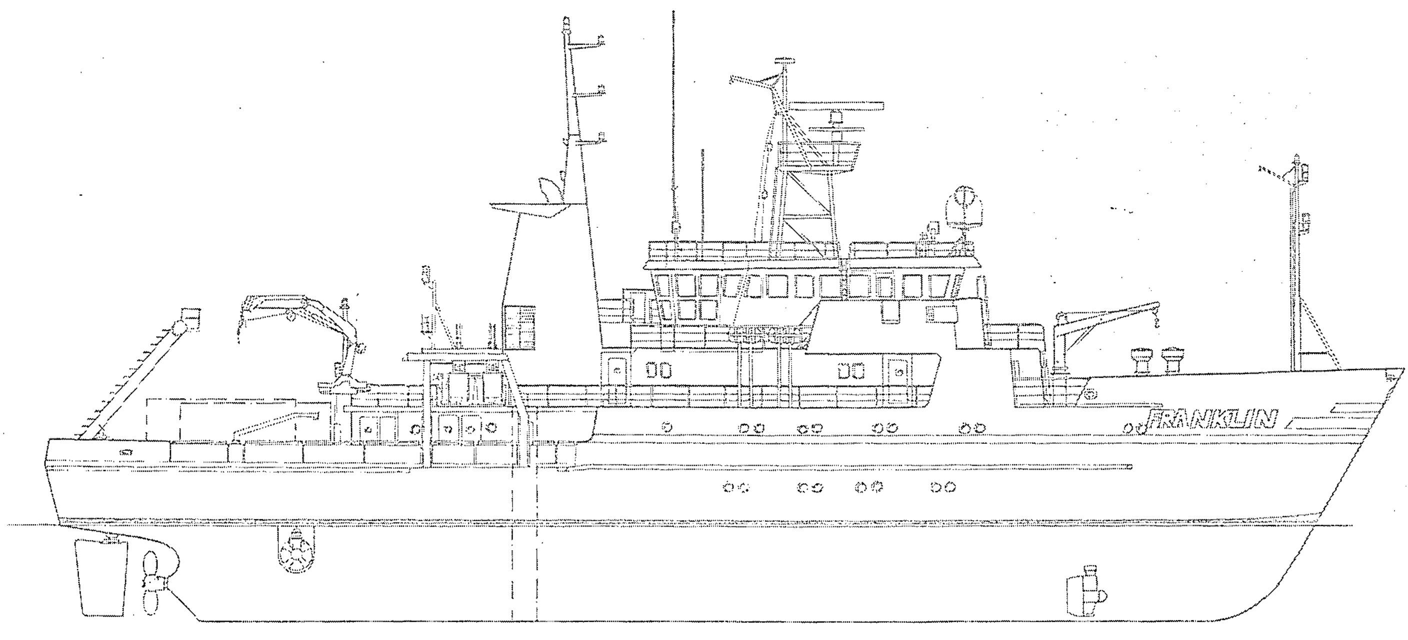
R.V. FRANKLIN

NATIONAL FACILITY
OCEANOGRAPHIC RESEARCH VESSEL

CRUISE SUMMARY

R.V. 'FRANKLIN'

FR 4/87



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AUSTRALIA

R.V. FRANKLIN IS OWNED AND OPERATED BY CSIRO

GM/NP

20 November 1987

CRUISE SUMMARY

RV FRANKLIN

FR 4/87

Scientific Program

The Leeuwin Current Interdisciplinary Experiment (LUCIE):
Formation off North West Shelf

Principal Investigators

Gary Meyers	CSIRO Division of Oceanography
Stuart Godfrey	CSIRO Division of Oceanography
Graham Harris	CSIRO Division of Fisheries Research

Cruise Objectives

1. CTD/Nutrient stations along cruise track (Fig. 1) from Fremantle to Port Hedland, comprising six transects of closely spaced stations across continental shelf and as many stations as possible on meridional transects to form closed boxes.

2. Continuous ADCP along cruise track.

3. Biological stations to measure productivity of surface waters at sunrise using 14-C uptake, particle size analyser and bacterial biomass measurements.

4. Calibration of NOSS/SEAS and Franklin XBT systems against CTD.

5. Observation of spatial extent of unusually energetic internal tides near Rankin platform on NW Shelf.

6. Detailed bathymetric survey of continental slope off Ningaloo.

Itinerary

Depart:	Fremantle	1200 hrs (local)	12 March 1987
Arrive:	Port Hedland	1200 hrs (local)	29 March 1987

Cruise Narrative

The cruise track is shown in Fig. 1.

We left Fremantle in fair weather and cruised slowly toward the first CTD station on Marmion section in 25 m depth, 9 nm from harbour entrance. This began the first leg of a closed box of stations to the bottom. The CTD touched bottom on the first cast; inspection after recovery did not show evidence of damage. The Marmion section was completed near midnight on 13 March and comprised 12 good CTD/nutrient stations and two biological stations. A bottle test to 1000 m did not reveal leaks. The weather continued fair, and all of the next day was spent on a northward leg, comprising 3 CTD/nutrient stations to the bottom, a biological station, and a sample of abyssal water for trace metal chemistry. The wide separation between stations was a relief and much appreciated by the crew after intense activity on the densely sampled Marmion section.

The Dongara section was started in spectacularly beautiful weather near sunrise on 15 March, and finished the following afternoon, completing the 'box'. The transect included 13 CTD/nutrient stations and two biological stations. The LUCIE Meteoriological Buoy was sighted at 7am on 16 March near 29° 31'S, 114° 15'E. At the end of the section calibration tests for the ADCP were done including

(i) cruising in a circle while gyro headings were recorded; and

(ii) cruising at various speeds from 0-12 kn for five minute intervals.
The ADCP has tended to show a high data rejection rate, in spite of good weather.

The next two days (17 and 18 March) were spent taking an XBT section across the Leeuwin Current with drops at standard LUCIE depths passing near Abrolhos Is.; a northward leg of (5) CTD and (2) biological stations between Dongara and Carnarvon section; an XBT section along the 200 m depth contour off Shark Bay; finally, another XBT transect across the Leeuwin. Calibration of the XBT units was started on this leg, with three XBTs dropped at each CTD station, one for the NOAA/SEAS recorder and one each for the Franklin from stern and hand launchers. The calibration test was subsequently repeated 17 times during the cruise. The weather remained fair throughout the period, but due to fresh SE trade winds (15-25 kn) and a large swell from SE on 18 March working conditions were less than ideal especially when travelling eastward into the swell. Spirits of the scientific crew seemed at a low point, partly because of the big swell, maybe in anticipation of resuming more intense activity of a LUCIE transect.

On 19 March another 'box' of CTD/nutrient stations was started. Although not originally intended to be stations to the bottom, many were extended to considerable depth because spooling problems had developed on the CTD winch. The 'box' was made-up of Carnarvon section, a northward leg, and Ningaloo section. In total 27 CTD/nutrient stations and 3 biological stations were made good; the box was completed on 22 March. ADCP recording was improved on 19 March as discussed below. The wind remained S to SE and slackened. Many scientific crew enjoyed the better weather by sunbaking during off hours. The big social event of this segment was the landing of a 4-foot shark. During this period a number of failures and improvements in the instruments occurred, as detailed in the following section on instruments. A detailed bathymetric survey along Ningaloo section was recorded on the sounder.

The XBT survey and 2 CTD stations were made in the vicinity of NW Cape, where the continental shelf is very narrow.

On 23 March began a large box between NW Shelf and 15°S made up primarily of nearly straight legs on 112°S30'E, 15°S, and 115°30'E. In total 25 CTD/nutrient, and 5 biological stations were made good. On Exmouth plateau (near 20°S) we saw a dramatic intrusion of low salinity water into the subtropical salinity maximum in the thermocline. Looking back over the records we found weaker intrusions were first recorded on Carnarvon section. The intrusions became a frequent occurrence as we travelled north. We thought they had their origin in the low salinity/high nutrient waters associated with Indonesion seas. This observation along with results from the biological experiments aroused intensive discussions among the biological and physical oceanographers and a paper was drafted summarising the results. The large box was completed on 27 March.

On 28 March a survey of closely spaced XBT stations near Rankin platform was completed. At least two wavelengths of the internal tide were seen, and a sharp jump in isotherms with surface manifestation, which might be 'breaking internal wave', was observed.

Except for the few days of moderate wind and high waves, the whole cruise occurred in fair to glorious weather, often in glassy tropical seas. It ended at noon on 29 March at Port Hedland. Harry Higgins was acknowledged as first and second prize for best man in the chow line.

Work Completed

Closed box of stations made up of Marmion and Dongara sections joined by a meridional, offshore leg (28 CTD/nutrient and 4 biological stations)

Closed box of stations made up of Carnarvon and Ningaloo sections joined by a meridional, offshore leg (28 CTD/nutrient and 3 biological stations)

Closed box of stations between NW Shelf and 15°S (26 CTD/nutrient and 5 biological stations)

Additional stations in Leeuwin Current (7 CTD/nutrient and 3 biological stations) completing a meridional transect 33°S to 15°S.

Continuous recordings of ADCP, depth sounder, meteorological station, thermosalinograph, and fluorometer.

77 XBT drops on Franklin recorder to survey temperature in Leeuwin Current area including 17 each on hand and stern launchers for calibration against CTD.
17 XBT drops on SEAS recorder for calibration against CTD.

106 XBT drops to survey internal tides near Rankin platform.

Instrument/Equipment Report

CTD - The CTD system worked well most of the time. Minor problems between CTD deck unit and computer occurred occasionally. On one occasion the Micro hung up completely and required changing of cables in the midst of a deep cast. Spooling problems with CTD winch were frequent during second half of cruise.

Thermosalinograph - The thermosalinograph did not send data to the Micro at proper time intervals, causing losses in data logging.

Crane - Frozen main bearing.

ADCP - During first week of cruise data rejection rate was very high. The threshold for vertical velocity was then changed to allow a higher value and this considerably improved the acceptance rate, and seemed to give acceptable 95% confidence limits (10cm/s). Because of lack of experience, we couldn't be sure the recorded data was good.

XBT - New cables and junction box were installed to allow drops by a hand launcher on the starboard side of the ship, at the CTD platform.

CTD plotting routines - The ability to plot series of CTD stations as a section in near real time is most impressive, allowing a good quick-look at the results during the cruise. Very useful tool for a cruise where stations are being sited according to features observed.

Harry Higgins
Biological Report

* = samples taken in conjunction with Harris/Griffiths for productivity experiments. Usually on at 30 m (sometimes 20 and 55 m)

P - samples taken at all depths for bacteria or in the upper 300 m of the water column for cyanobacteria

Abbreviations

Cyano	=	cyanobacteria
EM	=	electron microscope
CHN	=	carbon, hydrogen, nitrogen
DOC	=	dissolved organic carbon
TM	=	trace metal organic complexes
Nuts	=	organic nitrogen and phosporous

CTD#	Bacteria	Cyano	Em	Pigments	CHN	DOC	Nuts	TM
13	P	P		P				
14	*	*		*	*	*	*	
20	*	*		*	*	*	*	*
21	P							
22	P	P						
25	*	*		*	*	*	*	*
34	*	*		*	*	*	*	*
42	*	*		*	*	*	*	*
43	P	P						
44	P							
45	P	P						
48	*	*		*	*	*	*	*
53	*	*		*	*	*	*	
64	*	*		*	*	*	*	*
66	P		*					
67	P	P						
69	*	*		*	*	*	*	
74	*							
86	P	P		P				
87	*	*		*	*	*	*	
89			*					
91	P	P						
93	*	*	*	*	*	*	*	*
99				*			*	
101	*	*		*	*	*	*	
105	*	*	*	*	*	*	*	
106	P	P	*					
107	P	P						
111	*	*		*	*	*	*	
112	P	P		P				
Σ samples								
	219	141	6	53	21	19	19	26

In addition data was collected using the underway TURNER fluorometer and pH meter systems.

CTD PROFILER and ROSETTE SAMPLER

The repaired Rosette Deck Unit was installed prior to the cruise commencement. Both it and the CTD failed to operate correctly when tested. This fault was traced to a transposition of the sea cable in RJB 5 (main deck adjacent to transducer well), apparently made when re-wiring the new stainless steel junction box.

During the cruise the plastic knob on the Rosette Deck Unit failed. A new knob was turned from brass by the First Engineer.

No major problems were experienced with the CTD system during the cruise. On a number of casts the Rosette Deck Unit dial failed to rotate when firing bottle #1. This could be because of insufficient warm-up time of the deck unit, or miss-setting of the underwater release mechanism.

EK400 SOUNDER

An RS232 cable was provide to link the EK400 to Micro 3. No problems were experienced with the sounder during the cruise. The digital depth indication did not always lock to the bottom reliably. Good user instructions need to be provided to enable reliable bottom tracking.

ADCP PROFILER

No problems were experienced with the hardware. A few BIT failures were observed. Some difficulties were experienced by the scientific staff in obtaining acceptable profiles. This was overcome by a change in setup parameters. The transducer was inspected midway through the cruise. No problems were evident.

The new +5V power supply for the Gyro Interfaces was installed, and the modified pitch and roll gyro filter and control circuit installed. It was then discovered that the ADCP software for gyro control had not been implemented. Bob Beattie wrote and tested the required software. The ADCP Gyro Interfaces manual will require updating.

COMPAQ COMPUTER and NEC PRINTER

The NEC printer was re-installed in the #2 Rack in the Electronics Lab., and the parallel cable to same wired in permanently. An RS232 line to the VAX was also made permanent.

WET LAB VAX TERMINAL

The RS232 line to the VAX was installed, and checked out. The Wet Lab terminal failed to operate. As no manuals were available, this problem was not investigated further.

GPS LOCATOR

The problem experienced on past cruises of extraneous characters on the RS232 output was traced to an incorrect setting of the Control Character parameters. These should all be set to 0 for correct operation.

The RS232 splitter box was mounted in the rack at the rear of the 4000A. A new version of this is required urgently. An instruction sheet for initialising the 4000A was written. No problems in obtaining fixes were found, provided the REFPOS reference position was set accurately each day. This function should be implemented by software remote control.

FREEZER ALARM

This unit was mounted in the Operations Room. The Chem. Lab. fridge was connected using the junction box cabling.

With the help of the Electrical Engineer, a 12 pair screened twisted cable was run from the GP Lab. junction box (RJB 7) to the Scientific Store. A small junction box will need to be fitted in the store to provide a termination for this cable.

Using the new cable, the two freezers and the large fridge in the store were connected to the Freezer Alarm. Unfortunately, the fridge defrosts regularly, tripping the alarm, so this sensor was disabled. If an alarm is required for this fridge, a separate alarm will have to be constructed.

The GP Lab. fridge could not be found. Provided it has a freezer compartment (i.e. it is similar to the Chem. Lab. fridge), it can be connected to the Freezer Alarm.

TURNER FLUOROMETER

During the cruise the logged data became intermittent. It was discovered that the analog signals to Micro 2 were wired using RS232 cables. The fault was removed by rewiring the analog signals using the general purpose junction box cabling.

PH METER

The Ph Meter had been installed with the wrong connections to its chart recorder. This was remedied.

XBT SYSTEM

Access to the hand launcher socket on RJB 4 (port side, main deck) is difficult with a container on deck. A second socket was fitted to RJB 5 (main deck near transducer well). This was found to be much more convenient.

The old XBT Hand Launcher Switch was fitted adjacent to the XBT Deck Unit, and used to select either the Port or Starboard launcher positions. A new computer controlled switch is required to enable automatic selection of launch point. This would also allow automatic recording of the launch point by the XBT program.

A waterproof outside location for storing the hand launcher is required, to prevent damage to the cable if it remains on the deck. The most convenient location for this would be on the starboard side of the main deck, adjacent to the access door to the Scientific Store.

INMARSAT SYSTEM

No problems were experienced with this system.

MET SYSTEM

No problems were experienced with this system.

THERMOSALINOGRAPH

The previous problem of intermittent data transfer to Micro 2 was still evident. Normal data rates are obtained when the test position is selected, or when the main temperature sensing thermistor is disconnected.

In an attempt to locate the problem, the wiring to the main temperature sensor was checked thoroughly. No faults could be found. It appears that this problem is either due to a faulty thermistor (although the measured temperatures agree with the CTD surface temperature), or faulty software in the TSG Deck Unit. There does not appear to be any problems with the RS232 interface to the micro.

PARTICLE SIZE ANALYSER

Some time was spent investigating the high noise levels in this instrument apparently caused by use on the ORV. No cause or solution could be found. A faulty MC1488 RS232 driver chip was located and removed. A replacement chip was fitted in Port Hedland.

SHIP'S COMPAQ COMPUTER

Following discussions with the Master, it was decided to install the Compaq computer in the Ship's Office, and to install the remote display on the window pillar adjacent to the Chart Table on the bridge. Access to the computer can be abtained via the cable duct between the Electronics Lab. and the Winch Control area.

After discussions with Bob Beattie, it was decided that an RS232 splitter fitted in the line feeding the DELP terminal would be used to provide the information for display on the bridge.

This means that a VT220 emulation program will be required on the Compaq, and that no additional programming will be required on the DELP micro.

RADAR FIX LOGGING

A program for the NEC PC8201A was written to enable recording of radar fix information for subsequent processing on the VAX. Fix data is stored in ASCII columnar form, giving GMT date and time, range, bearing and mark.

BUOYANCY TEST

Four pieces of timber (two huon pine, two celery top pine) were attached in a string bag to the CTD frame prior to CTD #16. They were left attached for the remainder of the cruise, including several dips in excess of 5000 meters.

At the completion of the cruise, the pieces of wood were retrieved and stored in individual watertight plastic bags for shipment to Hobart, where changes in volume and density will be evaluated.

It appeared that all four pieces had absorbed sufficient water to make them useless for buoyancy.

CONCLUSIONS

No major problems were encountered during the cruise. The importance, however, of accurate documentation of all cables on the ORV cannot be overemphasised. No more cables should be installed without adequate documentation, and the task of documenting all existing cables should be completed as soon as possible.

David Edwards
29/3/1987

COMPUTING REPORT FOR FR 04/87

Bob Beattie

No major problems were experienced during the cruise. Most of my time was spent correcting minor deficiencies in the logging packages or adding features required by users.

1 SOFTWARE

1.1 XBT

Work done:

1. Improved user dialogue
2. The bathymessage/summary program now takes account of the maximum depth to good data.
3. Data files are now archived by MTSPOL
4. All XBT drops now generate a DELP event, but TO and T250 are not displayed if they are invalid.

Outstanding problems:

1. Automatic entry of position from DELP's NAV display file.

1.2 CTD

Work done:

1. Changes to startup procedures to support the new RS232 interface.
2. The cleanup program waits for a CTD or XBT drop to complete before printing mesasages on the console terminal.
3. Files of averaged data are now archived on the VAX.
4. The screen dump program SCRDMP was modified to speed up the hardcopy plotting of XBT and CTD profiles.

Outstanding problems:

1. Automatic entry of position
2. Modification of the dialogue for the OPTions program to reduce the number of Y/N questions!

.3 NAV

avid Crooks' modifications to IGTDRP were installed.

utstanding problems:

1. NFIX is no longer set to 0 when NAV is restarted. This results in ridiculous values for DRMIN (eg -12550!). A temporary fix was added to IGTDRP to test for out of range DRMIN's and set them to 9999. This keeps DELP happy.

.4 MTSPOL

ork done:

1. Added Dave Crooks' corrections to MTSPOL.
2. Changed format of VAXed files from 'FORTRAN' to 'LIST' carriage control to enable them to be listed on printers and terminals.
3. Modified the startup program MTSTRT to make it more difficult to select the 'Stop MTSPOL with end of cruise cleanup' option!

utstanding problems:

1. MTSPOL 'hangs' if a write to the VAX fails because the VAX disk is full.
2. It does not request operator intervention (eg via DELP) if it experiences problems writing to tape. It should be possible to force MTSPOL to start a new tape.
3. It would be desirable that MTSPOL be able to accept files with variable length records. Many of the current VAXEd fixed length record files have large amounts of wasted space from padding of records.
4. MTSTRT should delete old copies of files from remote micros before the the new copies are sent. The present system of copying and then purging will cause startup to fail if there is insufficient contiguous disk space for the new copy of MTSEND.TSK.
5. MICROx.DAT is not copied and/or deleted by MTSPOL during end of cruise cleanup. In particular, MICRO1.DAT can be very large (1200+ blocks).

.5 DELP

:n well once some initial misunderstandings over setup procedures :re rectified.

:tstanding problems:

1. Delp exited several times when operators were responding to an event. The cause is uncertain but appeared to be due to the absence of a required file. On restart, DELP went into initializatioon mode because it claimed there was no master file. A directory listing showed that several copies of DELP.MAS were present.

2. There were a number of suggestions for modification of the DELP display.

    1. The screen should only be left clear after an event requiring manual intervention. at present it is cleared after all events.

    2. Do away with the initial display requesting manual intervention and put the alarm on the event display.

    3. The message informing the user that a field in the event display contains invalid data is ambiguous. Inexperienced users tend to keep on typing <Return>.

    4. Use a default of 'N' to the question 'Do you want to enter any comments?'.

    5. There should be a timeout on this question, as it is often left unanswered. It may even be worhtwhile having timeouts on all questions.

.6 TSG, PH And Sounder

ork done:

1. Ken Suber's modifications to these programs were installed and the TSG and PH programs ran without problems.

2. The sounder program would not run because there are no <CR><LF>'s in the data stream. A 'quick and dirty' program was written to collect a few days worth of raw data for analysis.

3. The sounder data is much better than we thought. We were able to get good digital data to depths in excess of 5600m by careful attention to tuning.

1.7 GPS

This program ran well after modifications to allow for changed GPS data format and occasional bad data records.

It sends empty files to the VAX and tape if no GPS data is being received.

1.8 Turner Fluorometer

The logging program was modified so that it could be stopped cleanly, with the data files being archived by MTSPOL.

1.9 Doppler Profiler

We initialy had much difficulty in finding the best settings for the 'Data rejection criteria'. We finally settled on Sig/Noise =15 and a Vert Velocity Threshhold of 0.75m/s. This resulted in high data acceptance and 95% confidence limits of 0.06 - 0.1.

The main logging program performed well, but some of the subsiduary programs (especially MOP) are idiosynchratic and in need of re-writing.

Work Done:

1. Wrote a vertical (pitch and roll) gyro control program VGYRO and interfaced this to DOP. VGYRO also maintains a log of gyro useage in [4,7]VGYRO.LOG.

2. Tested and debugged the transmission of GPS data from GPD to the main logging program. Modified the screen display to incorporate the GPS data when it is avaliable.

3. Wrote a watchdog program that sets an event flag if DOP exits. Subsiduary programs can test the flag and take appropriate action.

4. Made minor modifications to MENU to make the user interaction more satisfactory.

5. Updated the Doppler logging manual.

Outstanding problems:

1. GPD 'hangs' when the CPU is heavily loaded. The cause is unknown, but it seems to happen when GPD is swapped out of memory. DOP should abort and restart GPD when this occurs. GPD could be made non-checkpointable if the available memory is increased.

2. GPD cannot handle large jumps in position between breaks in the periods of satellite availability.

3. MOP is singularly uncommunicative about its needs.

4. If you wish to go from 'bottom track' to 'normal' mode, you must disable and then re-enable the screen display. If you don't the screen display will continue to try to produce bottom track messages.

5. DOP probably does not handle ping data correctly when MENU exits. It probably either adds the post menu data to the 'pre menu' data or clears the buffers without resetting the number of pings to be collected. Solution - Wait for an averaging period to complete before checking that MENU has exited.

6. The Graphtec plotter 'hangs' due to error conditions very frequently. It is not known whether this is a hardware or a software problem.

NOTE

It would be appreciated if all Franklin programmers stopped using the extension '.DAT' for data files.

One of the OMS personnel was producing nutrient plots. He naturally entered the cruise ID when asked for the name of the plot output file. Result - 2 files called FR0487.DAT. Purging the directory would have resulted in the loss of 100 stations of hydro data! Ron's knees are still shaking.

2 HARDWARE

1. The VAX's printer seemed to have developed additional problems since it left Hobart. It was taken away for repair and will hopefully be ready for installation by the time Franklin returns to Fremantle in April.

2. A Micro11 disk shipped from Hobart was found to be dead on arrival. A second disk failed before Franklin left Fremantle. It is quite possible that these disks will be beyond repair.

3. A new type of RS232 interface was installed on the CTD micro. This has fixed the problem with interface 'hangups'. The old CTD interface port was used by the CTD control terminal for part of the cruise, but this was discontinued after several dips had to be aborted because the terminal would not respond

to input.

The RS232 interface on MICRO1 will also be replaced when time permits.

4. The MTSPOL tape drive failed with a parity error. Reseating the Read/Write cables fixed the problem.

5. The thermosalinograph is only transmitting data sporadically - typically 2 or 3 times per minute, but gaps of several minutes are common. This will be dealt with in more detail in the Electronics Report.

6. The doppler micro requires additional memory.

7. The VAX disk filled up on two occasions during the cruise. A cleanup of unwanted files gained an extra 30000 blocks, but space is still a problem.

Preliminary Results

RV Franklin is wonderfully equipped to display station data in the form of maps and/or sections a short time after the stations are completed. This capability was used to prepare the following 'quick-look' at results from the cruise.

The density (σ_t) and salinity sections 0-120 nm off Dongara near 30°S are displayed in figure 2A and B. The downward sloping isopycnals between stations 28 and 35 indicate the southward flowing Leeuwin Current. The salinity (Fig. 2B) is maximum at the surface off-shore (stations 24-28) because this area is near the edge of the subtropical evaporation cell of the S. Indian Ocean. The maximum salinity slopes downward with the isopycnals beneath the lower salinity of surface waters in the Leeuwin Current.

The density and salinity sections 0-120 nm off Ningaloo near 22°S are displayed in Figure 3. Downward sloping isopycnals approaching the shore again indicate the Leeuwin Current between stations 71 and 77. The salinity (Fig. 3B) has a maximum near 200 m depth, which originates at he surface in the subtropical evaporation cell at higher latitude. Lower salinity at the surface off-shore is generated by the excess of precipitation in the tropics over evaporation, and the lowest salinity again occurs in the southward flowing Leeuwin Current, which brings tropical surface water southward.

A comparison of the density sections at Dongara and Ningaloo suggests a narrower Leeuwin Current with higher speed at Dongara. An index of total current transport (T) in a two-layered system is

$$T = \frac{1}{2} (D_i + D_o) (D_i - D_o) \frac{g'}{f}$$

where D is depth at the maximum density gradient in the thermocline beneath the current and subscripts (i, o) refer to a location at the inshore or offshore edge of the current. The Coriolis parameter is f and reduced gravity is g'. Estimating T from $\sigma_t = 26.0$ gives $6.8.10^6$ m^3/s at Dongara and $5.1.10^6$ at Ningaloo suggesting that total flow in the current is not greatly different at the two sections, in spite of appearances. The surface $\sigma_t = 26.0$ at the outer edge of the current slopes downward from 100 m at Dongara to 200 m at Ningaloo, indicating an inflow to the Leeuwin Current from the open ocean. Geotropic and inverse methods applied to the LUCIE data set including direct current measurements will allow quantitative estimates of the absolute flow field.

An unexpected structure in subsurface salinity was found on this cruise. The subtropical, high salinity water in the thermocline often had intrusions of lower salinity water (S ≤35.0) occurring above and/or below the salinity maximum. These features were first clearly seen on the Carnarvon section (Fig. 4), where an intrusion appears on the $\sigma_t = 26.5$ surface. The most dramatic example was found over Exmouth Plateau (Fig. 5), where the intrusion occurred at $\sigma_t = 26.1$. On many occasions a temperature inversion stabilised by increasing salinity occurs at the bottom of the low salinity intrusion. These features usually seemed to be of small spatial extent (<30 nm); however, on one occasion of the NW Shelf near 16°S, a feature larger than 30 nm may have been observed (Fig. 6A and B). Water with a similar low salinity in the thermocline is found north of 15°S, which may be the source region for the intrusions.

A possible connection between the biological observations and physical environment was noted on the cruise. Density on a section surrounding Western Australia from 32°S to 15°S is shown in Fig. 7. The isopycnals slope upward from 15°S to the Carnarvon /Ningaloo area (stations 62-70). According to atlases the prevailing direction of ocean circulation at this season is south-eastward. The prevailing currents carry low salinity intrusions towards NW Cape, and upward along the isopycnals from 150 m depth to 50 m depth. The low salinity intrusions also have high nutrient levels. Thus, this mechanism transfers high nutrient waters from deep levels upward into the photic zone, where nutrients can supply the ecosystem.

Scientific Personnel

G. Meyers	(Chief Scientist)
S. Godfrey	(Principal Investigator)
G. Harris	(Principal Investigator)
R. Beattie	(Computer)
D. Edwards	(Electronics)
B. Griffiths	(Experimental Scientist)
R. Griffiths	(Hydrology)
D. Hao	(Visiting Scientist)
M. Herzfeld	(Student)
H. Higgins	(Experimental Scientist)
R. Plaschke	(Hydrology)
K. Ridgway	(Experimental Scientist)

General Comments

Combining physical and biological oceanography in a single cruise allowed us to have healthy interaction across disciplines and is highly recommended for future cruises. I think the cruise was largely successful, due entirely to the professionalism & high quality of work by the technical and scientific support staff.

I would like to thank everyone for their contributions.

Gary Meyers

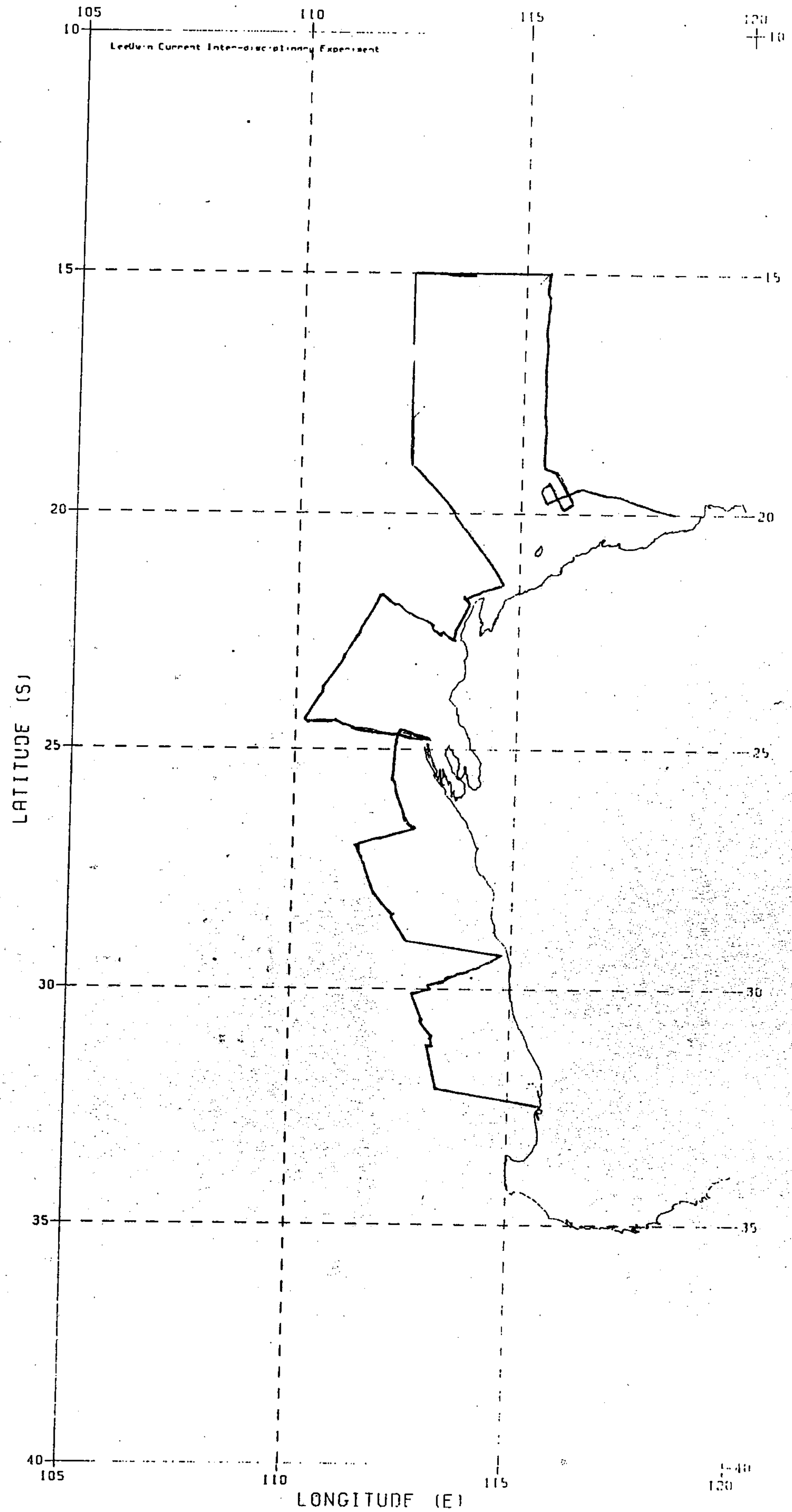

Fig. 1: Cruise track FR 4/87. Fremantle to Port Hedland, 12-29 March 1987.

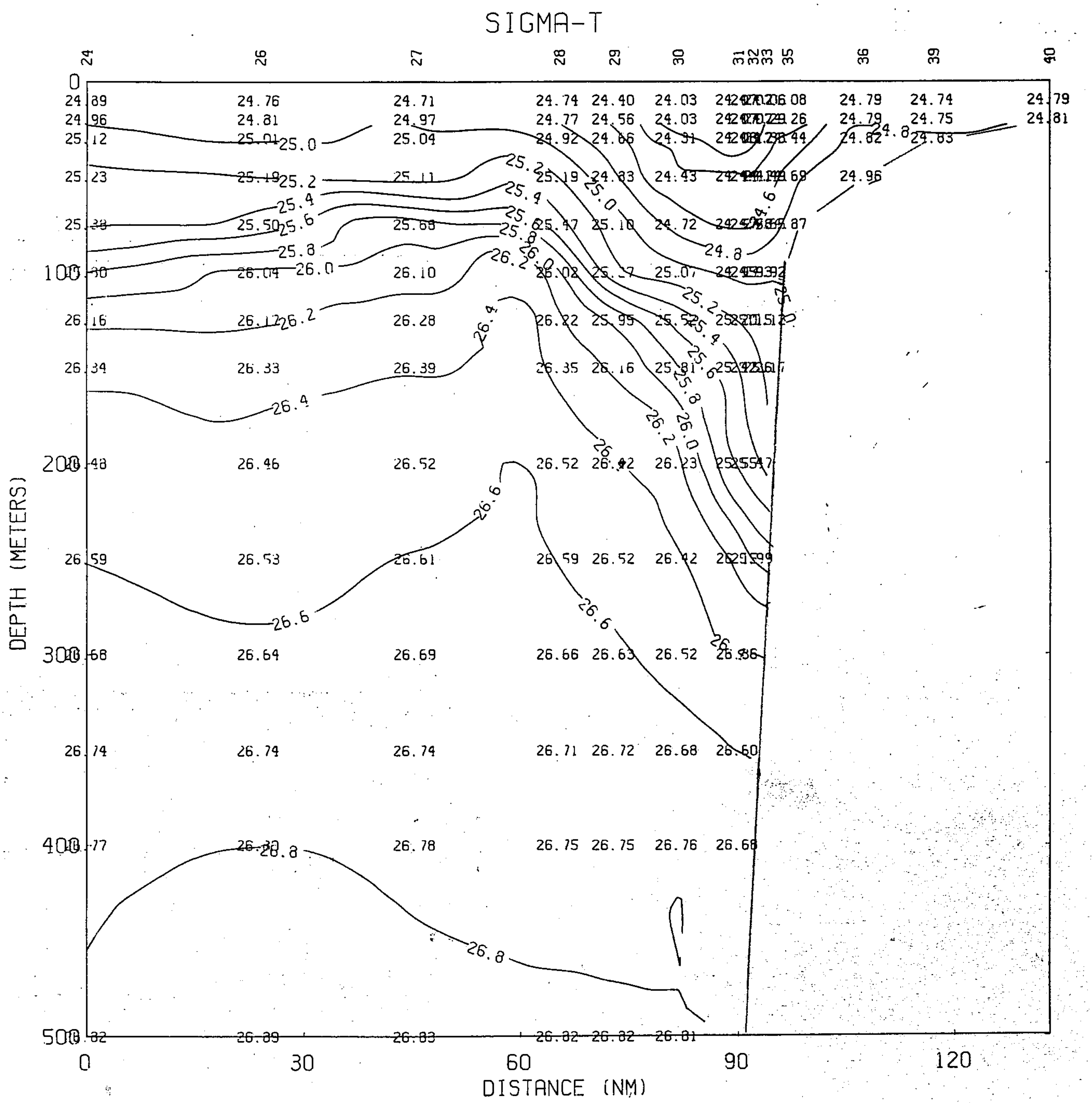

Figure 2A: Density on Dongara Section

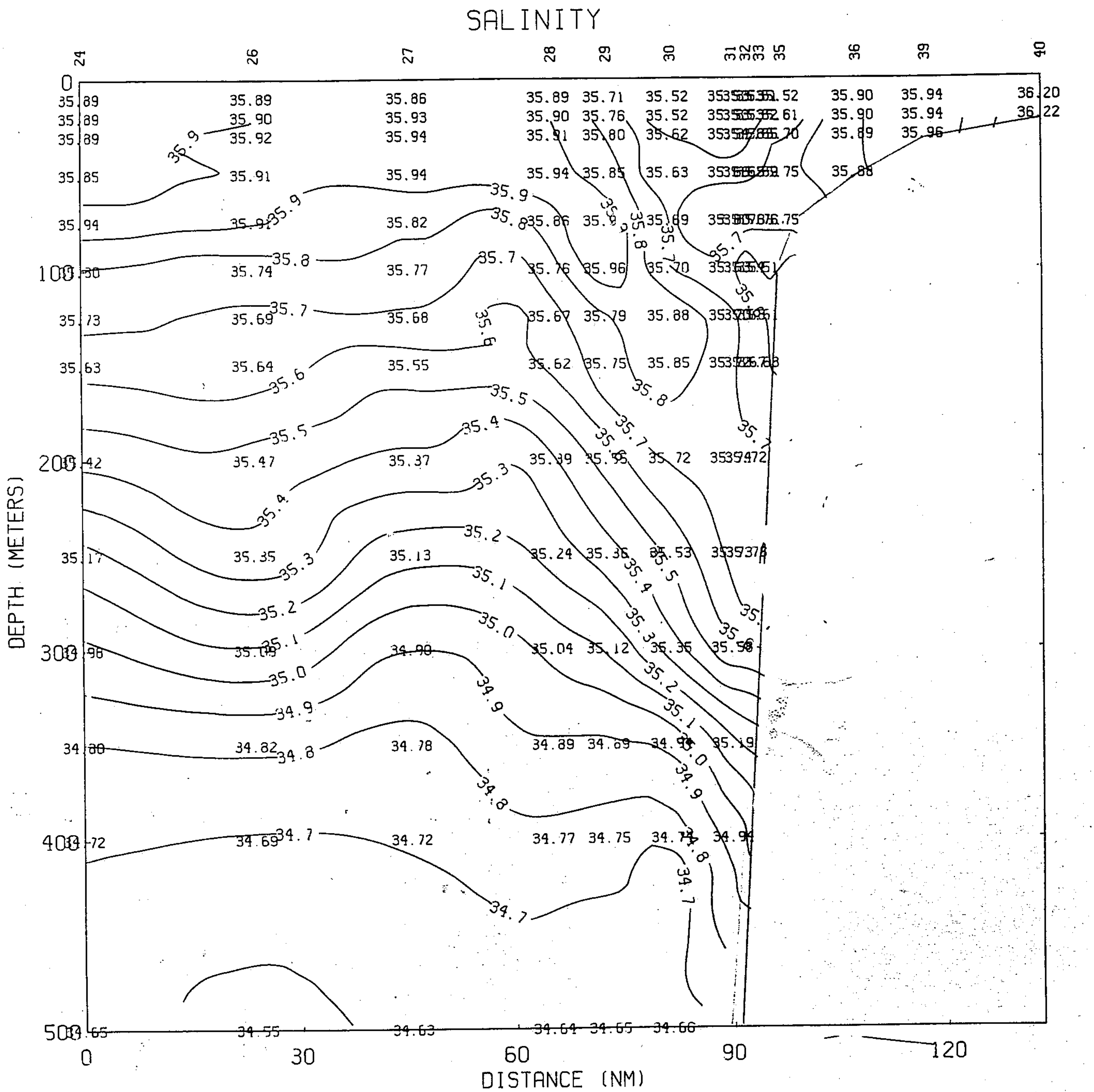

Figure 2B: Salinity on Dongara Section

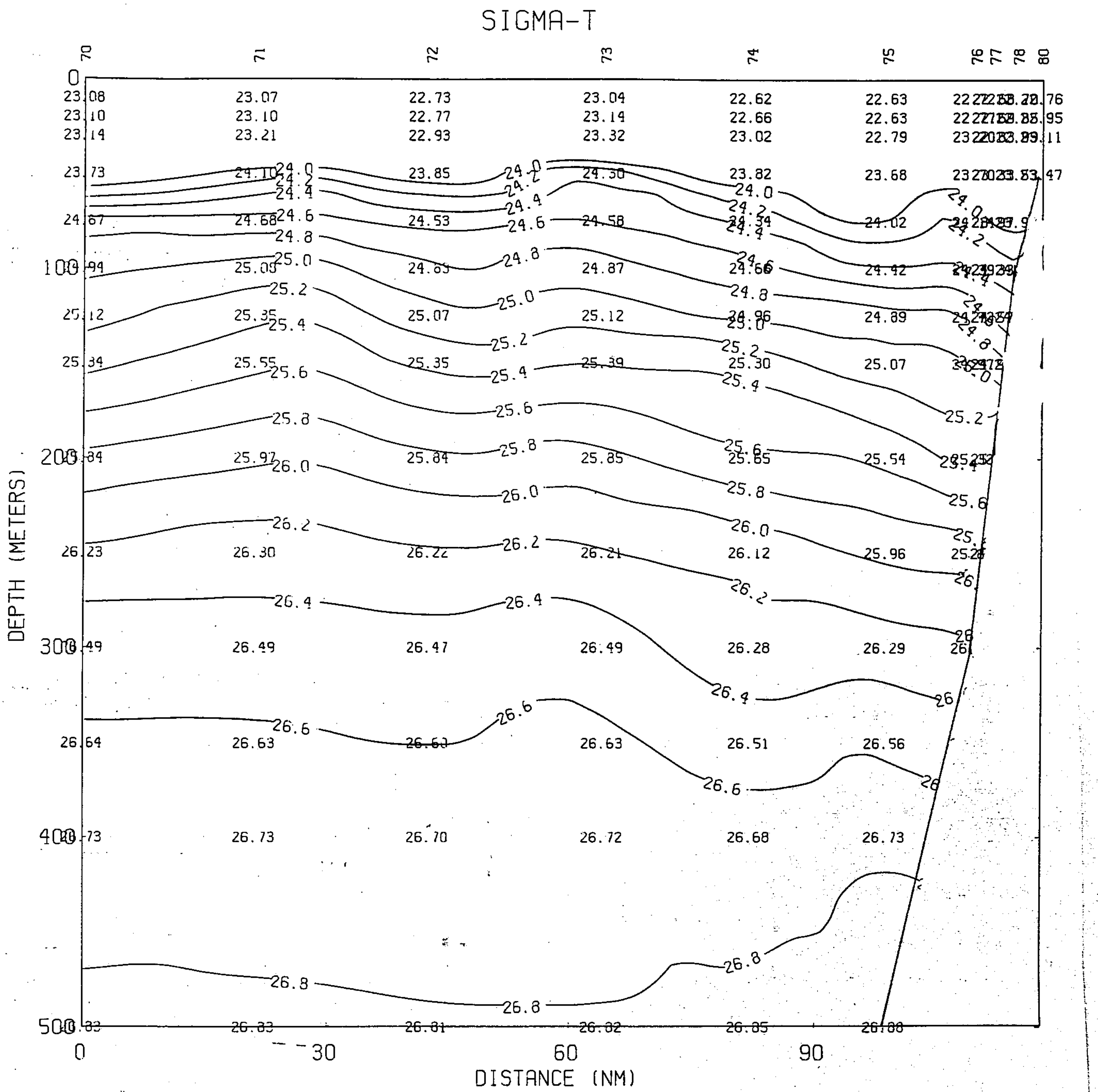

Figure 3A: Density on Ningaloo Section

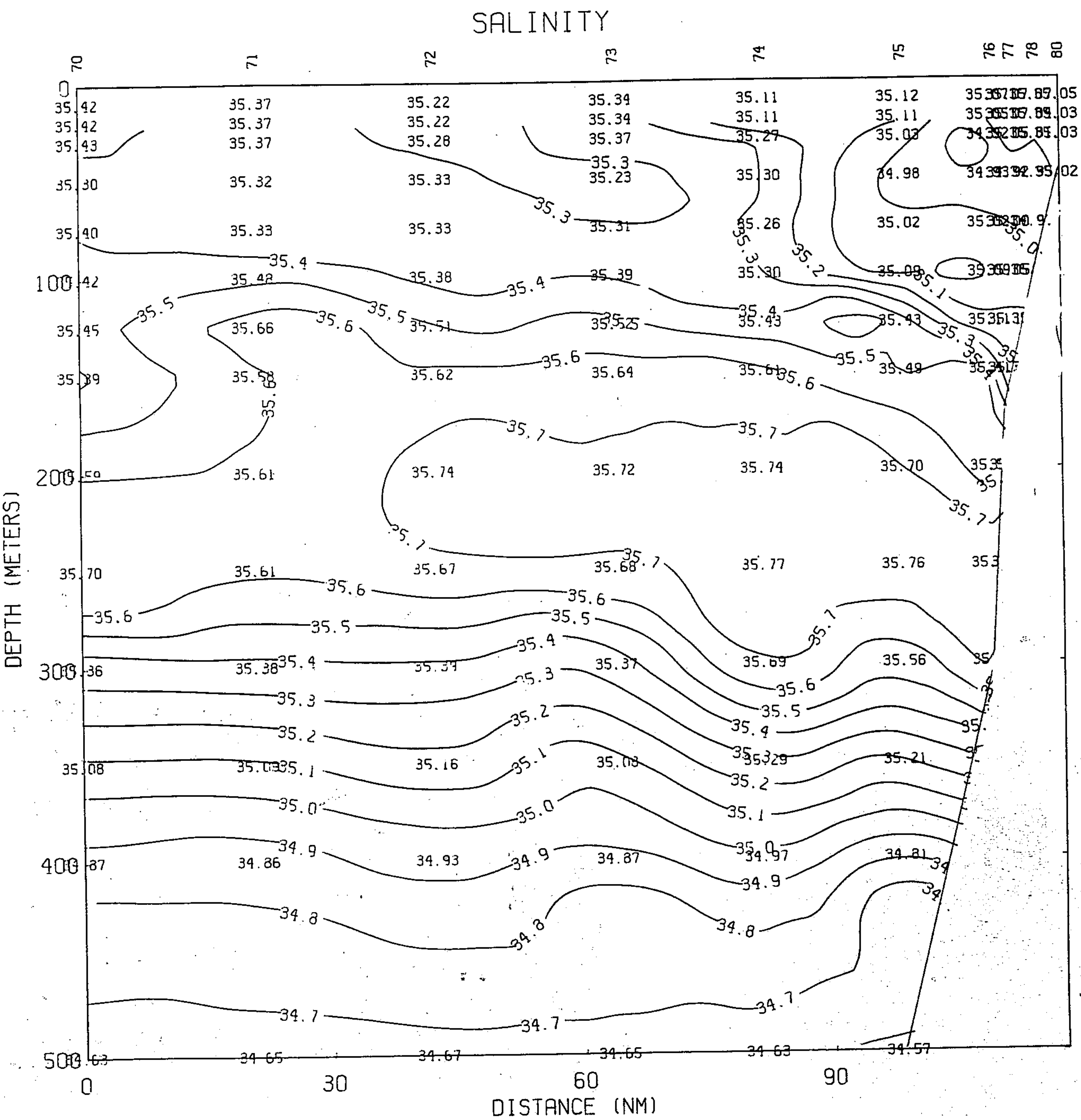

Figure 3B: Salinity on Ningaloo Section

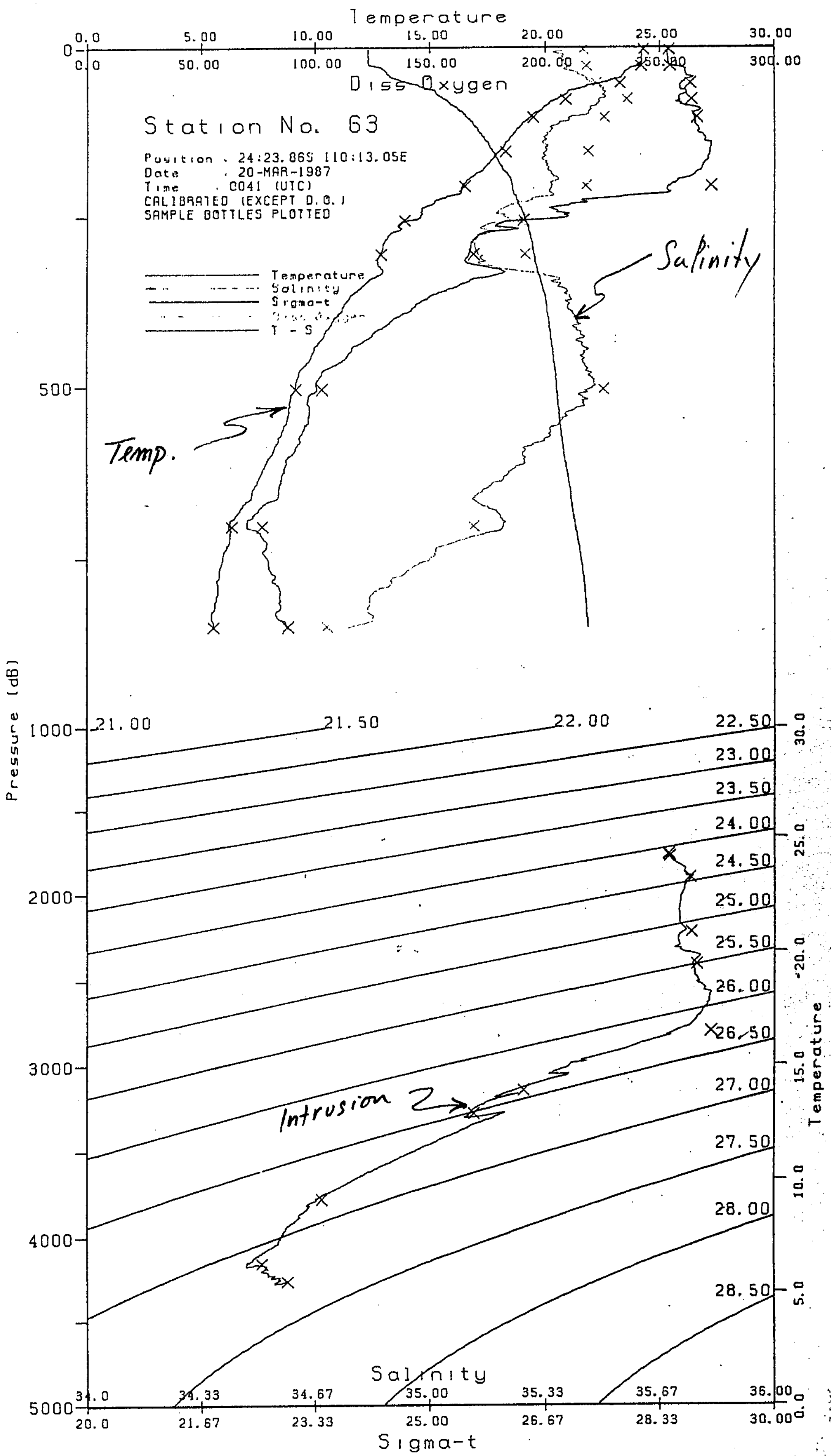

Figure 4: Temperature and salinity profiles (top) and T/S diagram (bottom)

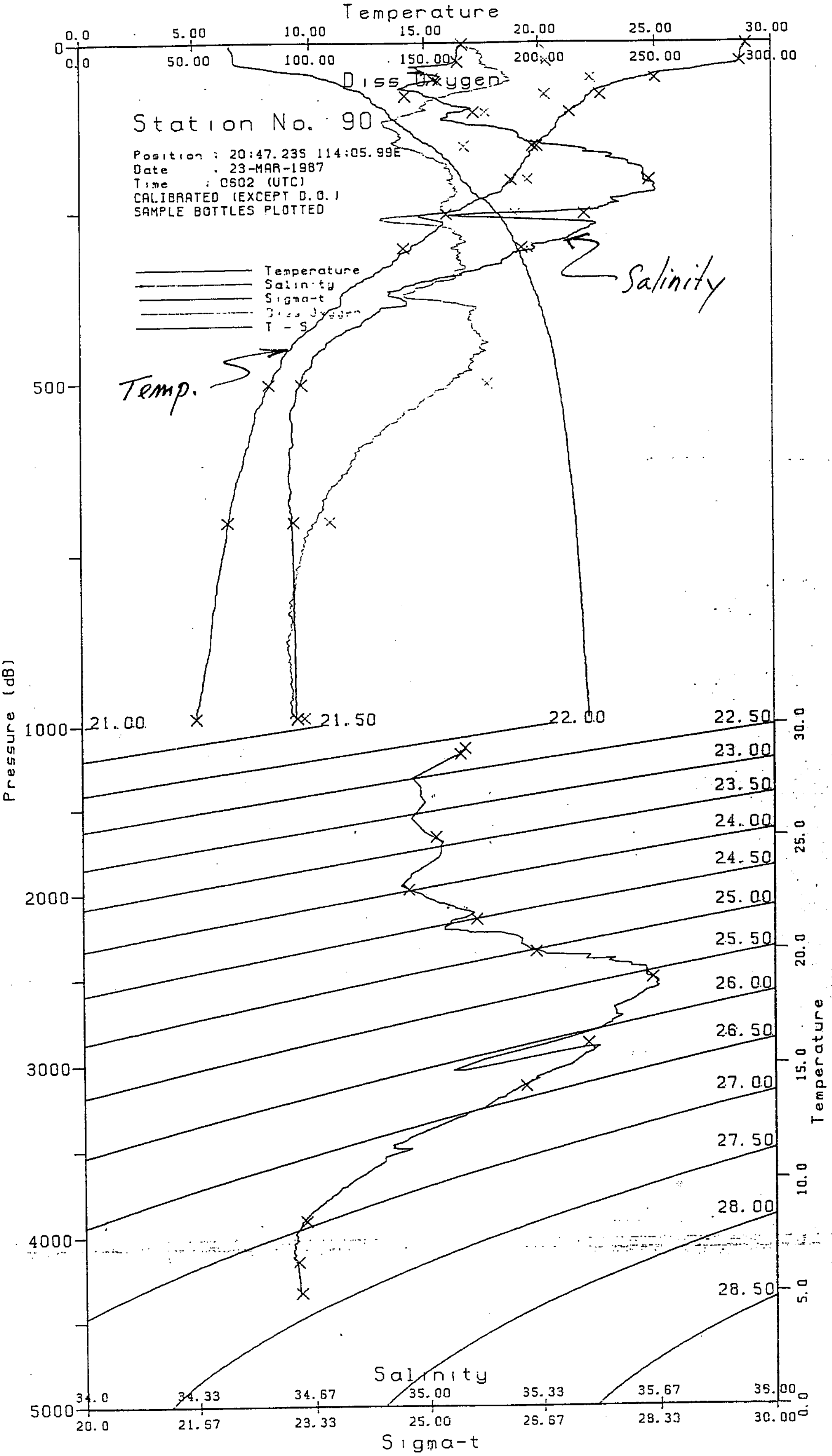

Figure 5: Temperature and salinity profiles (top) and T/S diagram (bottom)

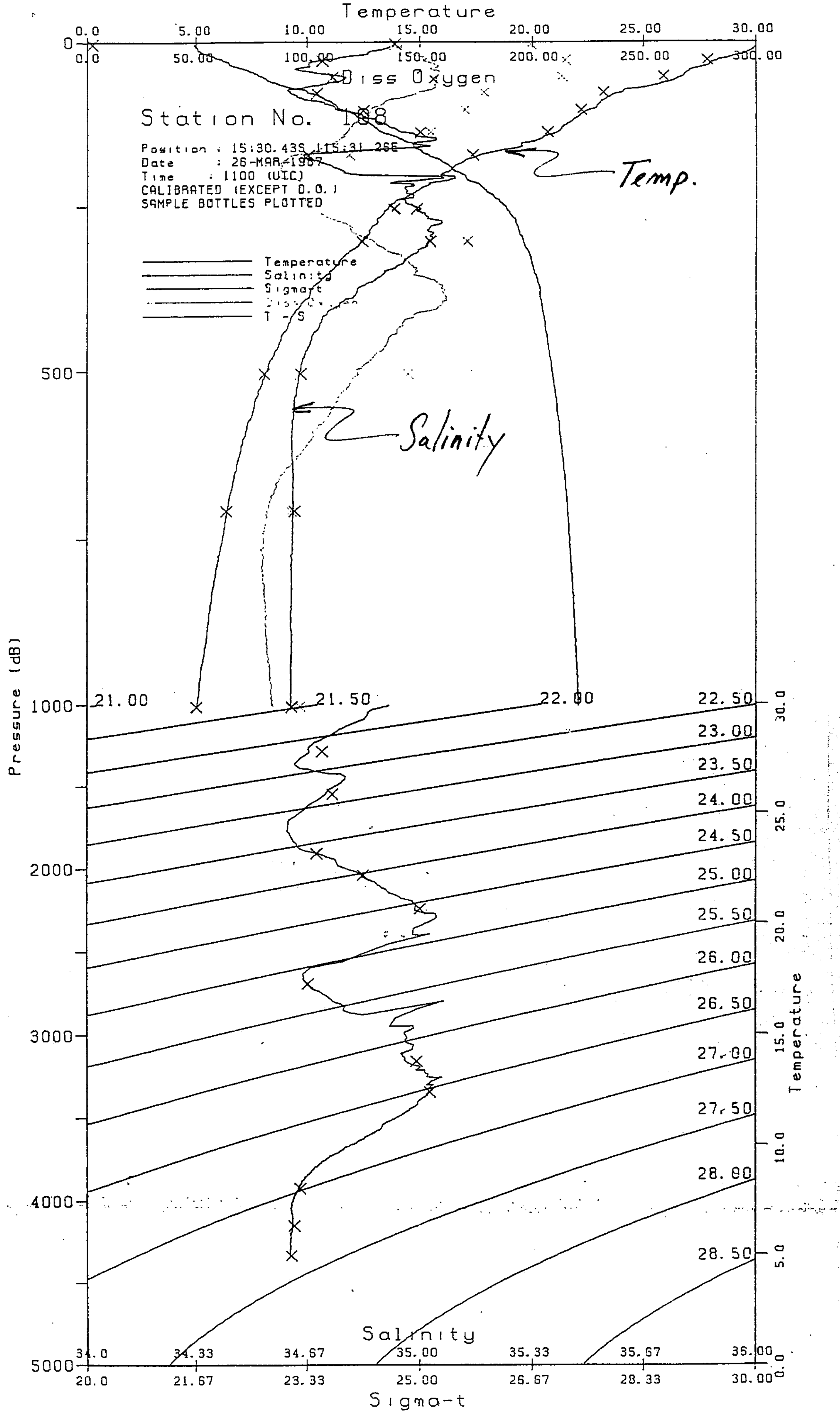

Figure 6A: Temperature and salinity profiles (top) and T/S diagram (bottom)

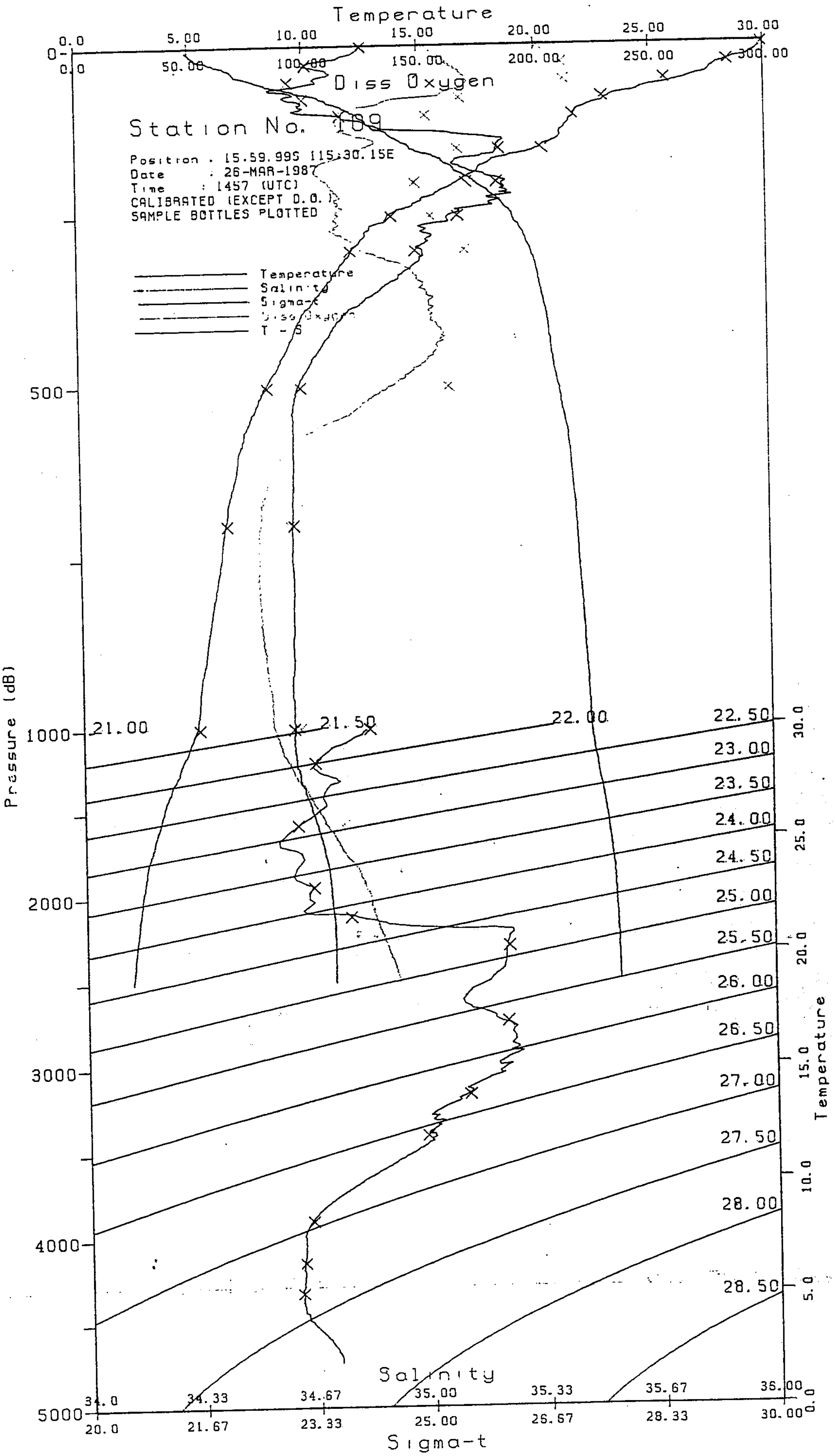

Figure 6B: Temperature and salinity profiles (top) and T/S diagram (bottom)

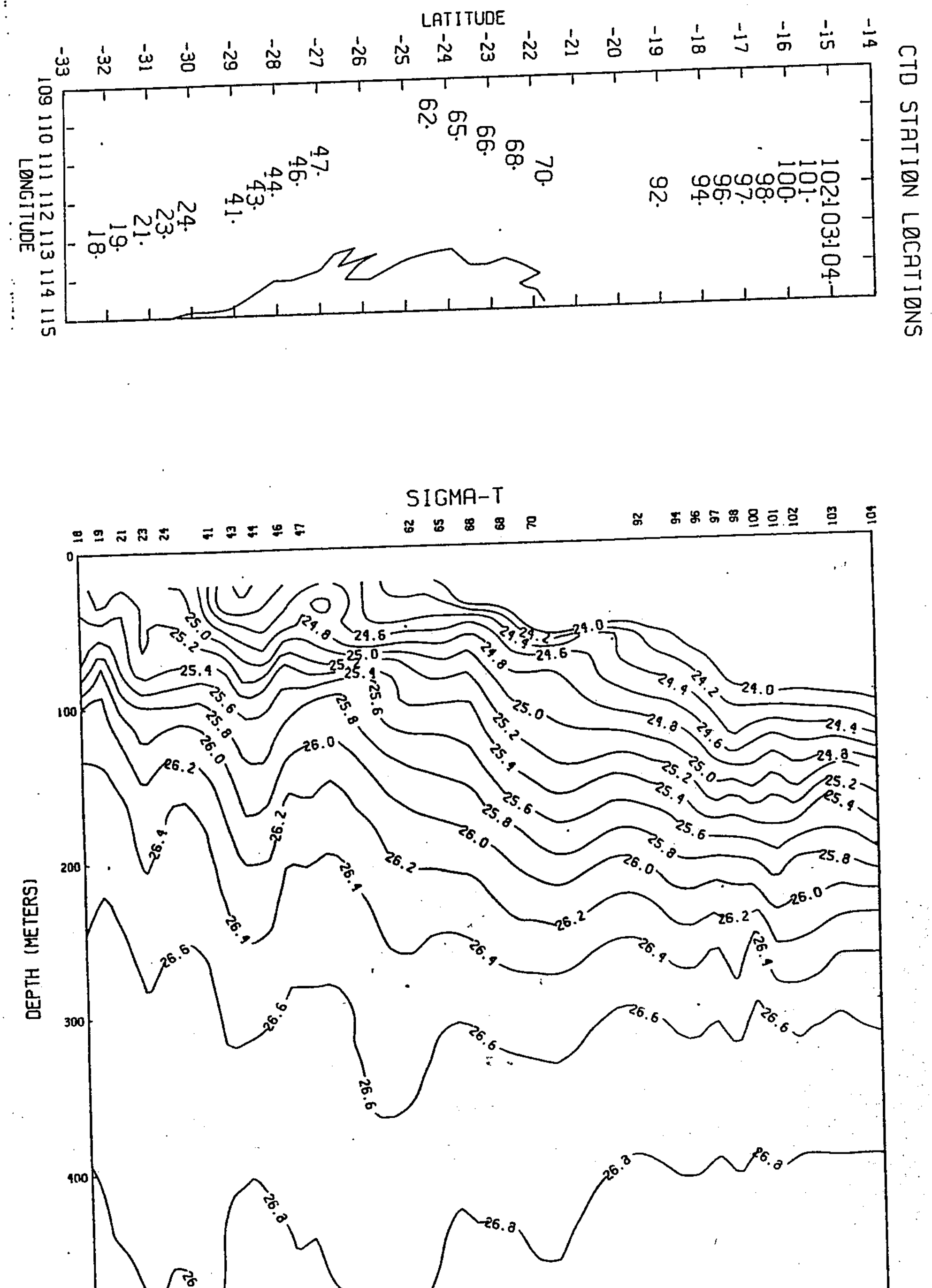

Fig. 7: Transect of density from CTD station 18 to station 104. High nutrient intrusions travel southward and upward into the photic zone on density surfaces 24.0 to 26.0