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Ecological processes in the marginal ice-zone of the northern Barents Sea

ICE-BAR 1995, CTD Observations

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CONTENTS

1. INTRODUCTION

This report deals with CTD and water sample observations collected as a part of the ICE-BAR ecological program in The marginal ice zone of northern Barents Sea during June 1995 by R/V 'Lance'. According to the Cruise Report by Hop and Falk-Petersen (1996), the overall goal of the ICE-BAR program is to understand the importance of the marginal ice-zone for the productivity and biodiversity in the northern Barents Sea. Latitudinal transects (N-S) will be used to determine how oceanographic and ecological processes changes across the marginal ice-zone from consolidated ice, through the ice-pack and out into open water.

For the ICE-BAR 1995 cruise, the hydrographic/oceanographic sub-program is to be considered as a support to the ecological program. According to the ecological program the main aim was to survey hydrographic conditions and underlying physical processes through the marginal ice-zone for selected stations along the 35° E longitude. Thus, we took the opportunity to collect CTD time series at the four stationary ice-stations in thick first-year ice, intermediate thick first-year ice, near the ice edge and in open water, simultaneous with measurements in the ecological program. The hydrographic program resulted in 92 CTD casts and 25 water samples for calibration. Fig 2 gives an overview of the CTD stations, and as indicated in Fig 2 it seems reasonable to split up the CTD stations into following main sections: Transect Svalbard-Hopen-35° E, Ice-stations I, II and III, transect along the ice-edge between 35° E and Hopen.

Hydrographic conditions off the ice edge have been thoroughly surveyed, whereas observations from the marginal ice area are more scarce. Therefore, in this investigation - the Ice Bar program - we will concentrate on observations in the ice pack at the stationary ice stations I, II and III.

2. INSTRUMENTATION

2.1 Description of OTS-1500 CTD probe

The CTD measurements were performed by using an OTS-1500 CTD, manufactured by Meerestechnik-elektronik GmbH. Table 1 gives the technical specifications for the OTS-1500 instrument. Water samples were collected by using a 10 liter Niskin bottle on a free, parallel cable, close to the CTD probe.

Sensor	Type	Range	Accuracy	Resolution	Time con.
Temperature	Pt 100	-2.38°C	±0.01°C	0.001°C	160 ms
Conductivity	7-pole cell	0..60 mS/cm	±0.01mS/cm	0.001 mS/cm	100 ms
Pressure	Piezo resis.	as required	±0.25% fs	0.025 dbar	20 ms

Table 1 Specification of the OTS 1500 CTD-sensors.

2.2 Pre-cruise calibration of OTS-1500 CTD

Calibration of the OTS-1500 CTD probe no.67 was carried out in the calibration tank at the Geophysical Institute, Bergen. Calibration was performed using water of constant salinity, while effects of temperature variation on conductivity (C) - and temperature (T) sensors deviation from the standard were observed. A Sea Bird CTD was used as standard for temperature and Portosal 8410A no 58672 salinometer as conductivity standard based on water samples. Table 2 gives the technical specifications for the standards, the Portosal and the Sea Bird calibrated towards Neil Brown conductivity and temperature standard.

Table 2a. Calibration of Sea Bird towards Neil Brown standard

T_{NB}	T_{SB}	T_{NB} -T_{SB}	ΔT_{mean}	C_{NB}	C_{SB}	C_{NB}-C_{SB}	ΔC_{mean}
0.368	0.367	0.001		29.320	29.287	0.033	
0.380	0.378	0.001	0.001	29.333	29.299	0.034	0.0348
0.396	0.394	0.002		29.351	29.314	0.037	
14.708	14.707	0.006		42.113	42.071	0.042	
14.711	14.705	0.006	0.0057	42.116	42.077	0.039	0.0387
14.800	14.794	0.006		42.204	42.166	0.038	
14.855	14.850	0.005		42.258	42.222	0.036	

Table 2b. Specifications for Portosal 8410A salinometer

Instrument	Serial #	Accuracy	Resolution
Salinity (salinometer)	59 721	0.003 PSU	0.0003 PSU

The calibration procedure was carried out as follows

1: 6 water samples for temperature about 9.9 °C

2: 5 water samples for temperature about 4.5 °C

3: 3 water samples for temperature about 4.1 °C

4: 4 water samples for temperature about -1.6 °C

Results from the calibration of CTD for temperature and conductivity are given in Table 3.

The engineering units for temperature and conductivity are obtained from OTS-1500 raw data signal by using the formula

$$Y=A+By+Cy^2+Dy^3+Ey^4$$

Y denotes scaled engineering units and y unscaled raw counts from the instrument. A to E are polynomial coefficients to be determined. The old coefficients were A=22.49889, $B=7.660579\times10^{-4}$, $C=8.852499\times10^{-11}$ D, E, F=0 for the temperature sensor and A=34.35566, $B=71.182136\times10^{-3}$, $C=-1.578963\times10^{-10}$ D, E, F=0 for the conductivity sensor.

Based on results from the calibration we have corrected the constant coefficient A with -0.4 for conductivity and -10.4×10^{-3} for temperature whereas the other coefficients are unchanged. Thus, the following coefficients are used in the calculations.

Temperature: A=22.48849, $B=7.660579\times10^{-4}$, $C=8.852499\times10^{-11}$ D, E, F=0

Conductivity: A=33.95566, $B=71.182136\times10^{-3}$, $C=-1.578963\times10^{-10}$ D, E, F=0

Table 3. Calibration data for OTS-1500 CTD

T_{SB}	T_{ME}	T_{SB}-T_{ME}	ΔT_{mean}	C_{SAL}	C_{ME}	C_{SAL}-C_{ME}	ΔC_{mean}
9.994	10.000	$-6.4x10^{-3}$		36.759	37.227	-0.468	
9.971	9.978	$-6.8x10^{-3}$		36.739	37.207	-0.468	
9.951	9.960	$-8.9x10^{-3}$		36.720	37.194	-0.474	
9.942	9.952	$-10.5x10^{-3}$		36.711	37.185	-0.474	0.473
9.936	9.950	$-16.5x10^{-3}$		36.704	37.180	-0.476	
9.921	9.956	$-13.9x10^{-3}$		36.714	37.190	-0.476	
4.490	4.505	$-15.0x10^{-3}$		31.842	32.241	-0.399	
4.463	4.477	$-14.0x10^{-3}$		31.819	32.213	-0.394	
4.442	4.456	$-14.0x10^{-3}$		31.801	32.197	-0.396	0.397
4.423	4.438	$-15.0x10^{-3}$		31.784	32.181	-0.396	
4.405	4.422	$-17.0x10^{-3}$		31.768	32.165	-0.396	
4.130	4.140	$-10.0x10^{-3}$		31.530	31.919	-0.389	
4.109	4.123	$-13.0x10^{-3}$		31.512	31.903	-0.391	0.391
4.097	4.110	$-13.0x10^{-3}$		31.501	31.894	-0.393	
-1.634	-1.619	$-15.0x10^{-3}$		26.672	26.995	-0.323	
-1.640	-1.622	$-18.2x10^{-3}$		26.667	26.991	-0.324	
-1.637	-1.625	$-12.0x10^{-3}$		26.669	26.992	-0.323	0.323
-1.637	-1.621	$-16.3x10^{-3}$		26.669	26.993	-0.324	

2.3 Post-cruise calibration of the OTS-1500 CTD

A post-cruise calibration of the CTD salinity was performed. Twenty five water samples were analyzed for salinity by using the Portosal 8410A salinometer at Geophysical Institute, with specifications given in Table 3. The salinity of the OTS-1500 shows a mean value of 0.004 higher than the Portosals values while the standard deviation for Portosal - minus CTD salinity is 0.06. Thus, based on the post-cruise calibration no corrections of the salinity parameters were made. There was no post-cruise calibration of temperature.

3. CTD OBSERVATION PROGRAM

During ICE-BAR 1995, 92 CTD casts were carried out with the OTS-1500 and 25 water samples were collected by using a Niskin water sampler. Fig 2 gives an overview of the CTD stations. For further details with respect to the measuring program reference is made to the Cruise Report (Falk-Petersen and Hop, 1996).

From an oceanographic point of view, the hydrographic observation program - the 92 CTD stations - can be divided in sections as follows:

1. CTD-stations 1-2: Storfjorden Svalbard
2. CTD-stations 3-9: Transect Storfjorden-Hopen
3. CTD-station 10-20: Transect Hopen towards 35° E
4. CTD-station 21-35: Ice-station I
5. CTD-station 36-38: Transect Ice-station I - Ice-station II
6. CTD-station 39-56: Ice-station II
7. CTD-station 57-60: Drifting in the ice
8. CTD-station 61-69: Ice-station III
9. CTD-station 70-73: Station IV
10. CTD-station 74-79: Transect towards north from station IV
11. CTD-station 80-85: Transect along ice-edge westwards to Hopen
12. CTD-station 86-92: Transect over northern Bear Island Channel

4. DATA PROCESSING AND PRESENTATION

On board the ship the CTD-observations were managed from a PC by using the acquisition program Multipar. Raw data counts were stored on the PC's hard disk and on separate diskettes. By running the Multipar program, raw data were converted to physical units in ASCII format and stored on diskettes.

After the cruise, the CTD data were processed on a PC at the Geophysical Institute, University of Bergen in order to utilize an existing vertical section program for the CTD profile data. First, 2db (2 m) despiked, averaged values of the CTD parameters were calculated for each down-cast CTD station profile. The final data then consists of 2 m averages of pressure, temperature and salinity The data base of down-cast CTD stations were then divided into segments according to the sectioning in chapter 4. This ad hoc

procedure allows the acquisition segments to be presented as plots of continuous profiles along straight lines

The results are then presented as computer contoured vertical sections of the hydrographical parameters temperature, salinity and density (sigma-t). The horizontal scale of the individual sections are given as distance in kilometers while contour sections of the ice-station observations - isopleth plots - have a horizontal scale in hours. In addition to the section contour plots, the hydrographic parameters for each CTD station are presented as vertical profiles.

5. OBSERVATIONS

5.1 General description

The surface currents of the Barents Sea are shown in Fig 1. The large-scale water masses in the investigation area of the Northern Barents Sea shown in Fig 2 are related to one branch of the Norwegian Atlantic Current entering the Barents Sea through the Bear Island Channel flowing eastward to 30° E where it splits into three branches. One of them flows northward into the investigation area between Hopen and the Great Bank where it submerges under the lighter Arctic water. Additionally, there is a minor inflow of Atlantic water through the Storfjord trench between Bear Island and Svalbard. One branch of Arctic water flows southwards into the Barents Sea between Svalbard and Franz Josefs Land. Usually the warm and saline Atlantic water are characterized by salinity above 35. Properties of intermediate Arctic water found between depths of 20-150 m are temperatures close to freezing point below -1.5 °C and salinity between 34.4-34.6. The Polar front is identified as the transition zone between the Atlantic and Arctic water masses. Because of the topographical influence on currents in steering and trapping them along slopes, the bottom topography in western Barents Sea mirrors the Polar front.

A striking feature of the hydrography in the marginal ice zone of the Central Barents Sea in spring/early summer is a 20 m thick layer of melt water due to melting of the thick first year ice. The melting results in a stable well mixed upper layer with low temperatures < 1 °C and salinity < 34.2. Generally, this stable layer extends about 20 nautical miles southward from the ice edge where a pronounced frontal transition zone is evident through an abrupt temperature increase from 1 to 2.5 °C. This stable layer results in

enhanced biological production.

As shown above, the hydrographic conditions and water masses off the ice edge have been thoroughly surveyed, whereas observations from the marginal ice area are more scarce. Therefore, in this investigation - the ICE-BAR program - we will concentrate the description on observations in the ice pack at the stationary ice-stations - ice-stations I, II, III - and then extend the transect into open water.

5.2 CTD observations at the ice stations

5.2.1 Ice-station I, observation period 60 hours

The station was located in a fast ice area where the ship was moored to a large ice floe of the size 10 km x 5 km with an open lead at the other side of the ship. The ice concentration was 8/10-9/10. CTD observations were obtained every 3 hours over a 60-hour period. The ship log shows a northerly drift of about 10 n. miles through the observation period superimposed on small semi-diurnal tidal excursions. Due to southerly winds of breeze strength, the ice conditions changed through the observation period so that the ship became gradually enclosed by the pack ice.

The hydrography at this station shows typical spring time conditions for the marginal ice zone. There is an equally stratified density field with a weak pycnocline at 15-20 m depth, where the halocline is produced by dilution of the surface layer by ice melting. Properties for the melt layer are a temperature of -1.6°C close to the freezing point and a salinity of 33.8. Below the pycnocline the water mass shows salinities between 34.2-34.4 and temperatures down to -1.8 °C; water properties related to winter convection. Below this layer down to 140 m there is a seasonal thermocline where the temperature increases to 0.5 °C. The deeper water mass shows properties similar to Barents Sea water. Both the pycnocline and thermocline show periodicity, most likely caused by semi-diurnal tidal forcing and meteorological forcing.

5.2.2 Ice-station 2, observation period 60 hours

The station was situated in the midst of thick hummocked first year ice of 7/10 concentration. The ship was enclosed by the ice pack with floes of smaller size than at station 1. During the observation period of 2.5 days, the ship log showed a northerly drift

of about 0.5 knots with insignificant tidal currents. During the period the wind increased to 10 knots resulting in more open leads around the ship.

Distribution of oceanographic parameters and water properties are very similar to station 1. The decrease in ice concentration reflects the appearance of a thin surface layer of about 3 m with warmer and less saline water, a temperature of -1.5 °C and a salinity of 33.6. The pycnocline is located at depths between 15-20 m and the corresponding seasonal thermocline is situated at 100-140 m depths. Also, at this station 12-hour periodic signals due to semi-diurnal internal tidal waves are significant.

5.2.3 Ice-station 3, observation period 24 hours

The station was located amidst small ice floes up to 50 m diameter of medium first year ice of 6/10-7/10 concentration (open drift ice- close drift ice). Some ice floes were destroyed by melting to stages of dried ice and rotten ice. The station was located near the ice edge and we noticed swell penetrating from open water.

The distribution of oceanographic parameters is very similar to station 2, but there is a more pronounced mixed layer at this station with a stronger pycnocline manifested by an abrupt increase in salinity from 33.4 to 34.2 at 20 m depth. Presumably, the melt water layer is more prominent in this area, due to the strong ice melting. In addition, the seasonal thermocline shows large variability with amplitudes of 40-50 m. Most likely, this transient feature is related to internal excursions induced by an eddy system at the ice edge or wind forcing. The water mass produced by winter convection is recognized in a thinner intermediate layer between 25 m and 50 m, above the deeper Barents Sea water.

5.2.4 Station 4, observation period 12 hours

The station was located in open water. Because of trawling, the ship was not stationary and only 2 profiles were successful. The observed surface water mass with a warm - temperature of 0.4-0.7 °C - and diluted mixed layer due to ice melting is typical for this season near the ice edge. A striking feature at this open water station is that the thermocline and halocline coincide at about 10 m depth, which differs from the properties in the marginal ice zone. The deeper waters show properties according to the water produced by winter convection with temperatures down to -1.8 °C.

5.2.5 Transect along the ice edge

This transect starts at station 4, goes northward along the edge of drift ice and then westwards towards Hopen, according to Fig 2. All changes in water mass characteristics observed in the upper layer of 30-50 are related to ship position, either in open water, close to the ice edge or in the midst of drifting ice floes of different concentrations. This is well illustrated by the presence or absence of a thermocline in the upper layer. As discussed for different stations above, in the highly concentrated area of ice floes, the thermocline is almost absent. In open water it is well pronounced and coincides with the halocline. The vertical extension of winter convection water varies between 30 m and 130 m due to varying bottom depth and dynamical processes in the water column. For instance, the deeper water masses in the through between Great Bank and Hopen show properties of Barents Sea water, while the dome structure in the area of station 84 indicates an eddy with cyclonic circulation.

5.3 Concluding remarks

The oceanographic data - CTD observations- show the dynamical state of the water column in the area where biological sampling took place. Common analyses of biological and oceanographic observations will permit us to reveal the links between the oceanographic fields, their stratification and dynamics. In further investigations it will be useful to measure O_2, PO_4, NO_2, NO_3 and Si near the ice edge to trace correlations with the biological processes.

Acknowledgement

Thanks are due to Steinar Myking for the data processing and to the scientists and crew on board R/V 'Lance' for their enthusiasm and for pleasant atmosphere during the ICE-BAR 1995 cruise.

6. REFERENCES

Falk-Petersen, S. and H. Hop, 1996. Ecological processes in the marginal ice-zone of the northern Barents Sea. ICE-BAR 1995, Cruise Report. Norsk Polarinstitutt, Rapportserie, No 93, Tromsø, 1996. 240 pp.

Loeng, H., 1989. Ecological features of the Barents Sea. In Proceedings of the sixth Conference of Comite Arctique International: 13-15 May 1985, L. Rey and V. Alexander (eds.), pp. 327-365, E. J. Brill.

7. LIST OF FIGURES.

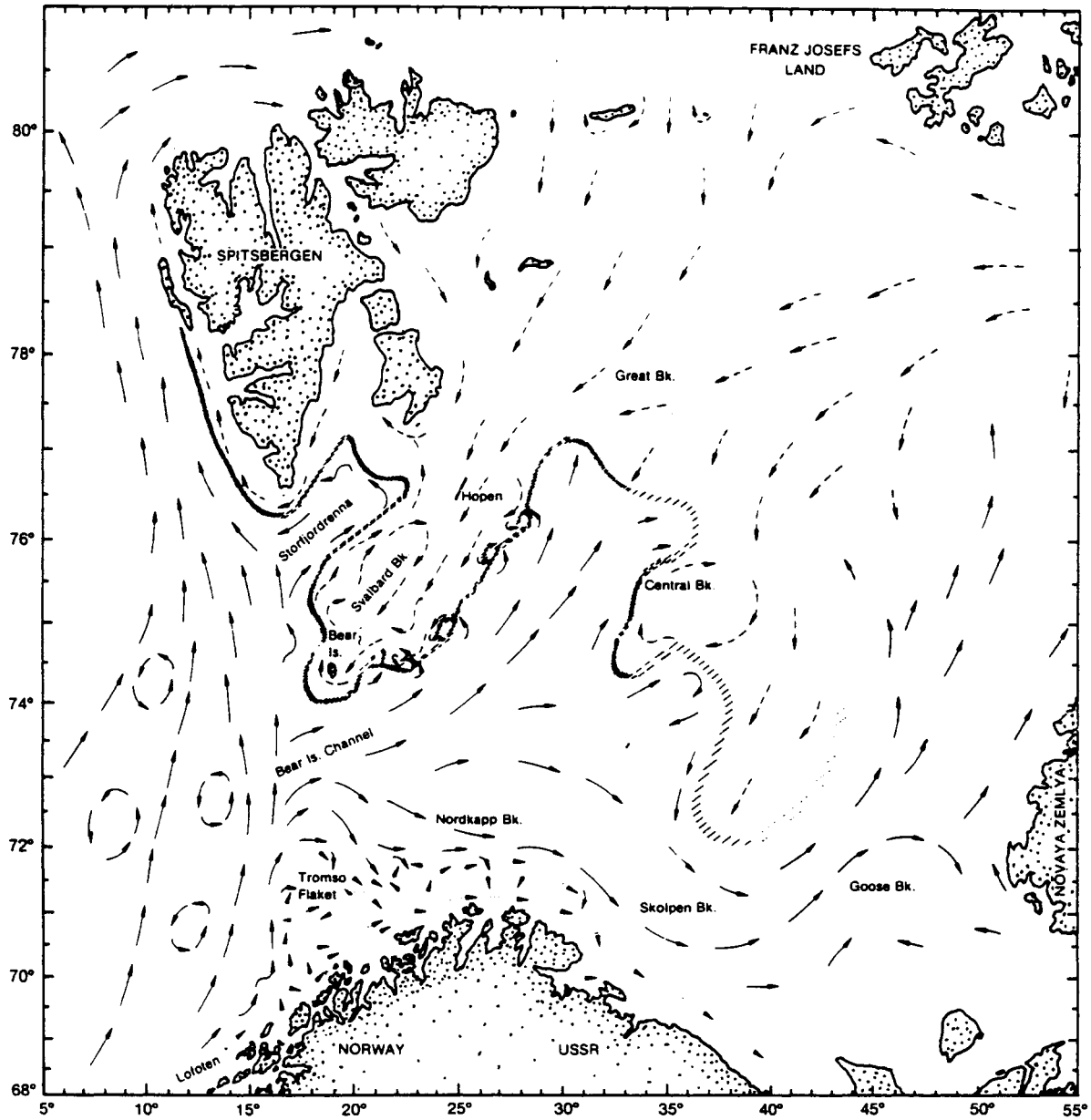


Fig. 1. Main features of surface currents in the Barents Sea. Atlantic currents (——►). Coastal currents (– – – –►) and Arctic currents (·····►). The hatched line indicates the mean position of the Polar front (Loeng, 1989).

Fig 1. Main feature of surface currents in the Barents Sea (after Loeng, 1989)

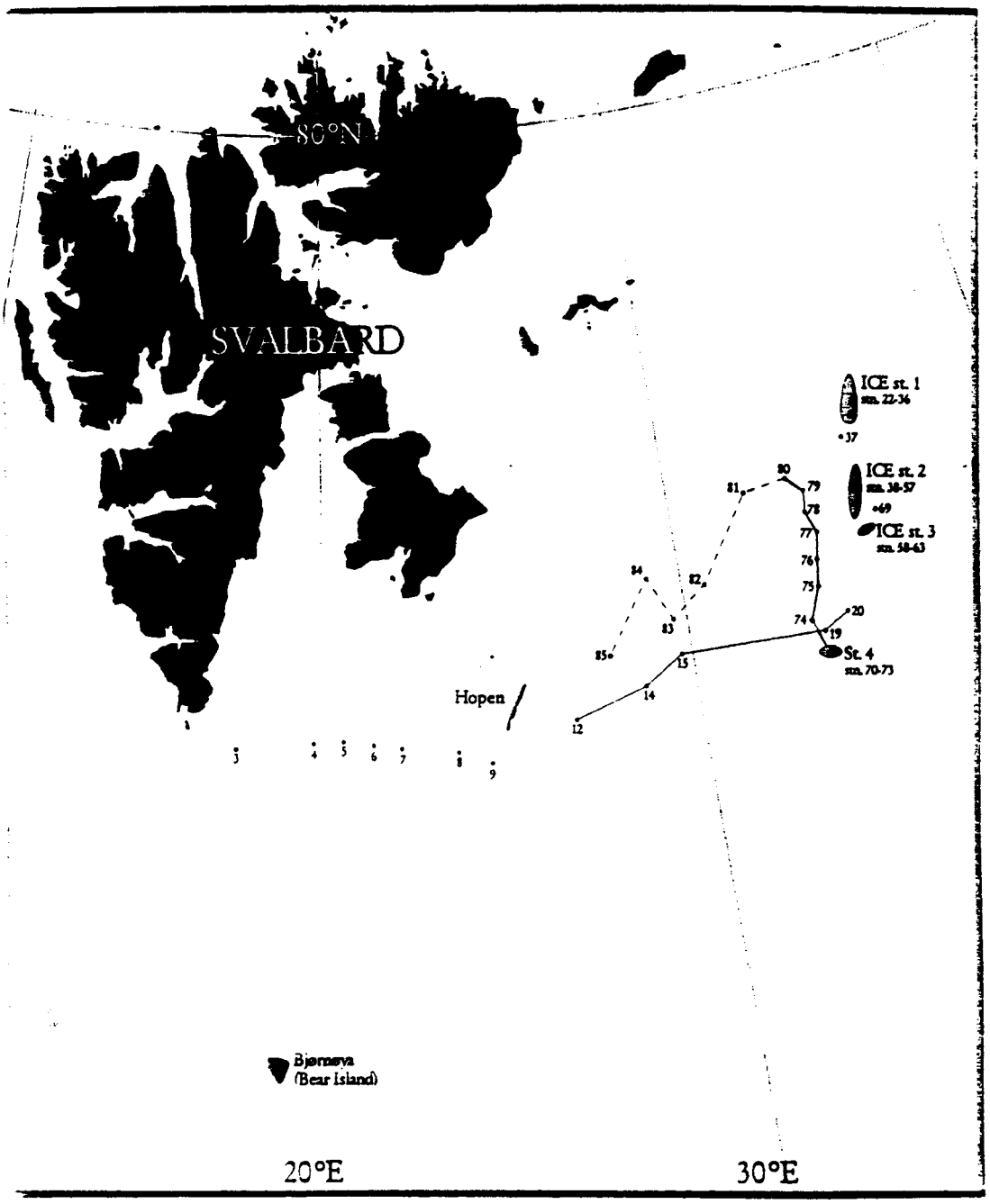
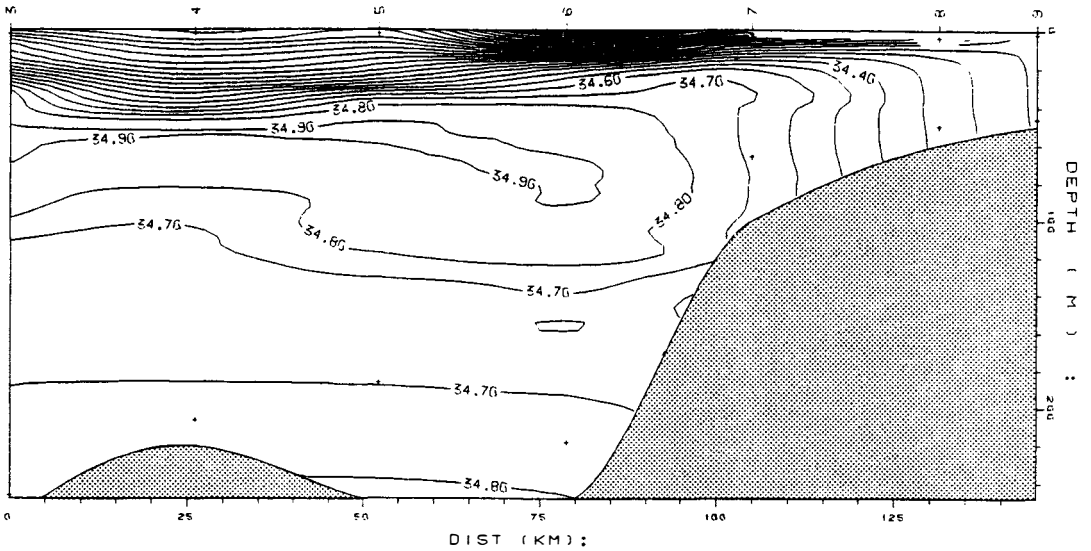


Fig 2. Overview of the investigation area where CTD-stations and transects are indicated



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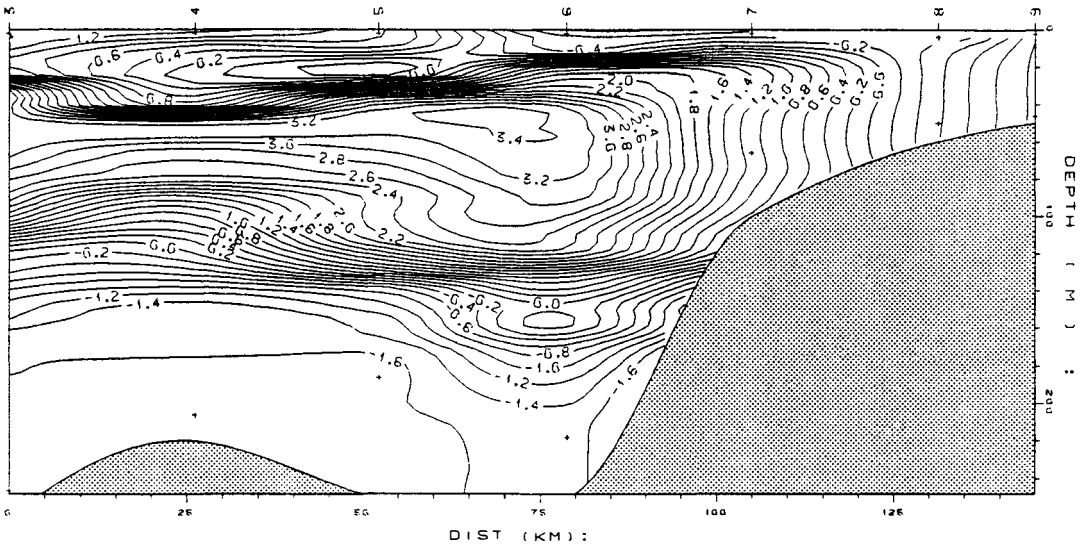

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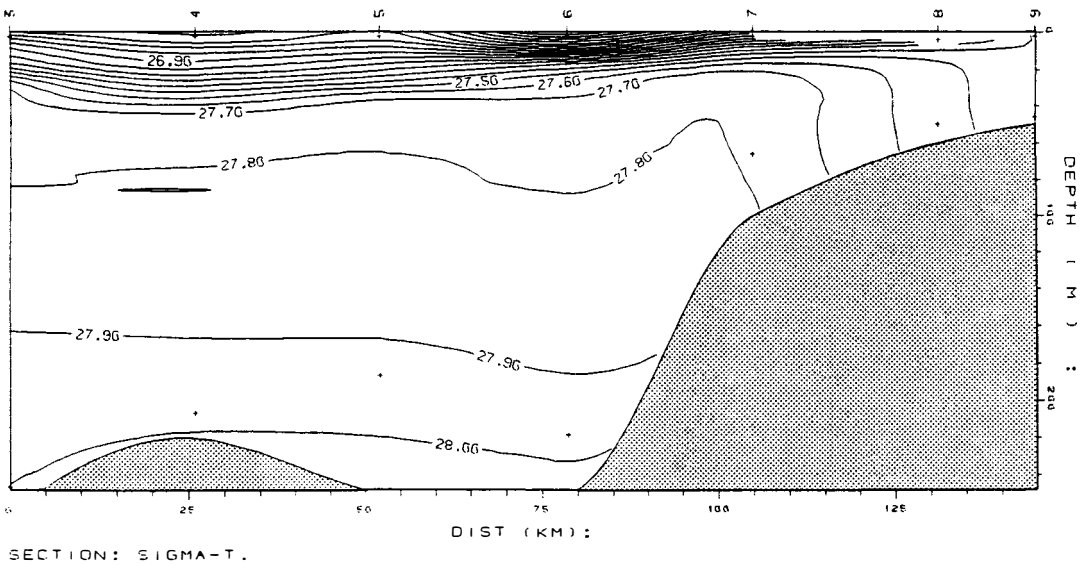

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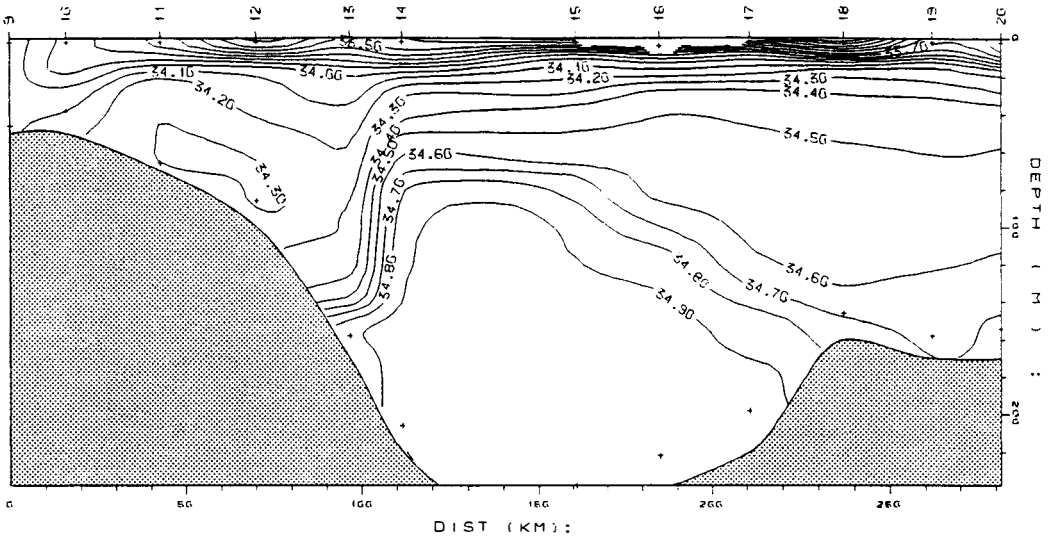
Fig 3. CTD-stations 3-9: Transect Storfjorden-Hopen



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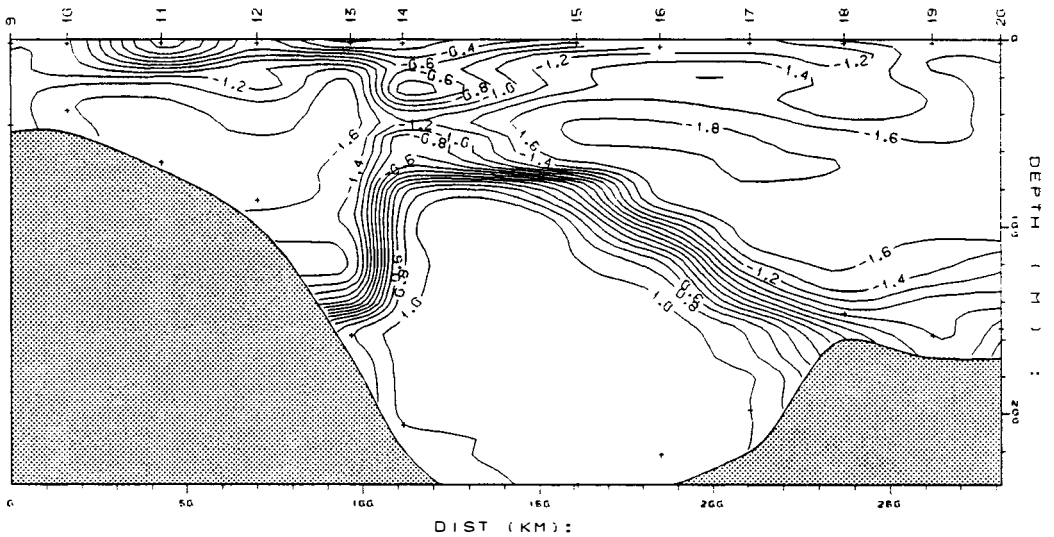

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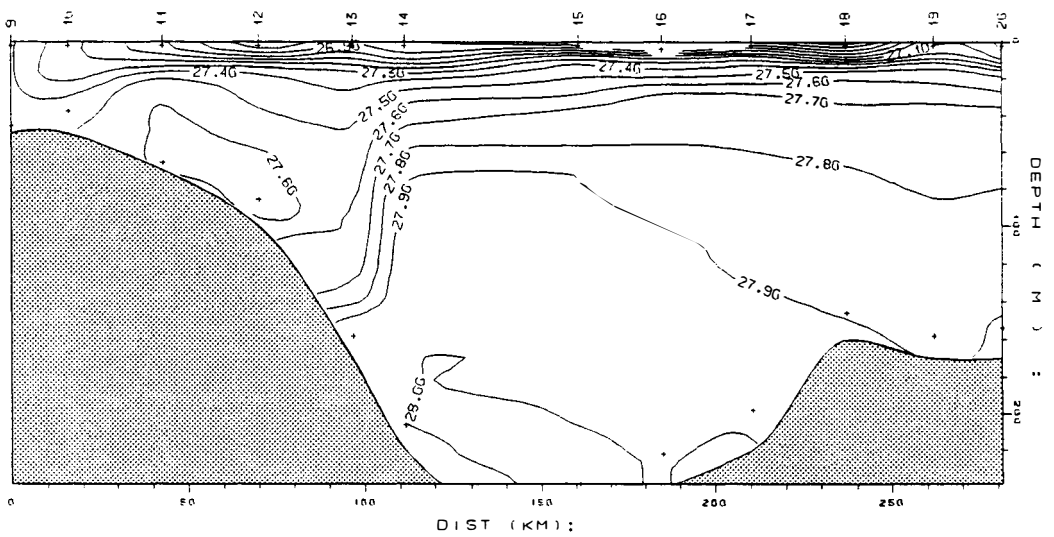

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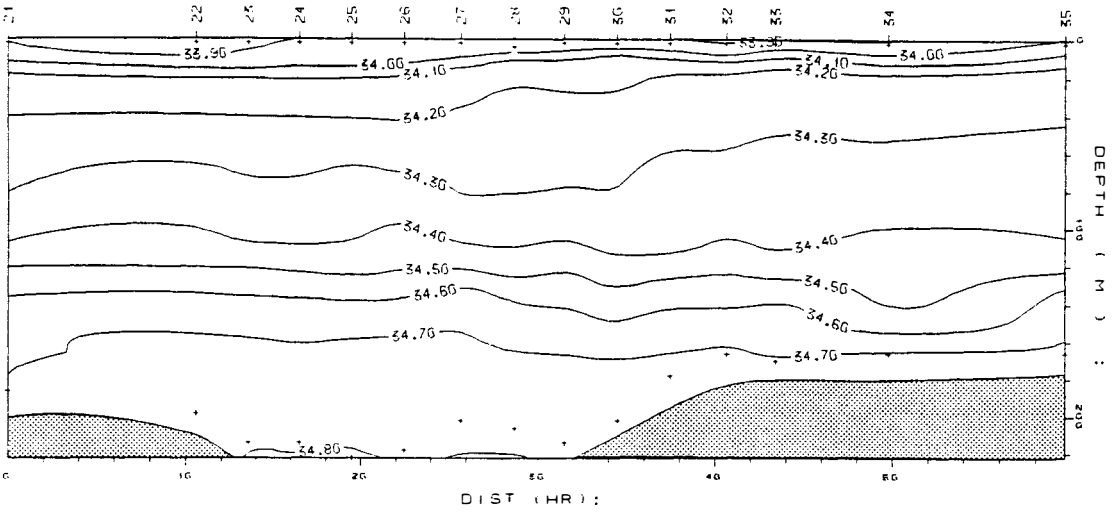
Fig 4. CTD-station 10-20: Transect Hopen-35° E



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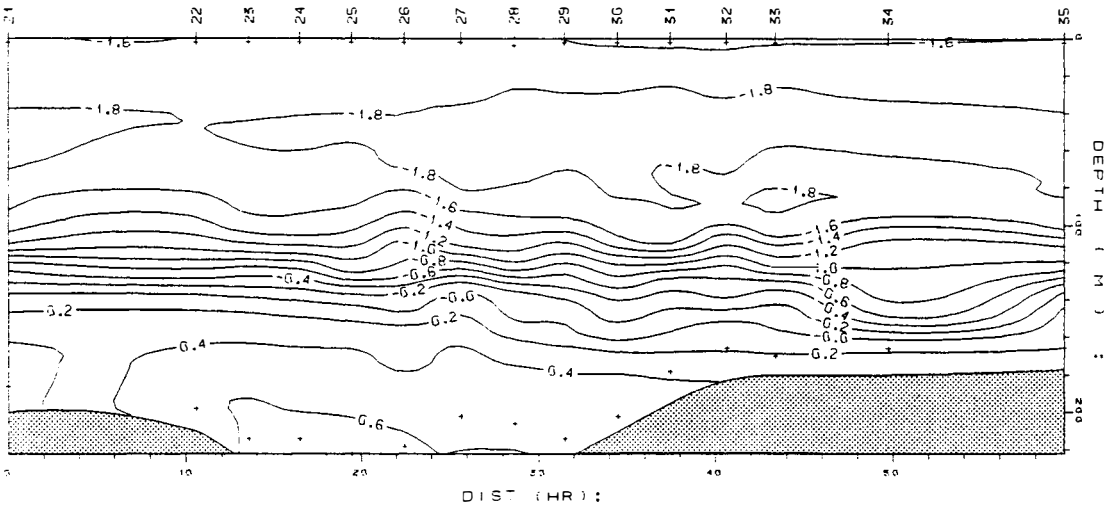

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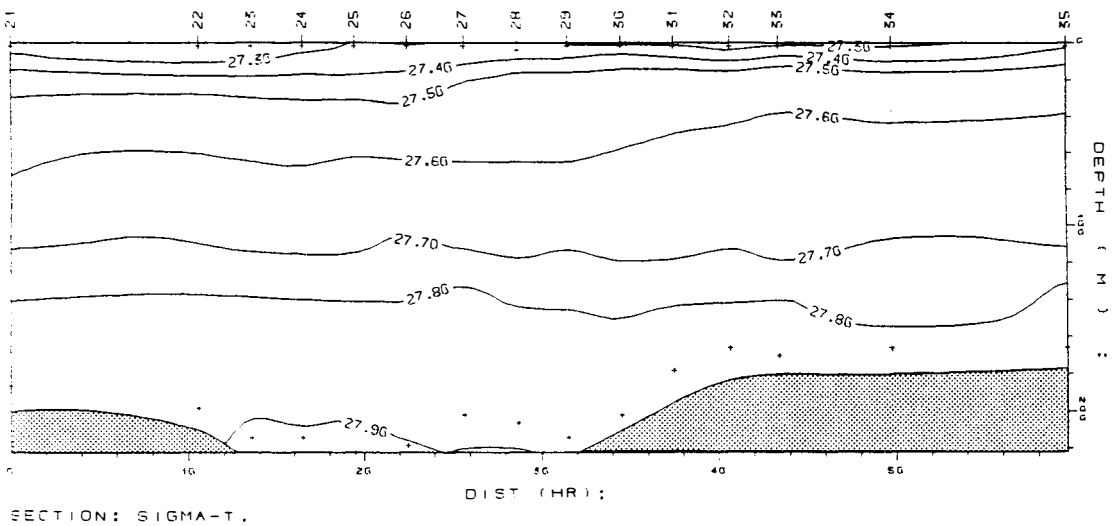

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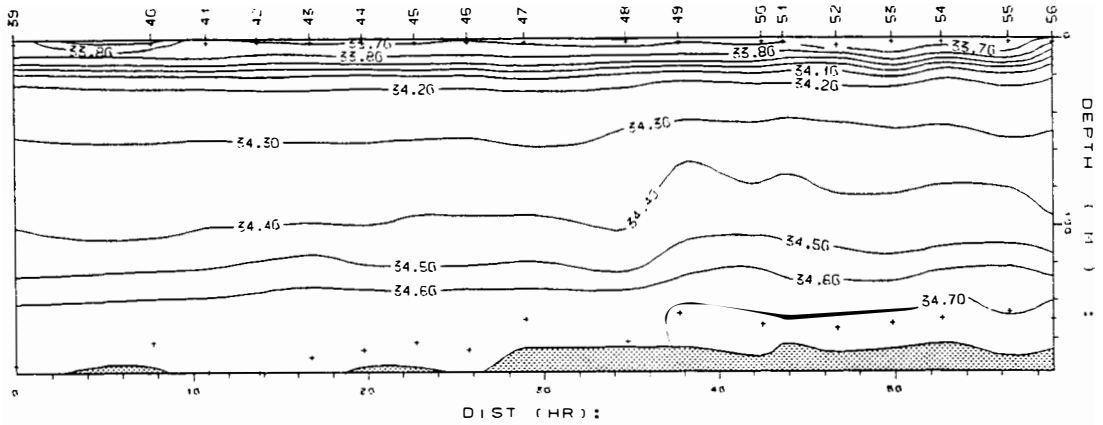
Fig 5. CTD-station 21-35: Ice-station I



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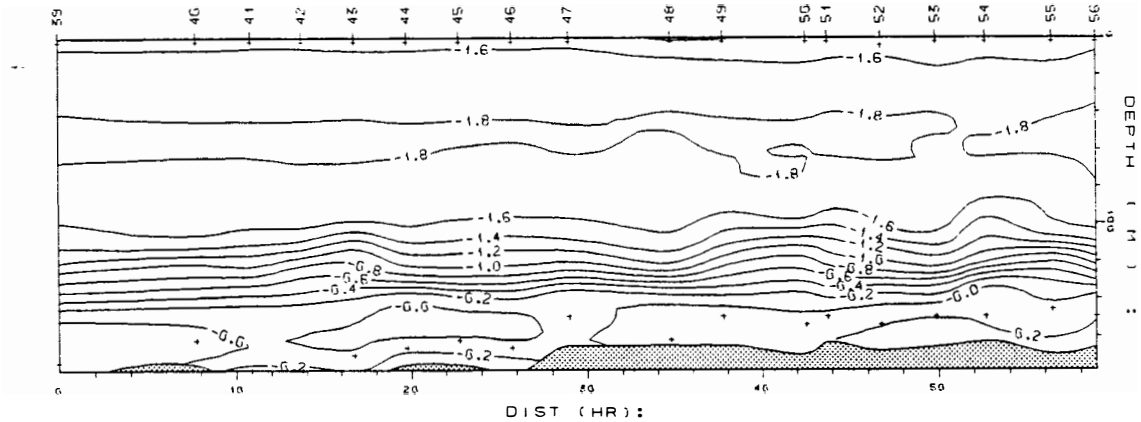

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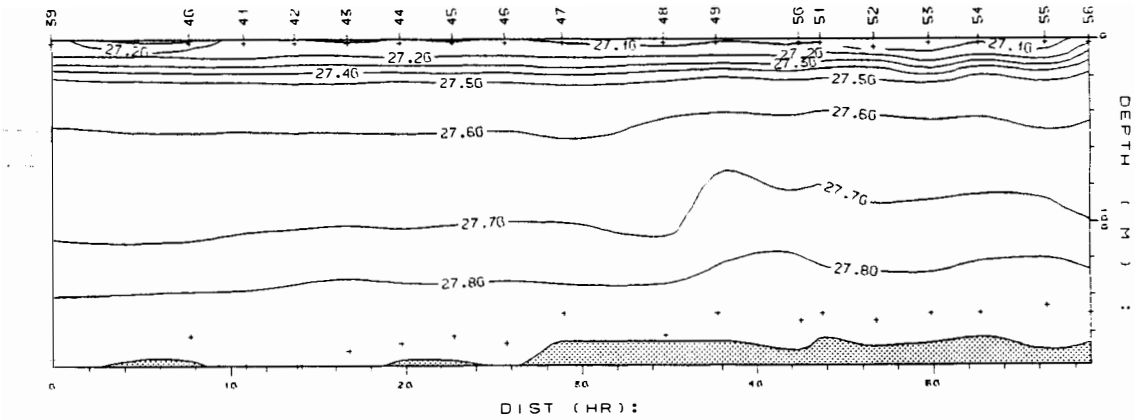

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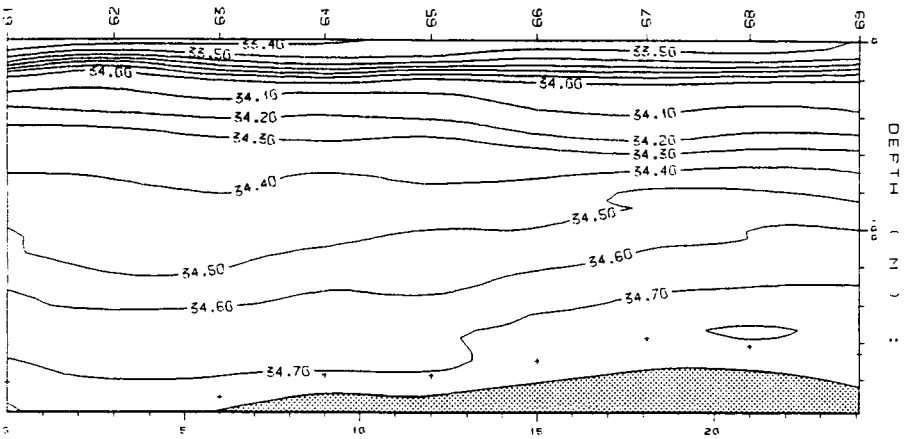
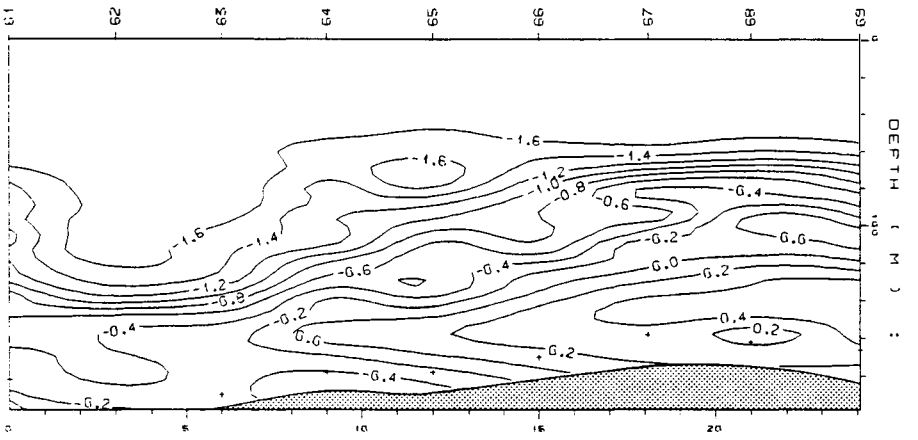
ICEBAR95 SN 39-56

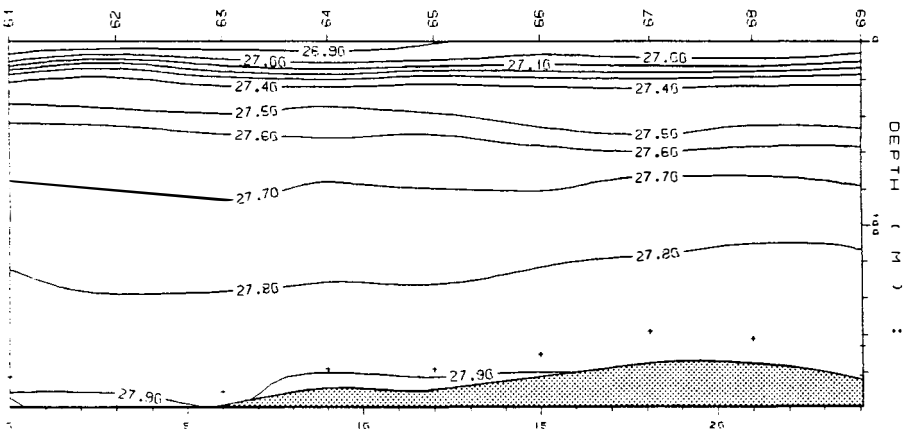
Fig 6. CTD-station 39-56: Ice-station II



SECTION: SALINITY (PSS 78)
TIME: JUN.22:15 7 - JUN.23:1511 1995
POS: 77.50°N 34.74°E - 77.65°N 34.94°E
ICEBAR95 SN 61-69

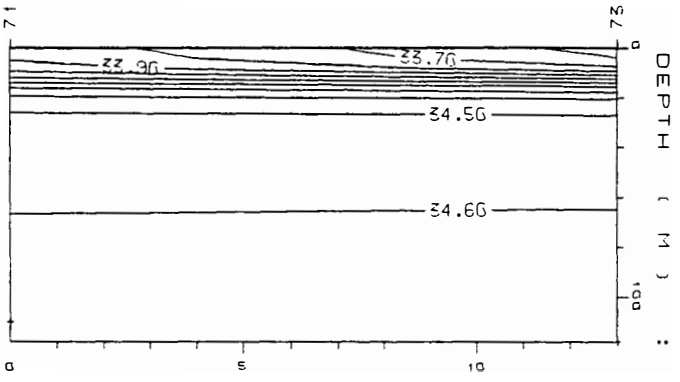


SECTION: TEMPERATURE (DEG. CEL.)
TIME: JUN.22:15 7 - JUN.23:1511 1995
POS: 77.50°N 34.74°E - 77.65°N 34.94°E
ICEBAR95 SN 61-69

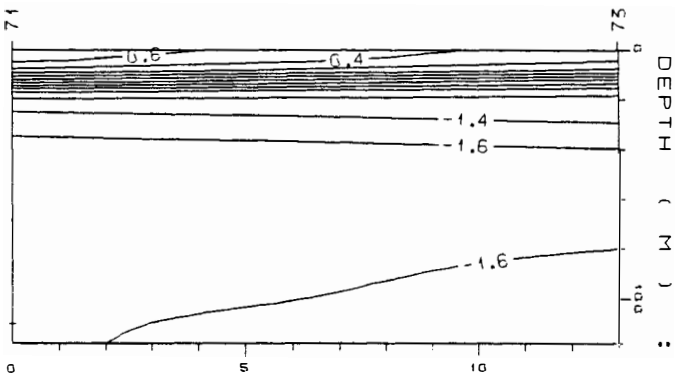


SECTION: SIGMA-T.
TIME: JUN.22:15 7 - JUN.23:1511 1995
POS: 77.50°N 34.74°E - 77.65°N 34.94°E
ICEBAR95 SN 61-69

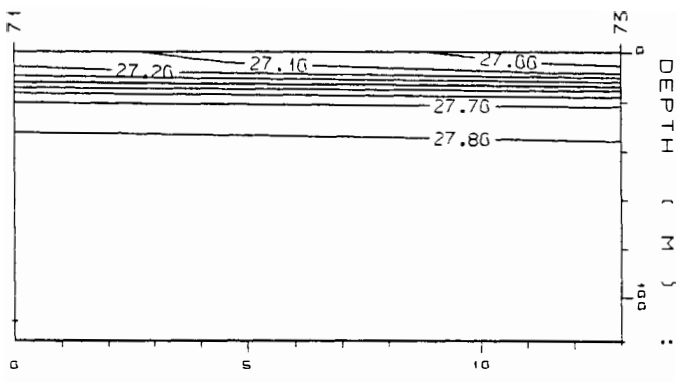
Fig 7. CTD-station 61-69: Ice-station III



SECTION: SALINITY (PSS 78)
TIME: JUN.24:12 4 - JUN.24:1935 1995
POS: 76.89°N 33.94°E - 77.00°N 34.19°E
ICEBAR95 SN 71-73

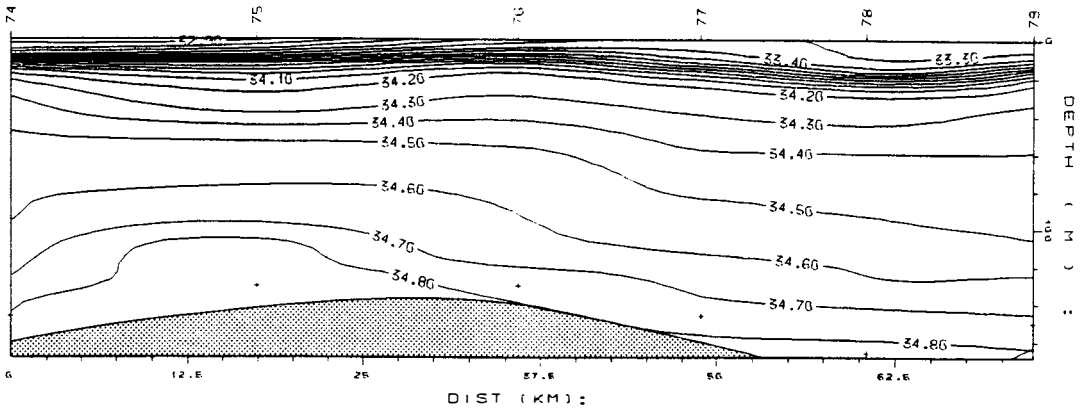


SECTION: TEMPERATURE (DEG. CEL.)
TIME: JUN.24:12 4 - JUN.24:1935 1995
POS: 76.89°N 33.94°E - 77.00°N 34.19°E
ICEBAR95 SN 71-73

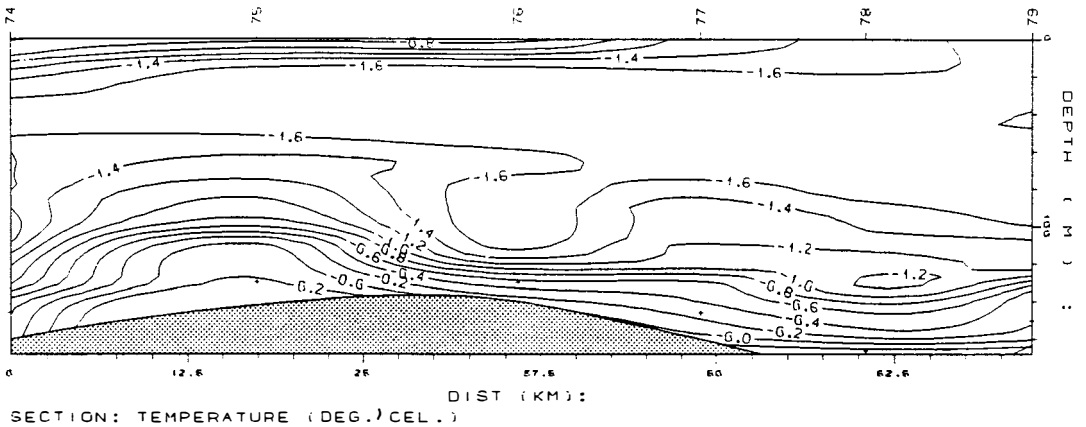


SECTION: SIGMA-T.
TIME: JUN.24:12 4 - JUN.24:1935 1995
POS: 76.89°N 33.94°E - 77.00°N 34.19°E
ICEBAR95 SN 71-73

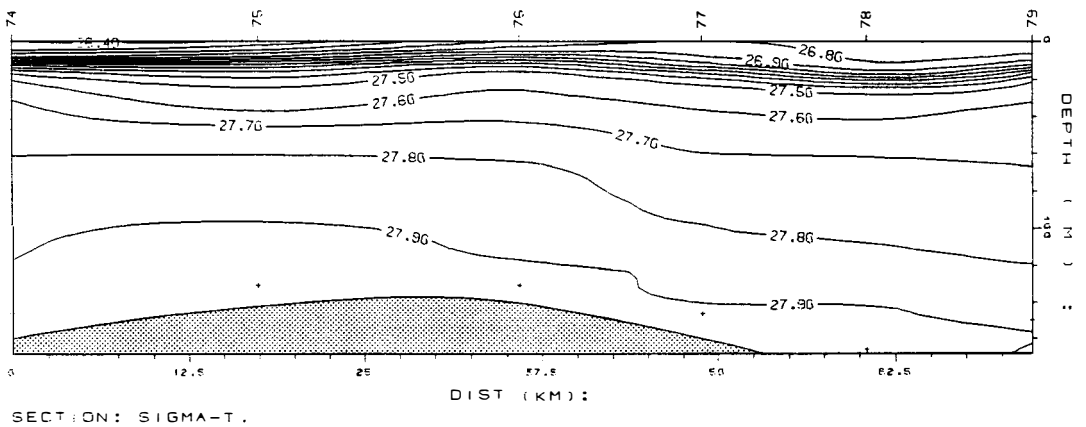
Fig 8. CTD-station 70-73: Station IV



SECTION: SALINITY (PSS 78)
TIME: JUN.24:2130 - JUN.25: 314 1995
POS: 77.07°N 33.57°E - 77.71°N 33.33°E
ICEBAR95 SN74-79

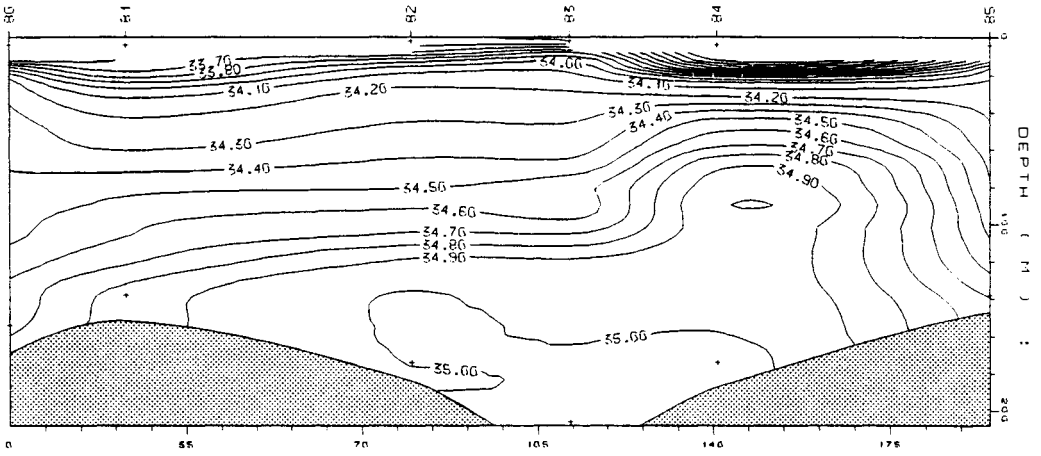


SECTION: TEMPERATURE (DEG.) CEL.)
TIME: JUN.24:2130 - JUN.25: 314 1995
POS: 77.07°N 33.57°E - 77.71°N 33.33°E
ICEBAR95 SN74-79

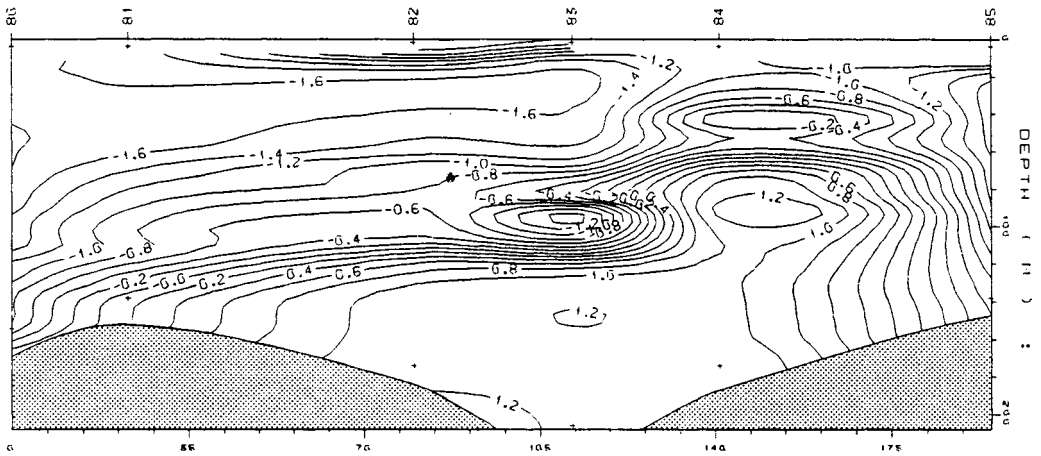


SECTION: SIGMA-T.
TIME: JUN.24:2130 - JUN.25: 314 1995
POS: 77.07°N 33.57°E - 77.71°N 33.33°E
ICEBAR95 SN74-79

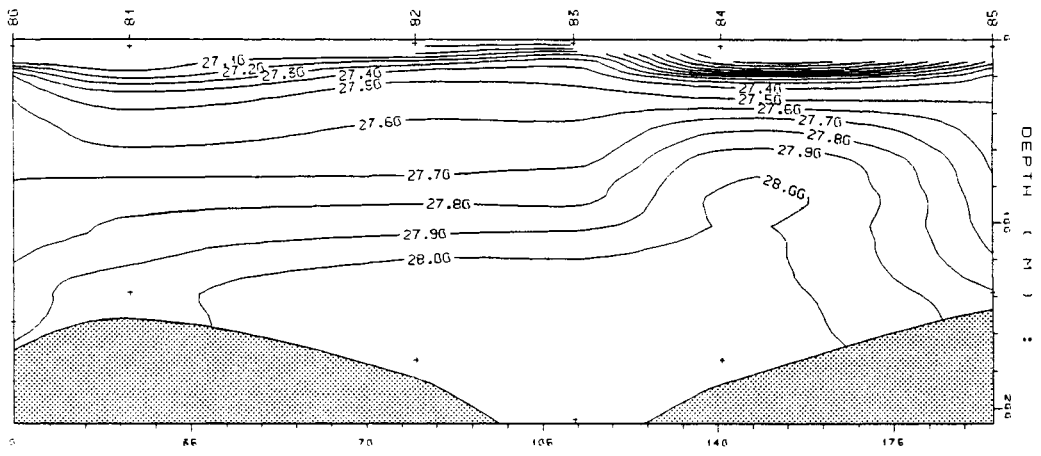
Fig 9. CTD-station 74-79: Transect towards north from station IV



SECTION: SALINITY (PSS 78)
TIME: JUN.25: 448 - JUN.26: 946 1995
POS: 77.78°N 32.93°E - 76.80°N 27.95°E
ICEBAR95 SN 80-85

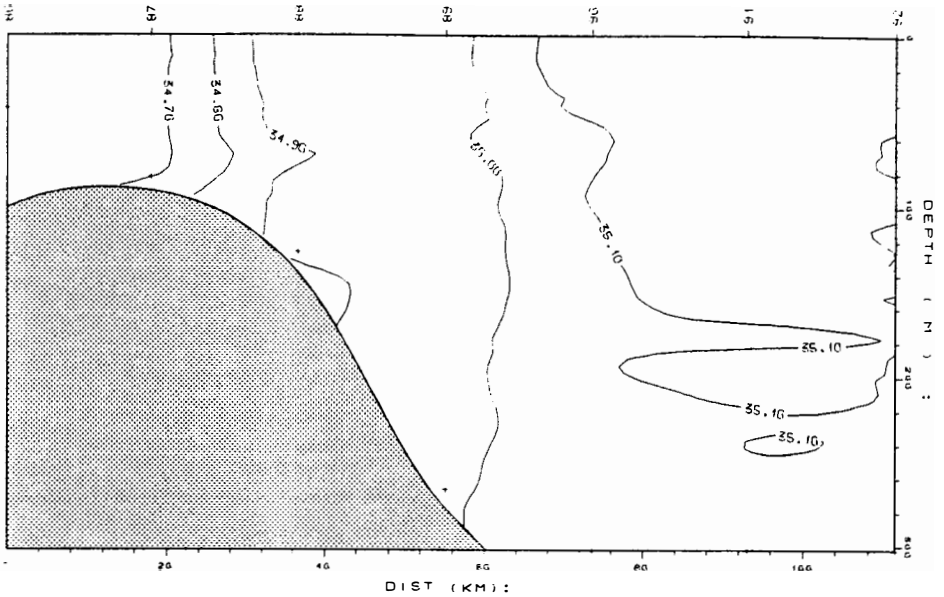


SECTION: TEMPERATURE (DEG. CEL.)
TIME: JUN.25: 448 - JUN.26: 946 1995
POS: 77.78°N 32.93°E - 76.80°N 27.95°E
ICEBAR95 SN 80-85

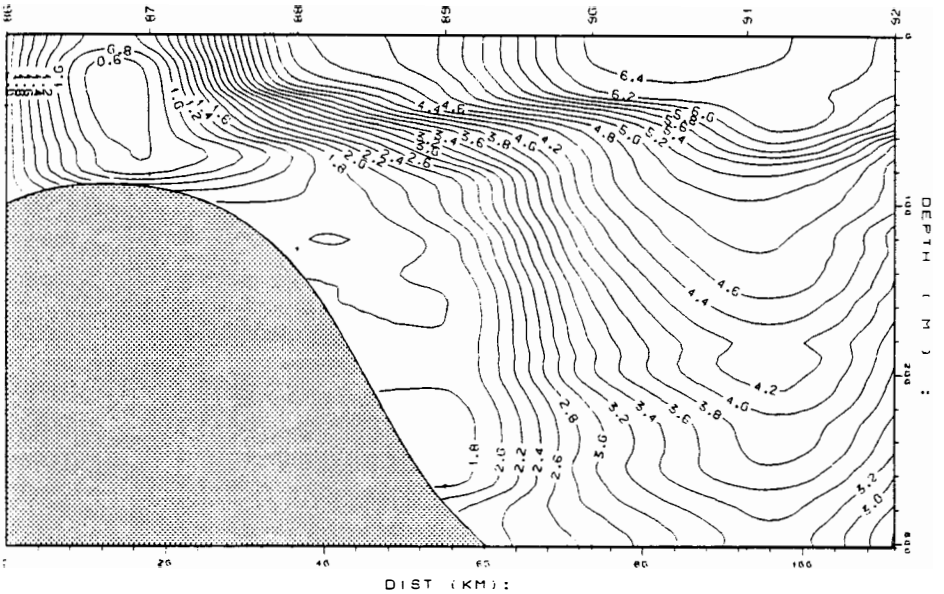


SECTION: SIGMA-T.
TIME: JUN.25: 448 - JUN.26: 946 1995
POS: 77.78°N 32.93°E - 76.80°N 27.95°E
ICEBAR95 SN 80-85

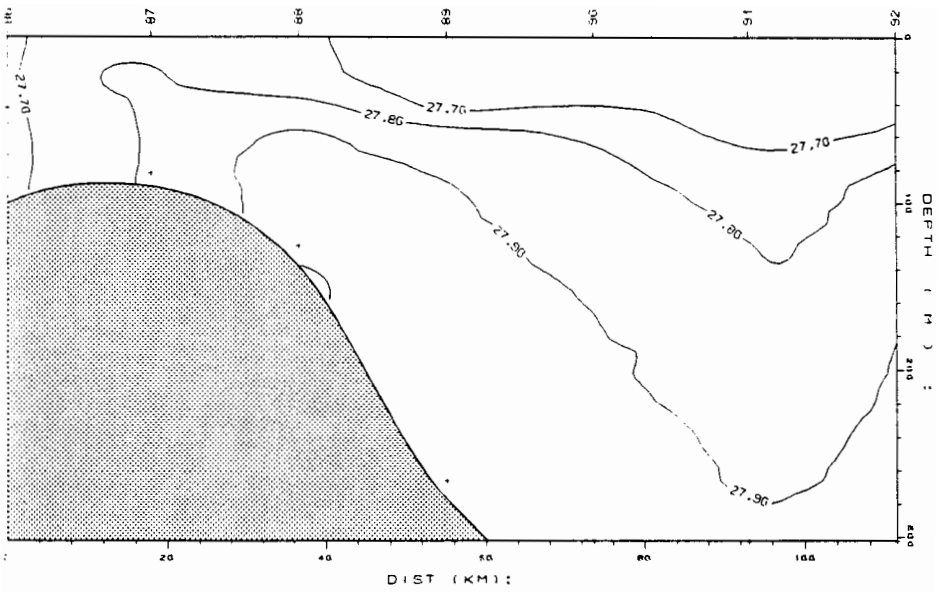
Fig 10. CTD-station 80-85: Transect along ice-edge westwards to Hopen



SECTION: SALINITY (PSS 78)
TIME: JUN.27:2355 - JUN.28: 655 1995
POS: 74.26°N 19.68°E - 73.26°N 19.68°E
ICEBAR95 SN 86-92

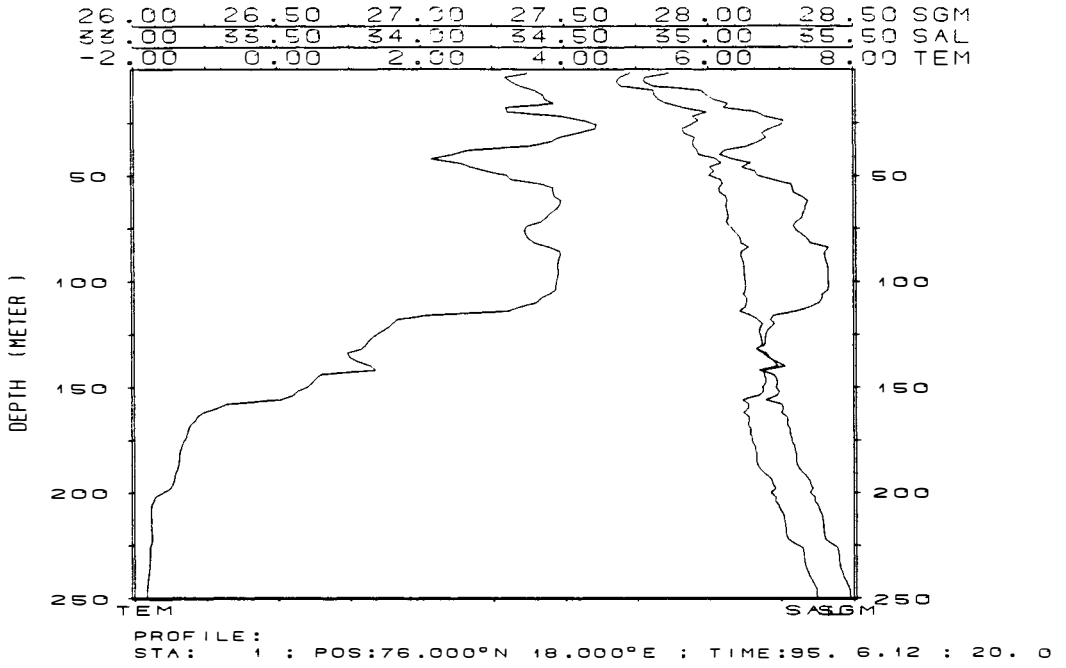


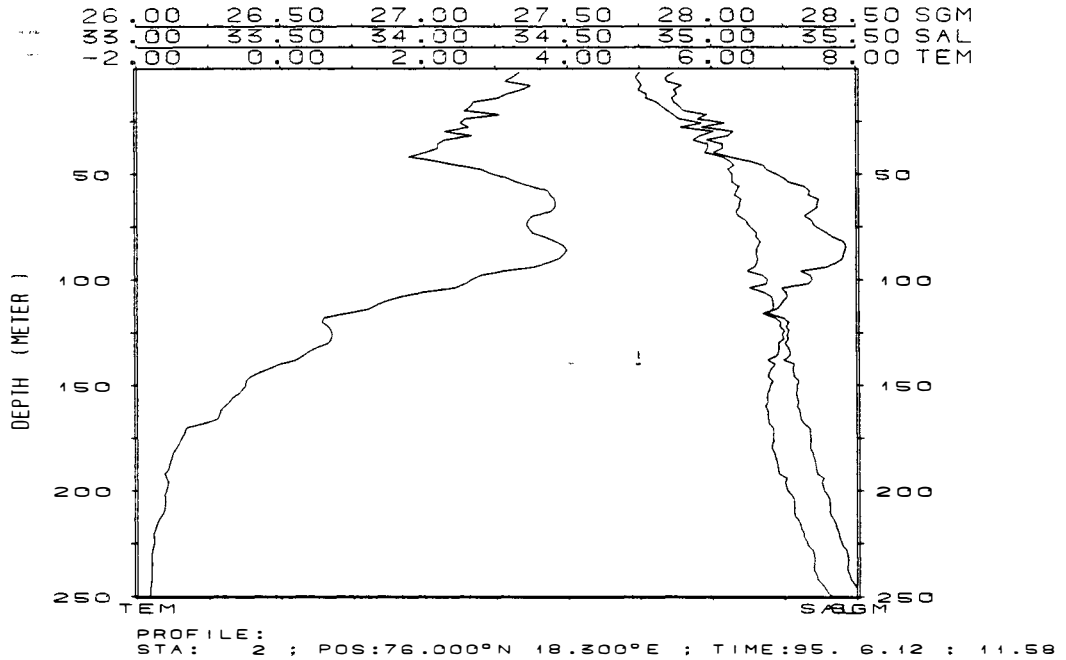
SECTION: TEMPERATURE (DEG. CEL.)
TIME: JUN.27:2355 - JUN.28: 655 1995
POS: 74.26°N 19.68°E - 73.26°N 19.68°E
ICEBAR95 SN 86-92



SECTION: SIGMA-T.
TIME: JUN.27:2355 - JUN.28: 655 1995
POS: 74.26°N 19.68°E - 73.26°N 19.68°E
ICEBAR95 SN 86-92

Fig 11. CTD-station 86-92: Transect over northern Bear Island Channel





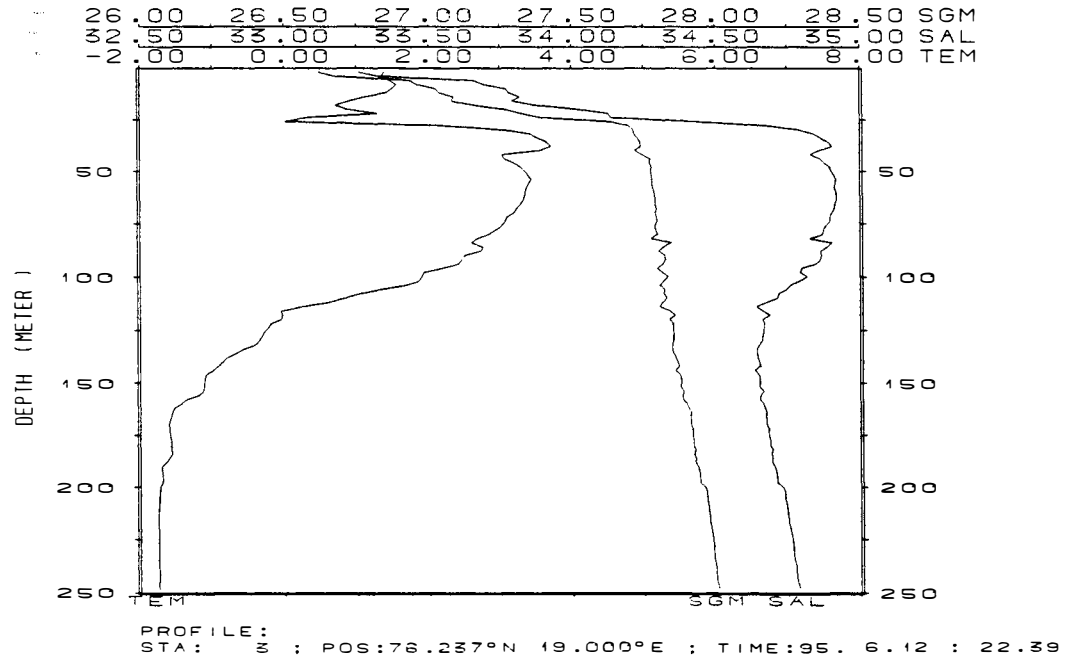
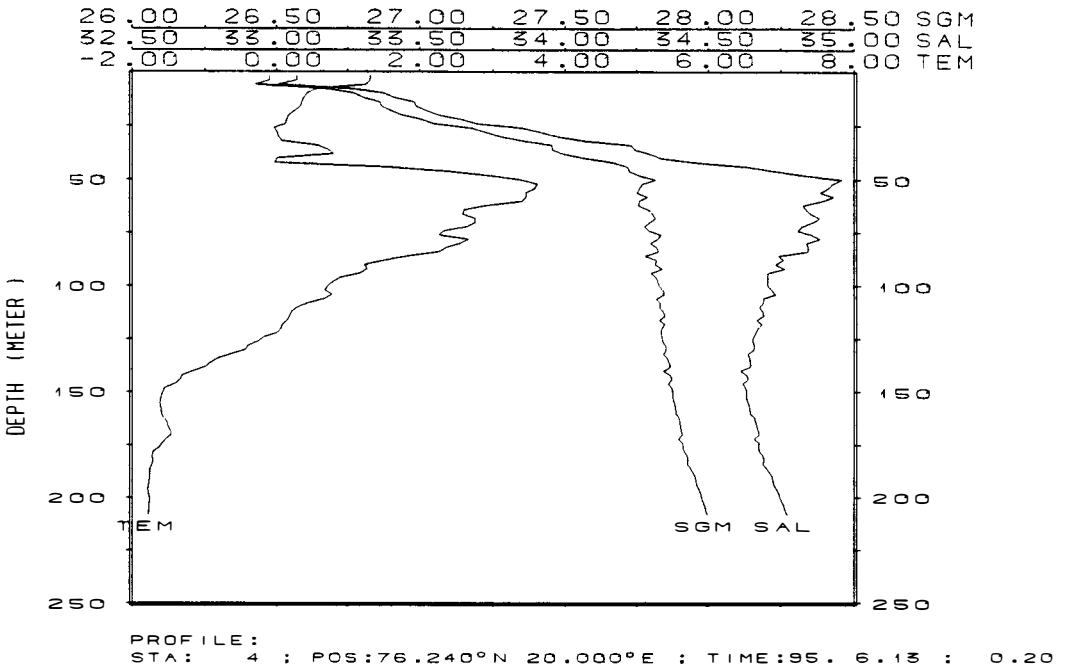
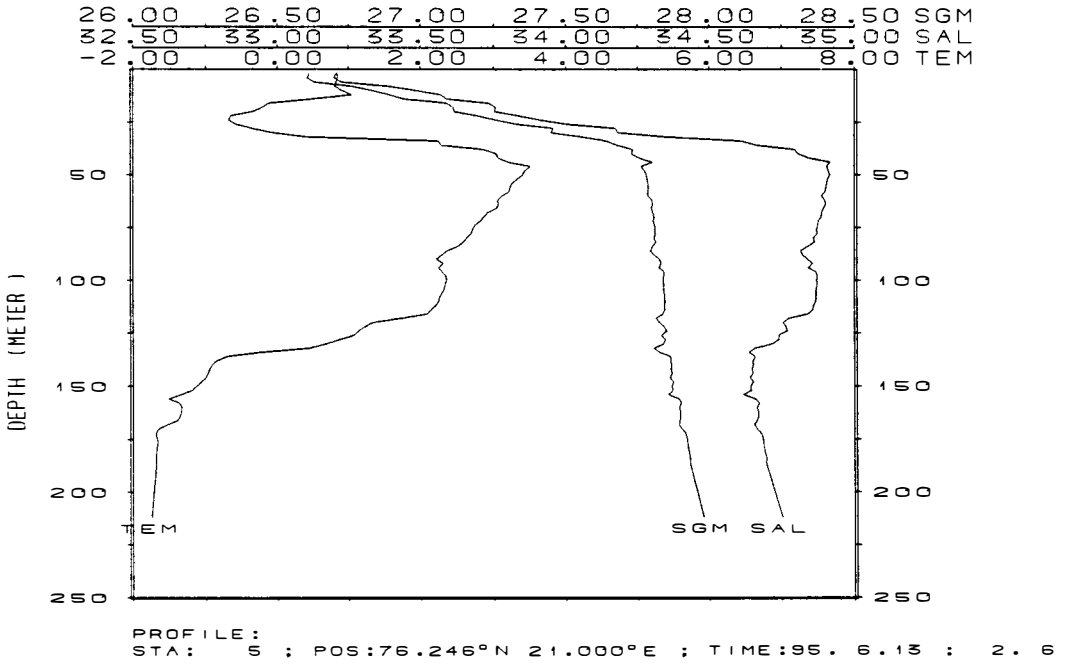


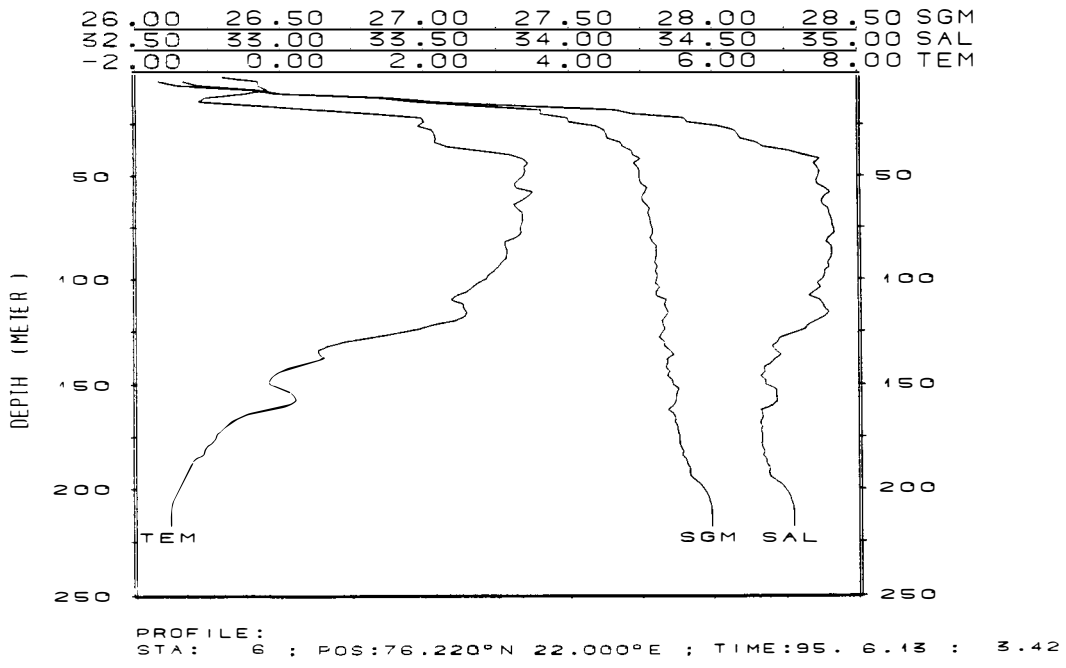
Fig 12. CTD stations 1, 2, 3. Vertical profiles of temperature, salinity and sigma-t



PROFILE:
STA: 4 ; POS:76.240°N 20.000°E ; TIME:95. 6.13 : 0.20

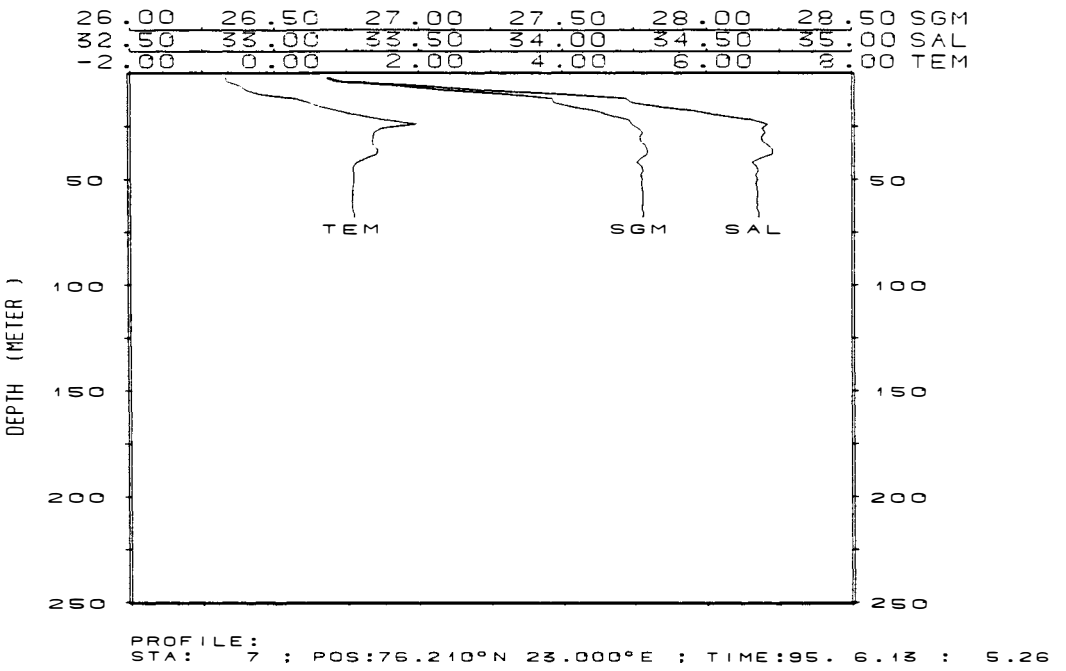


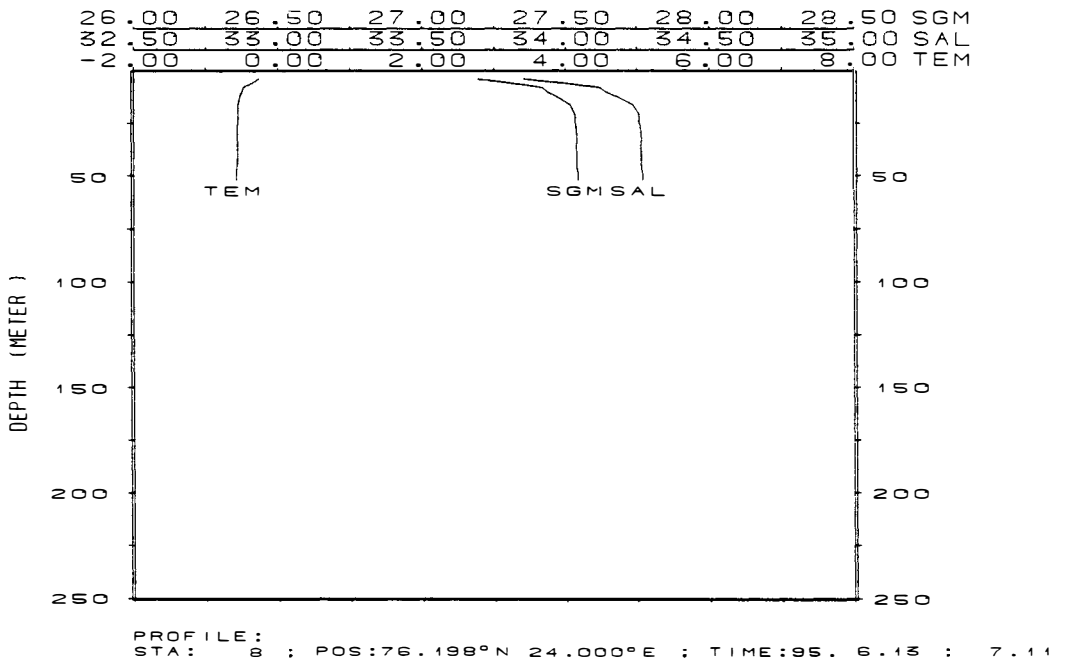
PROFILE:
STA: 5 ; POS:76.246°N 21.000°E ; TIME:95. 6.13 : 2. 6



PROFILE:
STA: 6 ; POS:76.220°N 22.000°E ; TIME:95. 6.13 : 3.42

Fig 13. CTD stations 4, 5, 6. Vertical profiles of temperature, salinity and sigma-t





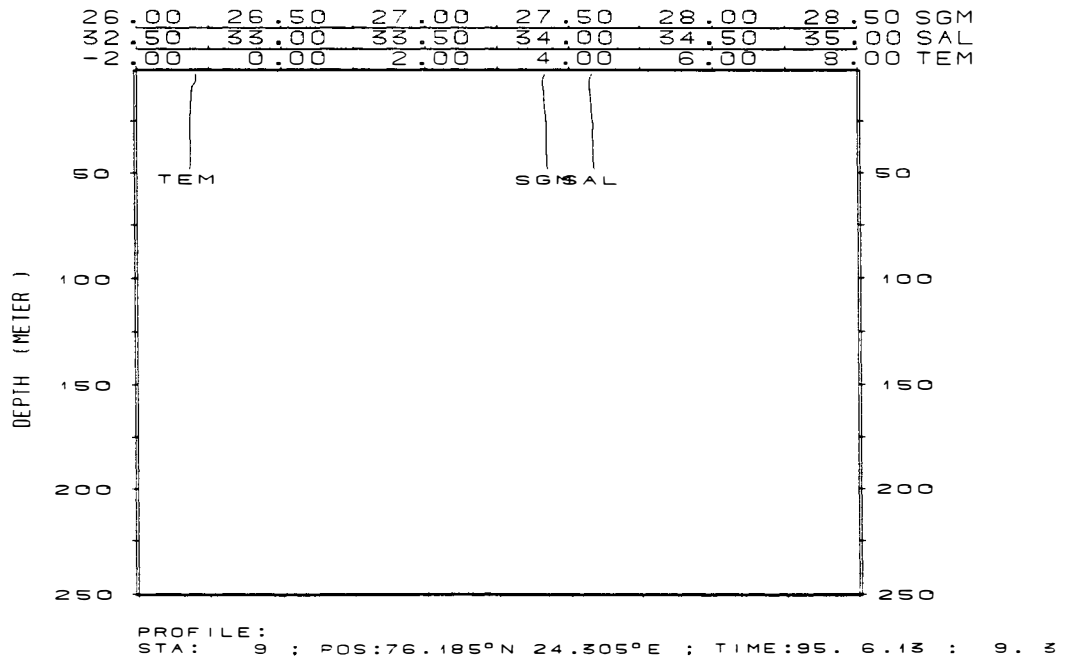


Fig 14. CTD stations 7, 8, 9. Vertical profiles of temperature, salinity and sigma-t

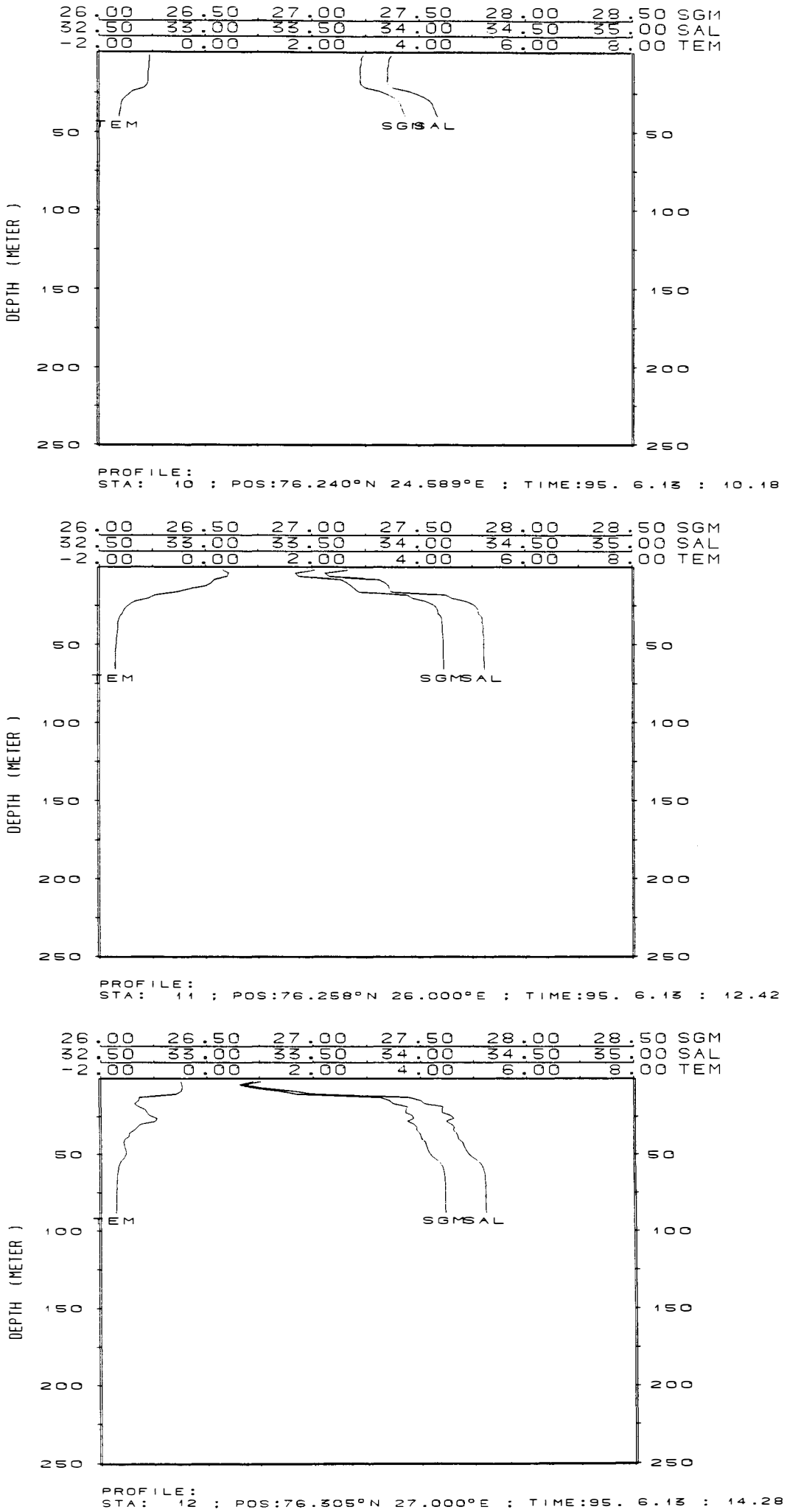


Fig 15. CTD stations 10, 11, 12. Vertical profiles of temperature, salinity and sigma-t

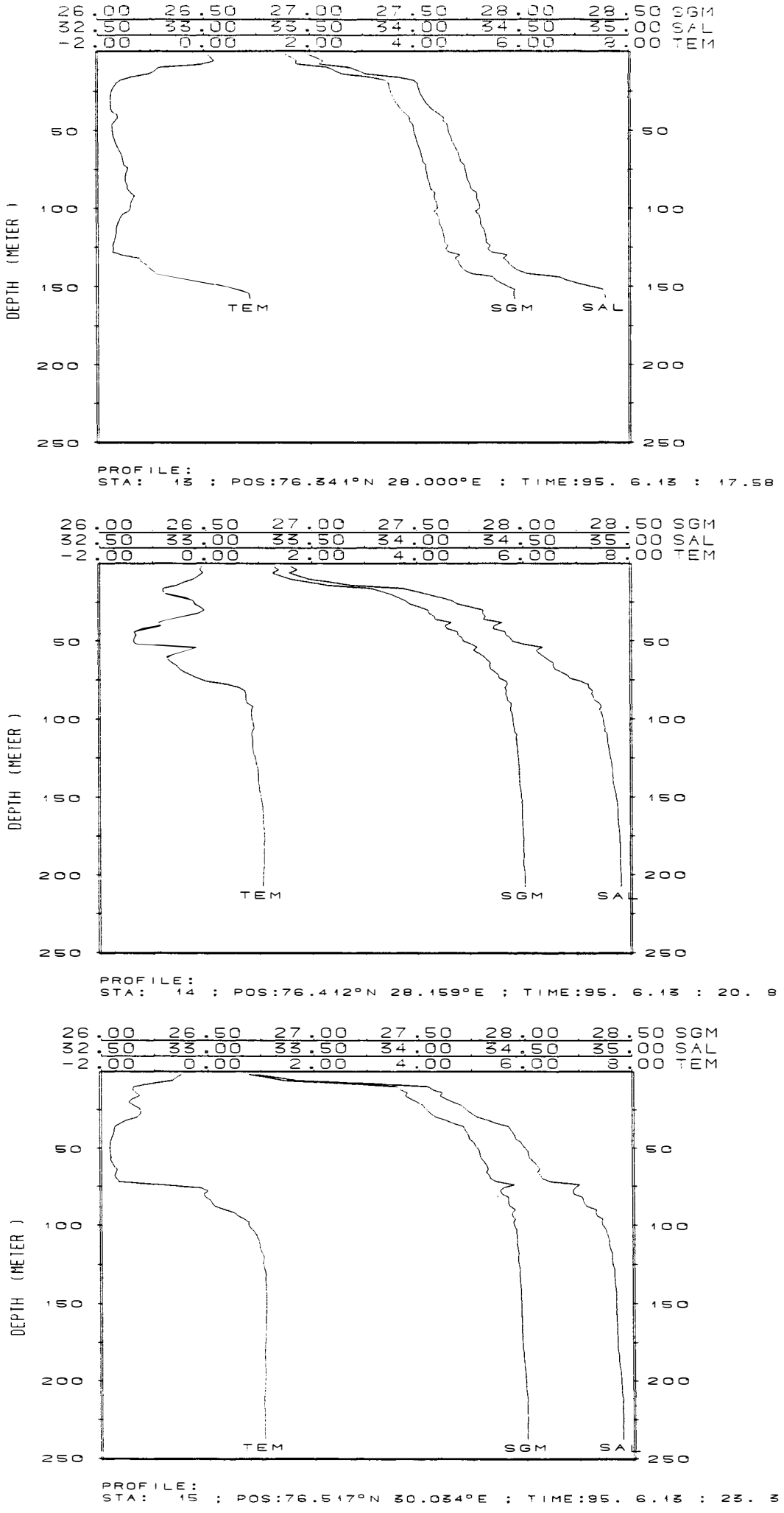


Fig 16. CTD stations 13, 14, 15. Vertical profiles of temperature, salinity and sigma-t

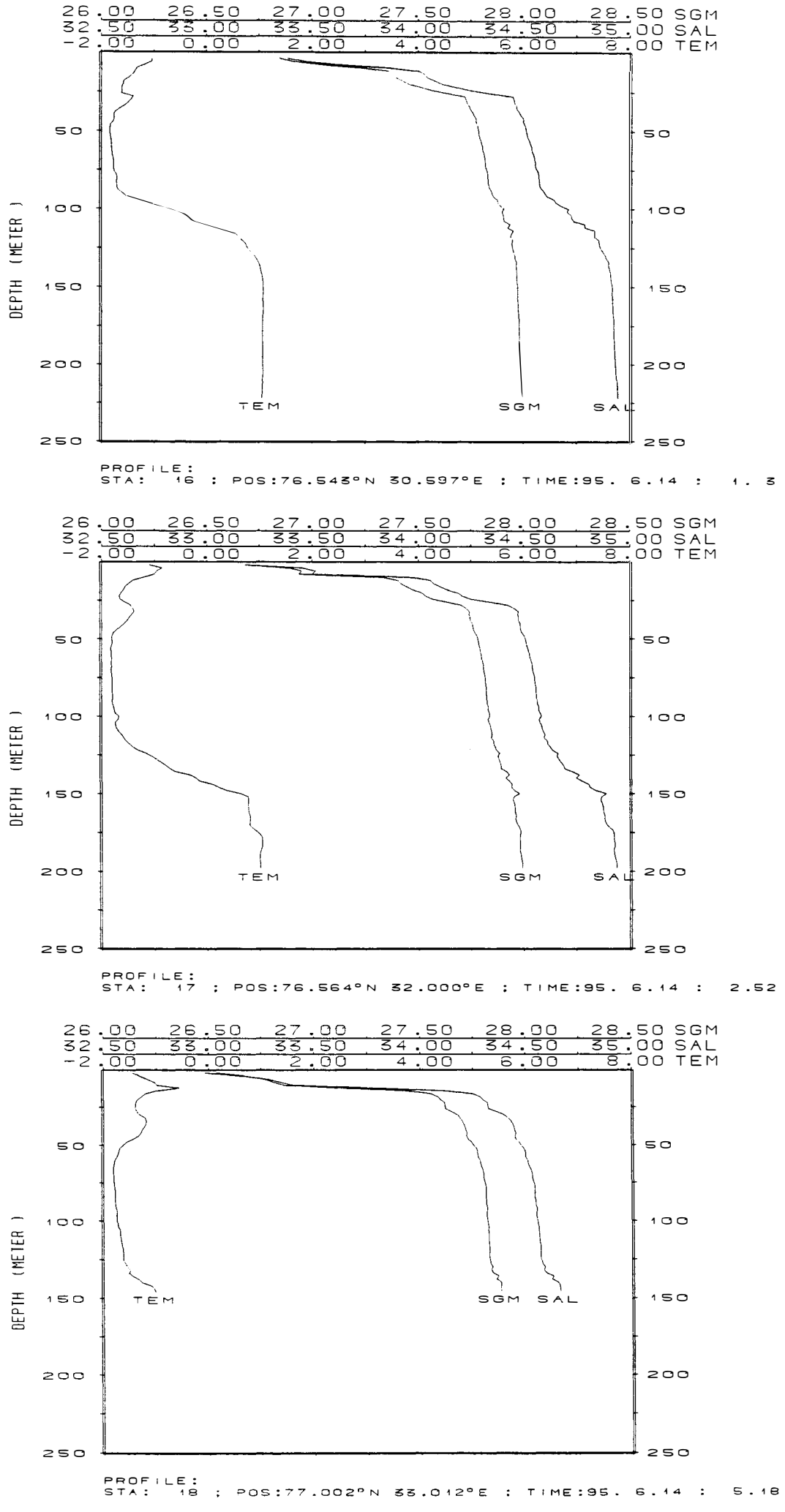
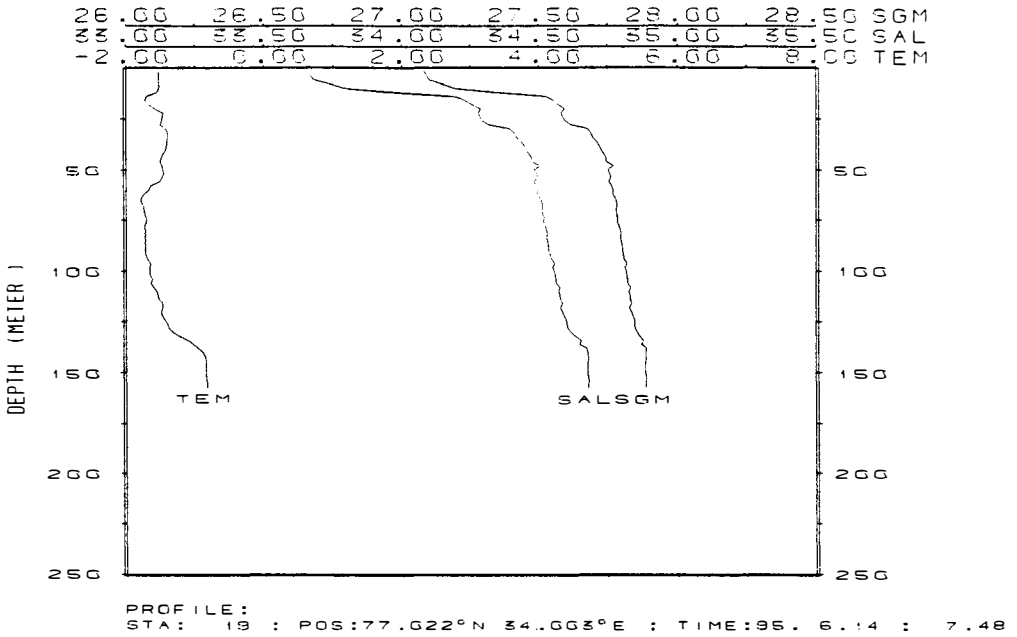
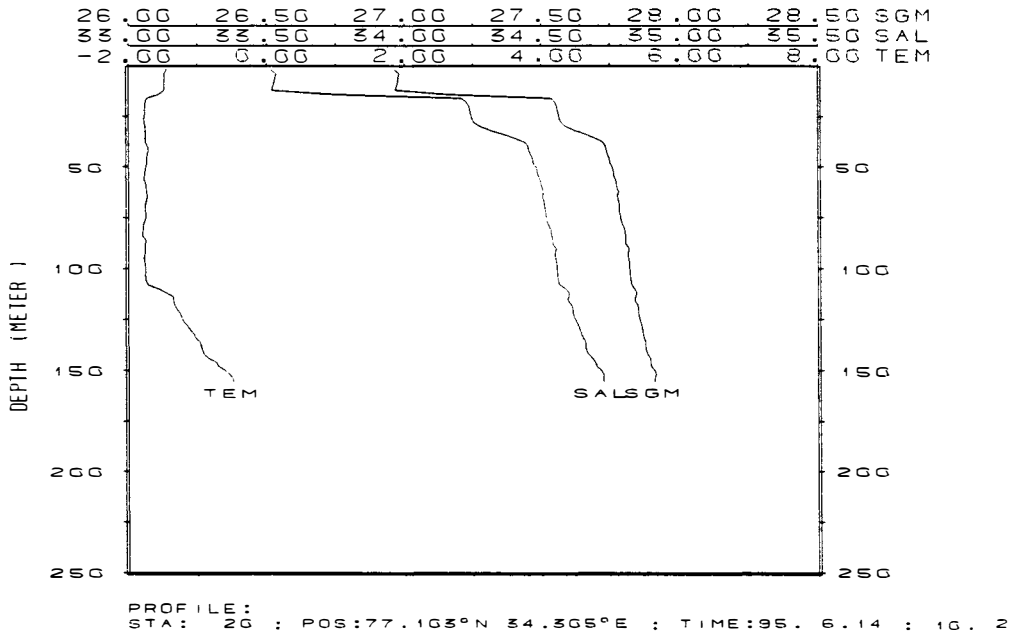


Fig 17. CTD stations 16, 17, 18. Vertical profiles of temperature, salinity and sigma-t





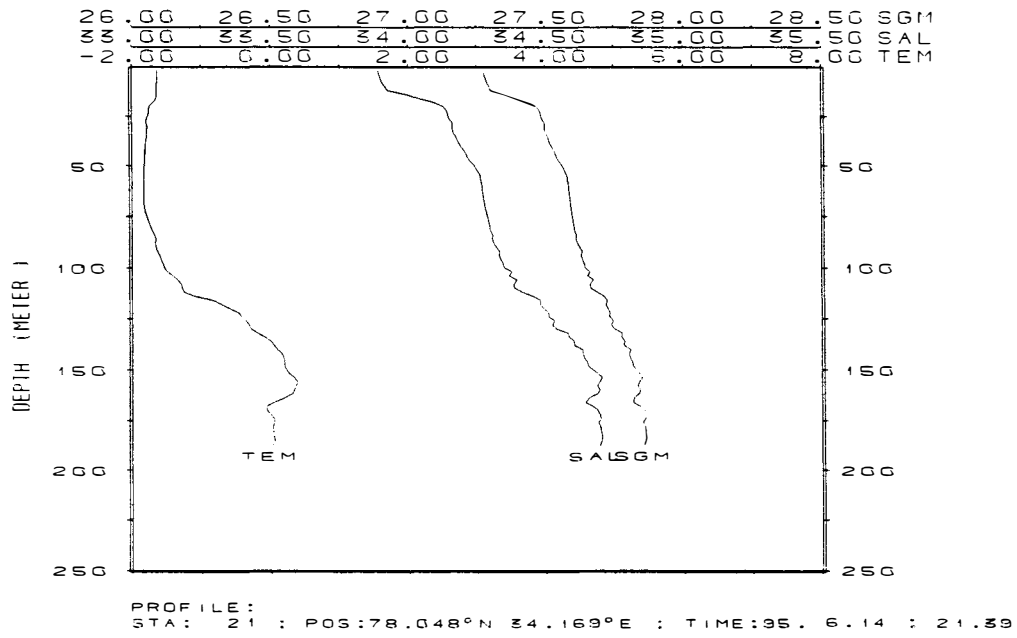


Fig 18. CTD stations 19, 20, 21. Vertical profiles of temperature, salinity and sigma-t

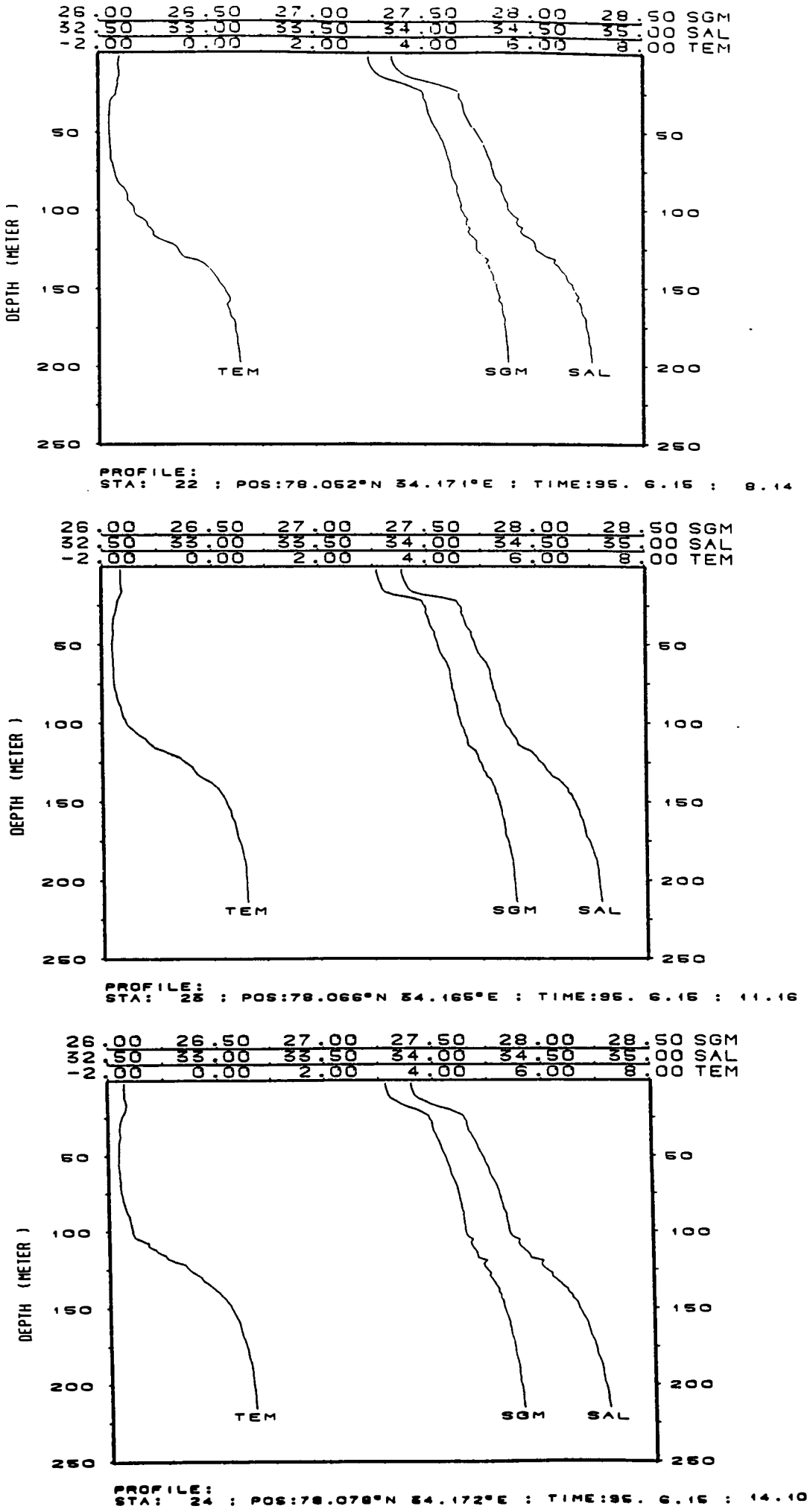
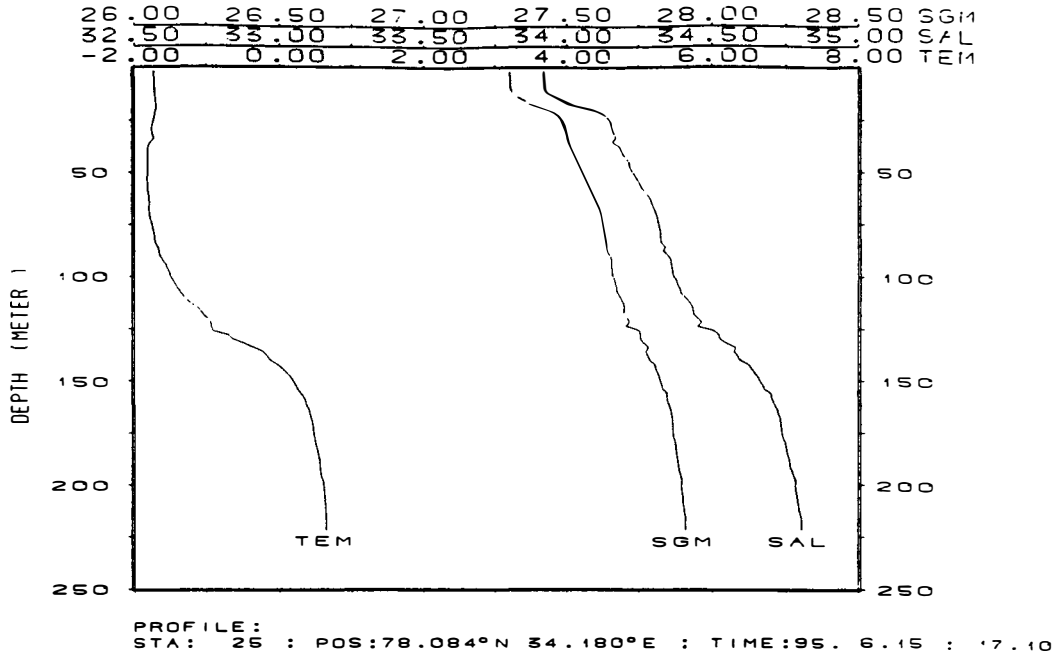
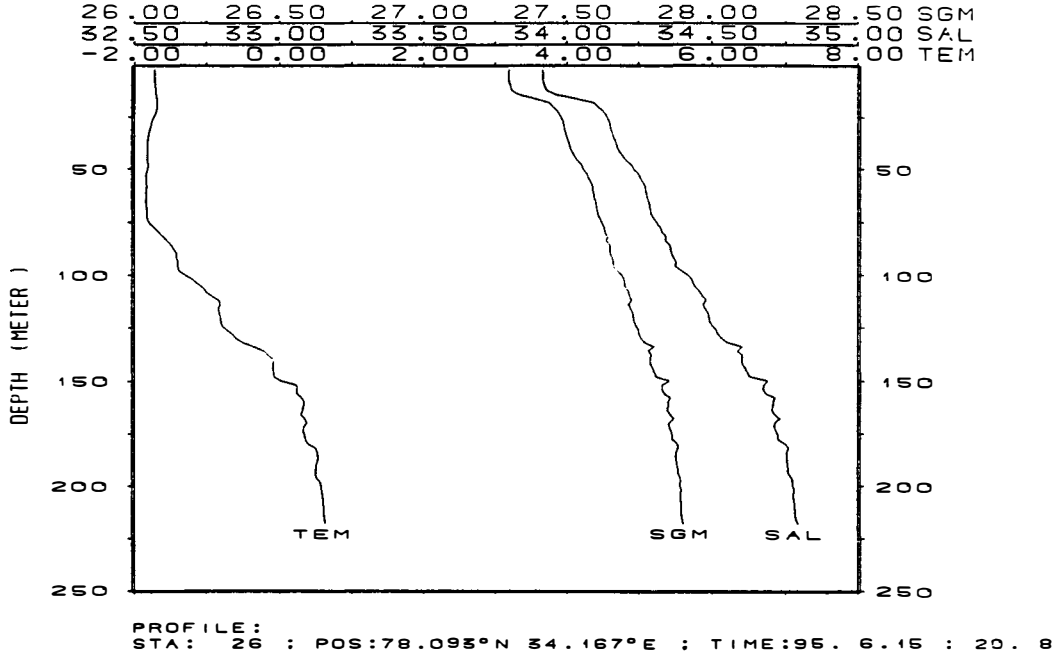


Fig 19. CTD stations 22, 23, 24. Vertical profiles of temperature, salinity and sigma-t





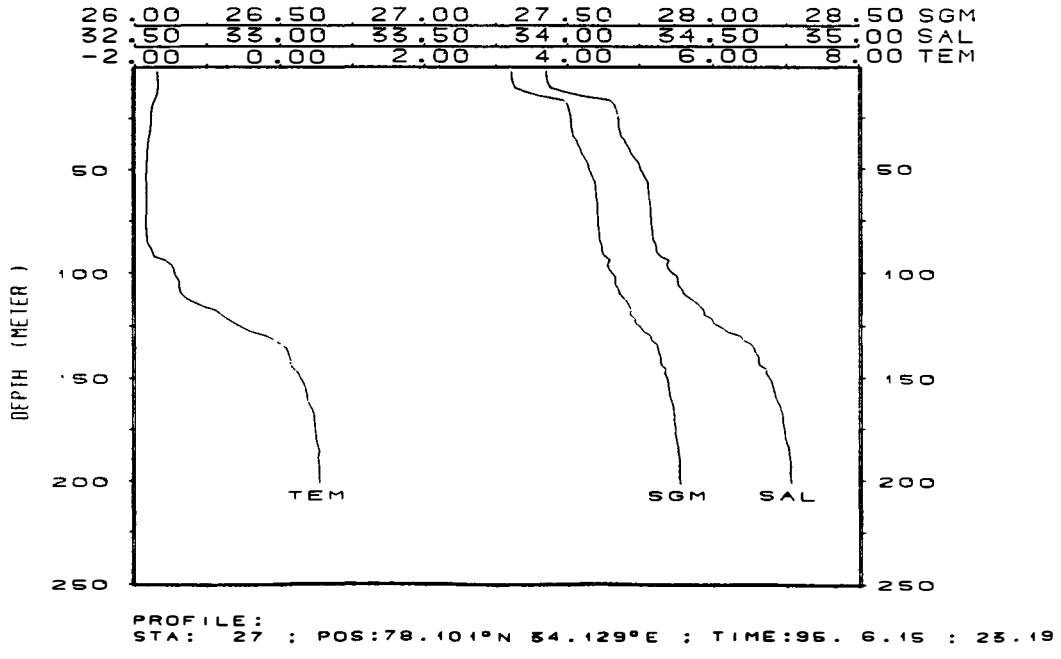
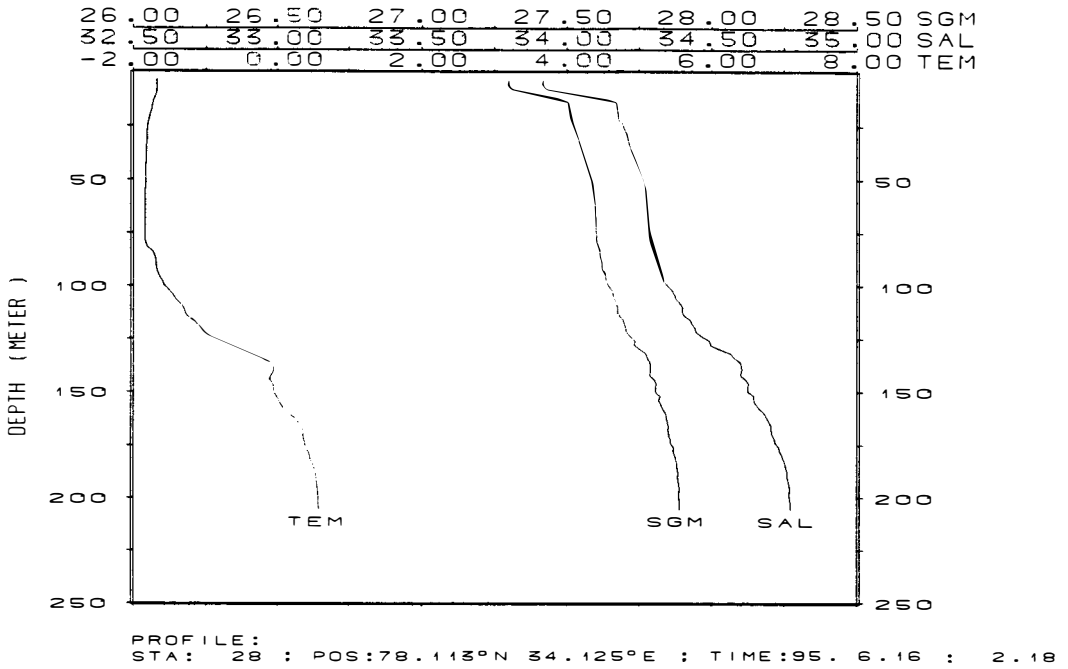
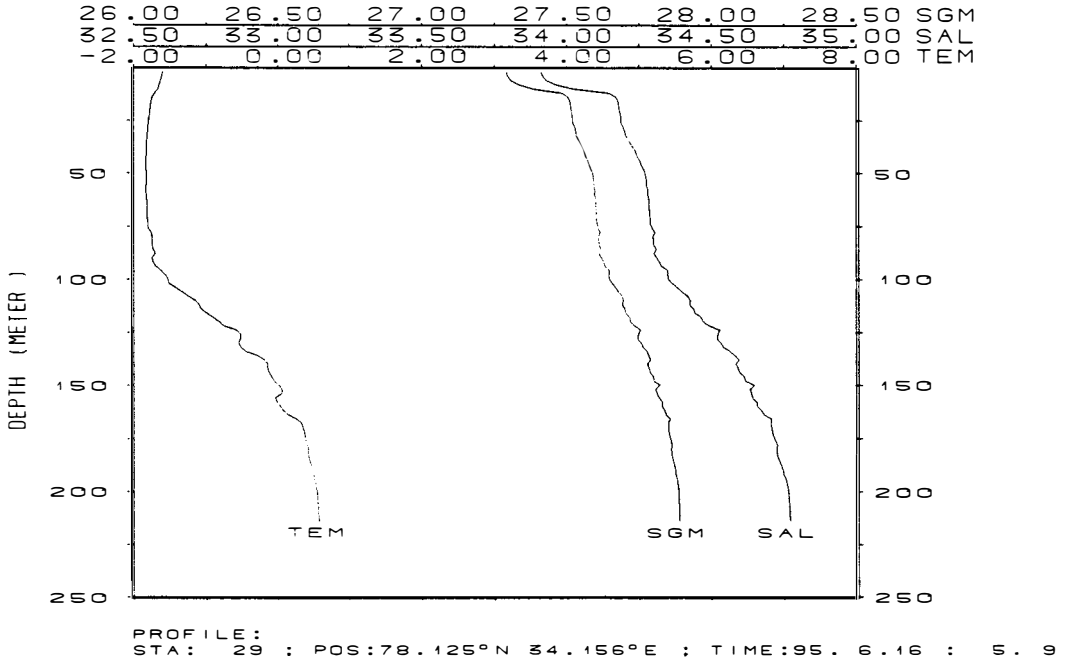


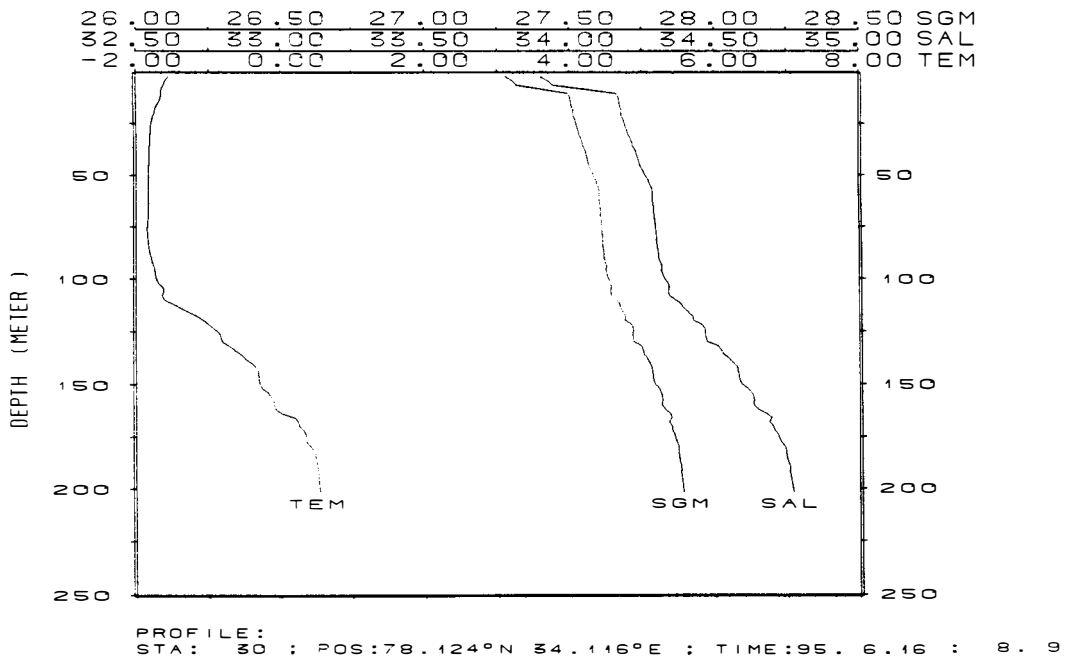
Fig 20. CTD stations 25, 26, 27. Vertical profiles of temperature, salinity and sigma-t



PROFILE:
STA: 28 : POS:78.113°N 34.125°E : TIME:95. 6.16 : 2.18



PROFILE:
STA: 29 : POS:78.125°N 34.156°E : TIME:95. 6.16 : 5. 9



PROFILE:
STA: 30 : POS:78.124°N 34.116°E : TIME:95. 6.16 : 8. 9

Fig 21. CTD stations 28. 29, 30. Vertical profiles of temperature. salinity and sigma-t

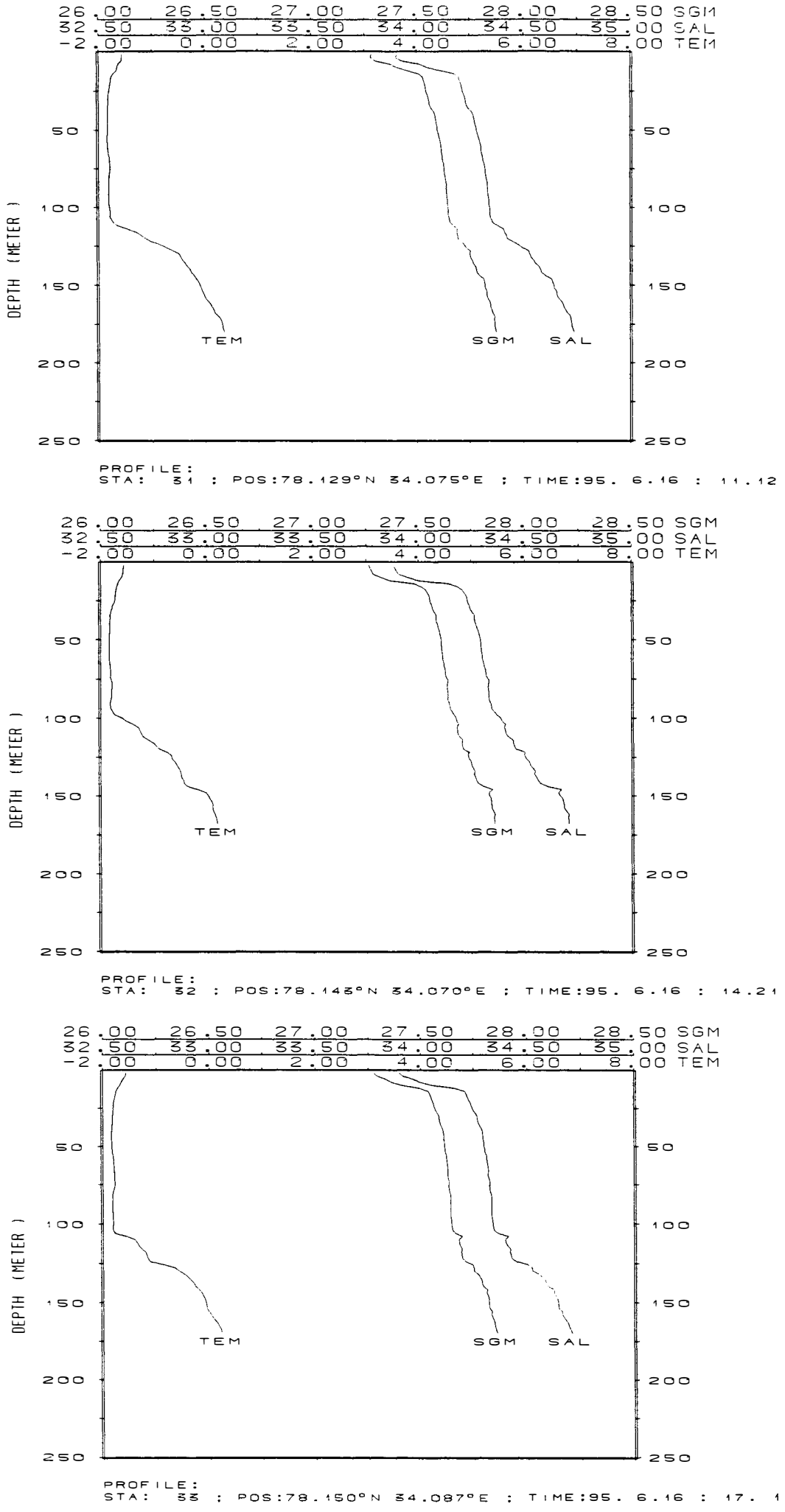


Fig 22. CTD stations 31, 32, 33. Vertical profiles of temperature, salinity and sigma-t

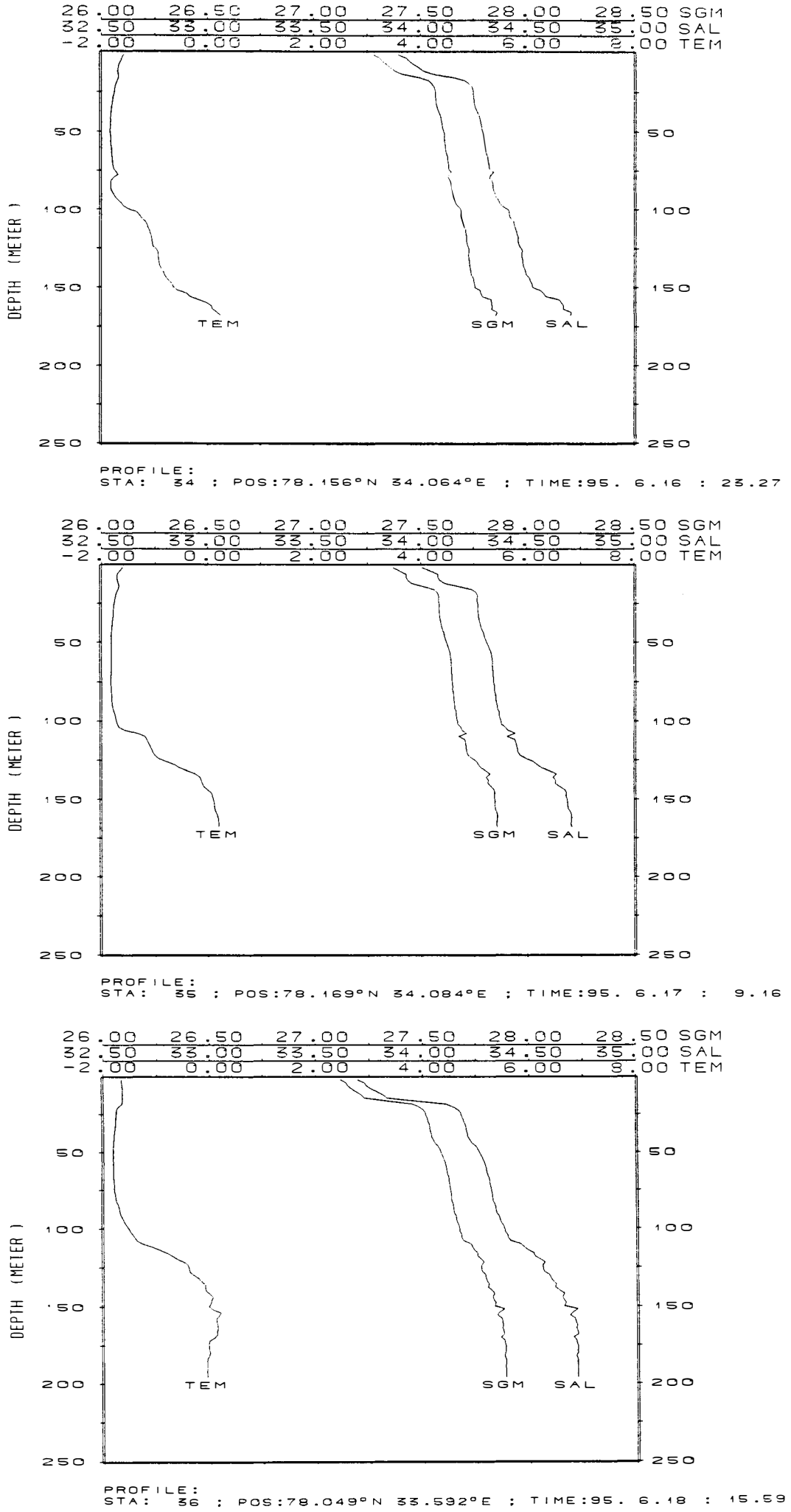


Fig 23. CTD stations 34, 35, 36. Vertical profiles of temperature, salinity and sigma-t

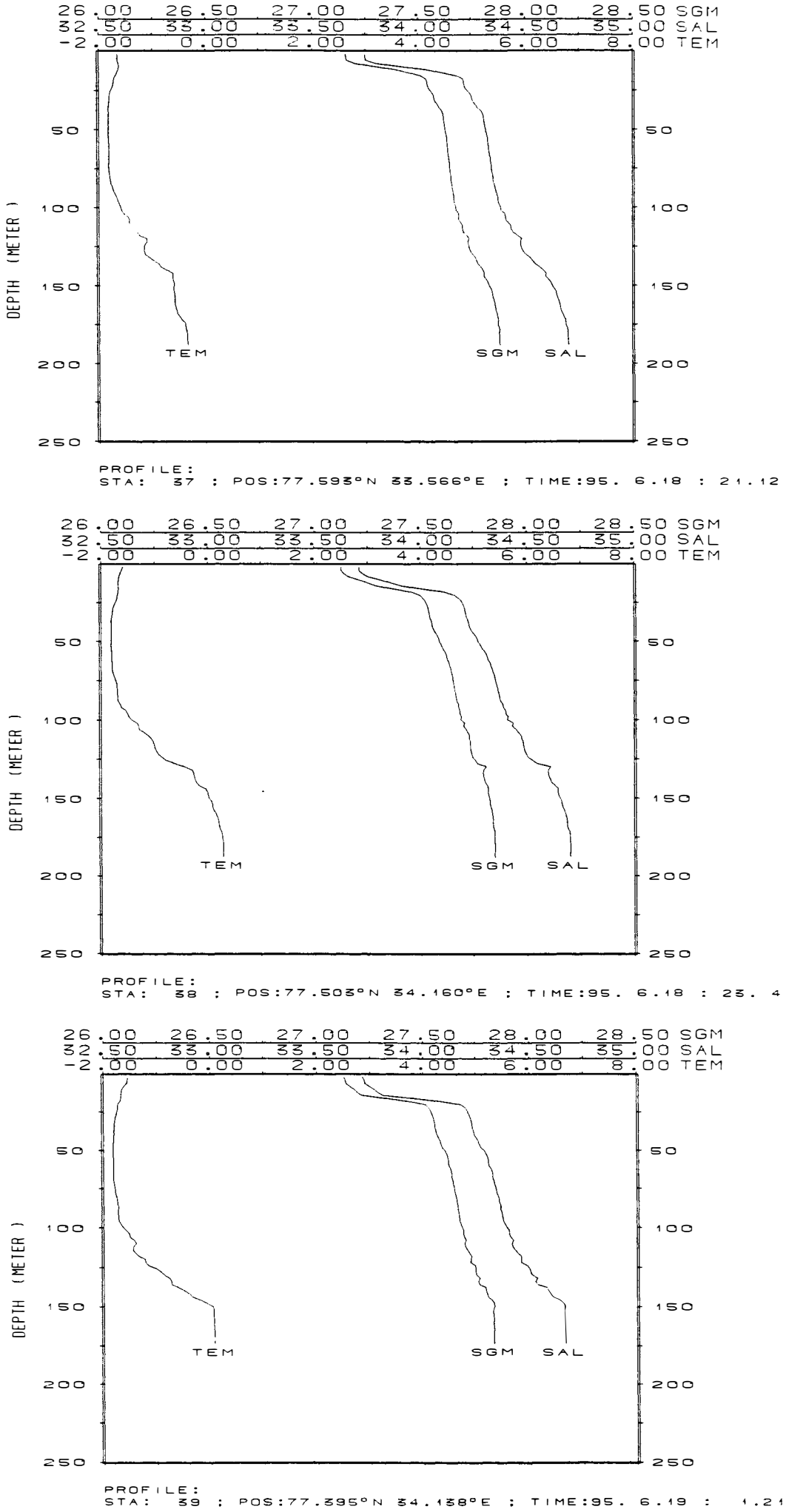


Fig 24. CTD stations 37, 38, 39. Vertical profiles of temperature, salinity and sigma-t

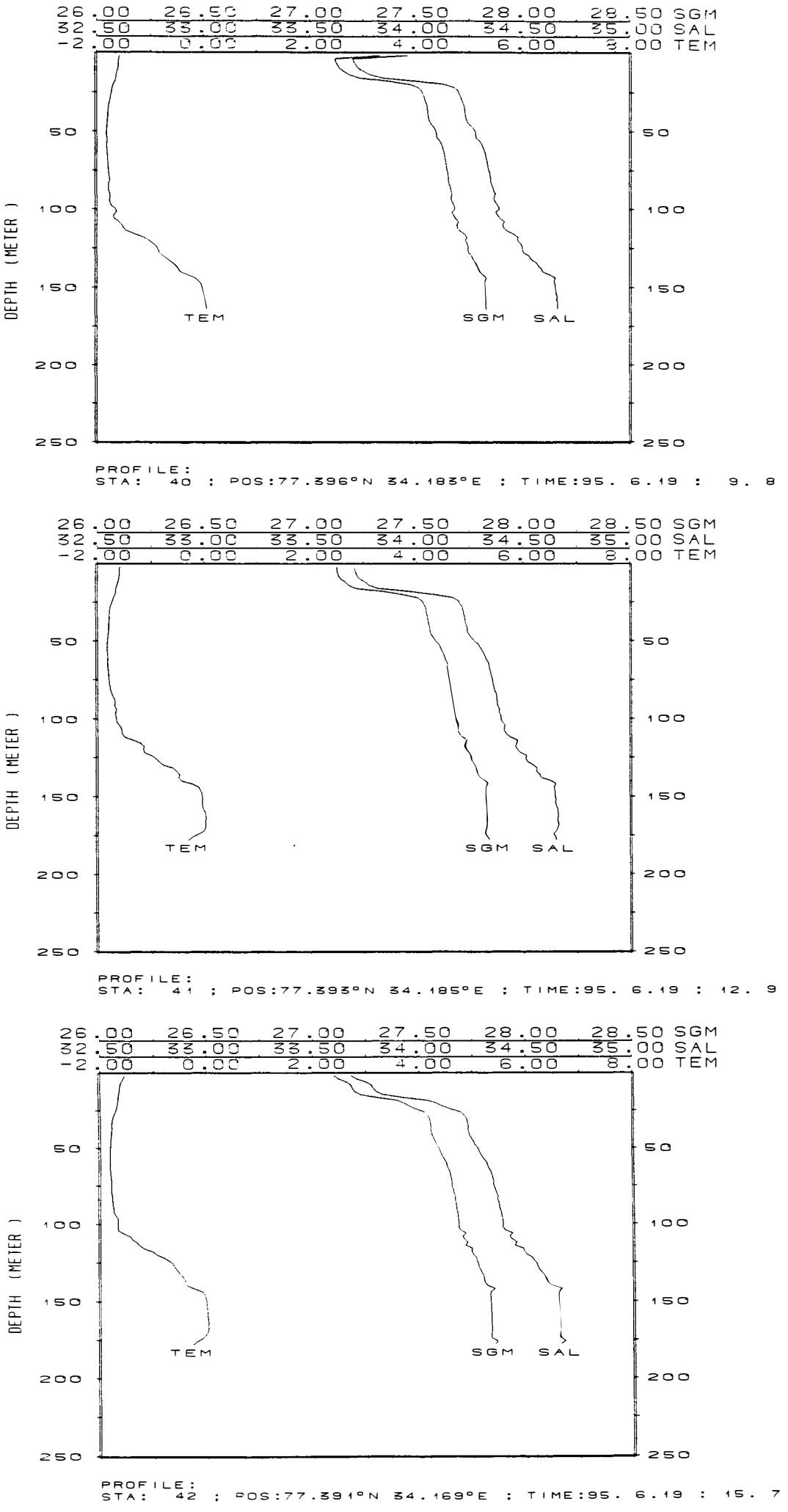
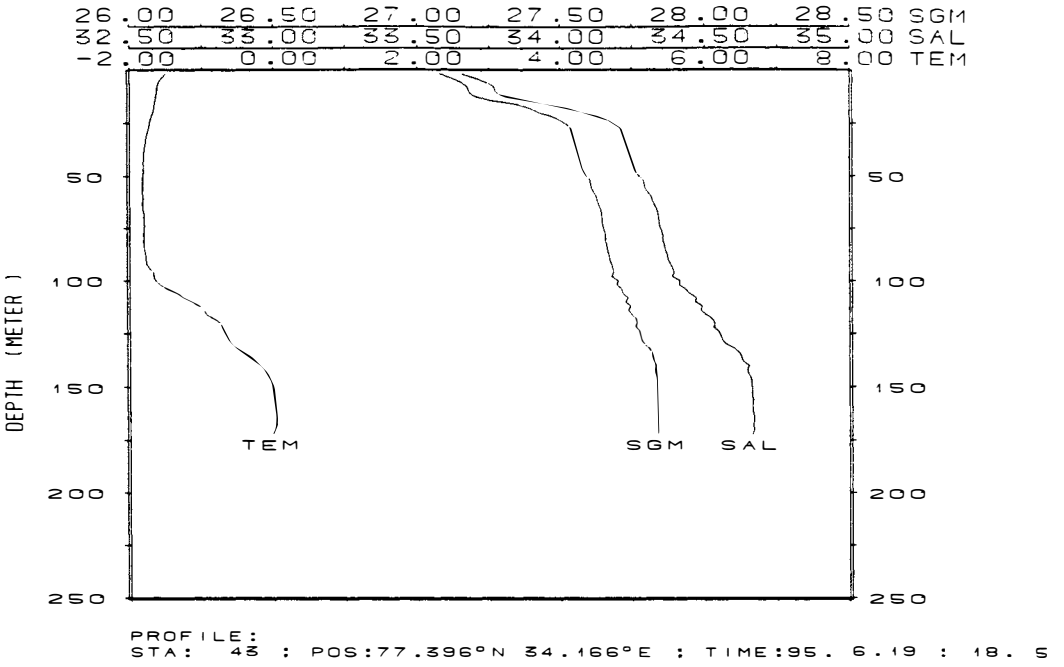
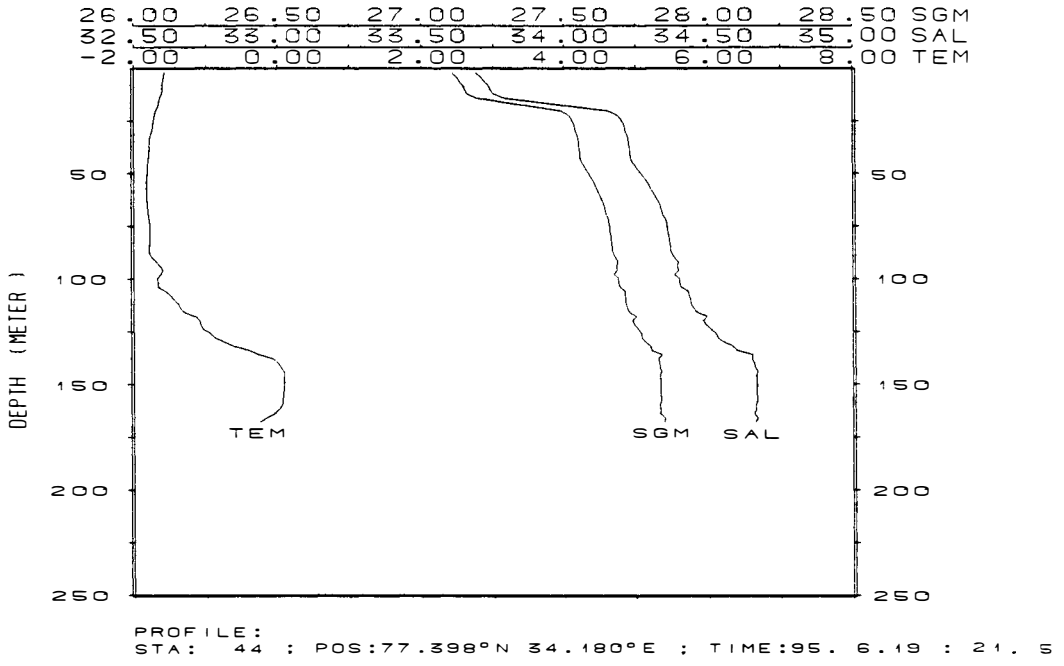


Fig 25. CTD stations 40, 41, 42. Vertical profiles of temperature, salinity and sigma-t





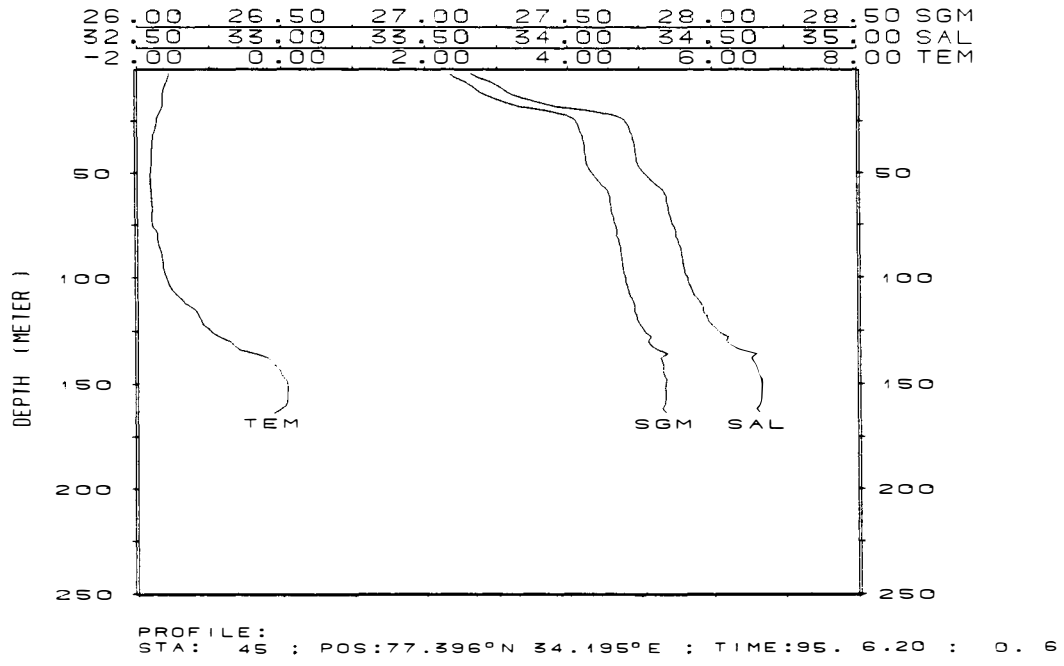
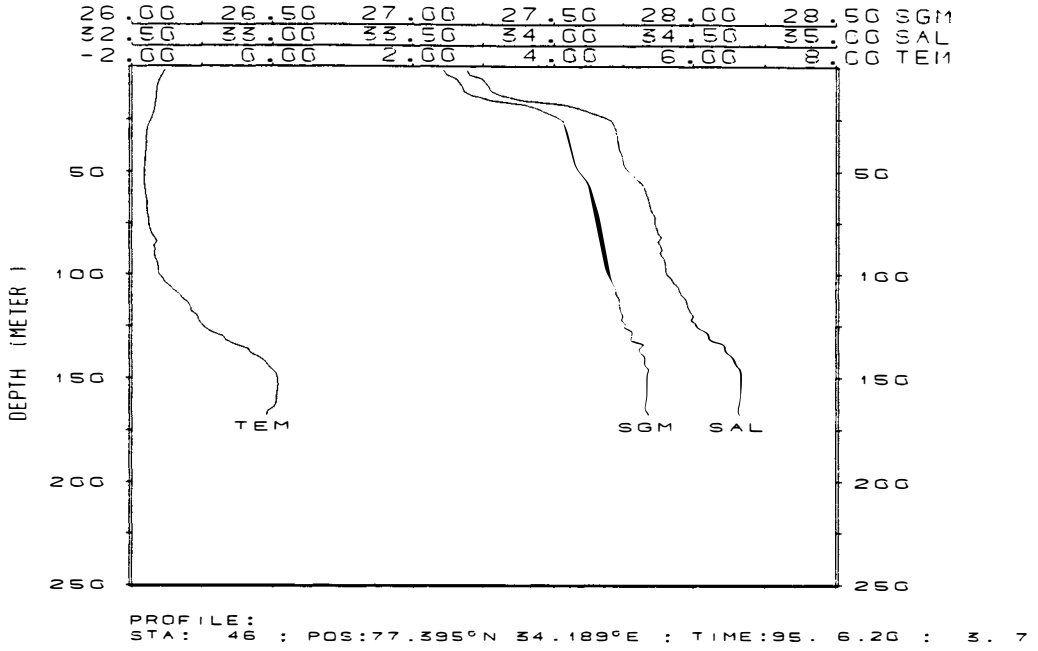
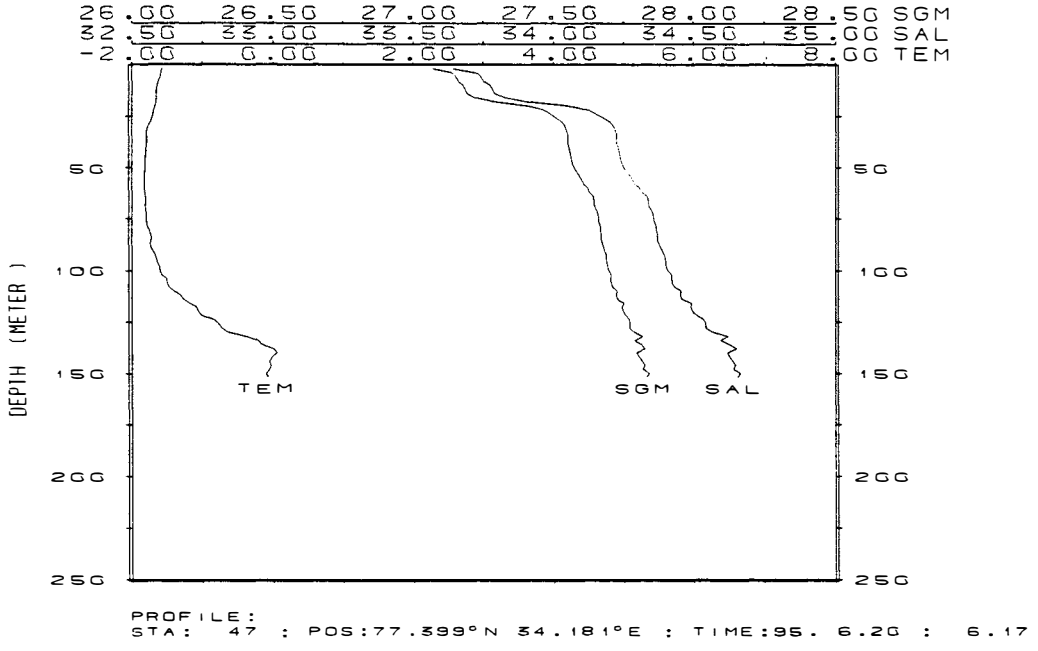


Fig 26. CTD stations 43, 44, 45. Vertical profiles of temperature, salinity and sigma-t





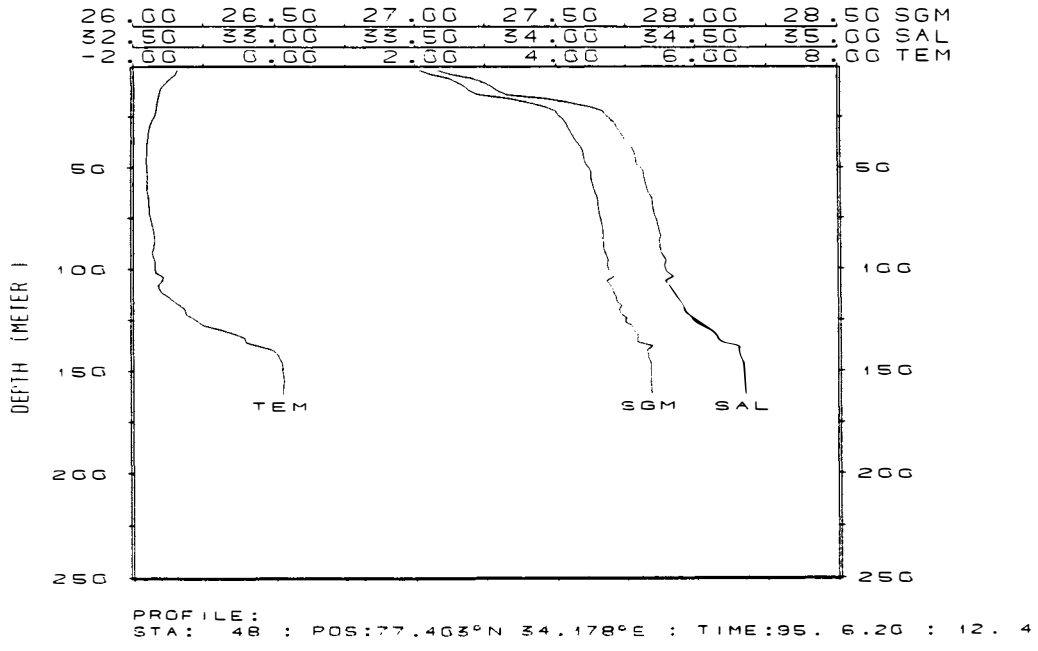
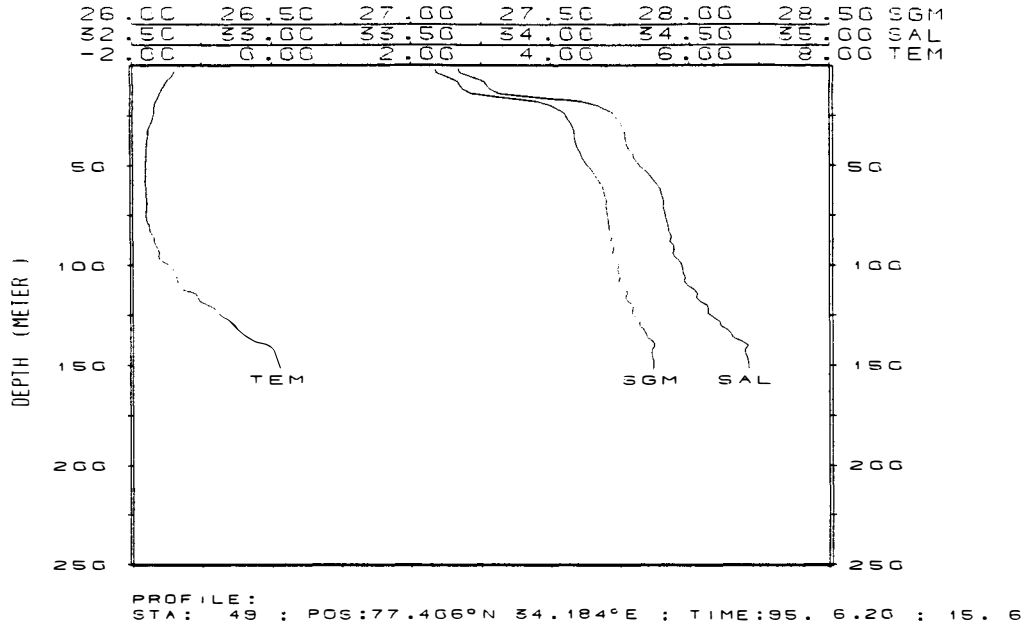
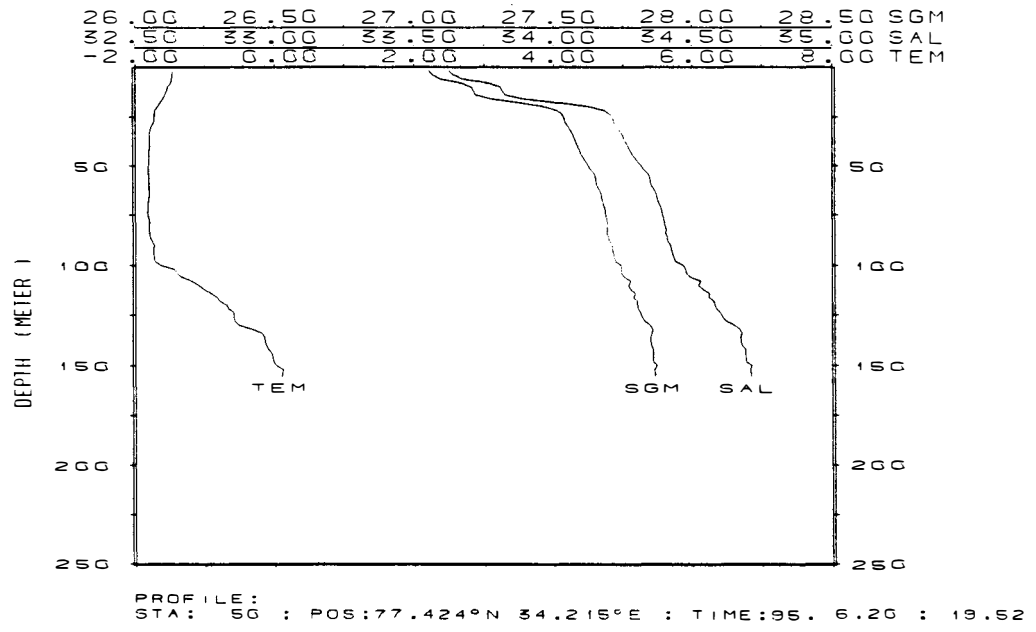


Fig 27. CTD stations 46, 47, 48. Vertical profiles of temperature, salinity an[illegible]gma-t





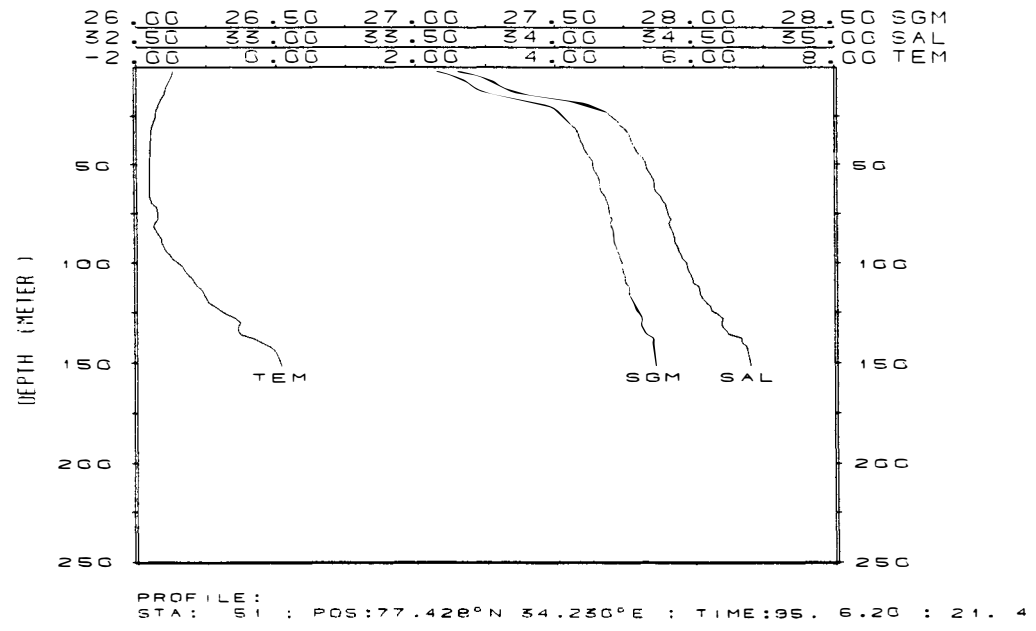
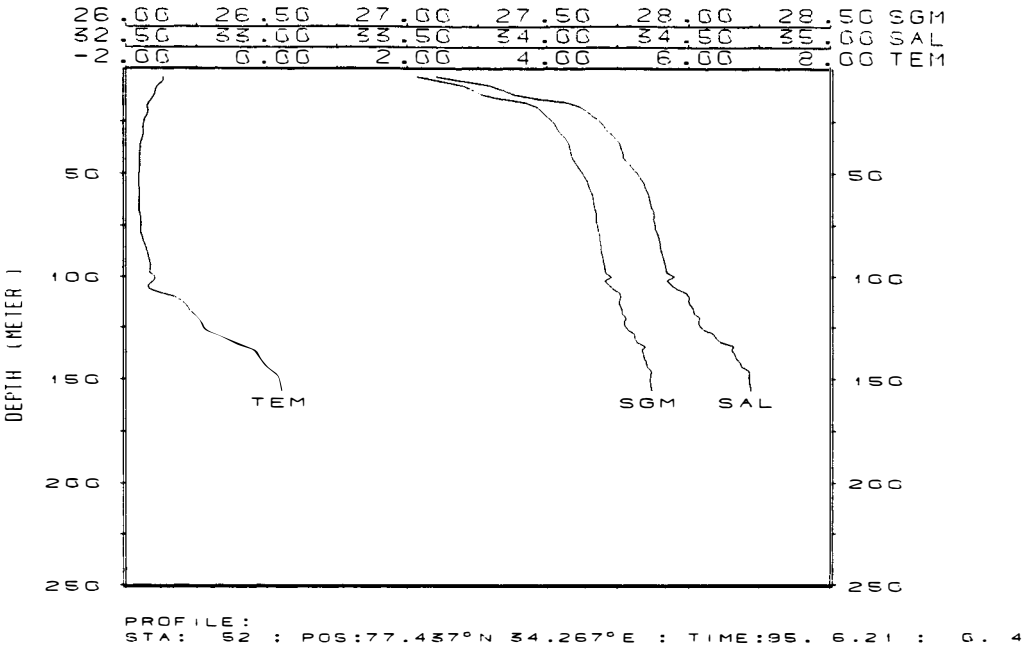
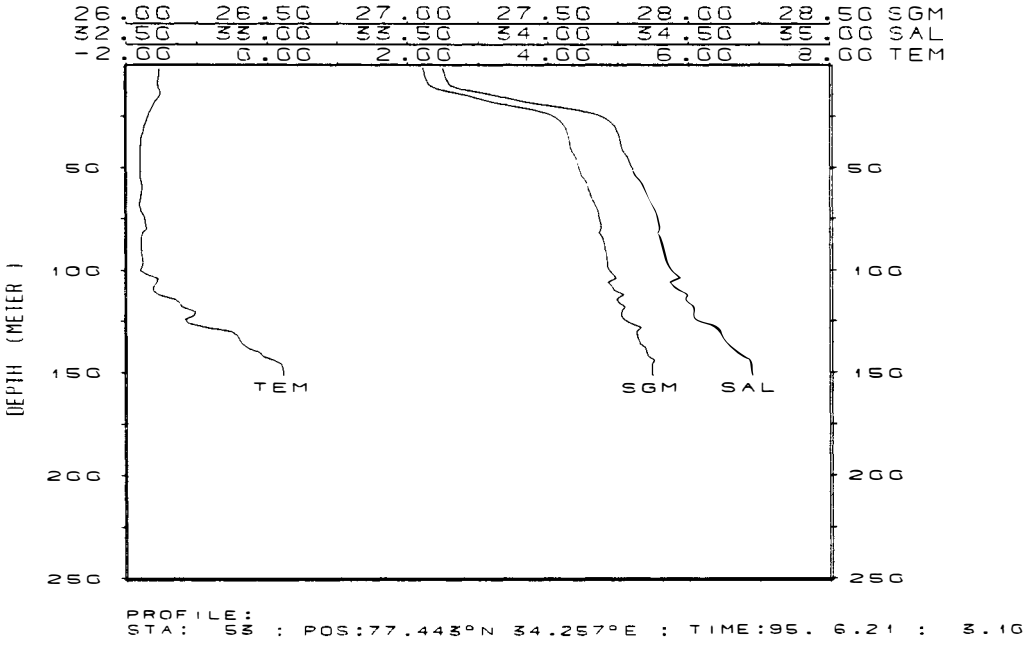


Fig 28. CTD stations 49, 50, 51. Vertical profiles of temperature, salinity and sigma-t





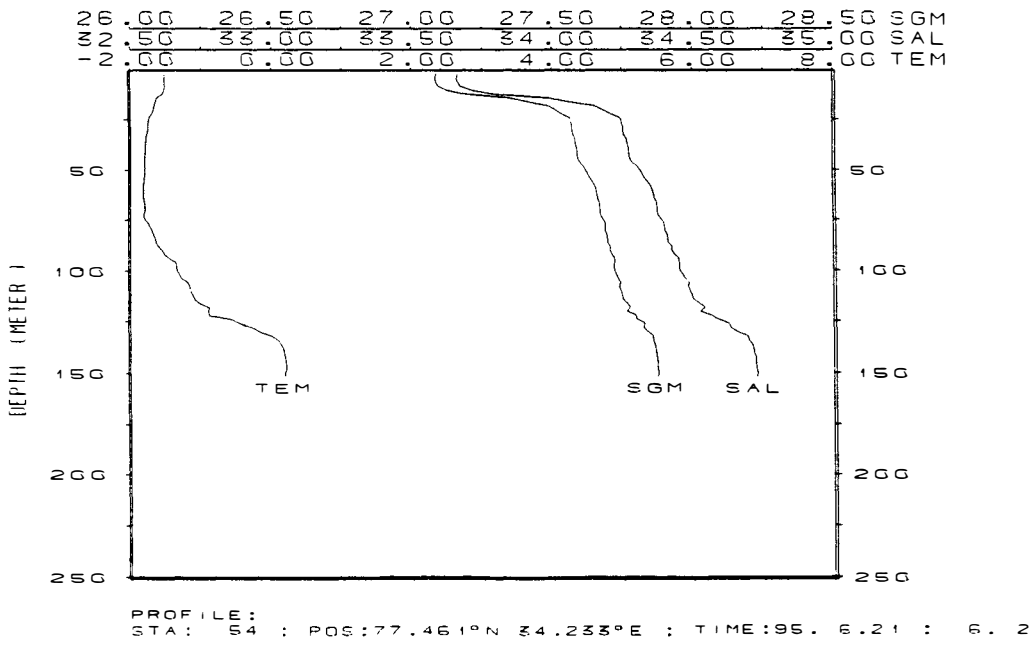
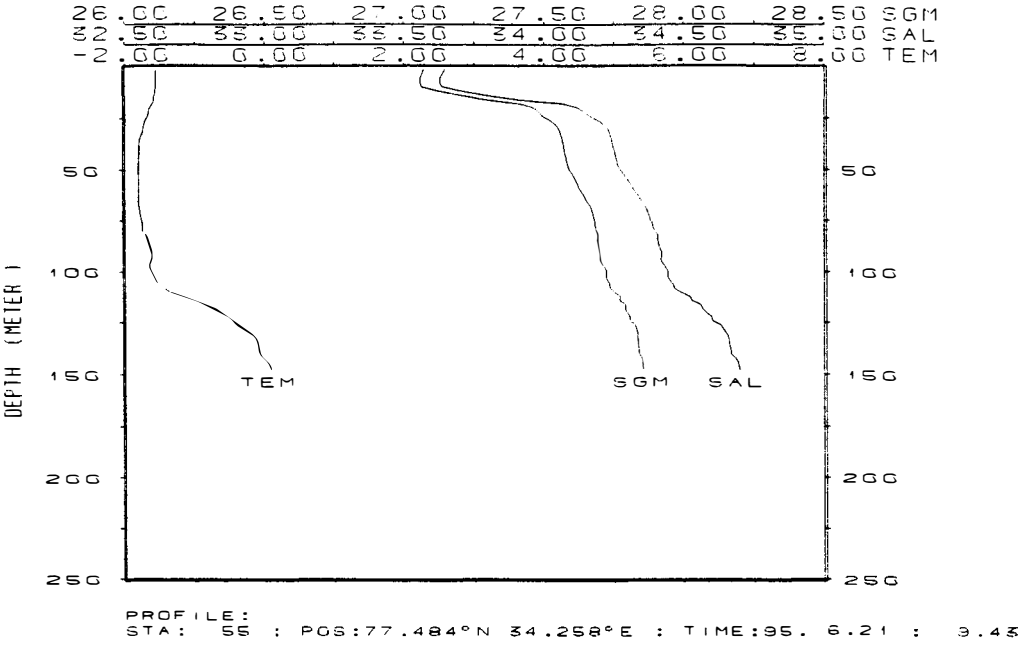
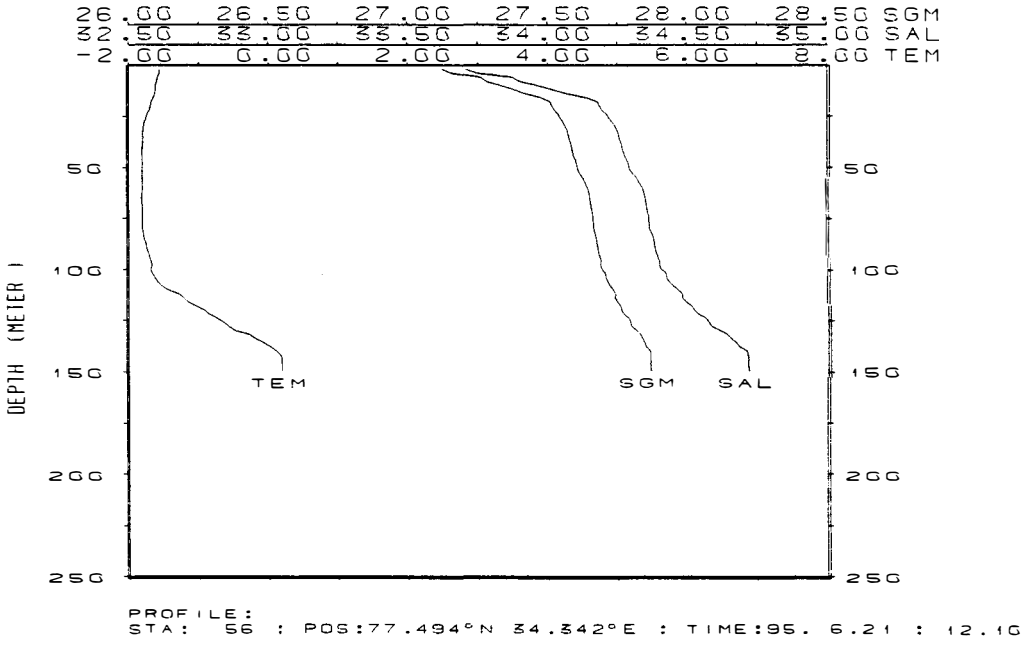


Fig 29. CTD stations 52, 53, 54. Vertical profiles of temperature, salinity and sigma-t





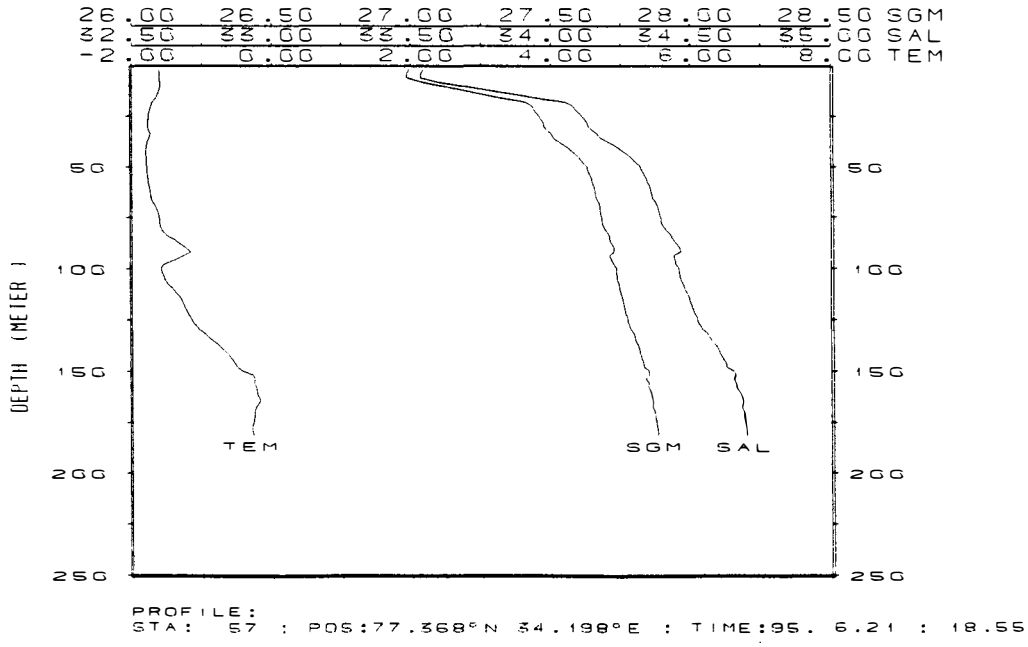
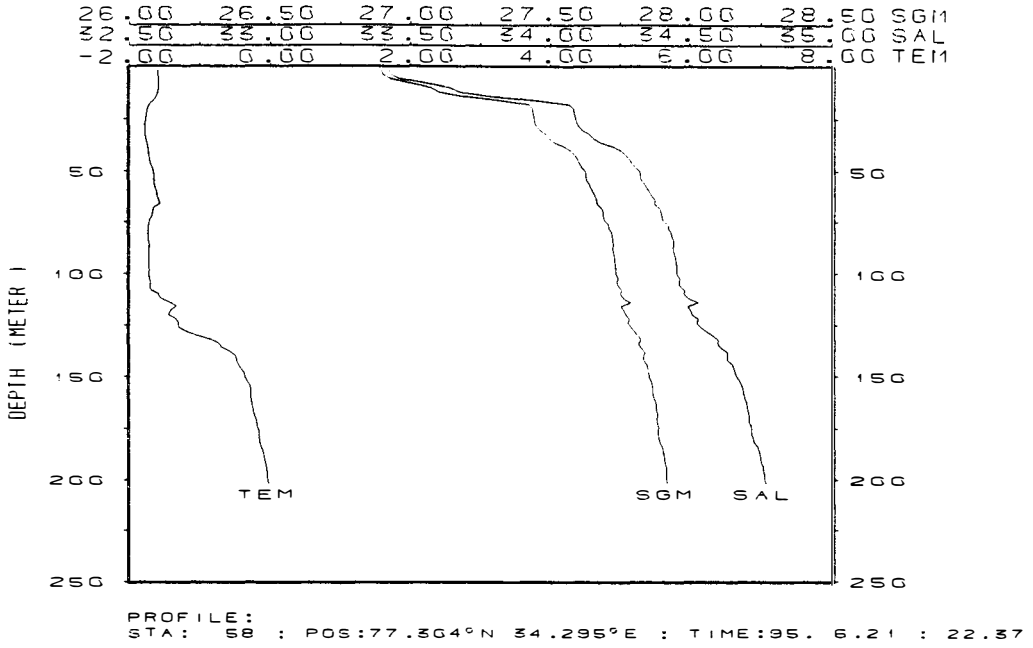
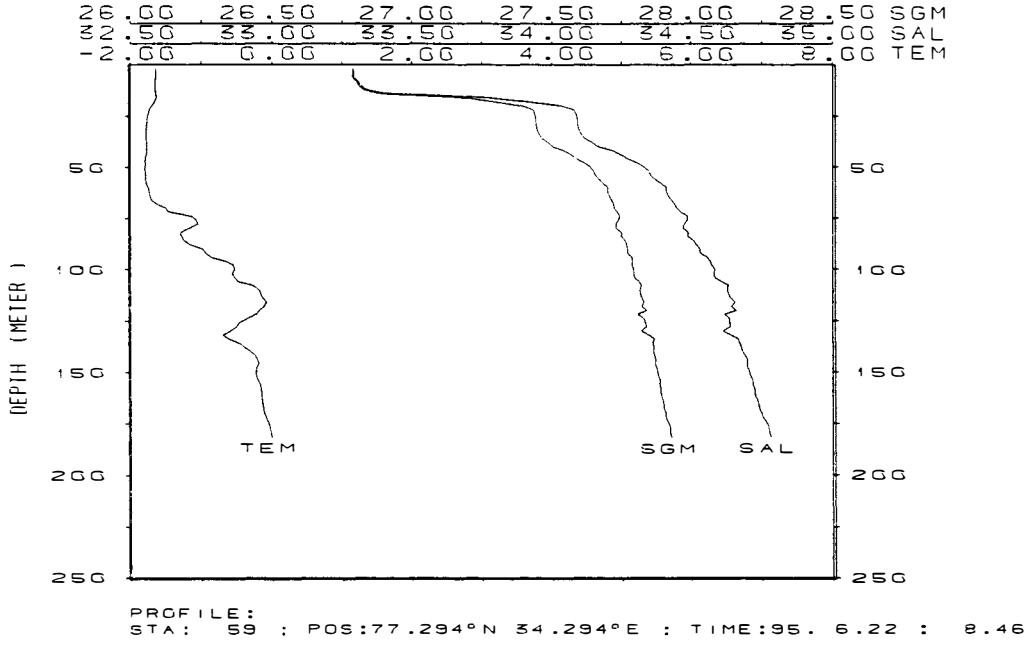


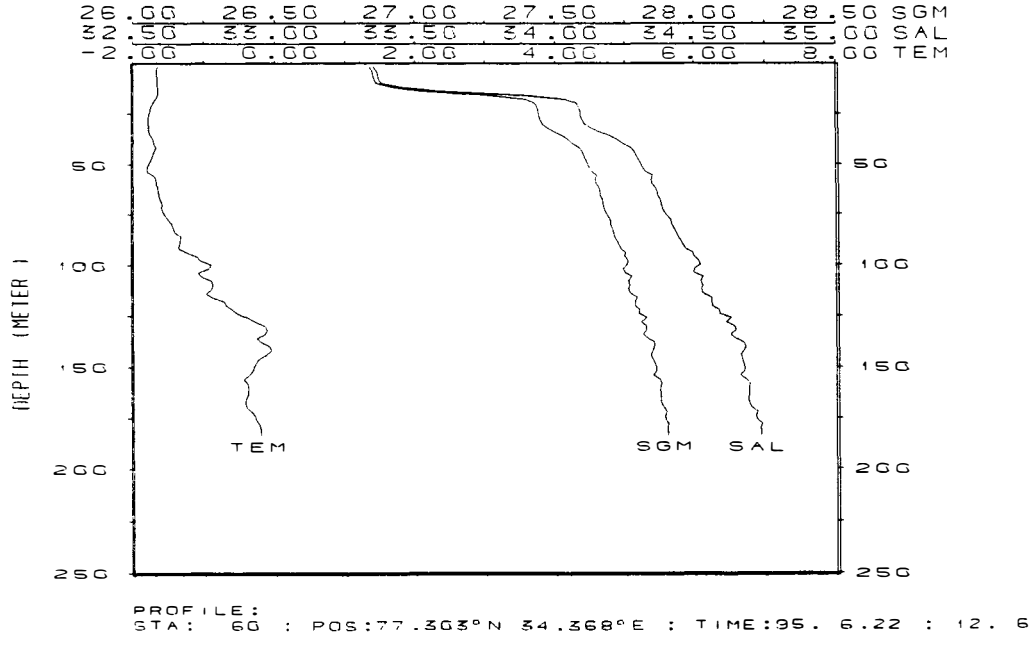
Fig 30. CTD stations 55, 56, 57. Vertical profiles of temperature, salinity and sigma-t



PROFILE:
STA: 58 : POS:77.304°N 34.295°E : TIME:95. 6.21 : 22.37

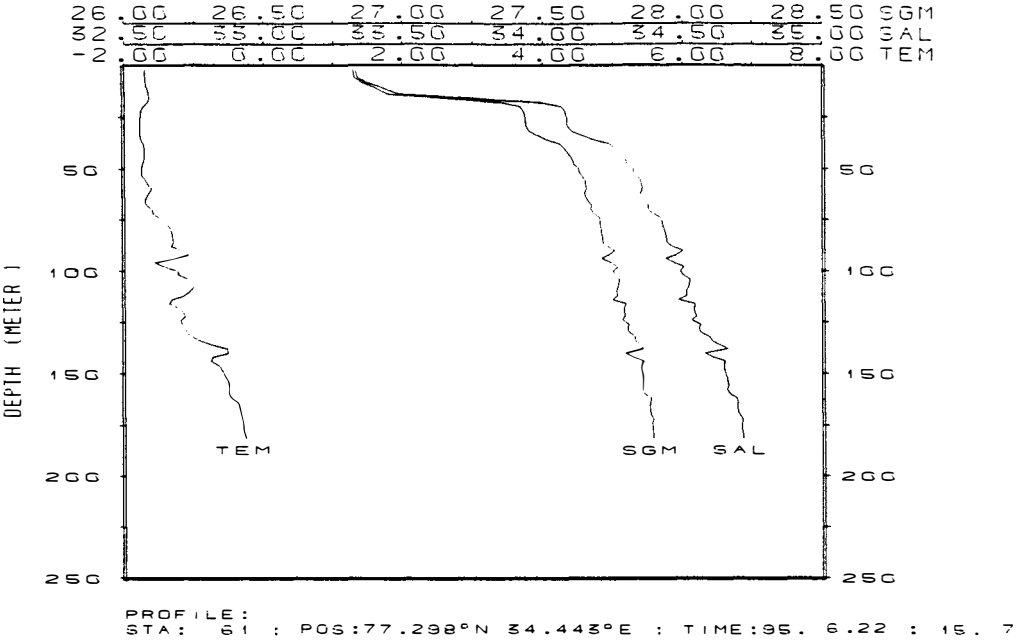


PROFILE:
STA: 59 : POS:77.294°N 34.294°E : TIME:95. 6.22 : 8.46

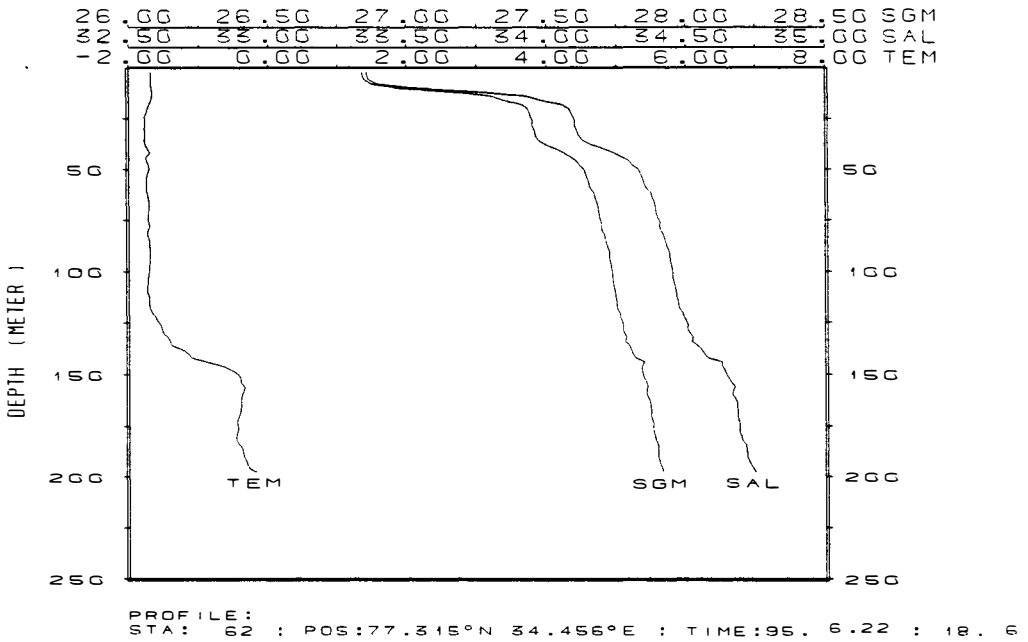


PROFILE:
STA: 60 : POS:77.303°N 34.368°E : TIME:95. 6.22 : 12. 6

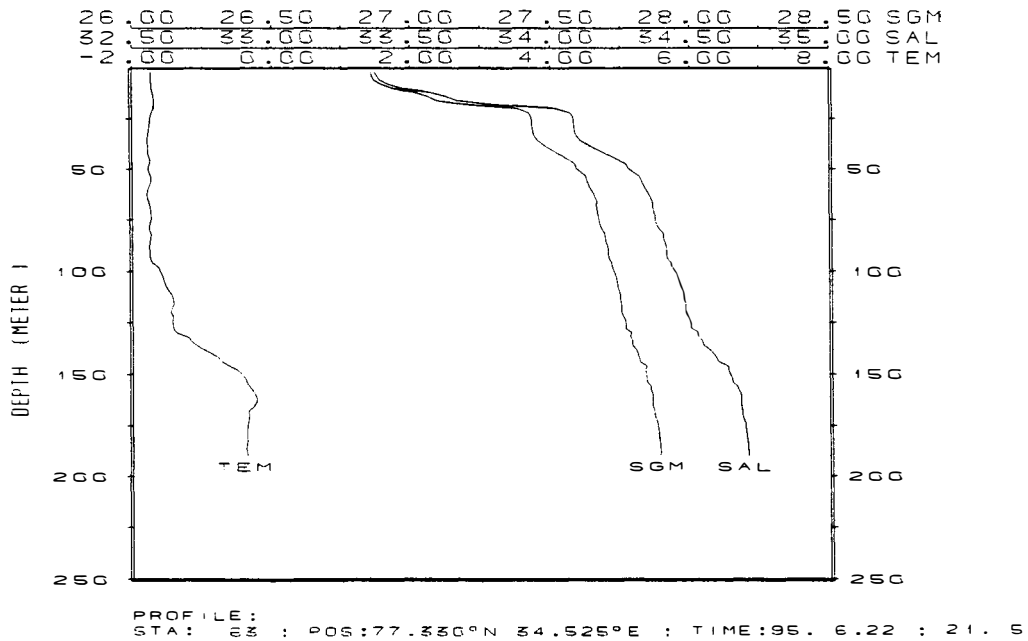
Fig 31. CTD stations 58, 59, 60. Vertical profiles of temperature, salinity and sigma-t



PROFILE:
STA: 61 : POS:77.298°N 34.443°E : TIME:95. 6.22 : 15. 7

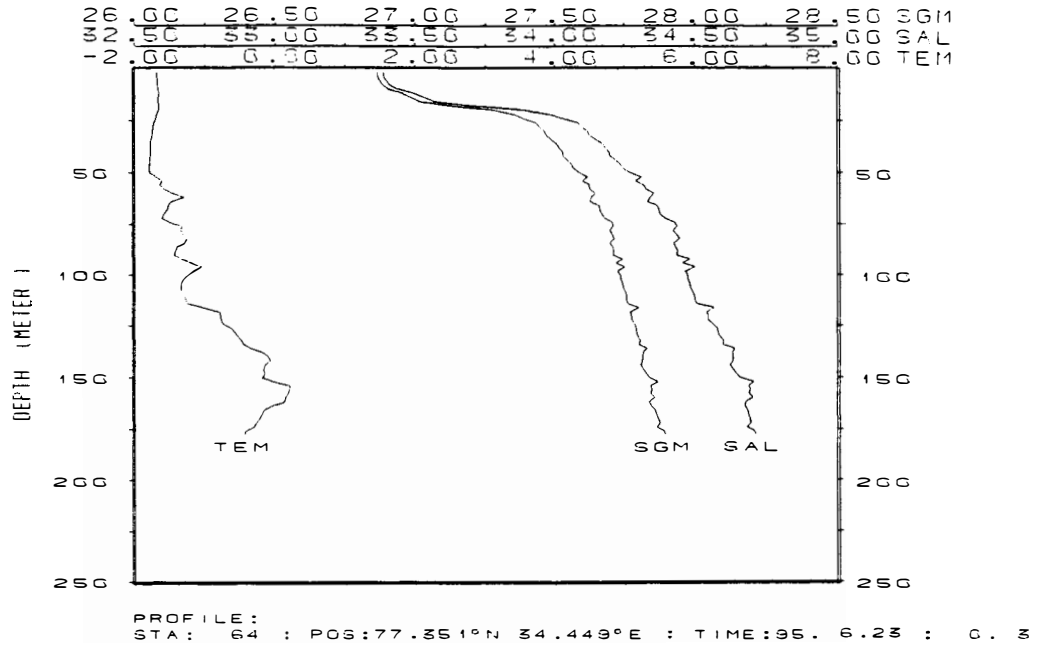


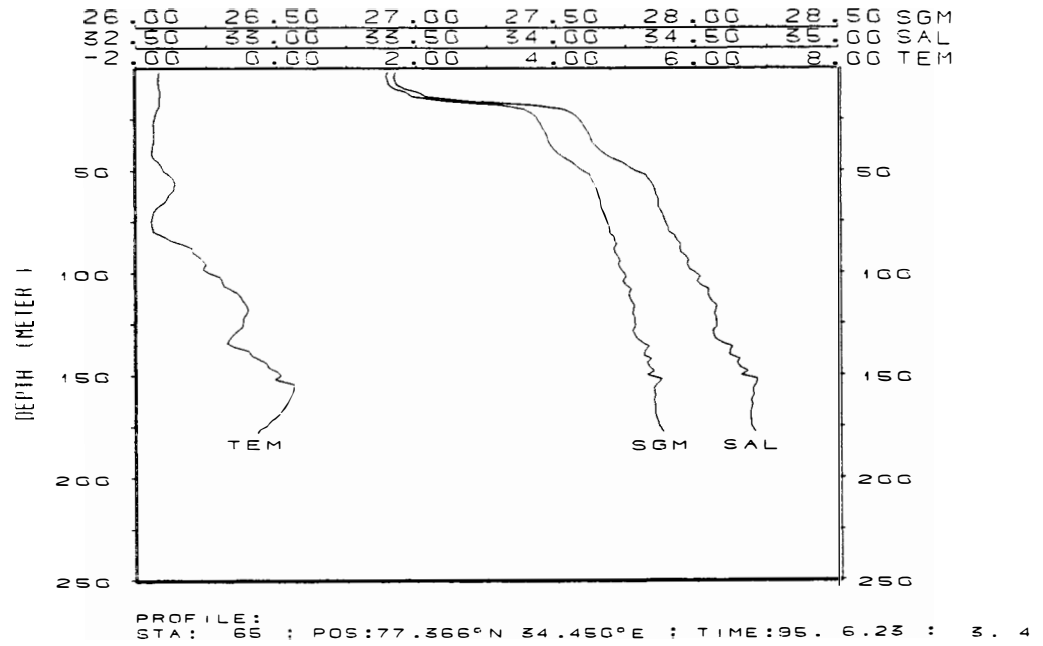
PROFILE:
STA: 62 : POS:77.315°N 34.456°E : TIME:95. 6.22 : 18. 6



PROFILE:
STA: 63 : POS:77.330°N 34.525°E : TIME:95. 6.22 : 21. 5

Fig 32. CTD stations 61, 62, 63. Vertical profiles of temperature, salinity and sigma-t





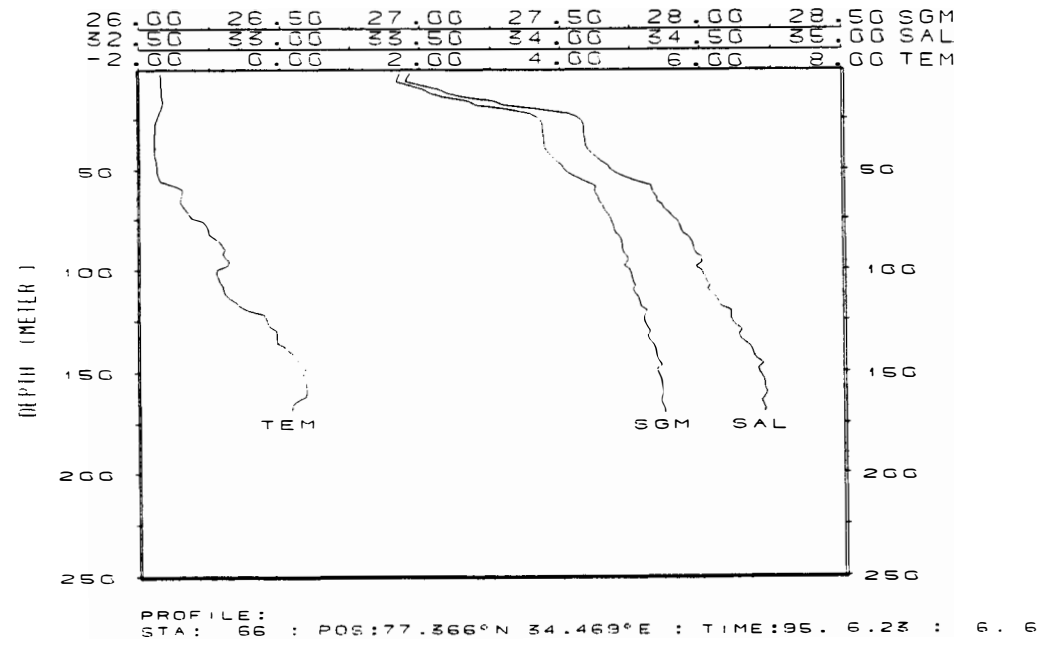
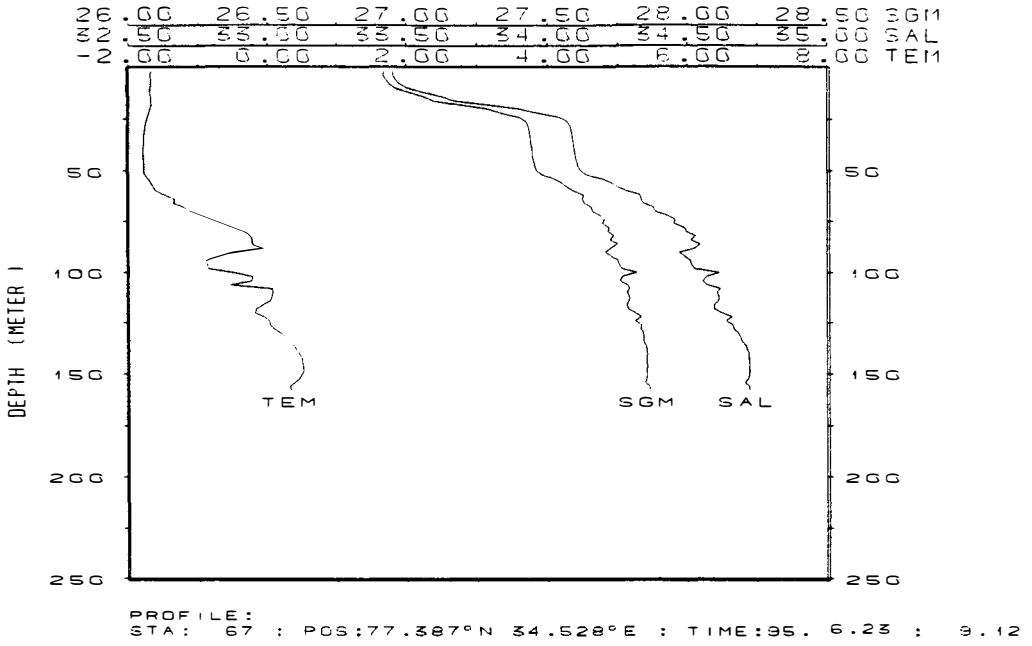
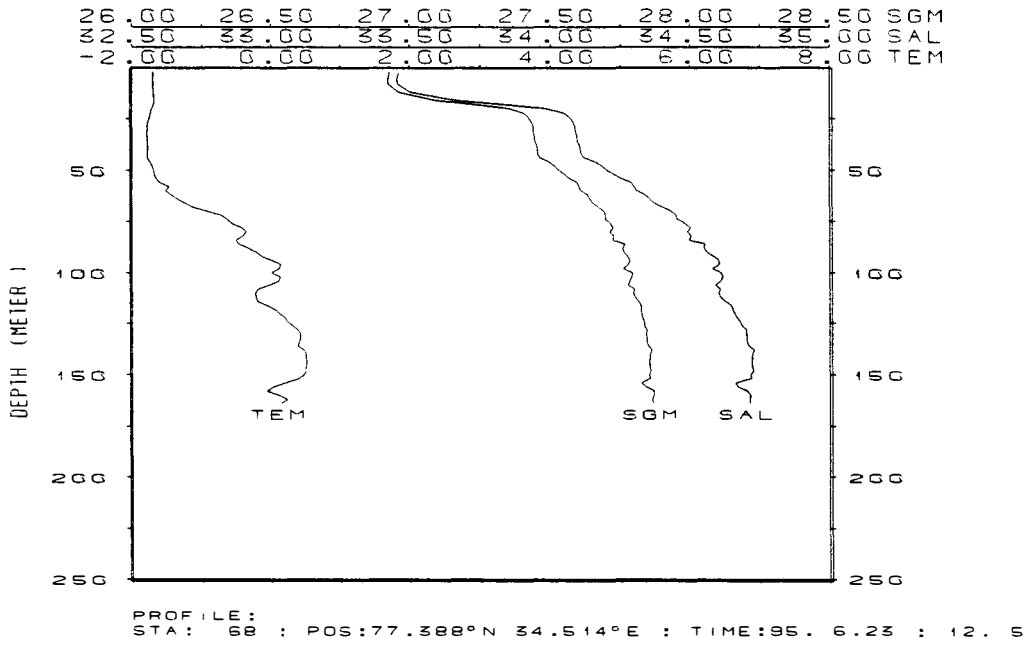


Fig 33. CTD stations 64, 65, 66. Vertical profiles of temperature, salinity and sigma-t





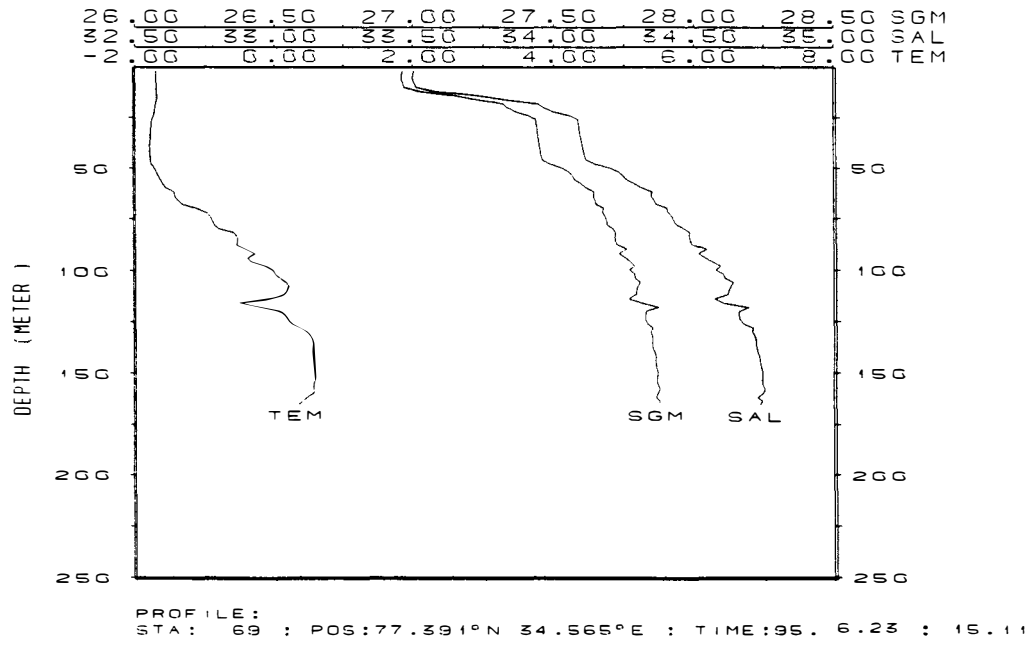


Fig 34. CTD stations 67, 68, 69. Vertical profiles of temperature, salinity and sigma-t

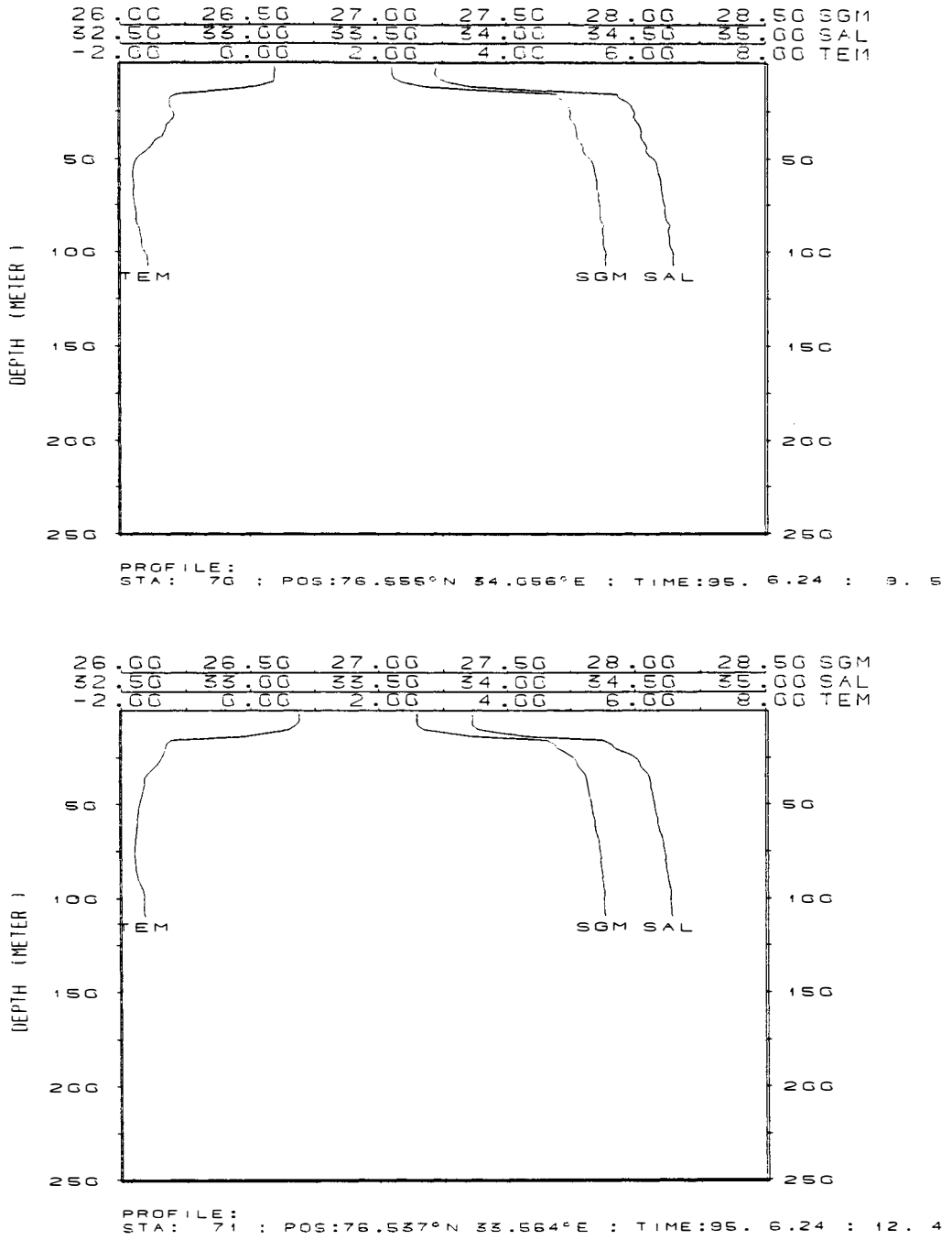
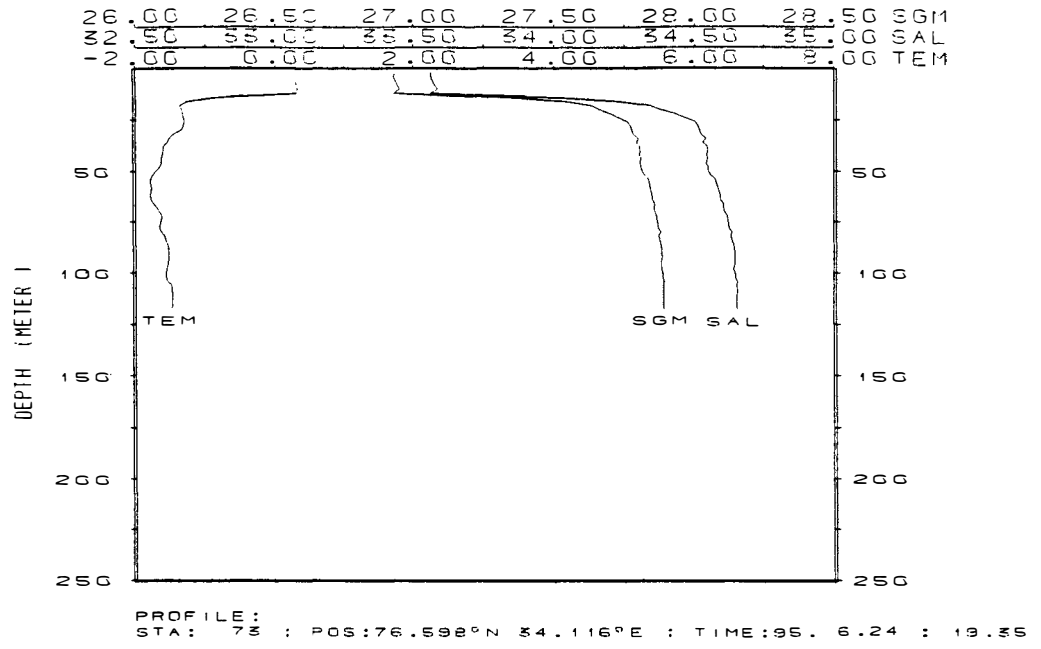
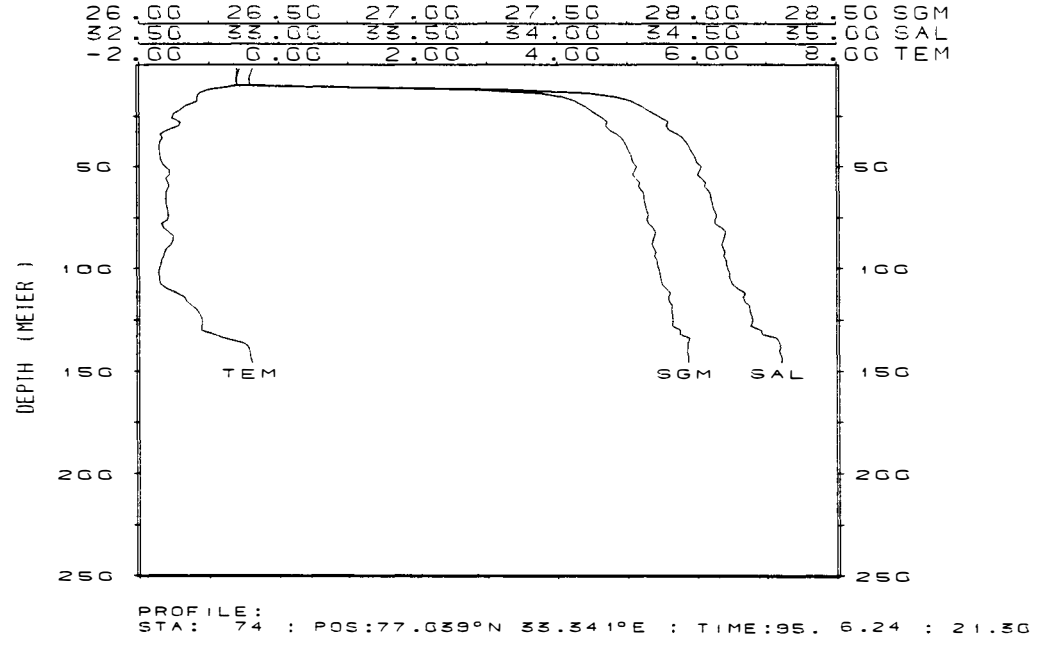


Fig 35. CTD stations 70, 71. Vertical profiles of temperature, salinity and sigma-t





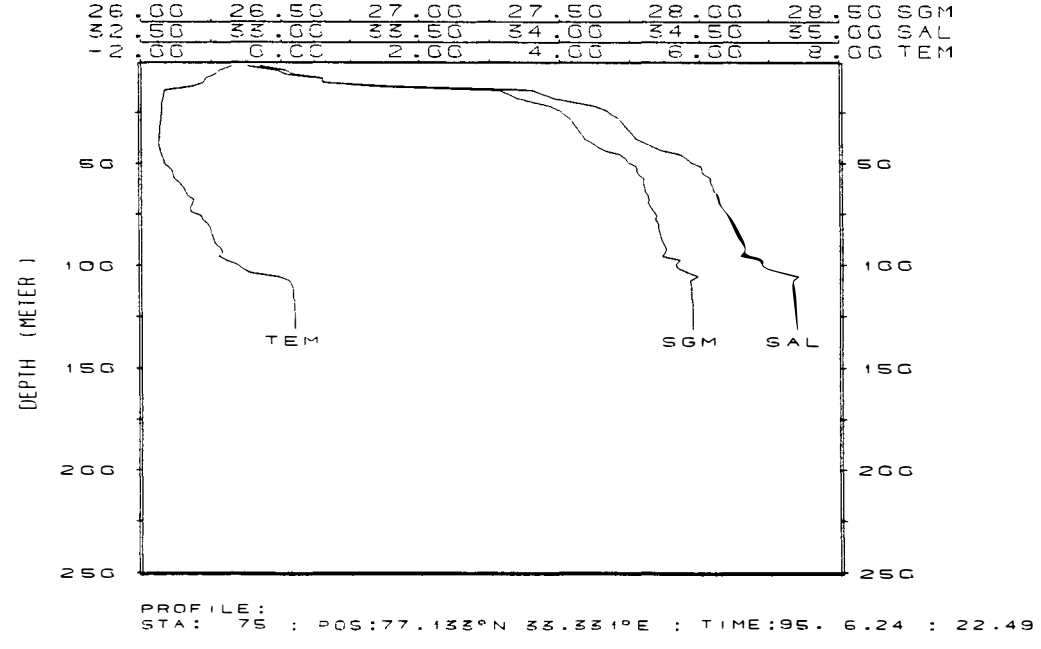
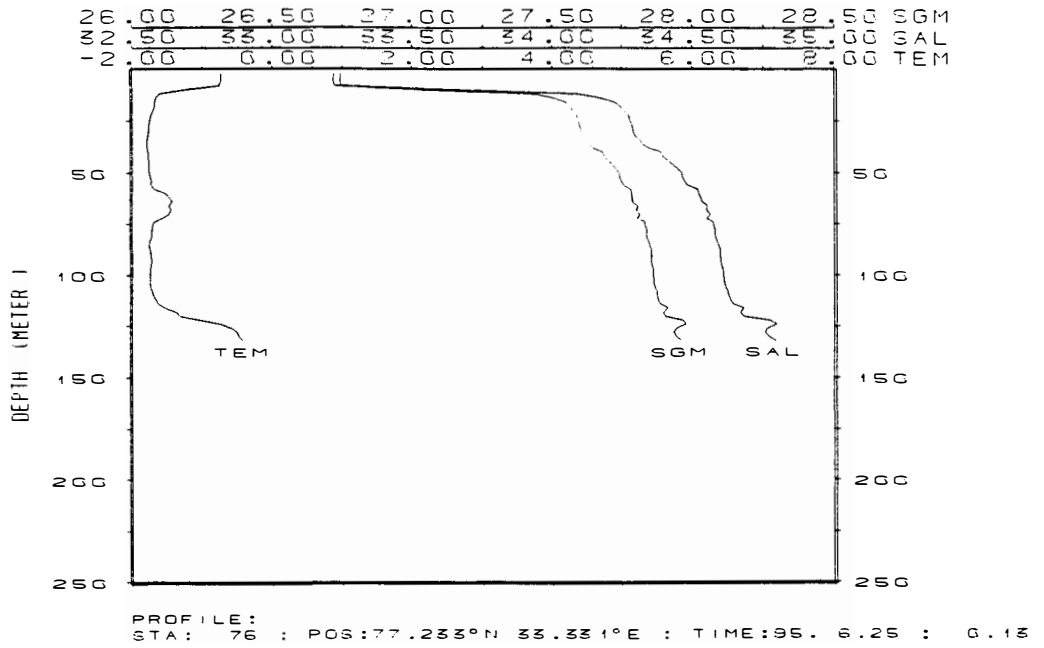
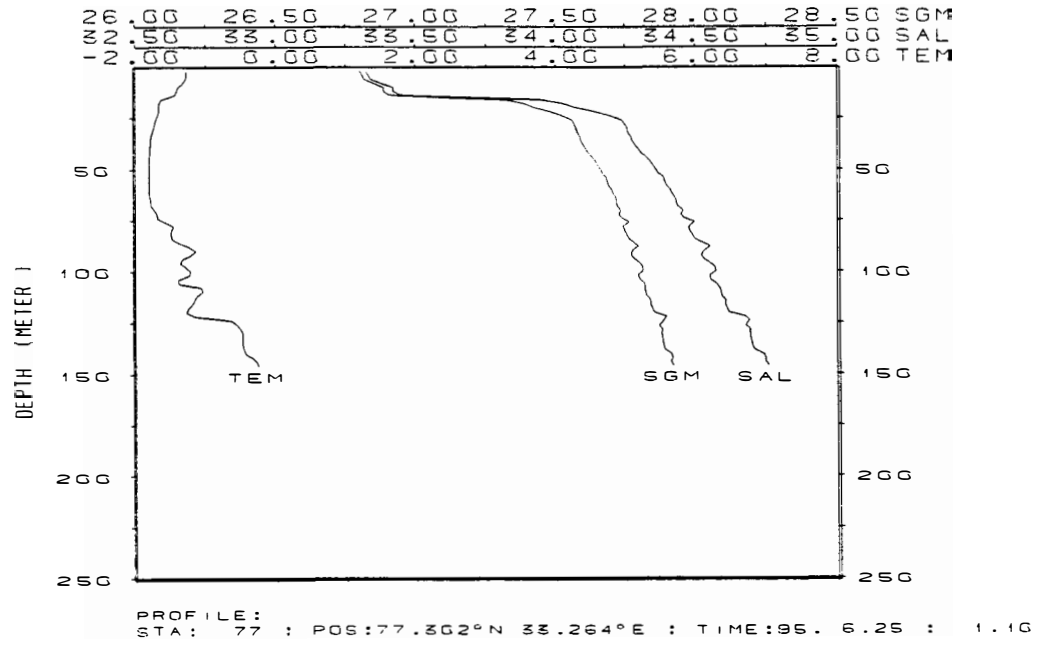


Fig 36. CTD stations 73, 74, 75. Vertical profiles of temperature, salinity and sigma-t





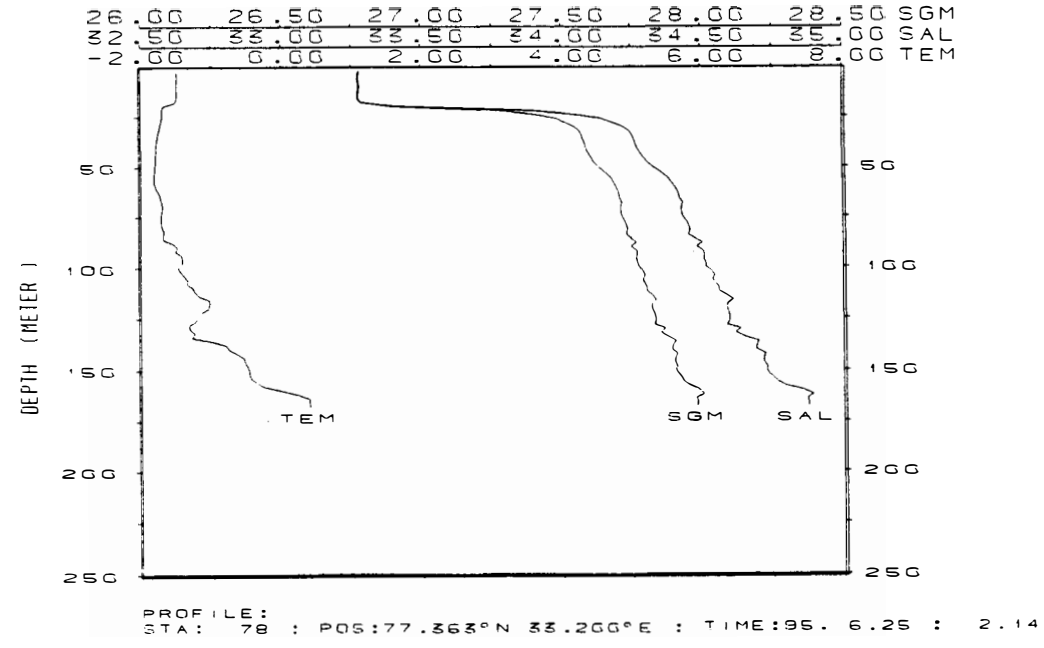
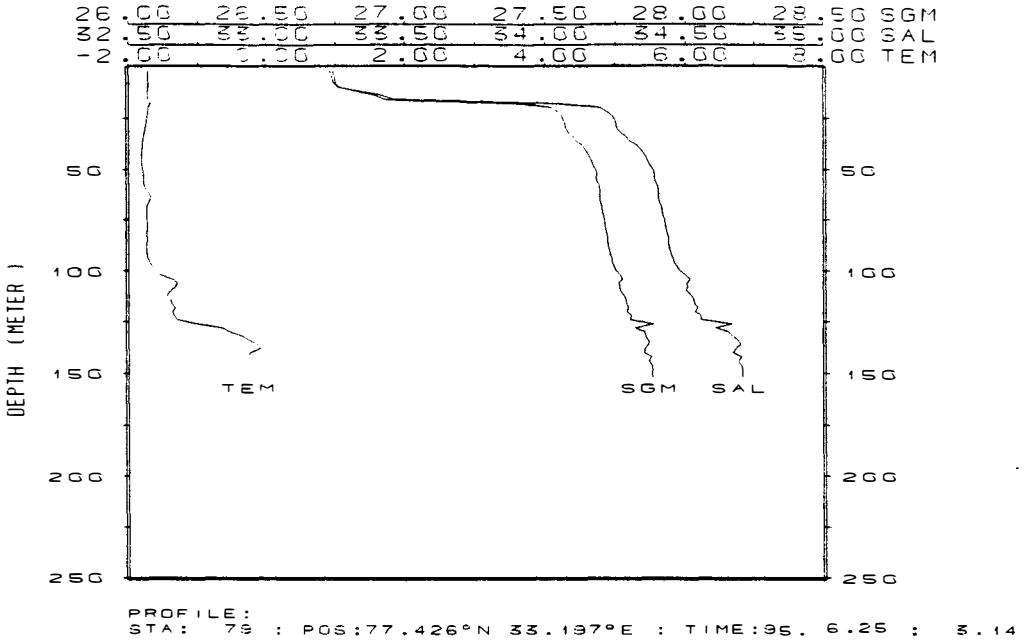
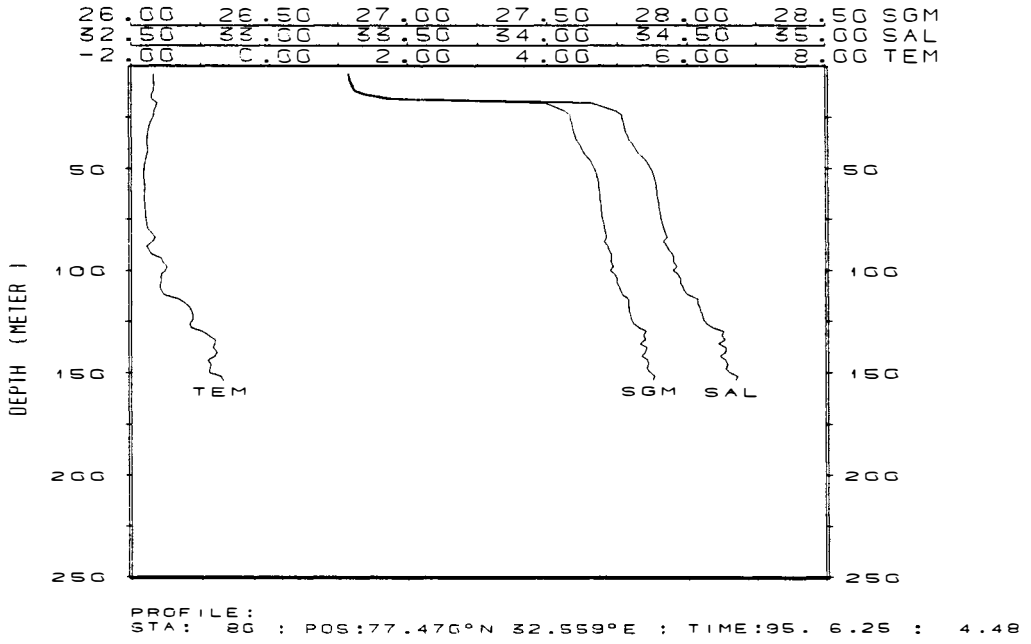


Fig 37. CTD stations 76, 77, 78. Vertical profiles of temperature, salinity and sigma-t





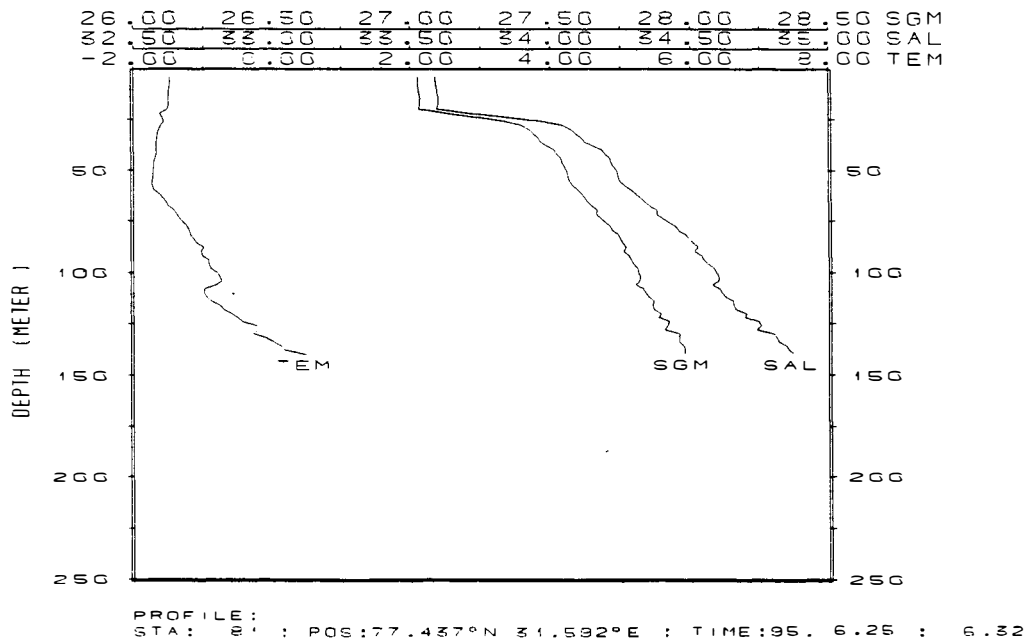
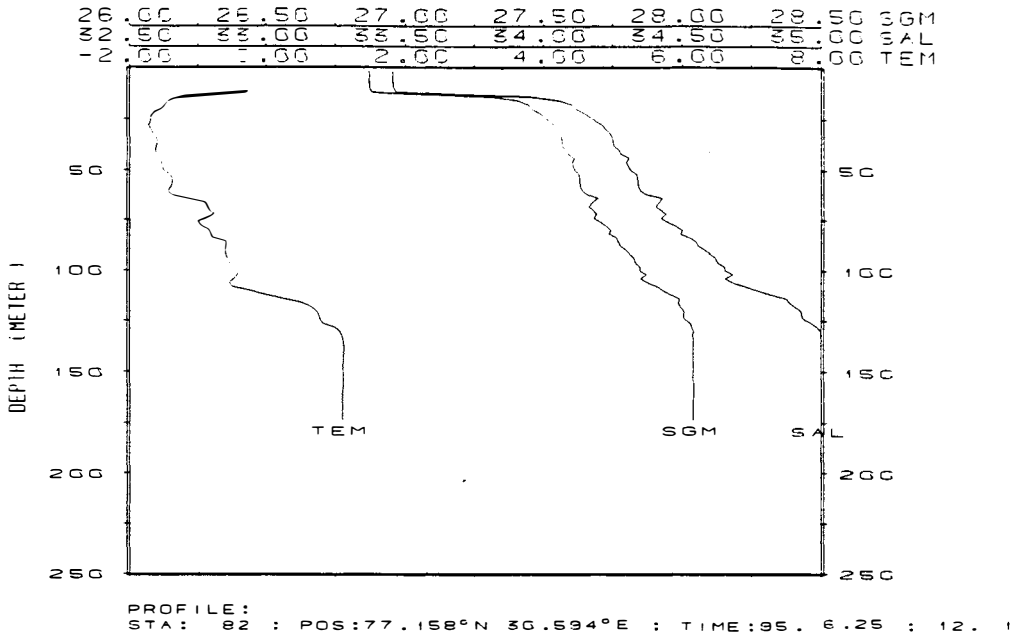
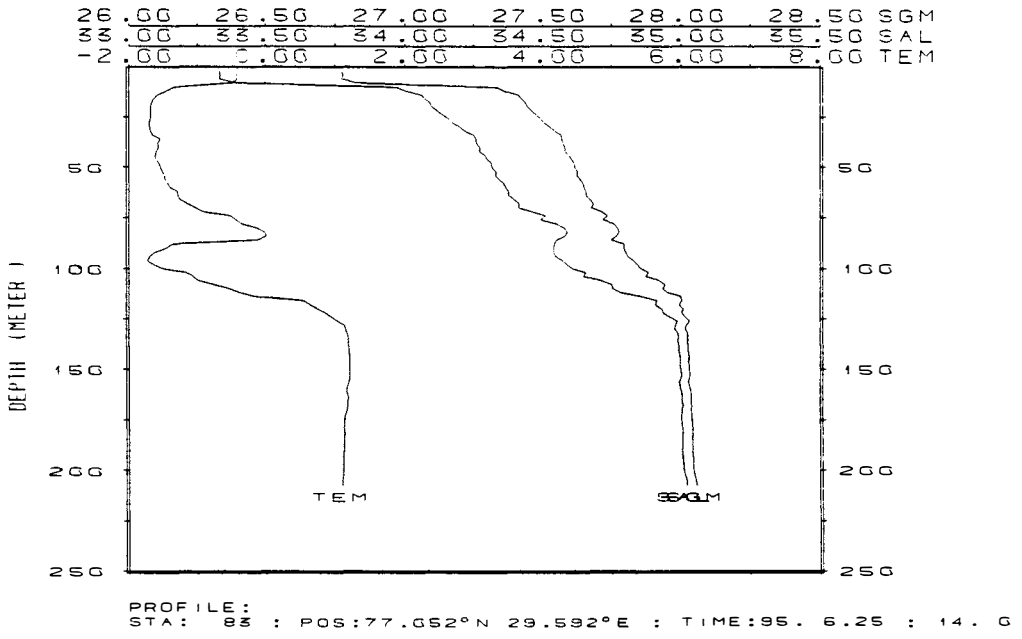


Fig 38. CTD stations 79, 80, 81. Vertical profiles of temperature, salinity and sigma-t





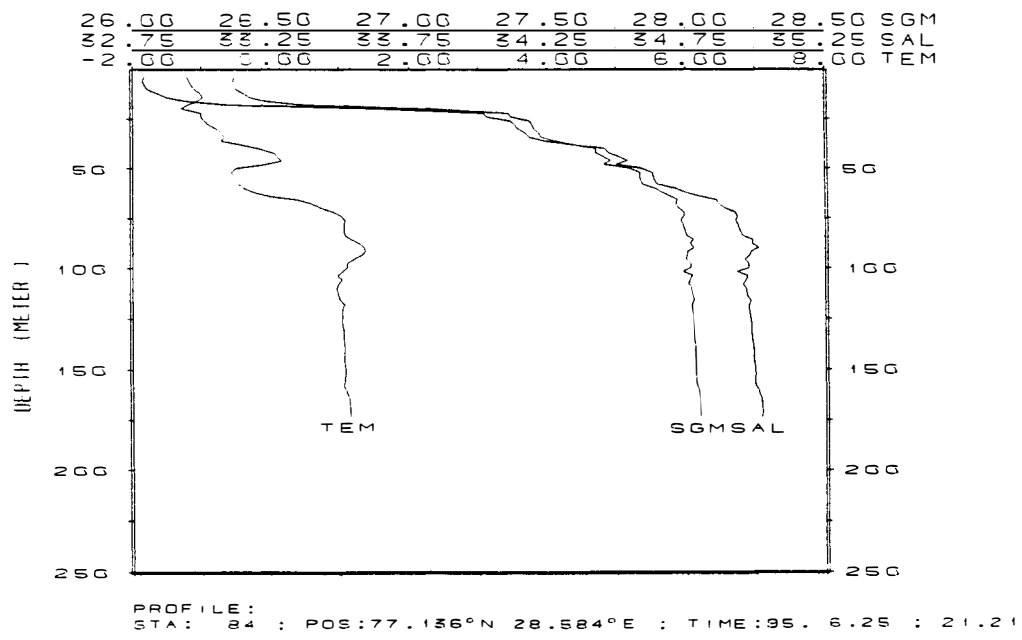
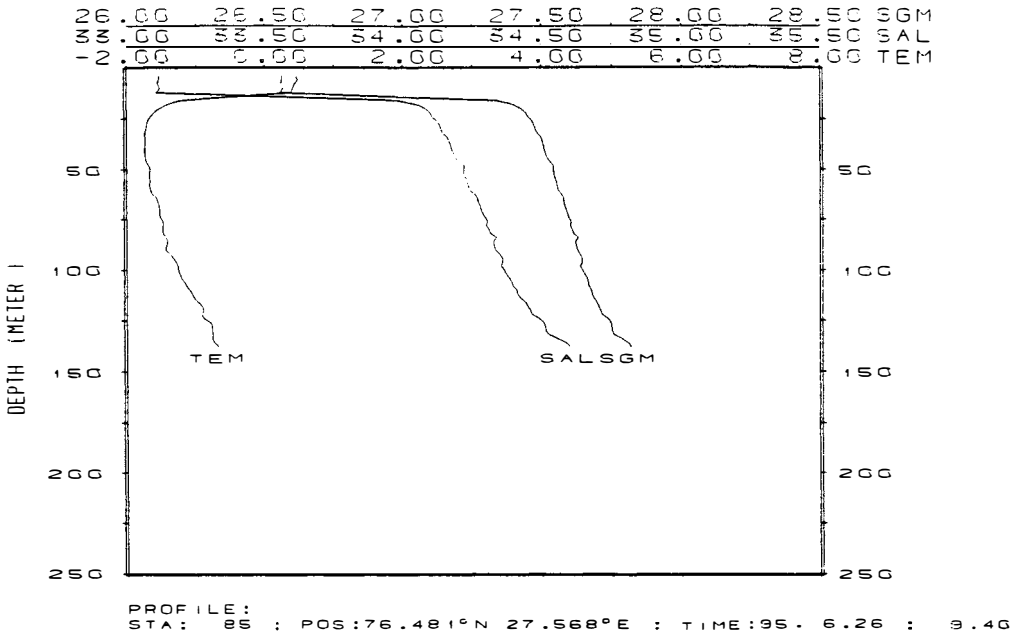
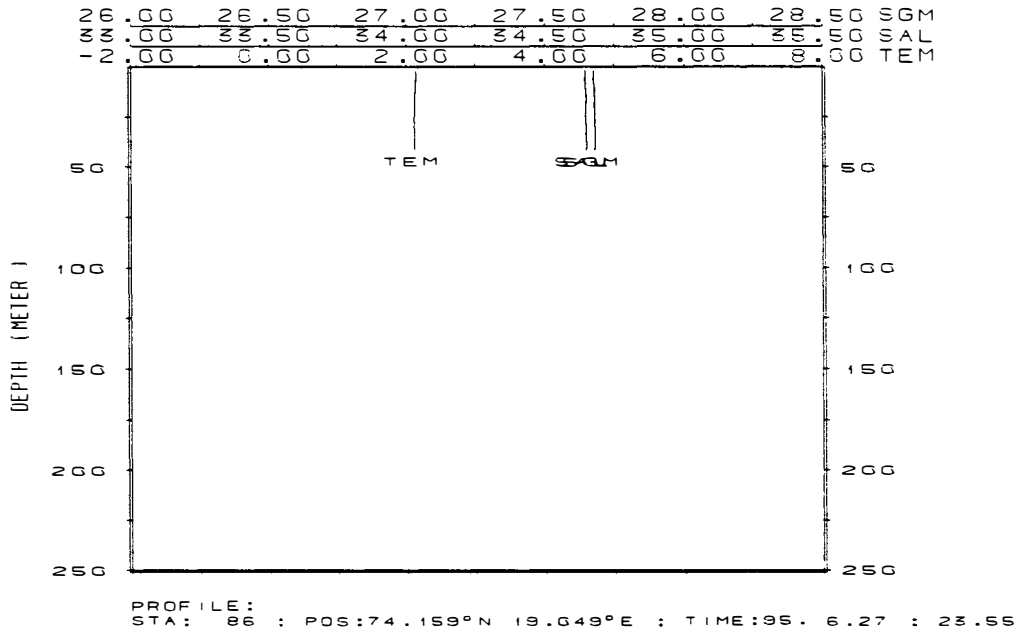


Fig 39. CTD stations 82, 83, 84. Vertical profiles of temperature, salinity and sigma-t





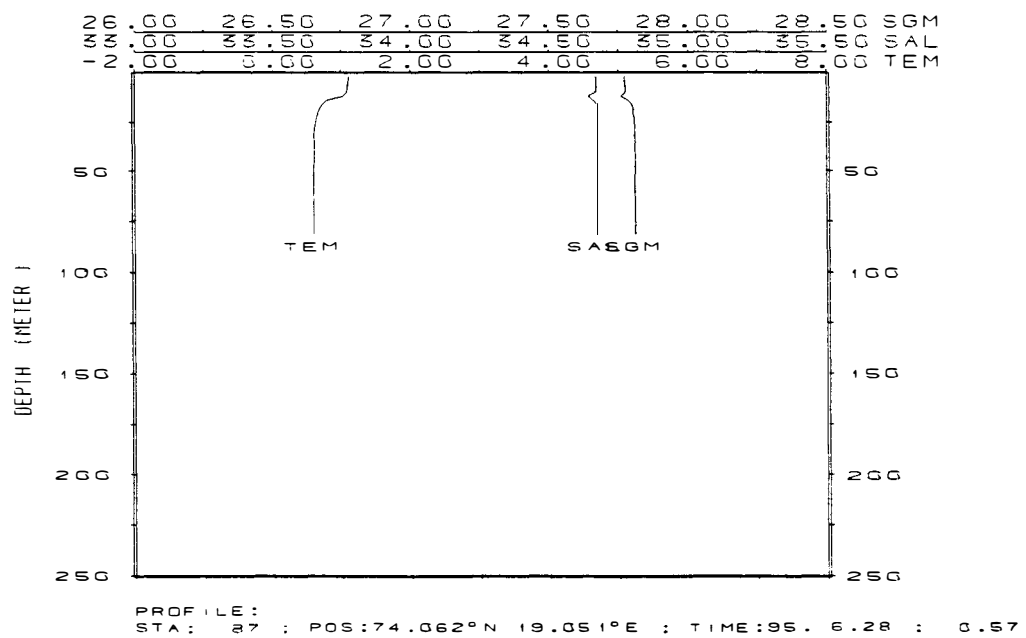
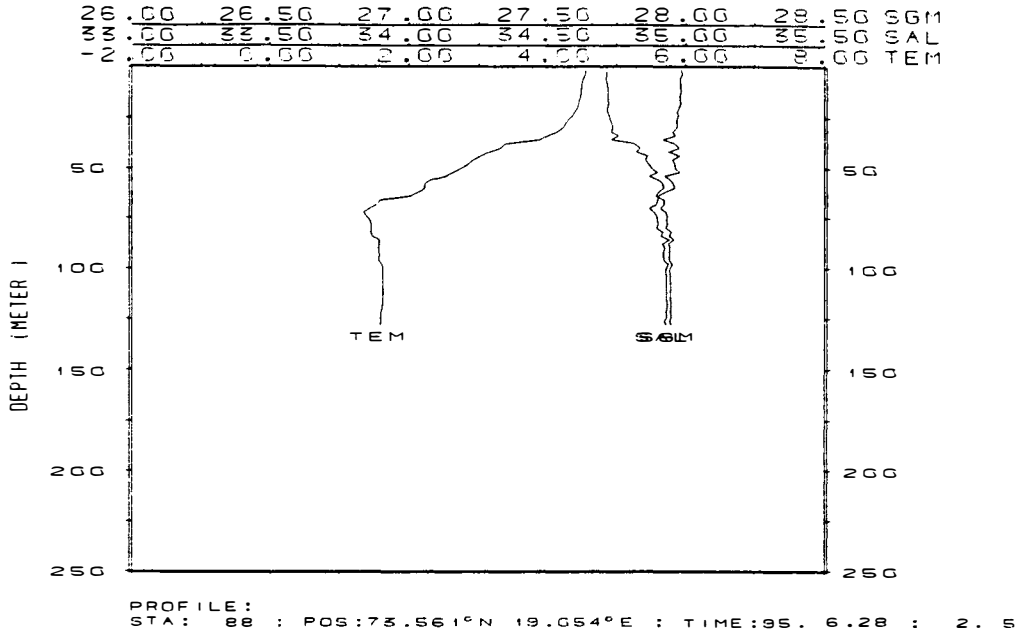
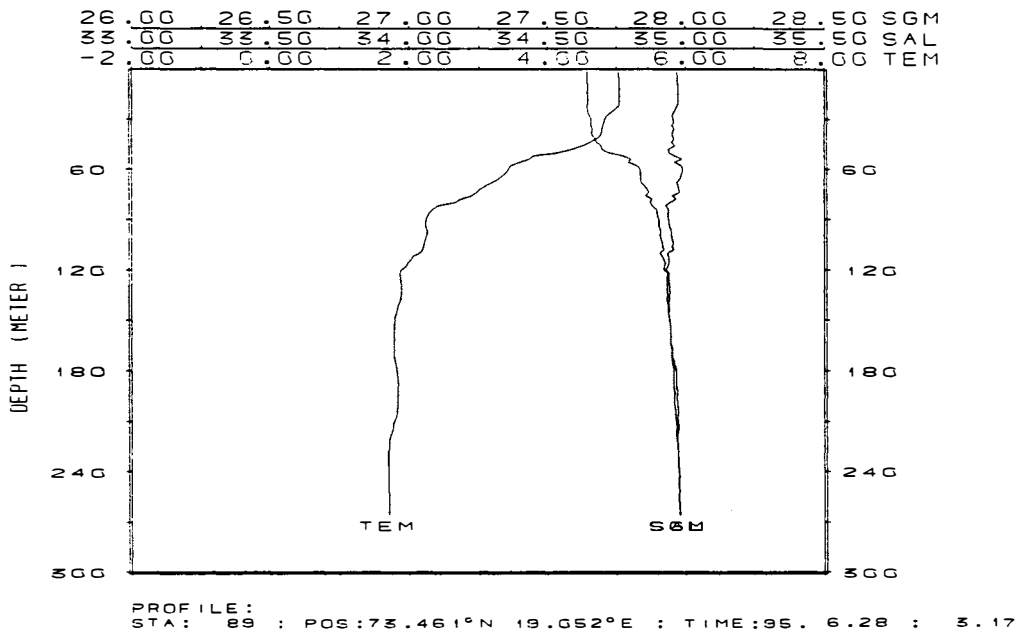


Fig 40. CTD stations 85, 86, 87. Vertical profiles of temperature, salinity and sigma-t





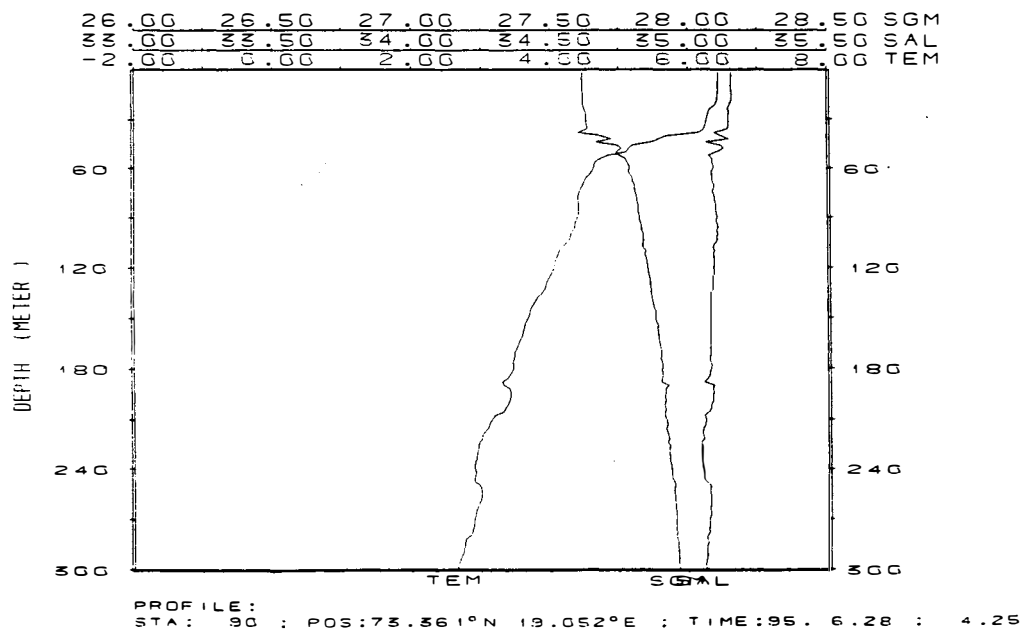


Fig 41. CTD stations 88, 89, 90. Vertical profiles of temperature, salinity and sigma-t

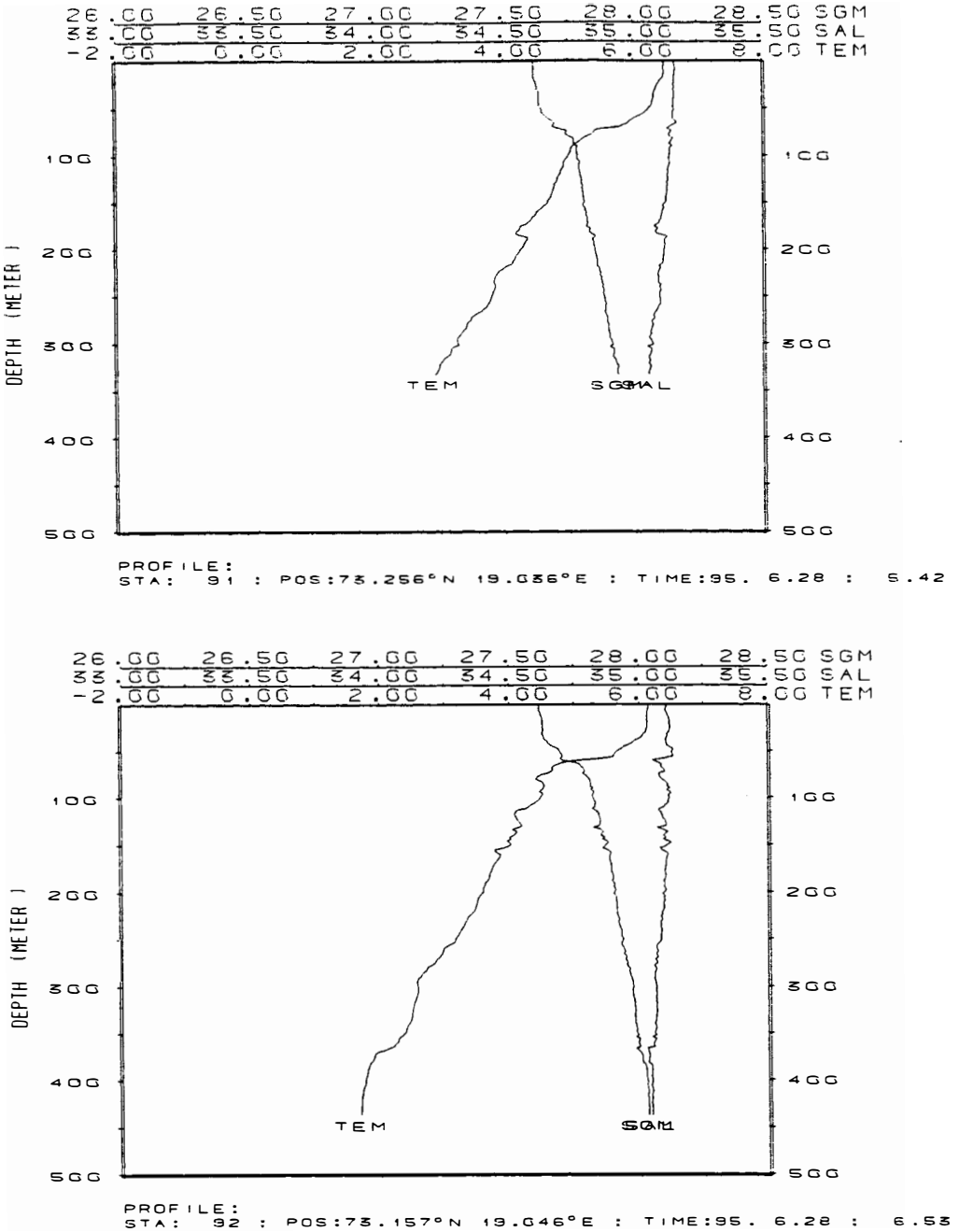


Fig 42. CTD stations 91, 92. Vertical profiles of temperature, salinity and sigma-t