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OBSERVATIONS OF THE ANTARCTIC POLAR FRONT DURING FDRAKE 76: A CRUISE REPORT

by

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Approved for Distribution: [signature]
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Abstract

During March/April 1976 the small-scale structure of the Antarctic Polar Front was observed in the Drake Passage. The observations were part of the International Southern Ocean Studies (ISOS) program called FDRAKE 76. The purpose of the program was to obtain densely sampled measurements of temperature, salinity, dissolved oxygen, and chemical nutrients in the Polar Front Zone (PFZ) and pilot measurements of horizontal and vertical velocities in order to explain the above scalar variability. The PFZ is a region where Antarctic and sub-Antarctic waters intermingle and presumably mix to affect the properties of Antarctic Intermediate Water. A report on the third leg of Cruise 107 of the R. V. THOMPSON is presented as well as a description of the measurements and a preliminary report of the data. A feature of interest is the pinching off of a northward meander of the circumpolar current system into a cyclonic ring of Antarctic Waters.

I. INTRODUCTION

The purpose of the polar front field program during FDRAKE 76 was to obtain measurements of the various scalar fields in the polar front with vertical and horizontal resolution surpassing previous studies and to obtain some direct measurements of vertical and horizontal velocities which might point out various dynamical processes related to the scalar variability.

The velocity data were obtained with 1) Vertical current meters (VCM's): neutrally buoyant floats equipped with vanes to sense vertical motion of the water. Five VCM's were built and prepared at W.H.O.I. and recorded 15 float days of good data during the experiment. 2) Profiling current meter (PCM): an Aanderaa current meter which slid down the CTD cable at 30 meters/min and recorded pressure, current speed, and direction. Walter Zenk from IFM, Kiel, West Germany provided this instrument. Using one of two reference buoys for relative navigation, 19 profiles were obtained.

Various scalar fields were measured with the following instrumentation: 1) CTD: A W.H.O.I./Brown CTD microprofiler was equipped with a sensor for continuous measurement of dissolved oxygen. A total of 101 stations were occupied. 2) XBT: 450 XBT's were collected for mapping of the thermal structure of the front and for statistical study of temperature interleaving in the frontal zone. An expanded scale system brought from Lamont by Dan Georgi was used for 300 of the stations. 3) Light Scattering: Gunnar Kullenberg from the University of Copenhagen obtained 48 stations in which the light scattering as a function of scattering angle was measured at discrete depths and continuous scattering at a fixed angle for depths between 0 and 1000 meters. 4) Quanta Meter: Kullenberg also made 11 quanta meter stations. The quanta meter is essentially an electronic secchi disk. 5) Over 950 samples were processed for nutrients using an autoanalyzer operated by Cliff Dahm of Oregon State. Of these, 240 were surface samples collected by the Chilean naval vessel A.G.S. YELCHO. 6) Isotope analysis: 28 samples were drawn for Tritium/Helium^3

and 78 for O^{16}/O^{18} analysis. The former will be done by Bill Jenkins at W.H.O.I. and the latter through Lou Gordon at Oregon State.

In addition to the above, a subsurface mooring was recovered containing instruments belonging to Pacific Marine Environmental Lab (NOAA) and Institut für Meereskunde, Kiel. During the course of the four-week THOMPSON Leg III study, YELCHO assisted in defining the mesoscale structure of the polar front. A meander in the circumpolar current/polar front was observed to pinch off forming an eddy of cold antarctic water which then drifted to the northeast in the circumpolar current.

This rapid evolution of the polar front needs to be studied using the combined data sets of the R/V THOMPSON and AGS YELCHO. Several references to the frontal eddy (FREDDY) appear in various places of this report. With the permission of S. Patterson and H. Sievers we present the synoptic structure of the polar front from the two two-week cruises of the Chilian vessel YELCHO. The operational definition of the polar front used is approximately 2° C isotherm at 200 meters depth. Figure 1 shows the detailed two dimensional section of the thermal structure. The "front" is located at XBT #42. The polar front is in fact a zone of transition between antarctic and subantarctic waters. This zone is 10-20 nm wide in Figure 1 and includes much of the interleaving regime. A more complete discussion is given by A. Gordon (1976 manuscript on FDRAKE 75). Our term polar front really denotes the southern edge of the frontal zone.

As Figure 2 shows, a northward meander of the polar front occurred between periods 1,2. This is further documented in the time series from the thermister chains (not discussed here) on the upper portion of mooring A (see next section). Figure 2 shows the configuration of the front when THOMPSON was in the area during Leg III and in the process of deploying the VACM's (Section VIII). In less than a week the meander pinched off and formed a cold ring of approximately 50 km diameter which subsequently drifted to the northeast at 10 cm/sec. The THOMPSON was able to pass through FREDDY making deep CTD stations upon its return to Punta Arenas. The depth extent and water mass properties (anomalously cold and fresh antarctic waters) (Figure 3) identify the eddy to a depth of 2500 meters.

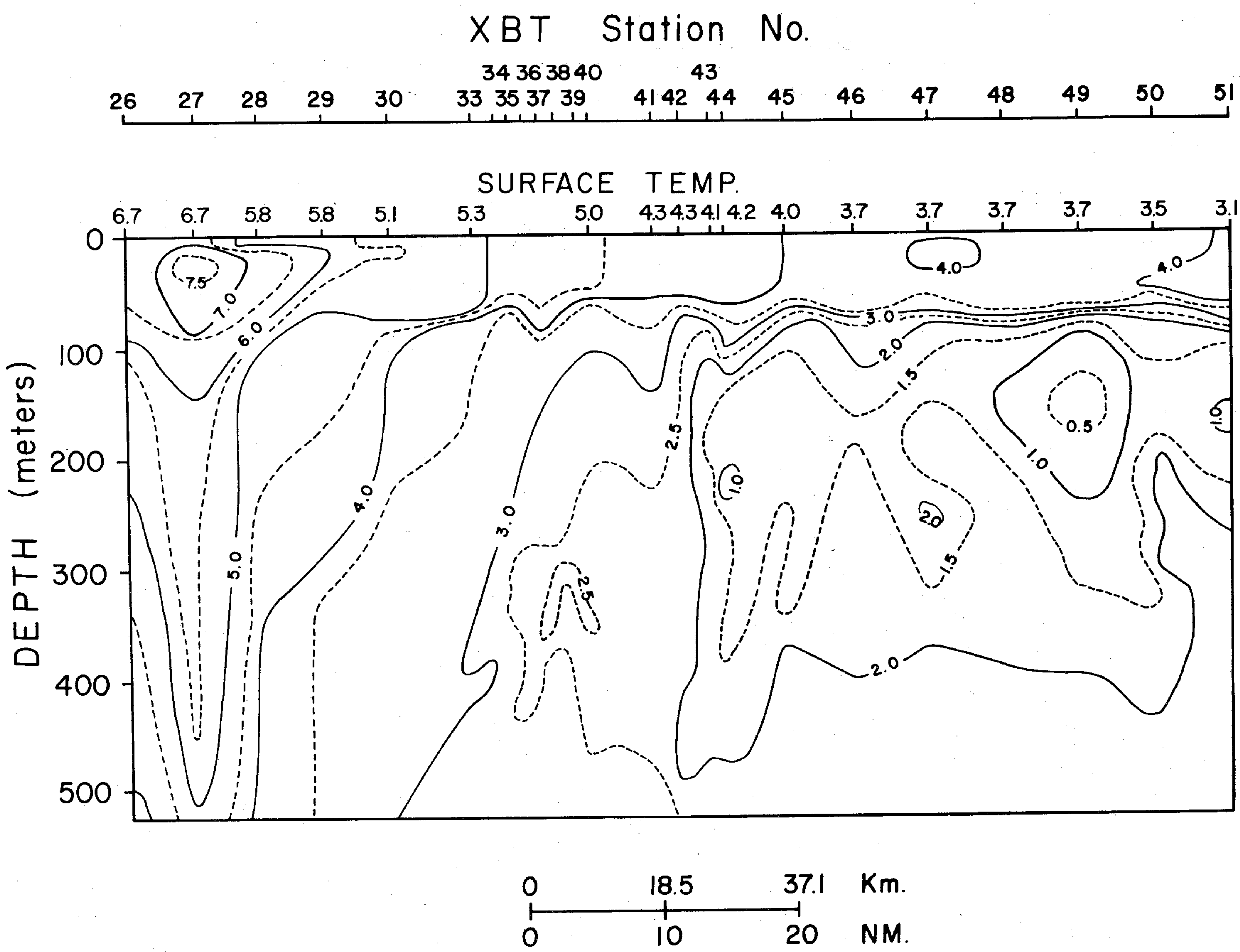

Figure 1. N-S section through the polar frontal zone contoured in 0.5°C intervals. The polar front defined by the 2° C isotherm at 200 m was encountered at XBT #42

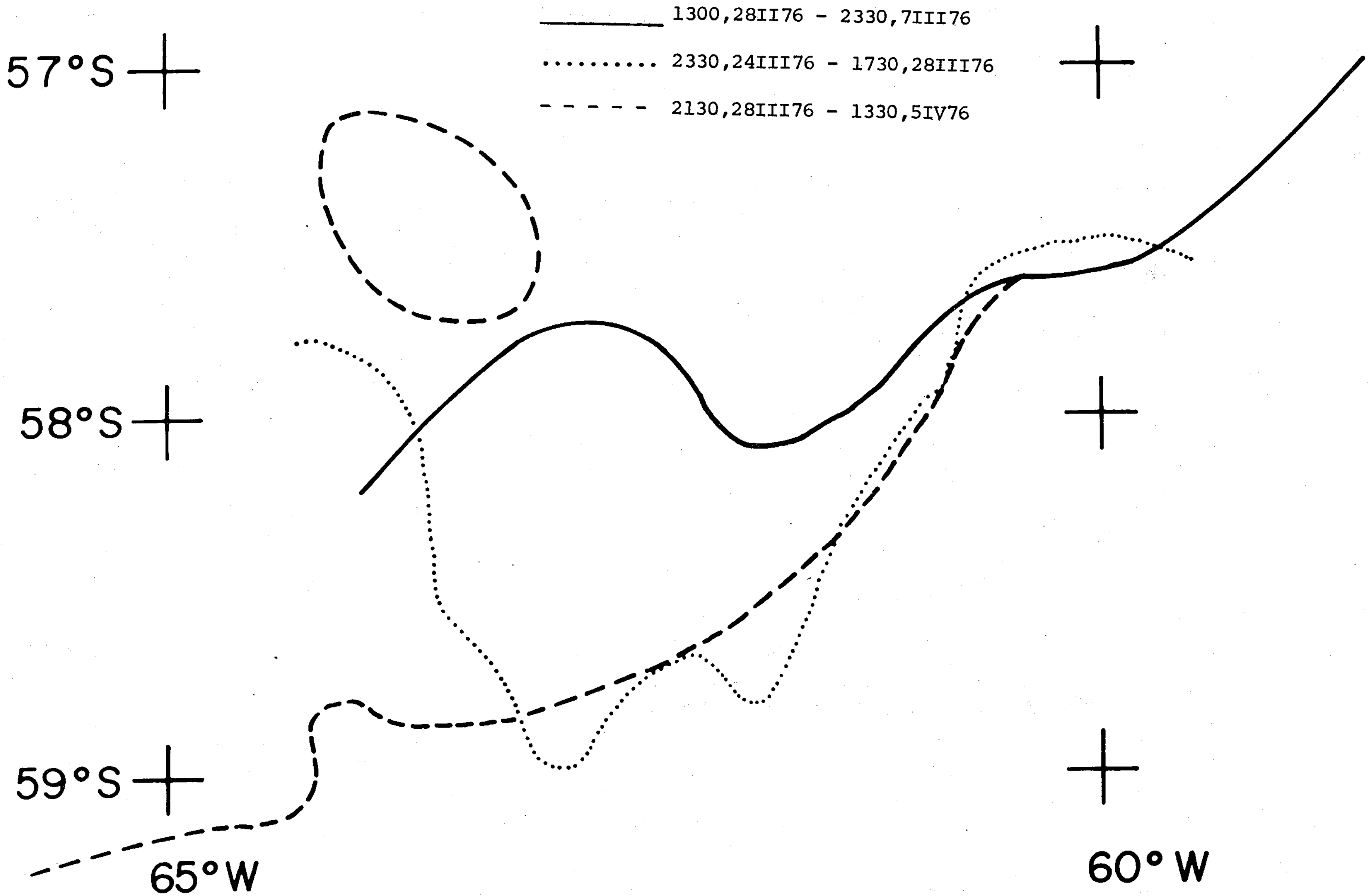

Figure 2. Three synoptic structures of the polar front showing the evolution of the cold water eddy according to the XBT observations of the Chilean vessel YELCHO

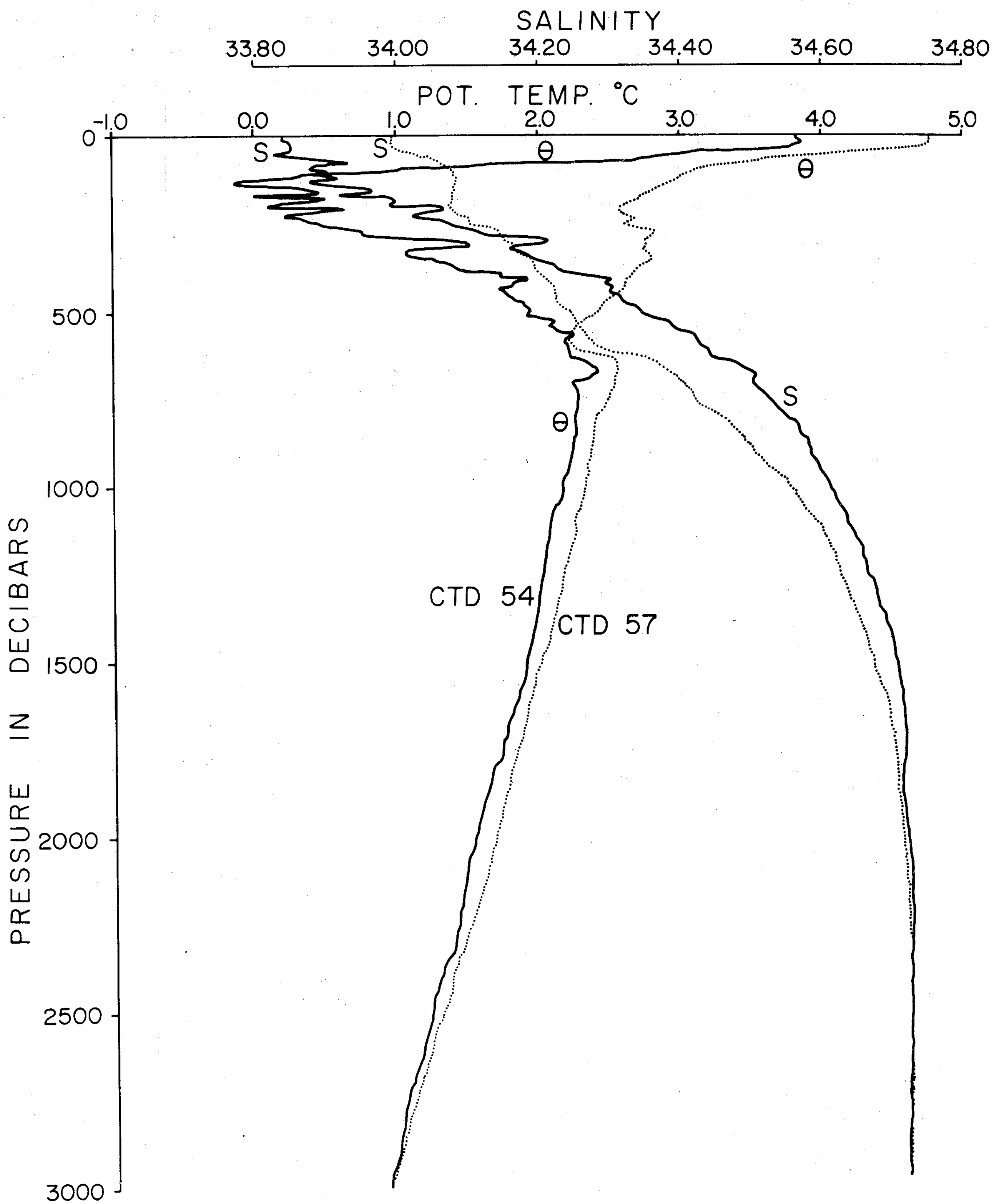

Figure 3. Continuous profiles of potential temperature and salinity from two CTD stations (54 and 57) taken inside and outside the cold water ring. Note that the eddy can be identified to a depth of 2500 meters

A discussion of measurements taken aboard the THOMPSON during Leg III follows. Although not as comprehensive as a data report, this report will provide the only overview of all activities during the Southern Ocean Polar Frontal Zone Experiment (SOPOFROZONEX).

The data collected during FDRAKE 76 should give, upon further analysis, a much clearer picture of the transfer processes at the polar front.

II. NAVIGATION AND MOORING OPERATIONS

A. Navigation

Navigation on Leg III was done by the scientific party with the assistance and advice of the deck watch officers. The navigation was primarily a task of record keeping and of quality control of satellite navigation fixes. Three means of geographically positioning the vessel were anticipated at the outset of the cruise: satellite navigation, radar navigation utilizing surface moorings and Omega. Satellite and radar navigation proved adequate for the scientific requirements. Use of the Omega system was never possible as the station located in Argentina, which was critical for the area we were working, was not available for navigation. Also, the shipboard Omega receiver had an electronic failure which could not be corrected.

The Magnavox 706 satellite navigation receiver provided consistently reliable and accurate geographical positioning of the vessel. Approximately 20 fixes per day were obtained with the interval between fixes varying between 15 minutes and 2 hours. Accuracies were generally better than 0.25 n.m. if course and speed were maintained during the pass. A relatively high incidence of abortive fixes occurred. This was due to the coincidence or overlapping of satellites during Doppler counting sequence. The use of tabulated satellite alerts and the manual aborting of lock-on was instrumental in reducing this type of failure which is inherent to the system when operating in high latitudes.

A plot of the ship's track during Leg III is shown in Fig. 4. Shown are the paths of unbroken runs, positions of float deployments, CTD sections and time series, and mooring positions. Ship's track while tracking floats is confused and is omitted for clarity.

B. Mooring Operations

Two mooring operations were performed on this cruise: 1.) the recovery of the instrumented upper-section of an O.S.U. intermediate mooring, and 2.) the deployment/recovery of two surface navigation buoys. These locations are indicated in Fig. 4.

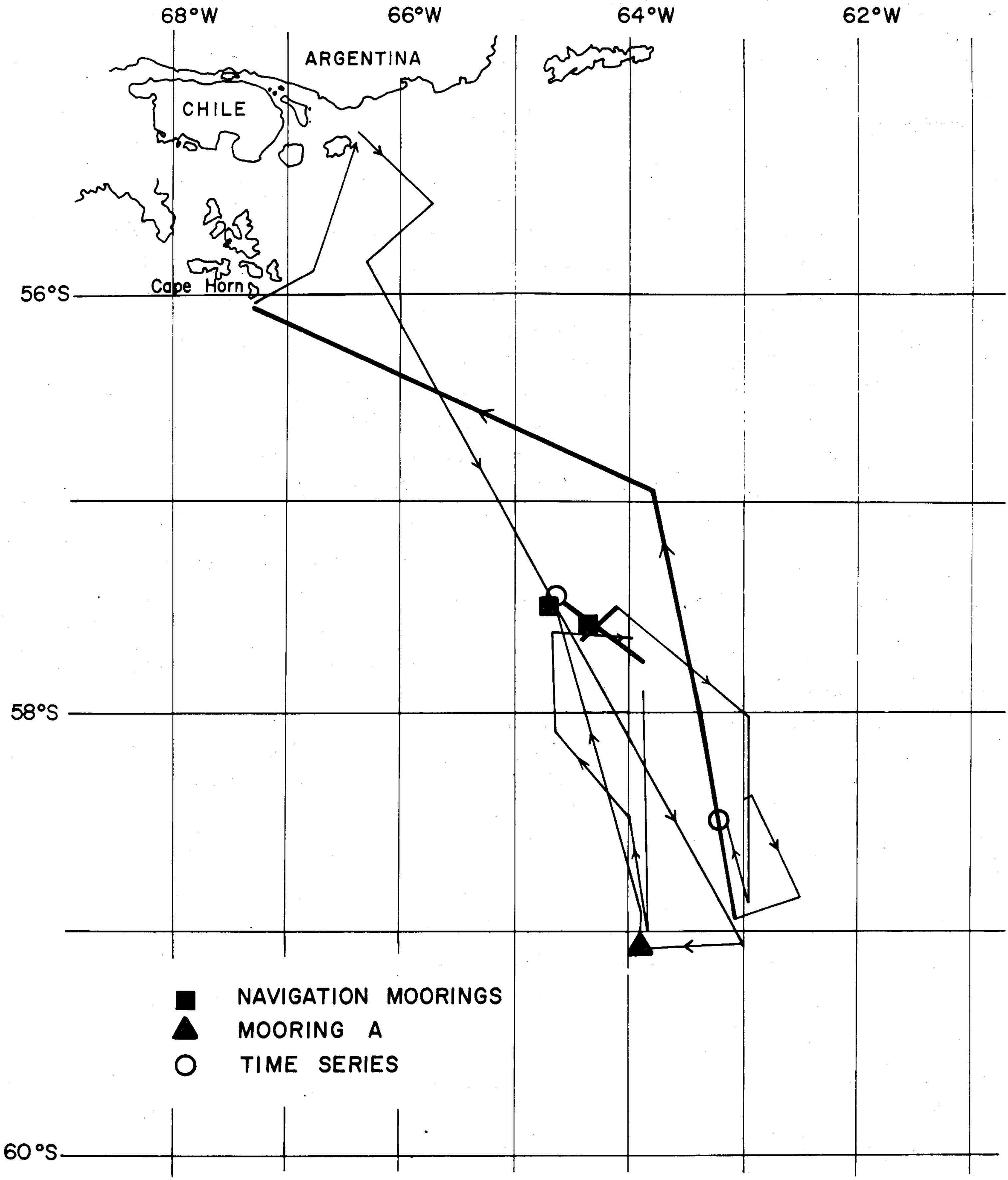

Figure 4. The R/V THOMPSON'S cruise track during leg III of FDRAKE 76 in the Drake Passage. The polar frontal zone was encountered in the vicinity of 58° S. Heavy lines denote CTD sections made while open circles mark locations of CTD time series

1. It had been requested that, if weather and time permitted, the upper section of O.S.U. mooring "A" be retrieved. This section was instrumented with current meters (3) of PMEL/NOAA (Hayes) and thermistor chains (2) of I.F.M., Kiel (Zenk). An acoustic release was placed at the 500 meter depth level which would permit this section to be detached for an early recovery (see Fig. 5).

On the morning of 17 March, the vessel arrived in the general vicinity of the mooring. Attempts to interrogate the AMF transponding release on the bottom were unsuccessful.* However, the lower Aanderaa thermistor chain had an acoustic data telemetry capability, the signals of which were received on a lowered hydrophone. As the telemetry had a very limited range, we were certain to be in close proximity to the mooring. At 1300 Z the release was successfully fired. The OAR radio signal was heard 3 minutes later indicating the time of surfacing. The mooring was sighted at 1308 Z at a range of approximately 600 meters. The mooring was recovered without incident from 1338 to 1420.

The mooring was in excellent condition. The following were noted about the instrumentation:

a. All 3 current meter rotors were out of their bearings on recovery. The lower bearing lock nut was missing in each case.

b. The test shackle on V-144 was in excellent condition with no sign of corrosion or wear.

c. The clamps holding the thermistor chain to the mooring line were slightly corroded.

d. Rotor events (spins) were placed on each of the current meters:

V-144	14:51:09 Z	17-III-76
V-143	15:00:07 Z	17-III-76
V-140	15:06:58 Z	17-III-76

*The release at 500 m was unable to transpond.

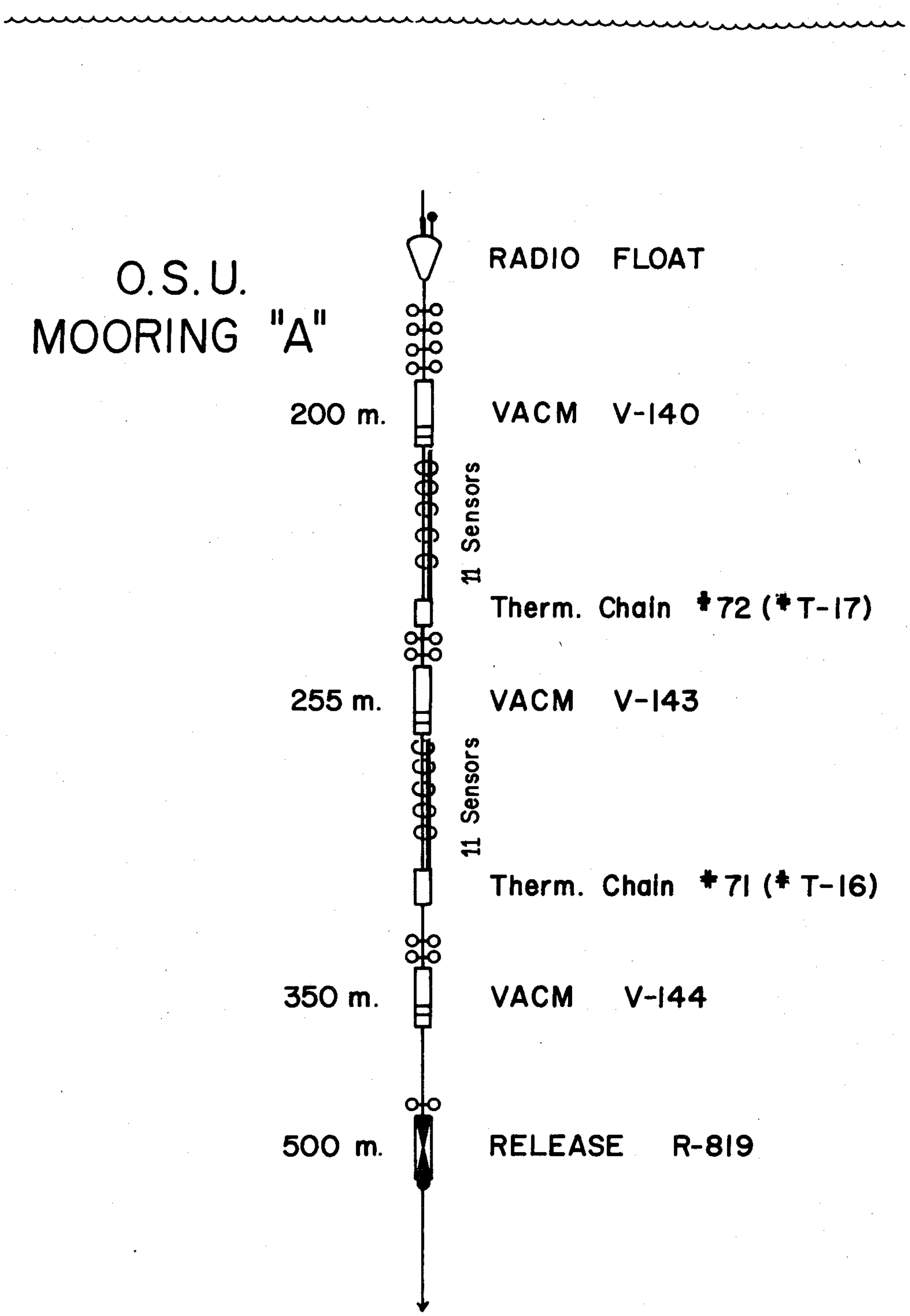

Figure 5. Schematic view of the top of the O.S.U. long term mooring "A". The independent upper mooring was equipped with three VACM's from PMEL, Seattle, and two Aanderaa thermistor chains from IfM, Kiel. This upper part, shown here, recorded temperature and current fluctuations in the interleaving regime north of the polar front. The mooring was set on 18 February 1976 and the top was recovered on 17 March 1976

e. The current meters were rinsed with fresh water and stored in their cases unopened. The thermistor chains were opened by Zenk and the data tapes read.

2. Two surface moorings, each equipped with a radar transponder, were deployed and later recovered during the cruise. Their purpose was to provide a means for high resolution, accurate and continuous relative navigation of the vessel while conducting a CTD, profiling current meter (PCM) time series and a dense CTD survey of the front.

The moorings were composed of a Plank-On-Edge (POE) surface float, an auxiliary (700 lb buoyancy) polyurathane flotation package, 3/8" plaited polypropelene mooring line and a 1500 lb anchor of 3 railroad wheels (see Fig. 6). All but the float were expendable. The POE was tethered to the mooring by a 2.2 meter length of shock cord secured at the nose. A 4 meter length of 3/8" chain was fastened at the keel as a safety line. The POE would ride on the shock cord with the auxiliary float suporting the mooring. However, if the auxiliary float should tow under or the shock cord should fail the load would transfer to the keel of the POE.

Each POE had a Motorola radar transponder mounted in a tower 10 ft above the water line. Power was supplied by 5 lead-acid "truck" batteries mounted in a well in the body of the float. With judicious use of the radar a useful life of 10 days could be obtained. Each POE also contained a light and an OAR radio.

The first mooring was deployed without incident in 90 min on the morning of 18 March. It was designated as "Edgar". The procedure for launch was to deploy the floats first, pay out the mooring line, attach the end to the anchor and then drop the anchor. The mooring line was cut to a length equal to the water depth of 4150 meters giving a 1:1 scope.

The second mooring was deployed during the evening of 20 March in the same manner as the first. It was designated as "Allan". During the process of paying out the mooring line, wind and current

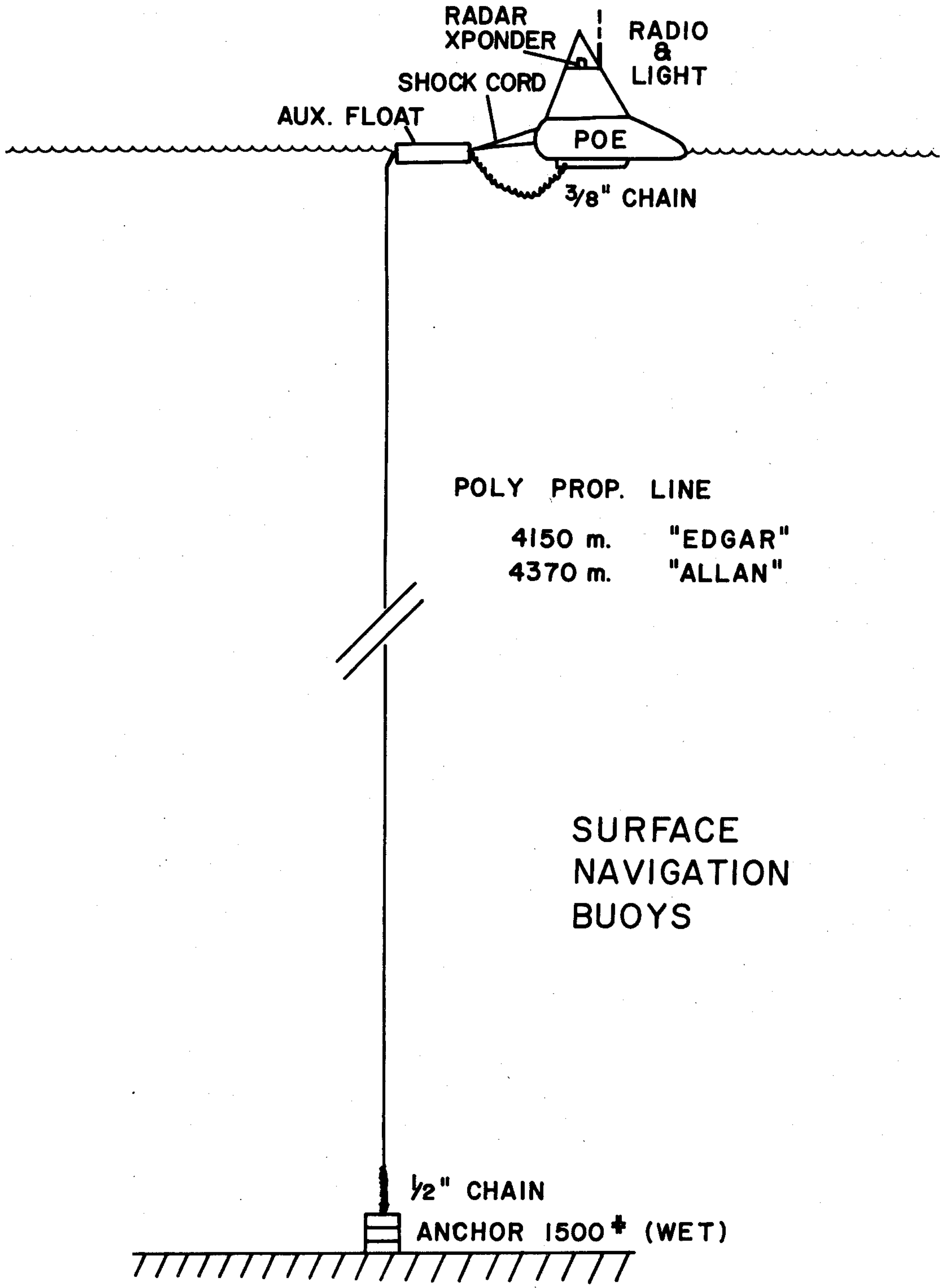

Figure 6. Schematic diagram of the navigation moorings. For precise navigational purposes two plank-on-edge (Poe) buoys, nicknamed "Edgar" and "Allan", were moored in the circumpolar current for periods of 5 and 3 days, respectively

set the vessel over an uncharted seamount. It was necessary to tow the mooring to a position of favorable topography and approximately 25 km southeast of "Edgar". This required 4 hours.

The positions of the moorings were continually monitored when in radar range at the time of "NAVSAT" fixes. Nominal positions thus obtained were:

EDGAR:	57°-28.35' S	64°-38.35' W
ALLAN:	57°-35.0' S	64°-20.5' W

Their position relative to each other was a range of 21.6 km at a bearing of 125°/305°. It is estimated that excursions of the buoys around the nominal positions did not exceed ±500 meters.*

The floats were recovered at the completion of the dense CTD program, on the morning of 23 March. Sometime during the early morning hours of 23 March "Allan" went adrift. The float was readily located and recovered during the morning of 23 March. Failure occurred at the keel of the buoy where the shackle pulled through the metal. Moderate to heavy swells and moderate sea and wind conditions on the 22 March are assumed to have precipated the failure.

The mooring "Edgar" survived intact and the float was recovered on the afternoon of 23 March. The float was pulled from the water to rail height by the ship's crane, the 4 meter shot of chain was stopped

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*The distance between the buoys was determined by the working range of the radar transponders, which was about 25% less than what was anticipated. "Edgar" was placed in a region of deep interleaving after two XBT crossings of the Polar Front had been made. "Allan" was deployed after two more front crossings. It was placed on a line normal to the Polar Front but on the warm side of its subsurface expression.

off, the float disconnected and the chain then allowed to drop overboard and sink. The auxiliary float had towed under in the current and remained submerged during the recovery operation and was subsequently lost.

Both floats were in excellent condition at recovery and both radios worked. The light on "Edgar" had failed.

III. XBT

Two recording systems were used aboard the T. G. THOMPSON during the third leg of FDRAKE-76. A standard Sippican Co. Expendable Bathythermograph (XBT) recorder was used to record approximately 150 traces. An expanded scale XBT recorder (EXBT), similar to one used on R. D. CONRAD during FDRAKE-75, recorded an additional 300 XBT shots.

The XBT work aboard the THOMPSON was carried out with the following objectives:

Temperature section work, polar front location
Temperature survey work in preparation for float launching (VCMs)
Monitoring of vertical temperature structure around deployed VCMs
Small scale, time and space, XBT experiments.

To facilitate organization of the XBT data, we show in Tables 1,2 the XBT number versus activity related to the above four scientific goals.

A. XBT Survey and Section Work

Of the total number of 472 XBTs taken, approximately 300 standard and expanded XBTs were taken for section work. Isotherm depths (for 0.5 C° increments of temperature) were routinely recorded and working plots made. These were used to steer the ship. During the course of the cruise, the polar front and frontal eddy (FREDDY) were crossed sixteen times by the THOMPSON. The positions of the front and FREDDY need to be combined with those taken by the AGS YELCHO before a complete time evolving picture of the polar front can be drawn. One of the XBT sections from the THOMPSON is shown in Fig. 1. This section is typical showing clearly the abrupt subsurface transition between cold, antarctic, and warm subantarctic waters. The 2° C isotherms at 200 meters was taken as the operational southern boundary of the frontal zone, "North" of this one enters a zone where interleaving and mixing of the two water masses occurs.

Table 1

XBT/Activity Table

No.	
8-51	CRS 150°, Section 1, 1st southward venture across PF
52	CTD #4, "A"
62-70	CRS 100°
70-74	CRS 180°, Section 2
75-84	CRS 300°
85-89	CRS 135°, Section #2b, cross PF start CTD section (#25,39)
90-93	CRS 170° in route to CTD #140, start down stream front survey
94-95	between CTD 41,42 and 42,43 part of down stream front survey
96-100	prior to float (VCM) launching
101-107	launch VCM's 4 and 5
108-112	over VCM's 4 and 5
115-127	CRS 150°, Section 3, speed 6 knots, across float trajectory VCM 1, 4, 5, end pt. CTD 4
131-139	CRS 045° } Section 4, additional survey
139-148	CRS 330° } for float #1
149,150-164	CRS 180°, Section #5, parallel to front
168	close to #5
169-180	searching for float #5 in the vicinity of eddy Freddy
180-199	CRS 180°, Section #6, re-establish PF position
199-221	CRS 340°-360°

Table 1 (Contd.)

XBT/Activity Table

No.	
223-227	CRS 90°, Section #7, CTD 54, jaunt to Freddy
228-230	CRS 180°, Section #7b, random venture in search of Freddy's rim
231-237	CRS 350° heading for VCM #2
223,224,245-254	CRS 130°, CTD 57 } Section #8, across Freddy and south to re-establish position
254-270	CRS 180°, CTD 58 } Section #8, across Freddy and south to re-establish position
271-274	CRS 330°, CTD 59, another crossing of PF
279-435	EXBT experiments 1, 2, 3, and 4
436-440	CRS 160°, heading south looking for PF
442-457	CRS 350° } North-South section in conjunction with CTD section (CTD #77-101)
458-472	CRS 300° } North-South section in conjunction with CTD section (CTD #77-101)

Table 2

EXBT Experiments

Experiment	
1	Yo-Yo #1: over float #1, EXBT's #279-306 3 at 10 min, 24 at 5 min intervals Lost ranging after ~1 hr
2	Yo-Yo #2: over float #1, EXBT's #309-334 25 at 5 min intervals, 1.5 hrs of data at nominal slant range 800 m
3	"Box": float #1 at center; EXBT's #335-356 ship speed 4 knots, 20 min on a side, XBT's every 5 min
4	"Cross": float #1 at center; EXBT's #360-435 ship speed 5 knots, XBT's every 5 min

Total number of EXBT ~150.

For most of the survey stations, water samples were drawn for surface salinities and silicates and bucket temperatures taken for calibration of the XBTs. Most of our work was in the vicinity of the sub-surface expression of the polar front; the surface expression occurs some 40-60 nm south of this (see Section VII, Chemistry). Therefore the surface variables do not show any profound change in most of our data.

B. EXBT System

The standard Sippican Co. Expendable Bathythermograph (XBT) bridge and recording system has an indicated temperature scale of -2° C-35° C, approximately 5° C/inch and a depth scale of 100 meters/inch. These fixed scales are somewhat awkward when one is working in regions of the ocean where the temperature of the entire water column varies by as little as 2° C. To overcome these limitations we replaced the Sippican XBT bridge and recorder with a simple and inexpensive bridge. We utilized an Hewlett Packard strip chart recorder (model 7100B) to plot the output from the bridge. Figure 7 illustrates the difference between the EXBT scales and the standard Sippican XBT recorder scales.

Theory of Operation

The Sippican XBT probe consists of a molded projectile with a thermistor recessed in the nose, which falls through the water column at an approximately constant rate. The resistance of the thermister is sensed through a copper wire which unwinds from a spool contained within the projectile (see Fig. 8a) and from a second spool remaining in the launcher.

The thermistor's resistance, R_T, decreases about 5% per degree centigrade temperature increase. In addition to the resistance change of interest, the resistance of the copper wire, R_C, and the sea water to ship's ground, R_{SW}, vary continuously. Figures 8a and 8c detail the resistance involved in the primary and secondary measurement loops. The secondary loop is identical to the primary loop except that it does not contain a thermistor.

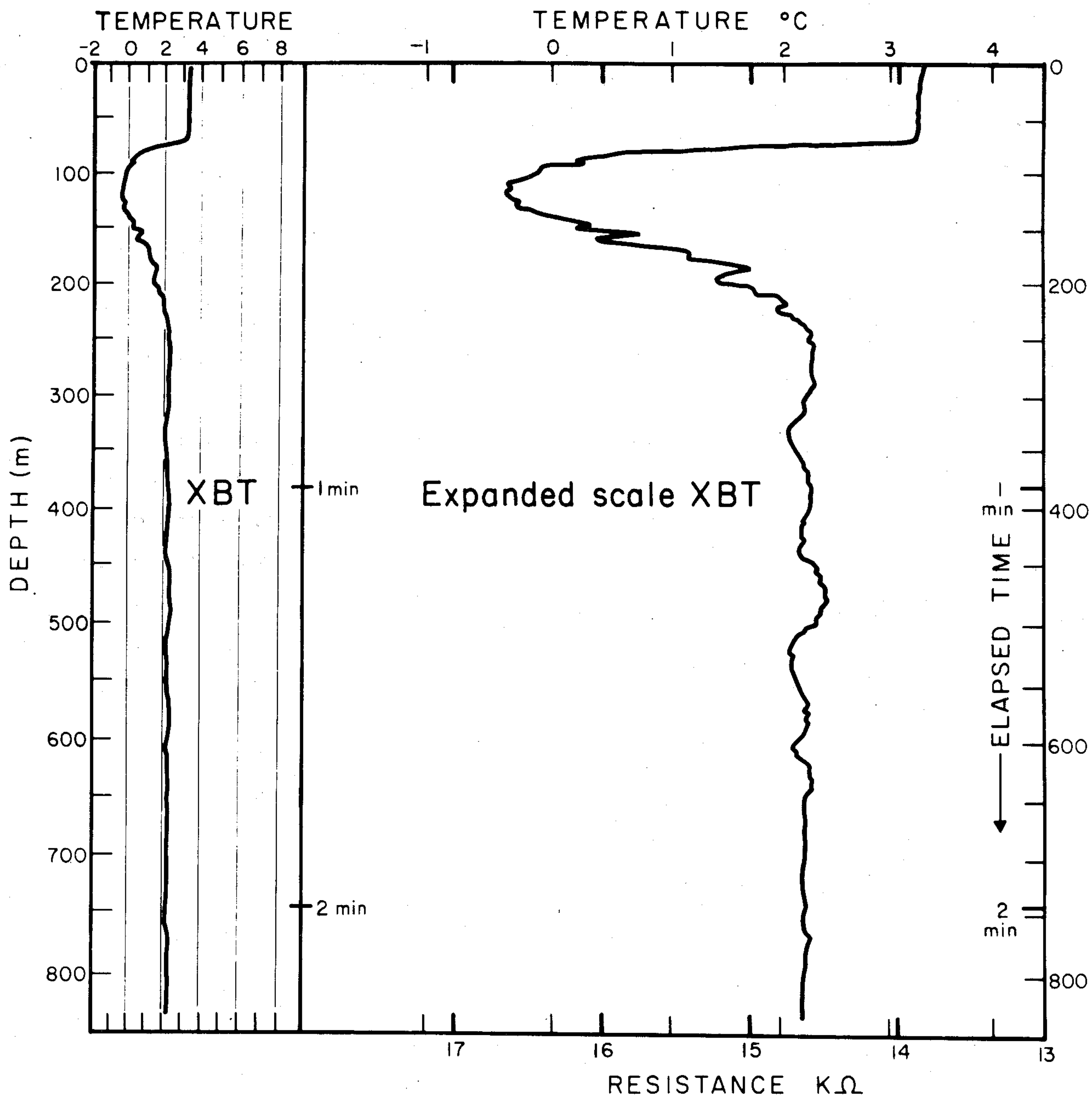


Figure 7. A comparison of a regular and an expended scale XBT profile. 300 of the total 450 expendable bathythermograph traces were recorded on an expanded scale. The oceanographic variables of depth and temperature are displayed as well as the engineering units of elapsed time and electrical resistance

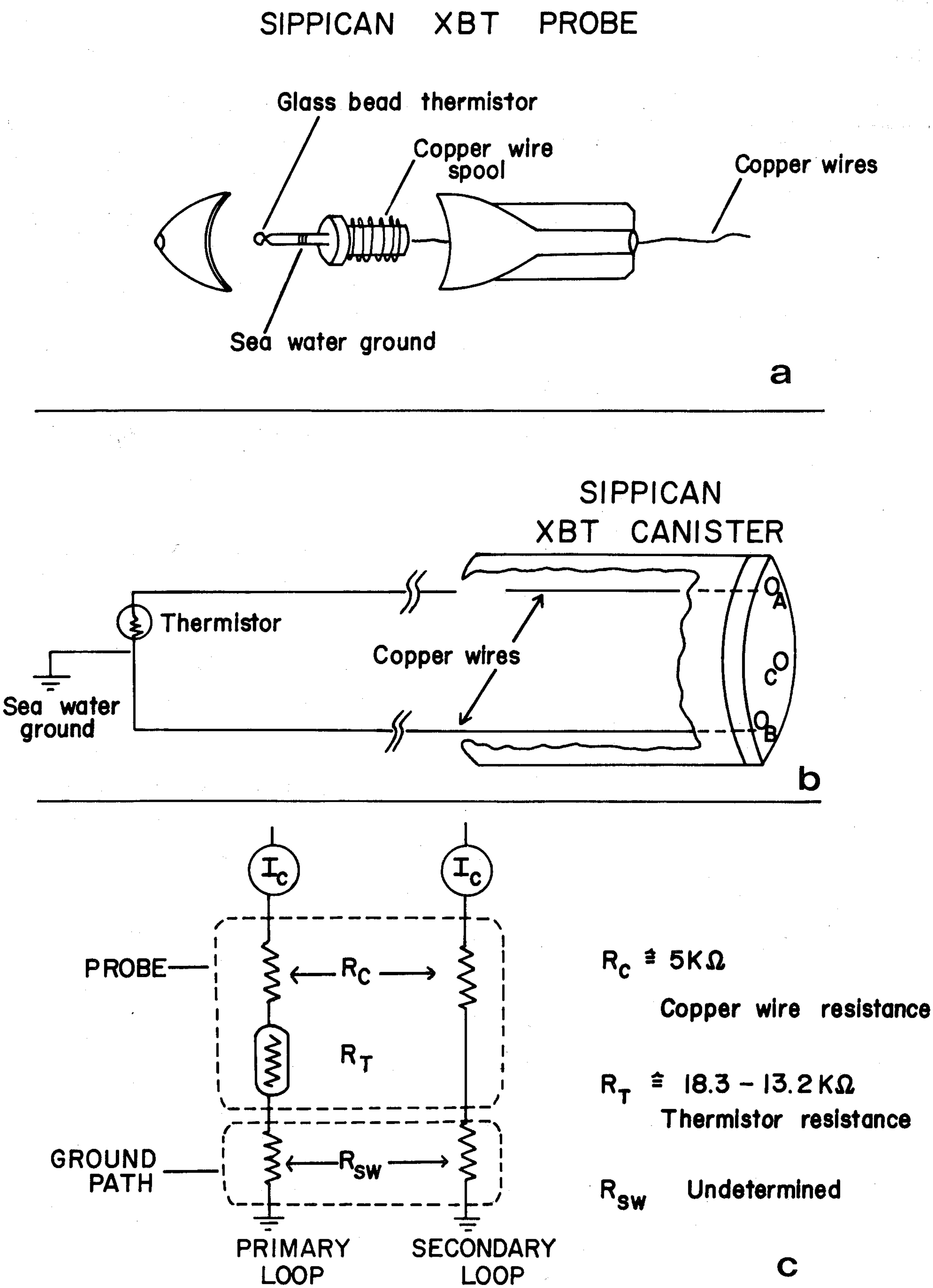


Figure 8. Details of a regular XBT system: probe (a), canister (b), and resistances network (c)

The expanded scale XBT recording system is comprised of the new bridge and analog recorder (Fig. 9). The bridge consists of a precision voltage source, a dual constant current source, and a differential amplifier (Fig. 10). The constant current source supplies two identical currents which flow through the primary and secondary loops of the XBT probe and sea-water-ship ground path (Fig. 8c). The constant current I flowing in the primary loop results in potential V_1:

$$V_1 = I \cdot (R_{sw} + R_c + R_t)$$

The current I in the secondary loop results in a potential V_2:

$$V_2 = I \cdot (R_{sw} + R_c) \ .$$

The resistance variation R_t can be isolated by monitoring the differential voltage $V_1 - V_2$.

$$R_t = (V_1 - V_2)/I \ .$$

The analog recorder is then used to record an output from the bridge proportional to R_t.

Below are given the resistance and temperature values supplied by Sippican Co. (Sippican Manual R-467B, Table 5-1) used to obtain R(T) and T(R) for interpretation of EXBT data. Also given below is the relationship between elapsed time and depth of the XBT probe.

Temperature °C	Resistance kΩ	Temperature °C	Resistance kΩ
-2.2	18.308	5.6	12.357
-2.0	18.094	6.0	12.085
-1.1	17.287	6.7	11.699
-1.0	17.186	7.0	11.506
0.0	16.329	7.8	11.080
1.0	15.518	8.0	10.958
1.1	15.433	8.9	10.496
2.0	14.752	9.0	10.439
2.2	14.591	10.0	9.948
3.0	14.028	11.0	9.483
3.3	13.800	11.1	9.434
4.0	13.344	12.0	9.043
4.4	13.057	12.2	8.950
5.0	12.697		

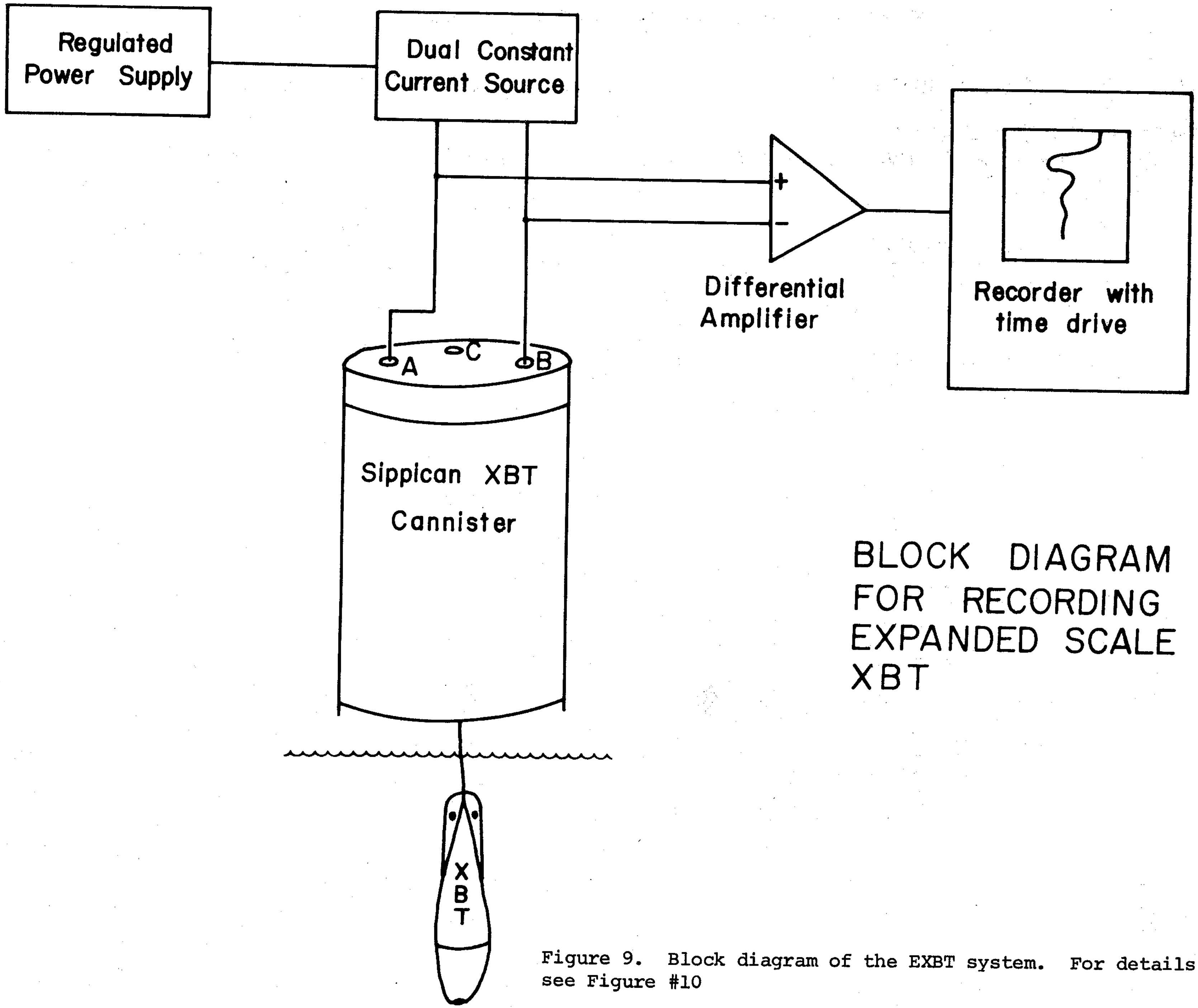


Figure 9. Block diagram of the EXBT system. For details see Figure #10

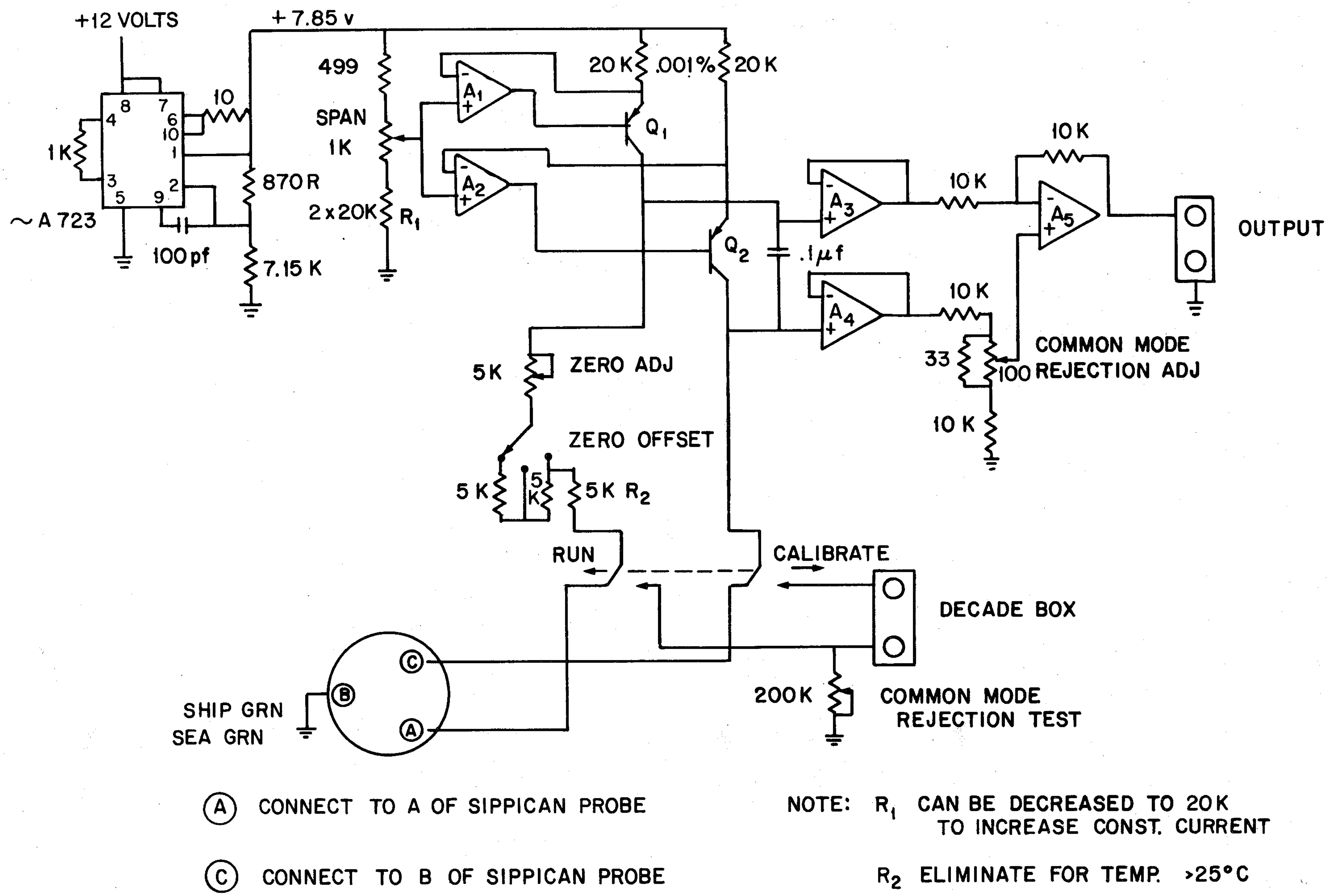


Figure 10. Electric circuit diagram of the EXBT-system

Least-square minimization was used to obtain 4th order polynomials for R(T) and T(R).

$A_0 = 16.32902$	$B_0 = 51.08125$
$A_1 = -.8336822$	$B_1 = -7.256200$
$A_2 = .2395431 \cdot 10^{-1}$	$B_2 = .4455120$
$A_3 = -.524036 \cdot 10^{-3}$	$B_3 = -.153488 \cdot 10^{-1}$
$A_4 = .844554 \cdot 10^{-5}$	$B_4 = .217192 \cdot 10^{-3}$

$$T(R) = B_0 + B_1R + B_2R^2 + B_3R^3 + B_4R^4$$

$$R(T) = A_0 + A_1T + A_2T^2 + A_3T^3 + A_4T^4$$

$$*D(t) = 6.472t - 0.00216\ t^2$$

T = Temperature [°C]

R = Resistance [kΩ]

D = Depth [m]

t = Time [secs]

*From Sippican (1970) Ocean Engineering Bulletin No. 1.

C. EXBT Experiments

Four EXBT experiments (Table 2) were carried out during Phase II of VCM Float tracking. The experiments were designed to elucidate space and time scales of the vertical temperature structure in the Polar Front Zone. By positioning the ship relative to the floats it was hoped that space and time variability of the finestructure, interleaving, would be separated. The first two experiments were carried out with the ship attempting to hold position relative to VCM float #1. (Nominal float depth 400 m.) The ship then steamed patterns relative to float #1 while XBT's were shot every 5 minutes.

The first 2 EXBT experiments (Yo-Yo #1 and Yo-Yo #2) were carried out on the 30 and 31st of March. Approximately 50 XBTs were shot at 5 min intervals. However, during Yo-Yo #1 an on-deck equipment failure in the TRACS system (see Section VIII, VCM) precludes the exact determination of slant range during the 2nd hour of the Yo-Yo. From slant range differences for floats #1 and #2 we estimate our position to have been 1.5 km-1.8 km. During Yo-Yo #2 all equipment functioned properly. We were able to position the ship relative to float #1 for 2 hours. About 1.5 hours of data was obtained while the ship held a slant range of 800 m.

Two additional experiments were carried out while the ship was underway. In experiment 3 the ship steamed a box pattern (20 min/side at 5 knots) centered on float #1. XBTs were shot every 5 min and slant ranges are available for the entire experiment. For the 4th experiment a cross pattern was steamed (approximately 6 km by 6 km). The ship speed was 5 knots and XBTs were shot every 5 min.

D. EXBT/CTD Intercomparisons

An attempt was also made to collect XBT and EXBT data during CTD casts (Table 3). The CTD data will be used to verify observed temperature fine structure in EXBT records. We hope to critically evaluate the temperature and depth resolution of the XBT probes.

Approximately 15 EXBT/CTD intercomparisons were attempted during this cruise. In Fig. 11 the CTD lowering #69 and EXBT #314 are presented. The temperature and pressure axis of the CTD trace have been adjusted to approximately match those of the EXBT. The EXBT trace has been digitized and the non-linearity in the temperature/depth trace removed.

Table 3

CTD/EXBT Intercomparison

	EXBT #	CTD
1	2	1
2	4	3
3	52	4
4	62	23
5	100	44
6	114	46
7	127	47
8	130	50
9	131	51
10	144	52
11	149	53
12	228	55
13	236/237	56
14	250	57
15	314	69

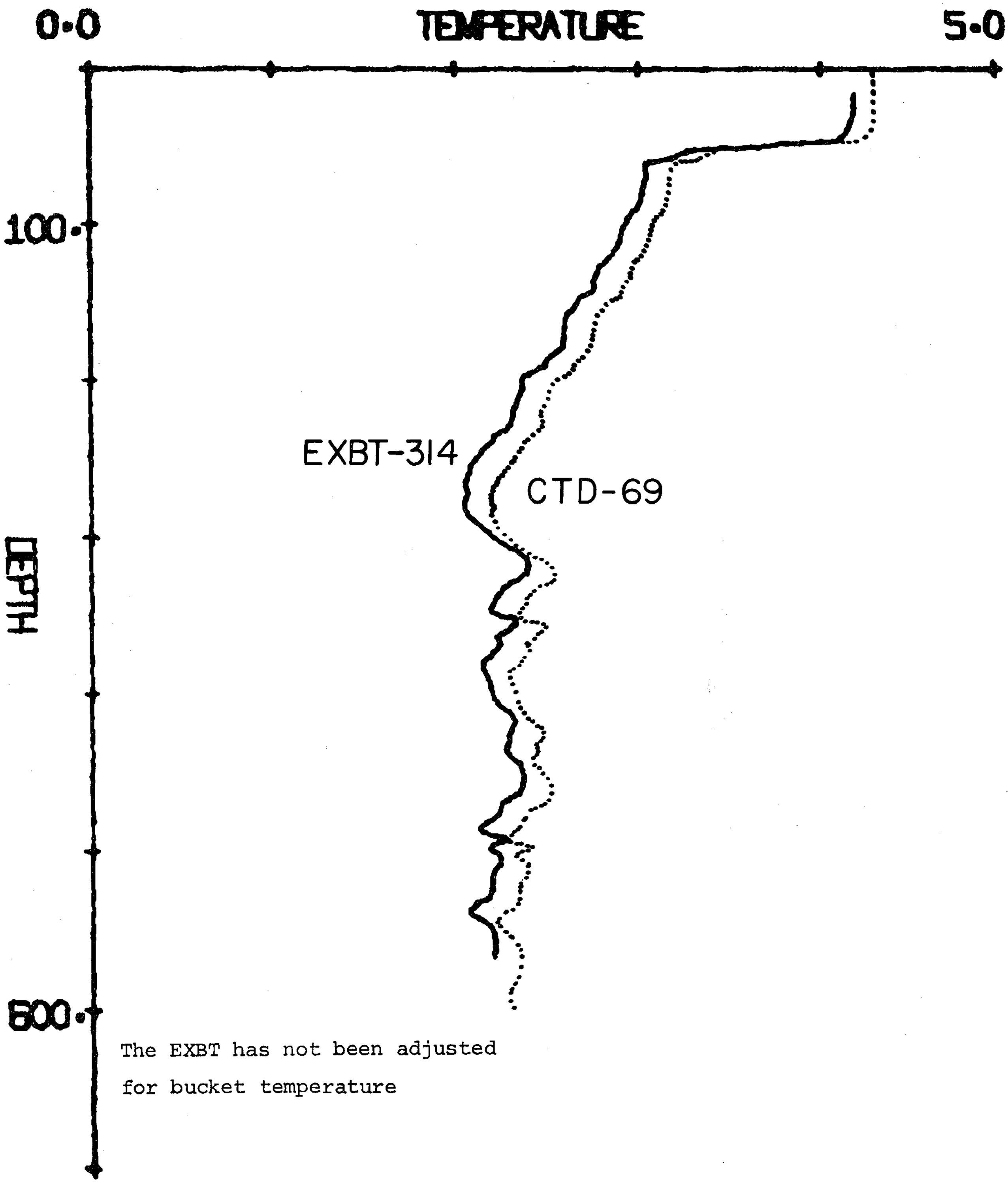


Figure 11. Graphical display of an EXBT/CTD intercomparison

E. XBTs (T_7 and T_4 Probes - Trials and Tribulations)

Of the three cases of T_7 (700 m XBT) aboard the THOMPSON, only one was used. A second case 12 T_7's was opened, of which there now remain 5. The first case of T_7's functioned properly, however, the 7 XBTs from the second case proved to be duds. Six of the 7 traces can be found on the third of 3 rolls of Sippican XBT paper: The T_7-XBT shots were

#458

#456

#455

#450A

#447

#445A

The above T_7's all showed a similar mode of failure: excessive spiking towards high temperature. In addition it was necessary to rewind wire onto the canister wire spool.

Approximately 42-1/2 cases of T_4's (400 m XBT) were shot during Leg III of FDRAKE 76. The overall success rate ran around 10 good XBTs per case of 12. Many of the T_4's were rewound prior to launching. The special handling appears to insure successful XBT shots! A summary of XBT station data is given in Table 4.

Table 4

XBT Station Log

TYPE	NO.	TIME		DATE	LAT.		LONG.		DEPTH	B.T.	SALT	SIL
EXBT	1	11	15	15/ 3/76	0	0.0S	0	0.0W	0	6.58	0.000	0.0
EXBT	2	13	18	15/ 3/76	0	0.0S	0	0.0W	0	0.00	0.000	0.0
XBT	3	0	25	16/ 3/76	0	0.0S	0	0.0W	0	0.00	0.000	0.0
EXBT	4	0	30	16/ 3/76	55	24.6S	65	35.9W	0	6.50	34.103	0.0
EXBT	5	1	35	16/ 3/76	55	24.6S	65	35.9W	0	6.70	34.081	1.6
XBT	6	0	0	16/03/76	0	0.0S	0	0.0W	0	0.00	0.000	0.0
XBT	7	0	0	16/03/76	0	0.0S	0	0.0W	0	0.00	0.000	0.0
XBT	8	2	30	16/ 3/76	55	30.0S	65	42.0W	0	6.00	34.097	1.3
EXBT	9	3	15	16/ 3/76	55	37.0S	65	54.0W	1410	0.00	0.000	0.0
EXBT	10	3	24	15/ 3/76	55	38.0S	65	54.0W	0	0.00	0.000	0.0
EXBT	11	3	45	16/ 3/76	55	41.0S	65	59.0W	1050	6.90	34.004	1.6
EXBT	12	4	58	16/ 3/76	55	48.9S	66	10.8W	490	6.70	34.069	1.7
XBT	13	0	0	16/03/76	0	0.0S	0	0.0W	0	0.00	0.000	0.0
XBT	14	0	0	16/03/76	0	0.0S	0	0.0W	0	0.00	0.000	0.0
EXBT	15	5	8	16/ 3/76	55	58.5S	66	21.1W	480	7.30	33.961	1.0
EXBT	16	6	0	16/ 3/76	56	6.3S	66	14.8W	295	6.50	34.109	1.1
XBT	17	0	0	16/03/76	0	0.0S	0	0.0W	0	0.00	0.000	0.0
XBT	18	0	0	16/03/76	0	0.0S	0	0.0W	0	0.00	0.000	0.0
EXBT	19	8	20	16/ 3/76	56	13.7S	66	4.5W	1005	6.90	34.021	1.0
EXBT	20	9	0	16/ 3/76	56	18.9S	66	0.3W	1385	7.10	33.976	2.3
XBT	21	0	0	16/03/76	0	0.0S	0	0.0W	0	0.00	0.000	0.0
XBT	22	0	0	16/03/76	0	0.0S	0	0.0W	0	0.00	0.000	0.0
XBT	23	10	15	16/ 3/76	56	29.8S	65	48.9W	2000	0.00	34.037	1.6
XBT	24	11	2	16/ 3/76	56	37.1S	65	41.5W	2035	5.90	34.085	1.7
XBT	25	12	0	16/ 3/76	56	43.6S	65	31.2W	2005	0.00	00.000	0.0
XBT	26	12	10	16/ 3/76	56	44.8S	65	30.4W	2040	5.90	34.075	1.4
XBT	27	13	0	16/ 3/76	56	51.0S	65	23.0W	2145	5.60	33.961	1.6
XBT	28	14	0	16/ 3/76	57	0.0S	65	12.7W	2155	5.70	34.082	1.3
XBT	29	15	0	16/ 3/76	57	8.5S	65	5.6W	2190	5.70	34.053	1.1
XBT	30	15	55	16/ 3/76	57	17.7S	64	57.4W	2280	5.30	34.035	1.4
XBT	31	0	0	16/03/76	0	0.0S	0	0.0W	0	0.00	0.000	0.0
XBT	32	17	5	16/ 3/76	57	24.4S	64	50.5W	2260	5.00	33.980	1.4
EXBT	33	17	23	16/ 3/76	57	28.1S	64	46.5W	2260	0.00	0.000	0.0
EXBT	34	17	40	16/ 3/76	57	31.4S	64	43.0W	2250	0.00	0.000	0.0
EXBT	35	18	0	16/ 3/76	57	34.5S	64	40.0W	2260	5.00	33.984	1.6
EXBT	36	18	20	16/ 3/76	57	37.8S	64	36.0W	2290	5.05	33.995	1.4
EXBT	37	18	25	16/ 3/76	57	38.5S	64	35.3W	2300	0.00	33.983	1.4
XBT	38	18	50	16/ 3/76	57	42.0S	64	31.0W	2330	4.90	33.997	1.6
EXBT	39	18	50	16/ 3/76	57	42.0S	64	31.0W	2330	4.90	33.997	1.6
EXBT	40	19	6	16/ 3/76	57	39.2S	64	28.3W	2330	5.00	33.993	1.4
XBT	41	20	05	16/03/76	57	48.1S	64	17.4W	2345	0.00	0.000	0.0
XBT	42	20	30	16/03/76	57	52.2S	64	12.9W	2005	0.00	0.000	0.0
XBT	43	21	00	16/03/76	57	56.4S	64	08.4W	2020	0.00	0.000	0.0
XBT	44	21	25	16/ 3/76	57	58.1S	64	7.8W	1840	4.10	0.000	1.6
XBT	45	22	6	16/ 3/76	58	6.1S	63	58.0W	1750	4.00	0.000	1.6
XBT	46	23	4	16/ 3/76	58	13.8S	63	49.0W	1640	3.70	33.872	2.3
XBT	47	0	0	17/ 3/76	58	23.1S	63	41.2W	1965	3.75	33.893	1.9
XBT	48	1	0	17/ 3/76	58	33.0S	63	31.5W	2130	3.70	33.904	2.1
XBT	49	2	0	17/ 3/76	58	43.3S	63	23.0W	2020	3.60	0.000	2.6
XBT	50	3	0	17/ 3/76	58	52.5S	63	12.9W	2140	3.60	33.849	3.9

XBT	51	4	0	17/ 3/76	59	1.9S	63	2.5W	2160	4.12	33.925	2.4
EXBT	52	16	50	17/ 3/76	59	4.3S	63	55.2W	2050	3.38	33.820	2.1
XBT	53	03	00	17/03/76	58	14.6S	63	58.3W	0	0.00	0.000	0.0
XBT	54	3	5	18/ 3/76	58	42.0S	64	0.0W	2055	3.45	33.845	3.4
XBT	55	4	0	18/ 3/76	58	35.0S	64	3.4W	2000	3.25	33.821	6.6
XBT	56	5	0	18/ 3/76	58	23.8S	64	10.1W	1950	3.10	0.000	5.0
XBT	57	6	0	18/ 3/76	58	15.4S	64	15.6W	2000	3.95	33.947	1.7
XBT	58	7	0	18/ 3/76	58	5.7S	64	21.8W	1500	4.20	33.989	2.7
XBT	59	8	0	18/ 3/76	57	56.1S	64	27.5W	1980	4.90	34.019	1.3
XBT	60	8	30	18/ 3/76	57	50.8S	64	30.6W	1900	4.80	34.009	2.1
XBT	61	9	3	18/ 3/76	57	45.5S	64	35.6W	1940	4.80	34.001	1.4
EXBT	62	7	0	20/ 3/76	57	26.2S	64	34.8W	2190	5.00	0.000	0.0
EXBT	63	8	0	20/ 3/76	57	27.3S	64	27.5W	2190	5.00	33.824	1.7
EXBT	64	8	30	20/ 3/76	57	28.6S	64	20.9W	2250	4.85	33.822	1.6
EXBT	65	9	0	20/ 3/76	57	30.0S	64	11.5W	1700	4.90	34.021	0.0
EXBT	66	9	30	20/ 3/76	57	31.7S	64	3.7W	2220	4.60	34.017	1.7
EXBT	67	10	0	20/ 3/76	57	33.4S	63	54.7W	2330	4.70	34.014	1.7
EXBT	68	10	36	20/ 3/76	57	34.8S	63	44.3W	2110	4.30	33.987	2.3
EXBT	69	11	5	20/ 3/76	57	36.7S	63	35.2W	2130	4.70	34.013	1.7
EXBT	70	11	34	20/ 3/76	57	38.0S	63	27.3W	2030	4.40	33.982	1.7
EXBT	71	12	0	20/ 3/76	57	41.9S	63	27.3W	1980	4.70	34.017	1.7
EXBT	72	12	30	20/ 3/76	57	47.7S	63	25.0W	1990	4.27	33.971	1.4
EXBT	73	13	0	20/ 3/76	57	52.5S	63	25.0W	2090	4.18	33.942	2.0
EXBT	74	13	15	20/ 3/76	57	56.5S	63	25.0W	2250	4.18	33.950	1.7
EXBT	75	13	45	20/ 3/76	57	55.7S	63	30.7W	2240	3.95	33.934	1.7
EXBT	76	14	15	20/ 3/76	57	51.8S	63	38.5W	2190	3.97	33.924	1.9
EXBT	77	14	45	20/ 3/76	57	48.9S	63	46.4W	2185	4.05	33.940	1.6
EXBT	78	15	20	20/ 3/76	57	45.0S	63	56.5W	2250	3.98	33.985	1.6
EXBT	79	15	45	20/ 3/76	57	43.2S	64	1.7W	2300	3.95	33.916	1.9
EXBT	80	16	15	20/ 3/76	57	39.7S	64	9.0W	2210	4.22	34.012	1.6
XBT	81	0	0	20/03/76	0	0.0S	0	0.0W	0	0.00	0.000	0.0
EXBT	82	16	45	20/ 3/76	57	36.6S	64	15.5W	2270	4.50	34.005	1.7
EXBT	83	17	15	20/ 3/76	57	35.6S	64	17.5W	0	4.80	34.021	2.3
EXBT	84	19	45	20/ 3/76	57	33.1S	64	24.7W	0	4.60	34.004	2.1
EXBT	85	4	50	21/ 3/76	57	35.3S	64	25.2W	0	4.60	33.945	2.6
EXBT	86	5	15	21/ 3/76	57	36.8S	64	21.9W	2150	4.50	34.011	2.1
EXBT	87	5	45	21/ 3/76	57	39.5S	64	8.8W	0	4.25	33.976	1.6
EXBT	88	6	15	21/ 3/76	57	42.3S	64	1.7W	2190	4.10	34.025	2.1
EXBT	89	6	45	21/ 3/76	57	45.2S	63	54.3W	2180	3.70	33.878	3.0
EXBT	90	4	0	23/ 3/76	57	29.1S	64	29.8W	2210	4.90	0.000	1.7
EXBT	91	4	30	23/ 3/76	57	33.0S	64	26.0W	2350	4.90	0.000	1.7
EXBT	92	5	0	23/ 3/76	57	37.9S	64	23.1W	2360	4.50	0.000	1.0
EXBT	93	7	15	23/ 3/76	57	37.9S	64	18.5W	0	4.70	0.000	2.9
EXBT	94	8	56	23/ 3/76	57	35.5S	64	13.5W	2250	4.50	0.000	0.0
EXBT	95	10	40	23/ 3/76	57	31.4S	64	3.8W	0	4.70	0.000	1.7
EXBT	96	19	5	23/ 3/76	57	28.7S	64	36.6W	0	5.60	0.000	0.0
EXBT	97	19	15	23/ 3/76	57	29.2S	64	34.3W	0	5.60	0.000	0.0
EXBT	98	19	44	23/ 3/76	57	30.0S	64	30.6W	0	5.25	0.000	0.0
EXBT	99	20	16	23/ 3/76	57	31.1S	64	25.4W	0	5.00	0.000	0.0
EXBT	100	21	10	23/ 3/76	57	31.6S	64	18.7W	0	4.83	0.000	0.0
EXBT	101	0	50	24/ 3/76	57	29.0S	64	16.1W	2010	4.70	0.000	1.9
EXBT	102	1	20	24/ 3/76	57	28.6S	64	11.4W	2010	4.70	0.000	1.7
XBT	103	0	0	24/03/76	0	0.0S	0	0.0W	0	0.00	0.000	0.0
EXBT	104	1	55	24/ 3/76	57	28.6S	64	7.6W	0	4.85	0.000	1.7
EXBT	105	2	25	24/ 3/76	57	29.7S	64	5.5W	0	4.70	0.000	1.6
EXBT	106	2	55	24/ 3/76	57	31.9S	64	5.6W	0	4.70	0.000	2.9
EXBT	107	3	20	24/ 3/76	57	34.0S	64	5.4W	0	4.40	0.000	0.0
EXBT	108	5	35	24/ 3/76	57	31.3S	64	4.7W	0	4.45	0.000	0.0
XBT	109	7	45	24/ 3/76	57	29.2S	64	3.3W	0	4.52	0.000	0.0
EXBT	110	9	10	24/ 3/76	57	28.4S	64	2.9W	0	0.00	0.000	0.0

EXBT	111	12	0	24/ 3/76	57	20.1S	64	4.1W	0	4.80	0.000	0.0
EXBT	112	16	25	24/ 3/76	57	25.9S	65	52.5W	0	4.90	0.000	0.0
EXBT	113	18	15	25/ 3/76	57	24.2S	63	50.2W	0	4.90	0.000	0.0
EXBT	114	23	3	24/ 3/76	57	14.1S	63	57.2W	0	4.90	0.000	0.0
EXBT	115	2	40	25/ 3/76	57	7.2S	63	59.8W	0	4.90	0.000	1.4
XBT	116	3	10	25/ 3/76	57	9.4S	63	57.7W	0	4.90	0.000	1.9
EXBT	117	3	40	25/ 3/76	57	11.6S	63	54.9W	0	4.90	0.000	1.9
EXBT	118	4	10	25/ 3/76	57	14.2S	63	51.2W	0	4.90	0.000	0.0
EXBT	119	4	40	25/ 3/76	57	16.6S	63	48.2W	0	5.10	0.000	0.0
EXBT	120	5	10	25/ 3/76	57	18.8S	63	45.0W	0	4.75	0.000	0.0
EXBT	121	5	40	25/ 3/76	57	21.2S	63	42.0W	0	4.50	0.000	0.0
EXBT	122	6	10	25/ 3/76	57	23.4S	63	38.8W	0	4.20	0.000	0.0
XBT	123	0	0	25/03/76	0	0.0S	0	0.0W	0	0.00	0.000	0.0
EXBT	124	6	43	25/ 3/76	57	25.8S	63	35.5W	0	4.20	0.000	0.0
XBT	125	0	0	25/03/76	0	0.0S	0	0.0W	0	0.00	0.000	0.0
EXBT	126	7	10	25/ 3/76	57	28.9S	63	32.8W	0	4.40	0.000	0.0
EXBT	127	7	40	25/ 3/76	57	31.6S	63	30.5W	0	4.35	0.000	0.0
EXBT	128	17	28	25/ 3/76	57	26.9S	63	23.8W	1970	4.40	0.000	0.0
EXBT	129	8	45	26/ 3/76	57	26.3S	63	19.5W	1950	4.50	0.000	0.0
EXBT	130	12	55	26/ 3/76	57	41.0S	63	22.9W	1980	4.10	0.000	0.0
EXBT	131	18	25	26/ 3/76	57	55.9S	63	34.7W	0	4.35	0.000	0.0
EXBT	132	19	30	26/ 3/76	57	52.6S	63	31.5W	0	4.30	0.000	0.0
EXBT	133	20	0	26/ 3/76	57	50.0S	63	26.0W	2030	4.25	0.000	0.0
EXBT	134	20	30	26/ 3/76	57	47.2S	63	20.4W	1960	4.90	0.000	0.0
EXBT	135	21	0	26/ 3/76	57	44.3S	63	14.5W	0	4.90	0.000	0.0
EXBT	136	21	30	26/ 3/76	57	41.0S	63	7.6W	0	4.82	0.000	0.0
EXBT	137	22	0	26/ 3/76	57	38.0S	63	1.0W	0	4.90	0.000	0.0
EXBT	138	22	30	26/ 3/76	57	34.9S	62	54.5W	0	5.10	0.000	0.0
EXBT	139	23	0	26/ 3/76	57	32.0S	62	48.2W	2090	5.15	0.000	0.0
EXBT	140	23	30	26/ 3/76	57	28.5S	62	51.1W	2075	5.00	0.000	0.0
EXBT	141	0	2	27/ 3/76	57	24.7S	62	55.0W	2060	5.05	0.000	0.0
EXBT	142	0	30	27/ 3/76	57	21.1S	62	58.3W	0	4.80	0.000	0.0
EXBT	143	1	0	27/ 3/76	57	16.6S	63	3.9W	1980	4.80	0.000	0.0
EXBT	144	1	30	27/ 3/76	57	13.2S	63	7.3W	2025	4.90	0.000	0.0
EXBT	145	2	0	27/ 3/76	57	9.5S	63	11.6W	0	4.90	0.000	0.0
EXBT	146	2	30	27/ 3/76	57	5.7S	63	15.7W	2100	4.95	0.000	0.0
EXBT	147	3	0	27/ 3/76	57	1.9S	63	20.0W	2040	4.80	0.000	0.0
EXBT	148	3	30	27/ 3/76	56	58.8S	62	22.6W	2040	4.80	0.000	0.0
EXBT	149	6	47	27/ 3/76	56	45.2S	63	20.1W	2125	4.90	0.000	0.0
EXBT	150	10	0	27/ 3/76	56	45.2S	63	17.2W	2120	4.90	0.000	0.0
EXBT	151	10	30	27/ 3/76	56	47.1S	63	16.4W	0	4.85	0.000	0.0
EXBT	152	11	0	27/ 3/76	56	50.8S	63	15.7W	0	4.80	0.000	0.0
XBT	153	11	30	27/03/76	0	0.0S	0	0.0W	0	0.00	0.000	0.0
EXBT	154	11	30	27/ 3/76	56	56.2S	63	15.7W	0	4.90	0.000	0.0
EXBT	155	12	0	27/ 3/76	57	0.8S	63	15.8W	0	5.10	0.000	0.0
EXBT	156	12	30	27/ 3/76	57	5.9S	63	15.9W	0	4.90	0.000	0.0
EXBT	157	13	0	27/ 3/76	57	9.6S	63	15.9W	2090	4.70	0.000	0.0
EXBT	158	13	30	27/ 3/76	57	14.8S	63	16.0W	2045	4.60	0.000	0.0
EXBT	159	14	0	27/ 3/76	57	20.1S	63	16.0W	2000	4.50	0.000	0.0
EXBT	160	14	30	27/ 3/76	57	25.9S	63	16.2W	0	4.40	0.000	0.0
EXBT	160B	14	45	27/ 3/76	57	28.0S	63	16.3W	1930	4.40	0.000	0.0
EXBT	161	15	0	27/ 3/76	57	30.1S	63	16.5W	1930	4.40	0.000	0.0
XBT	162	17	30	27/ 3/76	57	48.1S	63	25.1W	1980	4.40	0.000	0.0
XBT	163	18	00	27/03/76	57	50.8S	63	26.5W	0	0.00	0.000	0.0
XBT	164	18	10	27/ 3/76	57	51.5S	63	27.0W	2070	4.30	0.000	0.0
XBT	165	0	0	27/03/76	0	0.0S	0	0.0W	0	0.00	0.000	0.0
XBT	166	0	0	27/03/76	0	0.0S	0	0.0W	0	0.00	0.000	0.0
XBT	167	19	14	27/03/76	57	53.4S	63	36.3W	0	0.00	0.000	0.0
XBT	168	19	25	27/ 3/76	57	53.4S	63	38.3W	2170	4.45	0.000	0.0
XBT	169	21	30	27/ 3/76	57	59.9S	63	8.9W	2240	0.00	0.000	0.0

XBT	170	23	35	27/ 3/76	58	7.8S	63	44.2W	0	4.50	0.000	0.0
XBT	171	0	0	28/ 3/76	58	8.3S	63	49.0W	0	4.65	0.000	0.0
XBT	172	0	30	28/ 3/76	58	8.6S	63	53.7W	0	4.70	0.000	0.0
XBT	173	1	0	28/ 3/76	58	8.0S	63	58.8W	0	4.70	0.000	0.0
XBT	174	1	30	28/ 3/76	58	4.8S	64	3.7W	0	4.70	0.000	0.0
XBT	175	02	04	27/03/76	58	02.0S	64	07.6W	0	0.00	0.000	0.0
XBT	176	2	5	28/ 3/76	58	1.2S	64	8.7W	0	4.65	0.000	0.0
XBT	177	02	35	27/03/76	57	59.3S	64	05.8W	0	0.00	0.000	0.0
XBT	178	3	0	28/ 3/76	57	57.9S	63	59.3W	0	4.30	0.000	0.0
SURF	179	3	30	28/ 3/76	57	55.9S	63	54.0W	0	4.30	0.000	0.0
XBT	180	3	45	28/ 3/76	57	55.2S	63	52.7W	0	4.30	0.000	0.0
XBT	181	5	0	28/ 3/76	57	56.6S	63	53.3W	2360	4.60	0.000	0.0
XBT	182	5	30	28/ 3/76	57	59.0S	63	54.0W	1950	4.20	0.000	0.0
XBT	183	19	50	28/03/76	58	03.3S	63	55.5W	0	0.00	0.000	0.0
XBT	184	6	0	28/ 3/76	58	3.3S	63	55.5W	1950	4.60	0.000	0.0
XBT	185	6	30	28/ 3/76	58	6.9S	63	56.5W	1760	4.60	0.000	0.0
XBT	186	7	0	28/ 3/76	58	10.3S	63	57.7W	1470	4.70	0.000	0.0
XBT	187	7	30	28/ 3/76	58	15.4S	63	57.4W	2020	4.60	0.000	0.0
XBT	189	8	5	28/ 3/76	58	19.3S	63	57.0W	2000	4.80	0.000	0.0
XBT	190	8	35	28/ 3/76	58	24.0S	63	57.0W	2000	5.20	0.000	0.0
XBT	191	9	5	28/ 3/76	58	29.8S	63	56.9W	1960	5.00	0.000	0.0
XBT	192	9	35	28/ 3/76	58	32.8S	63	56.8W	1960	4.90	0.000	0.0
XBT	193	10	0	28/ 3/76	58	37.4S	63	56.3W	2040	4.80	0.000	0.0
XBT	194	10	31	28/ 3/76	58	41.9S	63	53.6W	2040	4.60	0.000	0.0
XBT	195	11	0	28/ 3/76	58	46.0S	63	54.5W	2050	0.00	0.000	0.0
XBT	197	11	35	28/ 3/76	58	50.5S	63	53.4W	0	0.00	0.000	0.0
XBT	198	12	0	28/ 3/76	58	55.4S	63	52.4W	2105	4.30	0.000	0.0
XBT	199	12	30	28/ 3/76	59	0.4S	63	51.1W	2110	3.70	0.000	0.0
XBT	200	14	30	28/ 3/76	58	59.3S	63	49.8W	2140	3.70	0.000	0.0
XBT	201	15	0	28/ 3/76	58	53.8S	63	52.2W	2100	4.40	0.000	0.0
XBT	202	15	30	28/ 3/76	58	44.3S	63	57.0W	2070	4.60	0.000	0.0
XBT	203	16	0	28/ 3/76	58	44.3S	63	57.0W	2070	4.80	0.000	0.0
XBT	204	20	30	28/03/76	58	39.6S	63	59.2W	0	0.00	0.000	0.0
XBT	205	16	32	28/ 3/76	58	39.6S	63	59.2W	2030	4.80	0.000	0.0
XBT	206	17	0	28/ 3/76	58	34.8S	69	1.9W	1990	4.90	0.000	0.0
SURF	207	17	30	28/ 3/76	58	29.7S	64	3.5W	0	5.40	0.000	0.0
XBT	208	18	0	28/ 3/76	58	26.0S	64	8.5W	1930	5.50	0.000	0.0
XBT	209	18	30	28/ 3/76	58	21.9S	64	13.8W	1800	5.50	0.000	0.0
XBT	210	21	30	28/03/76	58	17.8S	64	18.5W	0	0.00	0.000	0.0
XBT	211	19	0	28/ 3/76	58	17.8S	64	18.5W	2130	5.40	0.000	0.0
XBT	212	19	30	28/ 3/76	58	13.5S	64	23.4W	2070	0.00	0.000	0.0
XBT	213	20	0	28/ 3/76	58	8.6S	64	29.3W	1930	5.45	0.000	0.0
XBT	214	20	30	28/ 3/76	58	6.7S	64	33.2W	2100	5.02	0.000	0.0
XBT	215	21	0	28/ 3/76	58	1.7S	64	34.6W	1800	5.55	0.000	0.0
XBT	216A	21	24	28/ 3/76	0	0.0S	0	0.0W	0	5.50	0.000	0.0
XBT	216	21	30	28/ 3/76	57	56.0S	64	34.7W	1440	5.55	0.000	0.0
XBT	217	22	2	28/ 3/76	57	50.5S	64	34.4W	0	5.45	0.000	0.0
XBT	218	22	30	28/ 3/76	57	44.8S	64	35.0W	1700	5.50	0.000	0.0
XBT	219	23	40	28/03/76	57	39.2S	64	35.1W	0	0.00	0.000	0.0
XBT	220	23	0	28/ 3/76	57	39.2S	64	35.1W	2340	5.50	0.000	0.0
XBT	221	23	25	28/ 3/76	57	33.5S	64	34.6W	2340	5.75	0.000	0.0
XBT	222	0	0	28/03/76	0	0.0S	0	0.0W	0	0.00	0.000	0.0
XBT	223	0	8	29/ 3/76	57	33.0S	64	23.7W	0	5.00	0.000	0.0
XBT	224	0	30	29/ 3/76	57	33.2S	64	16.3W	0	4.70	0.000	0.0
XBT	225	1	0	29/ 3/76	57	34.1S	64	8.0W	0	4.20	0.000	0.0
XBT	226	1	30	29/ 3/76	57	37.3S	63	57.7W	0	3.70	0.000	0.0
XBT	227	2	0	29/ 3/76	57	39.4S	63	51.9W	0	3.90	0.000	0.0
EXBT	228	7	50	29/ 3/76	57	42.2S	64	9.6W	0	4.20	0.000	0.0
EXBT	229	10	15	29/ 3/76	57	42.4S	64	9.8W	0	4.10	0.000	0.0
XBT	230	10	47	29/ 3/76	57	44.9S	64	9.7W	0	4.20	0.000	0.0

EXBT	231	11	55	29/ 3/76	57	41.1S	64	3.2W	0	4.20	0.000	0.0
EXBT	232	12	30	29/ 3/76	57	37.6S	64	4.7W	0	4.20	0.000	0.0
XBT	233	13	0	29/ 3/76	57	34.2S	64	5.0W	0	3.70	0.000	0.0
EXBT	234	13	5	29/ 3/76	57	30.3S	64	7.5W	0	3.70	0.000	0.0
EXBT	235	13	45	29/ 3/76	57	30.3S	64	7.5W	0	3.80	0.000	0.0
EXBT	236	14	28	29/ 3/76	57	25.4S	64	10.4W	0	4.20	0.000	0.0
EXBT	237	15	2	29/ 3/76	57	25.2S	64	11.0W	2290	4.32	0.000	0.0
XBT	238	17	30	29/ 3/76	57	27.0S	64	11.9W	2300	4.25	0.000	0.0
XBT	239	18	30	29/03/76	57	29.5S	64	10.7W	0	0.00	0.000	0.0
XBT	240	18	30	29/ 3/76	57	32.1S	64	11.3W	1600	4.40	0.000	0.0
XBT	241	4	0	29/ 3/76	57	32.5S	64	12.0W	0	4.10	0.000	0.0
XBT	242	13	90	29/03/76	57	32.5S	64	12.0W	0	0.00	0.000	0.0
XBT	243	14	20	29/03/76	57	32.0S	64	11.7	0	0.00	0.000	0.0
XBT	244	19	25	29/ 3/76	57	32.0S	64	11.2W	0	4.30	0.000	0.0
XBT	245	20	15	29/ 3/76	57	31.2S	64	9.2W	0	4.40	0.000	0.0
XBT	246	20	45	29/ 3/76	57	33.0S	64	3.7W	0	3.75	0.000	0.0
XBT	247	21	15	29/ 3/76	57	35.4S	64	57.6W	0	3.60	0.000	0.0
XBT	248	21	45	29/ 3/76	57	38.5S	63	51.2W	0	3.60	0.000	0.0
XBT	249	22	15	29/ 3/76	57	41.5S	64	44.5W	0	3.70	0.000	0.0
XBT	250	21	45	29/ 3/76	57	44.0S	63	38.0W	0	4.20	0.000	0.0
XBT	251	23	20	29/ 3/76	57	47.3S	63	30.1W	0	4.45	0.000	0.0
XBT	252	23	45	29/ 3/76	57	49.7S	63	24.1W	0	4.60	0.000	0.0
XBT	253	0	15	30/ 3/76	57	53.8S	63	18.1W	2060	4.80	0.000	0.0
XBT	254	1	0	30/ 3/76	57	58.2S	63	9.4W	2140	4.70	0.000	0.0
XBT	255	3	45	30/ 3/76	58	3.0S	62	58.4W	0	4.70	0.000	0.0
XBT	256	19	75	30/03/76	58	05.8S	62	58.7W	0	0.00	0.000	0.0
XBT	257	4	0	30/ 3/76	58	5.8S	62	58.7W	1970	4.70	0.000	0.0
XBT	258	4	30	30/ 3/76	58	10.4S	62	58.8W	2200	4.70	0.000	0.0
XBT	259	5	0	30/ 3/76	58	14.8S	62	59.0W	2270	4.60	0.000	0.0
XBT	260	22	50	30/03/76	58	19.3S	62	59.2W	0	0.00	0.000	0.0
XBT	261	5	30	30/ 3/76	58	19.3S	62	59.2W	2250	4.05	0.000	0.0
XBT	262	6	0	30/ 3/76	58	23.3S	62	59.5W	1560	4.30	0.000	0.0
XBT	263	6	30	30/ 3/76	58	27.9S	62	59.7W	2070	4.10	0.000	0.0
XBT	264	18	00	30/03/76	58	33.0S	63	00.0W	0	0.00	0.000	0.0
XBT	265	18	00	30/03/76	58	33.0S	63	00.0W	0	0.00	0.000	0.0
XBT	266	7	20	30/ 3/76	58	33.0S	63	0.0W	1860	4.00	0.000	0.0
SURF	267	7	28	30/ 3/76	58	38.4S	63	4.0W	1850	3.70	0.000	0.0
XBT	268	7	30	30/ 3/76	58	38.4S	63	0.4W	1850	3.70	0.000	0.0
XBT	269	8	1	30/ 3/76	58	44.0S	62	59.5W	1850	3.50	0.000	0.0
XBT	270	8	30	30/ 3/76	58	47.4S	62	59.0W	2070	3.30	0.000	0.0
XBT	271	11	42	30/ 3/76	58	44.2S	63	0.0W	0	3.50	0.000	0.0
XBT	272	12	5	30/ 3/76	58	41.3S	63	3.0W	2020	3.90	0.000	0.0
XBT	273	12	30	30/ 3/76	58	38.0S	63	6.4W	2000	4.10	0.000	0.0
XBT	274	13	0	30/ 3/76	58	33.4S	63	9.9W	1980	4.40	0.000	0.0
XBT	275	13	30	30/ 3/76	58	28.5S	63	14.0W	0	4.50	0.000	0.0
EXBT	276	16	25	30/ 3/76	58	29.3S	63	13.2W	1900	4.50	0.000	0.0
EXBT	277	17	15	30/ 3/76	58	29.4S	63	14.0W	1930	4.30	0.000	0.0
XBT	436	1	0	2/ 4/76	58	22.6S	62	58.0W	1900	4.40	0.000	0.0
XBT	437	2	5	2/ 4/76	58	32.5S	62	51.2W	1990	3.80	0.000	0.0
XBT	438	3	0	2/ 4/76	58	40.5S	62	43.5W	2030	3.50	0.000	0.0
XBT	439	4	00	02/04/76	58	48.8S	62	35.3W	0	0.00	0.000	0.0
XBT	440	4	3	2/ 4/76	58	49.4S	62	35.1W	1980	3.10	0.000	0.0
XBT	441	5	0	2/ 4/76	58	54.5S	62	41.5W	0	2.55	0.000	0.0
XBT	442	6	0	2/ 4/76	58	56.2S	32	54.6W	2140	2.85	0.000	0.0
XBT	443	10	0	2/ 4/76	58	51.9S	63	0.6W	0	2.92	0.000	0.0
XBT	444	10	30	2/ 4/76	58	48.0S	63	2.0W	2100	3.32	33.901	4.7
XBT	445	14	10	2/ 4/76	58	39.0S	63	4.2W	0	4.50	0.000	0.0
XBT	446	17	25	2/ 4/76	58	30.5S	63	8.5W	1840	5.20	34.034	3.2
XBT	447	21	10	2/ 4/76	58	19.6S	63	17.3W	1710	4.60	34.029	2.8
XBT	448	1	15	3/ 4/76	58	10.5S	63	18.5W	0	4.50	0.000	2.0

XBT	449	5	35	3/ 4/76	58	0•5S	63	26•0W	2360	4•85	34•033	2•3
XBT	450	9	45	3/ 4/76	57	51•3S	63	28•5W	0	4•90	34•060	2•5
XBT	451	13	50	3/ 4/76	57	41•5S	63	33•0W	0	3•90	33•895	3•9
XBT	452	17	40	3/ 4/76	57	31.9S	63	36.2W	0	4.15	33.827	5.9
XBT	453	21	5	3/ 4/76	57	23•3S	63	41•0W	2060	3•70	33•831	5•4
XBT	454	1	40	4/ 4/76	57	9•4S	63	42•8W	2100	3•40	34•101	3•0
XBT	455	0	0	04/04/76	0	0•0S	0	0•0W	0	0•00	0•000	0•0
XBT	456	0	0	04/04/76	0	0.0S	0	0.0W	0	0.00	0.000	0.0
XBT	457	5	55	4/ 4/76	57	1•0S	63	46•0W	0	4•25	34•019	2•3
XBT	459	9	40	4/ 4/76	56	55•0S	63	52•0W	2230	4•60	0•000	0•0
XBT	460	14	20	4/ 4/76	56	51.1S	64	5•3W	0	4•60	0.000	0.0
XBT	461	14	30	4/ 4/76	56	50•5S	64	8•6W	2110	5•30	34•099	2•3
XBT	462	0	0	04/04/76	56	47•4S	64	30•6	0	0•00	0•000	0•0
XBT	463	20	70	04/04/76	56	47•4S	64	30•6	0	0.00	0.000	0.0
XBT	464	0	0	04/04/76	0	0•0S	0	0•0W	0	0•00	0•000	0•0
XBT	465	19	50	4/ 4/76	56	47•4S	64	30•6W	2070	5•75	0•000	0•0
XBT	466	0	30	5/ 4/76	56	41•5S	64	47•2W	2030	6•00	34•096	3•0
XBT	467	4	37	5/ 4/76	56	37.5S	65	1.0W	2000	6.20	34.074	2.8
XBT	468	8	35	5/ 4/76	56	34•5S	65	20•3W	0	6•10	34•116	2•0
XBT	469	13	30	5/ 4/76	56	29•0S	65	35•6W	1950	6•20	34•113	2•0
XBT	470	17	10	5/ 4/76	56	25•5S	65	51•0W	0	6•90	34•118	2•0
XBT	471	21	5	5/ 4/76	56	23•0S	66	6•6W	1600	6•60	0•000	2•5
XBT	472	6	30	6/ 4/76	56	14•1S	66	43•3W	145	7•40	0•000	0•0

IV. CTD

During Leg III, a total of 101 CTD stations were taken in the Drake Passage.* All but three of these included continuous measurement of dissolved oxygen with a Beckman MINOS probe borrowed from the University of Rhode Island. Because of limitations imposed by the oxygen probe, CTD stations were limited to pressures less than 3000 decibars.

Stations with the CTD were reference points for a number of other measurements (e.g., XBT, light scattering, nutrients) and were grouped into different types of activities (e.g., spatial survey of front, Yo-Yo's, over vertical current meters (VCMs)). Before discussion of instrument performance and of sample traces, we show in Table 5 a breakdown of CTD stations versus scientific activity.

A. Instrument Servicing

Two CTD fish (instruments #3 and #4) were taken on Leg 3 of R/V THOMPSON Cruise 107. The first three stations were used to evaluate the performance of each instrument and revealed the following problems. The temperature sensor of CTD #3 read cold by between .03 and .04° C at 2° C compared to reversing thermometers. The fast response temperature circuit did not appear to be functioning properly. The temperature circuit had ±2 m° C noise. The batteries on CTD #4 would not hold a charge and a power failure occurred half way through its test station. Three dead cells were replaced in CTD #4's battery pack but it still failed to hold a charge. Since CTD #4 was giving better performance, the battery pack, power supply, and oxygen interface boards were swapped from CTD #3 to CTD #4. CTD #4 was used for the remainder of the cruise. A summary of instrument servicing is given in Table 6.

B. Data Editing

The CTD stations were edited using CTDED with first difference criterion of $\Delta P = 1$ dbar; $\Delta T = .06°$ C and $\Delta C = .12$ mmho/cm above 800 dbars and $\Delta T = .015°$ C and $\Delta C = .03$ mmho/cm below 800 dbars. The stations were

*With the WHOI/Brown CTD.

Table 5

CTD/Activity Table

Start	End	Activity
1	3	Test stations - compare performance CTD fish #3 and #4
4		Recovery of "A" upper section
5	6	Locate frontal interleaving region to set P.O.E. buoys
7	18	28 hr time series to 1500 m relative to P.O.E. buoy with PCM profiles #3-15 to 600 m
19		5 cycle Yo-Yo 50-1500 m over 1.3 km to describe along front small scales
20	24	Across front small scale variations at .9 km spacing
25	39	Across front survey at 3 km spacing (60 km total) position relative to buoys. PCM profiles at CTD stations 30, 34, 39
40	43	Downstream front survey at 6 km spacing, buoy loose - poor navigation
44	56	Float ballasting and tracking over several days (Station CTD 46 - PCM relative to VCM #1)
54 &	57	Geostrophic eddy velocity - center eddy and outside
58		South of front
59	74	28 hr time series to 1500 m relative to VCM #1 at 400 decibars
75	76	Normal to front at 5 km from VCM #1 at float recoveries
77	97	Large scale section at 15 km spacing across Drake Passage through eddy - all stations to 3000 m
98	101	Bottom stations on continental shelf and slope off Cape Horn. 2 cast stations - separate oxygen and bottom finder

Table 6

Summary Table of Instrument Servicing

Date	CTD Station No.	Opened CTD	
10 March			Checked CTD data acquisition system
			Checked CTD #4
11 March			Checked CTD #3
			Terminated sea cable
			Checked Rosette
			Set up oxygen probe
12 March			Calibrated oxygen probe & checked A/D
		*	Offset pressure on CTD #3 to +12 decibars
13 March			Test cable termination to 1200 lb
14 March			Replace cable to Rosette fish
			Replace oxygen probe power supply
15 March	1 CTD #3		Oxygen data failed at 600 meters down
			Aligned O-ring and refilled O_2 probe with oil
	2 CTD #4	(No O_2)	Batteries failed on way up
	3 CTD #3		
16 March		*	Replaced 3 bad batteries in CTD #4
		*	Wired up CTD #4 for O_2 A/D board
		*	Checked CTD #4 conductivity linearity
17 March	4 CTD #3		
		*	Offset pressure on CTD #4 to +4 decibars
		*	Installed O_2 A/D board in CTD #4
		*	Exchanged CTD #3 and #4 in pressure housing
	5 CTD #4		Batteries low on way up
18 March		*	Exchanged CTD #3 and #4 battery pack and power supply base
	6 to 8		Note: All stations from here on are with CTD #4 with Rosette and oxygen probe
19 March	9 to 18		10 stations
20 March	19 to 24		7 stations
21 March	25 to 29		5 stations

Table 6 (Contd.)

Date	CTD Station No.	Opened CTD	
22 March	30 to 40		11 stations
23 March	41 to 44		4 stations
24 March			Eratic readings when trying to do station
			Rosette did not fire
			CTD would not switch off
			Cleaned end cap connector on CTD
			Fixed 2 bad solder joints in Rosette deck unit
	45 to 46		2 stations
25 March	47 to 48		2 stations
			Reterminated sea cable & tested (cut off 80 ft)
26 March	49 to 51		3 stations
27 March	52		Oxygen data noisy
28 March	53 to 54		2 stations
29 March	55 to 56		2 stations
			Reterminated sea cable and tested (cut off 60 ft)
			Reterminated sea cable and tested (cut off 130 meters)
30 March	57 to 61		5 stations
			Reterminated sea cable and tested (cut off 45 ft)
31 March	62 to 70		9 stations
1 April	71 to 76		6 stations
			connected bottom finder to CTD
2 April	77 to 81		5 stations
3 April	82 to 87		6 stations
			9 track tape drive #2 failed
			Aligned O-ring and refilled O_2 probe with oil
4 April	88 to 92		5 stations
5 April	93 to 98-1,98-2 (98-2 No O_2 Probe)		7 stations
			Oxygen data noisy
			Aligned O-ring and refilled O_2 probe with oil
		*	Replaced 4 pin connector on CTD end cap

Table 6 (Contd.)

Date	CDT Station No.	Opened CTD	
			Replaced + battery charger lead
			Fixed 9 track mag. tape
6 April	99-2		No O_2 probe
	99-1		O_2 probe
	100-1		O_2 probe
	100-2		No O_2 probe
	101-1		O_2 probe Sensor guards on
	101-2		O_2 probe
7 April			Checked calibration of oxygen probe

relatively error-free at this criterion except for occasional conductivity spikes towards lower values. The conductivity errors are attributed to biological fouling of the cell and on stations 10, 27, 48, 51, 60, 67, 77, and 79 the low conductivities persisted over significant intervals (>3 decibars). On station 48 the conductivity shift appeared to persist over the up trace and the cell was flushed with .1 N HCL. The temperature sign bit was disabled in order to record oxygen. The following stations encountered temperatures below 0° C; stations 4, 54, 77, 86, and 87. The acquisition program created some editing problems by occasionally writing data buffers out to magnetic tape in the opposite order and dropping up to 2 decibars of data. The editor was used to reorder the tape records.

C. Data Quality

A Rosette sampler was mounted on the CTD fish with up to 11 bottles to obtain temperature, salinity, and oxygen calibration data for the CTD and also supplemental nutrient data. The reversing thermometers indicate that the CTD #4 thermometer was reading cold by .009° C in the temperature range of 1 to 2° C. A histogram of thermometer-CTD temperature comparisons is shown in Fig. 12. A recalibration of the CTD #4 fully immerged in the bath is necessary after the cruise as a prerequisite to establishing final temperature and conductivity calibrations.

A nominal conductivity correction (.99913) obtained from the end of the previous cruise was applied to all conductivity data. The comparisons with Rosette salinities show little systematic drift over the cruise. A histogram of salinity differences and the time history of salinity differences in the deep water ($\theta \leq 2.5°$ C) are shown in Figures 13 and 14 respectively. The CTD salinities average low by .001 ‰. The Rosette salinities in the deep water were quality controlled by plotting a θ/S shown in Fig. 15. This θ/S may be used to establish a final conductivity calibration in conjunction with salinity difference time plot.

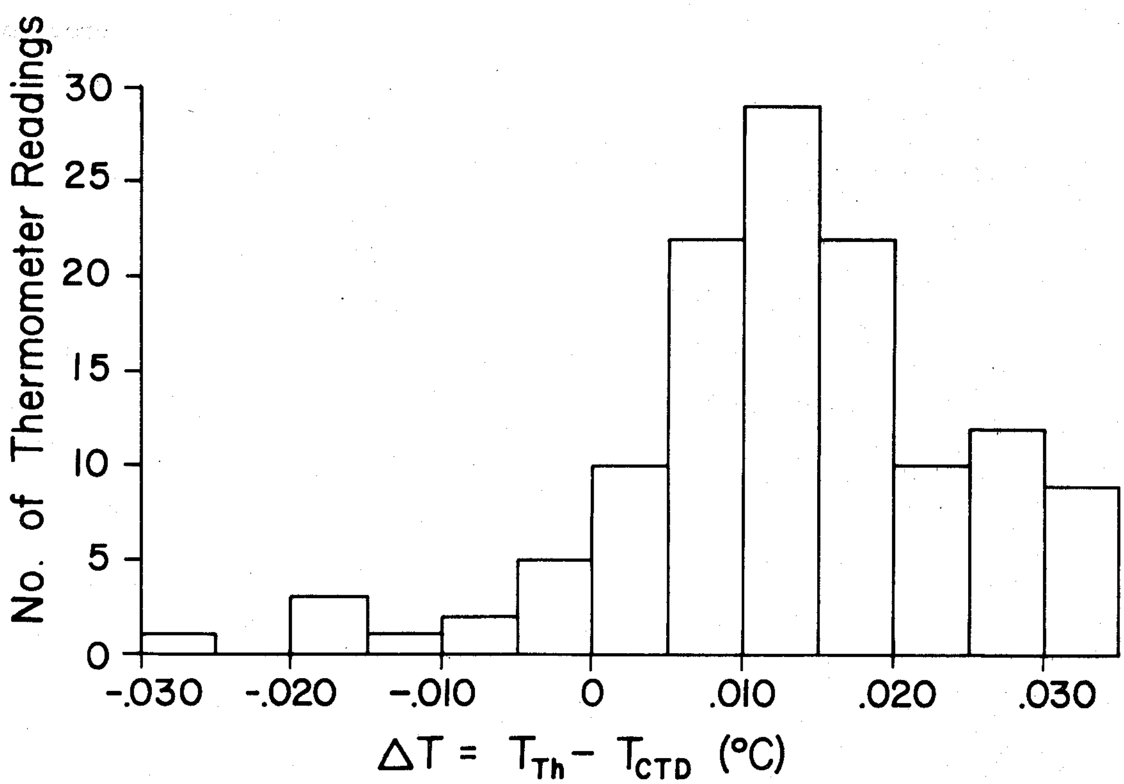


Figure 12. Histogram of the differences between rosette temperature readings and CTD measured temperature

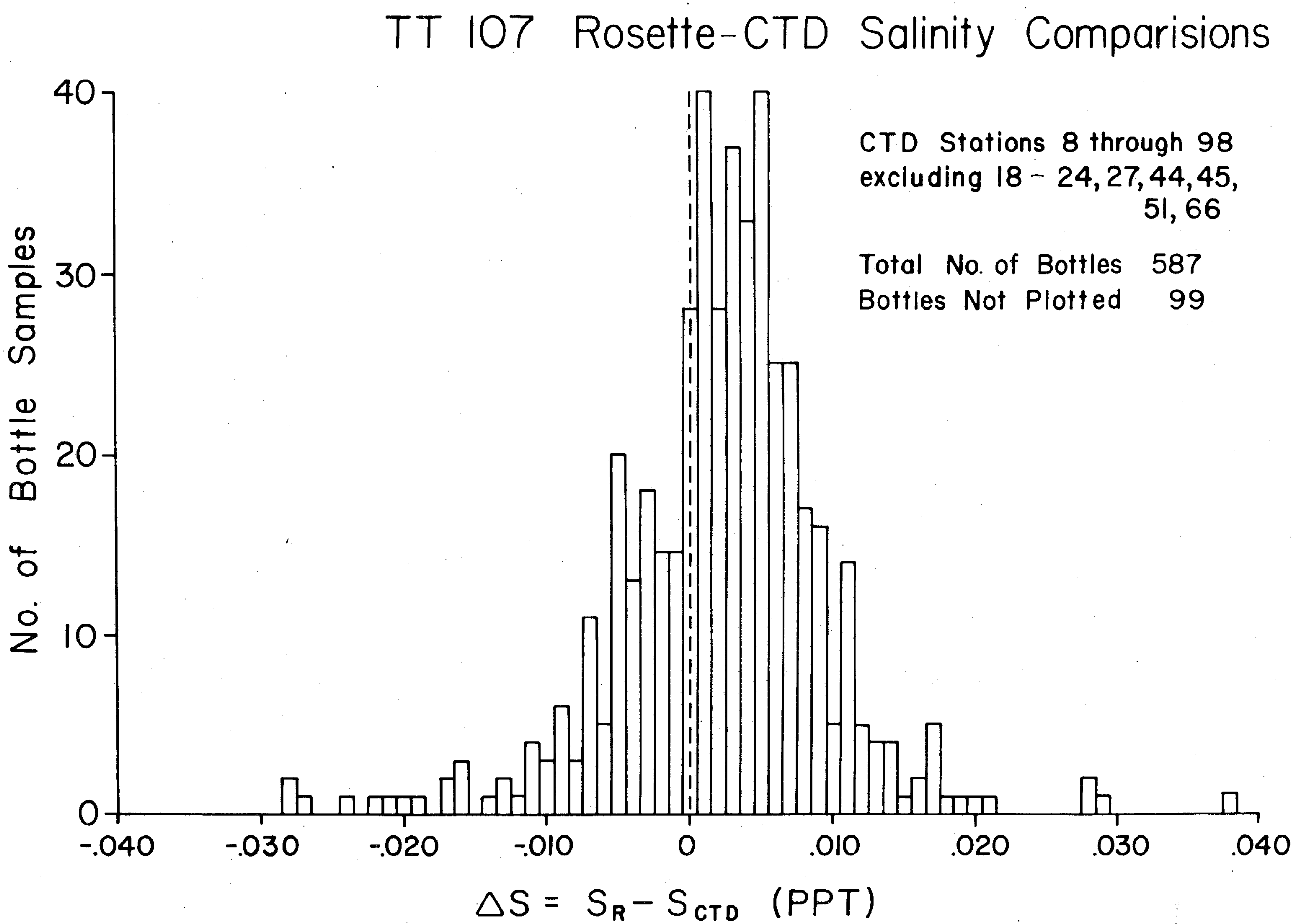


Figure 13. Histogram of differences between rosette salinity values and calculated CTD-salinity

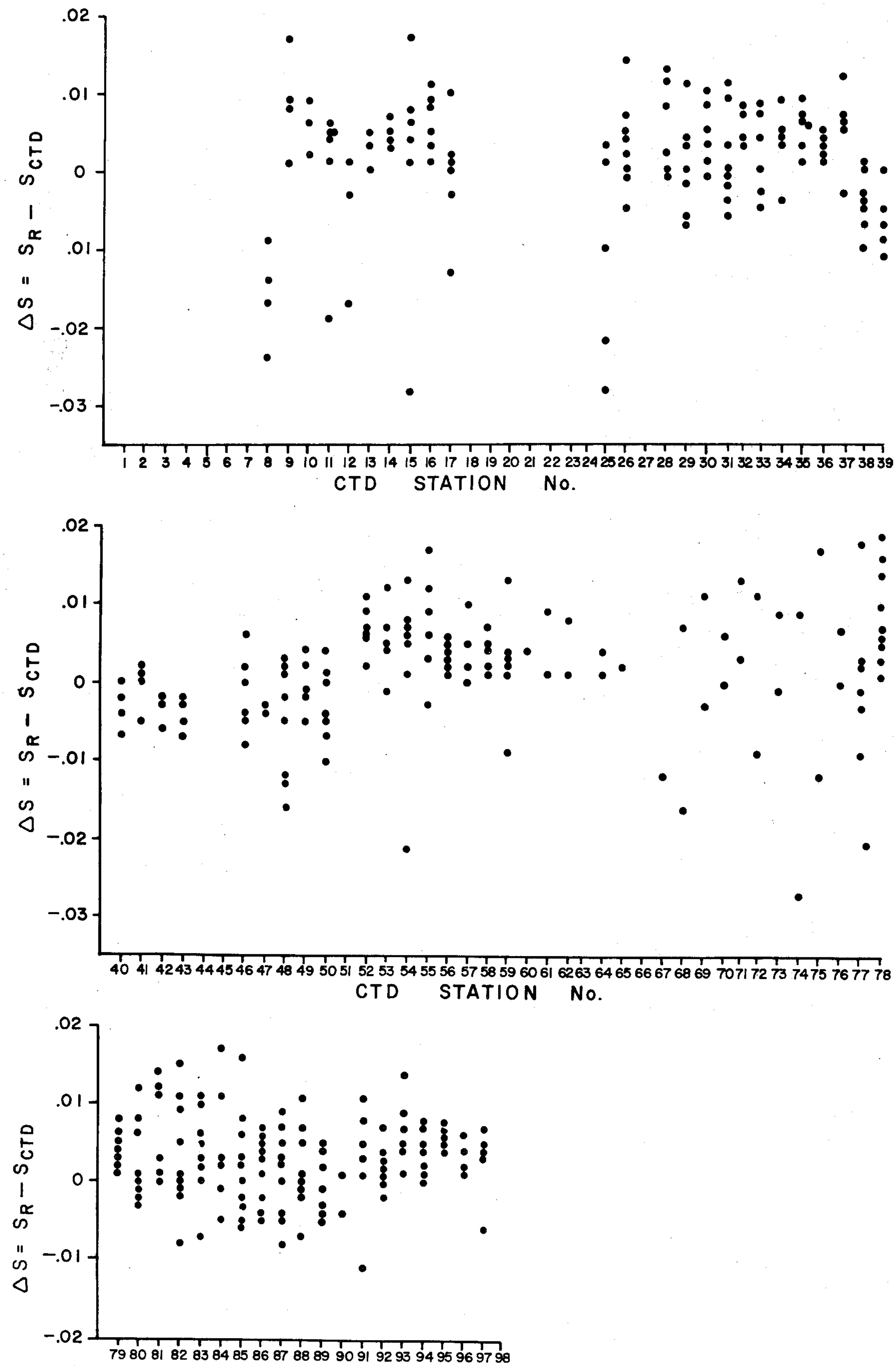


Figure 14. Time histogram of differences between rosette salinity values and calculated CTD-salinity

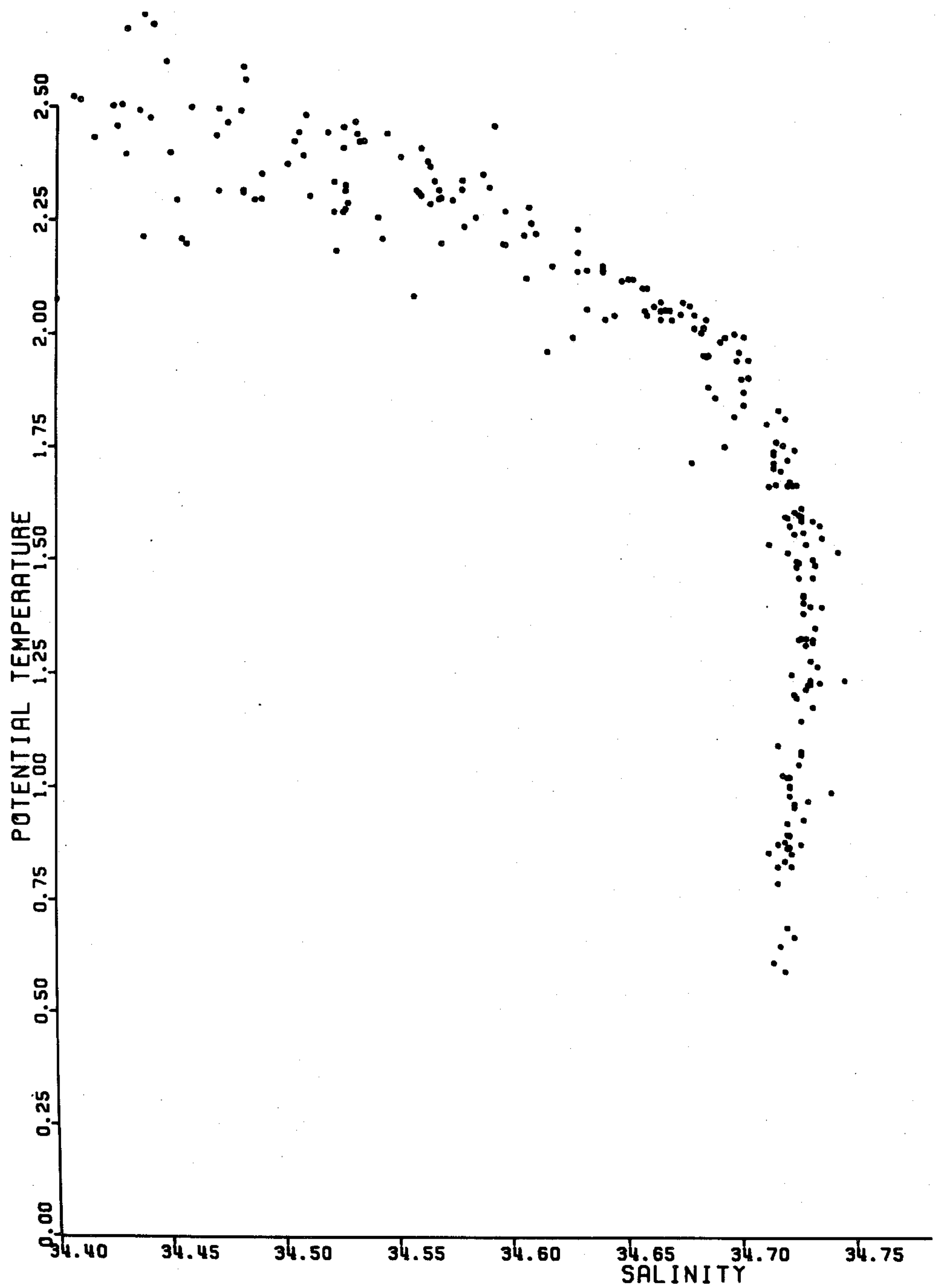
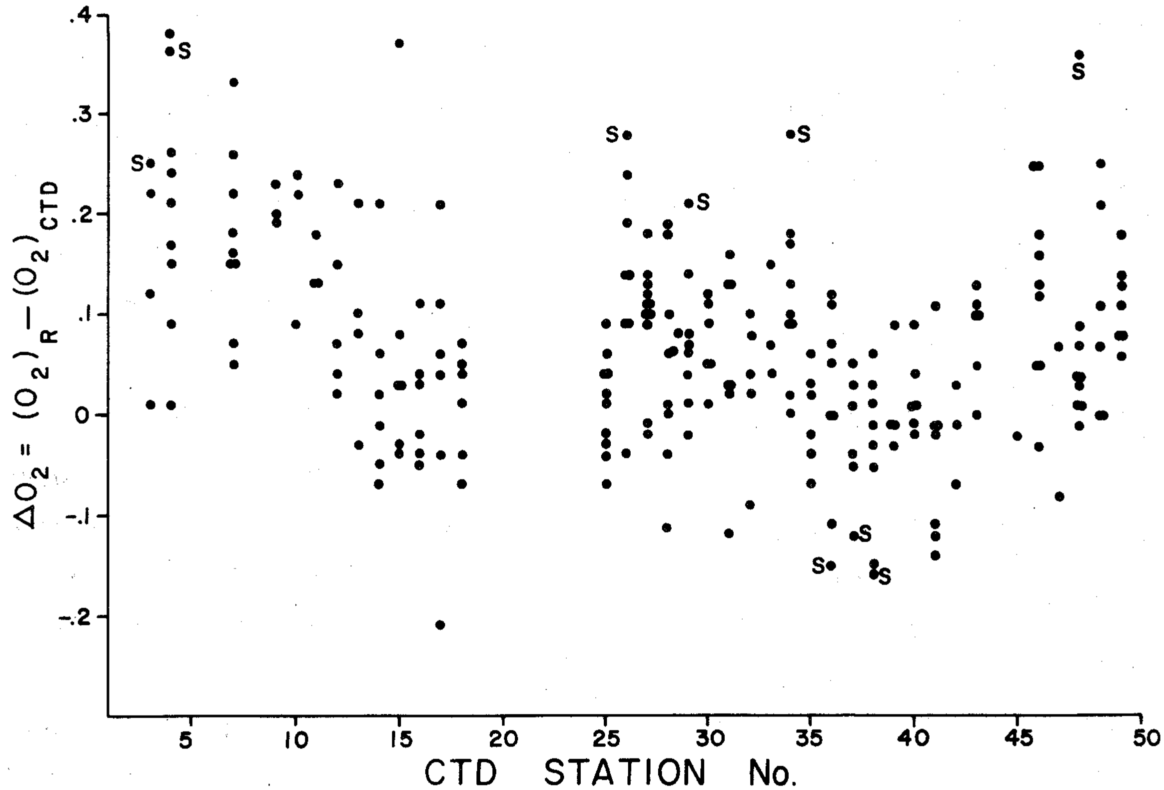


Figure 15. Potential temperature/salinity relationship for the deep water (θ ≤ 2.5° C) rosette samples

The oxygen probe behaved very well through most of the cruise (station 1: O-ring failure; station 2: no O_2 probe mounted; stations 5 and 6: failure of CTD power supply on uptrace; station 53: very noisy data due to seawater in power supply connector; station 54: slightly noisy data similar to 53; station 94: very noisy data due to corroded connector on CTD; stations 3, 4, 5, 6, and 7 have about twice the normal noise, apparently due to low batteries in CTD affecting the data digitalization. The least count of the data digitization corresponds to .04 mℓ/ℓ, thus the deep water θ-O_2 for each station is a band of that width.

The raw data set includes the internally applied temperature and pressure compensation of the Beckman MINOS DOM system, but does not yet include the residue temperature, salinity, and pressure corrections described in the system manual. The final data set ultimately will include these corrections, and other systematic corrections indicated by the bottle data, including possibly a linear pressure correction, and a time lag of the oxygen data relative to the CTD T and S, to take into account the response time of the DOM membrane (about 15 seconds). These final corrections show promise of yielding a very high quality data set: the raw data set itself is already quite good: in Fig. 16 the residue Δ_{up} = (bottle O_2 - probe O_2) is shown as a function of station number. The probe value is that recorded by the operator just before firing the Niskin bottle; in general the "real" value should lie within ±.04 mℓ/ℓ of this value. Station earlier than 12 should be discontinued. due to: 1) the higher probe noise level for stations earlier than 8, and 2) somewhat poorer bottle data due to poor sample drawing techniques. In the rest of the stations, the probe can be seen, in the mean, to read low - about .05 to .10 for stations 25 to 60 drifting to .1 to .2 towards end of cruise. Quite often the near surface bottle Δ_{up} (labeled S) is quite large, for unknown reasons, perhaps the pressure transducer zero pressure offset is not very repeatable. Also quite often the smallest values of Δ_{up} are at the bottom bottle,



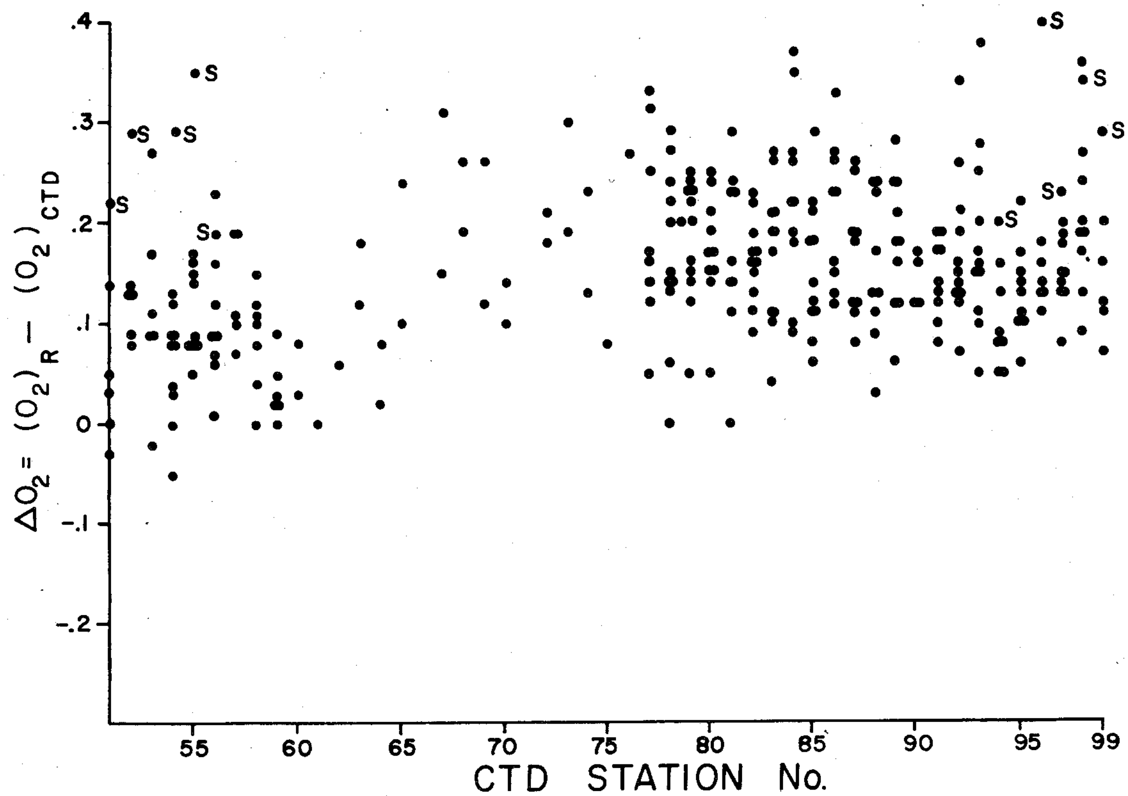


Figure 16. Time histogram of dissolved oxygen differences between rosette O_2-values and CTD O_2-probe data

the largest towards the top, suggesting a linear pressure correction may be appropriate. If this is true, then the stations will be split into two groups, the nominal 3000 db and the nominal 1500 db. It is likely that to some degree the transducer "remembers" what pressure level it reaches, and would behave differently for the two groups.

D. Sample Traces from Representative CTD Stations

In the following figures we show sample CTD traces which were selected as representative of the data set. Final calibrations and lag corrections have not been applied, therefore these data should be viewed as preliminary. However, as has been mentioned, the data quality is quite good. Only down traces are shown.

Station 38 (Fig.17a) was made in the interleaving region during our small scale survey of the northward meander prior to its pinching off (see Section I). Note the deep T_{min} of 2.5° C at about 775 meters depth. The structure above this points consists of cold, fresh leaves of high dissolved oxygen intermingled with warm salty layers of low oxygen. Due to a time lag of 15 sec for the oxygen probe, oxygen will delay temperature by about 20 meters on the down traces. The oxygen data show "interleaving" of high and low oxygen water between 1400 and 2200 meters. This interesting structure of circumpolar deep water was seen on several stations, on others the intermediate maximum is absent. On some (station 97, Fig. 22) the sharp O_2 gradient occurs only on the deep side of the minimum. This structure also shows up, although not as clearly, in a θ/S diagram (Fig.17b). The interleaving above the T_{min} is clearly evident in this figure and also in 17c, a θ/O_2 diagram for station 38.

Another station made in the interleaving zone at the polar front after Freddy was formed (station 83, Fig. 18a,b,c) shows somewhat broader leaves. Note the negative correlation between temperature and oxygen as well as the continual decrease in O_2 at each of the temperature minima: 6.3, 6.0, 5.6, and 5.2 mℓ/ℓ.

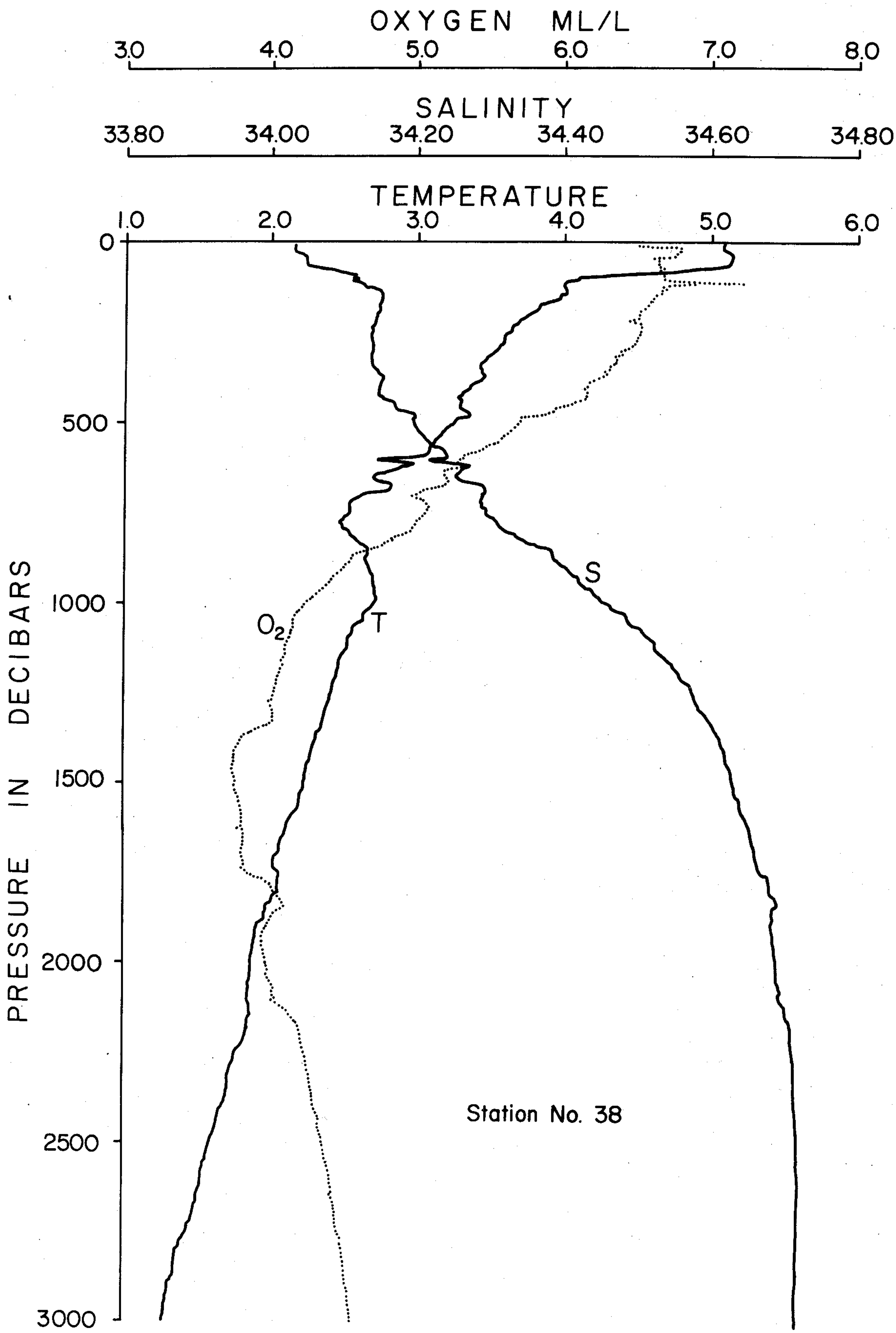


Figure 17a. Continuous temperature, salinity, and oxygen profiles of CTD station #38

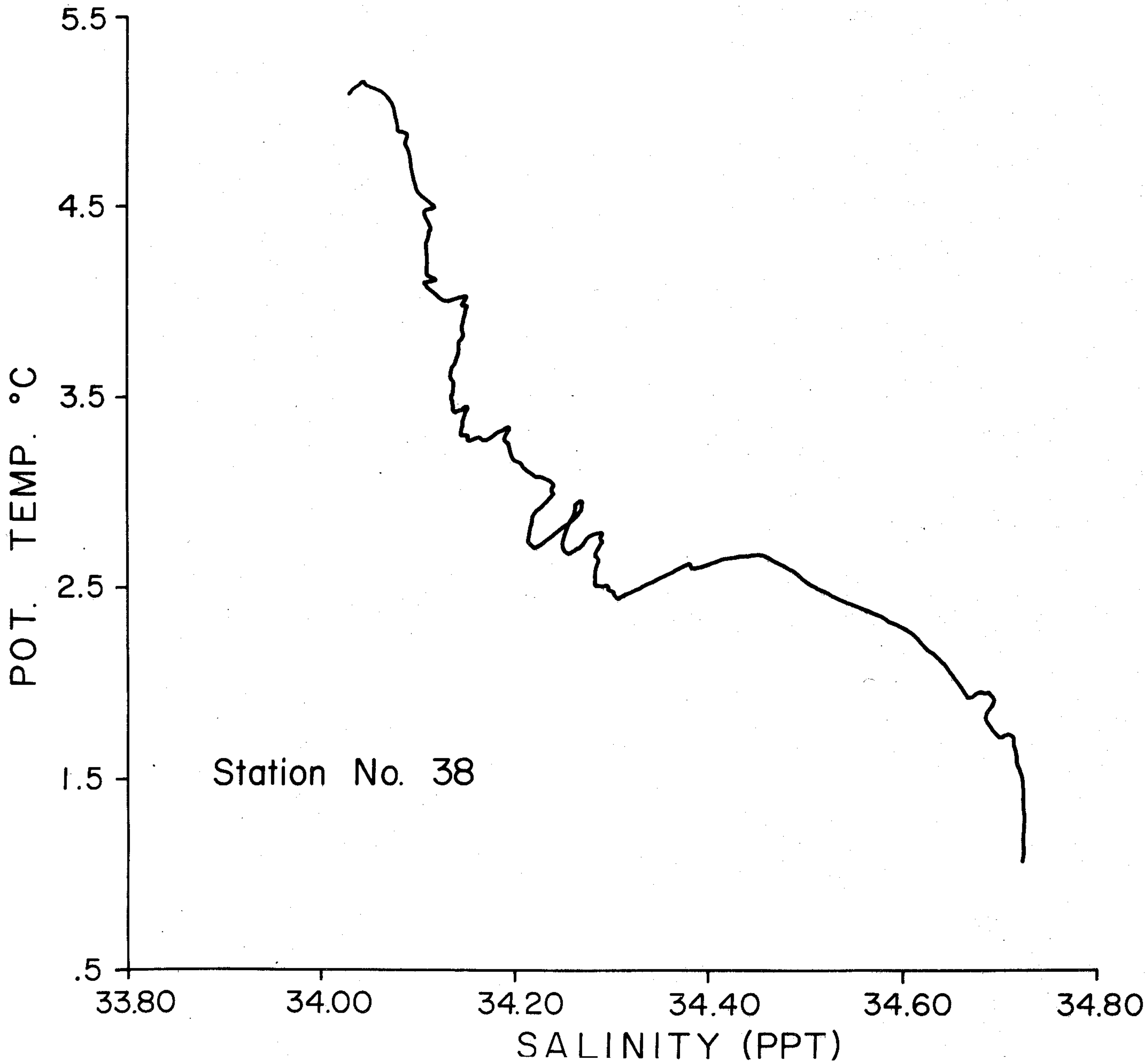


Figure 17b. Potential temperature/salinity diagram of CTD station #38

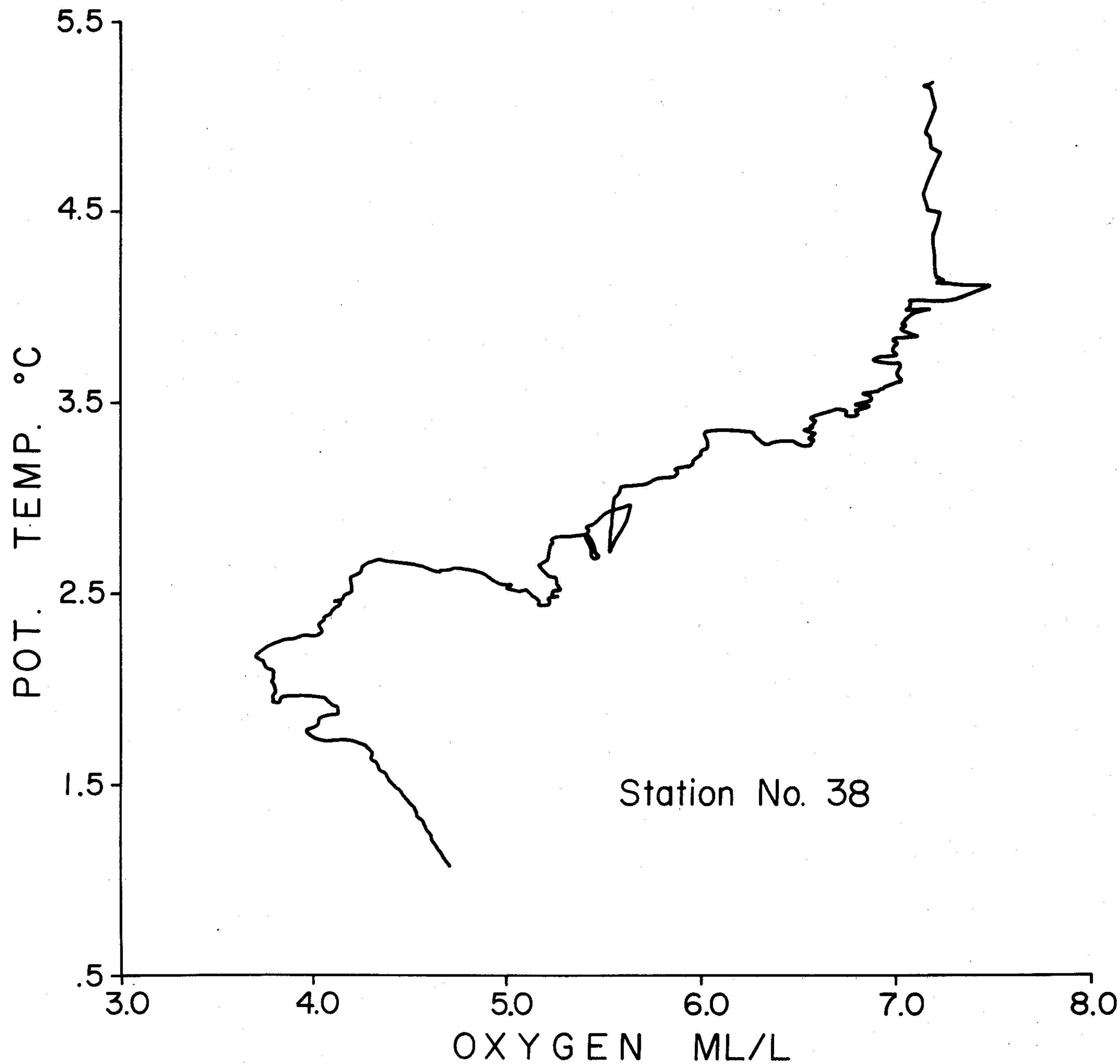


Figure 17c. Potential temperature/oxygen diagram of CTD station #38

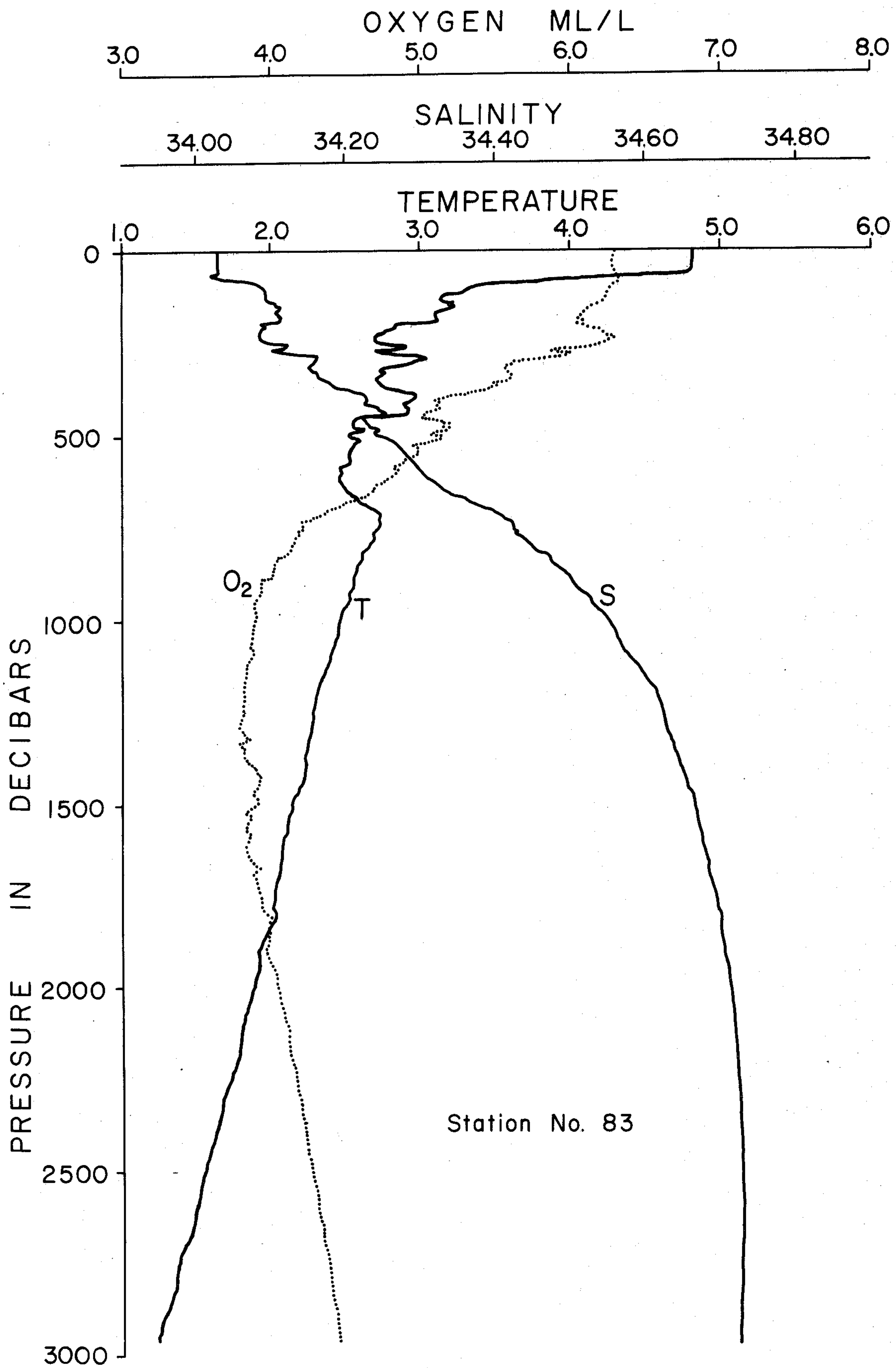


Figure 18a. Continuous temperature, salinity, and oxygen profiles of CTD station #83

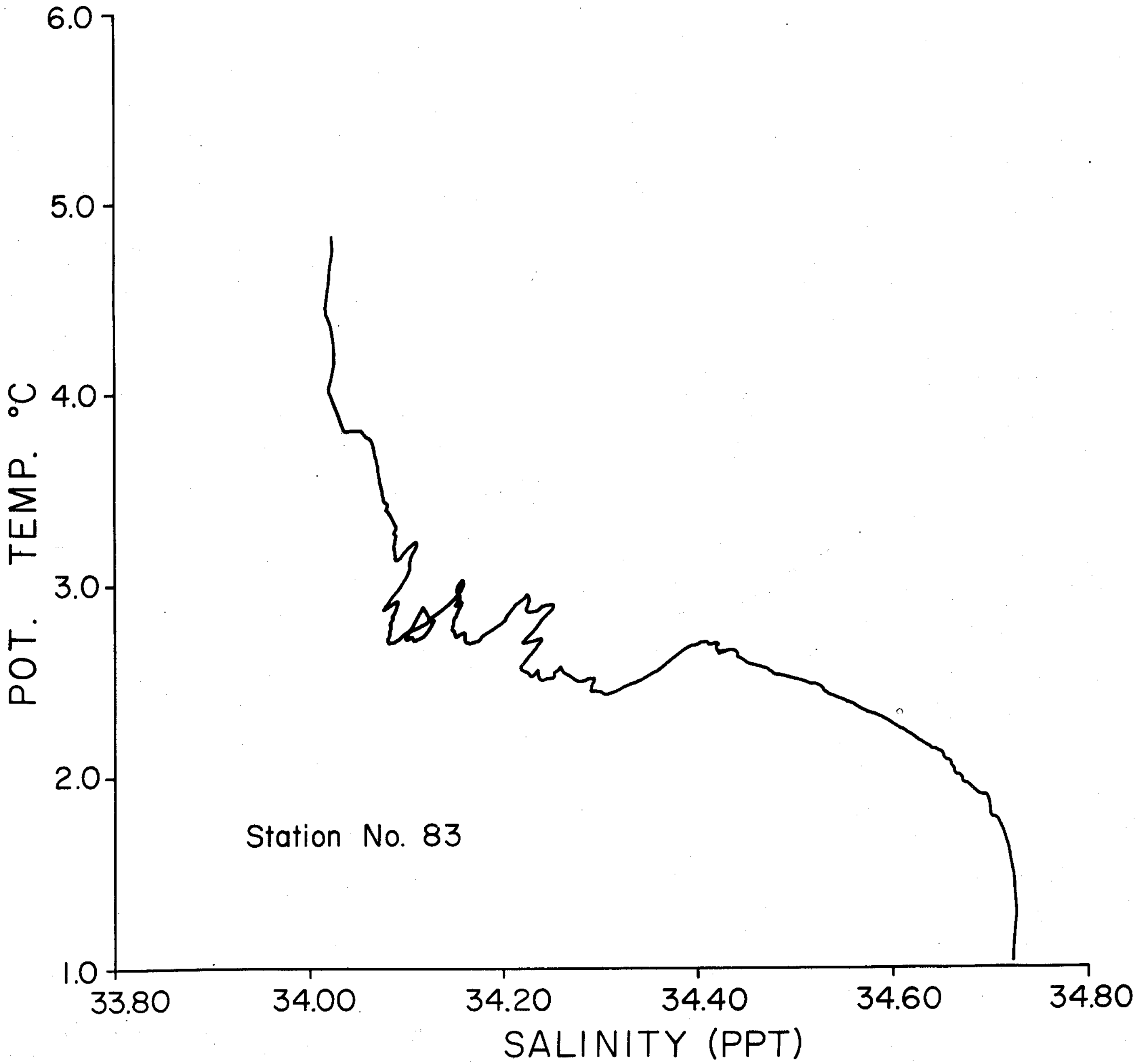


Figure 18b. Potential temperature/salinity diagram of CTD station #83

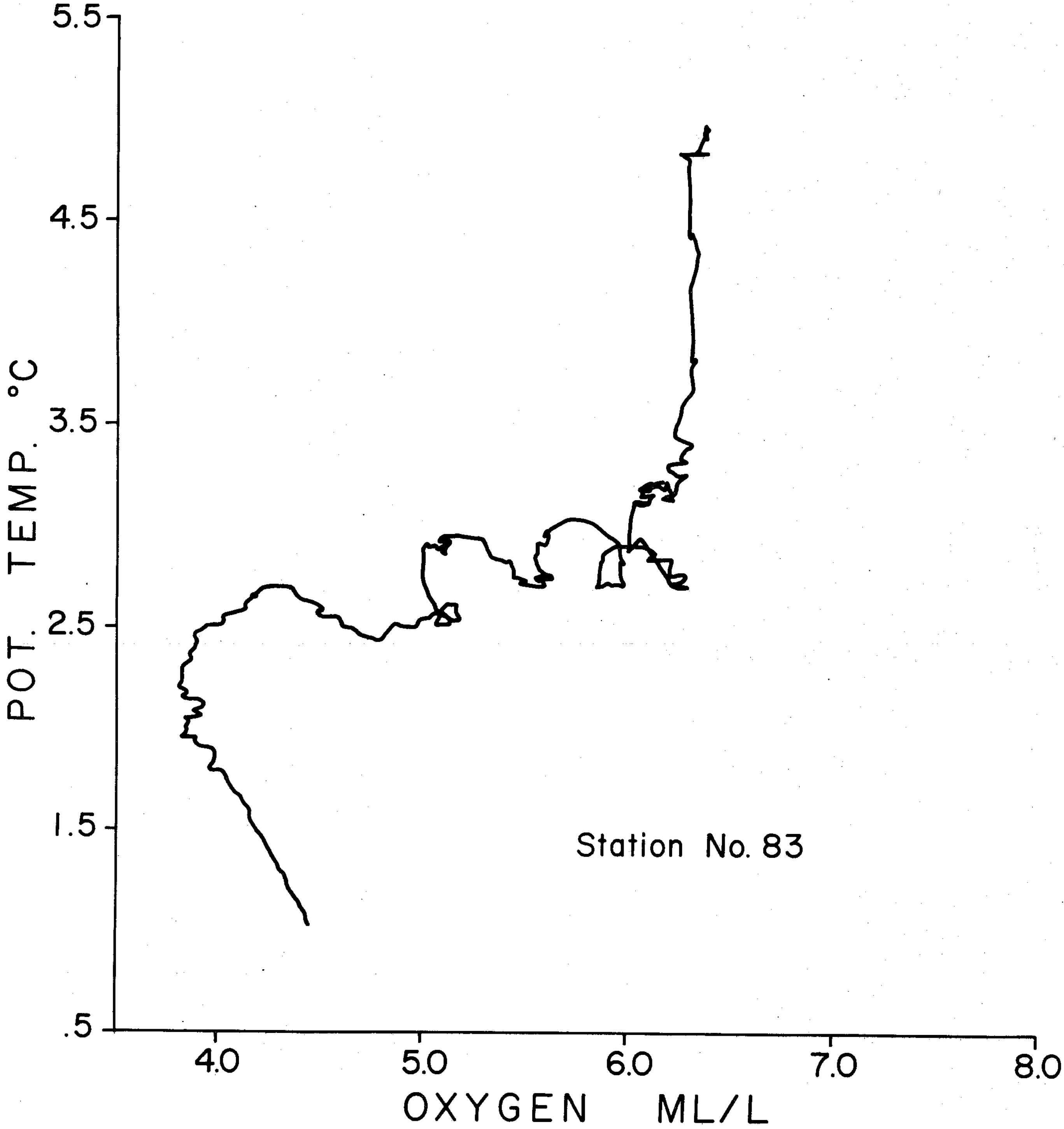


Figure 18c. Potential temperature/oxygen diagram of CTD station #83

In Fig.19 two stations (Nos. 21, 23), part of a closely spaced cross frontal survey, are displayed on a θ/S diagram. Lines of constant σ_θ are drawn to illustrate that much of the temperature/salinity variability in the interleaving zone has little density associated with it. The two stations shown are separated by only 2.7 kilometers.

The contrast between inside and outside Freddy was documented in the introduction. Here (Fig.20) we show station 88, which was located on the northern flank of the cold ring. The T_{min} at 1.5° C is broad and fractured by several cool and warm leaves of 50 meter vertical thickness.

As the subantarctic zone is approached, a subsurface salinity minimum appears (station 91, Fig.21). Several knees in the oxygen appear, but no extrema. The S_{min} (34.16 ‰, 3.8° C) persists at subsequent stations, though with slightly different T/S properties, up to the subantarctic zone (station 97, Fig.22). This shows a deep, weak S_{min} below a pycnostad of nearly constant dissolved oxygen concentration. Shallow interleaving is gone, however the oxygen structure in the circumpolar deep water is again present with a high oxygen gradient at 2600 decibars.

A summary of CTD station information appears in Table 7.

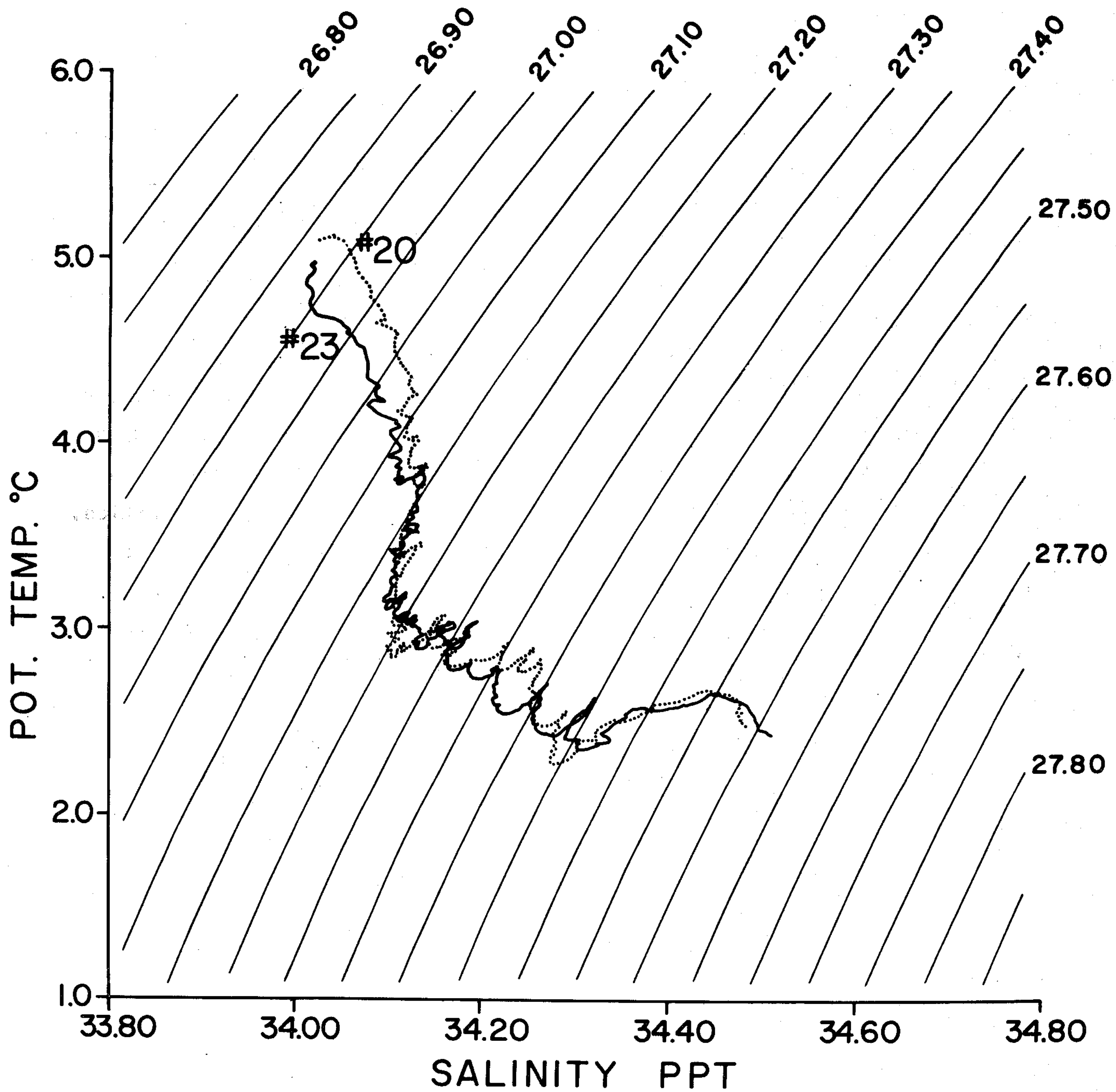


Figure 19. Potential temperature/salinity relationship of CTD stations #20 and #23. Lines of constant σ_θ -units are included to illustrate that most of the temperature/ salinity variations in the interleaving region are compensating in density

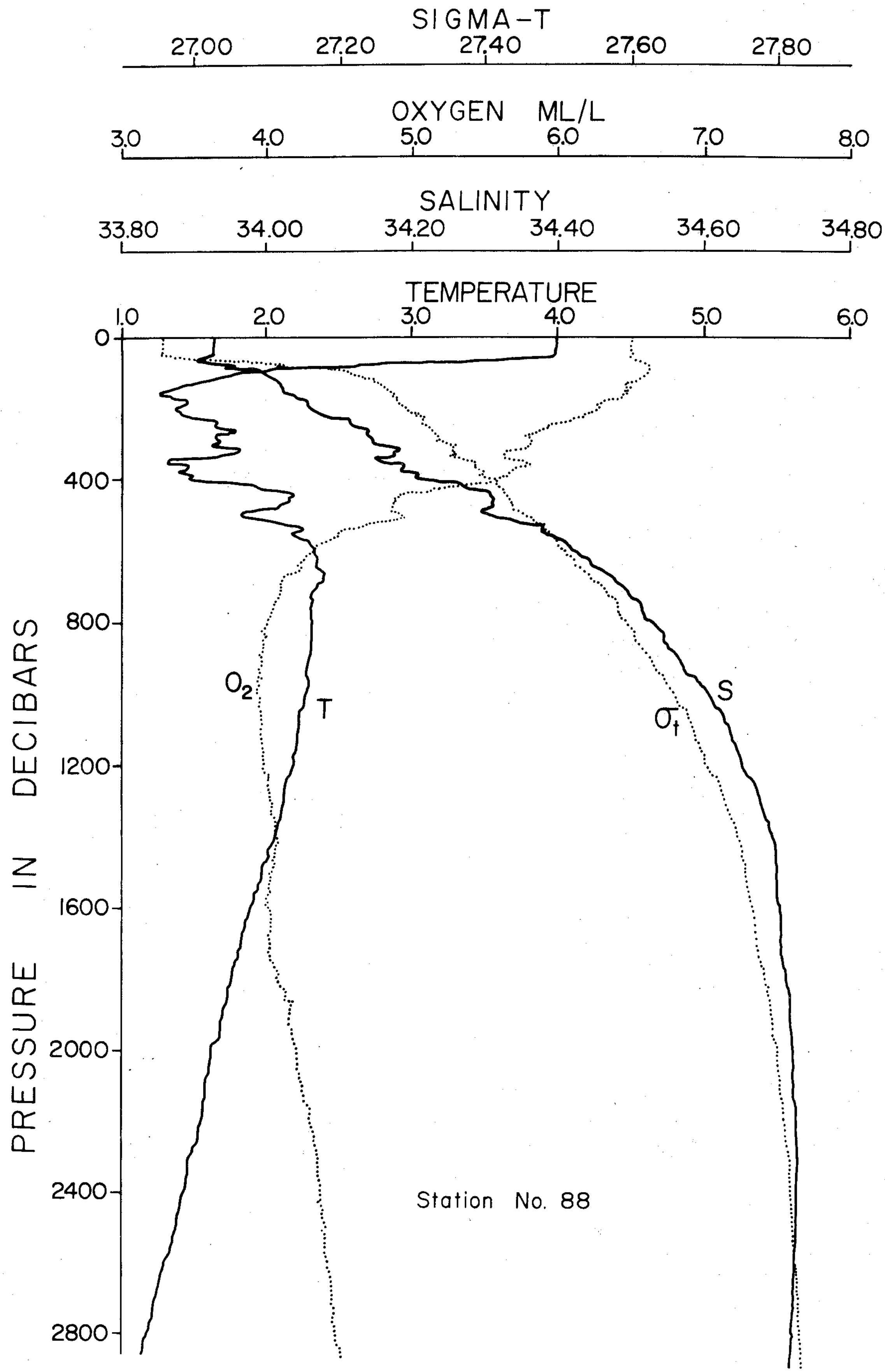


Figure 20a. Continuous temperature, salinity, and oxygen profiles of CTD station #88

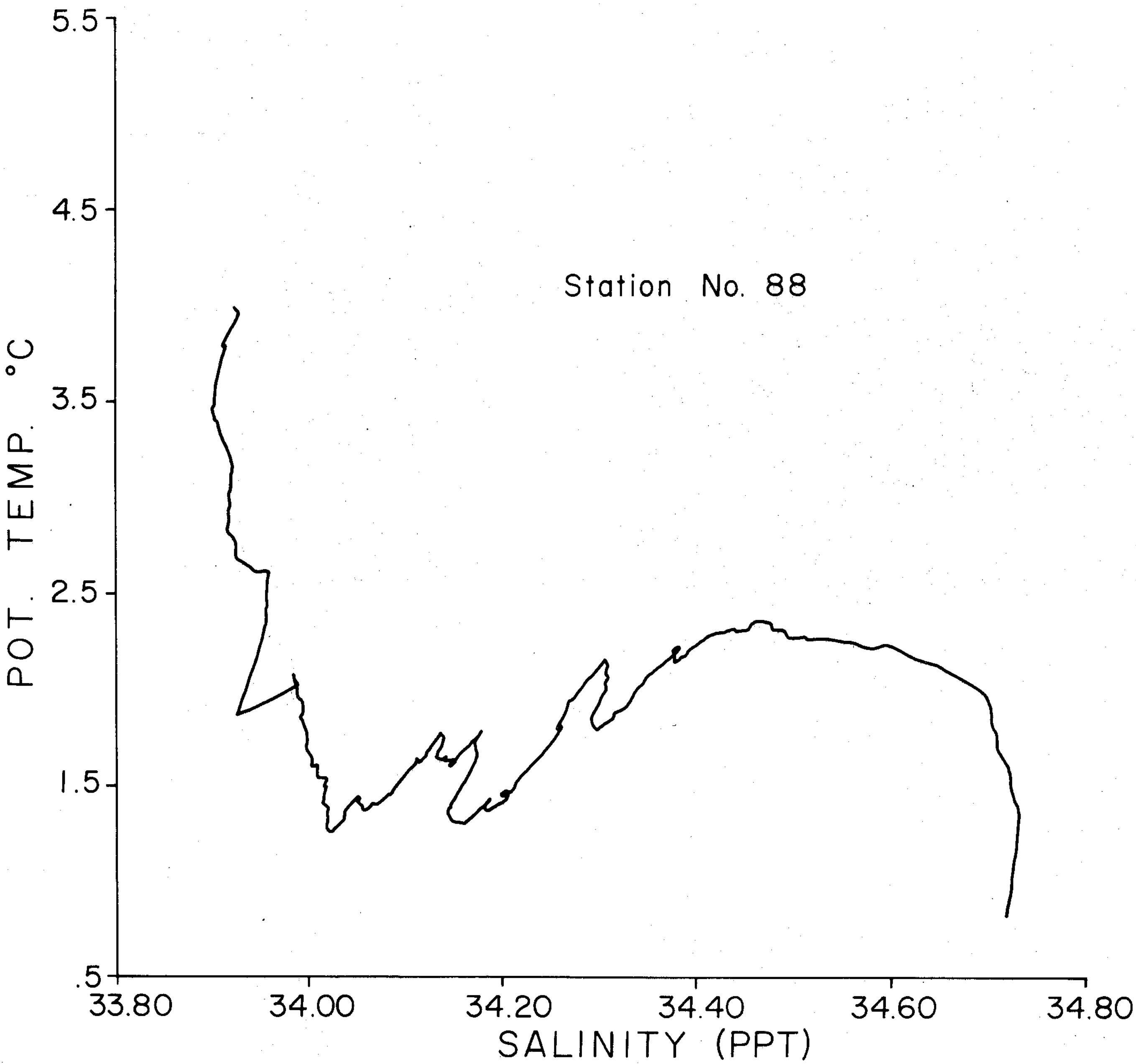


Figure 20b. Potential temperature/salinity diagram of CTD station #88

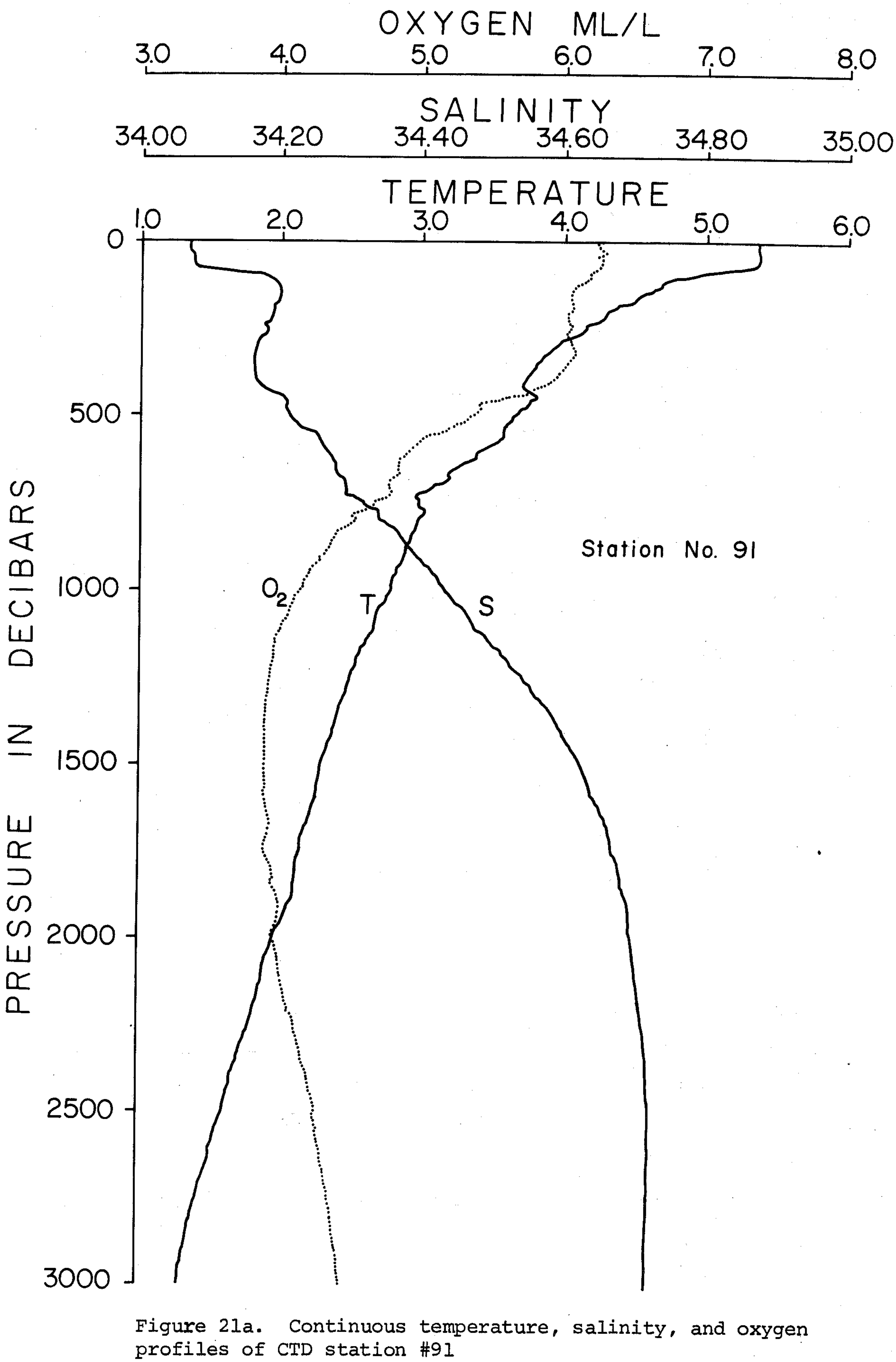


Figure 21a. Continuous temperature, salinity, and oxygen profiles of CTD station #91

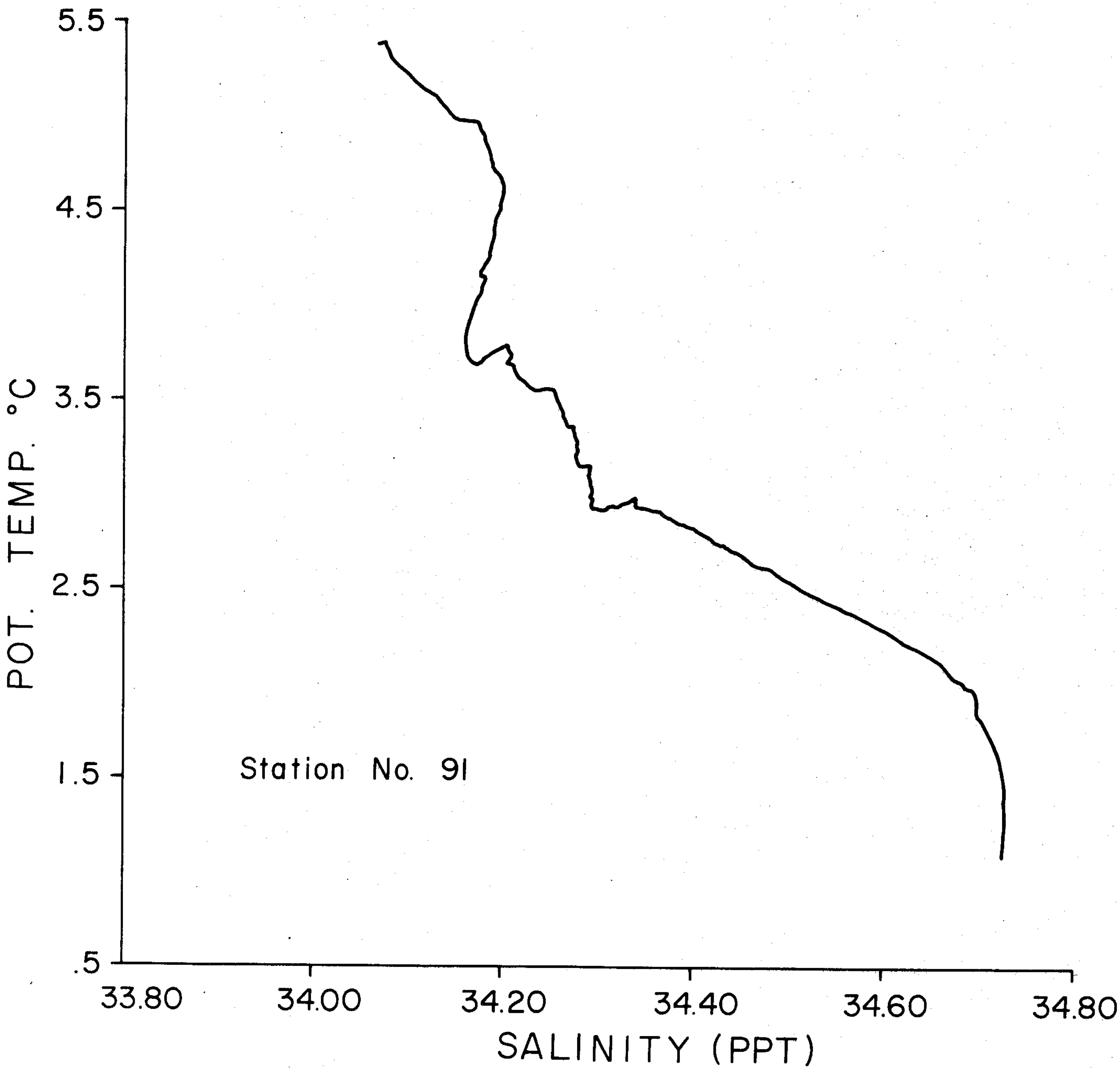


Figure 21b. Potential temperature/salinity diagram of CTD station #91

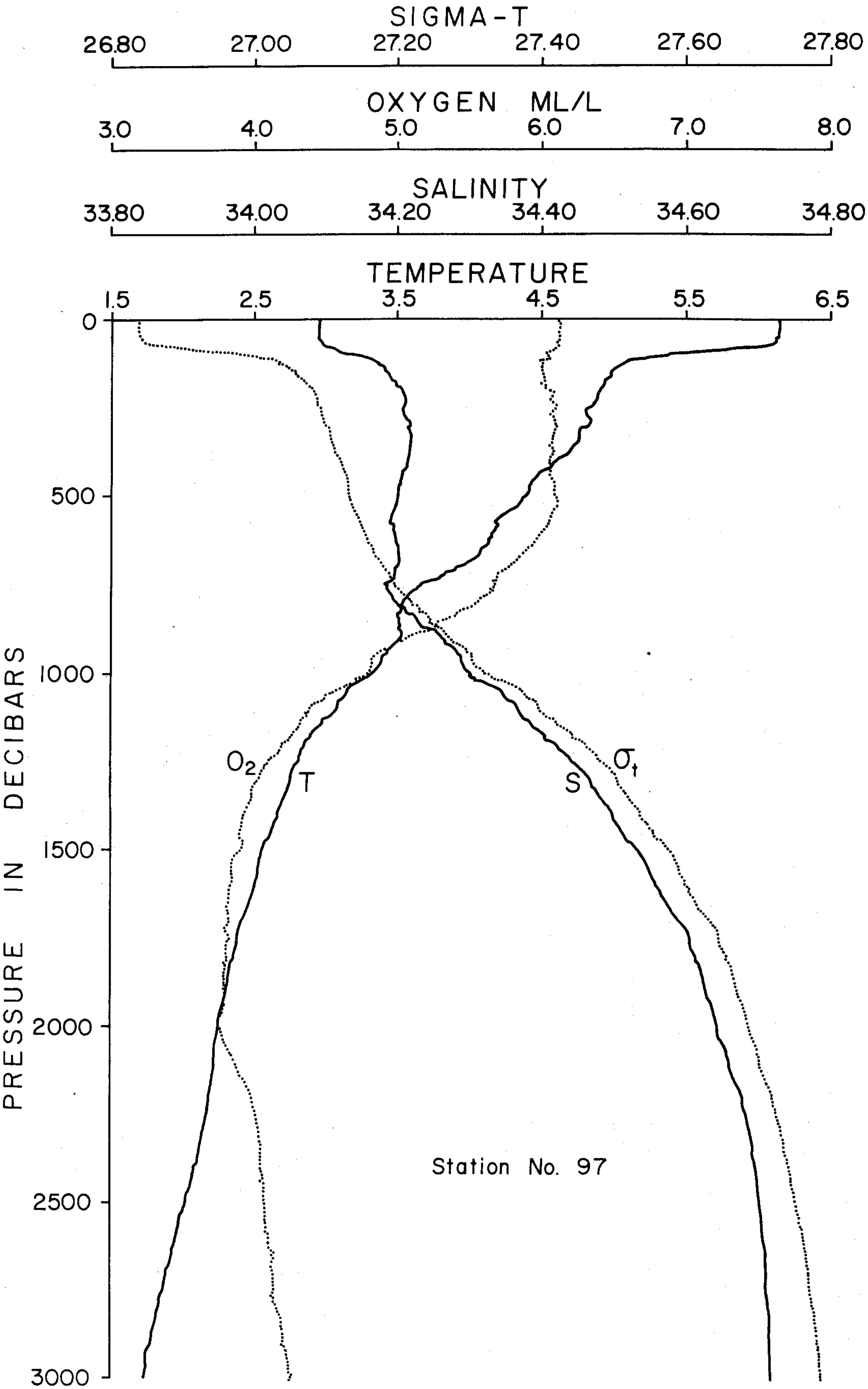


Figure 22a. Continuous temperature, salinity, and oxygen profiles of CTD station #97

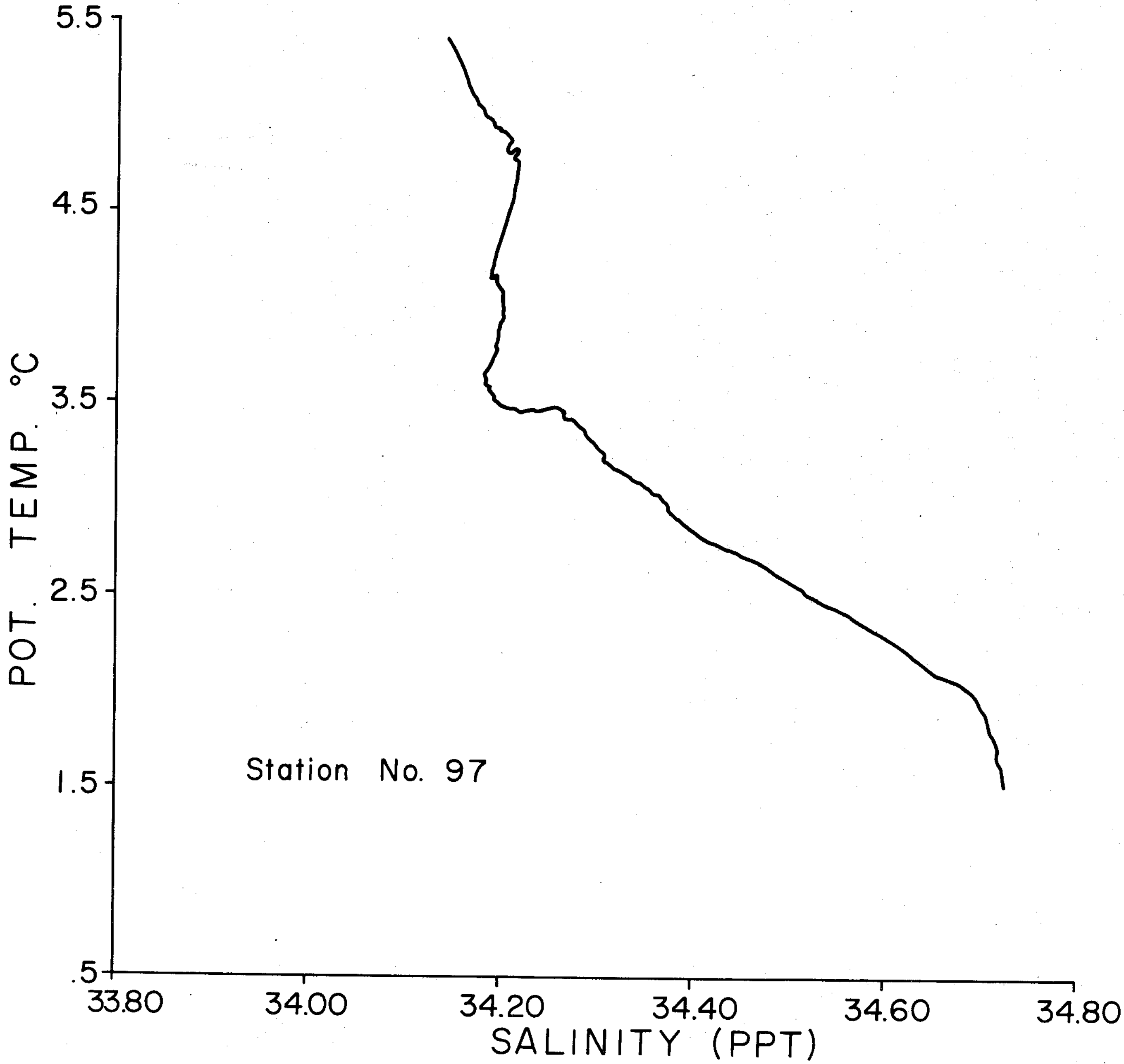


Figure 22b. Potential temperature/salinity diagram of CTD station #97

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Table 7

CTD Station Log

STATION NO.	DATE (YR-MO)	TIME	START LAT.	START LONG.	WATER DEPTH	PMIN	PMAX	END LAT.	END LONG.	NO. ROSETTES	END TIME
1	76-3-15	1301	55°30.7	65°44.6	1792	1.9	1553	55°30.3	65°43.7	10	1400
2	15	1826	55°29.1	65°41.9	-	0	1500	55°29.0	65°40.8	0	?
3	76-3-16	0011	55°24.0	65°35.9	2537	3.3	2016	55°24.5	65°33.0	6	0128
4	76-3-17	1700	59°04.3	63°55.2	3790	4.0	3020	59°04.3	63°55.2	11	1807
5	76-3-18	0015	58°54.8	63°54.0	3913	3.8	2999	58°54.3	63°52.7	11	0142
6	18	1000	57°36.2	64°38.9	4247	-	2976	57°31.2	64°36.3	11	1218
7	18	2022	57°25.0	64°38.1	4115	3.5	3009	57°23.2	64°36.8	11	2254
8	18	2359	57°24.85	64°37.6	4115	3.1	1001	57°23.9	64°36.8	5	0113
9	76-3-19	0159	57°25.6	64°38.1	4115	4.3	1509	57°24.8	64°37.7	5	0341
10	19	0420	57°25.1	64°37.8	4108	4.2	1515	57°24.7	64°38.0	4	0608
11	19	0648	57°25.9	64°38.6	4105	2.0	1506	57°25.5	64°38.0	6	0820
12	19	0947	57°25.1	64°36.7	4100	-	1512	57°23.7	64°36.2	6	1121
13	19	1212	57°24.9	64°37.2	4105	2.9	1511	57°23.6	64°37.8	6	1402
14	19	1443	57°25.1	64°37.6	4115	1.7	1542	57°24.1	64°37.7	6	1616
15	19	1653	57°25.2	64°37.3	4105	4.1	1515	57°24.8	64°36.3	6	1826
16	19	1854	57°25.3	64°36.7	4096	3.3	1502	57°24.2	64°35.9	6	2027
17	19	2105	57°25.4	64°37.8	4105	∿3.0	1517	57°24.3	64°37.0	6	2243
18	19	2318	57°25.3	64°37.2	4105	∿4.0	1514	57°23.5	64°36.7	6	0046
19	76-3-20	0130	57°25.2	64°36.8	4096	60*	1000	57°23.0	64°37.0	0	0325
20	20	0418	57°25.3	64°37.1	4105	2.2	1006	57°25.3	64°37.1	0	0445
21	20	0503	57°25.6	64°36.4	4096	2.6	1008	57°25.7	64°36.5	0	0529
22	20	0539	57°26.0	64°35.6	4096	1.3	1045	57°25.9	64°35.5	0	0609
23	20	0623	57°26.4	64°35.2	4096	1.5	1011	57°26.2	64°34.8	0	0657
24	20	0709	57°26.4	64°34.1	4096	38	1011	57°26.1	64°33.9	0	0735
25	76-3-21	0705	57°45.5	63°53.6	4057	3.3	3001	57°45.0	63°52.3	11	0851
26	21	1115	57°41.3	63°55.1	4105	∿5.0	2999	57°40.9	63°56.7	11	1246
27	21	1342	57°40.2	63°57.0	4209	4.8	3019	57°39.9	63°57.1	11	1457
28	21	1643	57°40.1	64°02.8	4096	2.9	3001	57°39.9	64°01.9	11	1817
29	21	2024	57°38.1	64°08.0	4303	3.6	2995	57°37.1	64°06.4	11	2204
30	76-3-22	0005	57°35.9	64°12.6	3409	2.7	1521	57°35.1	64°11.9	6	0142
31	22	0250	57°34.0	64°16.9	3184	1.5	2795	57°32.9	64°16.7	11	0422
32	22	0550	57°32.8	64°20.1	3904	2.1	3044	57°32.4	64°20.0	6	0629
33	22	0810	57°31.8	64°23.4	4378	1.6	1507	57°31.8	64°23.4	6	0908

*Yo-Yo

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Table 7 (Contd.)

STATION NO.	DATE (YR-MO)	TIME	START LAT.	START LONG.	WATER DEPTH	PMIN	PMAX	END LAT.	END LONG.	NO. ROSETTES	END TIME
34	76-3-22	1030	57°30.1	64°26.0	4378	-	3012	57°28.6	64°22.6	11	1302
35	22	1408	57°29.8	64°30.4	4256	3.7	1503	57°29.0	64°29.0	6	1458
36	22	1610	57°28.8	64°32.9	4143	2.9	3034	57°27.6	64°32.5	11	1733
37	22	1810	57°27.2	64°35.2	4105	-	1518	57°26.4	64°35.3	6	1910
38	22	2030	57°25.9	64°38.7	4115	2.9	3004	57°24.6	64°38.6	11	2242
39	22	2325	57°24.1	64°43.5	4190	2.8	3025	57°23.5	64°43.2	6	0147
40	76-3-23	0520	57°39.1	64°21.2	4397	3.1	1504	57°38.3	64°21.4	6	0625
41	23	0730	57°37.9	64°16.0	4171	1.3	1506	57°36.3	64°05.8	6	0840
42	23	0915	57°34.4	64°09.3	3933	3.0	1495	57°34.1	64°05.8	4	1015
43	23	1100	57°29.4	64°02.6	4124	5.1	1513	57°28.6	64°02.0	6	1210
44	23	2105	57°31.7	64°18.8	-	0	2000	57°30.9	64°18.2	0	2155
45	76-3-24	0305	57°33.1	64°05.8	-	3.8	2002	57°32.0	64°05.1	1	0451
46	24	2300	57°14.1	63°57.3	-	3.8	2989	57°12.8	63°51.9	11	0130
47	76-3-25	0805	57°32.9	63°28.9	-	4.3	1991	57°34.3	63°28.5	2	0906
48	25	1925	57°24.8	63°28.1	4105	3.6	3001	57°25.5	63°27.0	11	2055
49	76-3-26	0325	56°57.3	63°38.0	4162	3.0	1983	56°57.6	63°35.3	6	0425
50	26	1246	57°41.0	63°22.9	3676	3.4	2536	57°41.5	63°22.3	11	1463
51	26	1725	57°55.9	63°34.7	-	2.9	2005	57°55.3	63°36.0	6	1824
52	76-3-27	0637	56°45.5	63°20.5	3952	2.2	2015	56°45.0	63°19.0	6	0745
53	76-3-28	1238	59°00.8	63°51.0	3923	4.1	3010	59°00.3	63°49.2	6	1422
54	76-3-29	0220	57°39.9	63°51.0	3981	3.3	3050	57°40.2	63°53.2	11	0350
55	29	0740	57°42.2	64°09.6	4190	3.2	2955	57°40.2	64°09.5	11	0935
56	29	1438	57°25.1	64°10.4	4275	2.7	3079	59°24.6	64°12.2	11	1630
57	76-3-30	0140	57°59.9	62°59.8	3790	2.2	2973	58°01.2	62°58.3	11	0329
58	30	0900	58°48.5	62°58.5	3885	2.1	3001	58°48.7	62°55.7	9	1045
59	30	1405	58°28.7	63°14.0	3259	-	2014	58°28.7	63°13.0	6	1516
60	30	1910	58°27.7	63°11.2	3714	2.6	1505	58°28.1	63°12.2	2	2030
61	76-3-31	0320	58°27.8	63°13.3	3847	2.6	1478	58°27.5	63°12.8	2	0410
62	31	0538	58°27.2	63°12.2	3856	2.9	1515	58°27.0	63°11.6	2	0621
63	31	0727	58°26.0	63°09.0	3505	2.2	1510	58°26.0	63°09.0	2	0847
64	31	0945	58°25.5	63°09.0	3447	-	1521	58°25.5	63°09.6	2	1025
65	31	1144	58°25.0	63°09.9	3221	5.0	1509	58°25.3	63°10.1	2	1236
66	31	1412	58°24.6	63°09.9	3034	-2.4	1481	58°25.4	63°08.8	2	1520

Table 7 (Contd.)

STATION NO.	DATE (YR-MO)	TIME	START LAT.	START LONG.	WATER DEPTH	PMIN	PMAX	END LAT.	END LONG.	NO. ROSETTES	END TIME
67	76-3-31	1615	58°24.8	63°09.9	3034	4.2	1519	58°24.5	63°09.8	2	1655
68	31	1815	58°24.2	63°09.6	2958	3.0	1515	58°24.0	63°09.3	2	1854
69	31	2013	58°24.1	63°08.1	2921	3.2	1504	58°23.9	63°08.1	2	2055
70	31	2236	58°23.8	63°07.9	3015	3.4	1513	58°23.9	63°08.0	2	2300
71	76-4-1	0045	58°23.0	63°07.0	3259	∿3.0	1495	58°22.7	63°06.3	2	0138
72	1	0250	58°22.8	63°07.3	3296	∿2.0	1436	58°22.2	63°06.8	2	0340
73	1	0441	58°23.0	63°09.3	3128	2.8	1517	58°23.0	63°09.1	2	0526
74	1	0630	58°22.8	63°09.0	3072	3.4	1521	58°22.6	63°09.0	2	0717
75	1	1858	58°19.3	63°11.7	4096	2.2	1519	58°18.9	63°10.8	2	1937
76	1	2355	58°22.6	63°00.3	4000	2.9	1520	58°22.1	62°59.0	2	0045
77	76-4-2	0644	58°57.9	63°07.6	3860	1.4	3000	58°56.2	63°03.1	11	0845
78	2	1057	58°45.4	63°02.4	3904	4.0	3014	58°56.2	63°00.9	11	1242
79	2	1442	58°35.8	63°06.8	3771	3.3	3006	58°35.2	63°06.7	11	1622
80	2	1816	58°25.3	63°11.1	3240	2.7	2978	58°24.2	63°15.0	11	2010
81	2	2203	58°14.1	63°17.8	4247	3.8	3001	58°14.8	63°16.1	11	2356
82	76-4-3	0210	58°04.6	63°21.7	4105	5.3	3025	58°05.0	63°22.0	11	0412
83	3	0608	57°56.7	63°25.3	4095	2.1	2950	57°56.5	63°28.4	11	0823
84	3	1040	57°46.6	63°30.0	3733	9.0	3030	57°46.7	63°33.0	11	1230
85	3	1430	57°36.7	63°31.4	3894	2.9	3005	57°36.5	63°34.0	11	1620
86	3	1850	57°27.0	63°39.1	3752	2.4	3998	57°26.9	63°41.0	11	2033
87	3	2258	57°15.9	63°38.8	4134	4.5	3003	57°16.2	63°37.2	11	0050
88	76-4-4	0200	57°08.8	63°42.8	4143	4.3	3020	57°06.8	63°41.2	11	0402
89	4	0611	56°57.7	63°48.5	3923	∿3.0	3041	56°56.5	63°45.9	11	0817
90	4	1040	56°53.3	64°03.1	3981	4.5	2995	56°52.0	04°00.5	11	1252
91	4	1607	56°49.6	64°23.3	3942	2.8	2999	56°49.3	64°25.5	11	1810
92	4	2047	56°45.5	64°38.0	3923	∿4.0	3046	56°44.7	64°37.6	11	2244
93	76-4-5	0110	56°39.8	64°53.8	3485	4.8	3001	56°35.5	64°53.6	11	0255
94	5	0523	56°37.2	65°11.1	3771	2.7	2807	56°36.8	65°12.2	11	0718
95	5	1031	56°32.0	65°28.8	3828	5.1	2948	56°32.4	65°27.6	11	1210
96	5	1437	56°27.5	65°41.9	1990	4.5	2963	56°27.1	65°43.7	11	1625
97	5	1814	56°24.0	66°01.7	1930	2.6	3008	56°23.9	66°03.7	11	1956
98A	5	2219	56°19.1	66°20.5	925	4.3	1645	56°19.5	66°19.6	11	2343
98B	76-4-6	0032	56°19.4	66°19.5	920	∿4.0	1703	56°19.0	66°19.3	4	0138

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Table 7 (Contd.)

STATION NO.	DATE (YR-MO)	TIME	START LAT.	START LONG.	WATER DEPTH	PMIN	PMAX	END LAT.	END LONG.	NO. ROSETTES	END TIME
99/2	76-4-6	0310	56°15.3	66°35.6	920	2.4	907	56°15.3	66°36.0	6	0400
99/1	6	0431	56°15.4	66°36.5	827	2.4	821	56°15.7	66°37.3	6	0507
100/1	6	0643	56°14.5	66°43.3	256	2.5	258	56°13.6	66°45.0	3	0657
100/2	6	0730	56°13.4	66°45.4	218	2.8	223	56°13.1	66°46.0	3	0750
101/1	6	0840	56°10.5	66°52.5	106	3.5	104	56°10.3	66°52.0	3	0850
101/2	6	0900	56°10.2	66°51.1	106	3.9	-	56°10.2	65°51.0	-	0915

V. PROFILING CURRENT METER (PCM)

A. Introduction

One of the major objectives of this cruise was the investigation of possible Antarctic Intermediate Water (AAIW) formation in the Polar Front zone. The AAIW originates from the convergence of water masses with polar characteristics and those of subpolar properties. Its origin is associated with the presence of the Antarctic Circumpolar Current System whose cross-frontal velocity component yields a northward meridional transport of antarctic near surface water masses. This water sinks down on isopycnal surfaces and like in other comparable cases in the world ocean (i.e., Mediterranean outflow, Norwegian Sea overflow) can be clearly verified by its interleaving in the vertical distribution of temperature, salinity, and dissolved oxygen. The goal of using a vertical profiling current meter (PCM) was to estimate the correlation between the cross-frontal current component and other characteristic properties of the sinking AAIW such as low temperature and salinity values, together with high dissolved oxygen content.

B. Instrument Description

The vertically profiling current meter used is derived from a moored type Bergen meter (Aanderaa). Basically it consists of the recording unit, mounted up-side-down, and a nearly buoyant vane assembly sinking slowly down on the cable of the temperature-conductivity-pressure microprofiler (CTD). Consequently the PCM records the water motion relative to the drifting ship. This current profile may be transferred into an absolute vertical distribution of horizontal current by a vector addition of the ship's drift, if this is known. The instrument used (serial #776) is equipped with a Savonius-like rotor, thermistor, inductive conductivity cell, pressure sensor, and a magnetic compass. For specifications see Table 8. The data are recorded internally in 10-bit words on 1/4" magnetic tape and are telemetered acoustically. In order to obtain highest possible vertical resolution the instrument was run in the 'continuous' mode rather than by clock derived trigger pulses.

Table 8

Specifications on PCM #776

Measuring Ranges		Accuracy	Resolution	Miscellaneous
Temperature	-2.46 to +21.40° C	>±0.1° C	±0.023° C	time const. 63% in 2.5 sec
Conductivity	0 to 60 mmho	Not known (see right)	±0.059 mmho	for overall information due to insufficient flushing
Pressure	0 to 1000 psi (750 dbar)	>±1% FS	±0.73 dbar	hysteresis 0.5%
Speed	1.5 to >250 cm/s	-	±0.49 cm/s	gear ratio 240:1 rotor const., 43.5 cm/rev rotor threshold 1.5 cm/s
Direction	0 to 360°	±5°	±0.35°	

The actual sampling interval was controlled several times during the experiment (Table 9). The overall averaged sampling rate was 20.8 ± 3.1 sec/cycle. The sinking rate was adjusted to the region under investigation by means of a test station at the beginning of the cruise. A typical pressure vs. time diagram is shown in Fig. 23. With the obtained falling speed of <37 cm/s the averaged vertical sampling rate for a single sensor was <7.8 m. For an accurate analysis the time shift between scanned data channels (5 sensors + reference channel) has to be taken into account. Two accessories (both supplied by D. Pillsbury, OSU) were of great help in performing the measurements. An acoustic receiver was used to monitor the acoustic telemetry of the PCM in the near surface layers and during the stand-by periods. Acoustic telemetry was used as well for the display of the sampling rate on a recorder. A tape reader (suitcase translator) enabled the final check-out of the instrument after reloading and permitted an early look at the PCM data.

C. Operation

All operational data are summarized in Table 10. At the beginning of the cruise a necessary test station was occupied for the instrument's adjustment. Particular emphasis was given to a two-inertial period time series station in the polar front zone. The polar front at this site later was split off from the main front and became a cold water eddy. The sampling interval for 12 stations (#7 was repeated as #8) was 2h 24 min ± 26 min. The transformation of the obtained relative velocity data into absolute current profiles will be possible due to distance and range observation relative to a moored buoy, "Edgar". This measurement was performed every five minutes during the descent of the PCM (see section II). A second data set consisting of three PCM stations roughly with the same tidal/inertial phase (12-13 hours apart) was obtained during the first CTD section through the polar front. Again buoy navigation enabled the calculation of absolute current profiles.

A further single PCM station was obtained over VCM #1. This time no reference buoy was available. An adjustment of the relative velocity

Table 9

Sampling Rate of PCM

Test No.	Date (1976)	Time Z	Battery Cap.	Sampling Rate avgd 12 cycles sec/cycle
1	18 March	19:00	1/1	20.3
2	19 March	15:15	1/2	21.1
3	19 March	20:38	low	21.0
4	19 March	22:50	1/1	20.9
5	22 March	08:19	1/2	20.9

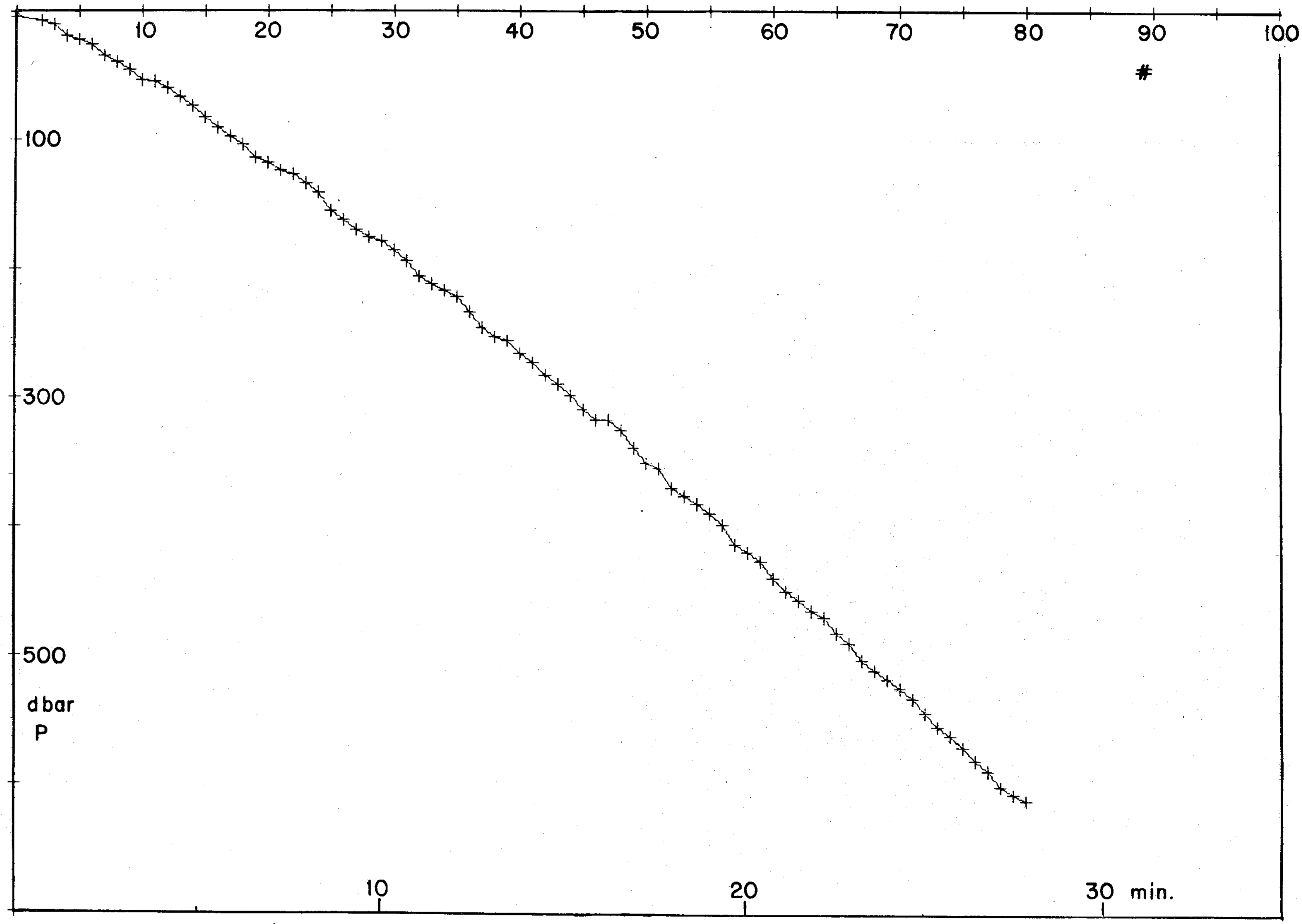

Figure 23. The sinking of the profiling current meter (PCM) on station #6. The instrument slides down the CTD cable and is halted by a cable mounted stopper approximately 3 meters above the CTD fish. The averaged sinking rate was less than 37 cm/s which implies a mean vertical resolution of less than 7.8 m

Table 10

PCM Station Log

PCM Profile No.	Date	CUT Time Start	CUT Time End	Position ϕ(S)	Position λ(W)	Water Depth m	ca Max. Depth m	Corresp. CTD Sta. No.	Time between PCM Stations Min.	Remarks
TT107-1	15 March	14:00	14:45	55°30.0	65°44.0	1935	400	1		Test Station
2	"	20:25	20:55	55°26.0	65°38.4	1950	600	2		
3	18 March	21:25	22:48	57°24.2	64°27.4	4143	600	7		
4	19 March	00:23	01:13	57°24.4	64°37.6	4115	600	8	178	
5	"	02:34	03:33	57°25.4	64°37.9	4115	600	9	131	CTD/PCM Time Series
6	"	05:03	08:03	57°25.0	64°37.8	4115	600	10	149	
7*	"	07:34	08:00	57°25.1	64°37.2	4105	100	11		
8	"	08:21	09:05	57°24.5	64°36.7	4105	600	11/2	198Δ	
9	"	10:23	11:22	57°24.5	64°36.4	4096	600	12	122	
10	"	12:58	14:04	57°24.3	64°37.9	4105	600	13	155	*No speed data
11	"	15:15	16:15	57°24.6	64°37.7	4115	600	14	137	
12	"	17:30	18:10	57°25.1	64°37.0	4105	600	15	135	ΔBetween 6 and 8
13	"	19:28	20:05	57°24.8	64°36.3	4096	600	16	118	
14	"	21:20	22:40	57°24.8	64°37.0	4105	600	17	112	
15	19/20 "	23:50	00:50	57°24.7	64°36.9	4105	600	18	150	
16	22 March	00:43	02:10	57°35.7	64°12.1	3180	600	30		
17	"	11:50	13:05	57°29.6	64°24.3	4369	700	34	667	Cross frontal section
18	23 March	00:40	01:50	57°23.7	64°43.2	4190	700	39	770	
19	25 March	00:20	01:26	57°13.5	63°54.4	3961	600	46		Over Float No. 1

profile may be possible by means of the float trajectory at a single depth.

D. Preliminary Data Analysis

All data tapes were decoded with the OSU reader. The counts for temperature, pressure, compass, and speed were punched on cards. By means of the ship's computer, IBM 1130, the preliminary data have been calibrated, edited, and plotted. The following calibration equations were used for a quick-look analysis:

Pressure: (dbar) $p = -32. + 0.7568 * N_P$

Temperature: (°C) $T = -2.7677 + 2.33993E{-}2 * N_T$

Compass: (°T) $\Theta = .351906 * N_\Theta + \delta$

Speed: (cm/s) $s = (G/1024) * (\Delta t)^{-1} * (R * \Delta N_s) + T_o$

with

N_i = parameter reading in counts

δ = magnetic variation = +14°

G = gear ratio = 240

R = rotor constant = 43.5 cm/rev

Δt = sampling interval = 21 sec

T_o = threshold speed = 1.5 cm/s

The obtained velocity data were decomposed into rectangular, North oriented components ($u_v v_r$) and superimposed with the ship's drift velocity components (u_D, v_D): Yielding true components of the current ($u_T v_T$):

$$u_r = s \sin \Theta \rightarrow u_T = u_r + u_D$$

$$v_r = s \cos \Theta \rightarrow v_T = v_r + v_D.$$

Finally the coordinate axes were rotated an angle α to obtain a cross frontal (u_c) and a front parallel (u_p) component.

$$u_c = u_T \cos \alpha - v_T \sin \alpha$$

$$v_p = u_T \sin \alpha + v_T \cos \alpha$$

The computer program plots the following quantities: s, Θ, u_T, v_T, u_c, v_p vs. p and p vs. time. Samples are shown in Figs. 24,25.

E. Discussion

At this moment only a limited statement can be made on the significance of the two displayed sample stations #6 and #8 (Figs. 24,25). The speed profiles of both stations indicate vertical scales of variability of 0(20-100 m) and magnitudes of 0(20-40 cm/s) after correction for the ship's drift. Vertical current shear is found to be of $0(10^{-3} - 10^{-2}\ \text{sec}^{-1})$. In the direction profiles, while station #6 shows a fairly unidirectional current, station #8 displays an anti-clockwise turning of the current with increasing depth associated with a cross-frontal flow ($u_c < 0$) below 380 dbar. The actual front direction as well as the drift corrections have to be applied carefully to the data for a more precise analysis. For this and any correlations with temperature and oxygen fluctuations, the complete CTD/PCM/XBT data set first has to be compiled.

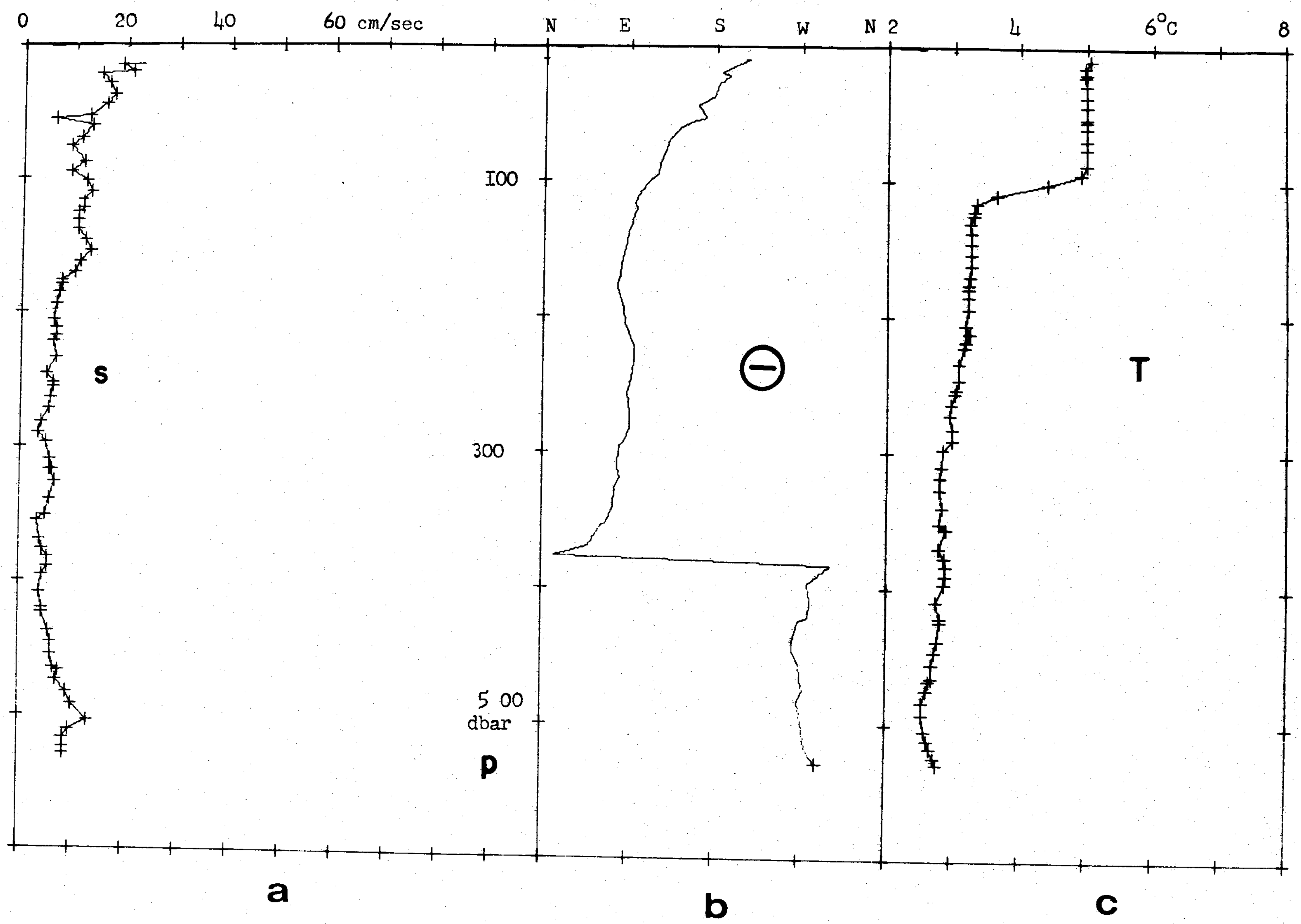

Figure 24a-c. Vertical distribution of relative speed(s), direction (θ), and temperature (T) on station #6. Values for p less than 20 dbar should be ignored

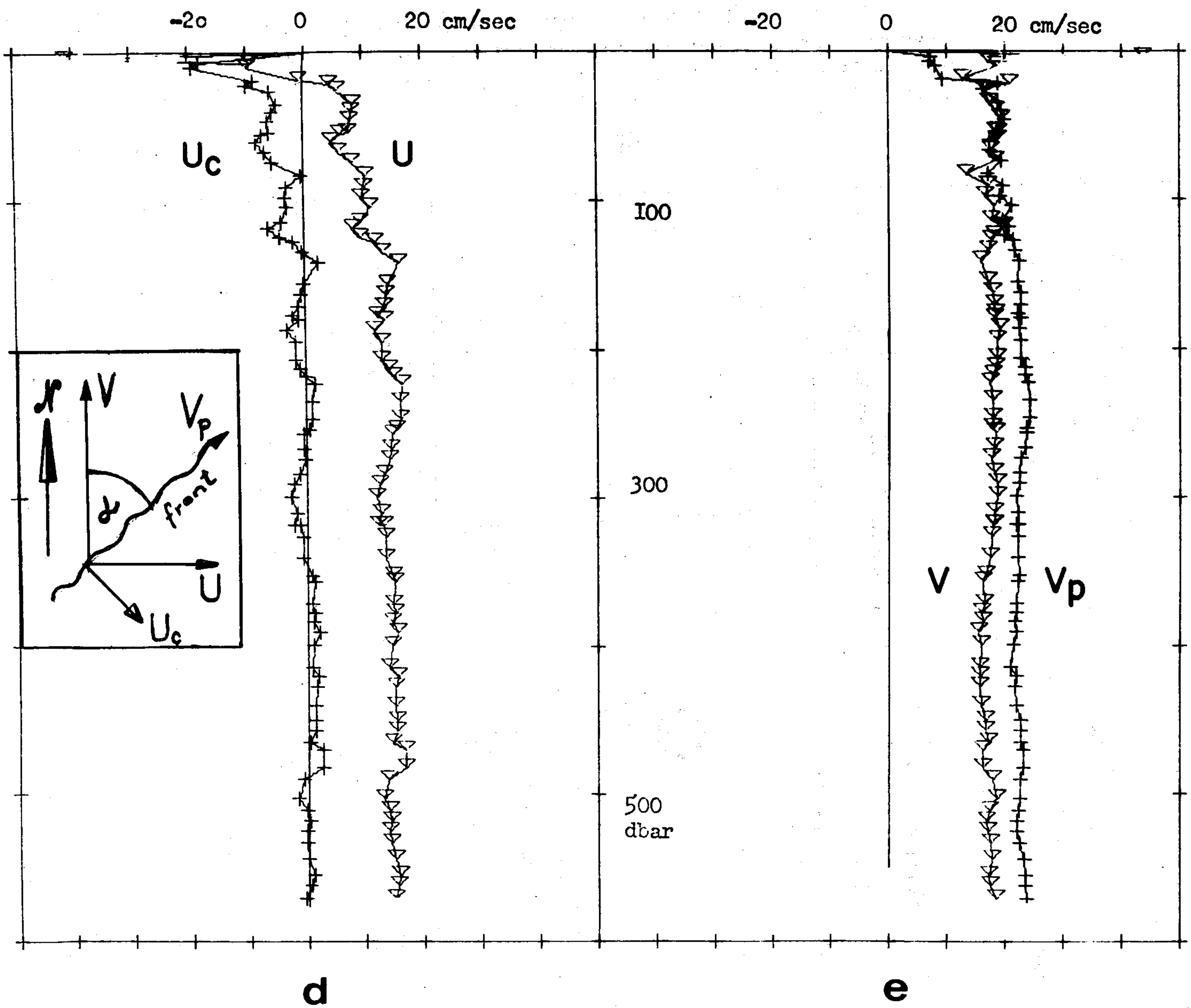

Figure 24d,e. Vertical distribution of velocity components as indicated in the insert. The ship's drift has been compensated for. Under the given assumption of $\alpha = 40°$ there was minimal cross frontal flow (U_c). The front parallel component (V_p) shows negligible depth dependence to 600 m

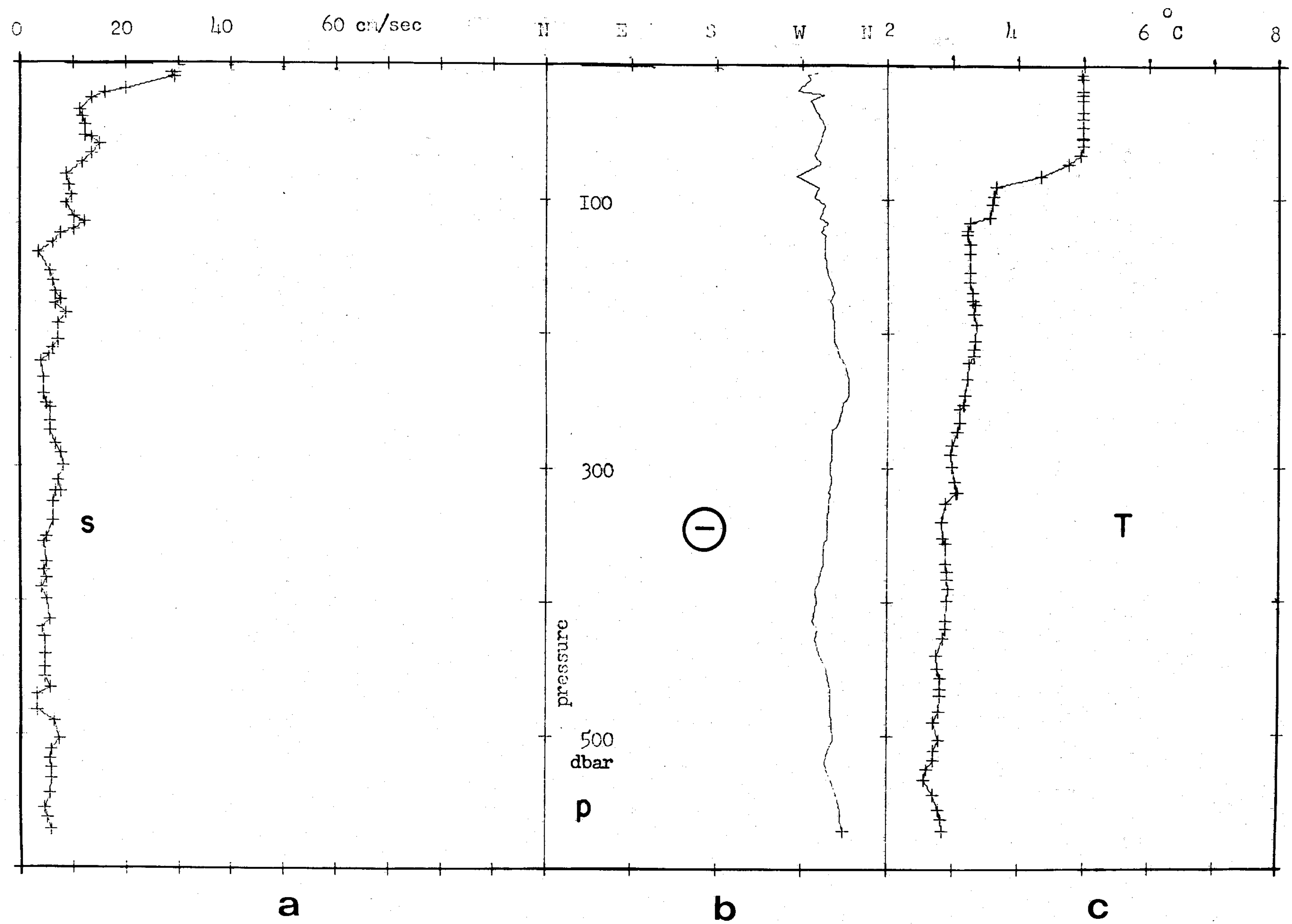

Figure 25a-c. Vertical distribution of relative speed(s), direction (θ), and temperature (T) on station #8. The current shears in an anticlockwise direction

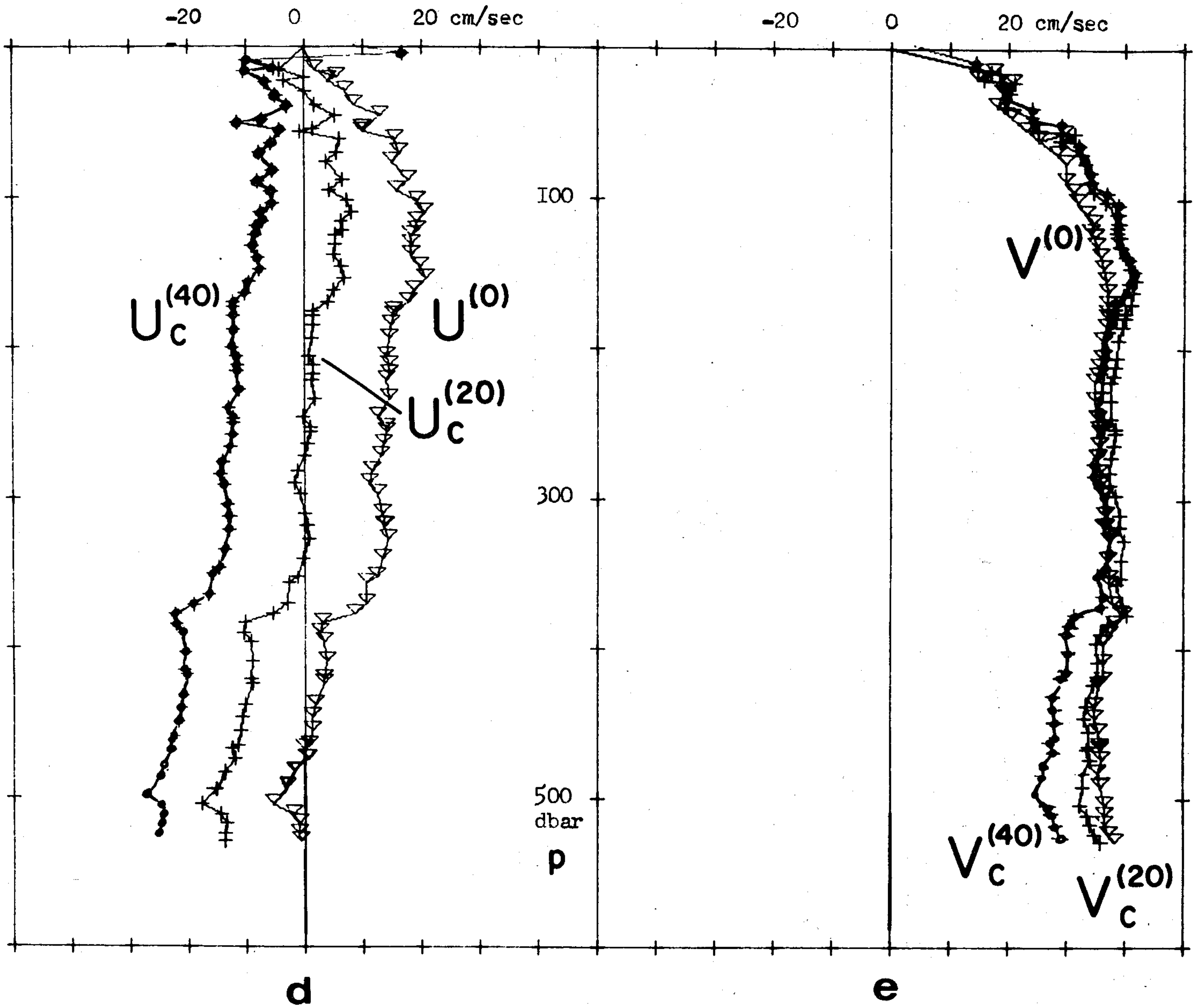

Figure 25d,e. Vertical distribution of corrected velocity components as shown in Figure 24d,e. For $\alpha \simeq 20°$ U_C shows minimal cross frontal flow

VI. OPTICAL MEASUREMENTS

A. Objectives

The objectives were to study certain aspects of the optical properties of the water masses with a view to

1. obtain an optical classification of the water,
2. observe the color index of the surface water, and
3. obtain information on the distribution and properties of the suspended matter.

For this purpose the following instruments were used:

1. A quanta meter which is an irradiance meter integrating over the spectral range 350 to 700 nm with the spectral response adjusted and calibrated so that the total number of quanta in that range is obtained. The detector is a photocell. The instrument is suspended from its cable and lowered to about the depth of 1% level of the incoming surface irradiance, taking measurements at discrete depths. The signal is integrated over 10 seconds and 3-5 measurements are made at each depth. The incoming surface irradiance is monitored by means of a separate quanta meter mounted at a suitable place on deck.

2. A color meter essentially consisting of two photocells measuring simultaneously the upwelling irradiance in the blue (465 nm) and the green (520 nm), the measurement is made about 1 m beneath the surface. The ratio of the signals blue/green defines an ocean color index: a large index is typical of very clear, low-productive waters whereas a low index indicates productive waters.

3. An instrument measuring the scattering function $\beta(\theta)$ defined as

$$\beta(\theta) = \frac{d\,\mathfrak{I}(\theta)}{E \cdot dV}$$

where $d\mathfrak{I}(\theta)$ is the intensity of the light scattered by the volume element dV in the direction θ from the incoming beam irradiating the volume element with the irradiance E. The scattering function is observed over the angular interval $\theta = 8^\circ$ to $\theta = 160^\circ$, with the resolution of 1°. The direct beam as well as the cut-off at $\theta = 180^\circ$ are also observed, yielding the necessary reference points and calibration data. The light source is a 10 watt halogen lamp and the detector is a photomultiplier tube (RCA 8644, spectral response S20). By means of optical filters mounted on the detector the scattering in different parts of the spectrum can be observed. However, the filter has to be changed on deck. In the present case a red glass filter, nominal wavelength 650 nm and a green glass filter, nominal wavelength 520 nm were used.

The optical system gives a parallel beam of light with a diameter of 8 mm. Part of the detector system can be rotated by means of a motor in a circular path around the scattering volume. The angular position of the detector is recorded with a resolution of 1°, counting from the direction of the direct beam. The aligning of the optical system is checked at intervals. An automatic control of the system is obtained through the measurement of the direct beam intensity. In addition to the scattering the relative temperature distribution is obtained by means of a thermistor.

The instrument is operated from a separate winch with 1200 m 7-conductor wire cable. When lowering the instrument the scattering at a fixed angle is observed, usually about 20°, and when hauling back the scattering function is observed at discrete levels. The signals are recorded on an analog recorder only.

All the instruments functioned very well during the cruise. The winch motor had to be replaced by a motor made for the voltage of the ship. This operation was carried out by members of the engine room crew under the supervision of the chief, and we are extremely grateful for this.

B. Data Set Description

In all, 11 quanta meter stations (Table 11), with 7 including color measurement, and 48 (2 lost stations) scattering meter stations (Table 12) were obtained. Stations 4-11 constitute Section A where the scattering meter was used at every 2nd CTD station, and stations 23-48 form

Table 11

Quanta Meter Station Log

Day	No.	Time Local	Sun Height	Position S	Position W	Color
March 15	1	1130-1150	- °	55°29.5	65°41.7	+
15	2	1500-1530	-	55°26.0	65°38.4	+
17	3	1105-1120	25	59°09.0	63°53.9	-
18	4	1330-1400	30	57°26.0	64°41.0	+
19	5	1215-1230	33	57°24.0	64°38.4	+
23	6	1310-1325	30	57°28	64°38	-
24	7	1450-1505	22	57°24	63°50	+
27	8	1555-1620	16	57°53	64°42	-
31	9	1300-1320	27	58°24.5	63°09.6	+
April 1	10	1520-1535	16	58°18.9	63°10.6	+
2	11	1145-1200	26	58°35.5	63°06.8	+

Table 12

Scattering Meter Station Log

Day	Time Local	No.	Filter	CTD No.	Position S	Position W
March 21	0000	3	Red	-	57°36	64°23
21	0900	4	Red	25	57°45	64°52
21	1130	5	Red	27	57°40	63°57
21	1900	6	Red	29	57°37	64°06
22	0100	7	Red	31	57°33	64°17
22	0530	8	Red	33	57°31	64°24
22	1130	9	Red	35	57°29	64°29
22	1530	10	Red	37	57°26	64°35
22	2200	11	Red	39	57°24	64°43
23	0230	12	Red	40	57°38	64°22
25	0530	13	Green	47	57°35	63°29
25	1730	14	Green	48	57°25	63°28
26	1050	15	Green	50	57°41	63°23
26	1430	16	Green	51	57°55	63°36
27	0430	17	Green	52	56°45	63°20
29	0030	18	Green	54	57°39	63°52
29	0330	19	Green	55	57°44	64°05
30	1200	20	Red	59	58°29	63°13
31	1400	21	Red	67/68	58°24	63°10
April 1	0300	22	Red	73/74	58°23	63°09
2	0500	23	Red	77	58°56	63°03
2	0900	24	Red	78	58°45	63°00
2	1230	25	Red	79	58°35	63°07
2	1610	26	Red	80	58°24	63°13
2	2000	27	Red	81	58°15	63°16
3	0030	28	Red	82	58°05	63°22
3	0430	29	Red	83	57°56	63°28
3	0830	30	Red	84	57°47	63°33
3	1230	31	Red	85	57°37	63°33

Table 12 (Contd.)

Day	Time Local	No.	Filter	CTD No.	Position S	Position W
April 3	1430	32	Red	86	57°28	63°38
3	1830	33	Red	87	57°16	63°39
4	0030	34	Red	88	57°07	63°38
4	0430	35	Red	89	56°56	63°46
4	0930	36	Red	90	56°52	64°01
4	1430	37	Red	91	56°50	64°24
4	1900	38	Red	92	56°45	64°38
4	2330	39	Red	93	56°38	64°54
5	0315	40	Red	94	56°37	65°14
5	0810	41	Red	95	56°32	65°28
5	1010	42	Red	96	56°27	65°42
5	1600	43	Red	97	56°24	66°04
5	2000	44	Red	98	56°20	66°20
6	0000	45,46	Red	99/1,2	56°16	66°37
6	0330	47	Red	100/1,2	56°13	66°45
6	0450	48	Red	101/1,2	56°10	66°52

Section B where the scattering observations were made at every CTD station. The other scattering stations were made in connection with the float tracking. The quanta meter lowerings were, with 2 exceptions, made around local noon, whenever they could be fitted into this schedule and during suitable weather conditions.

A considerable quantity of what appears to be good quality data has been obtained. These data will yield new basic information since optical measurements of this kind have not been made in these waters before. The scattering data in particular are unique. In situ measurements of the scattering function over such a considerable angular interval to such depths have never been made before. The scattering functions will yield much more information about the suspended particulate matter than observations at one angle only. The in situ observations are not hampered by the contamination problem which always has an influence on in vitro scattering measurements. This is, of course, especially the case when the water is very clear. It is doubtful that the small relative variations in the scattering properties found in the present observations would have been detected by in vitro techniques.

The quanta meter was lowered to 60-80 m. The 1% level was around 70 m in most cases. This shows that the water is very clear, and the color index is also high. Optically the surface water north of the front is similar to the water found in the western Mediterranean, and it is almost as clear as Sargasso Sea water. Unfortunately we could not go far enough south of the front to find the nutrient rich water at the surface and determine its optical properties.

The scattering meter was generally lowered to a depth slightly beneath the level of the internal temperature maximum. We did not go deeper than about 1000 m. Scattering functions were usually obtained at 5-10 levels, so as to cover the different water layers as indicated by the temperature distribution. In areas where interleaving was found, scattering functions were observed in water layers as thin as about 20 m. The results suggest that the cold water originating from south of the front contains more suspended matter than the warm water of northern origin. The interleaving displayed in the CTD records seems to appear also in the scattering records.

C. Sample Stations

A preliminary analysis of the data from a number of stations has been carried out.

Figure 26 shows two examples of quanta profiles, in the form of percentage of incoming surface irradiance as a function of depth. These profiles are representative of all observed, and the form is in general agreement with what is normally found.

Figures 27-29 show three profiles of light scattering (relative units) at a fixed angle together with the corresponding CTD profiles. No. 30 (CTD 84) was obtained in the southern part of the frontal zone, No. 32 (CTD 86) in the center of the eddy, and No. 35 (CTD 89) north of the eddy. These examples show the range of variation of the scattering and the structure vs. depth. This is especially interesting in the interleaving zones, and the correspondence with the T,S distribution is obvious.

Figure 30 shows examples of the scattering function at four different depths at station 19, where the green filter was used. The general shape of these functions is very characteristic, showing that the scattering is dominated by particles larger than the wavelength of the scattered light. The variation from 230 to 700 m is quite large. Note that the warm water of 455 m scatters less than the cold water at 485 m. It should be emphasized that these results are preliminary.

Acknowledgment

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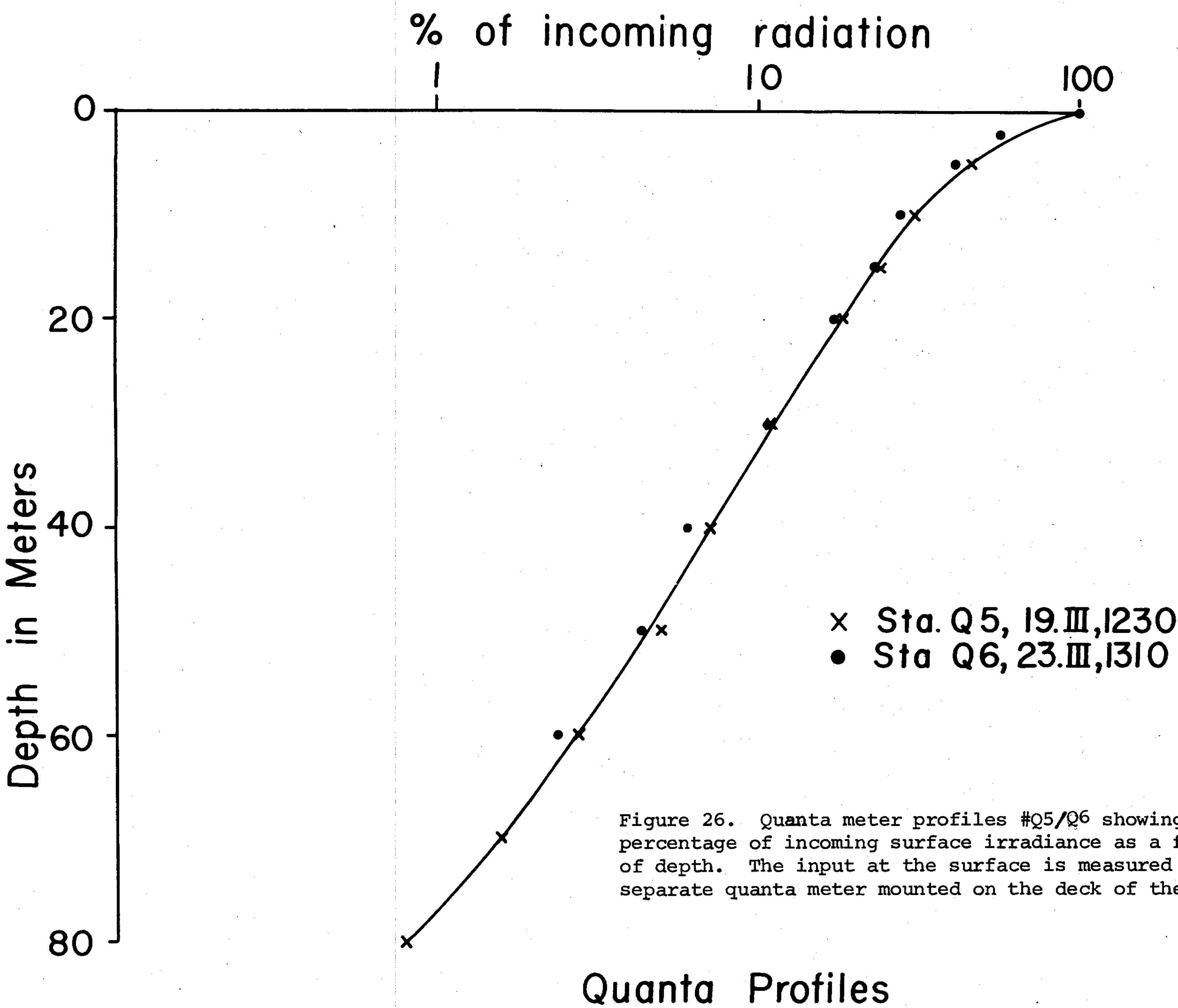

Figure 26. Quanta meter profiles #Q5/Q6 showing the percentage of incoming surface irradiance as a function of depth. The input at the surface is measured by a separate quanta meter mounted on the deck of the ship

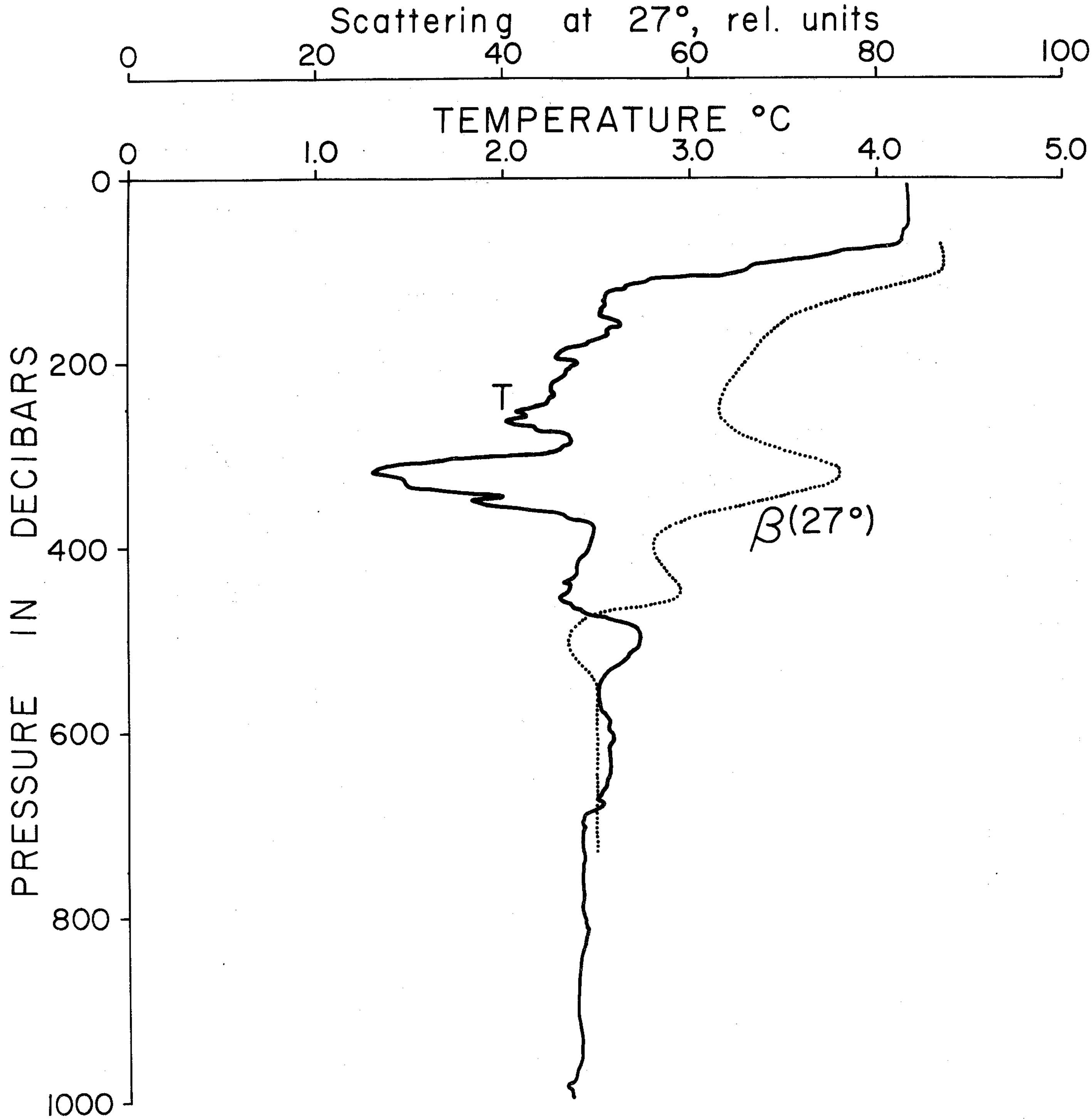

Figure 27. Combined temperature (from CTD station #84) and light scattering (station #30) profiles at a fixed angle of θ = 27°

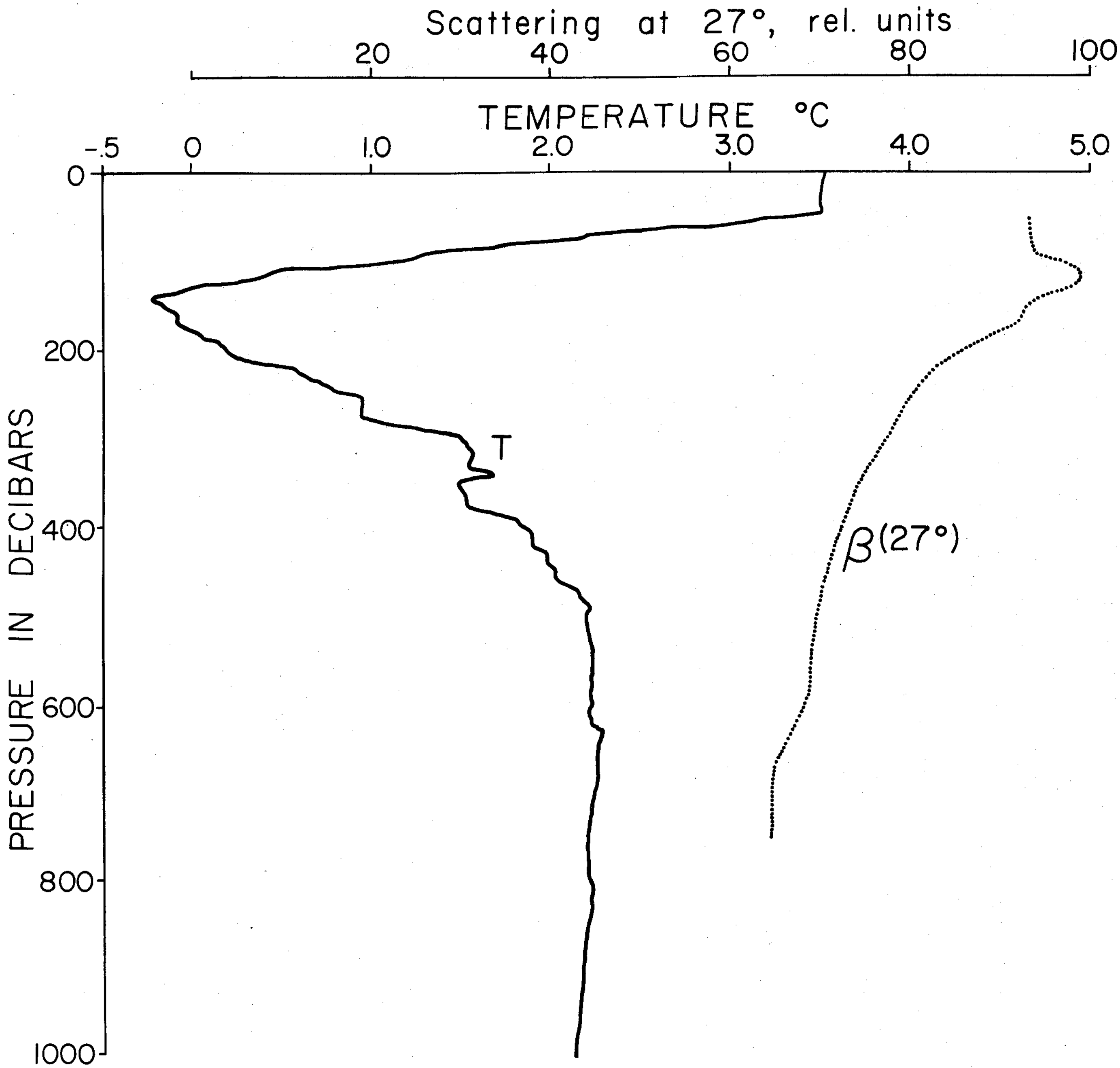

Figure 28. Combined temperature (from CTD station #86) and light scattering (station #32) profiles at a fixed angle of θ = 27°

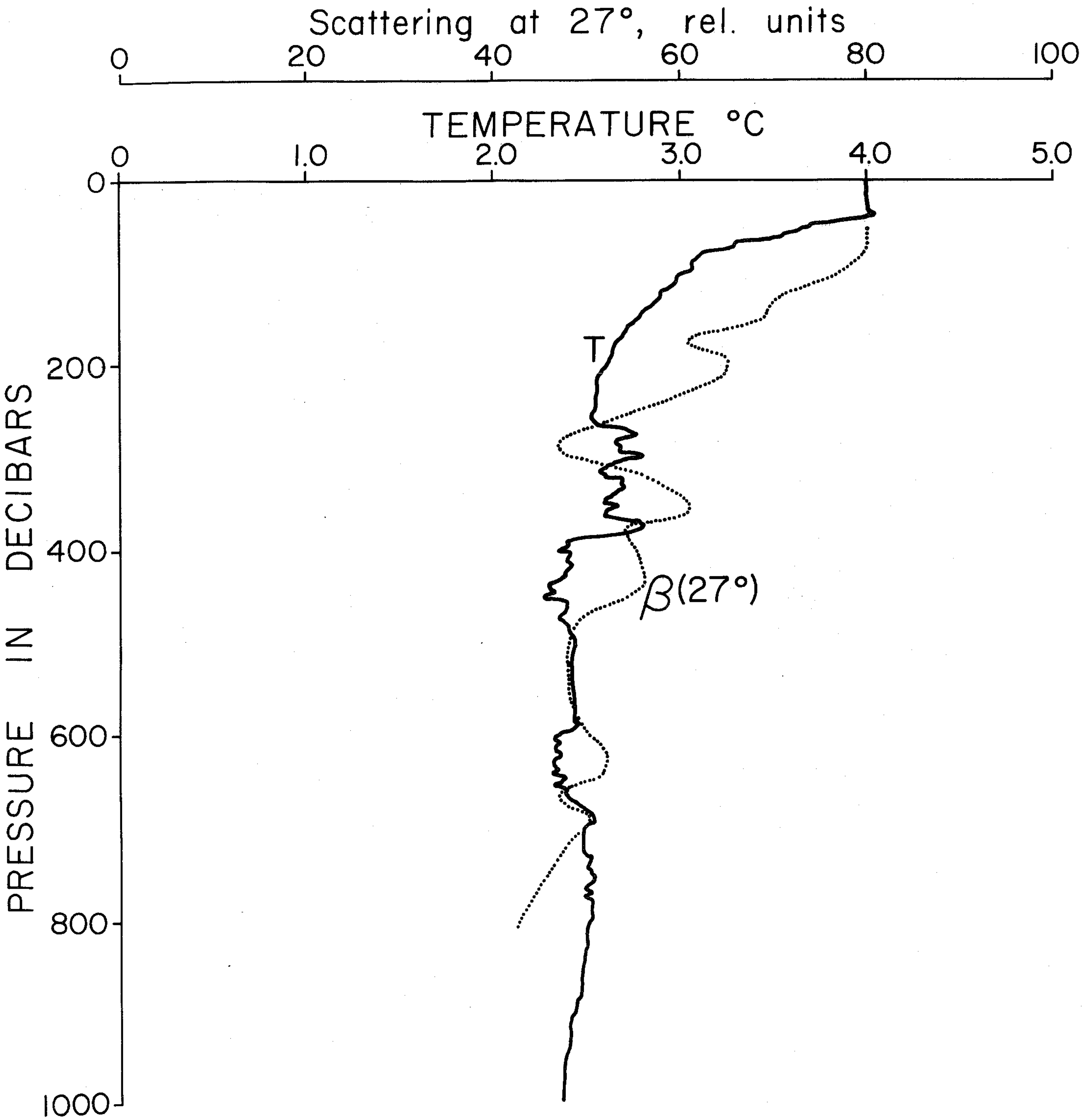

Figure 29. Combined temperature (from CTD station #89) and light scattering (station #35) profiles at a fixed angle of θ = 27°

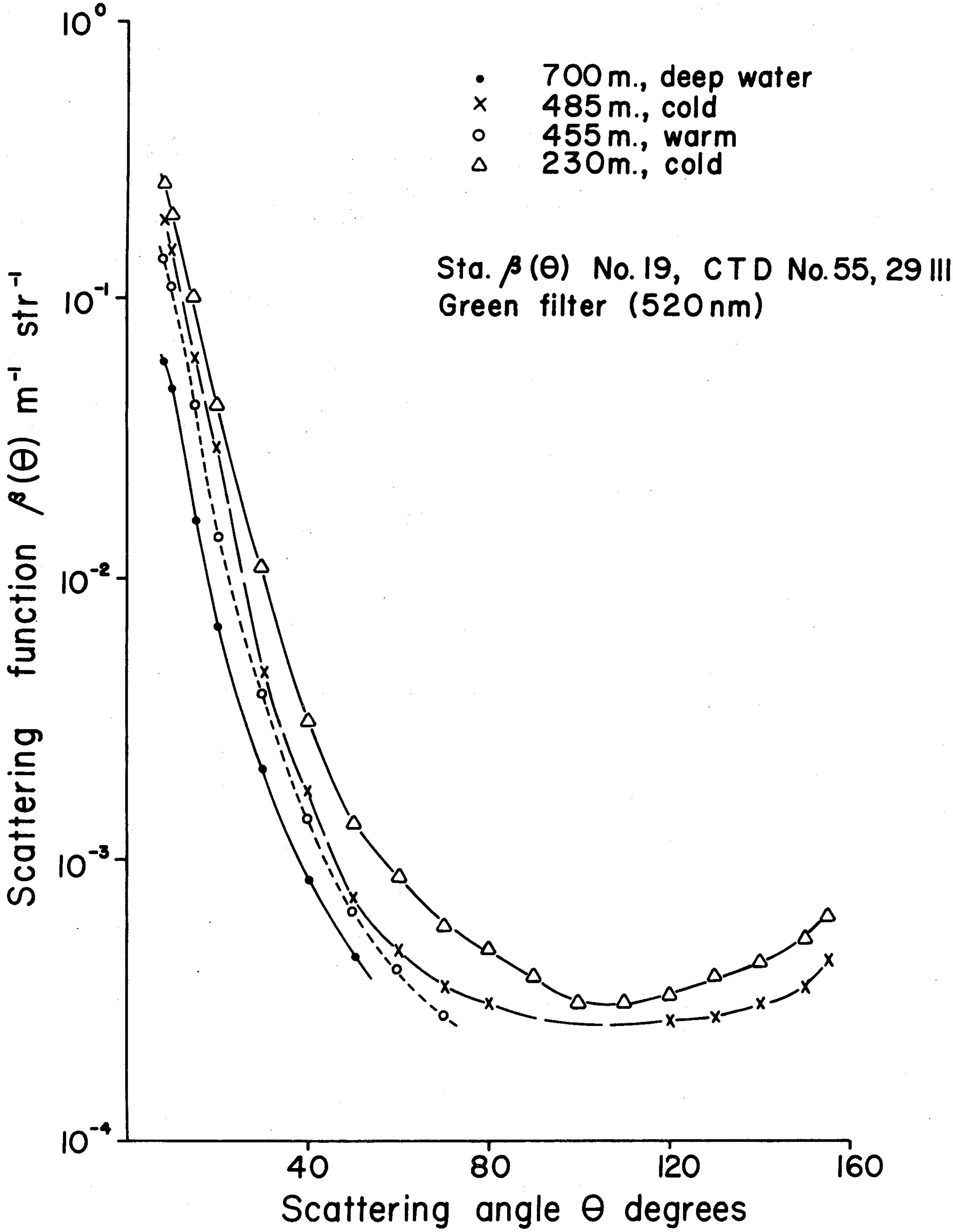

Figure 30. Scattering of green light as a function of scattering angle θ and depth on station #19

VII. CHEMISTRY

As a component of the ISOS polar front study, the chemical nutrients (phosphate, nitrate, and silicate) and certain isotopes (O^{18}/O^{16}, tritium, helium, and deuterium) were sampled. The nutrients were sampled routinely from all Niskin bottles tripped on the CTD rosette. The isotopes were sampled at four stations across the polar front and associated eddy seen during the cruise.

The nutrient samples were run as soon as possible after sampling on an Autoanalyzer II. In addition, continuous underway analysis of surface seawater was performed during the early stages of the cruise to help delineate the surface silicate signature. Also, surface samples collected by the Chilean ship, YELCHO, were analyzed during the first few days out of port to help determine the location of the polar front.

The first phase of the chemical participation in the polar front study involved processing 240 surface samples from the YELCHO for silicate concentration. This data (not included) indicated that the strong silica gradient associated with the southern extent of the polar front zone closely parallels the surface 4.0° C isotherm. Also, there appeared during the first survey a detached surface region of high silicate concentration north of the 4.0° C isotherm which disappeared from the area during a later survey. The high surface silicate levels indicate either a more southerly origin for this water parcel or an upwelling phenomena from below of richer nutrient water.

During the cruise, nutrient samples were drawn from 68 stations. These were analyzed for phosphate (PO_4), nitrate (NO_3), and silicate (S_iO_4). It is hoped that this data will provide additional parameters for studying the dynamic processes in the frontal region. A complete data list follows this report in the appendix.

Finally, the Autoanalyzer was configured to run continuous flow underway surface nutrients to help in the location of the frontal zone. The high silicate gradient appeared somewhat south of the main study area but was crossed twice during the cruise. The eddy which was encountered showed little manifestation of high surface silicate.

During the cruise, approximately 900-1000 samples were processed on the mini-computer interfaced Autoanalyzer II. The system performance was generally very good. The major chemical problem dealt with the silicate analysis. Periods of increased sensitivity variations were likely tied to a batch of a deteriorating reagent. This problem makes the silicate data at CTD stations 38, 39, 40, 42, and 43 of doubtful quality. Also, stations 59, 79, 80, and 100 may be affected slightly by this problem, but are still usable. Precision was consistently better than 1% probably near 0.5%, comparable to ISOS 1975 data (Gordon, et al. 1976). The computer functioned reliably up until the last two days of the cruise when a hardware failure necessitated manual calculation of seven stations. A more complete system description is given in Gordon et al. (1975).

Isotope samples were also collected during leg III of ISOS '76 for shore analysis of hydrogen, helium, and oxygen isotopes. The tritium and helium analyses are to be performed by Bill Jenkins at W.H.O.I. while the O^{18}/O^{16} and deuterium analyses will be coordinated by Lou Gordon at OSU. Results from these analyses will hopefully yield information on the relative age of the interleaving cold water fingers found in the polar front and give some information as to the sources of the composition of the water types. Tritium, with a half life of 12.6 years, can potentially yield information on mixing rates and water age while fractionation processes associated with sea ice formation, glaciation, and rainwater may be of value in studying the cold relatively fresh water minimum layers in the polar front.

Four stations (77, 81, 91, and 95) were sampled for isotopes. A total of 78 ampules were sealed for the O^{18}/O^{16} deuterium work and 29 copper sampling units were taken for the tritrium/helium studies. The stations were designed to provide a full north-south distribtuion from antarctic, frontal zone, antarctic intermediate, and subantarctic waters to separate the various components as fully as possible.

Continued data processing, plotting, and analysis will continue on the chemical data at OSU during 1976. Attempts will be made to integrate the chemical data with information provided by CTD, XBT, optical, and current profiling measurement in the frontal zone. This analysis will take the form of section plots, regression analysis, and various variable-variable analyses.

VIII. VCM PROGRAM

A. Vertical Current Meters (VCM)

The VCMs are neutrally buoyant-free floating instruments which are ballasted to predetermined depths and tracked acoustically. Time synchronized deck equipment provides float range data to 18 km or more depending on conditions. During this cruise, "hearing" was very good, and on occasion we tracked floats for nearly 24 km. The instrument is equipped with quartz crystal oscillator to provide a stable time base sufficiently accurate for tracking over periods of weeks.

The VCM measures relative vertical current, water pressure, and water temperature. Relative vertical current is sensed by an array of vanes mounted axially around the float, Fig. 31. Because the float compressibility is less (about 1/2) than that of the water, vertical motions in the water generate relative vertical flow past the vanes causing the entire float to rotate. This rotation is sensed relative to an internal compass. The sum of the pressure change (float vertical motion) and the rotation of the float (flow relative to the float) is a measure of total vertical water displacement; with a resolution of about 2 cm. The temperature measurement is accurate to about .010° C.

These data are recorded each 112.5 seconds on a digital data cassette recorder as average temperature and pressure for the record interval; accumulated turns at the time of recording; and total number of record intervals since a reference time zero. The pressure is telemetered to the ship each 7-1/2 minutes to confirm ballasting accuracy and permit calculation of horizontal range from depth and slant range measurements. The telemetry is a 20-bit digital word including 16 bits of pressure data, 3 bits for float identification, and a release confirm bit.

Preliminary data processing aboard ship consists of reading the data cassette and producing a computer compatible 9-track data record. Data from the 9T tape could be listed and plotted on the Calcomp in engineering units for an early check on quality and a preliminary scientific evaluation.

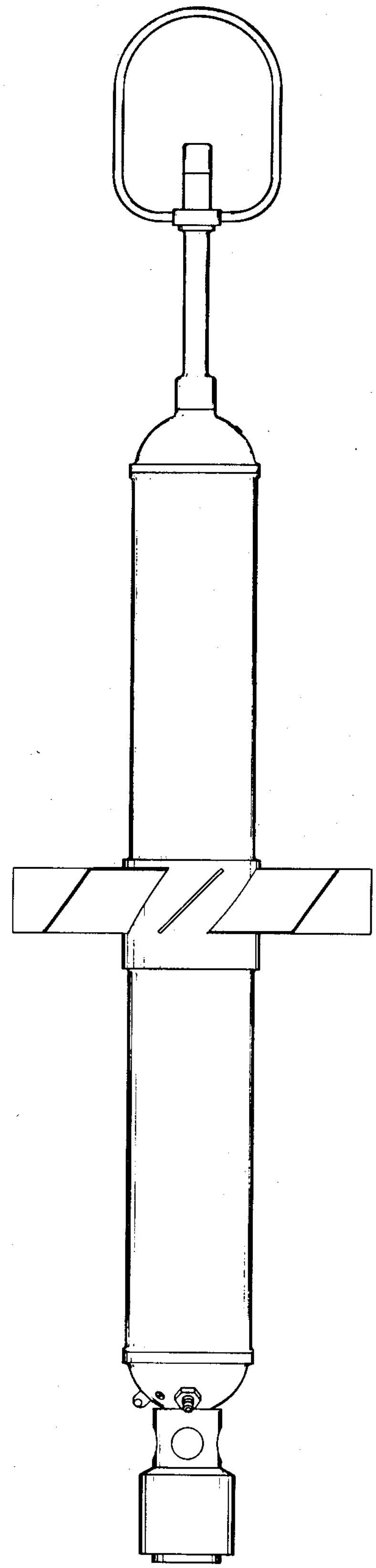

Figure 31. Scaled side view of the vertical current meter (VCM) showing its orientation when neutrally buoyant. The length of the instrument from recovery bail (top) to the transducer (bottom) is 1.2 meters. Vertical motion is sensed by 8 inclined vanes shown at the mid-point of the cylinder

The VCM includes an AMF acoustic release receiver and a release of W.H.O.I. design. On command from the ship, or on preset command from an internal timer, the float drops a 900 m weight and returns to the surface for recovery. A flashing light turns on at release time, and the "ping" rate doubles (every 2 seconds) to confirm release. The acoustic tracking capability and the light simplify finding the float on the surface in spite of its low profile in the water. Seven recoveries were made with ease under a variety of weather and light conditions during this cruise.

Two floats built in 1973 were modified and tested for use on the cruise; and three additional instruments were built in 1975 for ISOS. On these 5 VCMs, 4 were deployed and one served as spare parts and backup time base for the deck gear. At one time for a short period all four were in the water.

There were several malfunctions detected during preliminary testing and one instrument (VCM #4) sank at the rate of about 4 meters per hour due to a leak. The same instrument had an intermittent compass/ turns counter and the usefulness of the data is questionable.

The longest deployment was VCM #5 for 5 days, 16 hours, but no data record was made because of failure to properly seat the tape head and capstan on the recorder prior to deployment.

Table 13 summarizes VCM performance. There 12 days, 1 hour of good data records and an additional 2 days, 4 hours of questionable data from 19 days, 21 hours of total float time. For further reference to VCM hardware see Burt et al. (1974) and Dorson (1974).

VCM Ballasting

The VCM floats used in ISOS were weighed in a fresh water tank at Woods Hole and ballasted to be neutrally buoyant at a selected surface temperature and salinity standard of 8° C and 34.40 ‰. The ballast was then adjusted for depth based on *in situ* temperature and salinity at the desired depth. The float constants are approximately

Table 13

VERTICAL CURRENT METER (VCM) SUMMARY - FDRAKE 76 III

VCM Number	Data Record	Depth m Design	Depth Actual	Total Time	Data Recorded	Remarks
1 (1)	VCM TT 107/2	400	400	3d 10h	good	
1 (2)	VCM TT 107/6	370	400	2d 4h	good	
2 (1)	VCM TT 107/4	400	360	4d 4h	good	
2 (2)	VCM TT 107/5	500	640	2d 7 h	good	
4	VCM TT 107/3	560	560	2d 4h	questionable	Turns counter suspect
5	None	400	400	5d 16h	none	Tape head not seated
				19d 21h		Total float time
				12d 1 h		Good data

Note: d = days

h = hours

Analysis of data quality preliminary

VCM 4 sank at about 4 meters/hr while deployed

0.0804 gm/meter	ballast for depth,
0.332 gm/°C	temperature correction,
27 gm/‰	salinity correction.

The largest unknown for a new design is compressibility; and an adjustment was made in the ballasting equations based on an actual test drop (VCM #4, 17 March 1976).

A summary of desired depths and actual depths is included in Table 13.

B. Float Program Narrative

Two sea trials were made prior to full scale float work. The first was done on 15 March on our way out, in the lee of Cape Horn. All five vertical current meters, hereafter referred to as VCMs, were secured to the hydrographic conducting cable and lowered to depth to test their pressure telemetry and weight release (recovery) systems. From the telemetry we determined the thermal correction to their pressure calibration. The second trial was made during the afternoon of 17 March, approximately 10 miles north of the recovery site of the University of Oregon current meter and thermistor array. VCM #4 was launched for free drift at a depth of 290 m after the vertical temperature and salinity structure had been determined from a CTD sounding. The instrument sank to a depth of 332 m (in 80 min). After a drift of about an hour its weight was released and the instrument was recovered. The discrepancy between intended and true depth was used to determine a second order correction to the float compressibility.

The subsequent float work was done in two phases, from 23 to 29 March and from 30 March to 2 April, which are described below. Detailed float trajectories are shown in Fig. 32. The northern trajectories occurred in phase one and the southern in phase two. Float depths, drift times, and comments concerning float performance and the quality of the recorded data is given in Table 13. Float positions and times for these positions are listed in the accompanying VCM log (Section D). Also noted

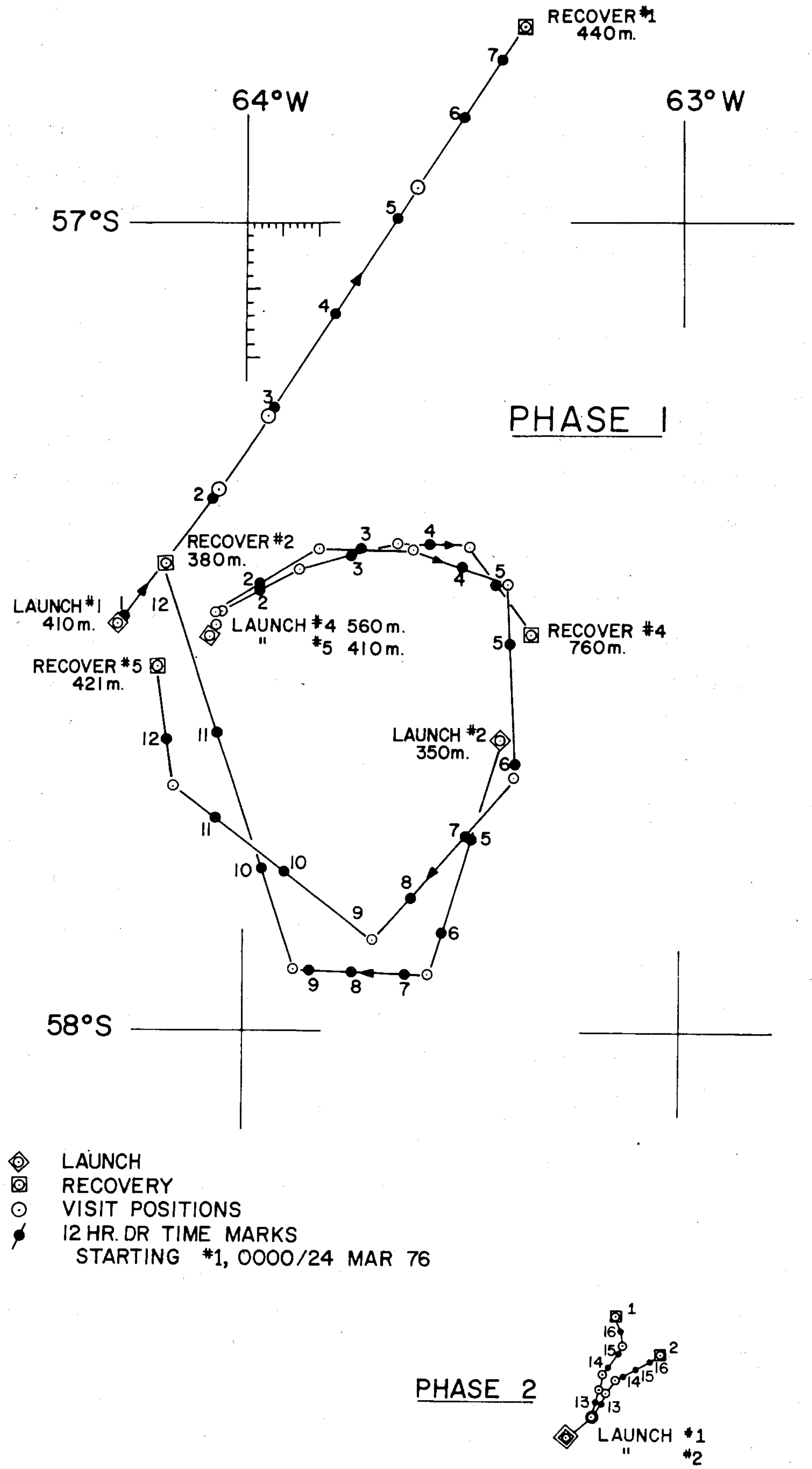

Figure 32. Float tracks of the VCM's during Phases 1 and 2. Note that VCM's 4 and 5 were entrained in the cold water ring described in the introduction

in this log are special events and the station numbers of CTD and XBT soundings made over the floats. In addition, XBT sections were usually made while running between floats to monitor the thermal structure of the front. These are described in Section III.

Phase 1

The first phase started after CTD Section A had been made across the front along the line shown in Fig. 4 during the period 20 to 23 March. VCM's 1, 4, and 5 were launched late on the 23rd and early on the 24th of March. Their location relative to the thermal structure of the front is shown in Fig. 33 . VCM 1 was in the interleaving region to the north of the front, VCM 4 was in the T_{min} layer along the frontal edge, and VCM 5 was above 4.* The synoptic horizontal structure of the front at the time of launch, inferred from the YELCHO survey is shown in Figure 2 after launch tracking began. Early on 25 March VCM 2 was launched south of the front, as shown in Fig. 33, after the necessity of exchanging this instrument's projector with that of VCM 3 which caused some ballasting difficulties. By the next day it had become evident from the pressure telemetry of VCM 4 that this float was slowly sinking (approximately 4 m/hr) and it was recovered during the morning of 26 March. Approximately 16 cm^3 of water were found in the float from a small leak in the lower end cap.

By 27 March the divergence between VCM 1, which was drifting northeast at a speed of 30 to 35 km/day (Fig. 32), and VCMs 2 and 5, which were both curving to the south at a similar speed, had become so great (≃100 km) that travel time between the three floats was becoming excessive. Therefore, VCM 1 was recovered on the morning of 27 March in order to devote full time to tracking VCMs 2 and 5.

By 28 March it appeared that the front was changing its configuration rapidly and that the portion of the front tracked by VCMs 2 and 5 was becoming a cul-de-sac with a large tongue of warm water sweeping

*The beginning of the VCM deployment nearly coincided with the arrival of the Chilean vessel AGS YELCHO for its second leg of polar front mapping.

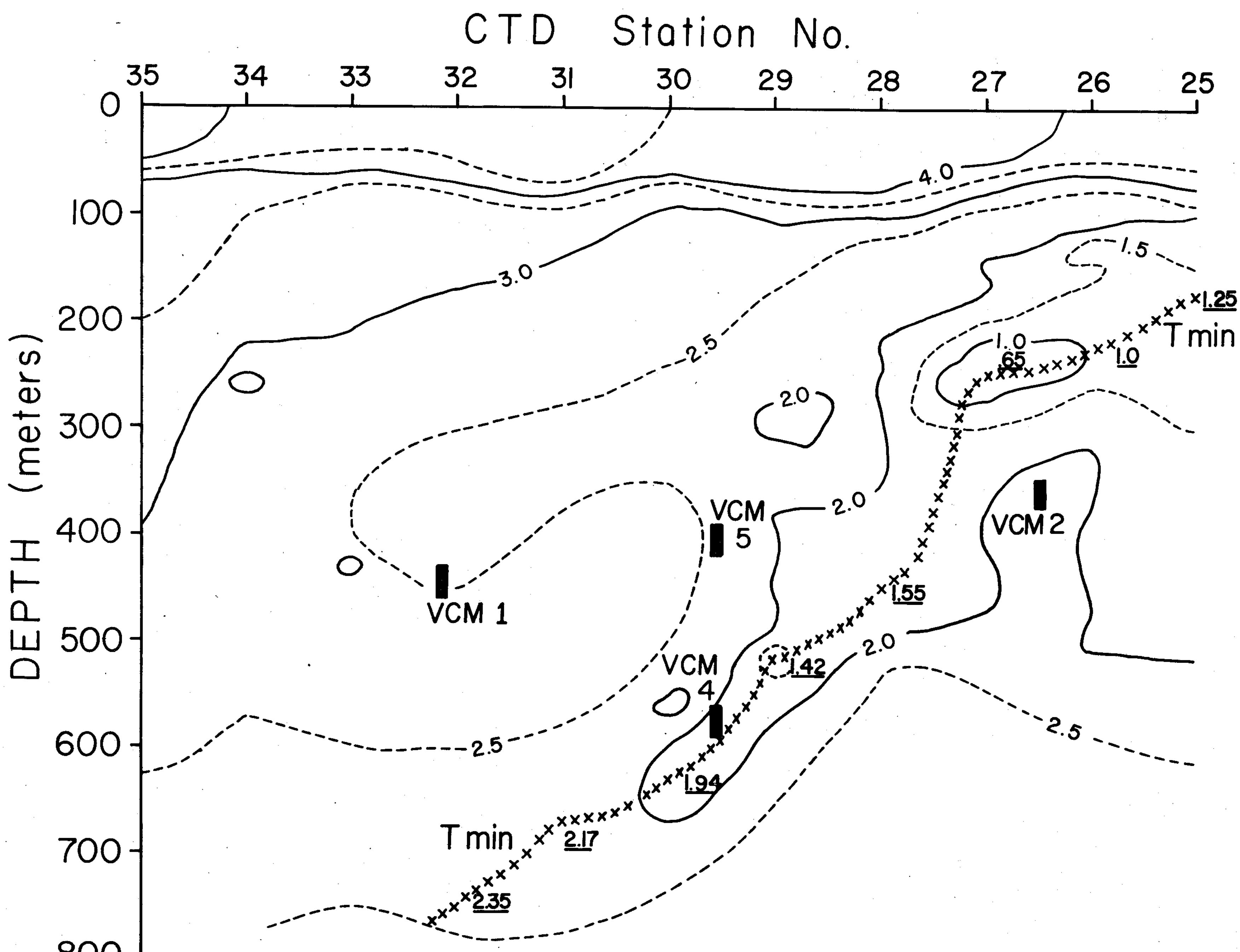

Figure 33. Cross frontal CTD section with the locations of VCM's 1, 2, 4, and 5 during phase 1 of VCM program

to the south of the floats. We decided to make a rapid XBT section to the south to determine the extent of this warm water and to re-establish the position of the polar front on its southern edge. The front was found by the afternoon of 28 March about 100 km to the south of the floats. On returning northward, late on the 28th, warm water was found to the west of the floats as well. This and the still curving trajectory of the floats made it highly likely that both VCMs were entrapped along the edge of a cold cyclonic eddy which had been formed by the large scale deformation of the front.* This eddy can be seen in the subsequent YELCHO survey shown in Fig. 2. It was decided to recover both floats and shift our operations to the new front re-established to the south. Both were recovered by late 29 March and phase one had ended.

Phase 2

After an XBT section across the front to the south VCMs 1 and 2 were launched in the early afternoon of 30 March. In order to economize on time spent in float tracking and to devote more effort in studying the interleaving process both floats were launched for different depths at the same location north of the front. Their position relative to the frontal thermal structure is shown in the XBT section of Fig. 34. VCM 1 was located in the interleaving zone at a depth of 400 m and VCM 2, although intended for a depth of 500 m, equilibrated at a depth of 640 m. The latter was our only major discrepancy in float ballasting (Table 13) and its cause is at this point still undetermined.

The weather had begun to deteriorate before the float launch and continued to do so (20-30 knot winds from the southwest with building seas). Starting in the afternoon of 30 March and continuing for the next 28 hours we made repetitive CTD lowerings every 2 to 2-1/2 hours, to a depth of 1500 m, over the drifting VCM 1 in order to measure the evolution of the interleaving relative to the float.** The distance to the float was

*The YELCHO was contacted during its continued survey of the front to the east and requested to return and verify that the northward meander of cold water had pinched off into a separate ring.

**An earlier CTD,PCM time series had been taken relative to a fixed geographical position.

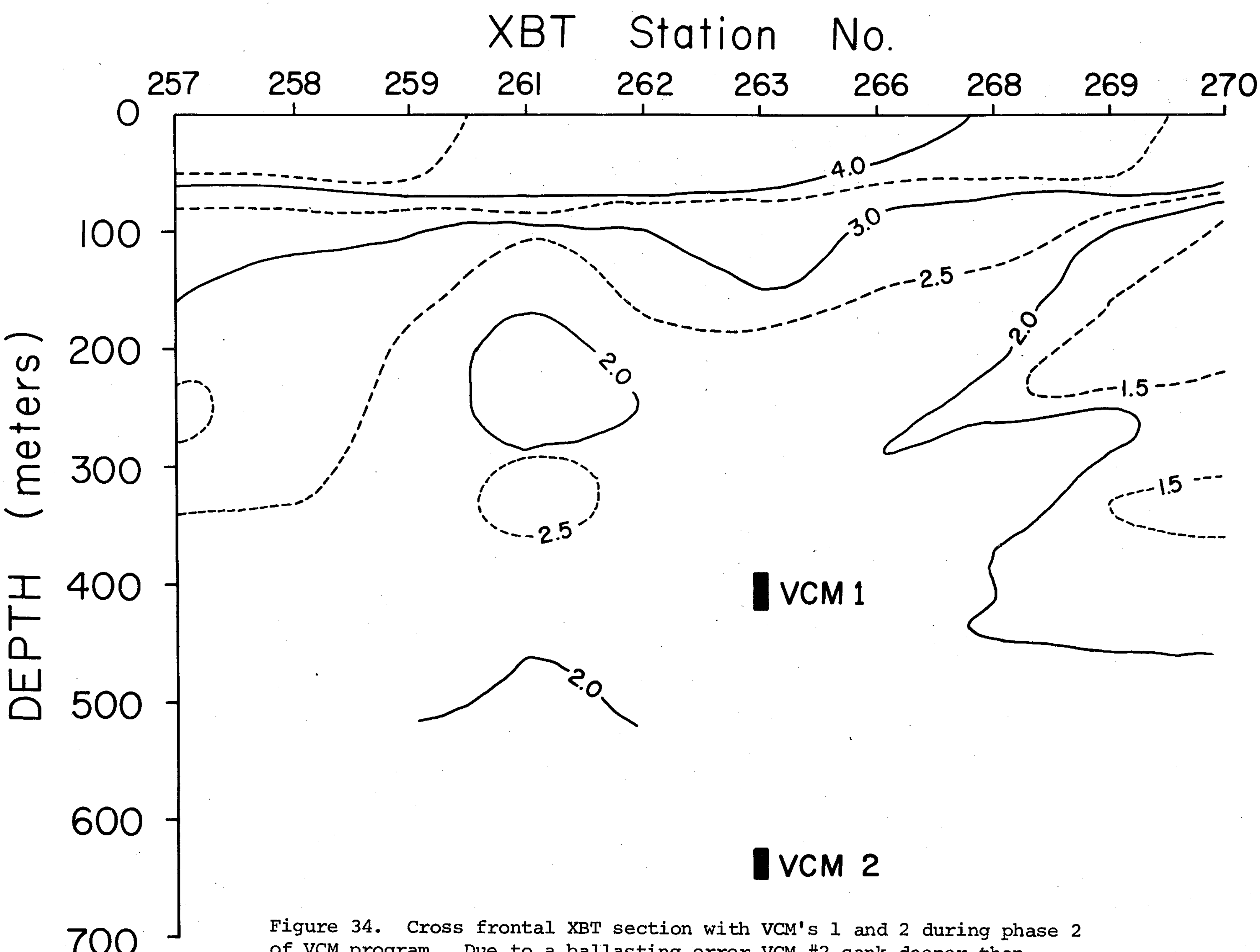

Figure 34. Cross frontal XBT section with VCM's 1 and 2 during phase 2 of VCM program. Due to a ballasting error VCM #2 sank deeper than planned and its location with respect to local temperature cannot be determined from the T-4 XBT probe data

monitored during the lowerings and was usually kept by good ship handling to less than 1200 m although this was difficult in the building seas. During this CTD series two XBT experiments were conducted (described in Section III) consisting of repeated soundings every 3 to 5 minutes to determine the time scales of layers in the vicinity of the float. During the first XBT series over VCM #1 the deck tracking equipment failed but was repaired and resynchronized with the floats in about 3 hours.

The CTD series terminated in the early morning of 1 April. The sea and weather having moderated considerably it was decided to carry out two experiments (also described in Section III) with XBT soundings to investigate the spatial coherence of the interleaving relative to the float. In the first experiment the ship maneuvered around the float in a box pattern, steaming on each side for 20 minutes at 4 knots. XBT soundings were made every 5 minutes.

In the second experiment XBT soundings were made every 5 minutes at 5 knots along two tracks, one north-south and the other east-west. Each track was 6 km in length and they intersected over the float. These experiments terminated around noon on 1 April. After making final CTD stations over each, VCMs 1 and 2 were recovered by late in the evening of 1 April. They had moved towards the north and northeast at a relatively low speed of 3 to 5 km/day during their entire drift (Fig.32). At this point the float program was terminated, with no equipment losses.

C. Sample VCM Time Series

The VCM data tapes were read and preliminary analysis was begun while at sea using a modified version of CTD program 3. VCM number 1 produced one of the longer data records recovered. Float 1 was deployed north of the front at a depth of 415 meters. During this period of three and one-half days the float maintained a fairly steady velocity of 30 m/sec to the northeast, away from the front. Its track can be seen in Fig. 32.

The calibration of float rotation to vertical displacement was done using a plot of relative displacement, proportional to float turns, vs. pressure as the instrument sank during deployment. From the slope of this curve the calibration constant was determined.

Figure 35 gives time series of pressure, temperature, and calculated vertical water displacement for float 1, drop 1. The float's pressure record shows that the instrument oscillated with an amplitude of upwards of 50 meters. Also evident in the plot is that the instrument slowly sank about 20 meters over the record length. This sinking was not attributed to a leak since the interior of the instrument case was dry upon recovery. The exact cause, though, has not yet been determined.

The absolute displacement, computed from pressure and turn data, shows a steady sinking of water, much greater than the instrument drift. The mean vertical velocity from the plot is almost .4 meters/hour downward. Large periodic vertical excursions of the water at the buoyancy period (1.5 hrs approximately) are also visible. Since there was large relative motion of water past the float the instrument operated away from velocity threshold most of the time. Although no spectral analysis has been done on the records as of yet, there is clearly seen a large signal due to the semi-diurnal tide.

A strong bimodal structure was observed in the temperature record caused by vertical advection of warm and cold layers by the float. There are two distinct regions of structure in the temperature plot. Initially, while the float was near the front, the temperature excursions were large, about .4° C, but later when the float had moved away, the temperature jumps declined to .13° C.

Eyeball temperature-displacement correlations were attempted from the data plots but the complicated structure changes with time. During some periods the float was sitting in warm water above a cold layer such that upward fluid displacement caused the temperature to jump to its lower level. At other times, after the float had been advected to a new area the opposite is often true. It is too early at this time to make any statements about layer displacements and vertical heat fluxes.

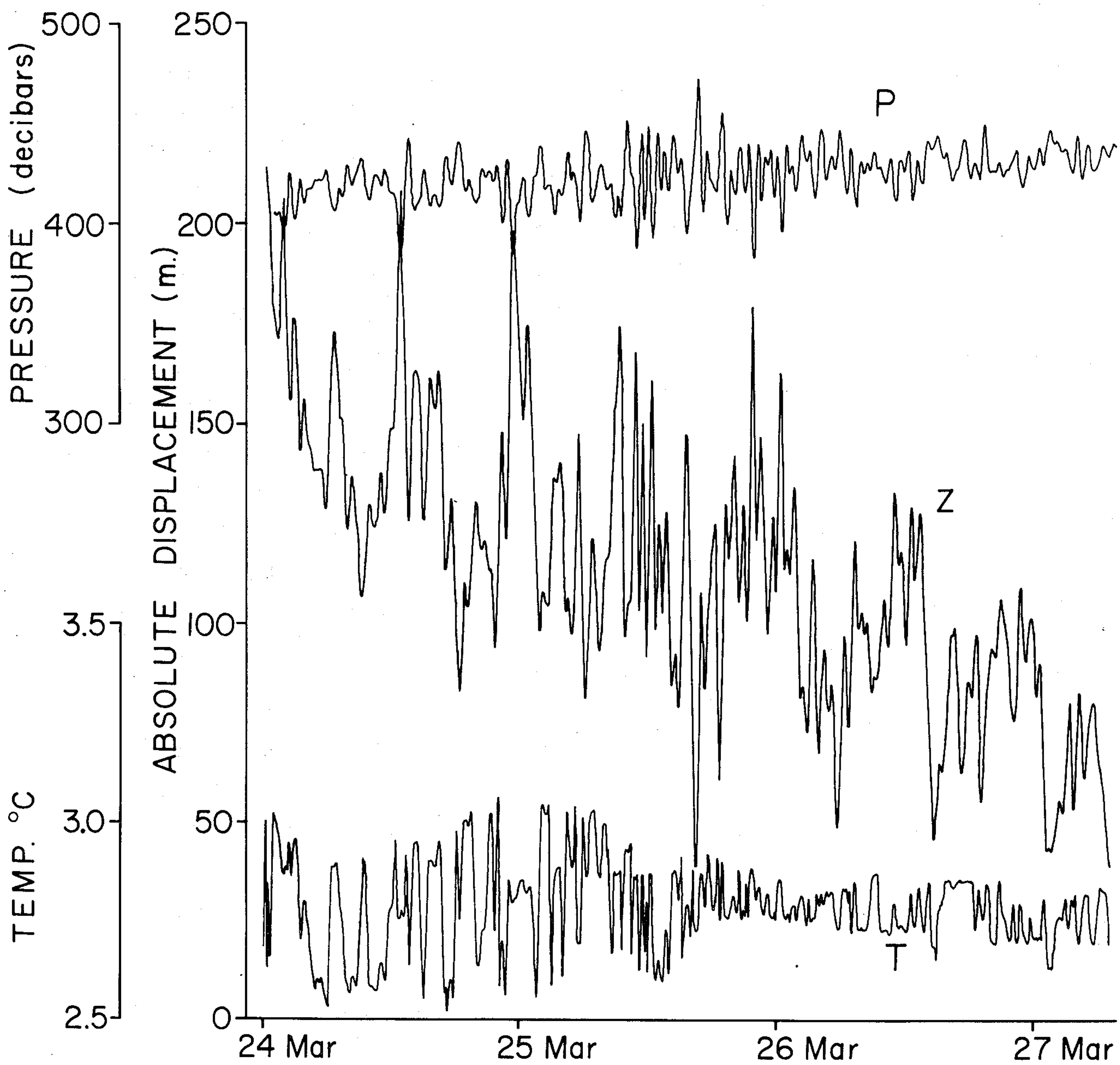

Figure 35. Time series of pressure, temperature, and absolute vertical displacement as recorded by VCM #1 during phase 1. The pressure record shows an instrument creep of 20 m over the record length. Large vertical excursions are visible near the buoyancy period (∿1.5 h) and the semi-diurnal period

D. Float Visit Log

Date	Time	Latitude	Longitude	VCM	Notes
			VCM Log - 1		
23III76	2105	57° 31.7S	64° 18.8W	1	CTD #44 (DR)
	2225	57° 29.9S	64° 17.4W	1	Launch #1
24III	1230	57° 20.0S	64° 03.1W	1	XBT 111
	2238	57° 14.4	63° 57.9W	1	CTD #46; XBT 114
26III	0402	56° 57.4	63° 36.5	1	CTD #49
27III	0642	56° 45.3S	63° 20.2W	1	CTD #52
	0940	56° 43.7	63° 18.0	1	Release #1 and recover
30III76	1335	58° 28.5	63° 14.1W	1	CTD #59
30III	1630	58° 29.2S	63° 13.3	1	Launch #1
	1924	58° 27.8	63° 11.4	1	CTD #60
	1935	27.8	11.4	1	XBT Time Series #1
31III	0257	58° 28.0	63° 13.5	1	CTD #61-74 Yo-Yo
	1018	58° 25.7	63° 09.6	1	Yo-Yo
	1142	58° 25.0	63° 09.9	1	Yo-Yo
	1945	58° 24.0	63° 08.3	1	XBT Time Series #2 begin
1IV76	0058	58° 22.9	63° 06.9	1	Yo-Yo
	0426	58° 23.0	63° 09.2	1	Yo-Yo
	0720	58° 22.6	63° 09.0	1	XBT Box; cross
	2030	58° 20.5	63° 08.3	1	CTD #75, Release #1 and recover
			VCM Log - 2		
25III76	1245	57° 38.3S	63° 24.7W	2	CTD #47, Launch #2
26III	1715	57° 55.8	63° 34.2W	2	(DR) float location
	1725	57° 55.9	63° 34.7W	2	CTD #51
28III	0346	57° 55.2S	63° 52.7W	2	XBT 180
29III	1438	57° 25.1S	64° 10.4W	2	CTD #56
	1630	57° 25.3S	64° 10.4	2	Release #2 and recover

Date	Time	Latitude	Longitude	VCM	Notes
			VCM Log - 2 (Contd.)		
30III76	1335	58°28.5^S	63°14.1^W		CTD #59
	1620	58°29.2^S	63°13.3	2	Launch #2
	1924	27.8	11.4	2	CTD #61-74 Yo-Yo
	1935	27.8	11.4		XBT Times Series #1
31III76	0257	58°28.5	63°11.8	2	1300 m east of float
1IV76	2300	58°23.0^S	63°01.0^W	2	Release #2 and recover
	2355	58°22.2^S	62°59.3^W	2	CTD #76
			VCM Log - 4		
24III76	0345	57°32.9	64°05.7		CTD #45
	0558	57°31.6^S	64°05.0^W	4	Launch #4
	1624	57°25.2^S	63°52.5^W	4	XBT 112
25III76	0610	57°23.4^S	63°38.8^W	4	XBT 122 (DR)
	1929	57°24.8^S	63°28.1^W	4	CTD #48
26IV76	1000	57°29.7^S	63°21.3^W	4	Release #4 and recover
			VCM Log - 5		
24III	0345	57°32.9^S	64°05.7^W		CTD #45
	0517	57°30.6^S	64°04.7^W	5	Launch # 5, XBT 107,109
	1810	57°24.2^S	63°50.0^W	5	XBT 113
25III	0630	57°25.8^S	63°35.5^W	5	XBT 124 (DR)
	1728	57°26.8^S	63°24.0^W	5	XBT 128
26 III76	1240	57°40.9^S	63°22.7^W		CTD #50, XBT 130
27III76	2004	57°53.3^S	63°42.5^W	5	Float located
29III76	0800	57°41.9^S	64°09.5^W	5	CTD #55, XBT #228
	1850	57°33.0^S	64°12.5^W		Release #5 and recover

E. Float Creep

Estimates of sinking rate of a vertical current meter (VCM) used in the Polar Front studies in March and April 1976 have been made based on the work of Paul Sullivan and reported in his thesis dated January 1975:

Creep Buckling of Shells of Revolution
Loaded under Uniform External Pressure.

His work describes estimates for creep in SOFAR floats which are made of aluminum tubes of the same alloy (6061-T6) as the VCMs; and have a radius to wall thickness ratio of 7.5 as compared to 8.5 for the VCMs.

The strain rate due to creep is the sum of the dominant term, $\bar{\dot{e}}_\theta$, and a perturbation term $\dot{e}'_\theta$.

The calculated strain rates for the VCM are

$$\bar{\dot{e}}_\theta = 2.77 \times 10^{-7} \text{ inches/inch/hour,}$$

and

$$\dot{e}'_\theta = 0.84 \times 10^{-7} \text{ inches/inch/hour,}$$

which total

$$3.61 \times 10^{-7} \text{ inches/inch/hour.}$$

The change in radius = 1.15×10^{-6} inches/inch/hour, and the total change in volume of the 48-inch long cylinder

$$= 1.105 \times 10^{-3} \text{ in}^3\text{/hour}$$

or

$$\Delta v = 1.81 \times 10^{-2} \text{ cm}^3\text{/hour}$$

The VCM buoyancy constant is 12.43 meters/cm^3, so the sinking due to creep

$$= 1.81 \times 10^{-2} \times 12.43$$

$$= 0.225 \text{ meters/hour.}$$

This agrees with the slow sinking seen in Figure 35.

IX. OTHER OBSERVATIONS

A. Meteorological Observations

1. Instrumentation and Data Reduction

During the cruise a small meteorological package was mounted approximately 7 m above sea level on the observation deck of the R/V THOMPSON. It consisted of the following sensors: wind vane, anemometer, compass, screened thermometer, and barometer. These sensors were installed in a line on an aluminum bar pointing fore and aft. The data were recorded on an Aanderaa data logger. The sampling rate of 10 min was controlled by a crystal clock. During the sampling interval the wind speed was integrated while all other sensors yielded instantaneous readings.

The instrument was set up in Punta Arenas and was dismounted after all hydrographic observations had been finished. The obtained meteorological data cover the time interval 11 March to 7 April 1976. Data decoding has been performed at computer facilities of the Rosenthiel School of Marine and Atmospheric Science, Miami. The following manufacturers' suggested calibration equations have been used:

wind vane (degrees)	$\alpha = .35191*N_\alpha$
anemometer (m/s)	$S = K/\Delta t*N_S$
compass (°T)	$\theta = .35131*N_\theta + \zeta$
temperature (°C)	$T = -44. + 8.1076E\text{-}2*N_T + 9.6902E\text{-}6*N_T*N_T$
barometer (mbar)	$P = 6.99243E{+}2 + .3826*N_P$
wind direction (°T)	$\beta = \alpha+\theta$; modulo (360)

with

N_i = parameter readings in counts

K = rotor constant = 38.2 m/rev

Δt = sampling interval = 10 min

ζ = magnetic variation = +14°

The automatically recorded data have been compared with the 6-hourly routine weather observations and found to be in reasonable agreement. Wind speed and direction from both sources together with barometric pressure and air temperature are shown in Fig. 36. Wind speed and

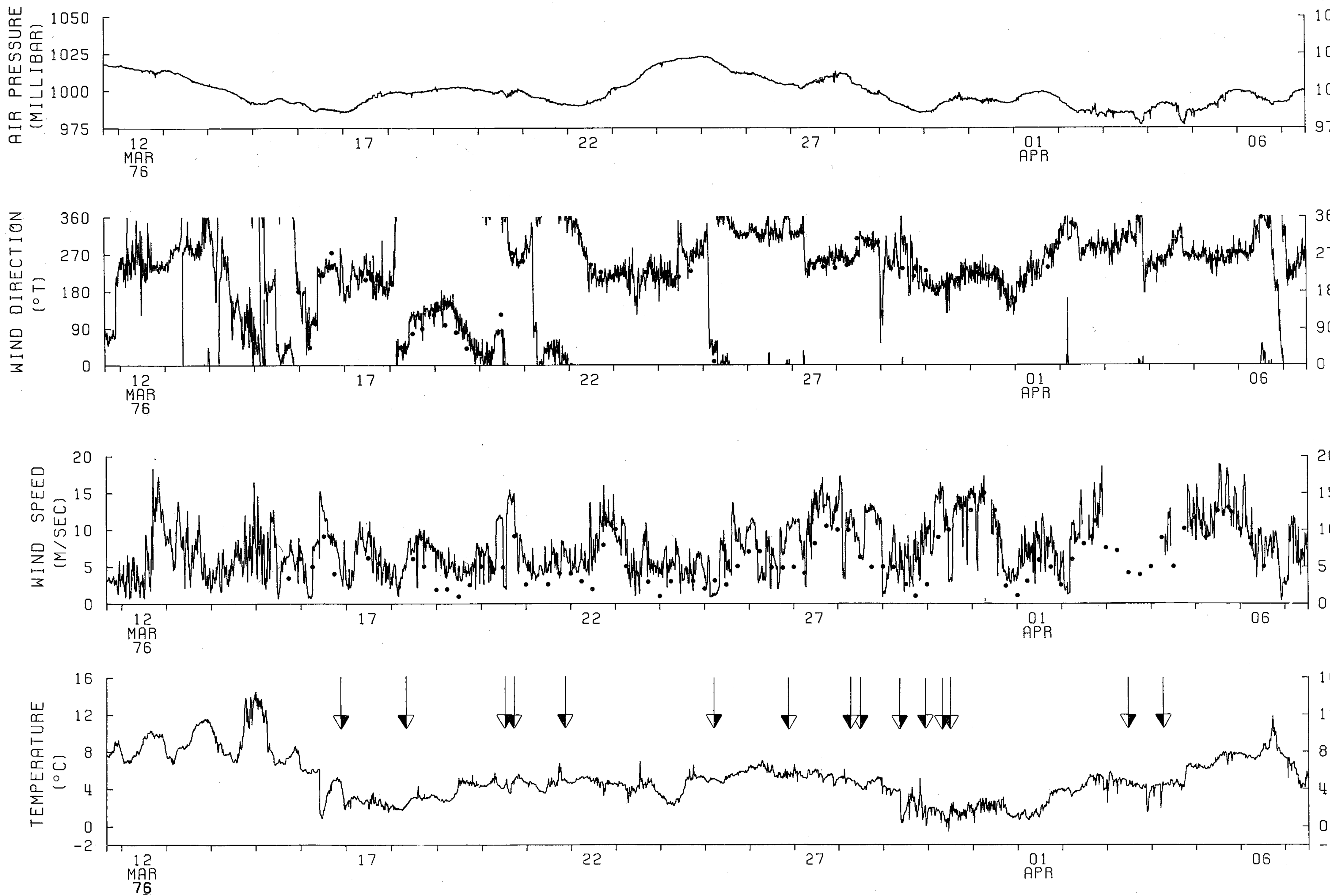

Figure 36. Meteorological observations, during leg III of T. G. THOMPSON, cruise 107. Time axis is given in CUT. The continuous data were obtained by an Aanderaa system mounted on the ship's observation deck approximately 7 m above the sea surface. Above the air temperature trace, crossings of the polar front and the cold water ring are shown by arrows. When passing from Antarctic into sub-Antarctic water masses the arrow is darkened on its right side and vice versa. The continuous wind speed and direction curves have not been corrected against ship's speed. For comparison the absolute wind values according to the ship's 6-hourly routine observations (dots) have been added. A continuous barometer record is shown on top of the graph.

direction from the Aanderaa recorder represent relative quantities because they have not been corrected against the ship's speed. The influence of the ship's speed (usually <10 knots) on the anemometer and wind vane readings may be seen from a comparison of the two shown curves. The 6-hourly speed is always smaller than the Aanderaa speed which at least partly may have been caused by different instrument calibration. Another uninvestigated effect on the wind sensors is caused by the ship's pitch and roll motion which amplifies the anemometer values. This contaminating effect is kept smaller by using propeller-shaped sensors as they were used for the 6-hourly data. The reason for the speed gap between 2 and 4 April is not known.

2. Data Discussion

The highest air temperatures, up to 15° C, were recorded during our passage through the Beagle Channel. After consideration of a phase shift of 4 hours against CUT the diurnal temperature variations are obvious in the beginning of the record. Most of the time, however, they are covered by other effects like cloudiness and sea surface temperature changes. After leaving the site of the initial test station on 16 March we encountered temperatures typically in the range 1-5° C. During the cruise the ship crossed at least 16 times the polar front or the rim of the cold water ring. The subsurface criterion of these frontal crossings (2° C at 200 m depth), was used to indicate the transitions in the air temperature trace. The direction of the horizontal temperature gradient is indicated by the darkened half of the arrows. A dark right half indicates a crossing from warm into cold water masses. In most cases the crossings are reflected in the air temperature curves. Changes are typically of O(1-2° C) and often coincide with the subsurface expression. See for instance 16 March 2000Z and 30 March 1205Z when the polar front was crossed the first and last time during the cruise. The final crossing of the cold water ring between 3 April 0945Z and 4 April 0555Z seems to be indicated in the air temperature curve approximately 8 hours earlier and later, respectively, which is of O(30 km) South and Northwest of the rim. A general increase of air temperature was observed when the ship approached the Cape Horn area during 5 and 6 April. The record was finished by re-entering the Beagle Channel on 7 April.

During the first half of the cruise wind speed in the Drake Passage was unusually low (<10 m/s). Winds coming from all directions were observed. Always when the speed increased the prevailing direction was found to be SW to NW. This wind direction is consistent with the predominent easterly surface current system. During the second half of the expedition, an increase of the mean wind speed was recorded, but seldom exceeding values >15 m/s. The maximum occurred during 5 April when strong winds from the west reached values of approximately 18 m/s.

Air pressure values were found in the range of 980-1024 mbar. There seemed to be a periodicity on the order of 3-5 days. Gradients usually were low with exception of a series of three perturbations between 3 and 4 April. In all three cases these atmospheric fronts were correlated with a 90° counterclockwise turning of the wind.

B. Report of an Amateur Birdwatcher (Jon B. Jolly)

Albatross

1. Wandering - These birds were always present from one to four or five and no particular increase in numbers was noted at the polar front.

2. Sooty - One Sooty was seen near the front.

3. Yellow-nosed - Two were seen at the front. Initially it was felt that this was a positive identification as the birds flew close aboard a long period - just a few feet away from the ship's side - and the nose coloring was clearly visible. I must enter some doubt here because subsequently, in looking through Edward Wilson's book, "Birds of the Antarctic," 1968, Humanities Press Inc., New York, it was noted that the grey-headed albatross is colored similarly - at least in that book. On the other hand, Watson's "Birds of the Antarctic," Antarctic Research Series, published by AGU, Washington, D. C., 1975, does not show this feature nearly so prominently for the grey-headed. Some question remains on this identification.

4. Other albatross - A rather stark and bizarre marking occurred on a number of Wandering Albatross - a pink-orange vertical mark on the head or perhaps upper nape. No reference to this could be found in the literature anywhere. This mark was ragged in some and smooth in others. The marking was about 5 cm long (high) and about 1 cm wide. It occurred on both sides of the head. It remained in the vertical position when the bird was either sitting in the water or in flight. At one time four birds near the ship had this marking. Could this be some sort of tagging activity by some agency or group? Many were seen without it.

Fulmars

All Fulmars listed in the main portion (illustrated) of Watson were seen. The Giant Fulmars in numbers of two or three were nearly always with the ship. The Southern and one Snow Petrel were seen just south of the frontal zone. One Antarctic Petrel was seen just north of the zone.

Cape Pigeons

Flocks on the order of 25 were with the ship at the frontal zone. The rump markings seemed to vary somewhat, and this feature, along with the somewhat darker wings than shown in Watson's illustration, leads one to believe that most of them were of the species D.c. australe. ever, no size differences could be seen, so it is presumed that they were of the D.c. capense variety because that's what the charts say. Many hours went into this identification effort with no satisfactory conclusion arrived at.

Prions

A lot of time was spent in trying for positive identification with no success. Definitely two sizes were seen and that is about all. The flitting of the bird makes tail identification all but impossible at a distance.

Gadfly Petrels

In the convergent zone at least two Blue Petrels flew at night into the ship's superstructure and were identified in the hand before releasing them.

Soft-plumaged Petrel - This bird was first sighted by Ms. Susan Pacla of Scripps on Leg II of ISOS and subsequently was seen by us. This was two birds just north of the convergent zone. From the references it appears this bird is not normally seen in this area.

Shearwaters

White-chinned Petrel - Three were seen at the frontal zone on an overcast day.

Storm Petrels

In the open ocean Wilson's Storm Petrels were always in evidence. These tiny birds were always with the ship in about the same numbers both at and away from the front.

Diving Petrels

Ms. Pacla had reported two species without differentiation. Fortunately for us, a South Georgia flew into the ship's superstructure and was identified in the hand. This occurred late at night during a steady drizzle of rain just north of the front. It was the only Diving Petrel seen by us on this cruise.

Specifics of Interesting Sightings

The Soft-plumaged Petrel was seen at 1100, 20 March at Lat. 58 00 S, Long. 64 10 W. Sky overcast, the bird was at a range of about 35 meters.

The Yellow-nosed Albatross was seen at Lat. 57 35 S, Long. 63 45 W, sky overcast, temperature about 7° C, range 2 meters. They were much more curious and unafraid than the Wandering. This occurred on 26 March.

The Wandering Albatross with the peculiar neck markings were seen in a group of 4 on 28 March at the frontal zone. Several were seen earlier just south of Cape Horn on about 18 March.

No exact position available for the South Georgia Diving Petrel.

Mammals

At 1300, 4 April saw pod of about 40-50 long-finned pilot whales. They came close aboard and remained about 1-1/2 hours. In comparing their length with the Albatross overhead, they appeared in some instances to be well over 20 feet in length - which is what the literature says (ANTARCTIC RESEARCH FOLIO SERIES).

A small school of larger whales were seen at a distance early in the cruise - only the spouts were seen.

On Leg II just preceding this one a pod of Sei whales were seen close aboard - no further details except fairly positive identification.

Dolphins were seen near the ship in the Straits of Magellan on departure - no further identification.

X. SUMMARY

All stations occupied on Leg III are summarized in Figs. 37 and 38 (in folder). The area represents only a fraction of the Drake Passage. The dense sampling on Leg III contrasts to more areal measurements on Legs I, II, and during FDRAKE 75. Many of the features observed and noted in this cruise report have analogs in the other data sets. Our data, however, represent the densest sampling of the three dimensional scalar fields in the passage and the most extensive continuous measurements of dissolved oxygen (some earlier GEOSECS stations were taken in the Scotia Sea). The vertical current meter float tracks proved to be instrumental in identifying the existence of a ring of cold water cast off from the circumpolar current. The combined data sets of the YELCHO and THOMPSON will be used to discuss the frontal eddy formation in a forthcoming note.

All data presented are preliminary and will be subject to change during the next several months. No single general publication of all SOPOFROZONEX results is planned, hence this cruise/preliminary data report has been prepared with some care so as to be a useful working document for the various participants in the experiment, as well as a general source of information for others within and without the ISOS program.

XI. ACKNOWLEDGMENTS AND PARTICIPANTS

The scientific personnel and affiliations of Leg III TT107 are listed below. The chief scientist (Joyce) wishes to thank each member of the scientific party for their contributions to a successful cruise.

We would also thank the University of Washington, the captain and crew of the THOMPSON for their very able assistance. We especially acknowledge the chief engineer, Ben Hartman and his assistants without whose aid none of the light scattering stations of Kullenberg would have been made.

We thank Doris Haight and Mary Raymer for their typing and drafting skills in preparing this report.

Without the support of the International Decade of Ocean Exploration (IDOE) and the International Southern Ocean Studies (ISOS) program and participants this work would not have been possible. The bulk of this work was supported under grant OCE75-14056.

Participants on Leg III were:

T. Joyce N. Bauchmann J. Dean M. McCartney R. Millard D. Moller A. Voorhis H. Whittemore	(Woods Hole Oceanographic Institution)
J. Toole	(MIT/WHOI Joint Program)
W. Zenk	(Institut für Meereskunde)
G. Kullenberg H. Hundahl	(University of Copenhagen)
J. Gallo	(Instituto Antartico Argentino)
N. Zuleta	(Instituto Hydrografico de la Armade de Chile)
D. Georgi	(Lamont-Doherty Geological Observatory)
C. Dahm	(Oregon State University)
J. Jolly	(Seattle, Washington)

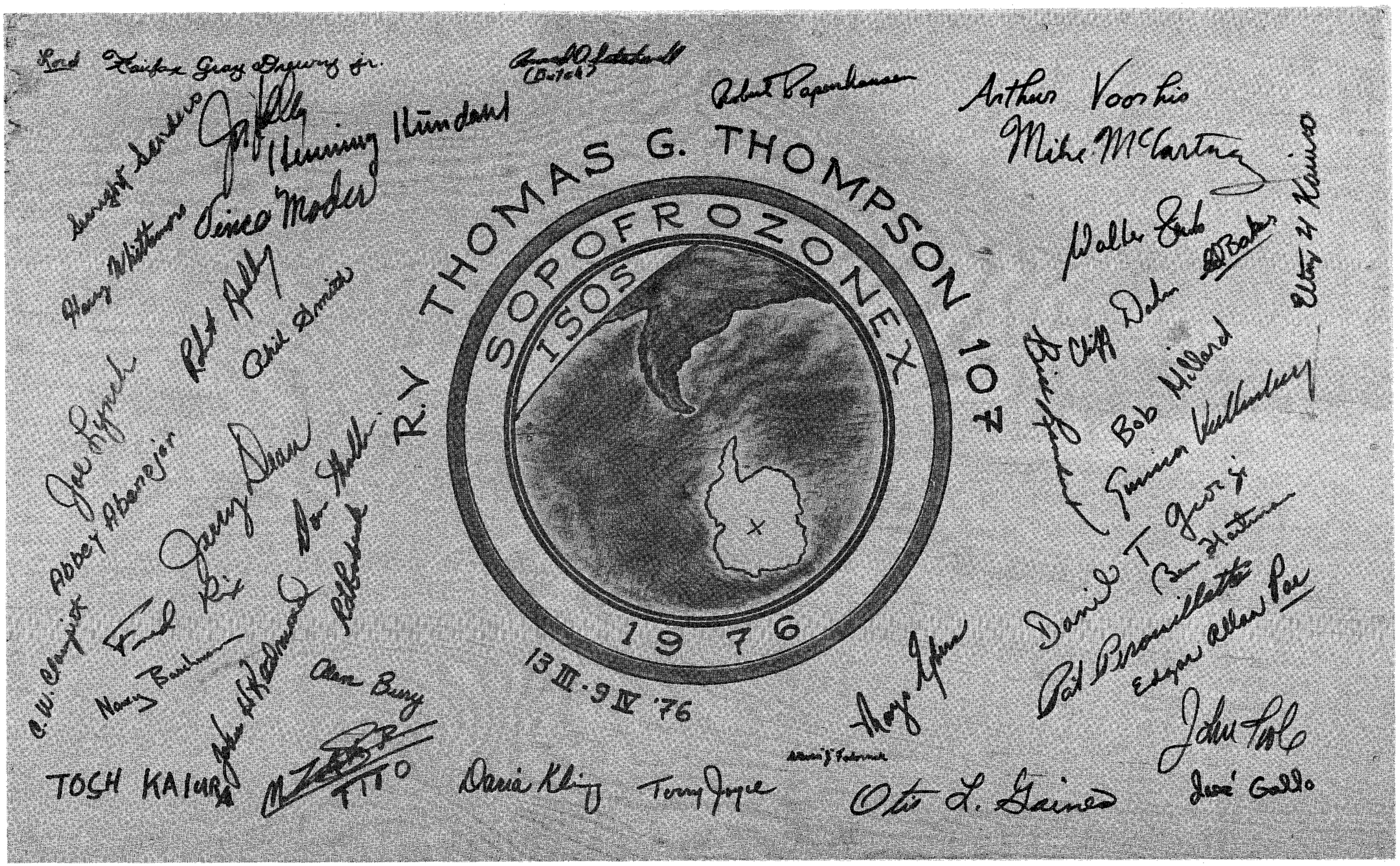

Figure 39. SOPOFROZONEX (Southern Ocean Polar Frontal Zone Experiment) participants

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APPENDIX

Pres, Temp, and Sal-C are pressure, temperature and salinity data taken from the CTD at the time of collection of water sample with the Rosette. Bottle salinity (conductivity) was measured with a University of Washington Bridge. Latitude and longitude are ending positions for each of the CTD stations.

NØ.	LAT.	LØNG.
1	55 30.3	65 43.7

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
39	6.306	34.316	1.38	19.6	1.3	7.00	34.111
39	6.306	34.316	1.38	19.5	1.3	7.01	34.115
397	4.610	34.319	1.64	24.0	11.1	6.81	34.230
397	4.611	34.319	1.66	24.0	11.1	6.83	34.230
643	3.827	34.271	1.78	25.7	15.0	6.68	34.179
643	3.827	34.271	1.81	26.0	15.7	6.65	34.230
977	3.153	34.391	2.25	32.4	40.1	6.12	34.209
978	3.137	34.391	.00	.0	.0	5.31	34.284
1556	2.538	34.642	2.48	35.8	80.4	4.18	34.545
1556	2.538	34.642	2.47	35.8	80.4	4.11	34.532

NØ.	LAT.	LØNG.
3	55 24.5	65 33.0

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
30	6.329	34.093	1.41	19.7	1.5	6.93	.000
296	4.756	34.211	1.64	23.0	10.6	6.77	34.961
575	4.019	34.175	.00	.0	.0	.00	.000
1229	2.790	34.430	2.43	35.1	65.1	4.34	34.438
1734	2.383	34.584	2.48	35.8	91.7	3.76	34.597
2017	2.268	34.618	2.43	35.1	93.9	3.90	34.628

NØ.	LAT.	LØNG.
4	59 4.3	63 55.2

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
37	3.020	33.913	1.69	24.5	5.2	7.56	.000
140	-.213	33.568	2.00	28.7	23.1	7.78	.000
250	1.569	34.317	2.28	33.3	45.2	5.96	.000
393	2.100	34.462	2.42	35.3	62.1	4.77	34.400
645	2.242	34.619	2.44	35.3	75.9	4.21	34.543
898	2.128	34.716	.00	.0	.0	4.74	.000
1097	2.070	34.754	2.34	33.5	89.2	4.49	34.683
1395	1.878	34.792	2.27	32.7	94.9	4.46	34.710
1699	1.658	34.804	2.26	32.5	102.0	4.57	34.726
2151	1.372	34.809	2.25	32.2	108.6	4.67	34.744
3021	.852	34.799	2.28	32.6	125.6	4.85	34.716

NØ.	LAT.	LØNG.
5	58 54.3	63 52.7

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
11	.000	.000	1.70	23.7	4.1	7.49	.000
101	.524	34.055	1.99	26.8	18.0	6.91	.000
203	.849	34.097	2.15	30.6	32.0	7.00	34.064
398	2.171	34.355	.00	.0	.0	.00	.000
651	2.308	34.519	.00	.0	.0	.00	.000
900	2.223	34.623	2.39	33.9	83.7	4.23	34.304
1197	2.040	34.676	2.38	33.6	97.1	4.09	33.849
2077	1.516	34.724	2.27	32.3	107.9	4.70	33.961
3004	.945	34.715	2.30	32.5	124.6	3.92	34.253

NØ.	LAT.	LØNG.
7	57 23.2	64 36.8

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
38	4.953	34.129	1.55	21.5	1.4	7.20	34.027
96	3.299	34.121	1.80	25.0	11.2	7.71	34.080
196	3.363	34.163	1.80	25.7	14.1	6.99	.000
297	3.056	34.158	1.88	27.2	18.2	6.75	.000
398	2.805	34.184	2.05	29.3	25.8	6.30	34.159
497	2.610	34.234	.00	.0	.0	7.08	34.043
597	2.412	34.285	2.27	32.7	43.7	5.38	34.282
796	2.723	34.460	2.29	32.7	44.4	5.58	34.282
996	2.498	34.522	2.43	34.7	70.8	4.19	34.506
1199	2.386	34.598	2.40	34.1	79.1	4.11	34.590
3018	1.257	34.695	2.26	31.9	113.5	4.69	34.724

NØ.	LAT.	LØNG.
9	57 24.8	64 37.7

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
19	4.975	34.017	1.58	22.2	1.6	6.96	34.122
208	3.310	34.114	1.86	27.4	15.4	6.94	34.086
411	2.755	34.139	.00	.0	.0	.00	.000
612	2.651	34.256	2.28	33.6	42.1	5.51	34.262
1017	2.445	34.491	2.47	36.2	72.1	4.31	34.508
1508	2.191	34.657	2.42	34.8	93.6	4.12	34.658

NØ.	LAT.	LØNG.
11	57 25.5	64 38.0

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
16	4.966	34.018	1.57	26.8	1.5	7.13	34.023
207	3.189	34.095	1.83	26.8	15.2	7.03	34.101
407	2.832	34.165	1.88	27.6	17.5	6.94	34.112
611	2.493	34.260	2.28	33.6	43.3	5.49	34.264
1010	2.418	34.507	.00	.0	.0	.00	.000
1506	2.130	34.663	2.45	35.7	98.8	4.02	34.644

NO.	LAT.	LONG.
12	57 23.7	64 36.2

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
15	4.942	34.016	1.57	22.0	1.6	7.08	34.022
207	3.314	34.118	1.84	26.8	15.6	6.83	34.121
410	2.768	34.168	1.91	27.9	19.0	6.65	34.136
608	2.441	34.263	2.29	33.8	44.4	5.38	34.264
1010	2.448	34.493	2.43	36.4	72.1	4.15	.000
1511	2.136	34.660	2.44	35.9	99.7	3.95	34.657

NO.	LAT.	LONG.
13	57 23.6	64 37.8

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
16	4.989	34.019	1.54	22.2	.0	6.19	34.022
207	3.284	23.108	1.78	26.1	.0	6.15	34.114
410	2.829	34.167	2.00	29.0	.0	5.93	34.167
610	2.484	34.263	2.23	32.0	.0	5.53	34.265
1010	2.521	34.482	2.42	.0	.0	4.26	34.426
1510	2.207	34.649	2.36	.0	.0	3.96	34.652

NO.	LAT.	LONG.
15	57 40.8	64 36.3

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
17	5.018	34.023	1.57	22.3	2.0	7.08	34.040
209	3.280	34.103	1.83	26.6	15.0	6.91	34.111
411	2.908	34.177	2.02	29.6	24.3	6.33	34.149
611	2.740	34.248	2.26	33.2	40.3	4.43	34.252
1010	2.547	34.475	2.46	35.9	69.3	4.20	34.481
1515	2.157	34.663	2.41	35.1	95.6	3.93	34.664

NO.	LAT.	LONG.
16	57 24.2	64 35.9

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
16	5.042	34.021	1.56	21.4	1.9	7.08	34.030
207	3.384	34.111	1.82	25.4	14.6	6.88	34.122
410	2.911	34.157	2.05	29.5	26.3	6.19	34.162
613	2.596	34.256	2.23	32.8	41.9	5.31	34.264
999	2.485	34.501	2.45	35.4	72.3	4.19	34.504
1504	2.132	34.657	2.46	35.1	101.2	3.74	34.658

NØ.	LAT.	LØNG.
17	57 24.3	64 37.0

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
17	5.177	34.032	1.54	21.7	1.6	7.05	34.034
208	3.241	34.108	1.84	26.7	15.5	6.84	34.114
410	3.040	34.179	2.04	29.8	25.7	5.99	34.171
609	2.689	34.273	2.18	31.5	36.9	5.26	34.270
1003	2.432	34.501	2.46	35.4	71.9	4.12	34.501
1516	2.155	34.662	2.43	34.7	97.0	3.99	34.661

NØ.	LAT.	LØNG.
18	57 23.5	64 36.7

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
17	5.388	34.065	1.52	20.6	1.6	7.00	.000
195	3.350	34.112	1.82	25.7	14.8	6.93	.000
392	2.879	34.141	2.02	28.7	24.2	6.33	34.063
608	2.691	34.286	2.29	32.3	45.0	5.27	34.023
608	2.703	34.286	2.29	33.2	45.2	5.17	34.146
1513	2.165	34.657	2.43	34.6	97.2	3.92	.000

NØ.	LAT.	LØNG.
25	57 45.0	63 52.3

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
35	3.571	33.880	1.66	23.7	3.1	7.35	33.852
106	1.537	34.006	1.92	27.6	19.2	7.35	34.016
208	1.633	34.082	.00	.0	.0	.00	.000
358	1.644	34.171	.00	.0	.0	.00	.000
411	1.691	34.201	2.21	32.0	40.5	5.64	34.332
598	2.362	34.777	2.37	34.3	56.7	4.99	34.355
1996	1.700	34.720	2.29	32.9	106.8	4.35	34.720
2195	1.617	34.730	2.24	32.1	104.4	4.54	34.733
2591	1.374	34.727	2.25	32.4	112.7	4.64	.000
2795	1.252	34.727	2.25	32.3	115.1	4.73	.000
3002	1.080	34.722	2.28	32.8	121.3	4.77	34.725

NØ.	LAT.	LØNG.
26	57 40.9	63 56.7

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
24	3.636	33.881	1.66	23.9	3.8	7.40	33.888
108	2.003	34.036	1.94	27.8	18.4	7.20	34.049
209	1.235	34.025	1.99	28.8	22.7	7.31	34.025
412	2.021	34.233	2.24	32.8	42.4	5.79	34.237
615	2.327	34.382	2.38	35.0	60.2	4.78	34.385
820	2.337	34.483	2.43	35.6	71.5	4.25	34.487
1022	2.301	34.569	2.41	35.3	79.0	4.13	34.574
1529	2.050	34.698	2.28	33.2	90.5	4.29	34.698
2029	1.724	34.720	2.28	33.0	105.7	4.38	34.719
2503	1.430	34.731	2.24	32.5	109.9	4.61	34.732
3002	1.072	34.724	2.26	32.8	121.4	4.68	34.719

NO.	LAT.	LONG.
27	57 39.9	63 57.1

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
31	4.110	33.891	.00	.0	.0	.00	.000
103	3.733	33.909	1.69	23.4	3.5	7.34	33.971
251	1.210	33.966	.00	.0	.0	7.31	34.021
396	1.847	34.117	.00	.0	.0	6.23	34.175
595	2.315	34.281	2.36	34.5	56.3	4.98	34.354
787	2.337	34.423	2.42	35.5	72.0	4.33	34.490
991	2.353	34.505	2.40	35.0	79.7	4.18	34.568
1481	2.076	34.634	2.27	33.2	90.0	4.34	34.700
1999	1.722	34.655	2.28	33.1	107.5	4.36	34.717
2508	1.466	34.670	2.23	32.4	109.5	4.68	34.730
3019	1.095	34.664	2.24	32.6	121.0	4.81	34.720

NO.	LAT.	LONG.
28	57 39.9	64 1.9

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
23	4.360	33.987	1.61	22.6	2.6	7.17	33.995
110	4.124	34.012	1.64	23.0	4.4	7.18	34.041
212	2.144	34.067	1.94	28.4	21.9	6.98	34.078
412	1.592	34.151	2.15	31.5	36.2	6.16	34.170
601	2.389	34.345	2.23	32.7	44.5	5.71	34.249
794	2.335	34.451	2.41	35.4	68.9	4.43	34.453
997	2.373	34.555	2.40	35.1	78.8	.00	34.568
1491	2.086	34.683	2.38	33.3	88.4	4.32	34.682
1997	1.715	34.730	2.21	32.4	101.4	4.46	34.730
2489	1.392	34.729	2.24	32.4	111.4	4.13	34.729
3004	1.075	34.722	2.25	32.7	121.3	4.79	.000

NO.	LAT.	LONG.
29	57 37.1	64 6.4

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
24	4.321	33.987	1.62	22.8	2.7	7.25	.000
110	2.930	34.077	.00	.0	.0	.00	.000
209	2.425	34.091	1.94	28.2	20.9	6.82	34.095
408	2.225	34.198	2.18	31.9	36.9	5.85	34.209
612	2.203	34.323	2.33	34.4	53.4	5.12	34.326
811	2.257	34.435	2.42	35.4	66.7	4.47	34.438
1007	2.372	34.558	2.40	35.2	77.7	4.08	34.558
1498	2.091	34.686	.00	.0	.0	.00	.000
1987	1.717	34.727	2.24	32.7	101.3	4.52	34.725
2481	1.387	34.728	2.23	32.6	110.9	4.60	34.671- Q
2995	.993	34.721	2.26	32.9	122.6	4.86	34.715

NØ.	LAT.	LØNG.
30	57 35.1	64 11.9

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
29	4.417	34.001	1.60	22.4	2.6	7.19	34.009
105	3.046	34.081	1.82	25.7	13.1	7.09	34.086
408	2.622	34.211	2.15	31.5	35.6	5.77	34.214
612	2.115	34.282	2.30	33.6	49.1	5.33	34.292
1017	2.355	34.561	2.40	35.0	77.9	4.20	34.560
1521	2.086	34.695	2.28	33.1	88.5	4.25	34.696

NØ.	LAT.	LØNG.
31	57 32.9	64 16.7

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
22	4.592	34.008	1.60	22.4	2.5	7.17	34.019
109	3.221	34.080	.00	.0	.0	.00	.000
209	2.774	34.089	1.89	27.4	18.0	6.92	34.092
411	2.461	34.170	2.13	31.0	32.0	6.11	34.166
613	2.435	34.306	2.33	33.8	49.9	5.21	34.307
816	2.429	34.423	2.43	35.3	65.7	4.24	34.430
1018	2.406	34.551	2.43	35.3	78.6	4.06	34.551
1522	2.145	34.674	2.33	33.9	90.4	4.11	34.683
2280	1.569	34.727	2.26	32.8	108.5	4.47	34.655 - Q
2795	1.214	34.725	2.27	32.8	118.4	4.67	34.719

NØ.	LAT.	LØNG.
32	57 32.4	64 20.0

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
26	4.867	34.015	1.56	21.8	1.6	7.12	34.024
157	3.092	34.089	1.83	26.3	14.4	7.06	34.098
511	2.510	34.204	2.18	31.9	36.4	5.82	34.207
1022	2.481	34.526	2.44	35.5	75.9	4.08	34.533
1526	2.156	34.671	2.33	34.0	91.4	4.08	34.674
3043	1.184	34.724	2.27	33.1	120.5	4.63	34.728

NØ.	LAT.	LØNG.
33	57 31.8	64 23.4

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
202	3.002	34.094	1.83	26.6	16.0	6.99	34.102
439	2.777	34.184	2.10	30.8	31.4	5.89	34.191
502	2.504	34.203	2.15	31.5	34.7	5.90	34.198
770	2.371	34.354	2.37	34.5	55.8	4.86	34.351
1005	2.501	34.515	2.42	35.4	73.7	4.11	34.519
1507	2.134	34.679	2.32	33.8	92.5	4.08	34.679

NO.	LAT.	LONG.
34	57 28.6	64 22.6

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
19	4.870	34.018	1.55	21.6	1.6	7.12	34.052
208	2.945	34.093	.00	.0	.0	.00	.000
354	2.968	34.194	2.10	30.7	30.7	5.86	34.202
400	2.751	34.190	2.13	31.0	32.1	5.89	34.193
688	2.504	34.341	2.31	34.1	53.7	4.90	34.346
810	2.544	34.432	2.41	35.2	64.7	4.45	34.436
1012	2.484	34.532	2.43	35.2	75.8	4.13	34.535
1510	2.145	34.673	2.34	34.0	92.7	4.13	34.677
2014	1.831	34.709	2.31	33.6	105.8	4.22	34.713
2529	1.472	34.729	.00	.0	.0	.00	.000
3015	1.191	34.724	2.26	32.7	118.5	4.72	34.720

NO.	LAT.	LONG.
35	57 29.0	64 29.0

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
19	5.038	34.037	1.53	21.3	1.6	7.09	34.040
205	3.480	34.127	1.78	25.9	14.6	6.88	34.133
401	3.161	34.179	2.04	29.7	26.6	6.02	34.185
638	2.531	34.280	2.26	33.1	45.1	5.31	34.289
993	2.600	34.500	2.43	35.4	73.3	4.01	34.624- Q
1507	2.125	34.663	2.40	34.9	99.8	3.90	34.664

NO.	LAT.	LONG.
36	57 27.6	64 32.5

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
30	5.078	34.043	1.54	21.3	1.6	7.09	34.046
108	4.115	34.134	.00	.0	.0	.00	.000
207	3.530	34.126	1.79	25.6	13.5	6.95	34.132
409	3.212	34.179	2.04	29.5	25.2	6.06	34.182
615	2.964	34.276	2.25	32.7	40.6	5.19	34.280
816	2.649	34.405	2.40	34.9	59.1	4.53	34.410
1015	2.565	34.514	2.44	35.4	72.4	4.06	34.159
1520	2.192	34.655	2.39	34.6	91.2	3.96	34.656
2020	1.901	34.717	.00	.0	.0	.00	.000
2522	1.547	34.728	2.27	32.8	106.4	4.48	34.726
3033	1.213	34.725	2.26	32.6	114.8	4.65	34.720

NO.	LAT.	LONG.
37	57 26.4	64 35.3

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
30	5.208	34.061	1.52	21.2	1.7	7.08	34.066
111	3.952	34.128	1.77	24.1	9.7	7.01	34.135
414	3.368	34.175	1.98	28.8	22.6	6.21	34.186
716	2.929	34.305	2.28	33.2	44.3	5.03	34.311
1014	2.659	34.482	2.41	35.4	68.7	4.08	.000
1520	2.244	34.642	2.42	35.0	91.2	3.91	34.639

NO.	LAT.	LONG.
38	57 24.6	64 38.6

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
29	5.051	34.030	1.55	21.7	.0	7.12	34.037
158	3.890	34.146	.00	.0	.0	.00	.000
204	3.731	34.152	1.76	25.5	.0	6.95	34.152
350	3.406	34.153	1.91	27.9	.0	6.66	34.152
677	2.800	34.279	2.26	33.5	.0	5.25	34.280
801	2.522	34.323	2.37	34.6	.0	4.99	34.328
1021	2.651	34.482	2.48	36.0	.0	4.13	34.424
1516	2.232	34.632	2.51	36.2	.0	3.68	34.635
2022	1.883	34.694	2.42	35.1	.0	3.95	34.697
2523	1.594	34.725	2.29	33.1	.0	.00	34.724
3002	1.278	34.725	2.28	33.2	100.0	4.53	34.725

NO.	LAT.	LONG.
39	57 23.5	64 43.2

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
29	5.430	34.082	1.56	21.8	.0	7.01	34.093
393	3.418	34.160	1.86	25.5	.0	6.35	34.165
685	3.037	34.323	2.16	31.5	.0	4.85	34.332
1009	2.615	34.483	2.45	35.8	.0	4.21	34.490
2535	1.631	34.724	2.37	33.8	.0	.00	.000
3028	1.286	34.725	2.31	33.7	.0	4.63	34.725

NO.	LAT.	LONG.
40	57 38.3	64 21.4

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
27	4.750	34.027	1.51	21.1	.0	7.12	34.035
108	3.260	34.088	.00	.0	.0	7.13	34.094
412	2.845	34.207	1.94	28.3	.0	5.73	34.311
610	2.386	34.284	2.33	33.8	.0	5.29	34.284
1009	2.328	34.527	2.47	36.0	.0	4.11	34.531
1507	2.125	34.684	2.26	33.1	.0	4.14	34.686

NO.	LAT.	LONG.
42	57 34.1	64 5.8

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
28	4.647	34.014	.00	.0	.0	.00	.000
103	3.010	34.089	1.83	26.3	.0	7.03	34.090
404	2.564	34.213	2.19	31.8	.0	5.73	34.219
603	2.457	34.308	.00	.0	.0	.00	.000
965	2.341	34.528	2.42	35.3	.0	4.11	34.529
1491	2.095	34.679	2.28	33.4	.0	4.22	34.681

NØ.	LAT.	LØNG.
43	57 28.6	64 2.0

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
150	2.697	34.073	1.89	27.2	.0	7.05	34.080
331	2.337	34.211	2.15	31.5	.0	5.78	34.214
412	2.565	34.224	2.22	32.1	.0	5.66	34.230
613	2.539	34.357	2.38	34.6	.0	4.79	34.364
1005	2.312	34.541	2.44	35.7	.0	4.13	34.557
1512	2.034	34.702	2.29	33.4	.0	4.24	34.705

NØ.	LAT.	LØNG.
46	57 12.8	63 51.9

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
30	4.769	34.033	1.52	22.0	2.0	7.16	34.035
109	3.258	34.094	1.76	25.8	12.9	7.10	34.100
212	2.987	34.094	1.79	26.7	15.6	7.09	34.094
414	2.870	34.183	2.06	30.9	30.8	5.93	34.179
614	2.388	34.272	2.18	33.5	45.3	5.41	34.272
1017	2.356	34.519	2.40	35.6	74.0	4.17	34.511
1607	2.089	34.693	2.27	33.3	83.9	4.28	34.626
2109	1.686	34.727	2.26	33.1	104.0	4.45	34.722
2534	1.420	34.727	.00	.0	.0	.00	.000
2990	1.207	34.725	2.21	33.2	118.1	4.65	34.720

NØ.	LAT.	LØNG.
48	57 25.5	63 27.0

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
29	3.869	33.930	1.63	23.5	3.3	7.36	33.933
207	1.662	34.049	.00	.0	.0	.00	.000
302	2.079	34.140	2.09	30.6	31.3	6.29	34.145
376	2.166	34.198	2.16	31.8	37.2	5.96	34.196
507	1.557	34.224	2.20	32.9	43.8	5.91	34.219
615	2.557	34.404	2.44	35.0	61.6	4.48	34.407
954	2.353	34.568	2.44	35.0	79.3	4.03	34.569
1381	2.091	34.692	2.35	33.5	88.3	4.19	34.679
1892	1.786	34.721	2.26	33.0	101.3	4.32	34.720
2469	1.412	34.730	2.20	32.9	111.3	4.53	34.721
3002	1.062	34.727	2.28	32.9	120.4	4.69	34.711

NØ.	LAT.	LØNG.
50	57 41.5	63 22.3

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
31	3.958	33.936	1.64	23.4	3.3	7.32	33.940
110	2.702	34.058	.00	.0	.0	.00	.000
210	1.822	34.058	1.99	28.7	22.7	7.00	.000
434	1.759	34.217	2.24	32.5	41.3	5.94	34.210
513	2.506	34.353	2.38	34.5	54.1	4.83	34.349
615	2.540	34.428	2.42	35.1	62.9	4.45	34.428
817	2.314	34.525	2.44	35.3	74.0	4.38	34.526
1019	2.254	34.602	2.40	34.9	80.7	4.20	34.597
1525	1.986	34.706	2.30	33.1	92.5	4.26	34.699
2027	1.659	34.721	2.28	33.2	105.6	4.46	34.711
2536	1.331	34.729	.00	.0	.0	.00	.000

NØ.	LAT.	LØNG.
51	57 55.3	63 36.0

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
17	4.310	33.962	1.61	22.9	2.6	7.26	33.977
249	1.400	34.056	2.05	30.0	25.5	6.98	34.064
613	2.456	34.399	2.40	35.0	60.8	4.53	34.414
1007	2.270	34.597	2.41	34.8	81.1	4.04	34.609
1510	1.945	34.690	2.34	33.8	99.8	4.11	.000
2006	1.676	34.704	2.28	33.0	104.3	4.33	34.725

NØ.	LAT.	LØNG.
52	56 45.0	63 19.0

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
22	4.842	34.026	1.56	22.0	2.3	7.17	34.037
405	2.864	34.157	2.04	30.5	26.9	6.17	34.164
567	2.607	34.217	2.20	32.4	37.4	5.73	34.223
1019	2.537	34.501	2.43	35.8	71.8	4.13	34.509
1525	2.232	34.637	2.34	34.7	83.8	4.10	34.639
2014	1.958	34.713	2.28	33.7	95.1	4.24	34.715

NØ.	LAT.	LØNG.
53	59 [illegible].3	63 49.2

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
20	3.645	33.897	1.66	23.9	4.1	7.43	33.909
176	.908	34.027	1.98	29.2	24.0	7.31	34.031
514	2.219	34.393	2.40	35.4	62.2	4.65	34.398
1019	2.165	34.640	2.31	34.3	83.5	4.15	34.647
2016	1.518	34.727	.00	32.0	104.3	4.57	34.734
2994	.885	34.715	.00	32.8	124.9	4.82	34.714

NO.	LAT.	LONG.
54	57 40.2	63 53.2

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
19	3.592	33.817	1.67	24.8	6.5	7.49	33.830
121	.816	33.899	.00	.0	.0	.00	.000
201	.559	34.036	2.07	29.9	26.9	7.24	34.015
372	1.336	34.215	2.29	33.7	45.4	6.00	34.220
658	2.443	34.505	2.44	35.9	72.9	4.17	34.524
754	2.319	34.535	2.44	36.1	76.8	4.13	.000
990	2.232	34.606	2.36	35.4	82.6	4.08	34.628
1227	2.117	34.660	2.29	34.3	86.0	4.21	34.666
1755	1.850	34.715	2.27	33.3	98.5	4.31	34.722
2024	1.656	34.719	2.29	33.5	106.2	4.42	34.727
3054	1.087	34.717	2.27	33.3	119.9	4.71	34.718

NO.	LAT.	LONG.
55	57 40.2	64 9.5

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
27	4.145	33.942	1.58	23.3	3.0	7.43	33.954
239	1.511	34.049	.00	.0	.0	.00	.000
307	2.331	34.176	2.14	31.6	34.7	6.00	34.193
493	1.528	34.190	2.21	32.8	40.4	6.15	34.199
600	2.536	34.359	2.33	34.9	55.5	4.78	34.365
805	2.364	34.474	2.47	35.9	70.5	4.33	34.471
1006	2.315	34.577	.00	.0	.0	4.05	34.584
1500	2.042	34.680	2.31	34.2	94.1	4.12	34.683
1980	1.787	34.717	2.27	33.2	102.3	4.33	34.723
2443	1.511	34.725	2.25	32.9	106.6	4.52	34.731
2956	1.128	34.720	2.26	32.9	119.2	4.72	34.726

NO.	LAT.	LONG.
56	57 24.6	64 12.2

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
29	4.300	33.948	1.61	23.0	2.7	7.23	33.951
259	1.659	34.080	2.03	29.6	26.1	6.75	34.082
413	1.876	34.186	2.20	32.3	38.0	6.00	34.192
615	2.500	34.373	2.36	35.0	57.8	4.69	34.378
817	2.359	34.476	2.42	35.9	70.2	4.24	34.482
1015	2.292	34.574	2.39	35.3	79.1	4.06	34.579
1493	2.069	34.687	2.30	33.7	91.7	4.17	34.690
1985	1.786	34.717	2.24	33.1	101.5	4.29	34.721
2504	1.490	34.729	2.21	32.8	107.6	4.55	34.730
3080	1.076	34.719	2.27	33.0	120.2	4.69	34.720

NO.	LAT.	LONG.
57	58 1.2	62 58.3

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
26	4.770	33.998	.00	.0	.0	.00	.000
198	2.723	34.082	1.91	27.7	18.0	6.90	34.087
395	2.720	34.196	.00	.0	.0	.00	.000
599	2.432	34.306	.00	.0	.0	.00	.000
797	2.550	34.419	2.45	35.7	63.2	4.47	34.424
1001	2.393	34.556	2.46	35.6	77.4	4.11	34.566
1449	2.149	34.664	.00	.0	.0	.00	.000
1993	1.839	34.711	2.32	34.0	102.1	4.27	34.713
2494	1.491	34.724	2.28	33.1	108.3	4.50	34.724
2974	1.157	34.722	2.22	33.1	118.5	4.67	34.722

NO.	LAT.	LONG.
58	58 48.7	62 55.7

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
152	1.597	33.979	.00	.0	.0	.00	.000
285	1.651	34.145	2.11	31.7	34.4	6.35	34.152
352	1.438	34.168	2.11	31.4	37.4	6.32	34.169
688	2.365	34.522	2.43	35.7	74.2	4.12	34.527
992	2.198	34.614	2.40	35.0	82.0	4.08	34.617
1499	1.896	34.714	2.26	33.1	91.7	4.35	34.718
1999	1.518	34.727	2.23	32.9	106.4	4.46	34.729
2448	1.210	34.723	.00	.0	.0	.00	.000
3003	.893	34.718	2.28	33.5	125.2	4.76	34.719

NO.	LAT.	LONG.
59	58 28.7	63 13.0

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
307	2.229	34.102	1.94	30.3	24.5	6.49	34.115
590	2.494	34.340	2.37	34.8	48.8	4.86	34.342
794	2.480	34.469	2.46	36.0	63.1	4.29	34.470
960	2.429	34.559	2.42	35.8	72.0	4.03	34.563
1474	2.101	34.676	2.37	34.6	86.2	4.06	34.683
2012	1.744	34.722	2.29	33.5	94.2	4.32	34.725

NO.	LAT.	LONG.
77	58 56.2	63 3.1

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
18	2.172	33.749	.00	24.7	10.9	7.64	33.758
120	.570	32.689	.00	28.7	23.5	.00	33.944
121	.567	32.698	.00	28.7	23.9	7.77	33.937
147	.005	34.033	.00	30.5	29.2	7.30	34.035
235	.862	34.205	.00	33.3	45.6	6.15	34.196
795	2.072	34.622	.00	34.9	82.2	4.19	34.640
996	2.004	34.681	.00	33.8	86.8	4.21	34.684
1497	1.688	34.723	.00	33.0	101.8	4.36	34.722
2000	1.397	34.727	.00	32.9	108.7	4.54	34.729
3003	.794	34.715	.00	33.4	127.5	.00	34.718
3001	.807	34.716	.00	33.4	126.8	4.77	34.713

NO.	LAT.	LONG.
78	58 56.2	63 .9

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
17	3.585	33.941	1.71	24.1	4.6	7.29	33.957
96	2.732	34.071	1.76	27.3	16.5	7.02	34.090
189	2.111	34.079	1.99	29.3	23.0	6.78	34.086
397	2.424	34.296	2.27	33.7	47.1	5.23	34.301
595	2.527	34.456	2.41	35.7	66.3	4.32	34.459
796	2.352	34.558	2.42	35.3	75.8	4.11	34.559
958	2.267	34.604	2.37	35.1	81.4	4.08	34.610
1501	1.980	34.712	2.27	33.4	86.8	4.26	34.685
1998	1.636	34.731	2.28	32.8	101.3	4.49	34.741
2496	1.150	34.724	2.23	32.9	115.2	4.70	34.738
3016	.870	34.717	2.24	33.3	124.3	4.64	34.722

NO.	LAT.	LONG.
79	58 35.2	63 6.7

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
16	4.472	34.023	1.65	22.6	2.9	7.13	34.028
100	3.221	34.085	1.83	25.9	12.7	7.06	34.093
203	2.721	34.088	1.84	27.5	17.5	6.92	34.094
398	2.643	34.204	2.19	31.9	34.5	5.79	34.207
594	2.548	34.340	2.37	34.7	52.6	4.87	34.345
798	2.546	34.467	2.39	35.4	67.8	4.24	34.471
984	2.372	34.576	2.43	35.5	79.9	4.04	34.578
1498	2.053	34.696	2.39	34.9	83.2	4.09	34.615
1894	1.777	34.707	2.35	34.2	107.4	4.14	34.711
2500	1.399	34.728	2.26	33.0	110.1	4.56	34.729
3007	1.030	34.720	2.29	33.5	121.7	4.79	34.721

NO.	LAT.	LONG.
80	58 24.2	63 15.0

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
15	4.455	34.025	1.62	22.5	3.1	7.13	34.033
141	2.891	34.068	1.86	26.2	13.1	7.00	34.080
304	2.472	34.112	2.00	29.2	23.4	6.57	34.112
445	2.548	34.218	2.22	32.3	37.3	5.71	34.224
583	2.491	34.298	2.31	33.8	47.1	5.19	34.299
779	2.522	34.443	2.43	35.6	64.5	4.37	34.441
988	2.421	34.558	2.42	35.4	79.6	4.06	34.564
1465	2.141	34.672	2.32	34.1	85.9	4.15	34.632
1962	1.816	34.718	2.29	33.4	100.5	4.29	34.716
2473	1.486	34.728	2.26	33.0	107.5	4.53	34.727
2984	1.096	34.722	2.30	33.3	119.8	4.69	34.719

NØ.	LAT.	LØNG.
81	58 14.8	63 16.1

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
33	4.400	34.024	1.67	22.4	3.0	7.13	34.038
186	2.959	34.093	1.75	25.1	14.7	6.99	34.104
398	2.331	34.153	.00	30.6	29.8	6.24	.000
409	2.465	34.175	.00	.0	.0	6.27	34.148
413	2.476	34.180	2.19	31.1	31.9	5.99	34.181
637	2.393	34.325	2.40	34.1	51.6	5.02	34.336
720	2.558	34.398	.00	.0	.0	4.54	34.410
1507	2.141	34.674	2.27	32.9	83.5	4.24	34.668
2010	1.798	34.717	2.29	33.0	101.4	4.28	34.720
2529	1.482	34.726	2.27	32.8	108.5	4.52	34.727
3001	1.169	34.721	2.28	32.9	117.9	4.68	34.722

NØ.	LAT.	LØNG.
82	58 5.0	63 22.0

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
32	4.373	34.008	1.61	22.3	3.0	7.17	34.017
110	3.178	34.067	1.85	25.4	11.7	7.08	34.082
210	2.663	34.086	1.92	27.4	18.2	6.85	34.097
401	2.124	34.140	2.14	30.6	30.1	6.31	34.145
604	2.008	34.242	2.28	32.8	42.8	5.69	34.241
810	2.480	34.424	2.44	35.1	63.0	4.46	34.416
1013	2.394	34.522	2.44	35.4	74.1	4.11	34.522
1514	2.138	34.664	2.39	34.3	93.1	4.01	34.664
2000	1.858	34.712	2.32	33.2	101.5	4.23	34.713
2490	1.572	34.726	2.28	32.8	107.2	4.45	34.726
3025	1.215	34.722	2.25	32.7	116.1	4.68	34.720

NØ.	LAT.	LØNG.
83	57 56.5	63 28.4

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
30	4.785	34.028	1.61	21.8	2.4	7.09	34.033
112	3.279	34.089	1.85	25.6	12.2	7.03	.000
211	3.069	34.111	1.86	27.1	17.4	6.74	34.122
415	2.922	34.230	2.20	31.8	35.3	5.53	34.236
616	2.480	34.315	2.35	33.8	49.0	5.07	34.325
818	2.653	34.445	2.43	35.1	64.1	4.30	34.448
1000	2.514	34.524	2.45	35.3	74.1	4.09	34.526
1524	2.124	34.667	2.37	34.4	93.9	4.03	34.669
1999	1.875	34.712	2.31	33.3	99.8	4.23	34.717
2458	1.575	34.726	2.28	32.9	106.5	4.47	34.726
2956	1.232	34.724	2.27	32.9	114.7	4.64	34.717

NO.	LAT.	LONG.
84	57 46.7	63 33.0

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
37	4.262	33.966	1.66	23.0	3.9	7.19	34.039
116	2.904	34.082	1.87	26.8	19.7	7.02	34.099
218	2.444	34.089	1.97	29.3	21.0	6.78	34.122
413	2.373	34.232	2.24	32.4	40.5	5.66	34.234
513	2.564	34.311	.00	.0	.0	5.15	34.322
758	2.444	34.423	2.41	35.2	62.3	4.65	34.450
1000	2.375	34.547	2.42	35.6	76.4	4.13	34.527
1482	2.129	34.677	2.32	33.6	87.0	4.53	34.673
1973	1.792	34.713	2.30	33.2	99.9	4.31	34.714
2474	1.490	34.726	2.26	32.8	106.0	4.54	34.725
3019	1.063	34.718	2.27	32.8	119.1	4.74	34.721

NO.	LAT.	LONG.
85	57 36.5	63 34.0

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
16	3.877	33.882	1.66	23.6	5.2	7.19	33.890
100	2.447	33.967	1.88	25.1	10.2	7.30	33.983
182	.914	34.015	2.01	29.2	24.1	7.22	34.018
263	1.365	34.141	2.17	31.1	34.1	6.50	34.136
322	.911	34.132	2.16	31.7	35.4	6.73	34.126
730	2.350	34.482	2.42	35.3	70.5	4.24	34.482
1001	2.253	34.590	2.39	35.0	80.4	4.07	34.596
1525	2.030	34.697	2.30	33.1	91.3	4.20	34.697
1999	1.714	34.724	2.26	32.6	101.4	4.38	34.725
2511	1.389	34.730	2.25	32.4	109.1	4.58	34.728
3000	1.103	34.723	2.27	33.0	118.8	4.70	34.720

NO.	LAT.	LONG.
86	57 26.9	63 41.0

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
27	3.490	33.820	1.71	24.2	6.3	7.39	33.927
106	1.898	33.937	1.88	25.5	10.9	7.50	33.938
207	.080	34.024	2.08	29.9	28.2	7.33	34.020
402	1.878	34.307	2.36	34.2	54.1	5.19	34.314
587	2.241	34.454	2.45	35.6	68.4	4.34	34.455
759	2.223	34.527	2.43	35.5	74.9	4.15	34.523
941	2.172	34.602	2.40	34.7	80.8	4.09	34.606
1489	1.987	34.709	2.27	32.8	87.9	4.29	34.702
1970	1.672	34.729	2.25	32.4	99.9	4.44	34.734
508	1.339	34.727	2.25	32.5	112.0	4.60	34.730
2996	1.037	34.720	2.27	32.7	121.0	4.91	34.718

NO.	LAT.	LONG.
87	57 16.2	63 37.2

PRES	TEMP	SAL.C	PO4	NO3	SIL	OXY	SAL.B
34	3.903	33.883	1.67	23.5	3.7	7.28	33.892
114	.266	33.911	1.98	26.9	17.1	7.78	33.903
214	.272	34.028	2.06	29.6	26.8	7.21	34.031
414	1.808	34.301	2.36	34.5	53.3	5.28	34.306
619	2.231	34.455	2.45	35.5	67.9	4.39	34.457
821	2.240	34.564	2.42	35.5	77.4	4.16	34.569
1024	2.187	34.632	2.35	34.2	81.9	4.15	34.639
2028	1.612	34.723	2.27	32.8	105.3	4.42	34.723
2519	1.363	34.726	2.26	32.7	110.6	4.64	34.722
3007	1.075	34.720	2.27	32.9	118.6	4.75	34.715

NO.	LAT.	LONG.
88	57 6.8	63 41.2

PRES	TEMP	SAL.C	PO4	NO3	SIL	OXY	SAL.B
18	3.811	33.901	1.70	23.9	3.7	7.29	33.912
110	1.486	34.008	2.02	27.6	18.3	7.34	34.015
211	1.504	34.071	2.09	29.7	25.8	6.87	34.071
412	1.911	34.261	.00	.0	45.9	5.56	34.319
612	2.210	34.387	2.44	35.3	60.5	4.68	34.387
812	2.314	34.517	.00	.0	73.5	4.13	34.522
1012	2.274	34.606	2.43	34.9	80.9	4.05	34.605
1513	1.958	34.699	2.35	33.7	89.4	4.15	34.700
1997	1.615	34.723	2.30	33.1	105.9	4.45	34.723
2509	1.377	34.729	2.28	32.6	108.7	4.59	34.727
3019	1.032	34.722	2.30	33.1	120.4	4.73	34.715

NO.	LAT.	LONG.
89	56 56.5	63 45.9

PRES	TEMP	SAL.C	PO4	NO3	SIL	OXY	SAL.B
26	4.265	33.972	1.65	22.9	2.9	7.10	33.977
108	3.043	34.095	1.85	26.6	14.9	7.00	34.094
208	2.529	34.098	1.96	28.3	20.5	6.76	34.093
410	2.352	34.208	2.17	32.1	36.5	5.81	.000
614	2.356	34.328	2.34	34.3	51.5	4.98	34.332
817	2.506	34.473	2.40	35.5	68.3	4.24	34.475
1015	2.342	34.567	2.44	35.4	77.8	4.06	34.564
1498	2.078	34.693	2.32	33.5	88.5	4.22	34.692
2015	1.697	34.723	2.29	33.1	103.7	4.36	34.720
2498	1.357	34.727	2.28	32.9	111.2	4.62	34.723
3040	1.125	34.722	2.29	33.0	118.6	4.72	34.719

NO.	LAT.	LONG.
90	56 52.0	64 .5

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
30	4.537	34.021	.00	.0	.0	.00	.000
109	3.526	34.101	.00	.0	.0	.00	.000
209	3.120	34.099	.00	.0	.0	.00	.000
412	2.491	34.096	.00	.0	.0	.00	.000
614	2.858	34.288	.00	.0	.0	.00	.000
819	2.090	34.312	.00	.0	.0	.00	.000
1019	2.405	34.489	2.45	35.8	70.9	4.25	34.490
1506	2.143	34.672	2.35	33.8	89.1	4.16	.000
1982	1.844	34.710	.00	.0	.0	.00	34.678
2571	1.487	34.729	2.27	32.8	104.8	4.59	34.730
2997	1.233	34.724	2.28	32.8	115.3	4.68	34.720

NO.	LAT.	LONG.
91	56 49.3	64 25.5

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
23	5.294	34.069	1.51	20.9	2.0	7.01	34.072
97	4.896	34.123	1.60	22.3	5.0	6.89	34.134
201	4.115	34.166	1.74	24.7	11.7	6.84	34.167
398	3.537	34.139	1.79	26.1	15.0	.00	34.200
578	3.602	34.252	2.14	31.0	30.9	5.38	34.257
747	3.080	34.303	2.28	33.2	42.8	5.03	34.311
1003	2.740	34.425	2.41	35.0	61.0	4.38	34.430
1506	2.315	34.620	2.41	34.7	82.8	4.05	34.628
1995	1.972	34.697	2.35	33.9	100.3	4.12	34.700
2456	1.645	34.726	2.28	32.8	104.5	4.47	34.731
2990	1.298	34.726	2.27	32.8	113.9	4.64	34.715

NO.	LAT.	LONG.
92	56 44.7	64 37.6

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
29	5.727	34.091	1.45	20.2	1.8	6.92	34.098
105	5.121	34.169	1.45	20.2	1.8	6.94	34.099
205	4.663	34.207	1.65	23.6	10.3	6.74	34.208
407	4.058	34.198	1.86	26.8	16.8	6.32	34.202
613	3.536	34.255	2.15	31.3	32.2	5.35	34.257
813	3.075	34.345	2.33	33.9	48.5	4.73	34.348
1022	2.749	34.438	2.43	35.0	63.0	4.29	34.442
1526	2.371	34.604	2.41	35.0	83.9	3.99	34.607
2033	1.991	34.686	2.41	34.7	100.3	3.97	34.688
2540	1.775	34.726	2.27	32.9	105.0	4.42	34.724
3049	1.356	34.725	2.27	32.8	112.3	4.59	34.725

NØ.	LAT.	LØNG.
93	56 35.5	64 53.6

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
28	6.103	34.070	1.43	19.9	2.0	6.82	34.075
106	5.306	34.145	1.67	22.7	7.6	6.59	34.154
207	4.891	34.204	.00	.0	9.4	6.65	34.211
407	4.459	34.204	1.76	25.1	12.2	6.63	34.218
614	3.794	34.202	1.98	28.6	20.7	6.07	34.207
807	3.380	34.273	2.23	32.4	35.9	5.29	34.382
997	2.931	34.378	.00	.0	.0	4.72	34.279
1483	2.443	34.582	2.46	35.7	81.4	4.18	34.587
1989	2.082	34.676	2.41	34.6	98.0	3.96	34.685
2480	1.887	34.714	2.31	33.5	99.2	4.32	34.719
3002	1.439	34.729	2.28	32.8	108.1	4.57	34.733

NØ.	LAT.	LØNG.
94	56 36.8	65 12.2

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
17	6.375	34.043	1.46	19.0	1.8	6.80	34.051
105	5.703	34.144	.00	.0	.0	.00	.000
207	4.986	34.219	1.61	22.7	9.1	6.72	34.226
399	4.622	34.214	1.68	24.3	11.4	6.64	34.219
600	3.973	34.182	1.85	26.6	15.6	6.44	34.189
798	3.451	34.236	2.15	31.3	30.2	5.53	34.241
1008	3.120	34.330	2.35	34.1	46.3	4.79	34.334
1500	2.503	34.558	.00	.0	.0	3.97	34.560
2001	2.163	34.672	.00	.0	.0	.00	.000
2558	1.838	34.718	.00	.0	.0	4.29	34.719
2810	1.695	34.724	.00	.0	.0	4.41	34.724

NØ.	LAT.	LØNG.
95	56 32.4	65 27.6

PRES	TEMP	SAL-C	PØ4	NØ3	SIL	ØXY	SAL-B
30	6.040	34.107	1.50	20.5	3.5	6.88	34.134
112	5.700	34.176	.00	.0	.0	.00	.000
207	5.027	34.225	.00	.0	.0	6.68	.000
398	4.606	34.209	1.67	23.6	11.2	6.46	34.216
585	4.035	34.184	1.83	26.3	15.3	5.53	34.191
801	3.574	34.238	2.10	30.4	29.5	4.83	34.224
995	3.074	34.332	2.32	33.7	47.0	4.06	34.340
1496	2.557	34.527	2.44	35.3	73.8	4.09	34.531
1994	2.213	34.664	2.36	34.2	88.7	4.19	34.672
2494	1.909	34.708	2.33	33.5	101.4	4.42	34.713
2948	1.706	34.725	2.34	33.2	103.9	.00	34.730

NO.	LAT.	LONG.
96	56 27.1	65 43.7

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
15	6.189	34.105	.00	.0	.0	.00	.000
110	5.897	34.143	.00	.0	.0	.00	.000
208	4.970	34.220	1.48	20.3	3.0	6.84	34.151
296	4.837	34.224	1.61	23.0	9.0	6.69	34.226
531	4.081	34.177	1.77	25.4	13.0	6.69	34.181
721	3.714	34.208	2.01	29.3	22.8	5.87	34.214
972	3.287	34.307	2.26	32.9	40.0	4.98	34.313
1460	2.597	34.498	2.44	35.4	67.4	4.20	34.328
1989	2.250	34.657	.00	.0	.0	5.45	34.382
2475	1.934	34.714	2.30	33.4	94.2	4.26	34.714
2963	1.672	34.726	2.28	32.9	100.9	4.45	34.730

NO.	LAT.	LONG.
97	56 23.9	66 3.7

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
16	6.157	34.091	1.35	19.6	1.6	6.91	33.978
88	5.814	34.124	.00	.0	.0	.00	.000
208	4.926	34.209	1.61	22.8	8.7	6.71	34.270
319	4.763	34.218	1.65	23.4	9.8	6.69	34.221
492	4.471	34.205	1.71	24.6	11.5	6.66	34.209
744	3.797	34.201	1.96	28.4	20.4	6.07	34.208
985	3.369	34.292	2.23	32.4	36.8	5.20	34.295
1504	2.552	34.541	2.41	35.4	72.6	4.02	34.592
1992	2.253	34.645	2.43	35.1	90.6	3.89	34.650
2486	2.018	34.708	2.31	33.3	91.5	4.23	34.764 - Q
3006	1.733	34.725	2.28	33.0	99.6	4.40	34.719

NO.	LAT.	LONG.
98	56 19.5	66 19.6

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
29	6.972	34.004	1.33	17.9	1.8	6.98	33.964
109	5.810	34.171	1.58	22.0	5.3	6.50	34.121
209	5.183	34.213	1.60	22.7	7.3	6.63	34.169
306	4.891	34.244	1.63	23.2	8.8	6.68	34.200
399	4.753	34.256	1.65	23.6	9.7	6.67	34.204
498	4.583	34.259	1.68	24.1	11.0	6.64	34.230
596	4.486	34.255	1.72	24.6	11.7	6.61	34.211
700	4.334	34.250	1.75	25.1	12.6	6.55	34.201
793	4.003	34.248	1.87	27.0	16.8	6.31	34.200
990	3.421	34.313	.00	.0	.0	.00	.000
1641	2.437	34.632	2.48	35.8	81.1	3.87	34.578
15	6.989	34.001	1.32	17.9	1.7	6.77	33.961
461	4.671	34.258	1.66	23.4	10.2	6.66	34.200
760	4.063	34.237	1.78	25.5	13.8	6.49	34.190
1703	2.344	34.659	2.33	33.4	73.2	3.91	34.608

NO.	LAT.	LONG.
99	56 15.5	66 36.6

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
14	7.447	33.909	1.31	17.0	1.9	6.65	34.222
382	4.922	34.252	1.62	22.8	8.8	6.71	34.209
534	4.765	34.265	1.76	25.1	13.0	6.68	34.218
693	4.257	34.247	1.65	23.4	9.9	6.56	34.203
805	3.870	34.253	1.92	27.7	19.4	6.04	34.217
907	3.423	34.323	2.17	31.3	34.1	5.71	34.248
0	.000	.000	1.34	17.3	1.6	6.67	.000
0	.000	.000	1.60	23.5	8.2	6.71	33.866
398	4.889	34.254	1.64	23.9	9.3	6.56	34.207
548	4.756	34.263	1.78	26.3	12.8	6.66	.000
700	4.210	34.247	1.96	29.1	20.0	6.18	34.219
730	3.795	34.258	.00	.0	.0	.00	34.208
820	3.632	34.294	2.06	30.5	25.6	5.32	34.278

NO.	LAT.	LONG.
100	56 13.6	66 45.0

PRES	TEMP	SAL-C	PO4	NO3	SIL	OXY	SAL-B
6	7.340	33.913	1.28	17.2	1.5	6.74	33.873
99	7.157	34.012	1.36	18.5	1.9	6.59	33.970
258	5.458	34.190	1.58	22.6	6.3	6.53	34.141

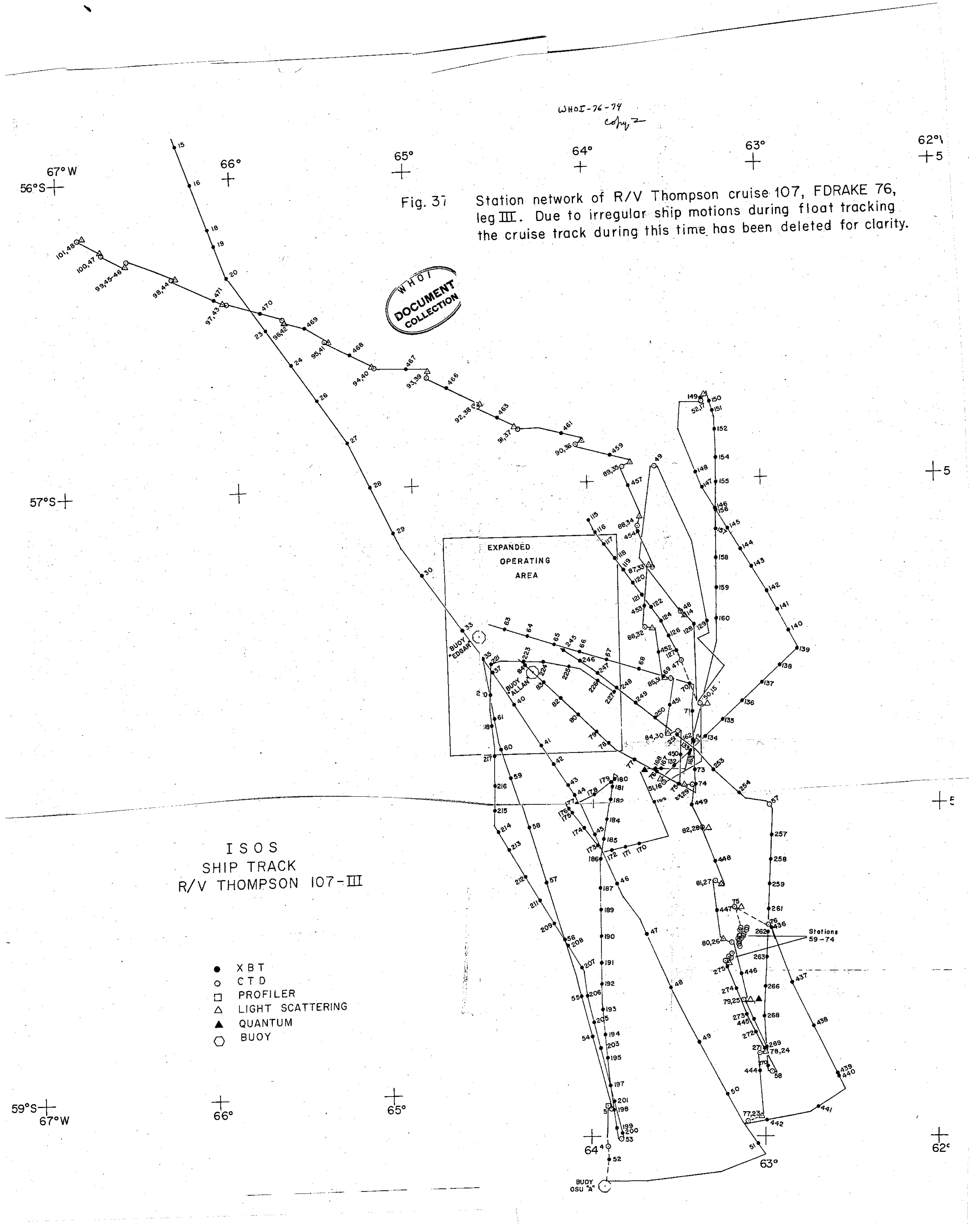

Fig. 37 Station network of R/V Thompson cruise 107, FDRAKE 76, leg III. Due to irregular ship motions during float tracking the cruise track during this time has been deleted for clarity.

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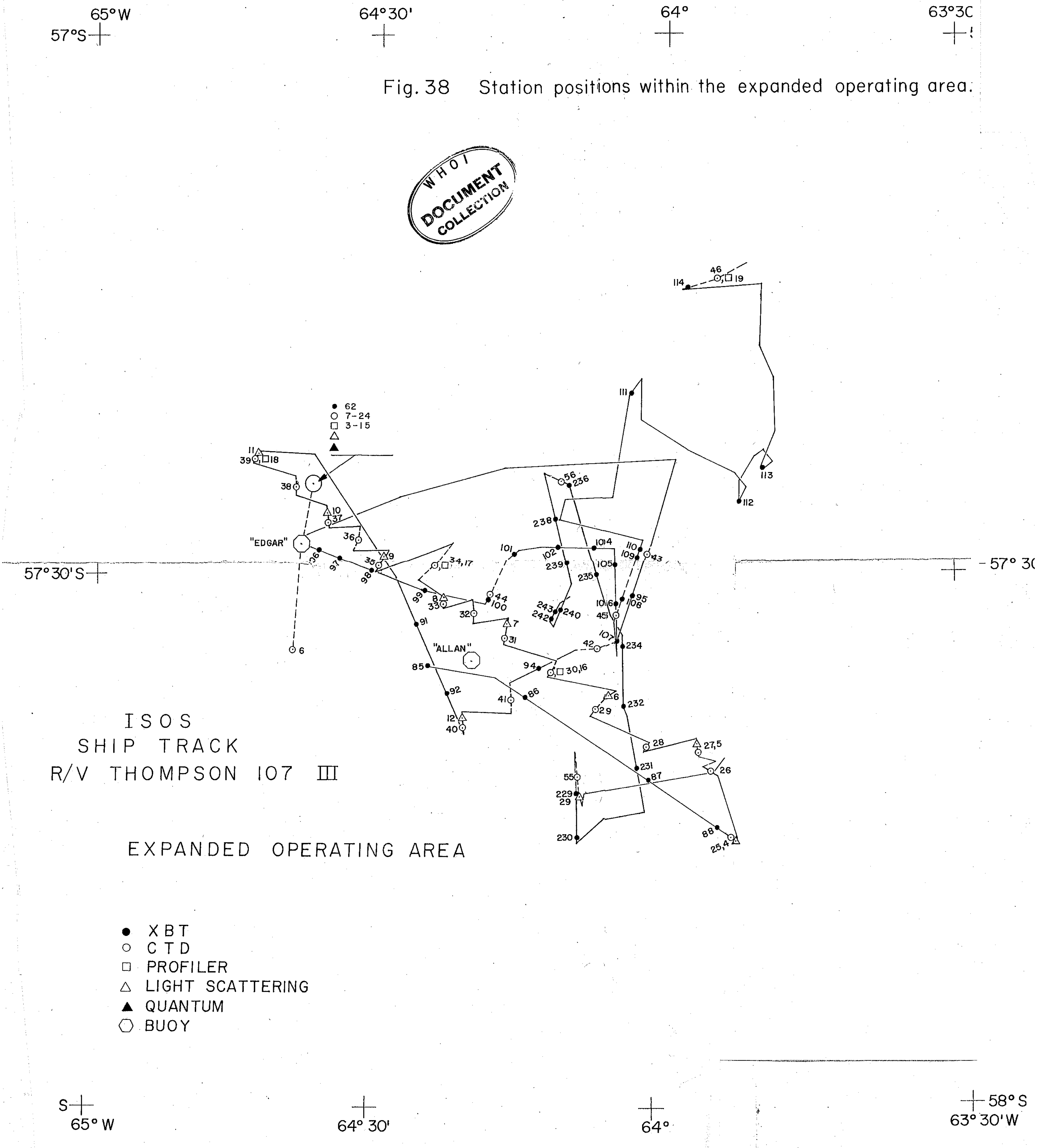
Fig. 38 Station positions within the expanded operating area.



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