 33 40.17W | full (47) | 1.58 |
| 50 | 30/04/93 | 04:17 | 22 29.55N | 33 55.96W | full (48) | 0.92 |
| 51 | 30/04/93 | 07:07 | 22 29.61N | 34 11.94W | full (49) | 0.32 |
| 52 | 30/04/93 | 09:47 | 22 29.77N | 34 28.17W | full (50) | 0.20 |
| 53 | 30/04/93 | 12:18 | 22 29.94N | 34 43.96W | full (51) | 0.26 |
| 54 | 30/04/93 | 14:36 | 22 29.53N | 34 59.84W | full (52) | 0.16 |
| 55 | 30/04/93 | 17:00 | 22 29.87N | 35 16.20W | full (53) | 0.00 |
| 56 | 30/04/93 | 19:50 | 22 44.97N | 35 16.10W | full (54) | 0.12 |
| 57 | 30/04/93 | 22:26 | 22 59.98N | 35 16.04W | full (55) | 0.02 |
| 58 | 1/05/93 | 01:01 | 23 15.37N | 35 16.06W | full (56) | 0.00 |
| 59 | 1/05/93 | 03:24 | 23 30.32N | 35 16.25W | full (57) | 0.84 |
| 60 | 1/05/93 | 06:02 | 23 29.87N | 34 59.76W | full (58) | 0.09 |
| 61 | 1/05/93 | 08:35 | 23 30.05N | 34 44.04W | full (59) | 0.00 |
| 62 | 1/05/93 | 12:37 | 23 30.23N | 34 12.37W | full (60) | 0.08 |
| 63 | 1/05/93 | 15:00 | 23 30.11N | 33 55.54W | short (61) | 0.00 |
| 64 | 1/05/93 | 16:58 | 23 30.12N | 33 39.35W | short (62) | 0.00 |
| 65 | 1/05/93 | 17:29 | 23 30.46N | 33 39.37W | full (63) | 0.45 |
| 100 | 1/05/93 | 19:49 | 23 30.13N | 33 23.00W | full | 0.02 |
| 101 | 1/05/93 | 22:21 | 23 29.87N | 33 7.04W | full | 2.75 |
| 102 | 2/05/93 | 00:57 | 23 30.15N | 32 50.57W | full | 0.46 |
| 103 | 2/05/93 | 03:16 | 23 37.53N | 32 58.18W | full | 3.58 |
| 104 | 2/05/93 | 05:27 | 23 45.03N | 32 58.64W | full | 1.35 |
| 105 | 2/05/93 | 07:29 | 23 44.93N | 33 6.78W | full | 2.77 |
| 106 | 2/05/93 | 09:56 | 23 37.29N | 33 15.21W | full | 0.79 |
| 107 | 2/05/93 | 11:42 | 23 37.57N | 33 6.84W | full | 3.34 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 108 | 2/05/93 | 15:09 | 23 37.60N | 32 39.58W | full | 0.65 |
| 109 | 2/05/93 | 18:07 | 23 30.14N | 32 24.00W | full | 3.15 |
| 110 | 2/05/93 | 20:48 | 23 29.98N | 32 8.16W | full | 2.53 |
| 111 | 3/05/93 | 01:32 | 23 30.48N | 31 51.76W | full | 2.35 |
| 112 | 3/05/93 | 04:38 | 23 30.15N | 31 35.33W | full | 0.93 |
| 113 | 3/05/93 | 07:15 | 23 29.91N | 31 19.21W | full | 3.67 |
| 114 | 3/05/93 | 09:51 | 23 30.13N | 31 3.01W | full | 1.27 |
| 115 | 3/05/93 | 12:25 | 23 30.28N | 30 46.78W | full | 1.33 |
| 116 | 3/05/93 | 16:37 | 23 30.02N | 30 30.26W | full | 4.14 |
| 117 | 3/05/93 | 19:21 | 23 30.13N | 30 14.22W | full | 1.05 |
| 118 | 3/05/93 | 22:12 | 23 29.90N | 29 58.16W | full | 3.39 |
| 119 | 4/05/93 | 00:47 | 23 30.31N | 29 41.69W | full | 0.48 |
| 120 | 4/05/93 | 03:46 | 23 30.26N | 29 25.19W | full | 0.18 |
| 121 | 4/05/93 | 06:32 | 23 29.94N | 29 8.74W | full | 0.23 |
| 122 | 4/05/93 | 09:08 | 23 30.13N | 28 52.45W | full | 0.00 |
| 123 | 4/05/93 | 11:53 | 23 30.22N | 28 36.17W | full | 0.14 |
| 124 | 4/05/93 | 14:28 | 23 30.18N | 28 19.51W | full | 0.45 |
| 125 | 4/05/93 | 16:59 | 23 30.15N | 28 3.37W | full | 0.28 |
| 126 | 4/05/93 | 19:36 | 23 45.04N | 27 59.84W | full | 0.35 |
| 127 | 4/05/93 | 22:28 | 23 59.94N | 27 59.82W | full | 0.27 |
| 128 | 5/05/93 | 02:52 | 24 29.94N | 27 59.99W | full | 0.32 |
| 129 | 5/05/93 | 06:03 | 24 29.92N | 28 16.51W | full | 0.41 |
| 130 | 5/05/93 | 08:31 | 24 30.23N | 28 32.88W | full | 1.85 |
| 131 | 5/05/93 | 10:40 | 24 30.12N | 28 43.86W | full | 3.30 |
| 132 | 5/05/93 | 12:50 | 24 30.12N | 28 54.91W | full | 3.55 |
| 133 | 5/05/93 | 15:22 | 24 30.35N | 29 11.29W | full | 1.79 |
| 134 | 5/05/93 | 18:16 | 24 30.02N | 29 27.76W | full | 2.02 |
| 135 | 5/05/93 | 20:44 | 24 29.89N | 29 44.46W | full | 8.70 |
| 136 | 5/05/93 | 23:10 | 24 29.87N | 30 0.42W | full | 0.49 |
| 137 | 6/05/93 | 01:37 | 24 29.82N | 30 17.06W | full | 4.34 |
| 138 | 6/05/93 | 04:05 | 24 30.18N | 30 33.54W | full | 3.87 |
| 139 | 6/05/93 | 06:15 | 24 29.87N | 30 50.15W | full | 2.01 |
| 140 | 6/05/93 | 16:19 | 24 44.97N | 31 6.41W | full | 1.22 |
| 141 | 6/05/93 | 18:47 | 24 30.04N | 31 6.60W | full | 3.59 |
| 142 | 6/05/93 | 21:44 | 24 45.02N | 30 50.01W | full | 1.28 |
| 143 | 7/05/93 | 00:14 | 24 58.27N | 30 43.64W | full | 1.00 |
| 144 | 7/05/93 | 02:40 | 25 12.62N | 30 36.85W | full | 0.72 |
| 145 | 7/05/93 | 04:54 | 25 26.47N | 30 29.98W | full | 0.39 |
| 146 | 7/05/93 | 07:12 | 25 39.96N | 30 23.01W | full | 3.46 |
| 147 | 7/05/93 | 09:30 | 25 53.79N | 30 16.13W | full | 0.09 |
| 148 | 7/05/93 | 11:52 | 26 7.81N | 30 9.63W | full | 0.00 |
| 149 | 7/05/93 | 14:11 | 26 7.89N | 29 53.16W | full | 0.18 |
| 150 | 7/05/93 | 17:44 | 26 21.70N | 29 35.85W | short | |
| 151 | 8/05/93 | 09:54 | 26 22.09N | 29 35.00W | full | 0.16 |
| 152 | 8/05/93 | 12:52 | 26 22.45N | 29 52.44W | full | 0.05 |
| 153 | 8/05/93 | 15:12 | 26 22.27N | 30 9.20W | full | 0.00 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 154 | 8/05/93 | 17:37 | 26 22.20N | 30 26.05W | full | 0.04 | |
| 155 | 8/05/93 | 20:15 | 26 22.08N | 30 46.86W | full | 0.12 | |
| 156 | 8/05/93 | 22:37 | 26 8.94N | 30 53.88W | full | 0.00 | |
| 157 | 9/05/93 | 00:53 | 25 54.57N | 31 0.29W | full | 0.01 | |
| 158 | 9/05/93 | 03:12 | 25 41.18N | 31 7.24W | full | 0.00 | |
| 159 | 9/05/93 | 05:27 | 25 27.04N | 31 14.19W | full | 1.22 | |
| 160 | 9/05/93 | 07:35 | 25 13.08N | 31 20.52W | full | 3.44 | |
| 161 | 9/05/93 | 10:14 | 24 59.22N | 31 27.05W | full | 2.08 | |
| 162 | 9/05/93 | 12:26 | 24 45.92N | 31 34.06W | full | 5.14 | |
| 163 | 9/05/93 | 18:09 | 24 29.95N | 31 41.57W | full | 4.51 | |
| 164 | 9/05/93 | 20:39 | 24 29.94N | 31 57.76W | full | 2.91 | |
| 165 | 9/05/93 | 23:06 | 24 30.19N | 32 14.39W | full | 1.55 | |
| 166 | 10/05/93 | 01:26 | 24 30.02N | 32 30.90W | full | 0.60 | |
| 167 | 10/05/93 | 03:45 | 24 29.86N | 32 47.17W | full | 4.57 | |
| 168 | 10/05/93 | 05:50 | 24 29.91N | 32 58.05W | full | 4.48 | |
| 169 | 10/05/93 | 07:48 | 24 29.88N | 33 9.10W | full | 4.57 | |
| 170 | 10/05/93 | 09:44 | 24 30.10N | 33 19.79W | full | 5.58 | |
| 171 | 10/05/93 | 11:40 | 24 30.07N | 33 30.76W | full | 5.02 | |
| 172 | 10/05/93 | 13:41 | 24 30.07N | 33 41.89W | full | 5.01 | |
| 173 | 10/05/93 | 15:37 | 24 30.22N | 33 52.90W | full | 5.13 | |
| 174 | 10/05/93 | 17:40 | 24 30.26N | 34 4.20W | full | 3.99 | |
| 175 | 10/05/93 | 19:32 | 24 30.18N | 34 15.10W | full | 5.86 | |
| 176 | 10/05/93 | 21:35 | 24 29.95N | 34 26.12W | full | 4.27 | |
| 177 | 10/05/93 | 23:23 | 24 29.97N | 34 37.15W | full | 5.80 | |
| 178 | 11/05/93 | 01:13 | 24 30.07N | 34 47.81W | full | 3.18 | |
| 179 | 11/05/93 | 03:04 | 24 30.22N | 34 58.95W | full | 0.81 | |
| 180 | 11/05/93 | 05:33 | 24 30.13N | 35 15.35W | full | 0.08 | |
| 181 | 11/05/93 | 07:51 | 24 30.15N | 35 31.96W | full | 0.82 | |
| 182 | 11/05/93 | 10:12 | 24 29.70N | 35 48.40W | full | 3.02 | |
| 183 | 11/05/93 | 12:25 | 24 29.81N | 36 4.34W | full | 0.65 | |
| 184 | 11/05/93 | 14:51 | 24 29.66N | 36 20.84W | full | 1.23 | |
| 185 | 11/05/93 | 17:01 | 24 29.79N | 36 37.34W | full | 0.79 | |
| 186 | 11/05/93 | 19:14 | 24 29.93N | 36 53.64W | full | 0.03 | est. |
| 187 | 11/05/93 | 21:29 | 24 29.84N | 37 10.30W | full | 0.15 | |
| 188 | 11/05/93 | 23:55 | 24 44.42N | 37 10.58W | full | 0.08 | est. |
| 189 | 12/05/93 | 02:41 | 24 59.21N | 36 54.85W | full | 0.21 | |
| 190 | 12/05/93 | 05:10 | 25 14.43N | 36 53.99W | full | 0.11 | |
| 191 | 12/05/93 | 08:15 | 25 29.73N | 36 38.03W | full | 0.34 | |
| 192 | 12/05/93 | 10:40 | 25 44.79N | 36 37.70W | full | 0.28 | |
| 193 | 12/05/93 | 13:33 | 25 59.73N | 36 37.64W | full | 1.93 | |
| 194 | 12/05/93 | 16:06 | 26 15.06N | 36 37.91W | full | 1.98 | |
| 195 | 12/05/93 | 18:33 | 26 29.69N | 36 37.57W | full | 1.35 | |
| 196 | 12/05/93 | 21:05 | 26 44.87N | 36 37.67W | full | 0.01 | |
| 197 | 12/05/93 | 23:33 | 27 0.01N | 36 37.79W | full | 0.00 | |
| 198 | 13/05/93 | 02:44 | 27 15.18N | 36 20.85W | full | 0.05 | |
| 199 | 13/05/93 | 05:46 | 27 29.86N | 36 4.58W | full | 5.34 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 200 | 13/05/93 | 08:24 | 27 40.58N | 35 51.54W | full | 0.84 | |
| 201 | 13/05/93 | 10:59 | 27 40.90N | 35 34.65W | full | 1.27 | |
| 202 | 13/05/93 | 13:09 | 27 40.90N | 35 17.97W | full | 0.57 | |
| 203 | 13/05/93 | 15:28 | 27 40.87N | 35 0.17W | full | 0.64 | |
| 204 | 13/05/93 | 17:49 | 27 40.65N | 34 42.33W | full | 0.35 | |
| 205 | 13/05/93 | 20:10 | 27 25.86N | 34 37.53W | full | 1.70 | |
| 206 | 13/05/93 | 22:18 | 27 12.58N | 34 33.90W | full | 0.82 | |
| 207 | 14/05/93 | 00:23 | 27 0.10N | 34 30.00W | full | 1.59 | |
| 208 | 14/05/93 | 02:42 | 26 45.05N | 34 29.84W | full | 0.81 | |
| 209 | 14/05/93 | 04:56 | 26 30.18N | 34 30.03W | full | 0.61 | |
| 210 | 14/05/93 | 07:06 | 26 29.82N | 34 46.78W | full | 0.47 | |
| 211 | 14/05/93 | 09:16 | 26 30.18N | 35 3.49W | full | 1.42 | |
| 212 | 14/05/93 | 11:31 | 26 30.25N | 35 20.35W | full | 0.36 | |
| 213 | 14/05/93 | 13:45 | 26 30.00N | 35 35.99W | full | 1.72 | |
| 214 | 14/05/93 | 17:12 | 26 0.16N | 35 36.96W | full | 3.57 | |
| 215 | 14/05/93 | 19:28 | 25 45.11N | 35 36.88W | full | 5.07 | |
| 216 | 14/05/93 | 21:46 | 25 30.09N | 35 36.97W | full | 2.13 | |
| 217 | 15/05/93 | 01:22 | 25 7.46N | 35 15.12W | full | 1.29 | |
| 218 | 15/05/93 | 08:00 | 24 15.07N | 34 24.98W | sled (test) | | |
| 219 | 15/05/93 | 09:15 | 24 14.62N | 34 24.78W | sled (aborted) | | |
| 220 | 15/05/93 | 10:50 | 24 15.89N | 34 24.65W | sled tow | | |
| 221 | 15/05/93 | 16:00 | 24 19.73N | 34 24.60W | sled tow | | |
| 222 | 16/05/93 | 02:51 | 24 53.49N | 34 22.51W | sled tow | | |
| 223 | 16/05/93 | 21:10 | 23 37.08N | 32 39.92W | sled tow | | |
| 224 | 17/05/93 | 22:28 | 22 31.87N | 31 16.76W | full | 1.38 | |
| 225 | 18/05/93 | 00:44 | 22 27.30N | 31 2.35W | full | 0.84 | |
| 226 | 18/05/93 | 03:00 | 22 21.79N | 30 46.99W | full | 1.07 | |
| 227 | 18/05/93 | 05:13 | 22 16.28N | 30 31.72W | full | 0.81 | |
| 228 | 18/05/93 | 07:21 | 22 1.42N | 30 31.76W | full | 0.88 | |
| 229 | 18/05/93 | 09:37 | 21 46.39N | 30 31.61W | full | 1.12 | |
| 230 | 18/05/93 | 11:49 | 21 31.90N | 30 31.26W | full | 0.37 | |
| 231 | 18/05/93 | 13:54 | 21 20.62N | 30 31.87W | full | 0.00 | |
| 232 | 18/05/93 | 16:08 | 21 31.29N | 30 21.39W | full | 0.00 | |
| 233 | 18/05/93 | 18:15 | 21 41.67N | 30 9.95W | full | 0.00 | |
| 234 | 18/05/93 | 20:39 | 21 52.09N | 29 58.33W | full | 0.00 | |
| 235 | 18/05/93 | 22:49 | 22 1.94N | 29 46.81W | short | 0.00 | |
| 236 | 19/05/93 | 00:46 | 22 12.61N | 29 36.14W | short | 0.00 | |
| 237 | 19/05/93 | 02:41 | 22 23.16N | 29 24.42W | short | 0.00 | |
| 238 | 19/05/93 | 04:40 | 22 34.12N | 29 12.82W | short | 0.05 | est. |
| 239 | 19/05/93 | 06:35 | 22 44.04N | 29 1.53W | short | 0.07 | est. |
| 240 | 19/05/93 | 09:03 | 22 58.36N | 28 45.93W | short | 0.63 | est. |
| 241 | 19/05/93 | 11:35 | 23 12.60N | 28 30.50W | short | 0.62 | est. |

**TABLE II: Sled tow data**

| **Cast** | **Day, Time** | **Position** | | **Day, Time** | **Positon** | |
|---|---|---|---|---|---|---|
| | Start | Lat | Long | End | Lat | Long |
| 220 | 5/15, 11:13 | 24°15.8N | 34°25.2W | 5/15, 14:23 | 24°20.2N | 34°24.6W |
| 221 | 5/15, 16:33 | 24°20.4N | 34°24.1W | 5/16, 00:33 | 24°37.2N | 34°22.9W |
| 222 | 5/16, 03:08 | 24°53.3N | 34°22.1W | 5/16, 11:08 | 24°32.2N | 34°23.8W |
| 223 | 5/16, 21:30 | 23°36.7N | 32°39.9W | 5/17, 11:16 | 23°07.1N | 32°57.5W |

**TABLE III: Cruise-mean CTD profile, interpolated to 10m intervals.**

| **P** (dbar) | **T** (C) | **S** (PSU) | $\Theta_{0.3}$ (C) | $\sigma_{0.3}$ |
|---|---|---|---|---|
| 10.00 | 22.238 | 37.382 | 22.297 | 27.239 |
| 20.00 | 22.182 | 37.384 | 22.239 | 27.257 |
| 30.00 | 22.138 | 37.387 | 22.192 | 27.274 |
| 40.00 | 22.082 | 37.391 | 22.134 | 27.293 |
| 50.00 | 22.013 | 37.391 | 22.063 | 27.313 |
| 60.00 | 21.901 | 37.382 | 21.949 | 27.339 |
| 70.00 | 21.753 | 37.365 | 21.799 | 27.369 |
| 80.00 | 21.590 | 37.346 | 21.634 | 27.401 |
| 90.00 | 21.442 | 37.326 | 21.484 | 27.429 |
| 100.00 | 21.327 | 37.313 | 21.366 | 27.452 |
| 110.00 | 21.209 | 37.295 | 21.246 | 27.472 |
| 120.00 | 21.050 | 37.263 | 21.086 | 27.493 |
| 130.00 | 20.867 | 37.225 | 20.900 | 27.515 |
| 140.00 | 20.651 | 37.177 | 20.681 | 27.540 |
| 150.00 | 20.345 | 37.106 | 20.373 | 27.570 |
| 160.00 | 19.994 | 37.028 | 20.020 | 27.606 |
| 170.00 | 19.580 | 36.933 | 19.604 | 27.645 |
| 180.00 | 19.144 | 36.838 | 19.166 | 27.689 |
| 190.00 | 18.718 | 36.745 | 18.738 | 27.731 |
| 200.00 | 18.377 | 36.675 | 18.395 | 27.766 |
| 210.00 | 18.085 | 36.617 | 18.101 | 27.797 |
| 220.00 | 17.825 | 36.567 | 17.839 | 27.825 |
| 230.00 | 17.578 | 36.520 | 17.590 | 27.852 |
| 240.00 | 17.339 | 36.476 | 17.349 | 27.878 |
| 250.00 | 17.112 | 36.434 | 17.120 | 27.902 |
| 260.00 | 16.892 | 36.394 | 16.899 | 27.925 |
| 270.00 | 16.671 | 36.352 | 16.676 | 27.947 |
| 280.00 | 16.462 | 36.314 | 16.465 | 27.969 |
| 290.00 | 16.255 | 36.276 | 16.257 | 27.989 |
| 300.00 | 16.048 | 36.238 | 16.048 | 28.010 |
| 310.00 | 15.854 | 36.203 | 15.853 | 28.029 |
| 320.00 | 15.668 | 36.171 | 15.665 | 28.048 |
| 330.00 | 15.471 | 36.136 | 15.466 | 28.067 |
| 340.00 | 15.284 | 36.104 | 15.278 | 28.086 |
| 350.00 | 15.094 | 36.072 | 15.086 | 28.105 |
| 360.00 | 14.908 | 36.041 | 14.899 | 28.123 |
| 370.00 | 14.721 | 36.010 | 14.710 | 28.142 |
| 380.00 | 14.535 | 35.980 | 14.522 | 28.160 |
| 390.00 | 14.357 | 35.952 | 14.343 | 28.179 |
| 400.00 | 14.181 | 35.925 | 14.166 | 28.196 |
| 410.00 | 14.017 | 35.901 | 14.000 | 28.213 |
| 420.00 | 13.853 | 35.876 | 13.835 | 28.230 |
| 430.00 | 13.693 | 35.852 | 13.674 | 28.246 |
| 440.00 | 13.536 | 35.829 | 13.515 | 28.262 |
| 450.00 | 13.377 | 35.806 | 13.355 | 28.278 |
| 460.00 | 13.218 | 35.783 | 13.196 | 28.295 |
| 470.00 | 13.062 | 35.762 | 13.038 | 28.311 |
| 480.00 | 12.913 | 35.742 | 12.888 | 28.326 |

**TABLE IV Hydrographic properties at the target surface**

| Group | Count | P | θ | S | -dT/dp | -dS/dp | dσ/dp | Rρ | N |
|---|---|---|---|---|---|---|---|---|---|
| | | dba | C | PSU | $10^{-3}$ C/dba | ppm/ dbar | $10^{-3}$ dbar$^{-1}$ | | $10^{-3}s^{-1}$ |
| A | 7 | 339.3 | 15.592 | 36.151 | 17.1 | 2.88 | 1.79 | 1.81 | 4.15 |
| B | 18 | 312.6 | 15.624 | 36.161 | 22.0 | 3.96 | 2.10 | 1.69 | 4.49 |
| C | 15 | 327.1 | 15.594 | 36.151 | 20.5 | 3.64 | 2.00 | 1.72 | 4.39 |
| D | 17 | 332.3 | 15.657 | 36.170 | 20.4 | 3.56 | 2.04 | 1.75 | 4.43 |
| E | 8 | 292.5 | 15.676 | 36.176 | 19.5 | 3.49 | 1.90 | 1.71 | 4.27 |
| F | 9 | 298.5 | 15.724 | 36.191 | 20.4 | 3.67 | 1.97 | 1.70 | 4.35 |
| G | 6 | 304.4 | 15.665 | 36.173 | 18.7 | 3.21 | 1.92 | 1.78 | 4.30 |
| H | 11 | 294.2 | 15.761 | 36.202 | 17.6 | 3.12 | 1.75 | 1.73 | 4.10 |
| I | 18 | 322.2 | 15.662 | 36.172 | 18.9 | 3.29 | 1.91 | 1.76 | 4.28 |
| J | 15 | 319.4 | 15.657 | 36.170 | 20.0 | 3.50 | 2.00 | 1.74 | 4.38 |
| K | 9 | 325.6 | 15.607 | 36.155 | 18.4 | 3.17 | 1.87 | 1.77 | 4.24 |
| L | 8 | 343.7 | 15.589 | 36.150 | 17.6 | 3.00 | 1.84 | 1.80 | 4.20 |
| M | 19 | 348.6 | 15.632 | 36.163 | 18.2 | 3.12 | 1.88 | 1.79 | 4.25 |
| N | 7 | 293.6 | 15.631 | 36.163 | 22.7 | 4.05 | 2.18 | 1.70 | 4.58 |
| All | 166 | 321.2 | 15.640 | 36.165 | 19.4 | 3.40 | 1.93 | 1.74 | 4.31 |

**TABLE V: Regional Groups of Stations.**

| Group | Casts |
|---|---|
| A | 5 - 10 |
| B | 27 - 33, 38, 41 - 49 |
| C | 50 - 62, 65, 100 |
| D | 21 - 26, 101 - 111 |
| E | 112 - 119 |
| F | 120 - 128 |
| G | 129 - 134 |
| H | 147 - 149, 151 - 158 |
| I | 12 - 20, 159 - 167 |
| J | 168 - 182 |
| K | 183 - 191 |
| L | 191 - 198 |
| M | 199 - 217 |
| N | 224 - 230 |

**TABLE VI: GC calibration**

| File | Date | Time | Std Loop | Stds | Fit* | A | B | C | Max Error |
|---|---|---|---|---|---|---|---|---|---|
| **GC A** | | | | | | | | | |
| 2SA | 24/4 | 1015 | 1 | 1.6-1.1 | L/C | -.000 | 0.047 | 340.5 | 111.28 |
| 24SA | 27/4 | 0400 | 1 | 1.6-1.2 | L/C | 0.00004 | 0.011 | 358.7 | 205.29 |
| 34SA | 28/4 | 0940 | 1 | 1.6-1.2 | L/C | 0.00004 | 0.0088 | 361.8 | 96.72 |
| 47SA | 30/4 | 0000 | 1 | 1.6-1.2 | L/C | 0.00003 | 0.0159 | 361.2 | 406.29 |
| 57SA | 1/5 | 0400 | 1 | 1.6-1.2 | L/C | 0.00003 | 0.0165 | 372.1 | 417.46 |
| 111SA | 3/5 | 0100 | 1 | 1.6-1.2 | L/C | 0.00003 | 0.0104 | 365.34 | 136.2 |
| 128SA | 5/5 | 0400 | 1 | 1.6-1.2 | L/C | 0.00007 | 0.0103 | 348.3 | 345.37 |
| 140SA | 6/5 | 1030 | 1 | 1.6-1.2 | L/C | -0.000002 | 0.0517 | 358.67 | 466.5 |
| 140SAS | 6/5 | 1300 | 1/3 | 1.4-1.1 | C | 0.000001 | 0.00009 | 121.41 | 186.6 |
| 151SA | 7/5 | 2000 | 1/3 | 1.4-1.1 | L/C | 0.000003 | -0.0091 | 126.88 | 216.45 |
| | | | | | C | 0.000003 | -0.0083 | 129.07 | |
| 157SA | 9/5 | 0100 | 1 | 1.6-1.2 | C | 0.000021 | 0.0065 | 352.45 | 313.88 |
| 163SA | 9/5 | 1600 | 1 | 1.6-1.1 | L/C | -0.000006 | 0.0733 | 363.87 | 446.69 |
| 180SA | 11/5 | 0630 | 1 | 1.6-1.1 | L/C | -0.000002 | 0.0541 | 372.40 | 1823.3 |
| 189SA | 12/5 | 0250 | 1 | 1.6-1.1 | L/C | 0.0000003 | 0.0382 | 383.5 | 114.13 |
| 208SA | 14/5 | 0300 | 1 | 1.6-1.2 | L/C | 0.00006 | 0.0137 | 376.47 | 281.97 |
| 224SA | 16/5 | 2110 | 1 | 1.6-1.2 | L/C | -0.000004 | 0.0635 | 380.79 | 255.04 |
| 228SA | 18/5 | 1300 | 1 | 1.6-1.2 | L/C | 0.000063 | 0.0535 | 368.93 | 291.64 |
| **GC B** | | | | | | | | | |
| 3SB | 24/4 | 1700 | 1 | 1.6-1.1 | L/C | -0.0000 | 0.187 | 704.17 | 1337.9 |
| 19SB | 26/4 | 1820 | 1 | 1.6-1.2 | L/C | 0.00018 | 0.0113 | 712.22 | 980.0 |
| 39SB | 29/4 | 0200 | 1 | 1.6-1.2 | L/C | 0.002 | 0.0125 | 710.33 | 1066.4 |
| 59SB | 1/5 | 0800 | 1 | 1.6-1.2 | L/C | 0.00015 | 0.0232 | 707.73 | 377.08 |
| 111SB | 3/5 | 0000 | 1 | 1.6-1.2 | L/C | 0.00022 | 0.0026 | 695.4 | 1673.0 |
| 128SB | 5/5 | 0125 | 1 | 1.6-1.2 | L/C | 0.00024 | -0.0010 | 691.19 | 1960 |
| 140SB** | 6/5 | 1000 | 1 | 1.4-1.1 | C | -0.00003 | 0.1562 | 643.62 | 1717.7 |
| 140SBS | 6/5 | 1300 | 1/3 | 1.4-1.1 | C | 0.000002 | 0.0050 | 222.48 | 176.54 |
| 150SBS | 7/5 | 2100 | 1/3 | 1.4-1.1 | C | 0.000002 | 0.0047 | 234.83 | 244.38 |
| 163SB | 9/5 | 1600 | 1 | 1.6-1.2 | L/C | 0.00181 | 0.093 | 699.95 | 673.62 |
| 179SB | 11/5 | 0300 | 1 | 1.6-1.1 | L/C | 0.000034 | 0.159 | 703.04 | 742.65 |
| 199SB | 13/5 | 0600 | 1 | 1.6-1.2 | L/C | -0.000045 | 0.190 | 702.44 | 402.65 |
| 220SB | 15/5 | 1255 | 1 | 1.6-1.2 | L/C | 0.00055 | 0.0089 | 701.11 | 874.16 |
| 223SB | 17/5 | 0830 | 1 | 1.6-1.2 | L/C | 0.000249 | 0.0113 | 699.42 | 1527.56 |
| 230SB | 18/5 | 0815 | 1 | 1.6-1.2 | L/C | -0.00006 | 0.2403 | 688.63 | 1724.73 |

L/C - linear cubic
C - cubic
** Calibrated across cubic range only

## APPENDIX 1: CTD CALIBRATIONS

### CTD System

During the cruise 202 CTD casts were completed using an RVS Neil Brown MkIII CTD (s/n 01-1195) and WHOI 24 bottle rosette pylon and frame. Despite a few breakdowns at the start of the cruise the system worked very well and only three hours were lost when the CTD cable was re-terminated. Also 5 casts were completed using the sled and winch control system.

### CTD Calibration

Temperature: The CTD temperature calibration was found to have drifted by less than one milli-degrees from last year s NATRE cruise and was therefore left unchanged.

Pressure: The pressure reading had increased by 4.7 decibars compared with last year and this was subtracted from the data.

Salinity: Salinity samples were taken from 24 casts (Table A1). An average offset of 28ppm was found from the first 10 casts and this was added to the CTD data. The last 10 casts showed that the CTD remained in calibration for the rest of the cruise.

Table A1: Salinity calibrations using Autosal. Note CTD was re-calibrated after station 53. Archived data for stations 1-53 were re-calculated using the new calibration.

| Cast Number | Samples | Reading |
|---|---|---|
| 1 | 23 | 0.0348 |
| 2 | 24 | 0.031 |
| 4 | 23 | 0.0289 |
| 10 | 24 | 0.0288 |
| 13 | 24 | 0.0277 |
| 22 | 24 | 0.0272 |
| 27 | 24 | 0.0282 |
| 31 | 24 | 0.0264 |
| 45 | 19 | 0.0262 |
| 48 | 23 | 0.0256 |
| 53 | 24 | -0.001 |
| 60 | 16 | -0.0011 |
| 100 | 22 | -0.0011 |
| 115 | 18 | -0.0005 |
| 147 | 24 | -0.0002 |
| 151 | 24 | -0.0013 |
| 156 | 24 | -0.002 |
| 163 | 24 | 0.0004 |
| 176 | 24 | 0.0001 |
| 205 | 24 | -0.0014 |

## APPENDIX 2: CONFIGURATION AND USE OF THE ROSETTE SYSTEM

24 5-litre Niskin bottles were needed to sample vertical distribution of $SF_6$. A 43" rosette frame and a 60" cage were borrowed from the WHOI CTD group. There was an upper section to the cage that housed a General Oceanics pylon, rosette and Niskin bottles.

The lower section housed a Neil Brown CTD hung vertically from an A bracket below the pylon. The vertical distance from the T and C probes to the centre of the Niskin bottles was 112cm. Three sets of shock cords were wrapped around the lower section of the CTD and to three legs of the cage 120° apart. A 31" shock cord was wrapped around the CTD and a 15" shock cord was wrapped around the cage leg. Hooks were taken out of the ends of one of the shock cords, and the hooks from the other were inserted into it. The cords were wrapped in vulcanising tape and a tie wrap was put on the end of the cords near where they went around the CTD. This turned out not to be a good idea. All of the stretch of the shock cord was taken in the short length of cord that was not taped. One of the cords gave out near the end of the cruise and was replaced by a new cord and not wrapped in tape. This new one showed no signs of strain whereas the wrapped ones showed cracking and necking down after the first couple of casts.

About 525lbs of weight, in the form of 28lb slugs of lead from the WHOI Stockroom, were added to the bottom ring and vertical pipes of the lower cage. These were held in place by hose clamps. Adding this weight enabled the cage to be lowered at about 30m/min to about 50m, and then the speed slowly increased to about 60m/min while maintaining a tension on the CTD wire of between 500 and 1000lbs.

Considerable corrosion appeared on the rosette rings and the aluminium stanchion on which the rosette was mounted after the first few casts. More and larger anodes were added to both rosette rings and the stanchion and this seemed to alleviate the problem.

## APPENDIX 3: CAROUSEL PUMP AND VALVE

For the fall 1992 and spring 1993 sampling cruises, OC253 and CD78, a carousel with more syringes was needed due to the spreading of the $SF_6$ patch. A 50-port valve was built by McLane for the greater number of samples required. Along with this, new software was written to run this valve and pump combination.

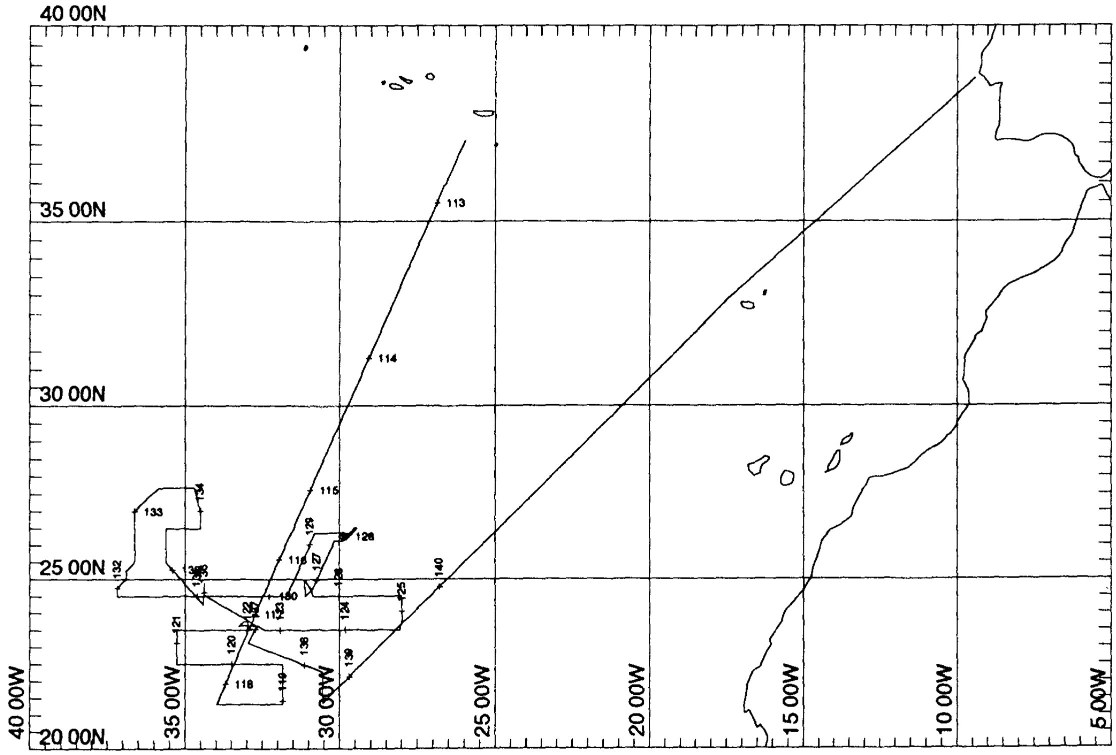
When the valve was first tested before OC253, the valve would not mechanically return to the home, valve position 1, although it indicated it was home in the software. There are two microswitches in the valve. One counts revolutions and the other counts valve position. It was thought that if the microswitch that indicated valve position was wired, fine adjustments could be made to align the valve mechanically. This did not work. On OC253 in order to  fool  the software into thinking the valve was home, the pump would first be programmed for deployment. The valve would then have to be mechanically turned with a screwdriver to align it to the home position. This was difficult to do due to the position and stiffness of the valve.

Before CD78, two things were done to make the valve more user-friendly. Firstly, the microswitch to indicate revolutions was hooked back up so that when the valve was commanded to go home, it obeyed. Second, new software was written for the 50-port valve called PUMP1_47.BAS. It had menu commands to enable small adjustments to the valve from the keyboard to align the valve in the home position. It was found that due to backlash of the stepping motor, trying to move the valve one step of the motor wouldn t work. The software was modified to make the stepper motor go twenty steps, which is a small movement compared to one valve position. This worked fine. The software version to do this is called PUMPADJ.BAS, and is installed into the tattletale in place of PUMP1_47.BAS.

The pump and 50-port valve system, on the sled, was used four times on CD78, with the sled towed at 2 to 2.5kts. In addition to a depressor weight of 500lbs, hung below the sled, about 300lbs of lead weight, in the form of 28lb slugs, were added to the sled frame. The resulting wire angle was around 45¡ at 2.3kts. The direction of tow was constrained by the need to have the wind on the starboard side. An effective sampling programme with the carousel system will usually require towing from the stern.

With the exception of a couple of syringes which only partially filled, the pump and valve worked well. It was again started by a lanyard switch hooked to a General Oceanics pylon. When that position was tripped from the deck unit, two pins on the pump electronics housing were shorted to enable the pump. Mechanical alignment of the valve to the home position was not a problem on this cruise either. At the end of each cast, the valve returned almost to its proper position; when the alignment pin was inserted, a small amount of force on the pin was all that was needed to put the valve in the proper place for deployment. Therefore, though we had the capability to align the valve using the computer keyboard, it was not needed.

Figure 1




MERCATOR PROJECTION

SCALE 1 TO 15000000 (NATURAL SCALE AT LAT. 33)

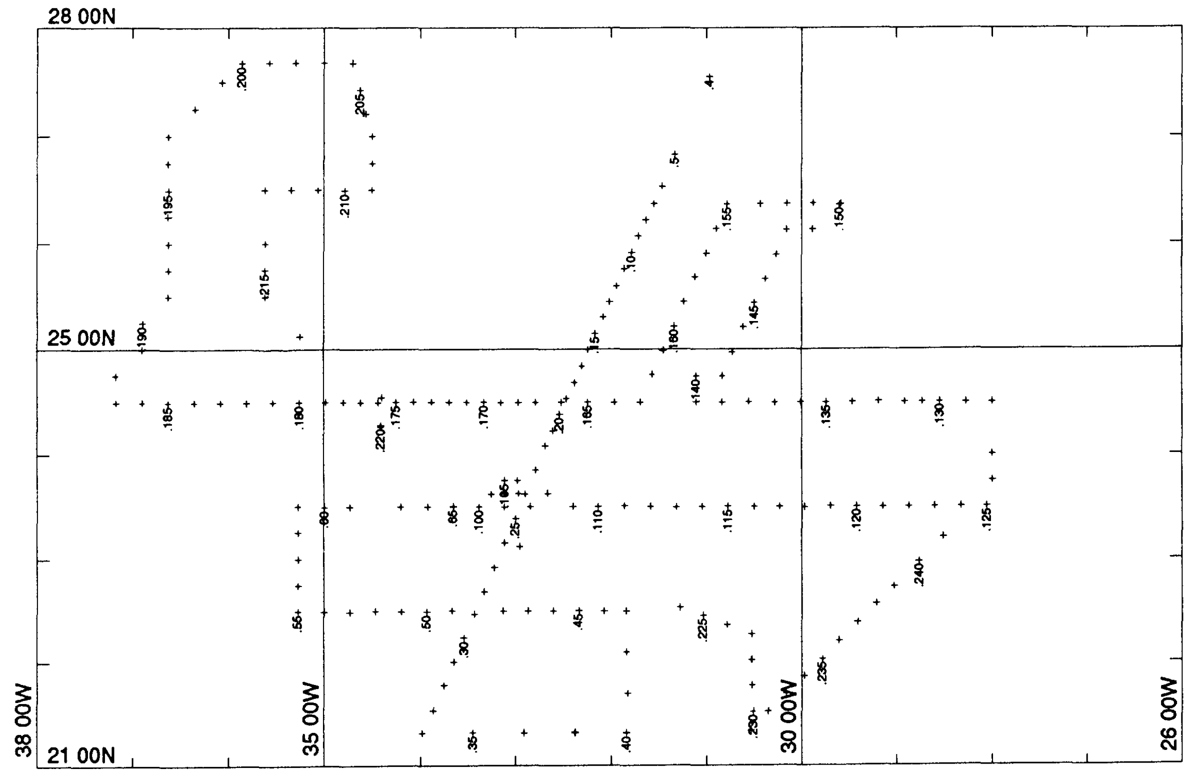
INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 0

GRID NO. 1

— Track plotted from bestnav

RRS Charles Darwin 78 Cruise Track

Figure 2




MERCATOR PROJECTION

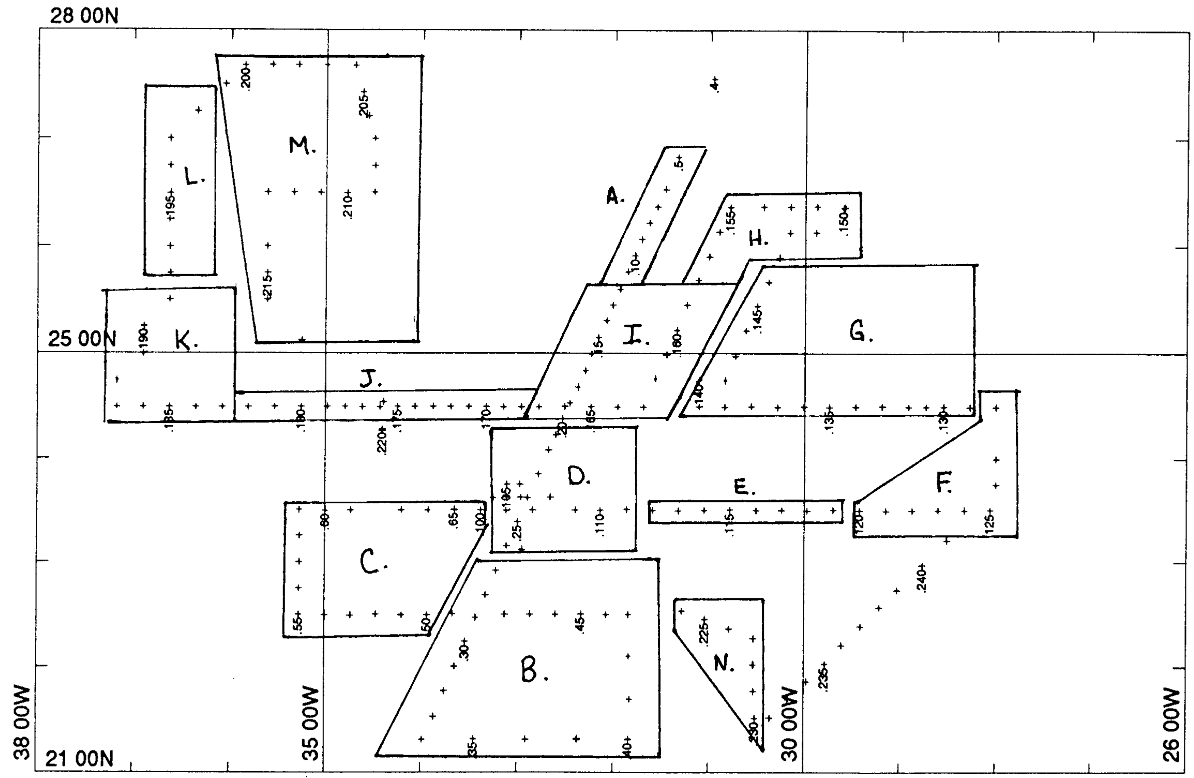
GRID NO. 1

SCALE 1 TO 5000000 (NATURAL SCALE AT LAT. 33)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 0

RRS Charles Darwin 78 CTD Stations in Work Area

Figure 3




MERCATOR PROJECTION

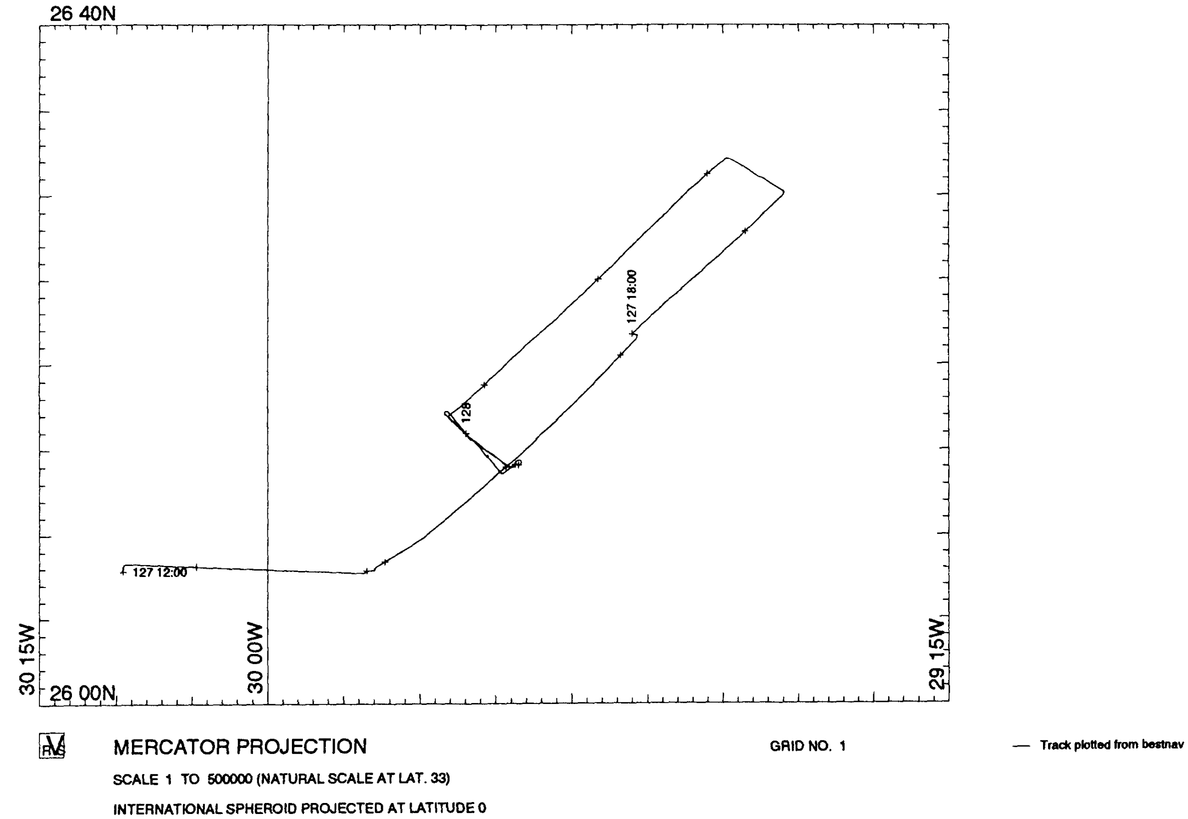
GRID NO. 1

SCALE 1 TO 5000000 (NATURAL SCALE AT LAT. 33)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 0

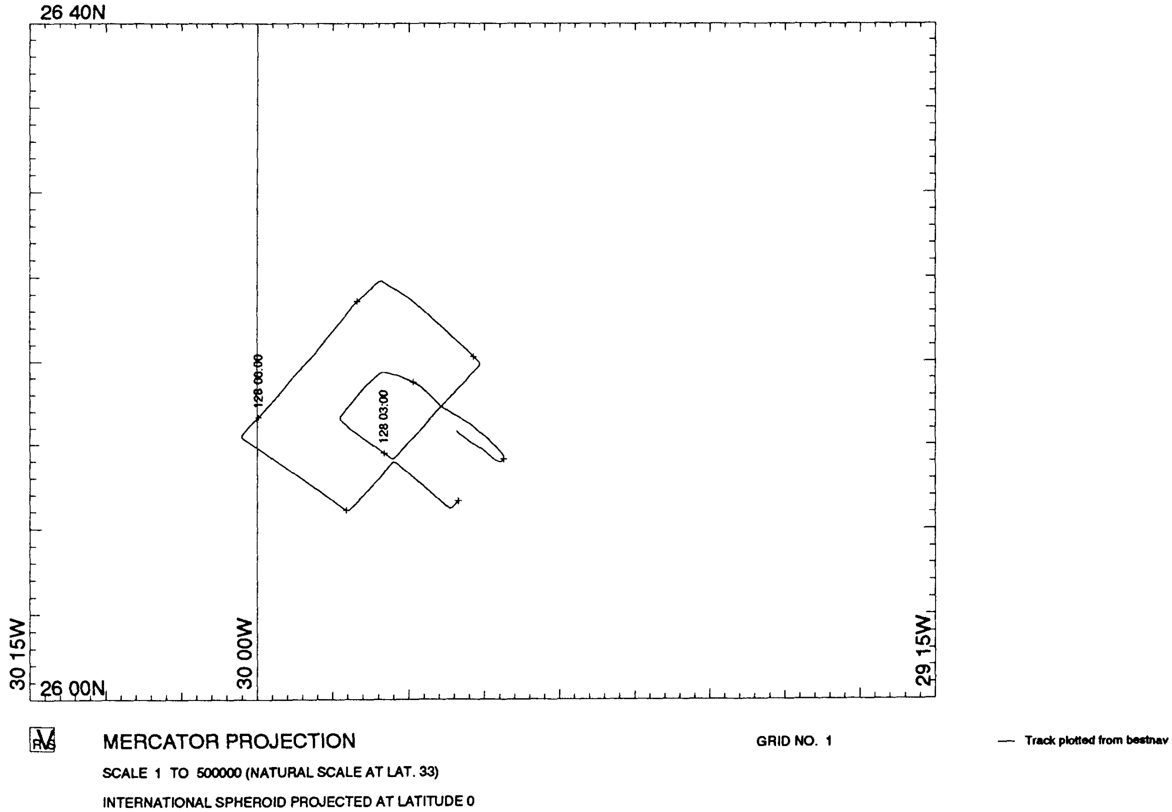
**RRS Charles Darwin 78 CTD Stations in Work Area**

Figure 4



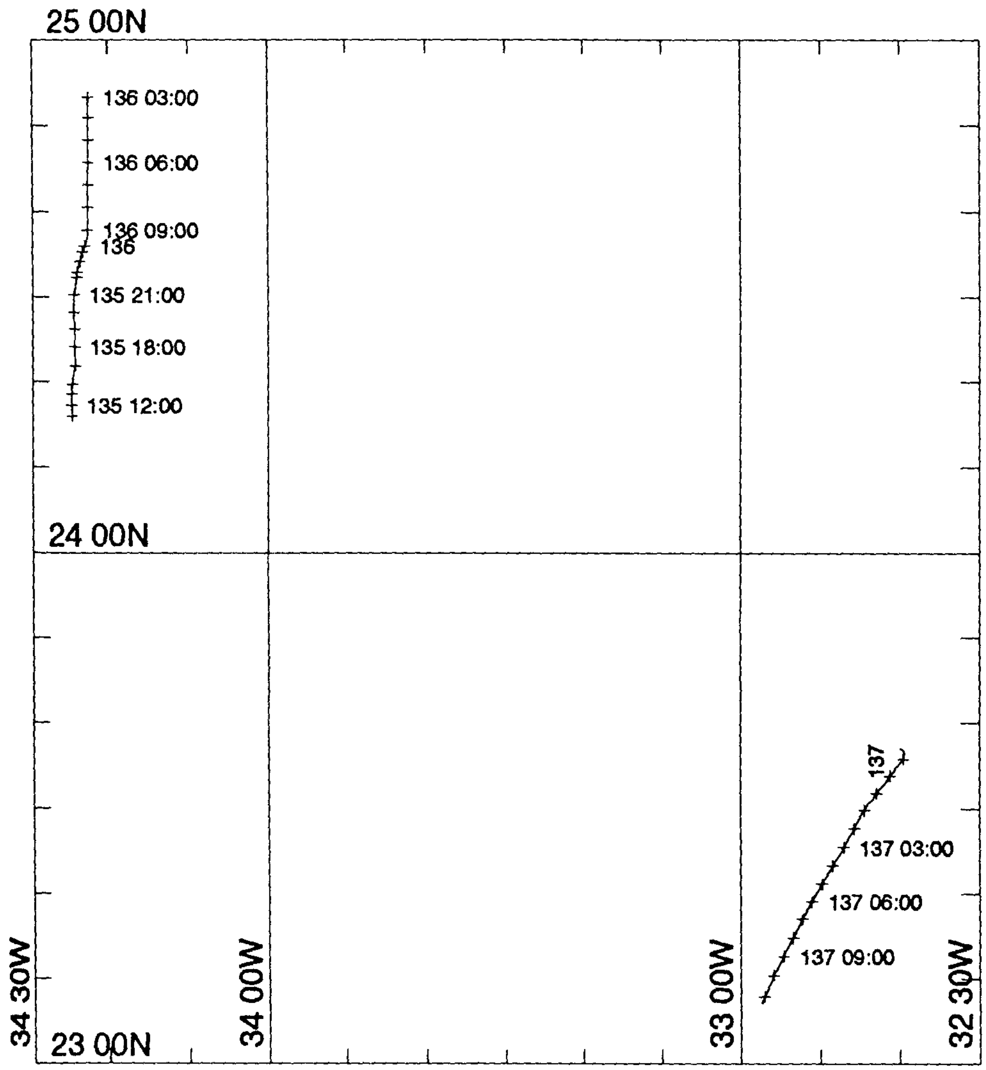

RRS Charles Darwin 78 Search Area 1

Figure 5




RRS Charles Darwin 78 Search Area 1

Figure 6




MERCATOR PROJECTION

SCALE 1 TO 1500000 (NATURAL SCALE AT LAT. 33)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 0

RRS Charles Darwin 78     Sled Tows in Work Area

Figure 7

SLED TOWS -- CONCENTRATION VERSUS DISTANCE

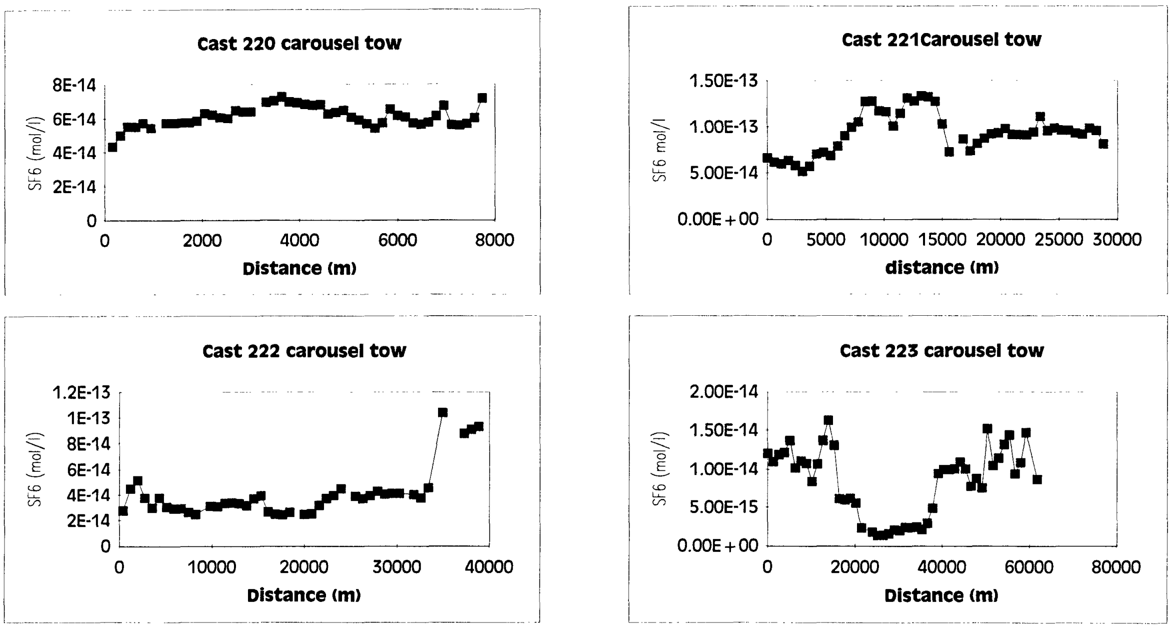
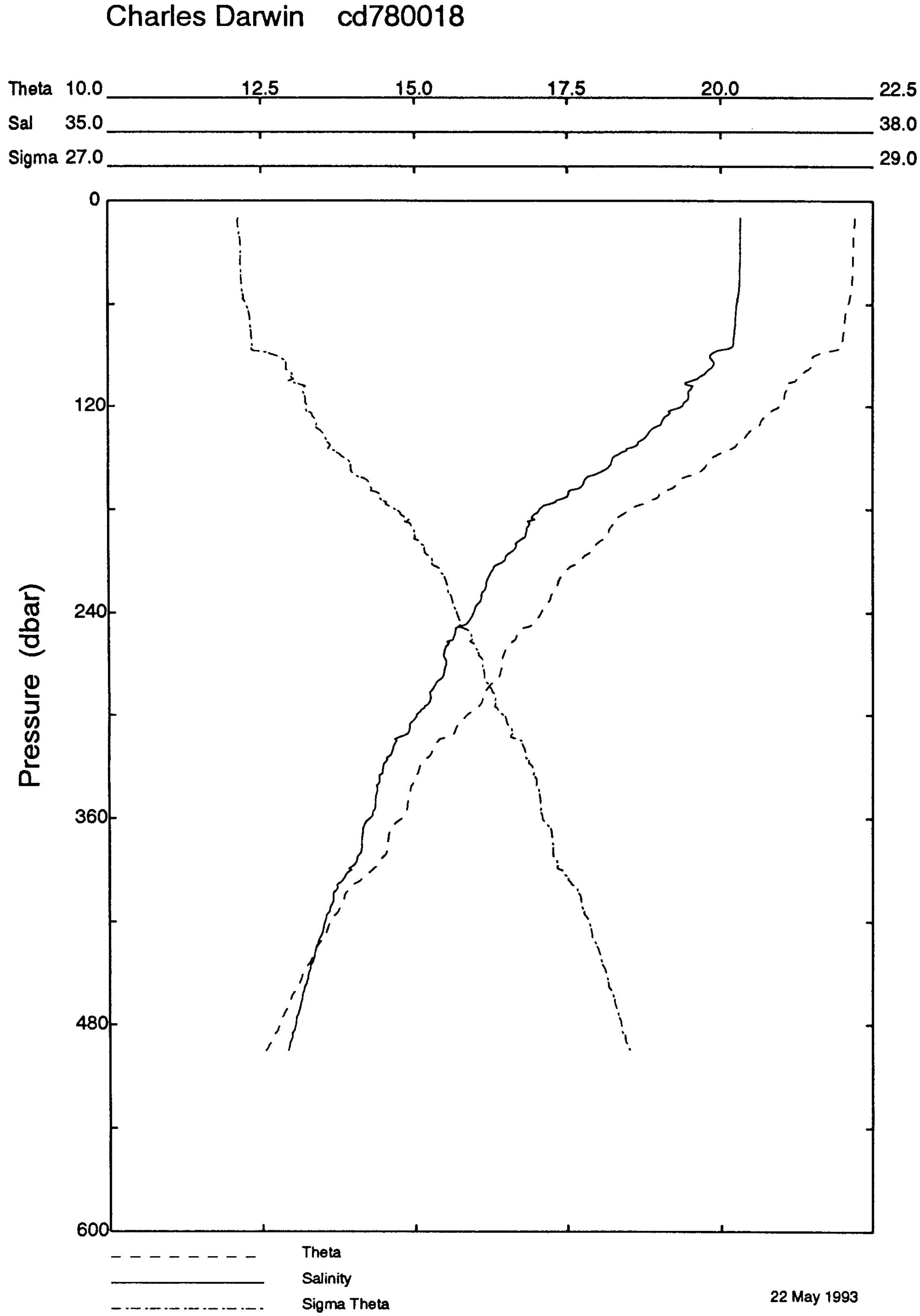


Figure 8



Charles Darwin cd780018
Theta 10.0
12.5
15.0
17.5
20.0
22.5
Sal 35.0
38.0
Sigma 27.0
29.0
0
120
240
360
480
600
Pressure (dbar)
Theta
Salinity
Sigma Theta
22 May 1993

Figure 9

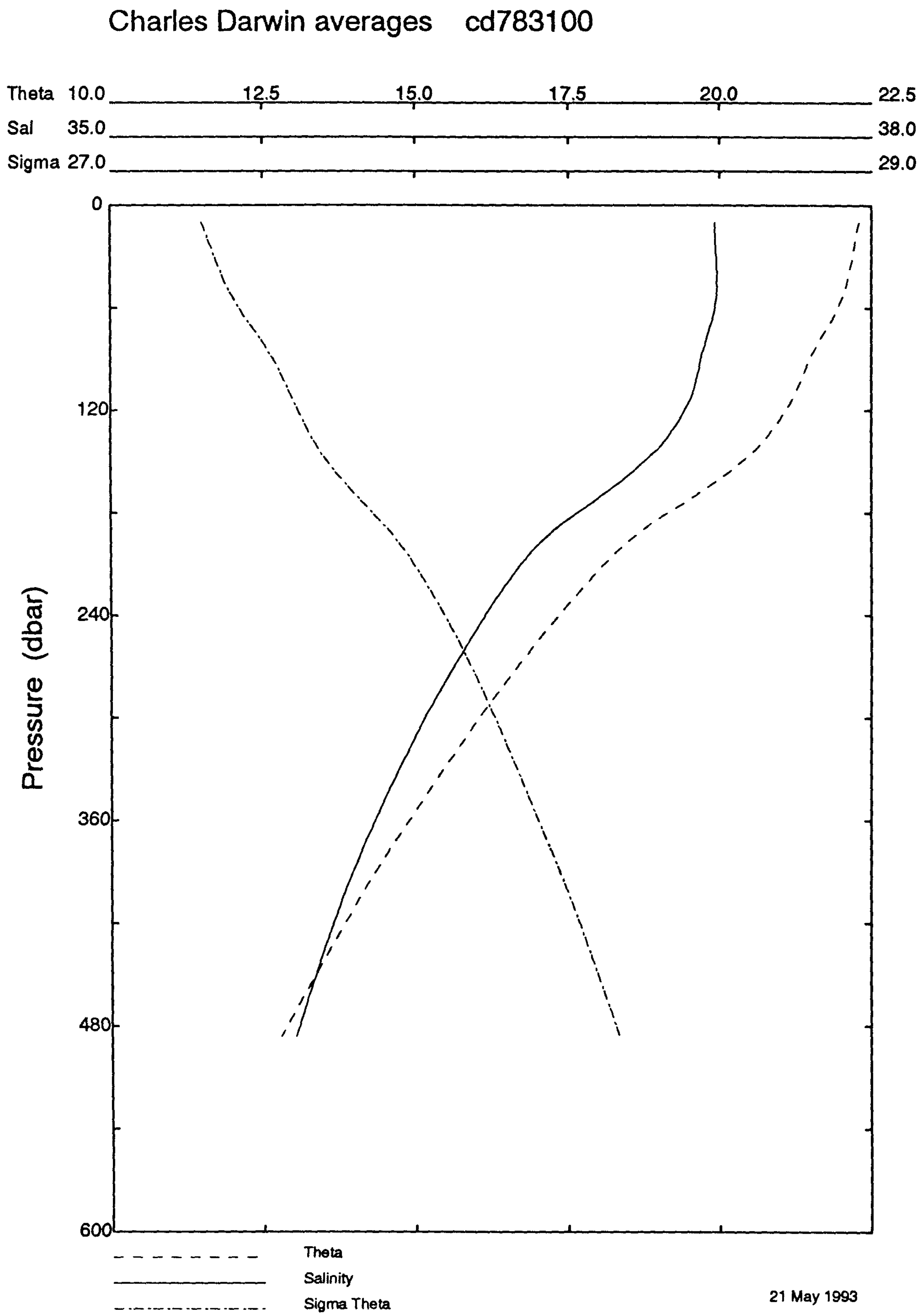
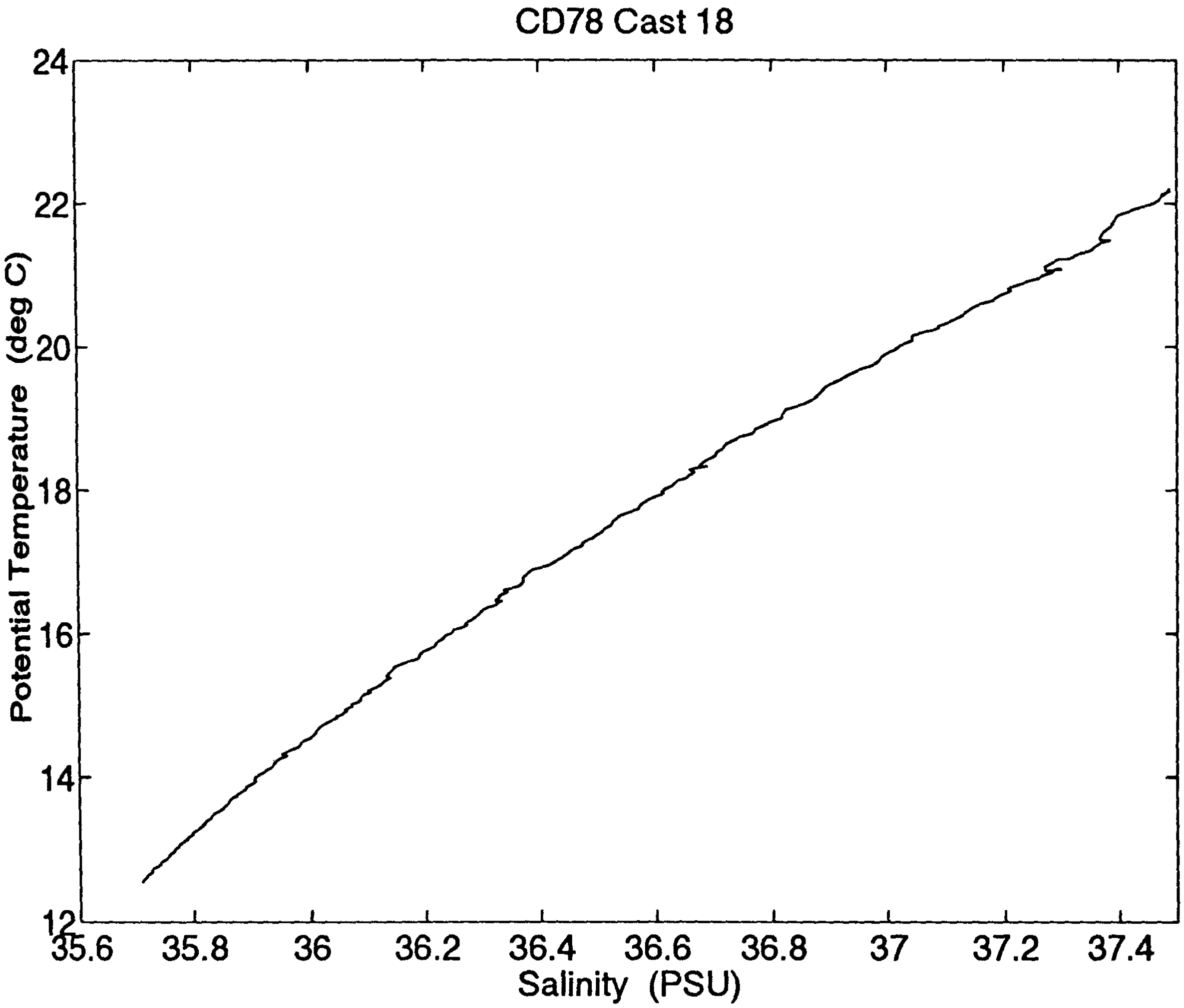
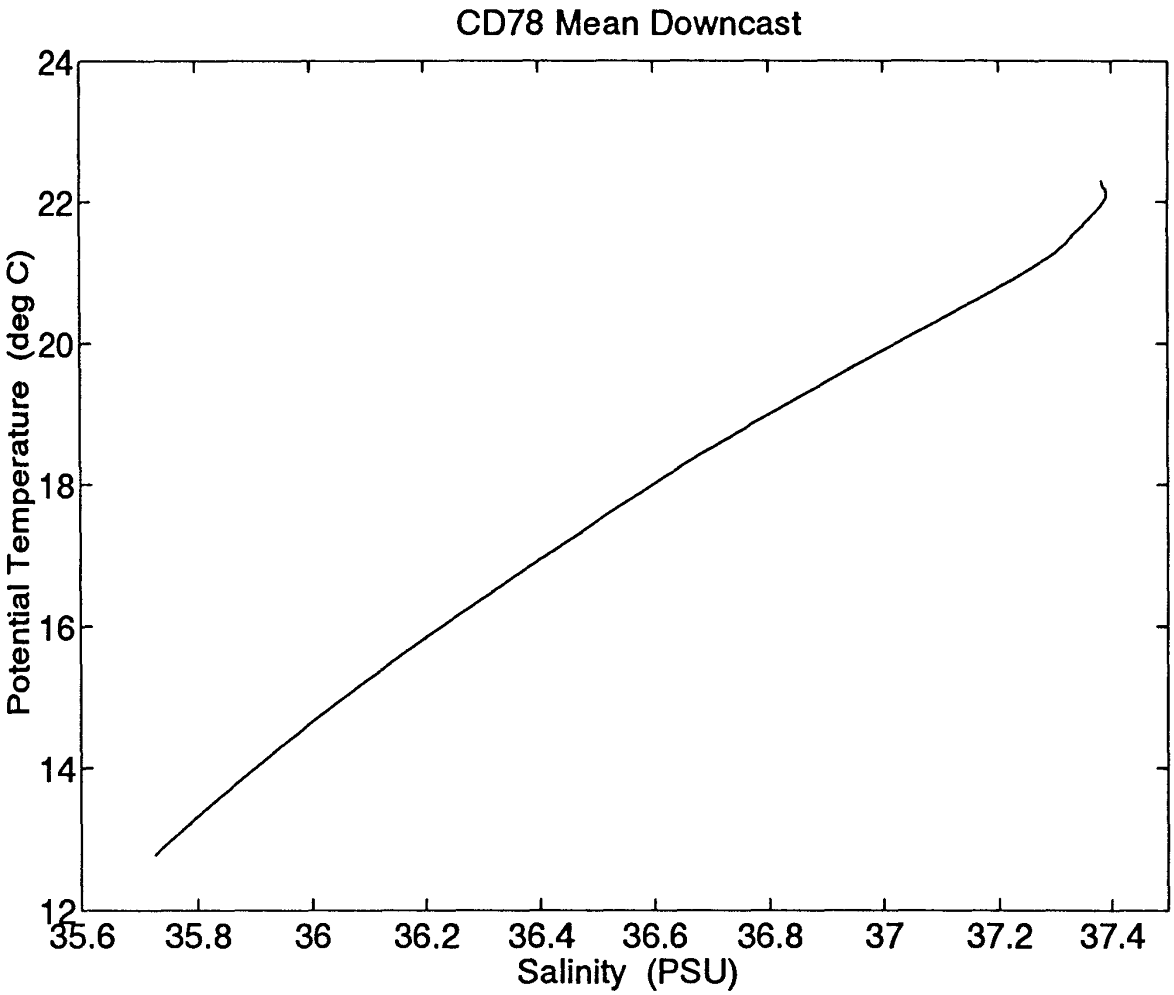

Charles Darwin averages cd783100
Theta 10.0
12.5
15.0
17.5
20.0
22.5
Sal 35.0
38.0
Sigma 27.0
29.0
0
120
240
360
480
600
Pressure (dbar)
Theta
Salinity
Sigma Theta
21 May 1993

Figure 10



CD78 Cast 18
Potential Temperature (deg C)
24
22
20
18
16
14
12
35.6
35.8
36
36.2
36.4
36.6
36.8
37
37.2
37.4
Salinity (PSU)

Figure 11



CD78 Mean Downcast
24
22
20
18
16
14
12
Potential Temperature (deg C)
35.6
35.8
36
36.2
36.4
36.6
36.8
37
37.2
37.4
Salinity (PSU)

Figure 12a

Area A

Column integral in density space:
3.6E-15
Mean sigmap
28.0637
Mean cd68 pressure:
320.928
RMS CD 68 Width:
29.4257

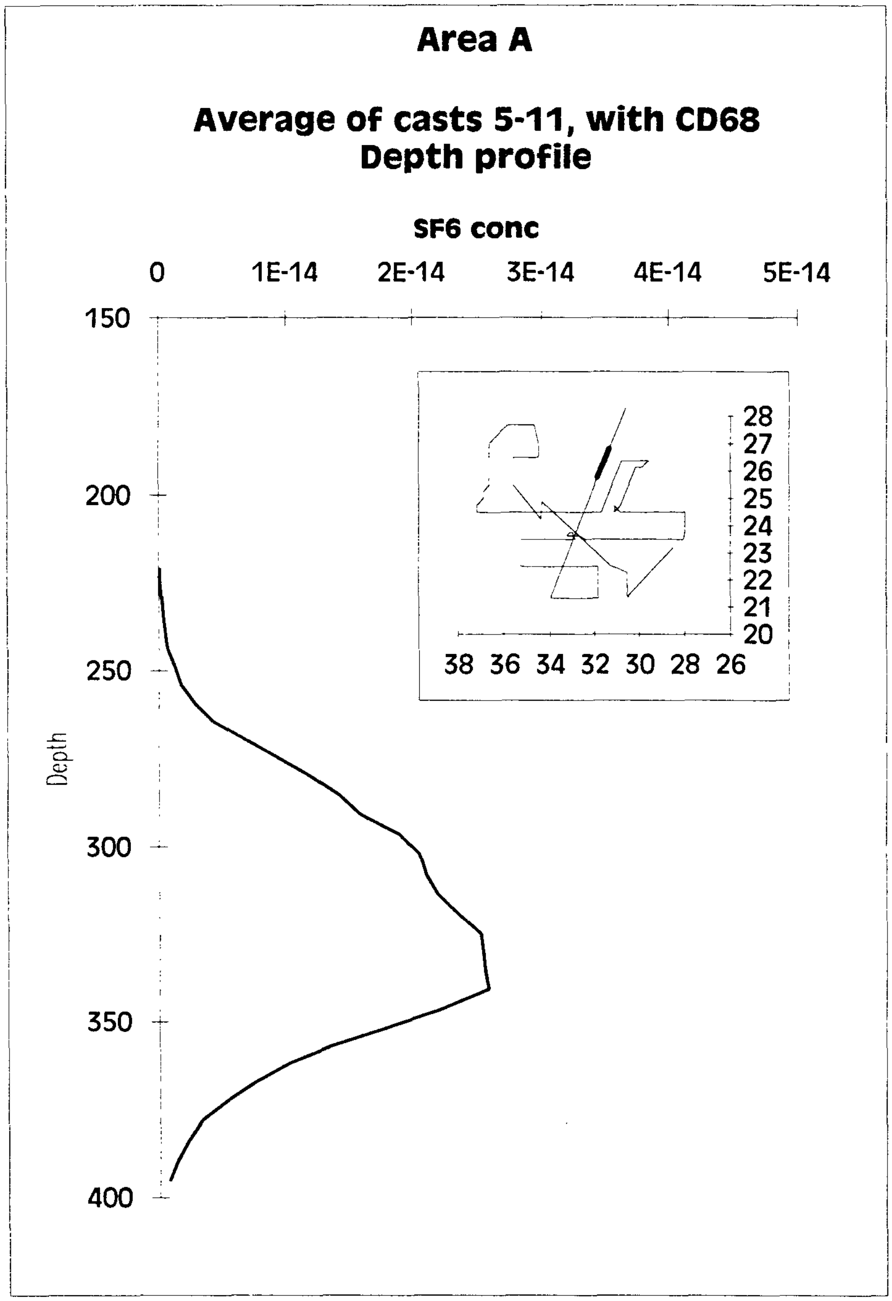
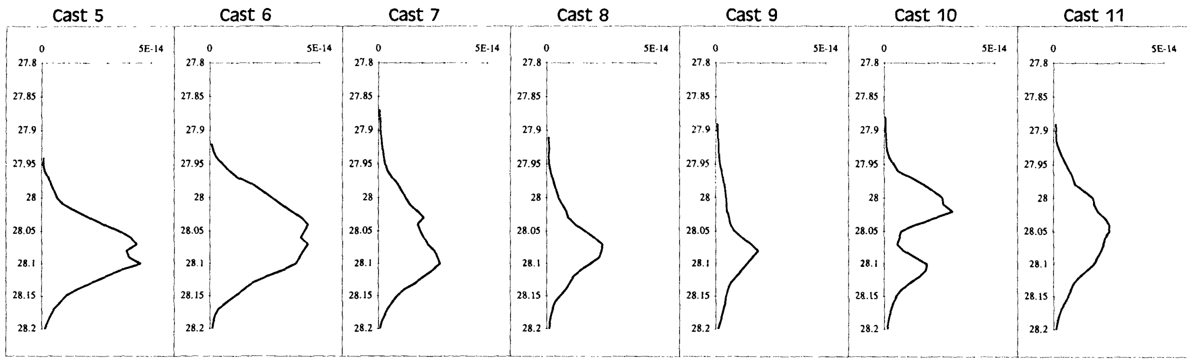


Figure 12b



Cast 5
Cast 6
Cast 7
Cast 8
Cast 9
Cast 10
Cast 11
0
5E-14
27.8
27.85
27.9
27.95
28
28.05
28.1
28.15
28.2

Figure 13a

Area B

Column Integral in density space:
1.73E-15
Mean sigmap
28.0436
Mean cd68 pressure
310.007
RMS CD 68 Width:
31.43599

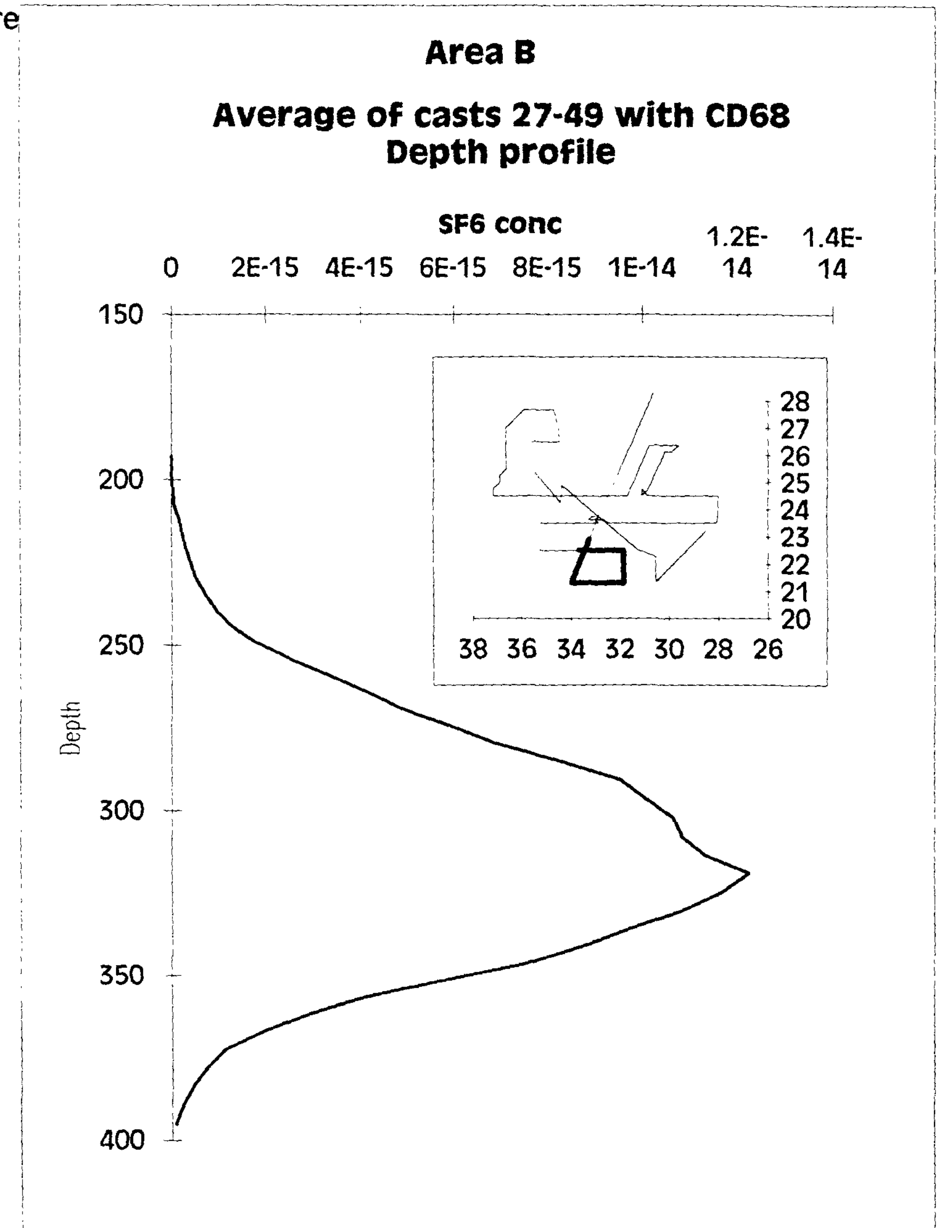


Figure 13b

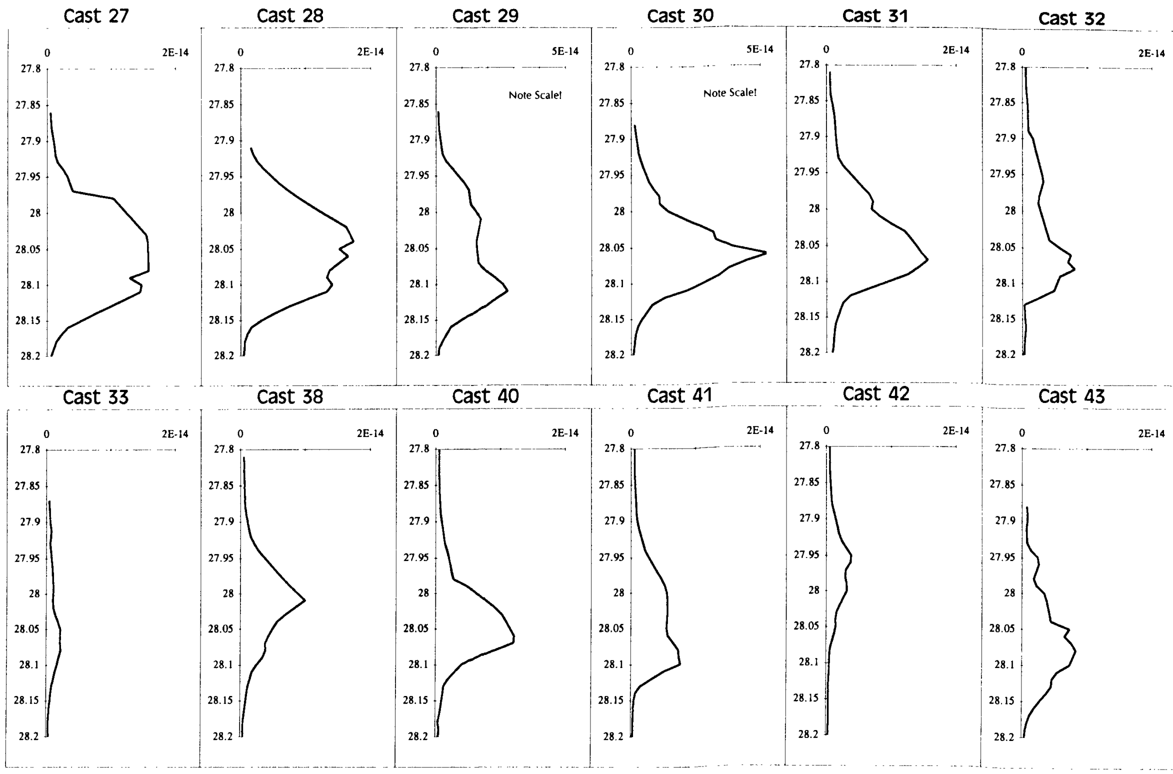

Cast 27
Cast 28
Cast 29
Cast 30
Cast 31
Cast 32
Cast 33
Cast 38
Cast 40
Cast 41
Cast 42
Cast 43
Note Scale!
Note Scale!
0
2E-14
5E-14
27.8
27.85
27.9
27.95
28
28.05
28.1
28.15
28.2

Figure 13c

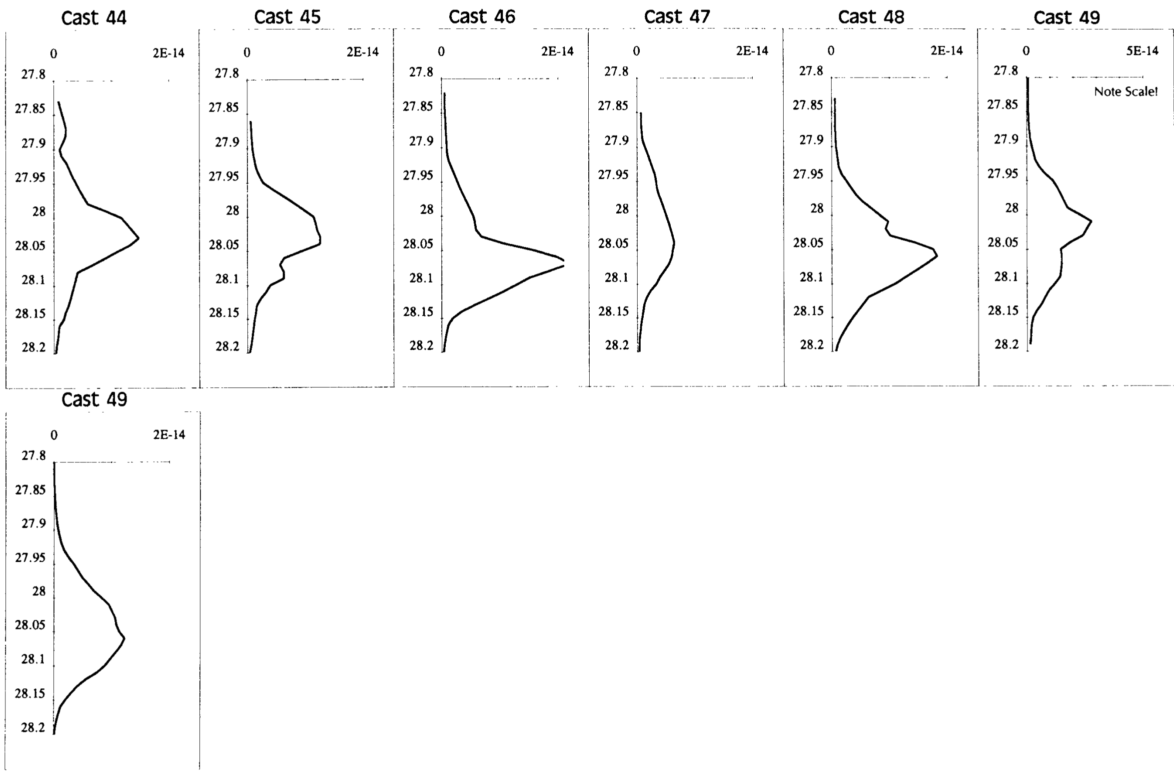

Cast 44
Cast 45
Cast 46
Cast 47
Cast 48
Cast 49
0
2E-14
5E-14
Note Scale!
27.8
27.85
27.9
27.95
28
28.05
28.1
28.15
28.2
Cast 49

Figure 14a

Area C

Column Integral in density space:
5.56E-16
Mean sigmap
28.04443
Mean cd68 pressure:
310.4178
RMS CD 68 Width:
33.97823

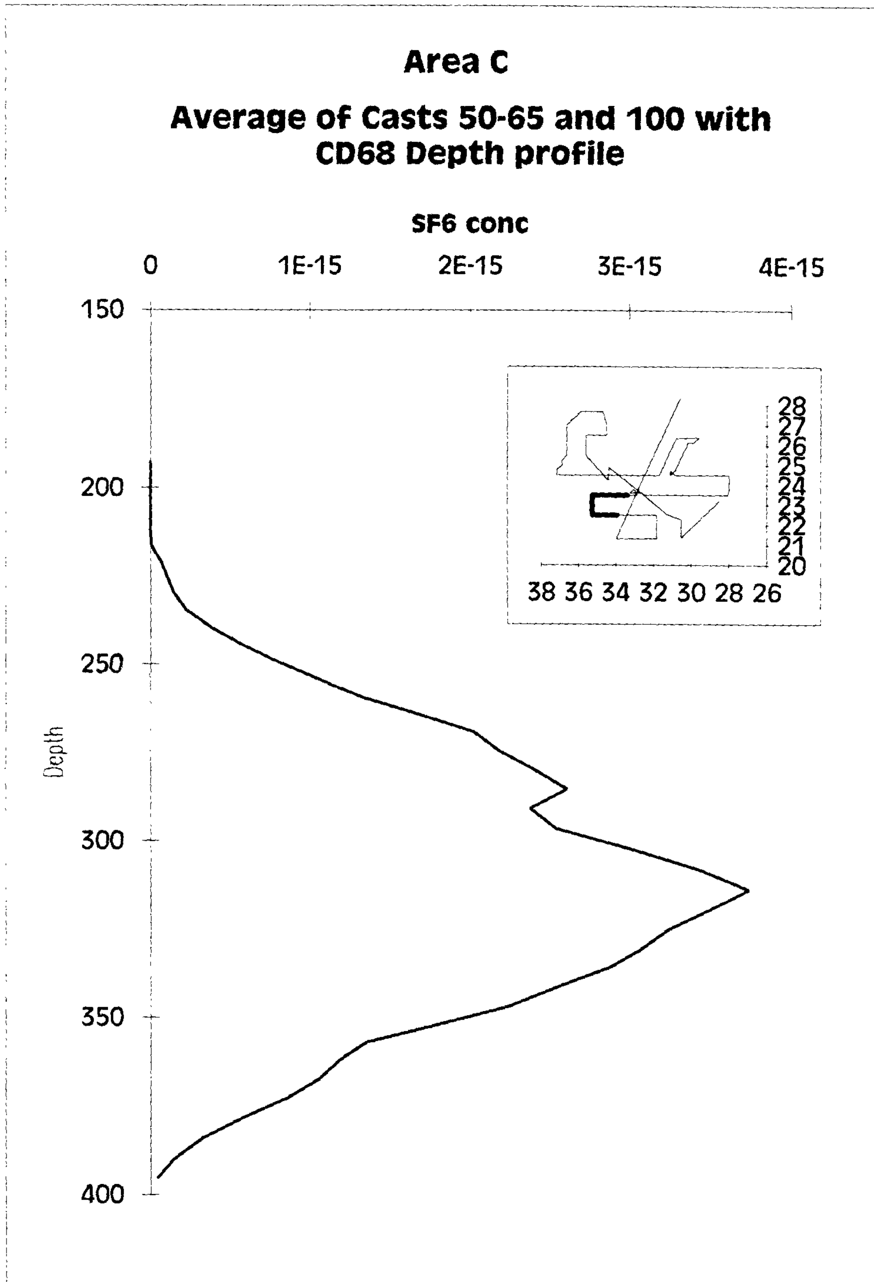


Figure 14b

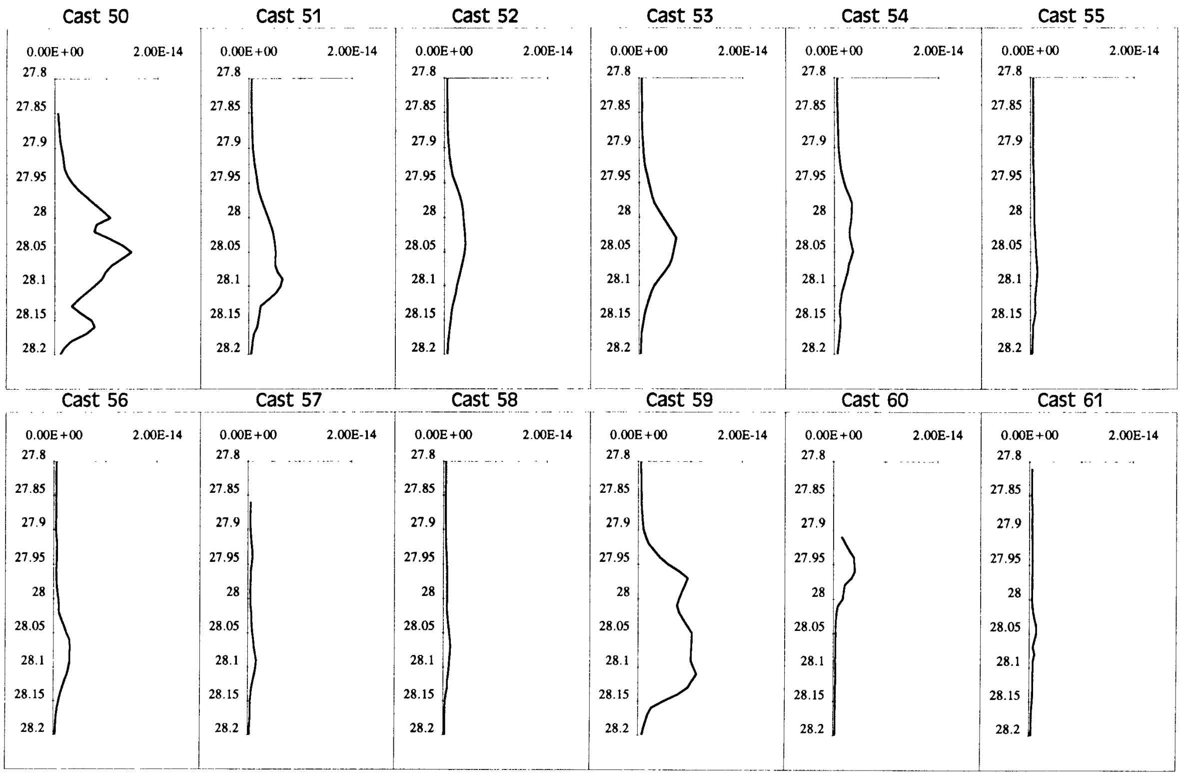



Figure 14c

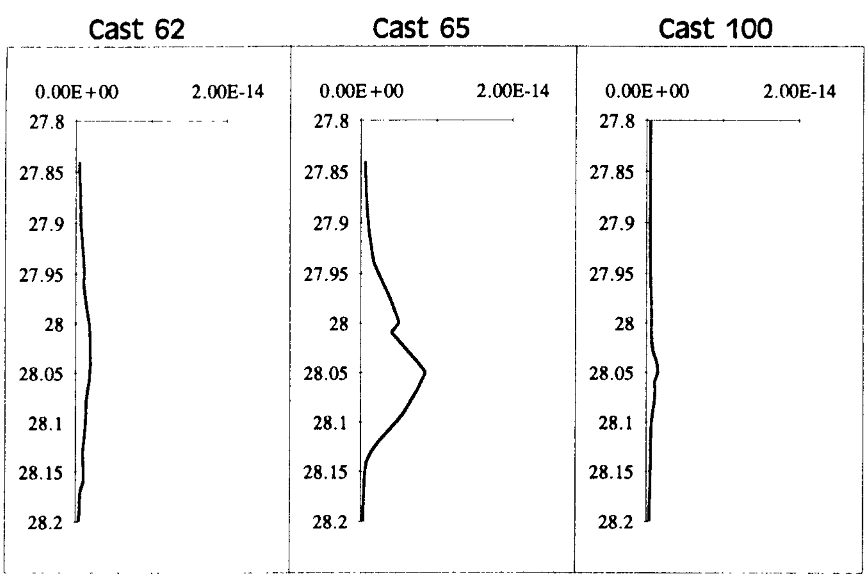


Figure 15a

Area D

Column Integral in density space:
4.09E-15
Mean sigmap
28.06248
Mean cd68 pressure
320.3006
RMS CD 68 Width:
30.52039

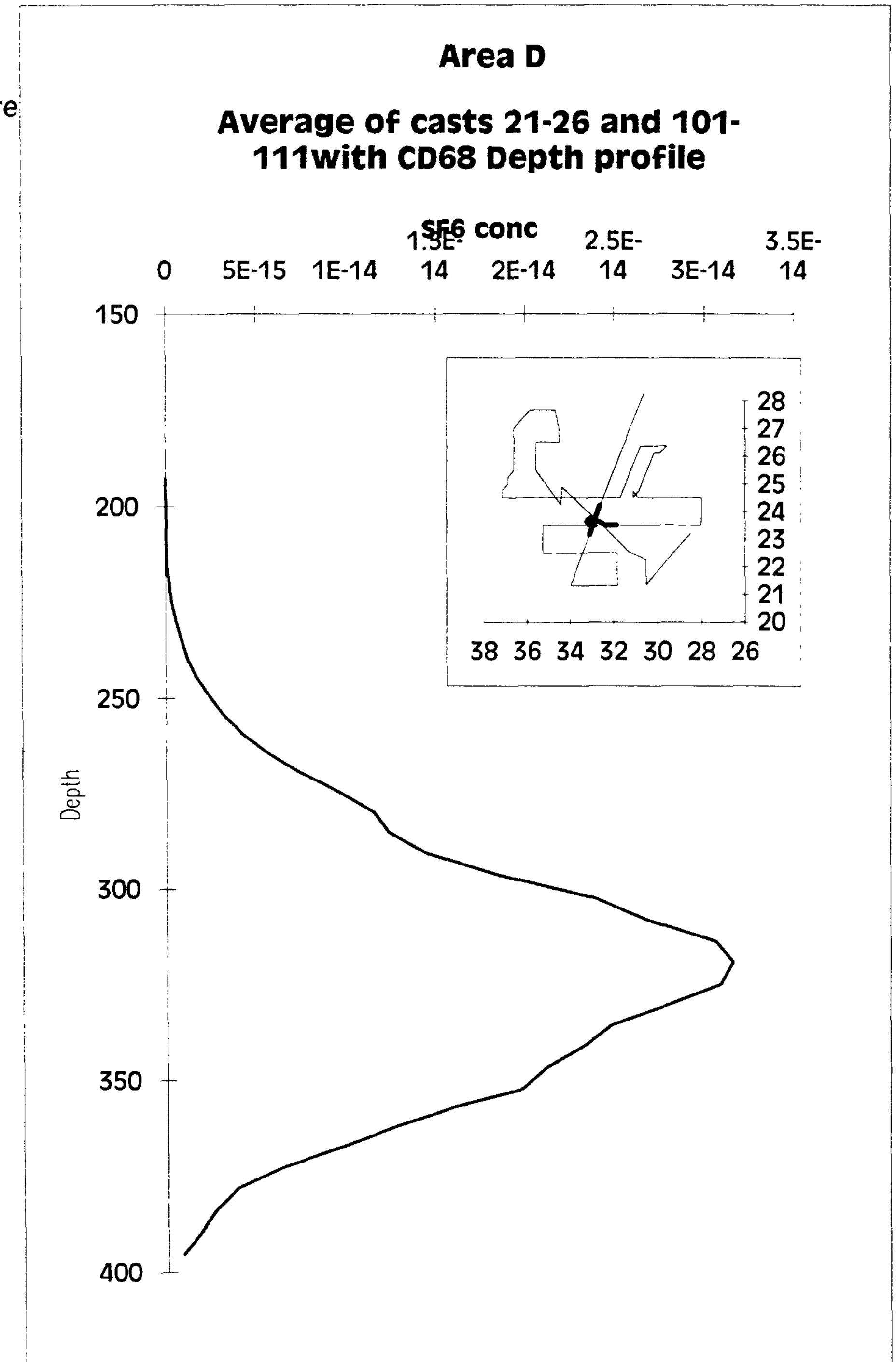


Figure15b

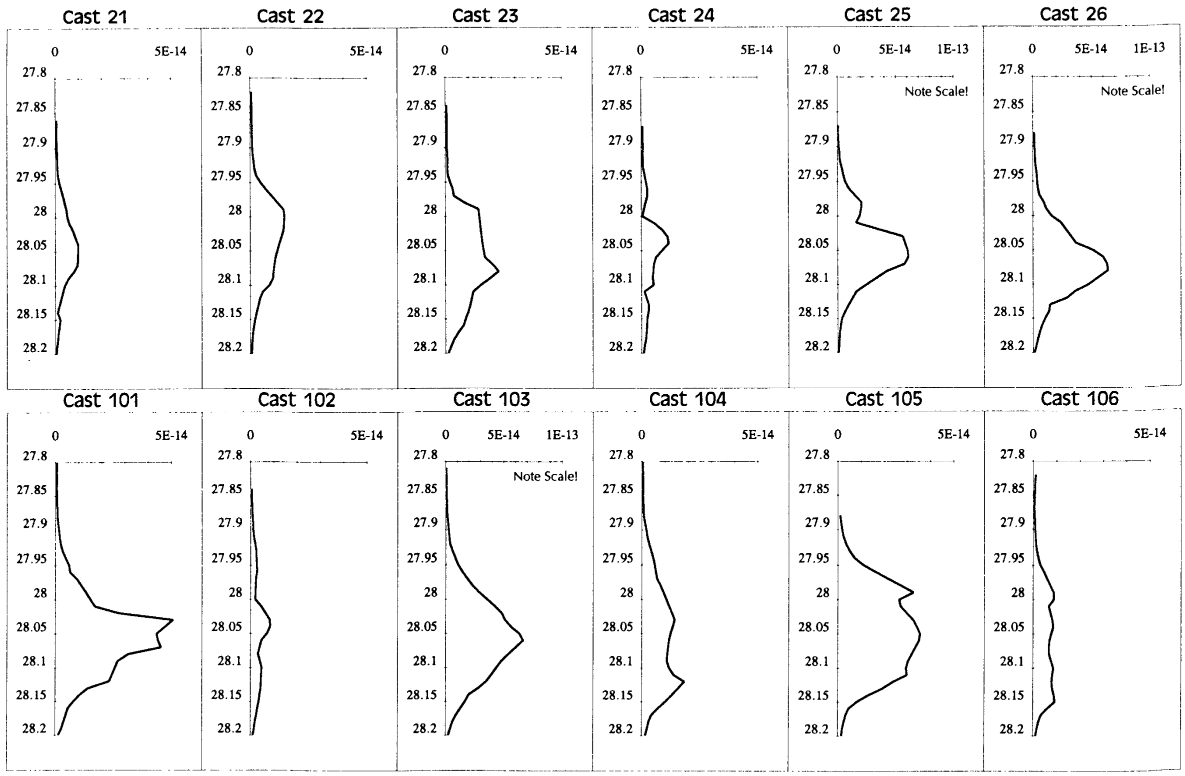



Figure15c

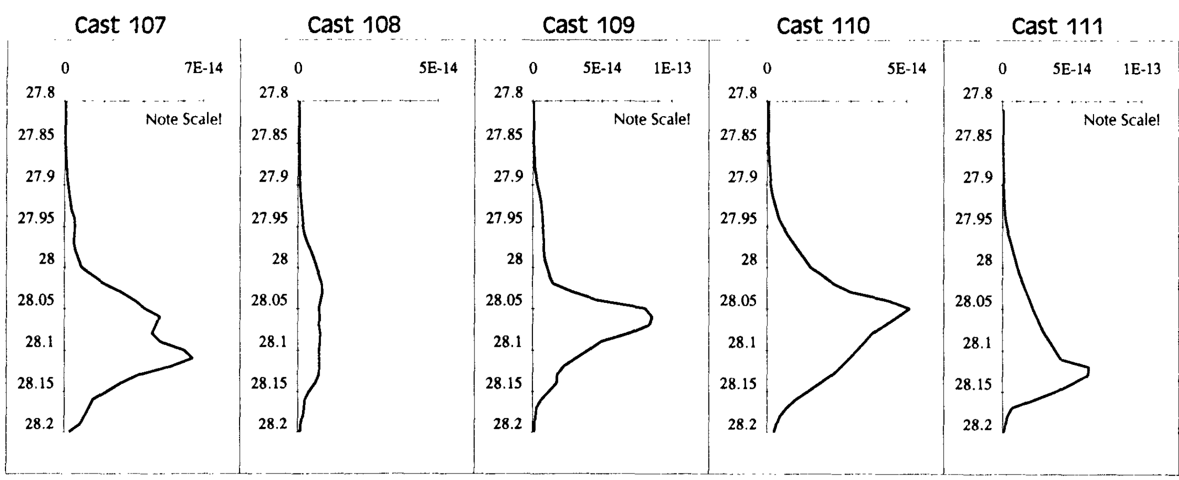


Figure16a

Area E

Column Integral in density space:
4.16E-15
Mean sigmap
28.04906
Mean cd68 pressure:
312.9763
RMS CD 68 Width:
29.11196

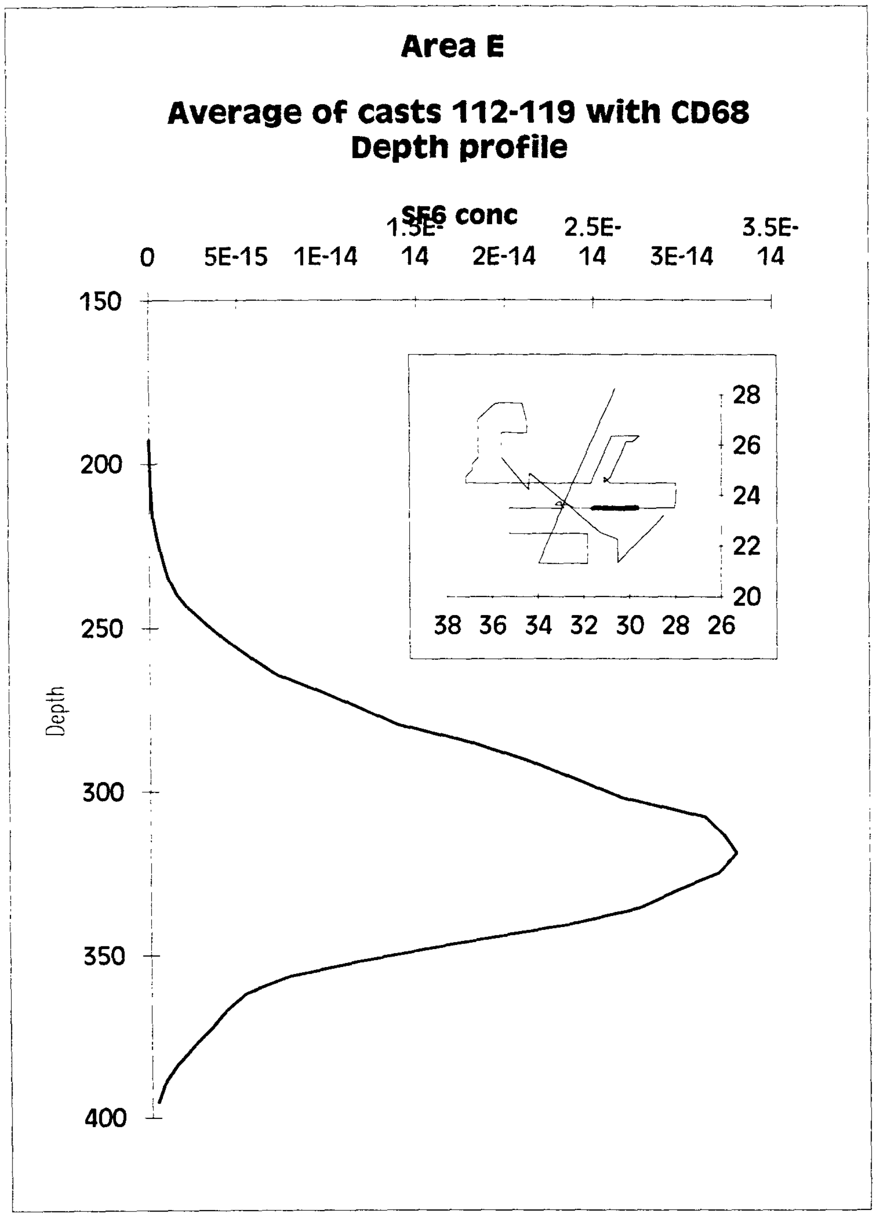


Figure16b

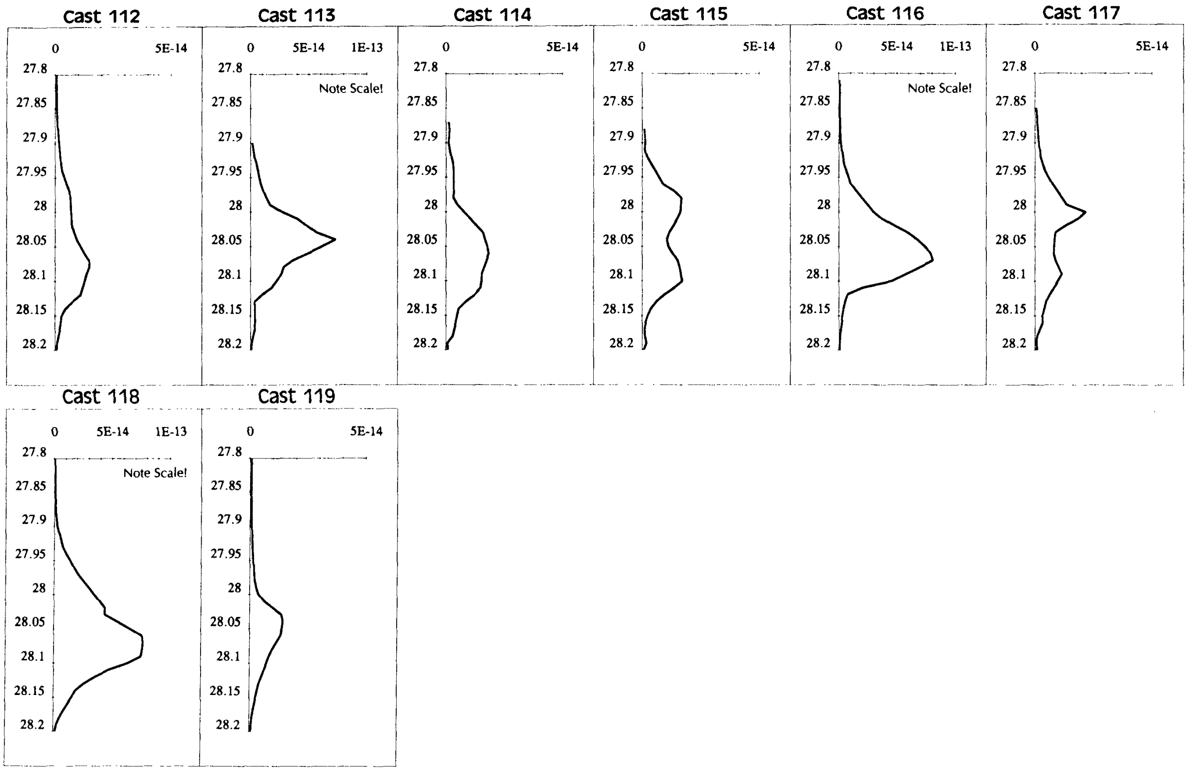

Cast 112
Cast 113
Cast 114
Cast 115
Cast 116
Cast 117
Cast 118
Cast 119
0
5E-14
1E-13
Note Scale!
27.8
27.85
27.9
27.95
28
28.05
28.1
28.15
28.2

Figure 17a

Area F

Column integral in density space:
6.01E-16
Mean sigmap
28.05904
Mean cd68 pressure:
318.4042
RMS CD 68 Width:
31.2402

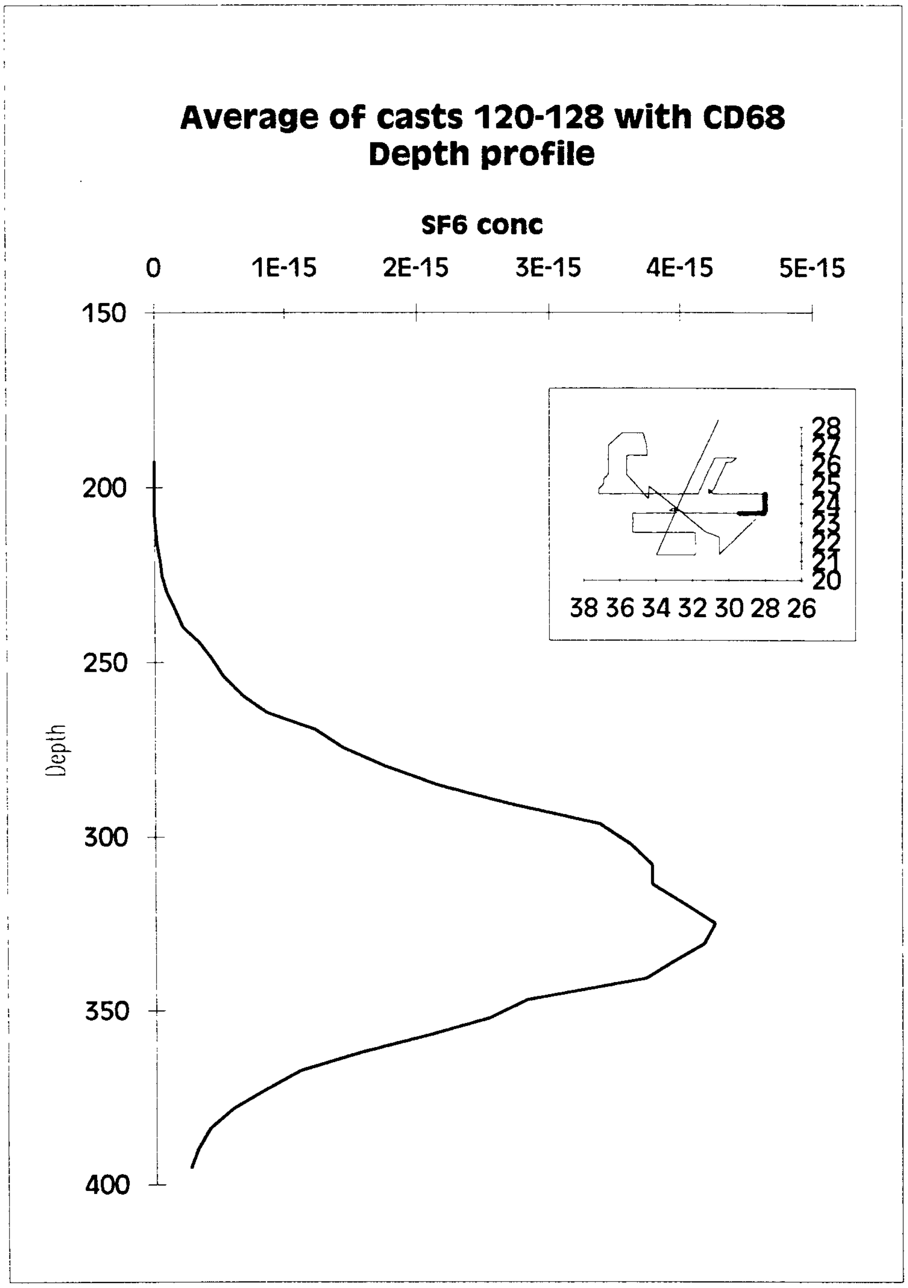


Figure 17b

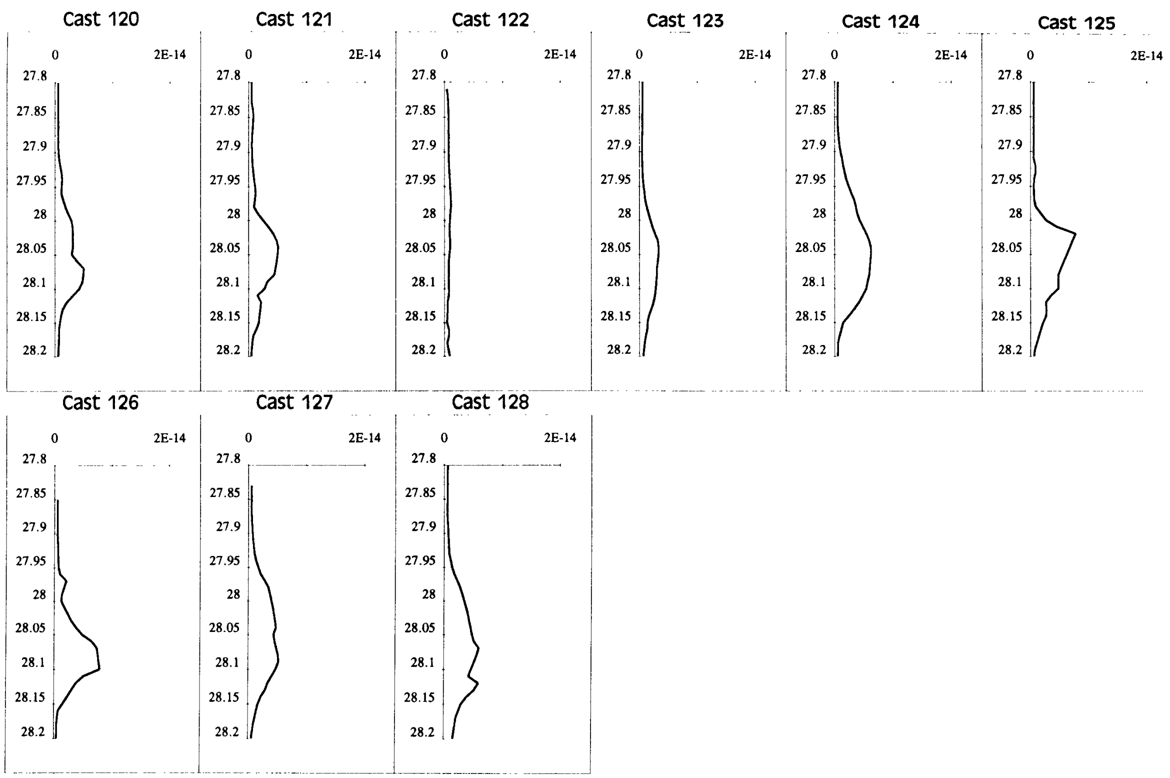

Cast 120
Cast 121
Cast 122
Cast 123
Cast 124
Cast 125
Cast 126
Cast 127
Cast 128
0
2E-14
27.8
27.85
27.9
27.95
28
28.05
28.1
28.15
28.2

Figure 18a

Area G

Column Integral in density space:
4.84E-15
Mean sigmap
28.05794
Mean cd68 pressure:
317.7726
RMS CD 68 Width:
30.16065

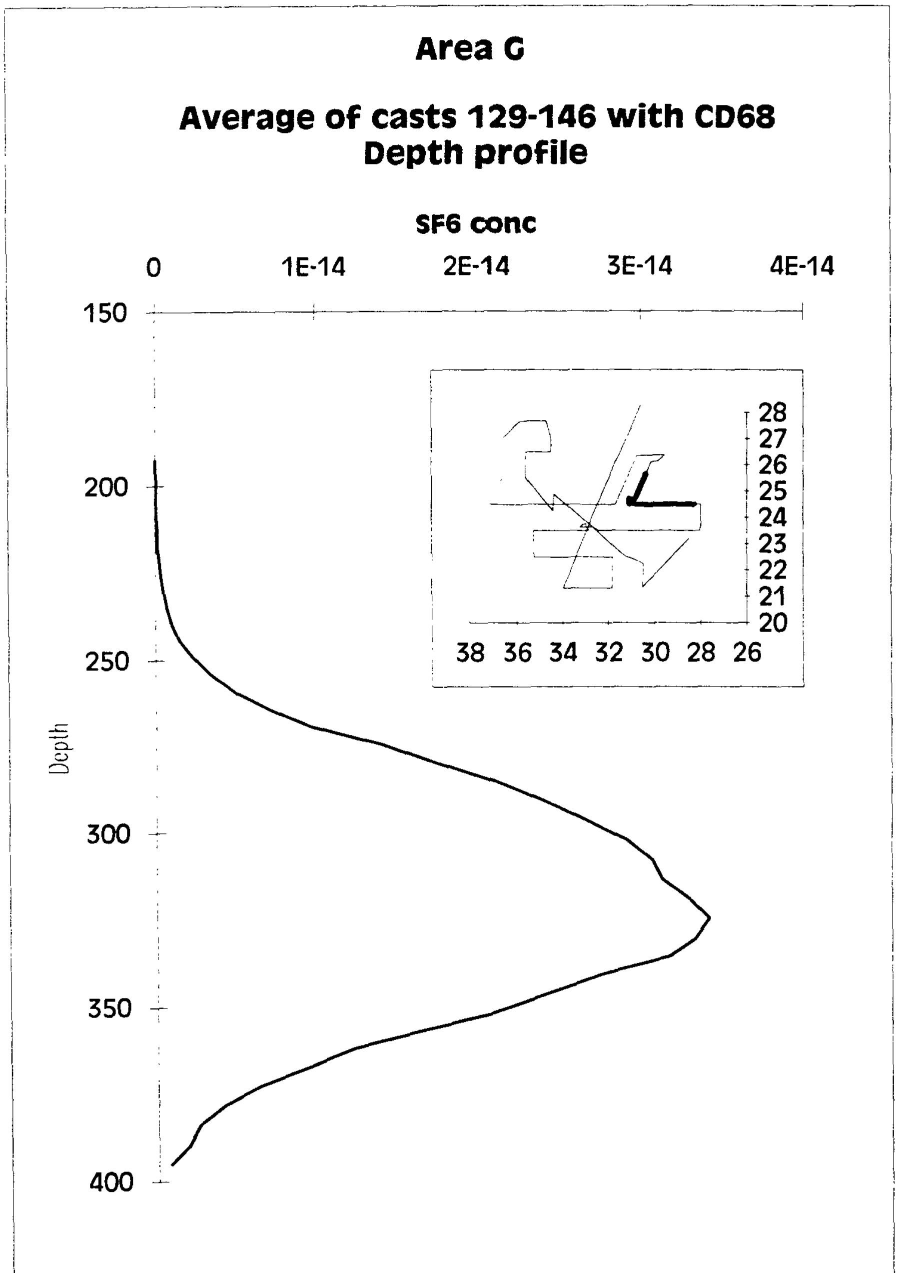


Figure 18b

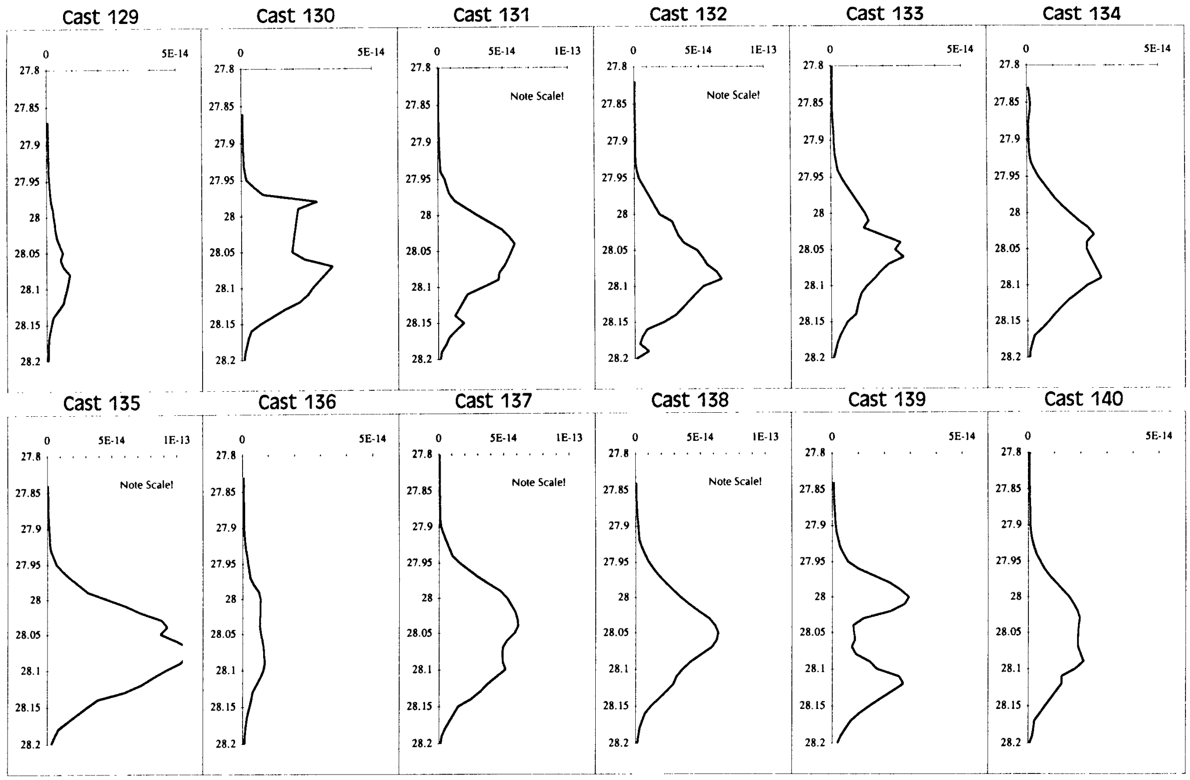



Figure 18c

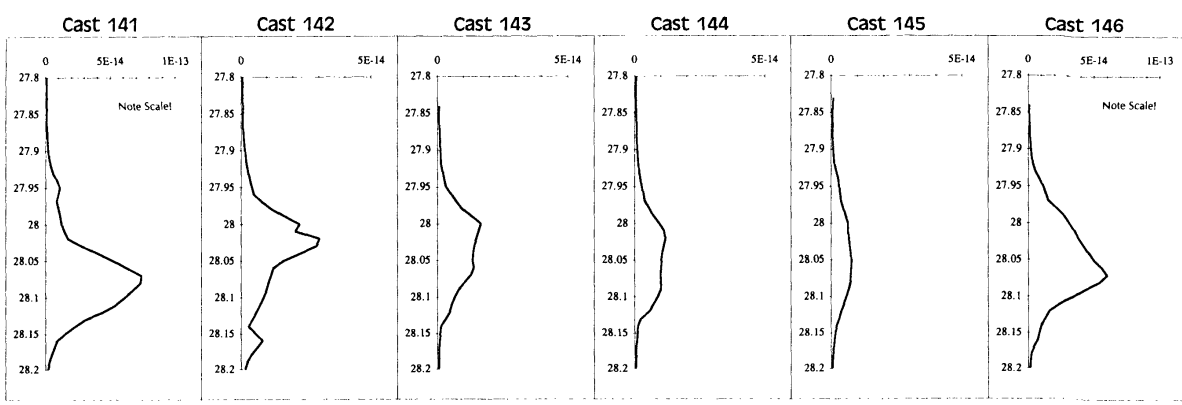


Figure 19a

Area H

**Column Integral in density space:**
**1.8E-16**
**Mean sigmap**
**28.0782**
**Mean cd68 pressure:**
**328.964**
**RMS CD 68 Width:**
**46.8257**

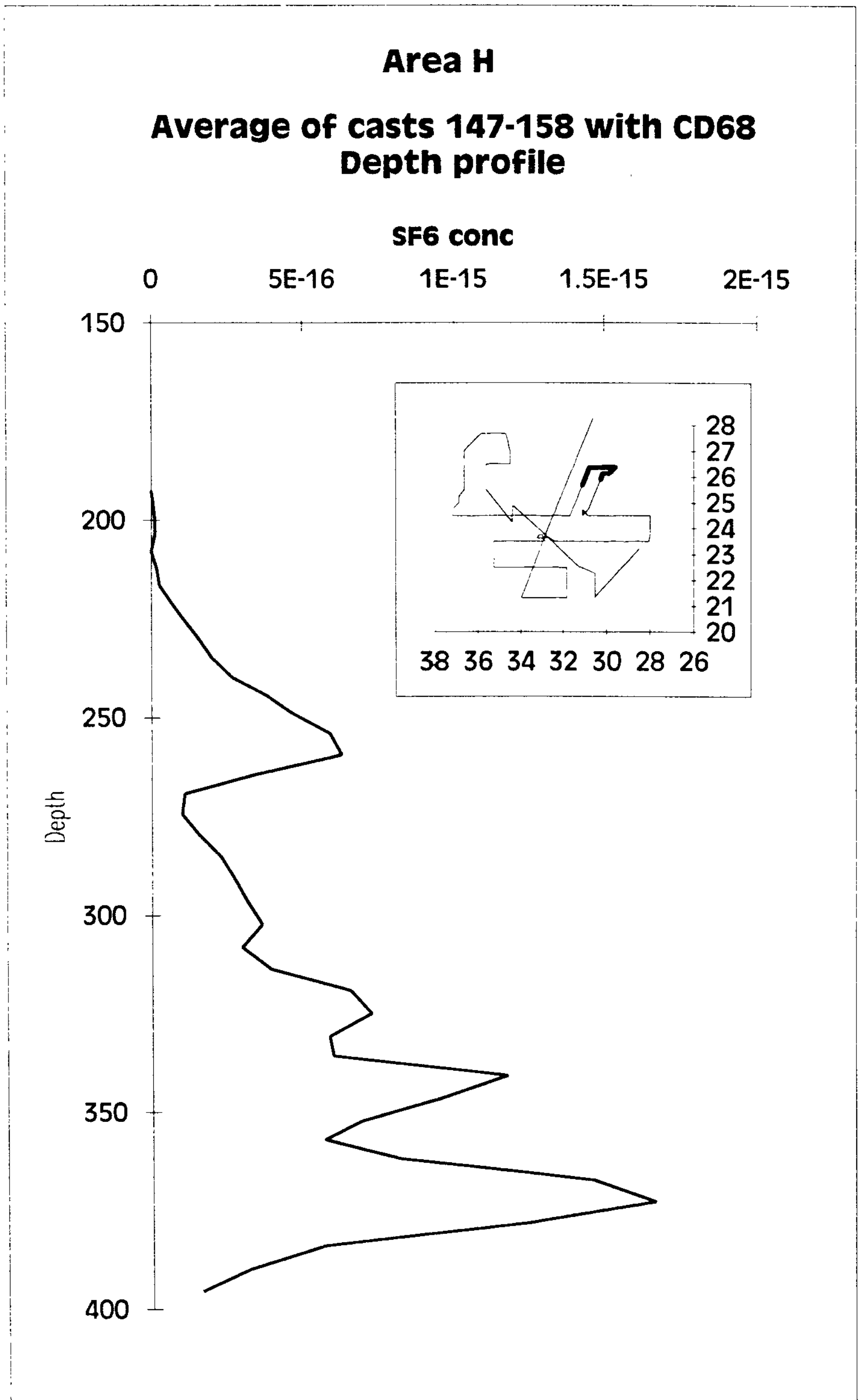


Figure 19b

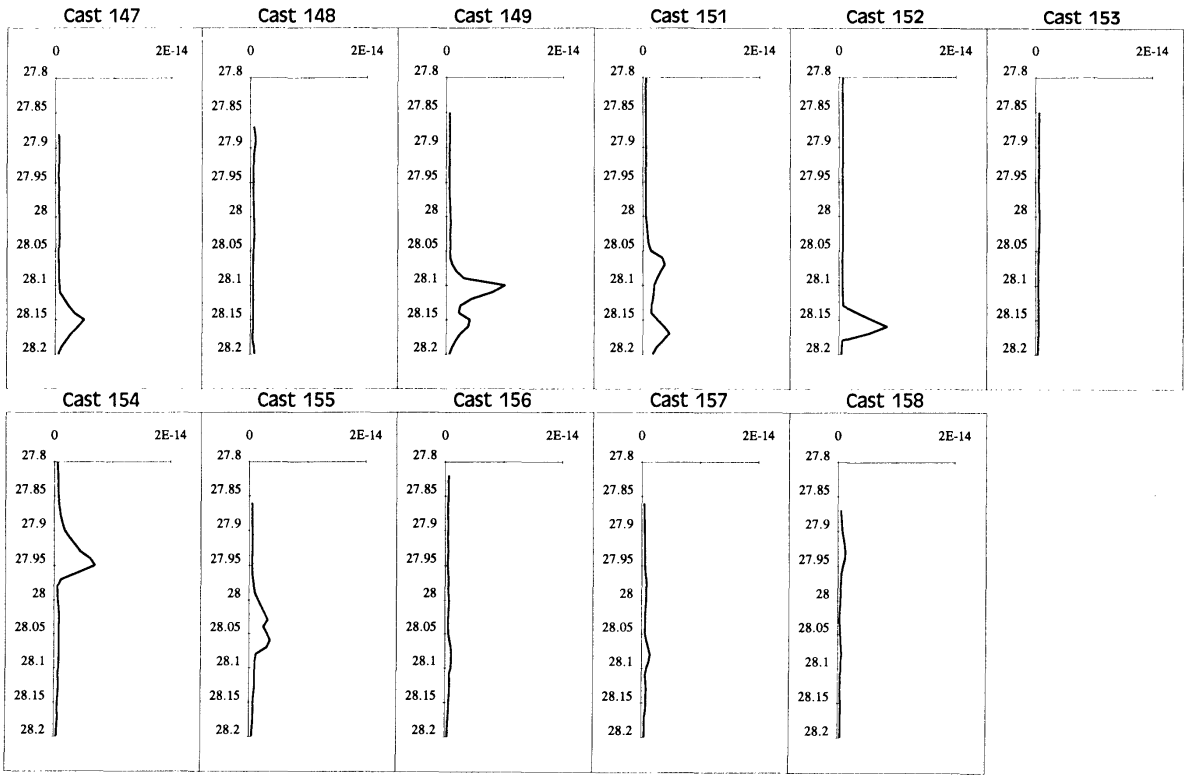

Cast 147
Cast 148
Cast 149
Cast 151
Cast 152
Cast 153
Cast 154
Cast 155
Cast 156
Cast 157
Cast 158
0
2E-14
27.8
27.85
27.9
27.95
28
28.05
28.1
28.15
28.2

Figure 20a

Area I

Column Integral in density space:
5.74E-15
Mean sigmap
28.05272
Mean cd68 pressur
314.8748
RMS CD 68 Width:
30.42777

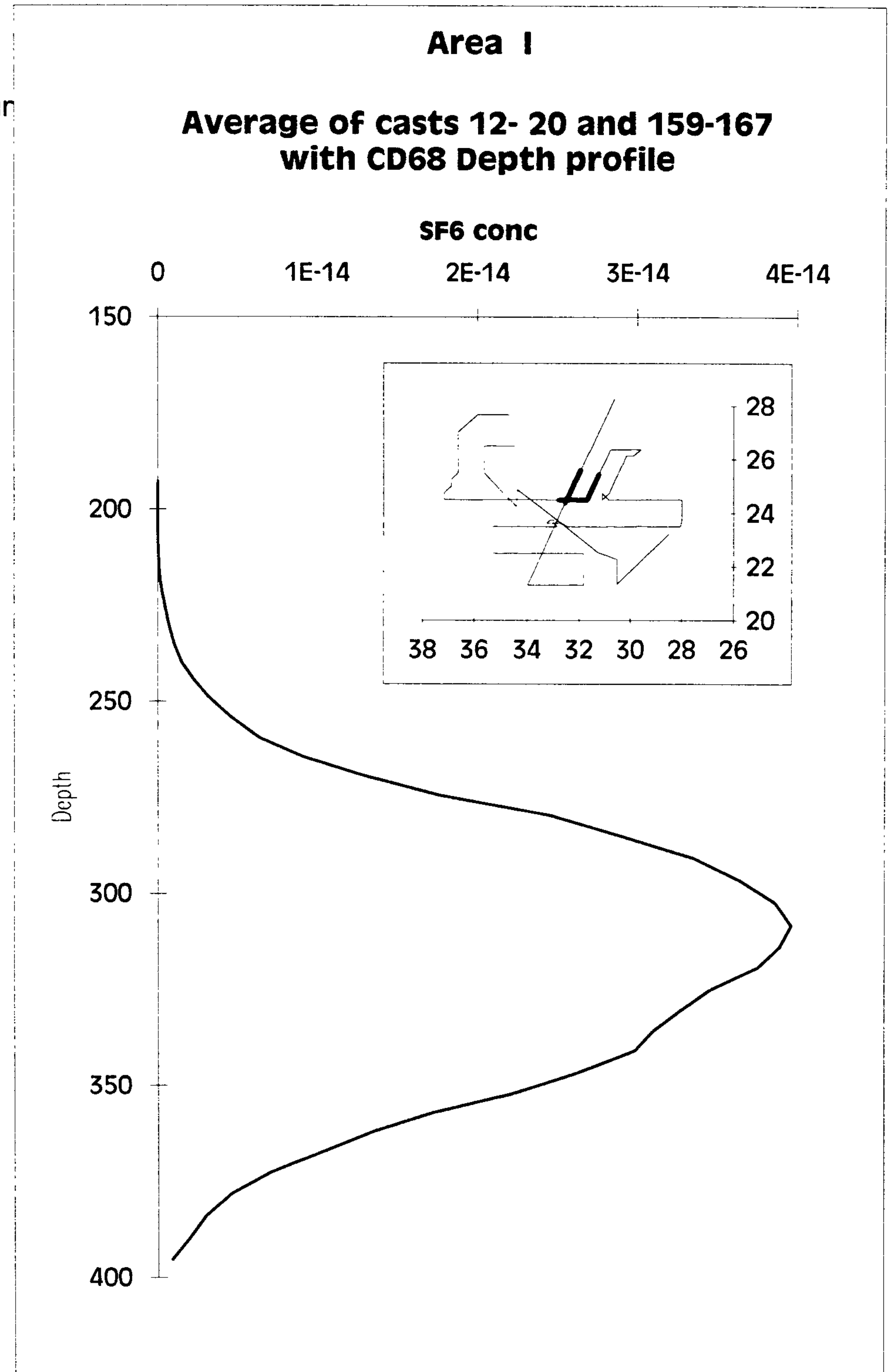


Figure 20b

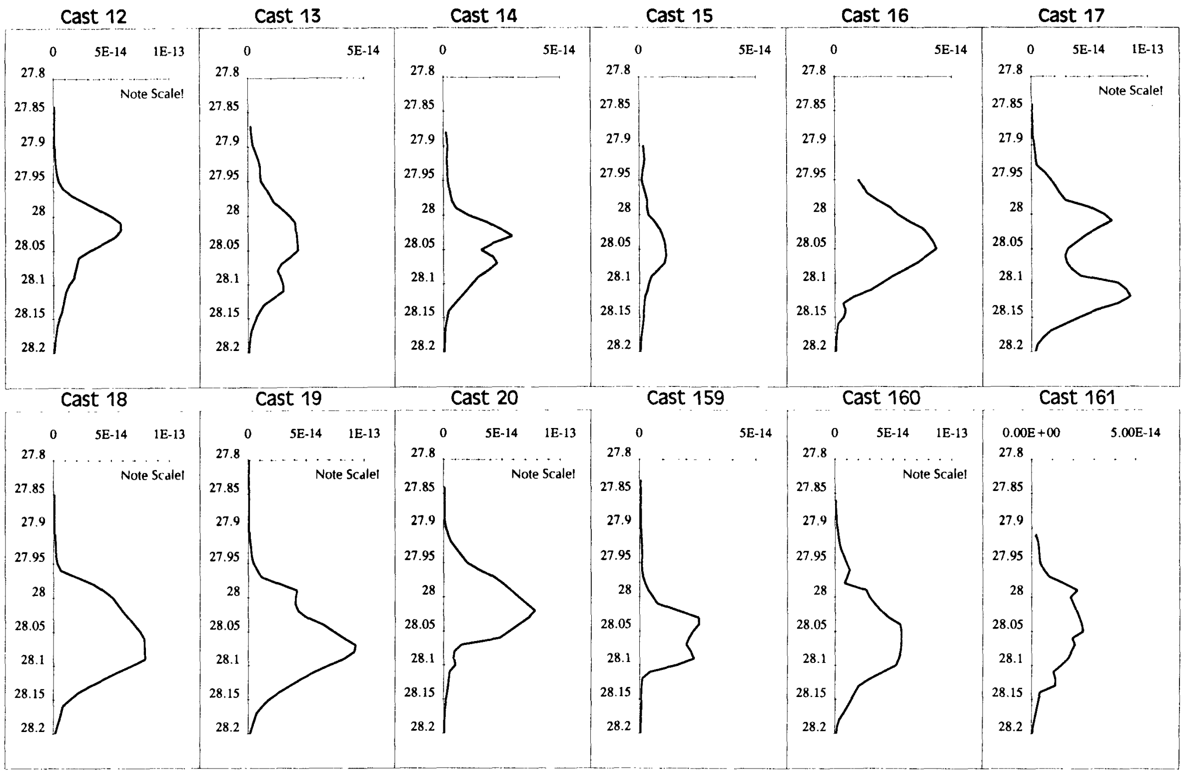



Figure 20c

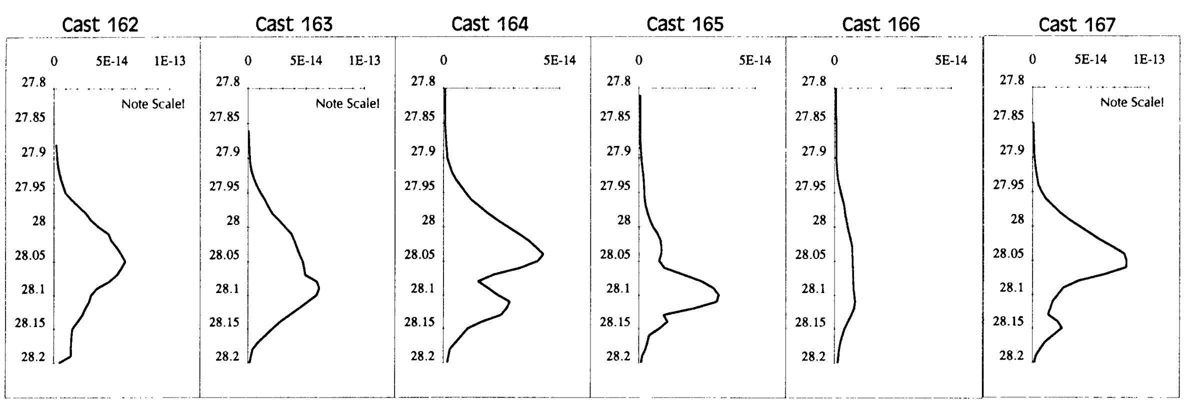


Figure 21a

Area J

Column Integral in density space:
8.04E-15
Mean sigmap
28.05943
Mean cd68 pressure
318.6186
RMS CD 68 Width:
30.89238

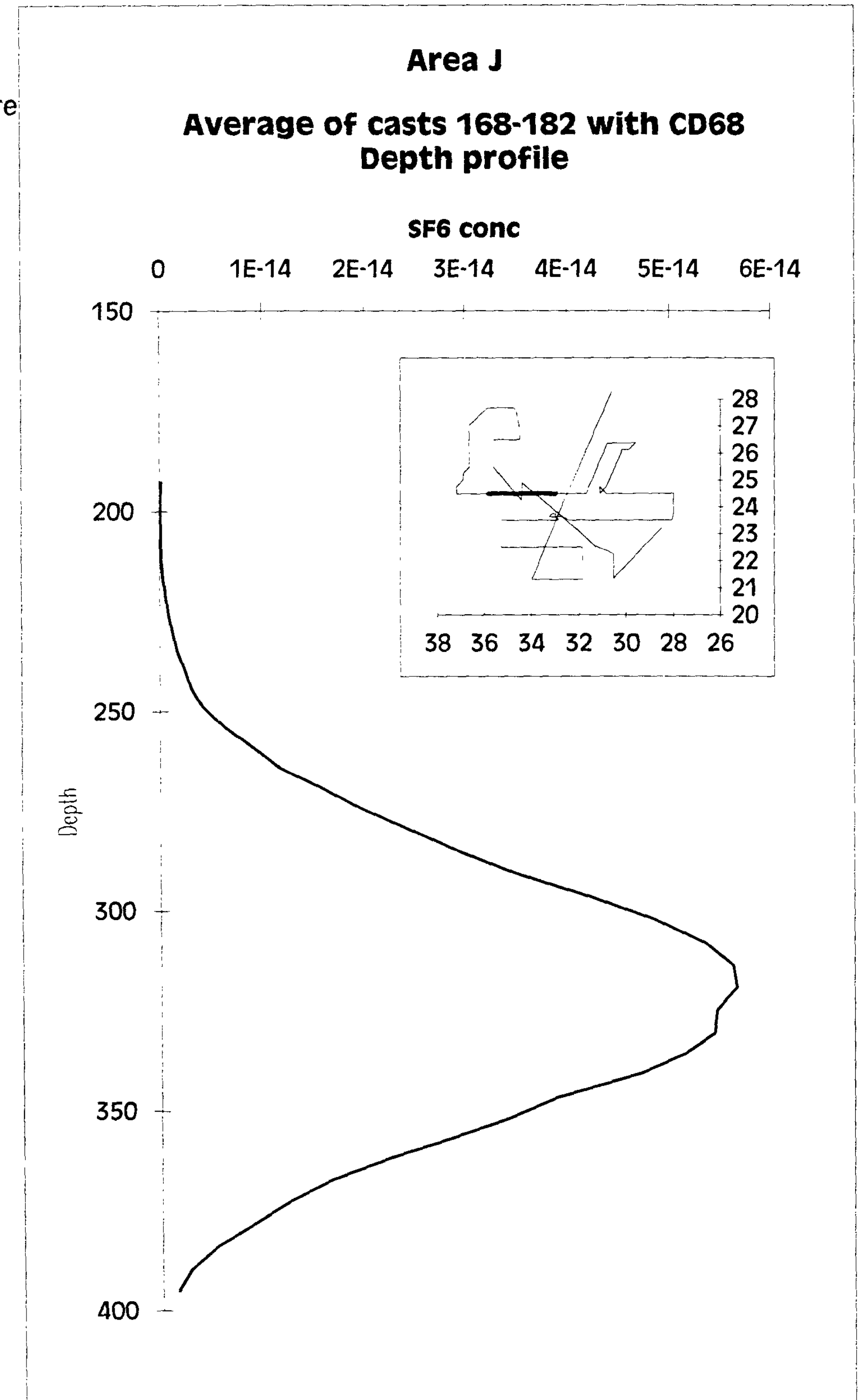


Figure 21b

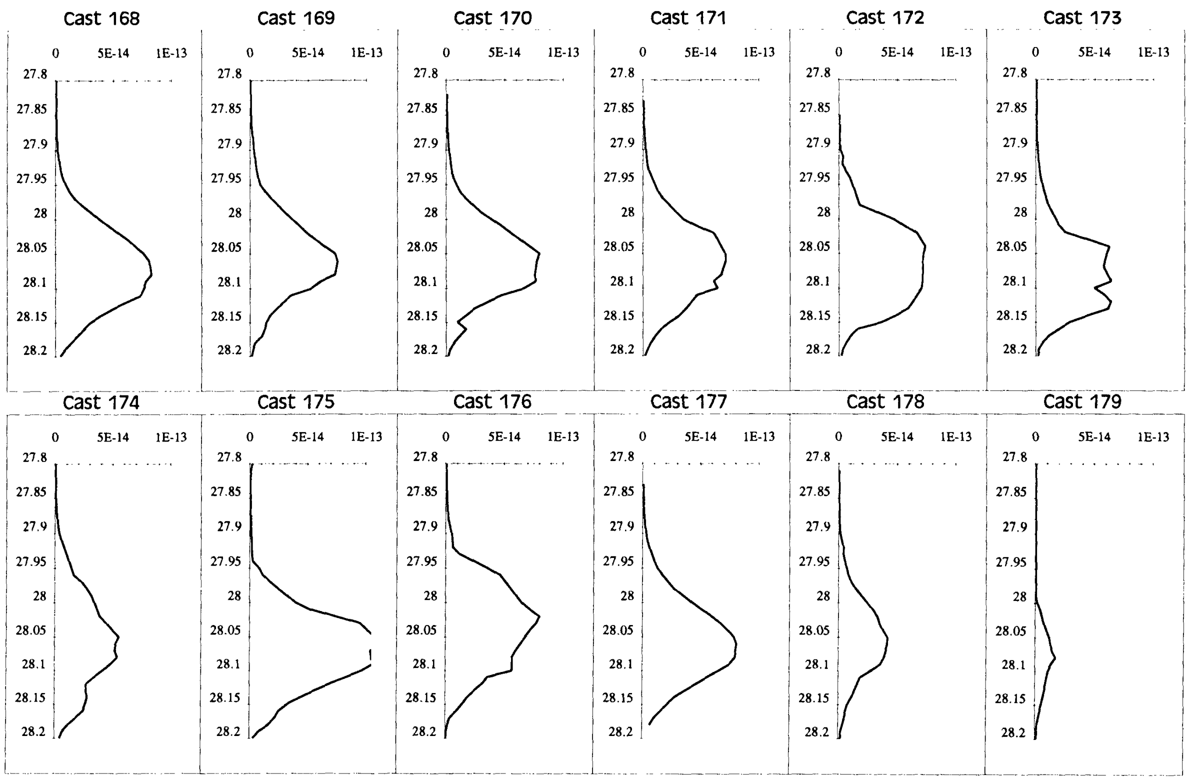



Figure 21c

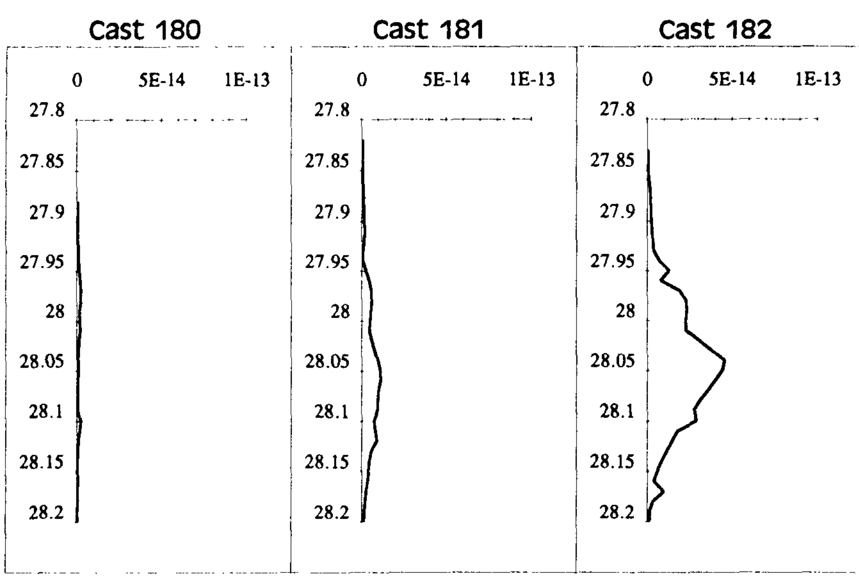


Figure 22a

Area K

Column Integral in density space:
8.66E-16
Mean sigmap
28.05655
Mean cd68 pressure:
317.0606
RMS CD 68 Width:
31.81439

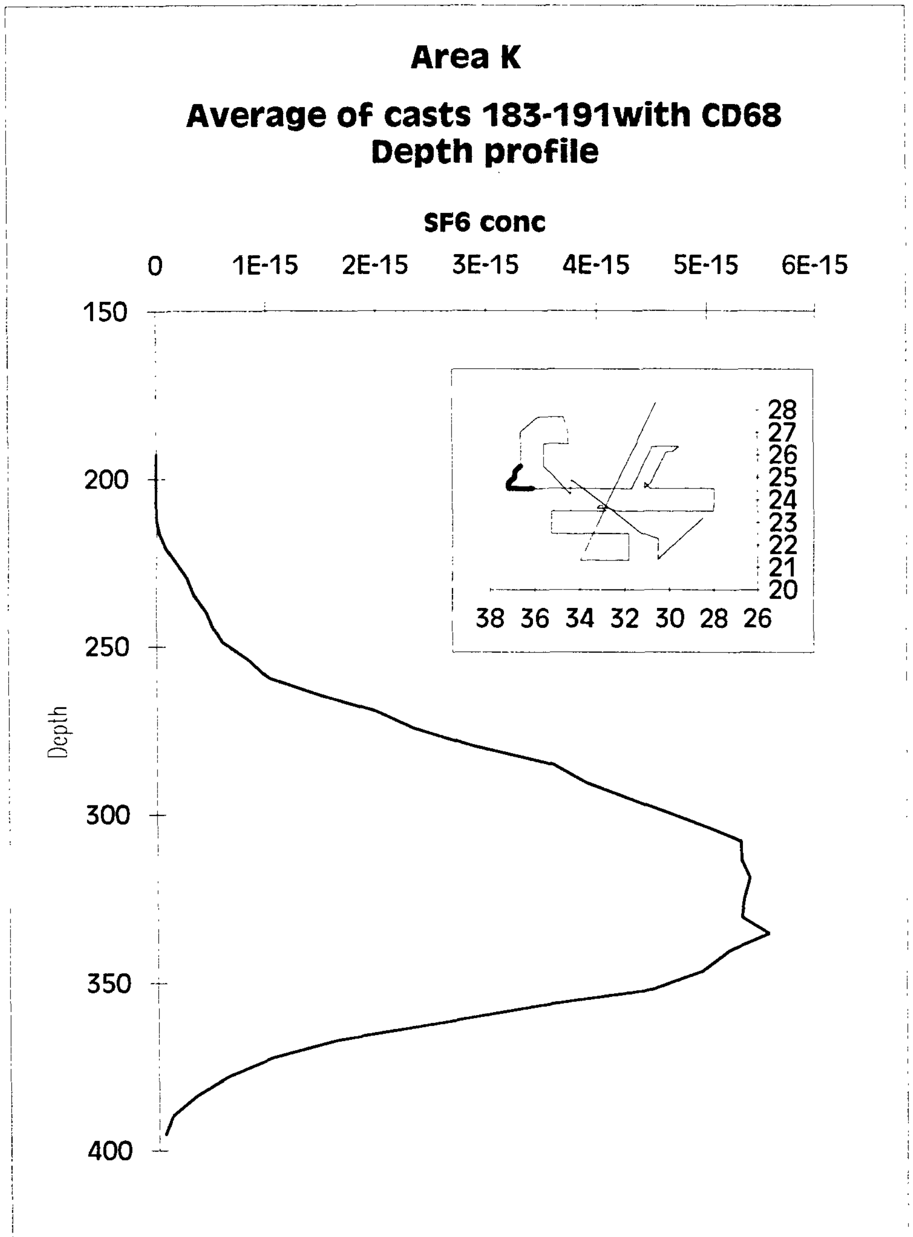
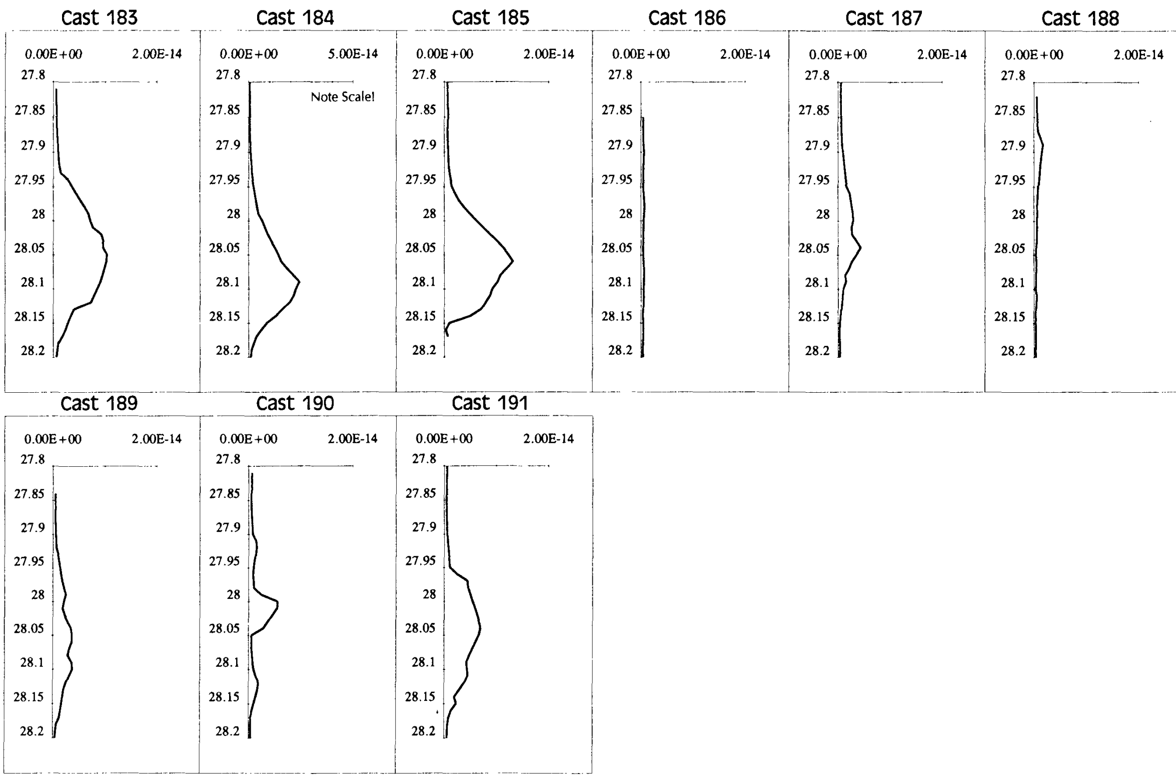


Figure 22b



Cast 183
0.00E+00
2.00E-14
Cast 184
0.00E+00
5.00E-14
Note Scale!
Cast 185
0.00E+00
2.00E-14
Cast 186
0.00E+00
2.00E-14
Cast 187
0.00E+00
2.00E-14
Cast 188
0.00E+00
2.00E-14
Cast 189
0.00E+00
2.00E-14
Cast 190
0.00E+00
2.00E-14
Cast 191
0.00E+00
2.00E-14
27.8
27.85
27.9
27.95
28
28.05
28.1
28.15
28.2

Figure 23a

Area L

Column Integral in density space:
1.53E-15
Mean sigmap
28.06673
Mean cd68 pressure
322.6952
RMS CD 68 Width:
31.44292

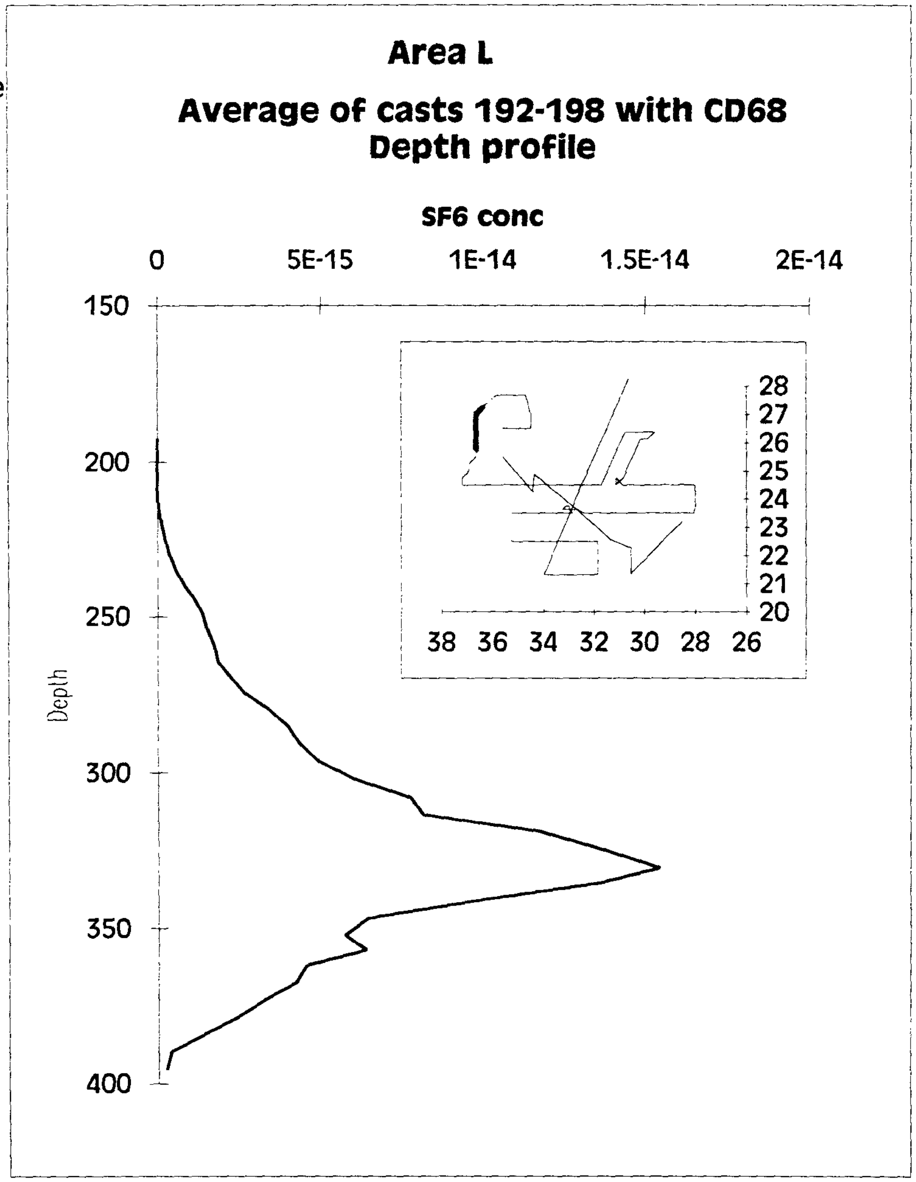


Figure 23b

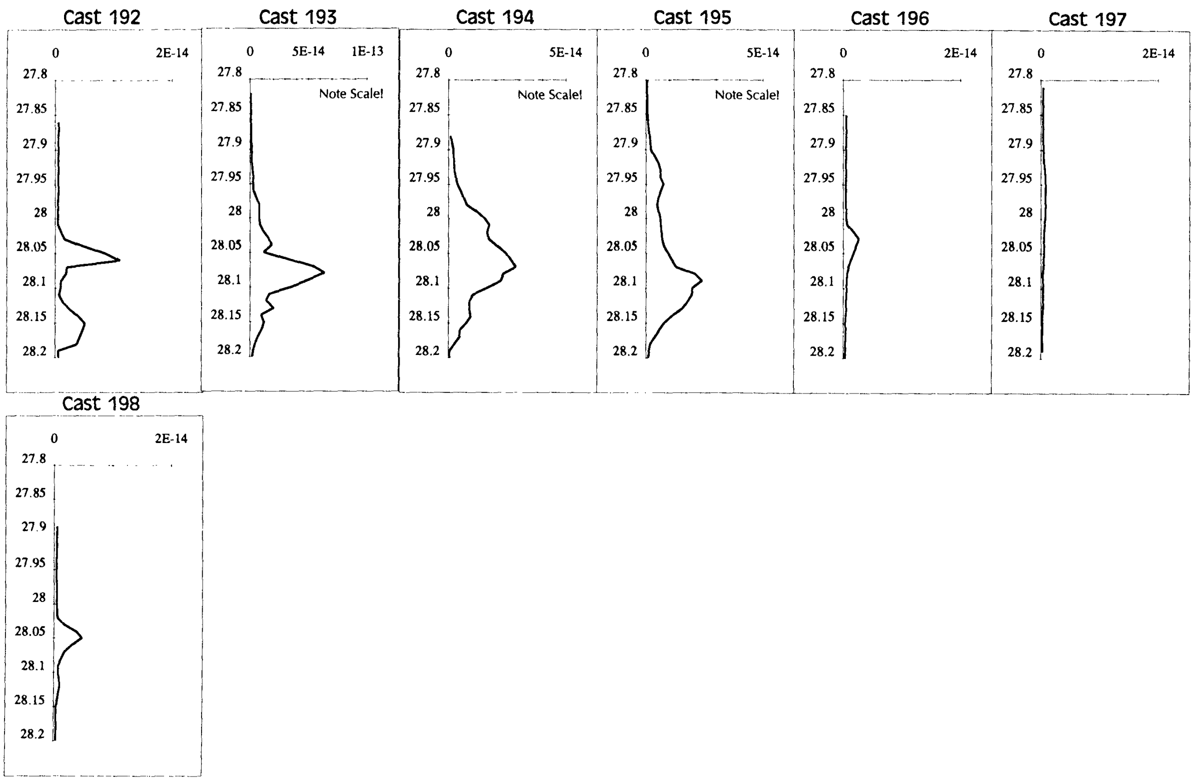

Cast 192
0
2E-14
Cast 193
0
5E-14
1E-13
Note Scale!
Cast 194
0
5E-14
Note Scale!
Cast 195
0
5E-14
Note Scale!
Cast 196
0
2E-14
Cast 197
0
2E-14
Cast 198
0
2E-14
27.8
27.85
27.9
27.95
28
28.05
28.1
28.15
28.2

Figure 24a

Area M

Column Integral in density space:
3.07E-15
Mean sigmap
28.06356
Mean cd68 pressure:
320.8799
RMS CD 68 Width:
30.6507

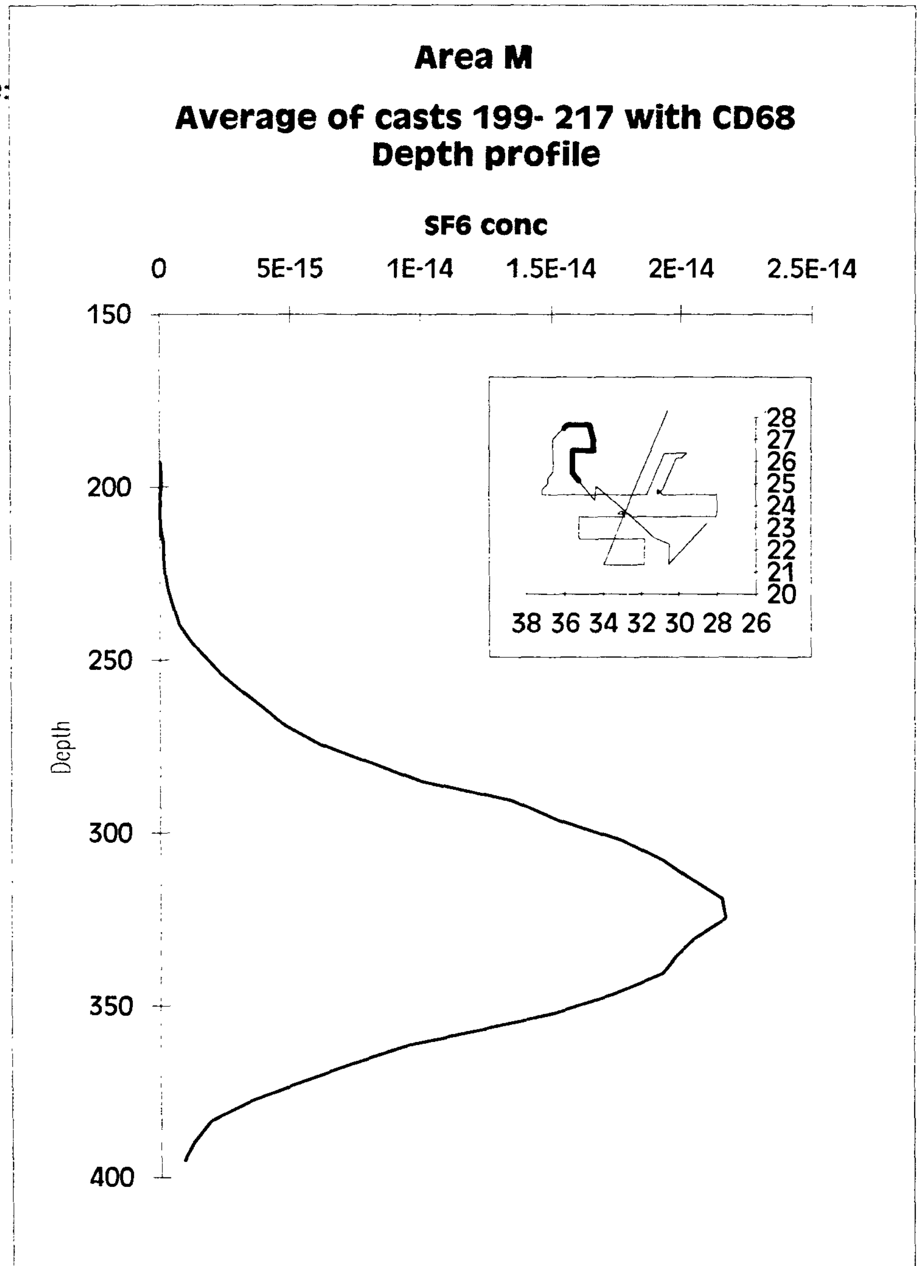


Figure 24b

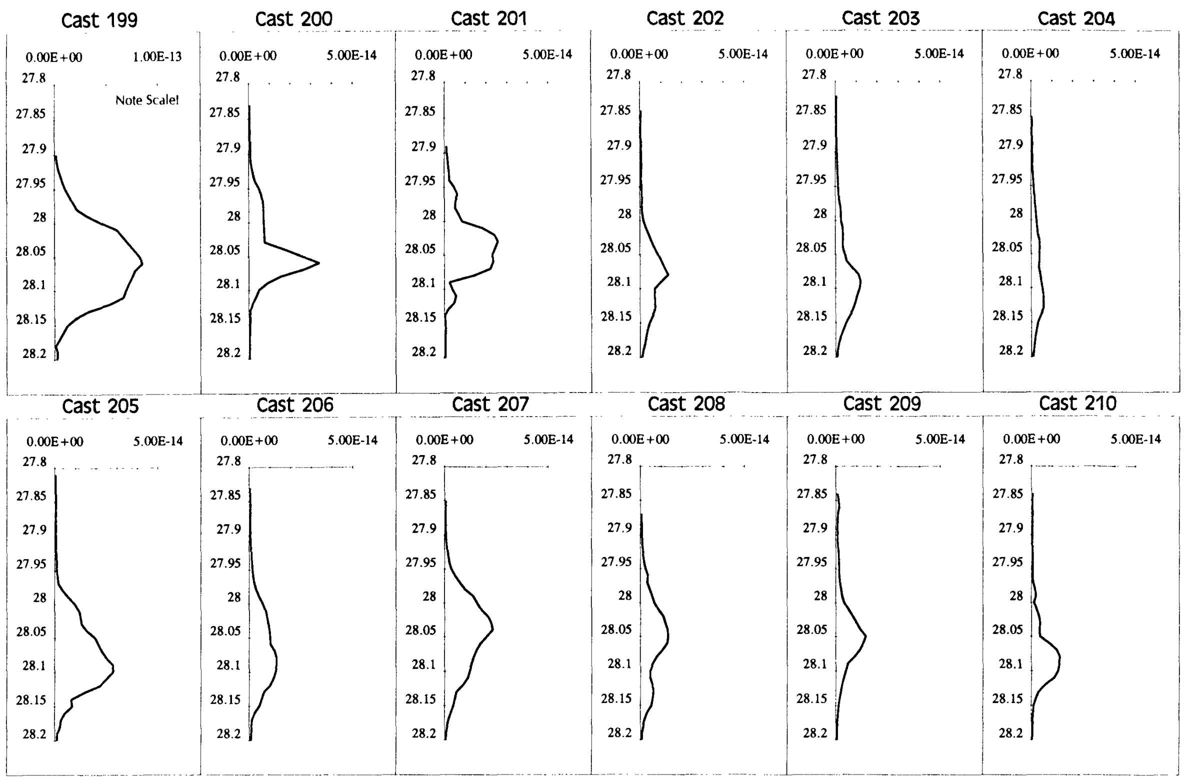

Cast 199
0.00E+00
1.00E-13
Note Scale!
Cast 200
Cast 201
Cast 202
Cast 203
Cast 204
Cast 205
Cast 206
Cast 207
Cast 208
Cast 209
Cast 210
0.00E+00
5.00E-14
27.8
27.85
27.9
27.95
28
28.05
28.1
28.15
28.2

Figure 25a

Area N

Column Integral in density space:
2.06E-15
Mean sigmap
28.06319
Mean cd68 pressure:
320.6238
RMS CD 68 Width:
32.03053

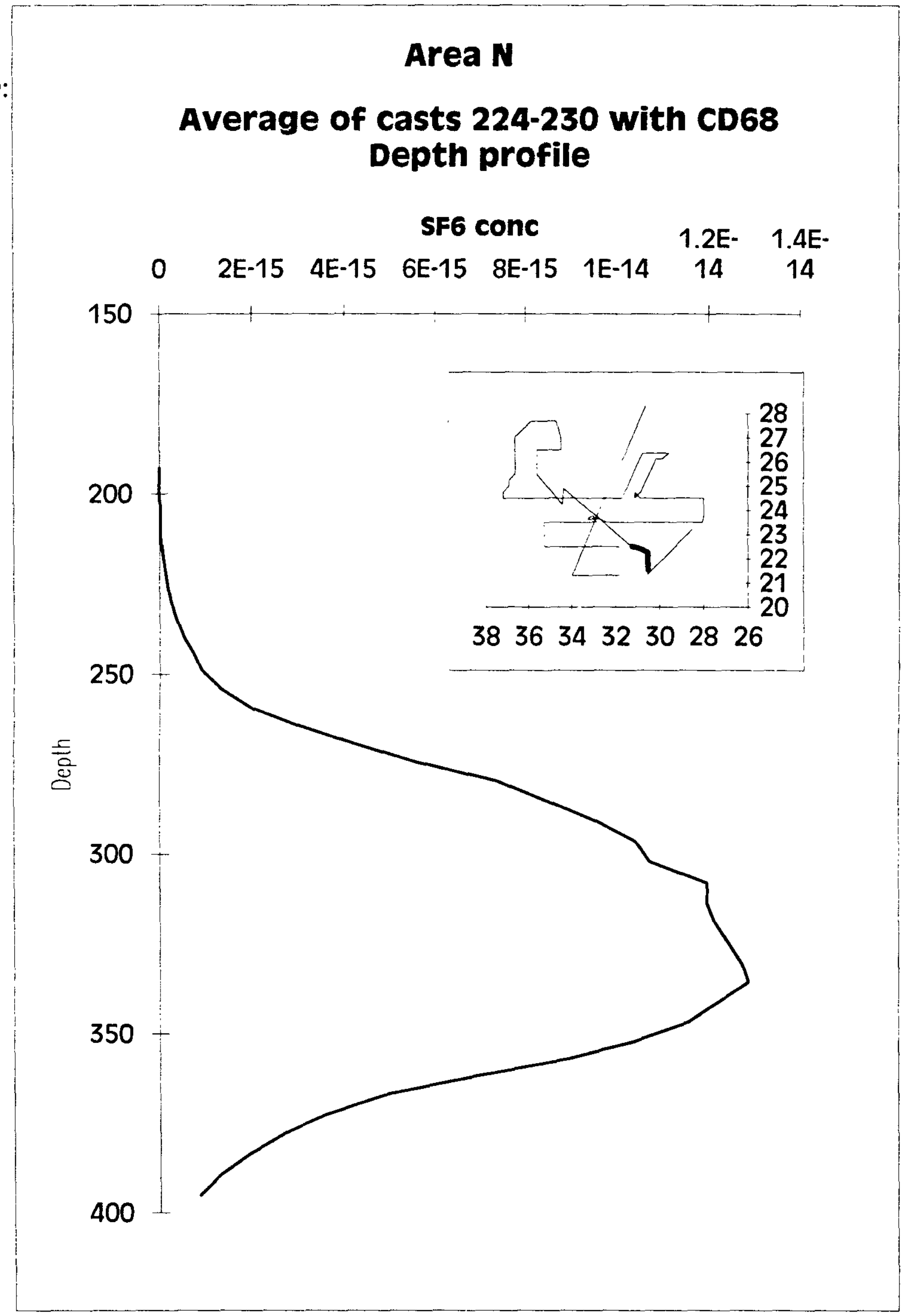


Figure 25b

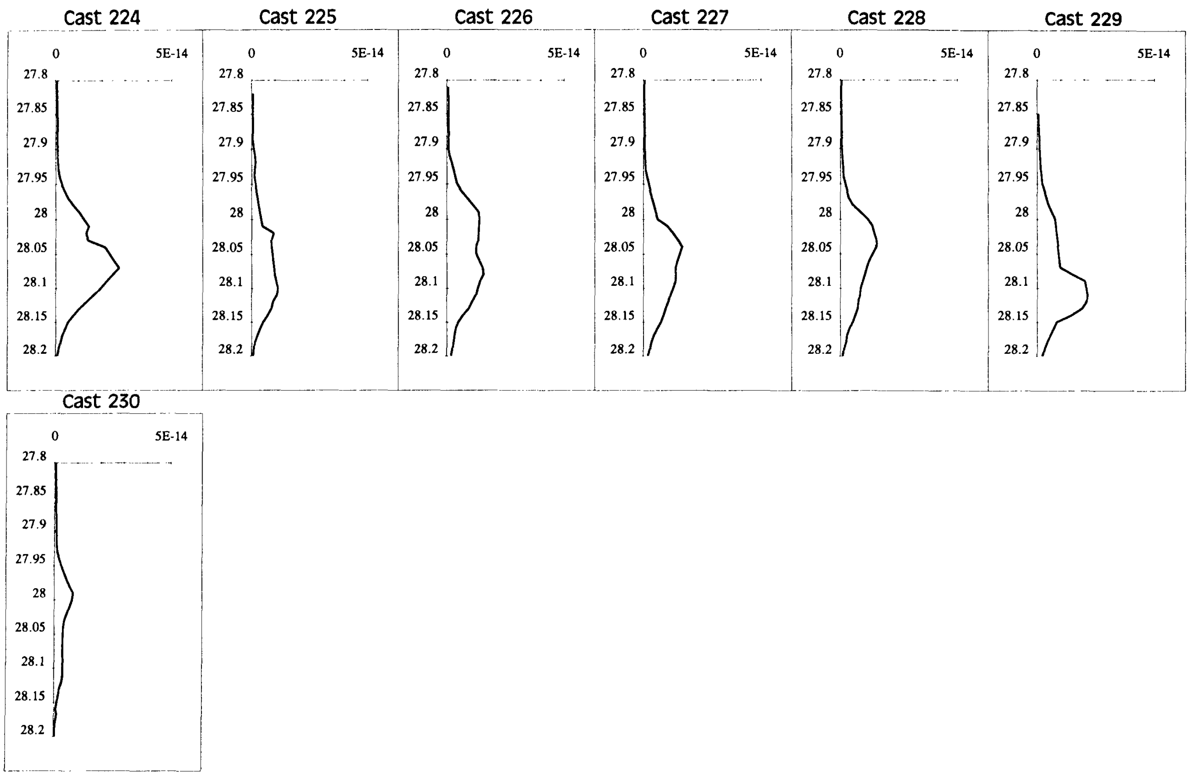

Cast 224
Cast 225
Cast 226
Cast 227
Cast 228
Cast 229
Cast 230
0
5E-14
27.8
27.85
27.9
27.95
28
28.05
28.1
28.15
28.2

Figure 26

Column Integral in density space:
3.2E-15
Mean sigmap
28.05779
Mean cd68 pressure:
317.7156
RMS CD 68 Width:
31.14419

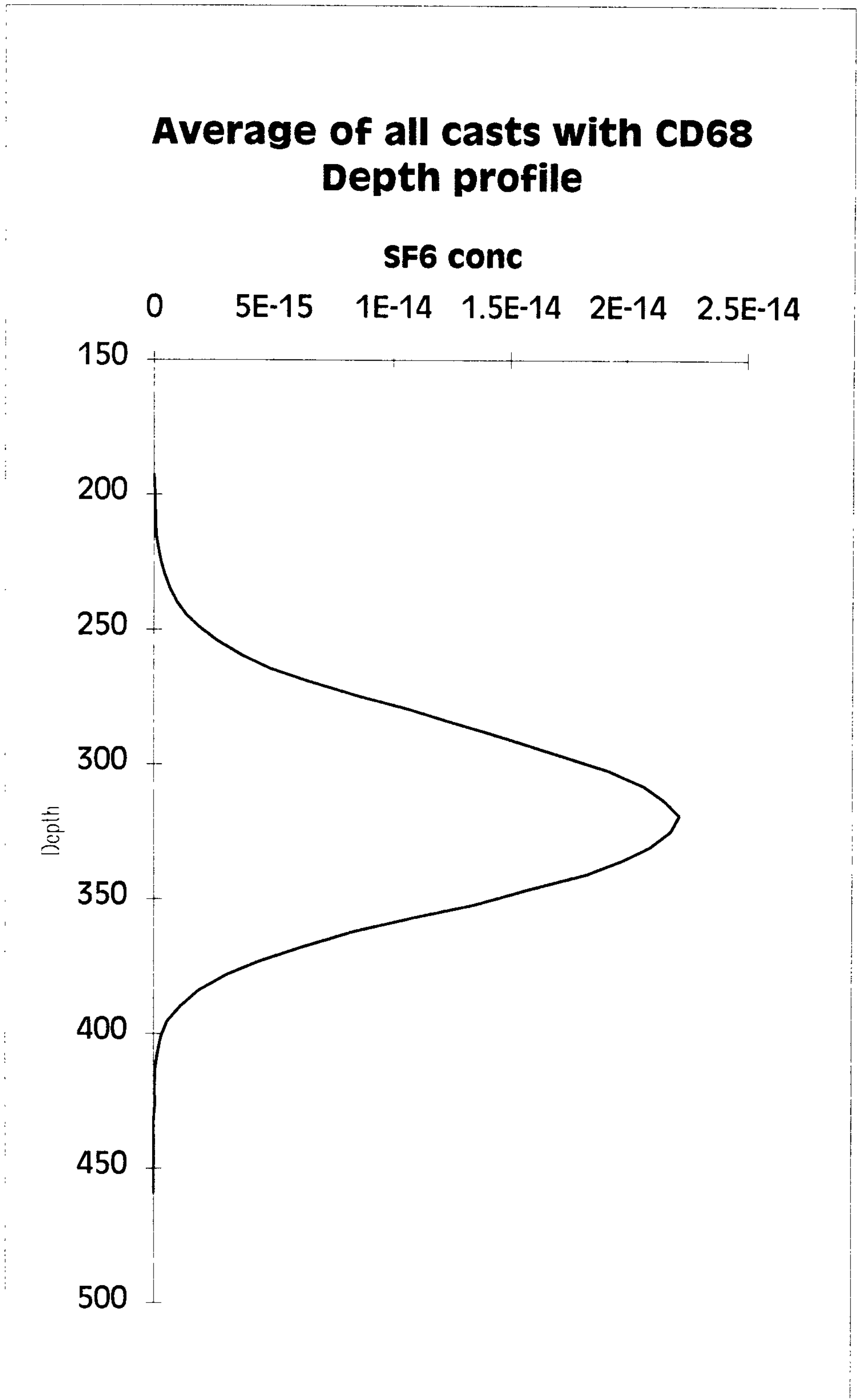


Figure 27

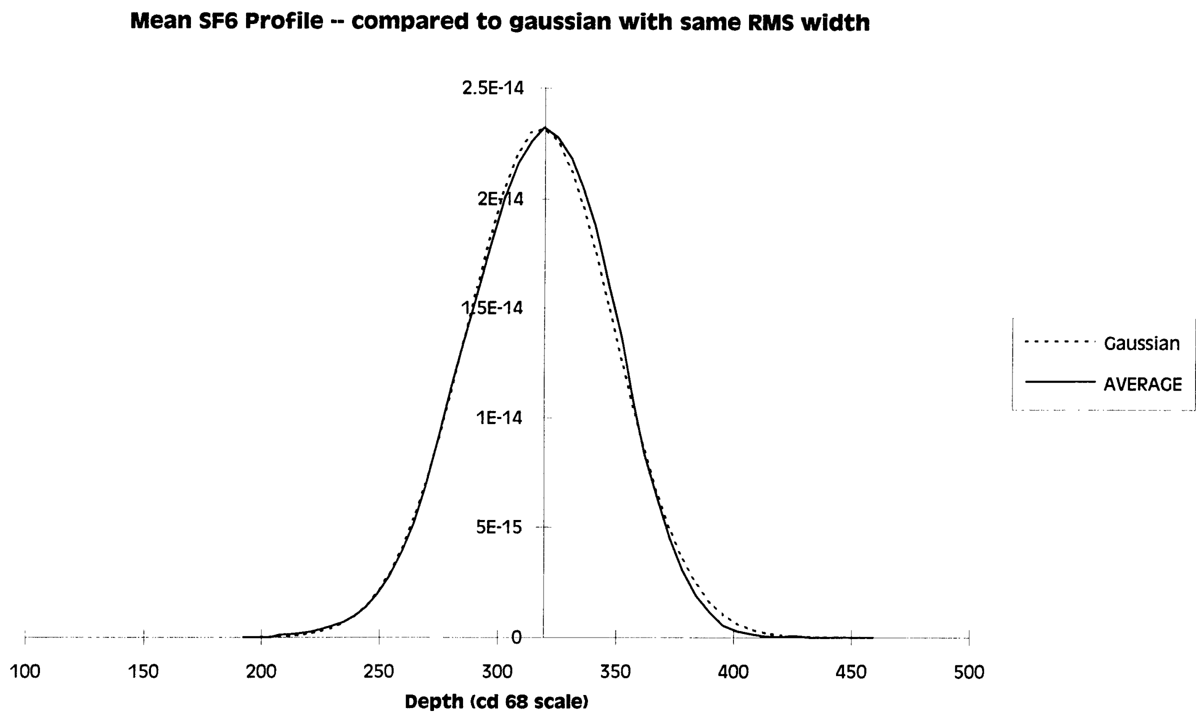
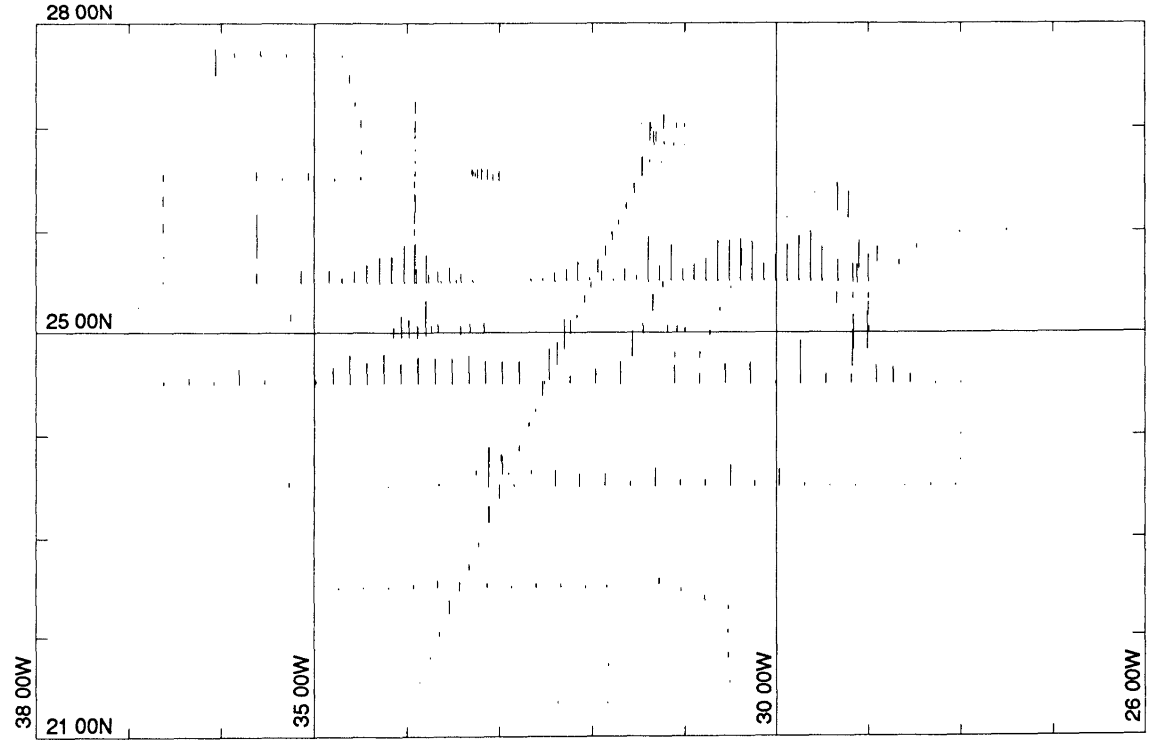

Mean SF6 Profile -- compared to gaussian with same RMS width
2.5E-14
2E-14
1.5E-14
1E-14
5E-15
0
100
150
200
250
300
350
400
450
500
Depth (cd 68 scale)
Gaussian
AVERAGE

Figure 28



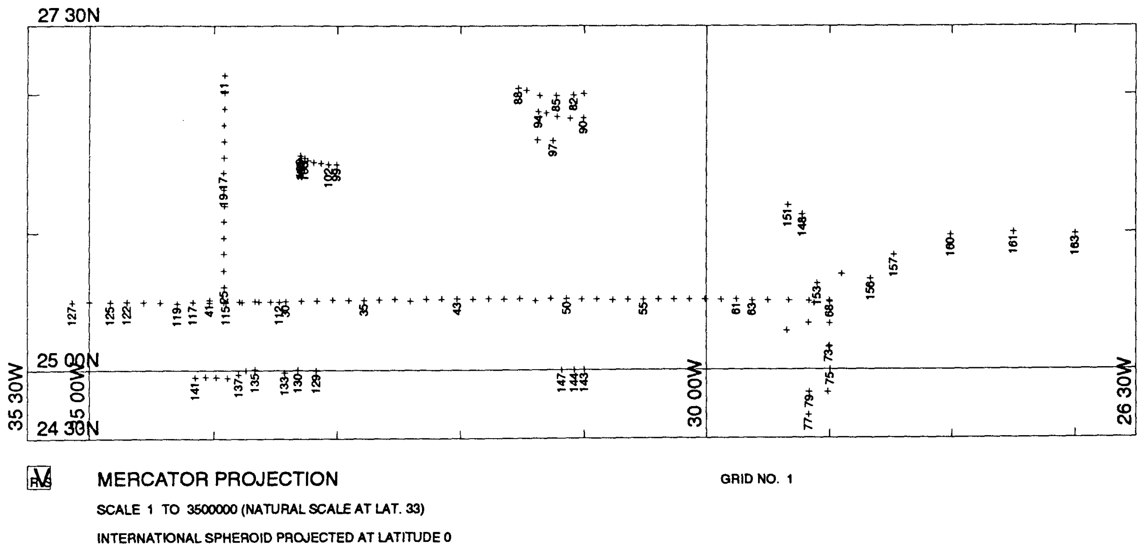

MERCATOR PROJECTION

SCALE 1 TO 5000000 (NATURAL SCALE AT LAT. 33)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 0

RRS Charles Darwin 78 & CSS Hudson SF6 Column Integrals

Figure 29




CSS Hudson CTD Stations in Work Area

Figure 30

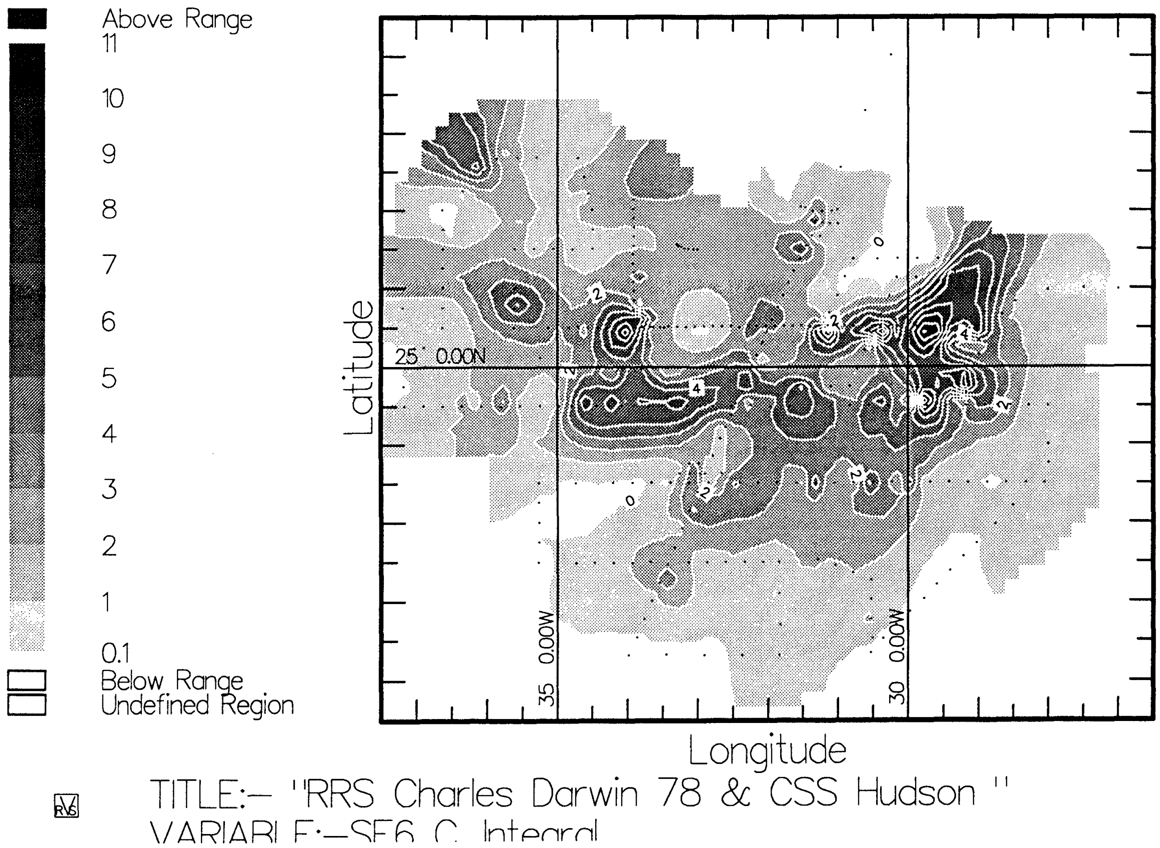
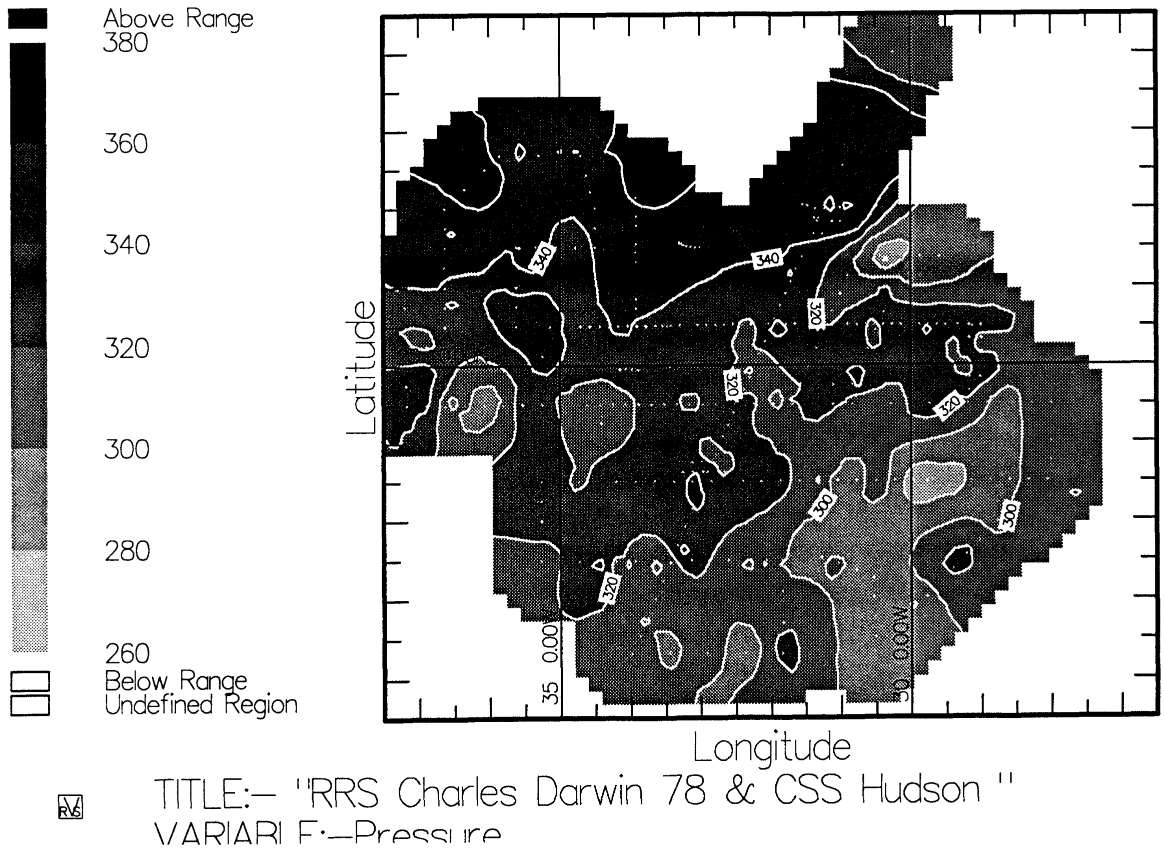
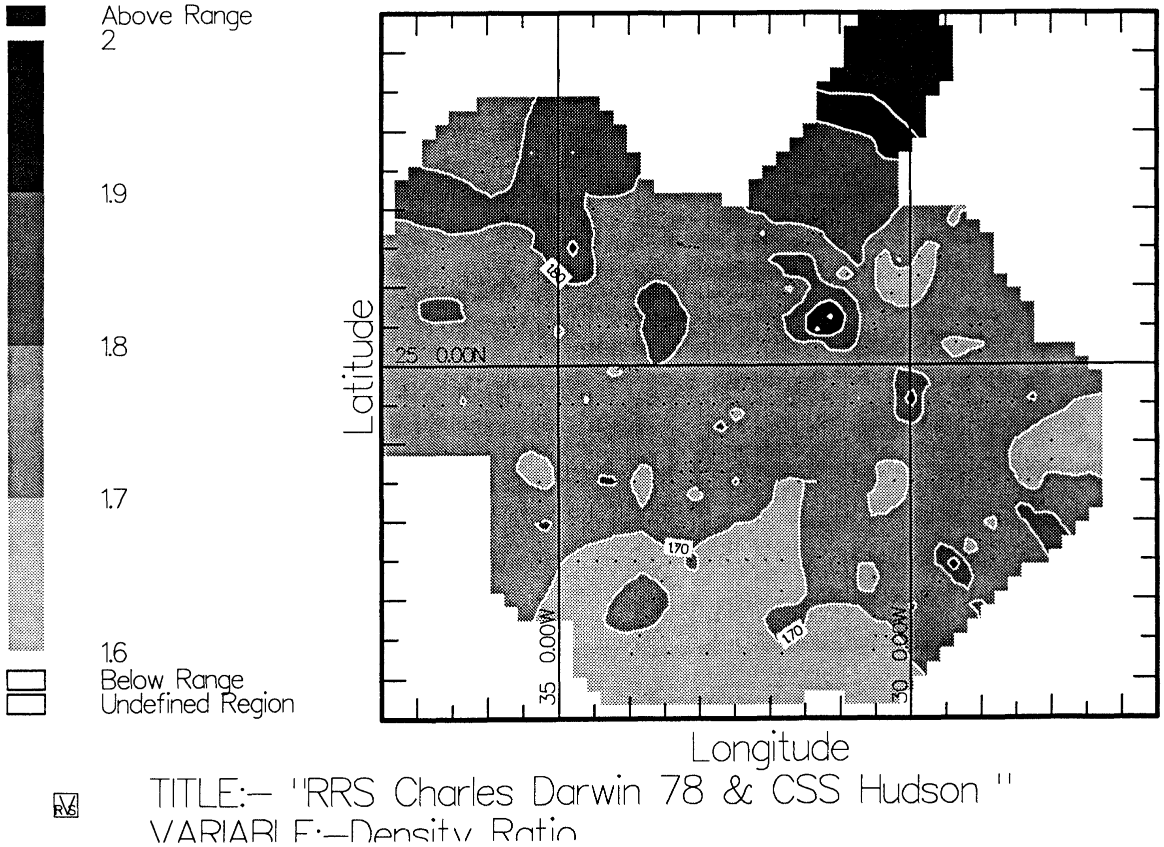

Above Range
11
10
9
8
7
6
5
4
3
2
1
0.1
Below Range
Undefined Region
Latitude
25 0.00N
35 0.00W
30 0.00W
Longitude
TITLE:– ''RRS Charles Darwin 78 & CSS Hudson ''

Figure 31



Above Range
380
360
340
320
300
280
260
Below Range
Undefined Region
Latitude
Longitude
340
340
320
320
320
300
300
320
35 0.00W
30 0.00W
TITLE:– "RRS Charles Darwin 78 & CSS Hudson "
VARIABLE:–Pressure

Figure 32



Above Range
2
1.9
1.8
1.7
1.6
Below Range
Undefined Region
Latitude
25 0.00N
35 0.00W
30 0.00W
Longitude
TITLE:– "RRS Charles Darwin 78 & CSS Hudson "
VARIABLE:–Density Ratio

Figure 33

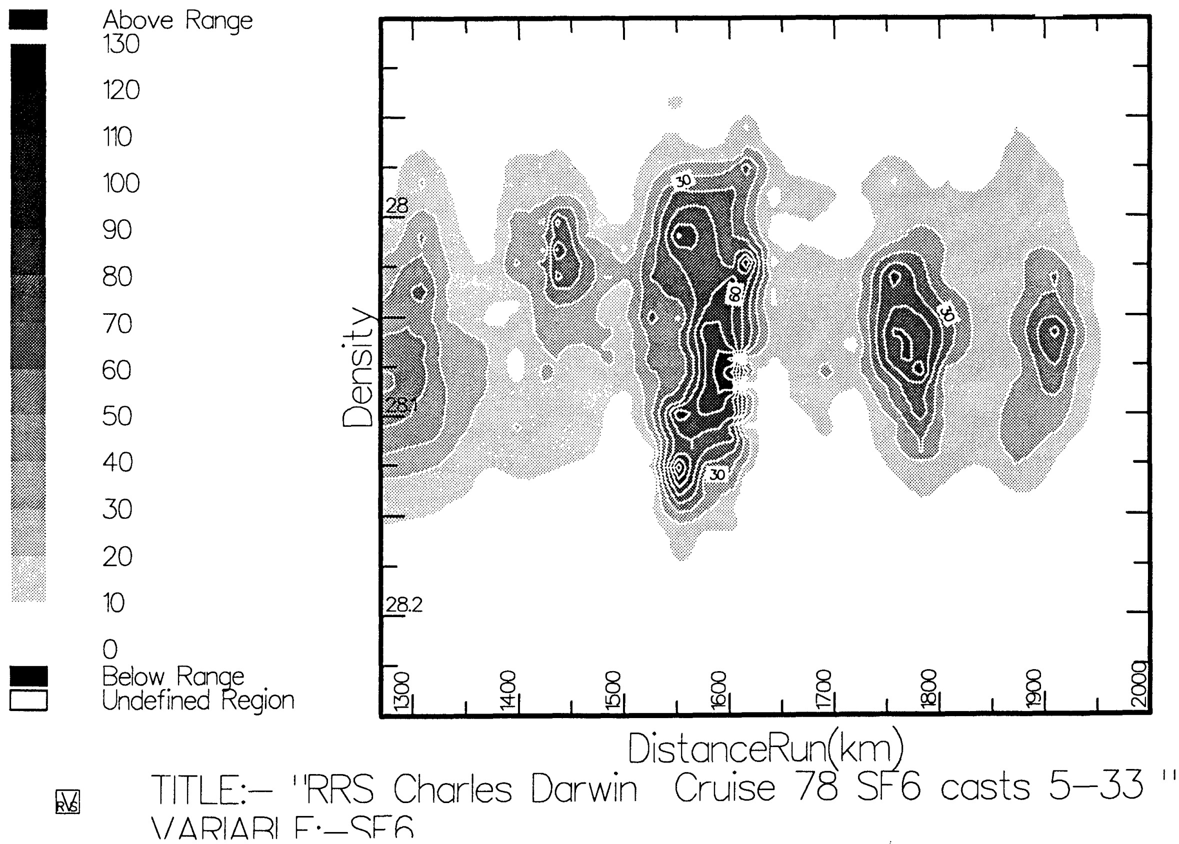
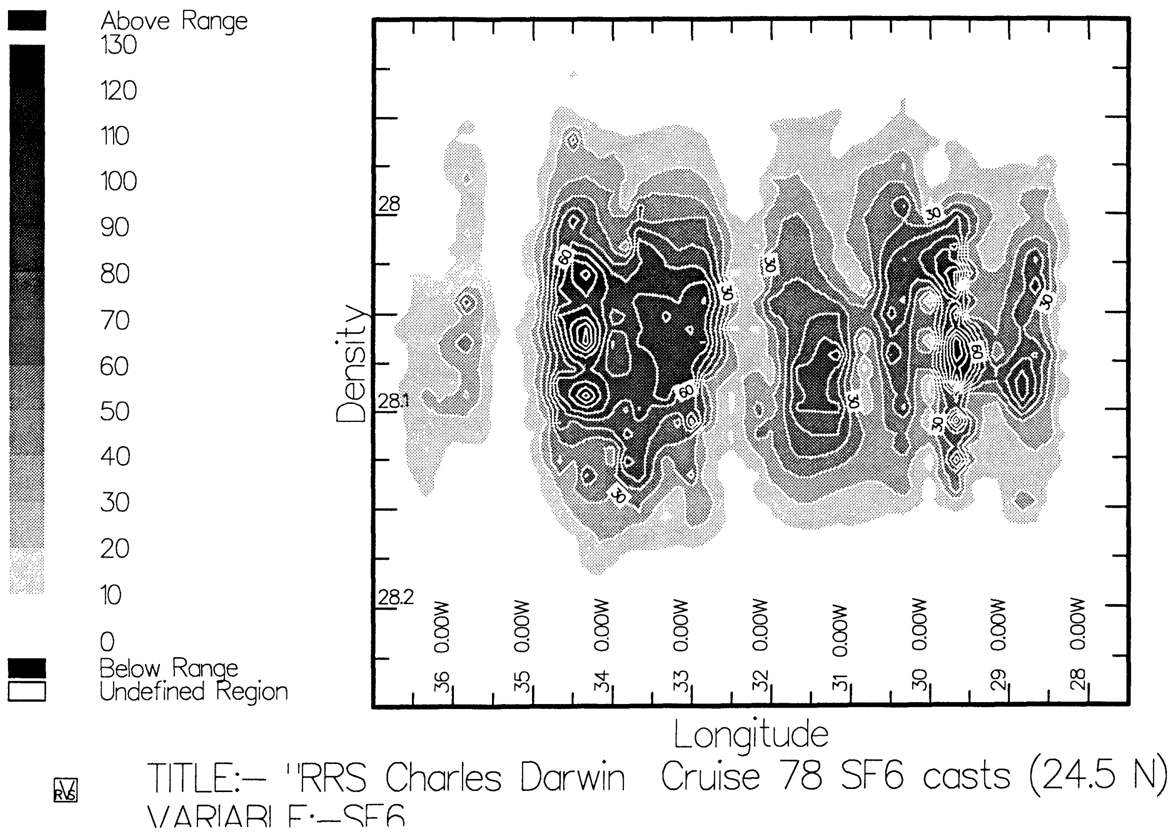
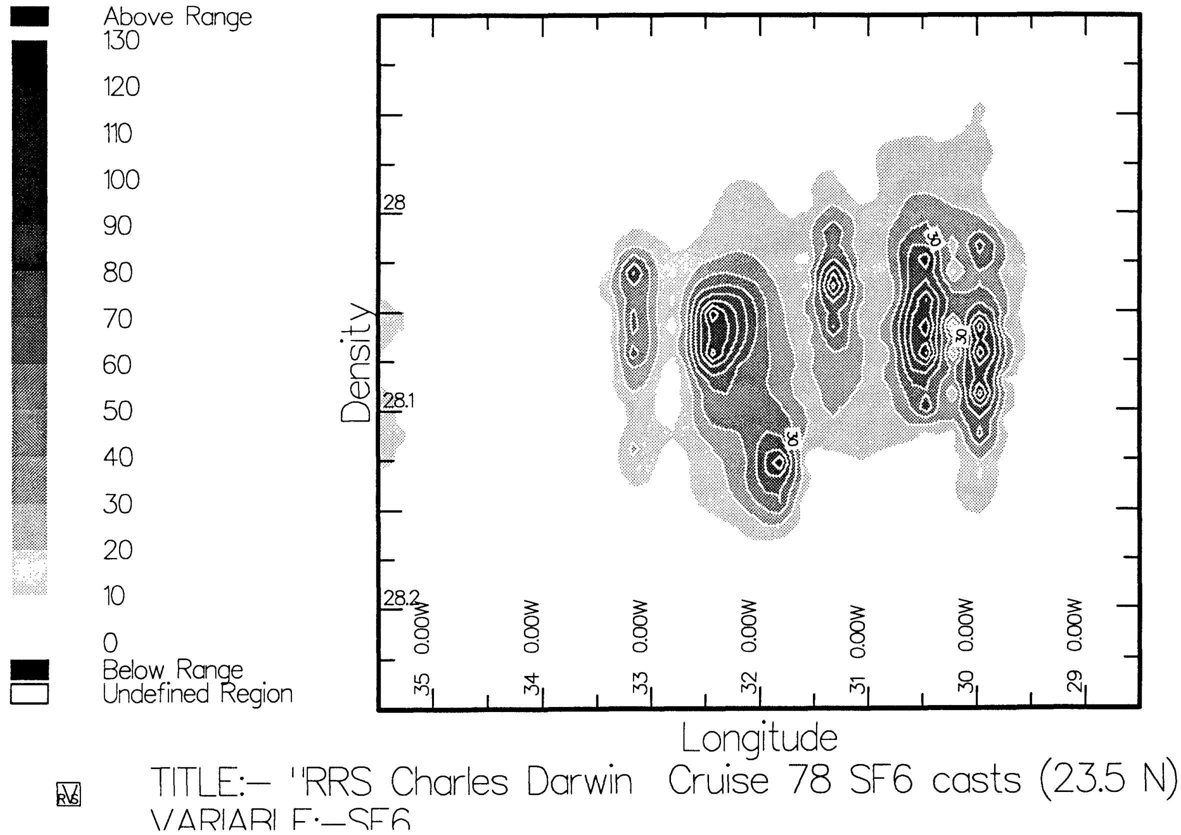

Above Range
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Below Range
Undefined Region
Density
28
28.1
28.2
30
60
1300
1400
1500
1600
1700
1800
1900
2000
DistanceRun(km)
TITLE:– ''RRS Charles Darwin Cruise 78 SF6 casts 5–33 ''
VARIABLE:–SF6

Figure 34



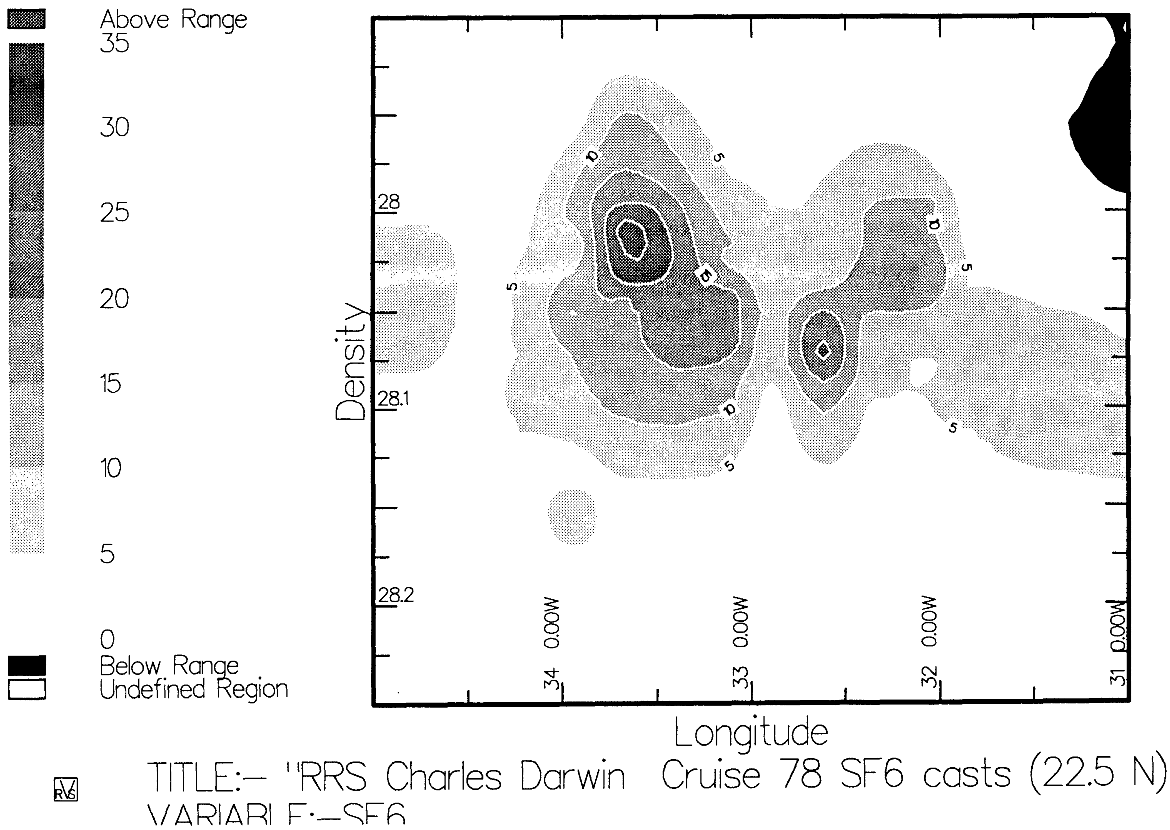
Above Range
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Below Range
Undefined Region
Density
28
28.1
28.2
36 0.00W
35 0.00W
34 0.00W
33 0.00W
32 0.00W
31 0.00W
30 0.00W
29 0.00W
28 0.00W
Longitude
TITLE:— ''RRS Charles Darwin Cruise 78 SF6 casts (24.5 N)
VARIABLE:—SF6

Figure 35



Above Range
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Below Range
Undefined Region
Density
28
28.1
28.2
35 0.00W
34 0.00W
33 0.00W
32 0.00W
31 0.00W
30 0.00W
29 0.00W
30
Longitude
TITLE:– ''RRS Charles Darwin Cruise 78 SF6 casts (23.5 N)
VARIABLE:–SF6

Figure 36


Above Range
35
30
25
20
15
10
5
0
Below Range
Undefined Region
Density
28
28.1
28.2
34 0.00W
33 0.00W
32 0.00W
31 0.00W
Longitude
TITLE:– ''RRS Charles Darwin Cruise 78 SF6 casts (22.5 N)
VARIABLE:–SF6