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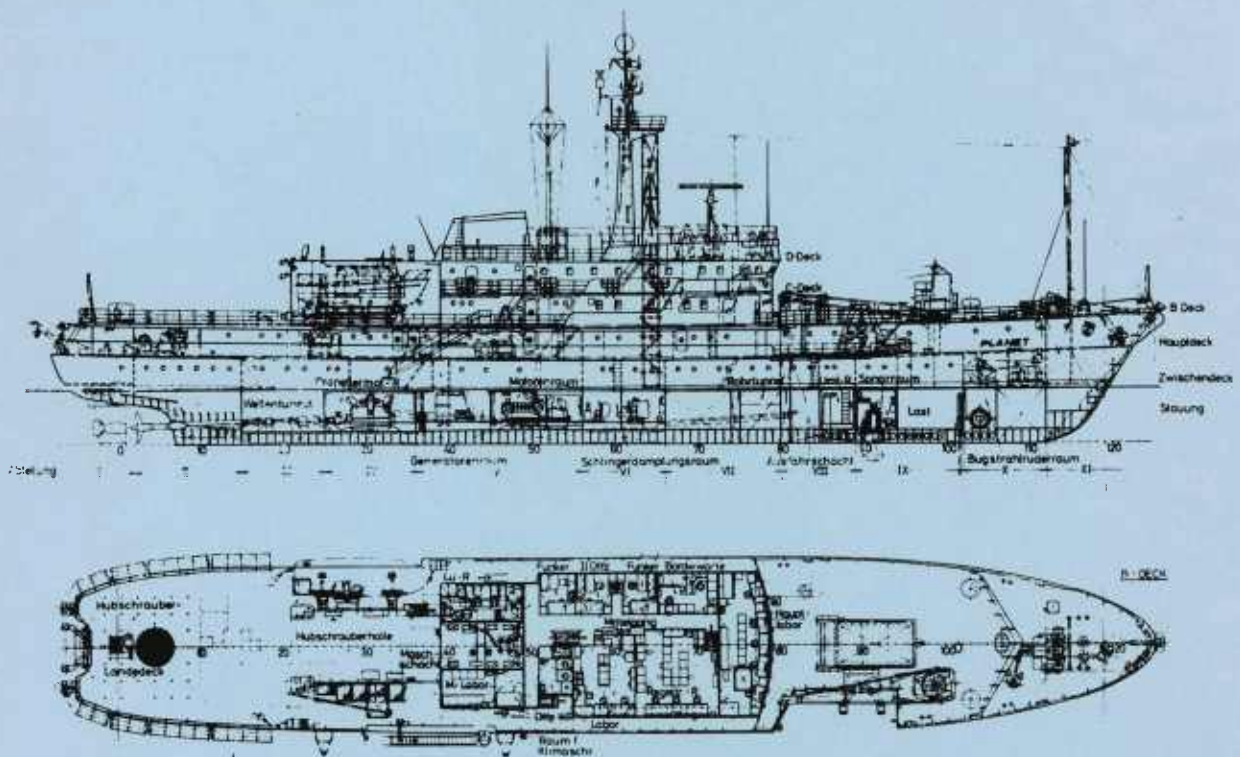
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NSTL, Mississippi 39529-5004



CTD Measurement from the Norwegian Sea during NORDMEER 87 June 1987, WFS Planet



Denis A. Wiesenburger

Ocean Science Directorate
Oceanography Division

George F. Krebs

Sverdrup Technology, Inc.

Pavel Pistek

Ocean Science Directorate
Ocean Sensing and Prediction Division

ABSTRACT

During June 1987, researchers from the Naval Ocean Research and Development Activity (NORDA) participated in a cruise in the Norwegian Sea aboard the WFS PLANET. They collected high precision conductivity-temperature-depth (CTD) measurements at fifty-one (51) stations using a Neil Brown Mark IIIB CTD with an attached in situ fluorometer. The CTD stations were situated along one transect between the Shetland and Faeroe Islands and along three other transects which crossed frontal boundaries in the Norwegian Sea proper. Many of the stations were coincident with orbits of the Navy's GEOSAT satellite. From these data, the dynamic height at each station will be calculated in order to correlate and verify GEOSAT altimetric measurements with oceanographic data along the altimeter ground tracks.

This report describes the preliminary results produced by NORDA from the WFS PLANET cruise, NORDMEER 87. The purpose of the cruise is described and a detailed listing of station locations and data collected are provided. All procedures used for instrument calibration, data collection, verification and processing are given. Vertical profiles of potential temperature, salinity (PSS78), sigma theta and relative chlorophyll fluorescence are presented for each station. A plot of potential temperature versus salinity for each station is also given. Contour plots of temperature and salinity for the four transects are used to describe the different water masses in the region.

ACKNOWLEDGMENTS

The authors wish to thank the Captain and crew of the WFS PLANET for their cooperation in making NORDMEER 87 a successful field experiment. We also thank Herr Jurgen Sellschopp, Chief Scientist during NORDMEER 87, for inviting us to participate in this exercise and to all the scientists aboard PLANET who helped us overcome the language barrier. Special thanks are due to Mr. Arnie Schuetz of NRL who assisted in the CTD launchings, regardless of the weather, to Kim David Saunders who provided the CTD plotting programs and to Ms. Laura Wise who typed the manuscript. An additional thanks is given to Neptune, god of the sea, who was forgiving in his treatment of us as we crossed the Arctic Circle. This work was funded by the Office of Naval Research, Program Elements 61153N and 63207N, through the NORDA Defense Research Sciences Program.

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CTD MEASUREMENTS FROM THE NORWEGIAN SEA DURING NORDMEER 87, JUNE 1987, WFS PLANET

INTRODUCTION

The Naval Ocean Research and Development Activity (NORDA) is a participant in the U.S. Navy Space Oceanography Program whose overall objective is to use satellite derived data (thermal infrared, radar altimeter, etc.) in interpretation of ocean dynamics and thermodynamics. One goal of this program is to learn how to effectively use satellite sea surface measurements to improve our knowledge of air-sea interaction processes and to input these results into numerical models. In situ ocean measurements coincident with satellite data are a required component of the Space Oceanography Program, as such measurements are important in validation of remotely sensed satellite data.

To accomplish its mission, the Space Oceanography Program arranged NORDA participation in a cruise to the Norwegian Sea during June 1987. The purpose of this field experiment was two-fold: The primary purpose of the experiment was to collect high precision conductivity-temperature-depth (CTD) measurements along transects which cross frontal boundaries. The station locations were coincident with orbits of the Navy's GEOSAT satellite. The CTD data from each station will be used to calculate the dynamic height at each station in order to correlate and verify GEOSAT altimetric measurements with oceanographic data along the altimeter ground tracks. In a secondary effort, the CTD was also fitted with an in situ fluorometer which allows the measurement of chlorophyll fluorescence in the ocean. These data will be used by NORDA's Biological and Chemical Oceanography Branch to estimate variability in phytoplankton biomass across the oceanic frontal boundaries that were encountered during the cruise.

Cruise Description

This field exercise was conducted aboard the Wehrforschungsschiff (WFS) PLANET, an 80 meter research vessel (see cover drawing) operated by the Forschungsanstalt der Bundeswehr für Wasserschall- und Geophysik (FWG) out of Kiel, Federal Republic of Germany (FRG). Herr Jurgen Sellschopp of FWG was Chief Scientist during the cruise, which was designated NORDMEER 87. The PLANET departed from Kiel, FRG on 01 June 1987 and returned to Kiel, FRG on 19 June 1987. An intermediate port call was made in Trondheim, Norway from 1000 hrs 08 June 1987 to 1000 hrs 09 June 1987. Between 01 and 19 June 1987, 51 CTD stations were successfully completed in the Norwegian Sea by NORDA personnel. One additional STD (salinity-temperature-depth) station was collected by FWG personnel using the Plessey STD aboard the PLANET.

In addition to the CTD and STD stations occupied during the cruise, FWG scientist towed a thermistor chain with 60 thermistors to a depth of 180 m and a Schleppfisch (Batfish) was towed in an oscillating mode to a depth of 100 m. The Schleppfisch made continuous measurements of temperature, salinity, depth and sound velocity. A second Schleppfisch was towed by personnel from the Marineamt Laboratory in Wilhelmshaven, FRG. Requests for information on these data should be addressed to the Chief Scientist at FWG, Klausdorfer Weg 2-24, 2300 Kiel 14, FRG (tel. 49-431-7204-123). During the cruise, personnel from the U.S. Naval Research Laboratory (NRL) continuously

operated an RD Instruments acoustic doppler current profiler (ADCP) to obtain real-time measurements of currents down to a depth of several hundred meters. They also operated a Trimble global positioning system (GPS) navigation unit, which has an internal LORAN-C receiver, to provide continuous, precise position during the cruise. Those concerned about these data should contact Dr. Clifford Trump, NRL, Code 5140, Washington, D.C. 20375 USA (tel. 202-767-2528). This report will concern itself only with the CTD data collected by NORDA during the cruise. Cruise participants, their affiliation and dates that they were aboard WFS PLANET are given in Table 1.

After departing Kiel, FRG at 1300 hrs on 01 June 1987, WFS PLANET proceeded through the North-East Canal (NORD-OSTSEE-KANAL) which connects the Baltic Sea to the North Sea. PLANET then proceeded through the North Sea toward the Shetland Islands. The first CTD station was occupied at 60°14.3N, 002°25.8W in the vicinity of the Shetland Islands on 03 June 1987. A transect of nine (9) CTD stations was occupied between the Shetland and Faeroe Islands and is designated the Shetland-Faeroe Transect. The location of all CTD stations taken during the cruise is shown in Figure 1. Stations were occupied in sequential order. After this CTD transect, a second CTD transect was made beginning at 65°48.6N, 001°30.6W (Station 10) on 06 June 1987 and continued southeast toward the Norwegian coast. The stations along this transect were taken at crossover points of the GEOSAT satellite track and are designated GEOSAT Transect 1. After Station 18 was completed, PLANET transited to Trondheim, Norway to disembark several scientists and to embark one (see Table 1). Upon leaving Trondheim, a third CTD transect (Stations 19-34, GEOSAT Transect 2) was conducted and completed on 11 June 1987. After this transect, the FWG thermistor chain and the Batfish were towed for several days along the solid lines shown in Figure 1 (points D-L).

After this period, CTD stations were resumed on 15 June 1987 with Station 35 at 65°56.5N, 005°17.8W and sampling was continued until Station 51 was completed on 17 June 1987. Stations 39-51 were again coincident with GEOSAT tracks at crossover points and this transect was designated GEOSAT Transect 3. At approximately the same location as Station 51, Station 52 was occupied using the FWG Plessey STD for comparison. At the completion of Station 52, WFS PLANET proceeded south along the coast of Norway, through the Baltic Sea and arrived Kiel, FRG at 2000 hrs 19 June 1987.

METHODS

Field Data Collection

Vertical temperature and conductivity measurements were made using a Neil Brown Instruments Systems, Inc. MARK IIIB CTD System (Serial No. 2301-01). This CTD system has been modified by the addition of an extra data channel that digitizes a 0-5 Volt DC analog signal from an external sensor and transmits it as part of the normal CTD data cycle. During NORDMEER 87, a SeaMarTech, Inc. Model 6000 in situ fluorometer was interfaced to the CTD via this extra channel. Prior to the cruise, the CTD system was calibrated and operationally checked by the Sensor Calibration Laboratory of the U.S. Naval Oceanographic Office (NAVOCEANO). A post-cruise check of the instrument was also conducted by NAVOCEANO to insure that the unit had remained in calibration during the cruise. Thus, at the beginning and end of the cruise the CTD was certified to be operating within the manufacturers specified accuracies. In the pre-cruise check the CTD had a temperature

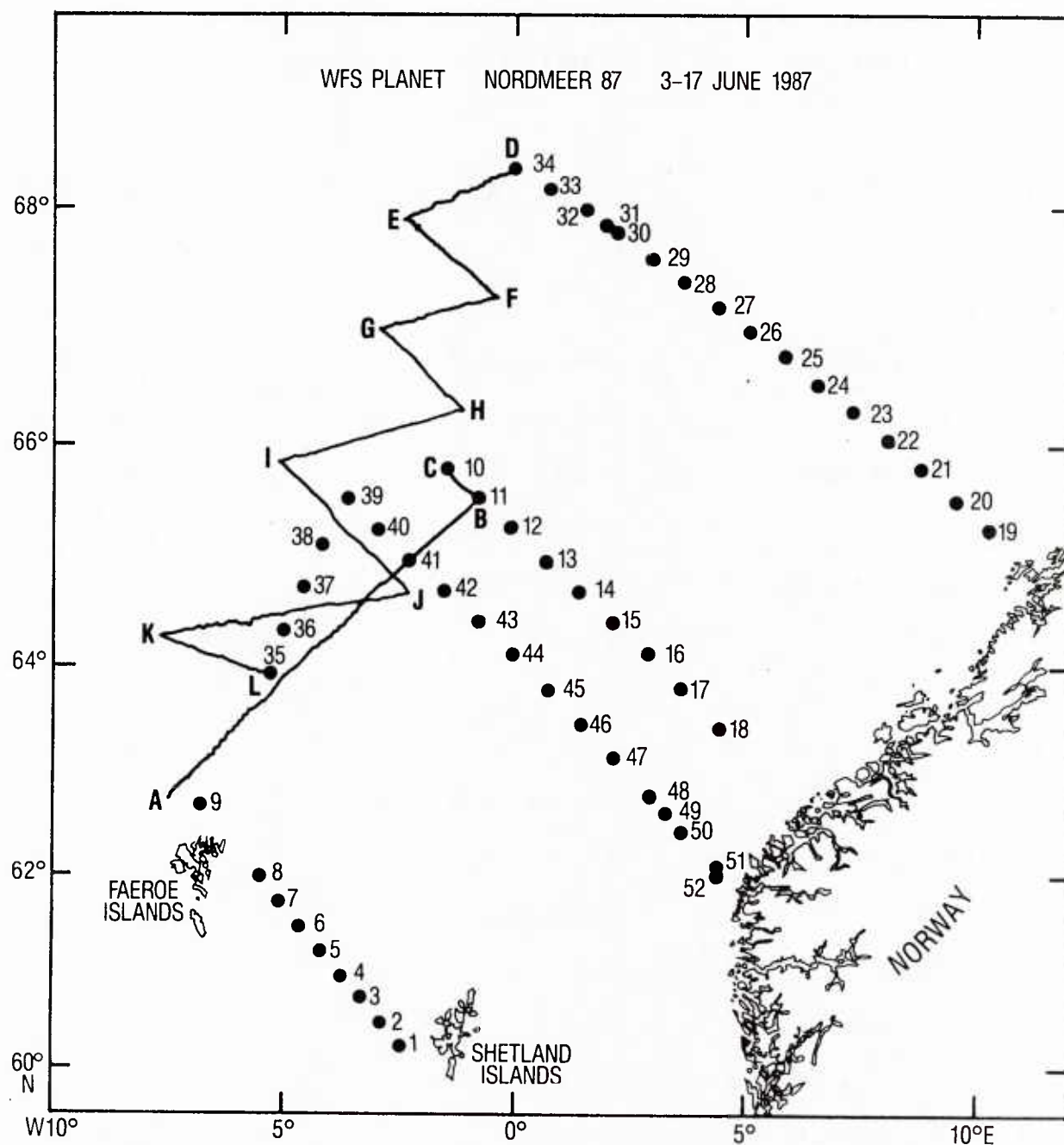


Figure 1. Station location map WFS PLANET cruise NORDMEER 87. Solid lines indicate track over which the thermistor chain and batfish were towed.

Table 1. Scientific Party, WFS PLANET, NORDMEER 87 Cruise, 01-19 June 1987.

Name	Affiliation	Dates Aboard
Dieter Beling	FWG ¹	1-19 June 87
Jorg Beyer	Fachhochschule Kiel	1-8 June 87
Claus Bode	FWG	1-19 June 87
Hans Ebel	FWG	1-8 June 87
Jurgen Heidotting	MarA/Geophys ²	1-19 June 87
George F. Krebs	Sverdrup Technology, Inc.	1-19 June 87
Dr. B. Edward McDonald	NORDA ³	1-8 June 87
Niecke	Fachhochschule Kiel	1-8 June 87
Dr. Steve A. Piacsek	SACLANTCENTRE ⁴	1-8 June 87
Dr. Pavel Pistek	NORDA	8-19 June 87
Rabe	FWG	1-19 June 87
Arnim F. Schuetz	NRL ⁵	1-19 June 87
Jurgen Sellschopp	FWG (Chief Scientist)	1-19 June 87
Dr. Klaus-Jochen Stepputat	FWG	1-19 June 87
Jorg Theis	MarA/Geophys	1-19 June 87
Jan Tiefensee	FWG	1-19 June 87
Dr. Clifford Trump	NRL	1-8 June 87
Dr. Denis A. Wiesenburg	NORDA	1-19 June 87
Dr. Karl O. Westphal	FWG	1-19 June 87

¹Forschungsanstalt der Bundeswehr fur Wassershall- und Geophysik, Kiel, FRG

²Marineamt, Stabsabteilung Geophysik, Wilhelmshaven, FRG

³Naval Ocean Research and Development Activity, NSTL, Mississippi, USA

⁴SACLANT ASW Research Centre, La Spezia, Italy

⁵Naval Research Laboratory, Washington D.C., USA

error of -0.002°C at 7.78°C and an error of -0.003°C at 0.749°C . The conductivity error (at salinity = 34.736) at 7.79°C was -0.003 and was -0.005 at 0.75°C . These conductivity errors were used to correct the CTD data collected to allow salinity (Practical Salinity Scale - 1978, PSS78) to be calculated with a precision of better than 0.001. The conductivity offsets were linear ($r^2 = 0.9750$) with temperature, thus a correction equation was derived for conductivity using the calibrations at 0.7468°C , 7.7888°C and 15.3089°C . The conductivity was corrected before salinity was calculated. A sample of the pre-cruise calibration data for the CTD used during NORDMEER 87 is presented in Table 2. No temperature correction was made since the temperature offset of the CTD was less than 0.01°C .

At each CTD station, the CTD-fluorometer package was deployed from the starboard hydrographic winch aboard PLANET on an electromechanical cable electronically interfaced to the CTD readout/data logging system. On deck readings of temperature and pressure were recorded and the CTD was placed just below the surface so surface measurements of pressure, temperature, conductivity and fluorescence could be recorded. The CTD was then lowered at a rate of 25 meters per minute for the first 100 m and then at a rate of 50 meters per minute to the maximum depth obtained. As the CTD package was lowered through the water column, the serial data transmissions from the CTD were recorded on analog tape and also digitized in 0.5 - 1.0 decibar (dbar) averages and the averages are stored on a cassette tape. This averaging is accomplished using a Hewlett-Packard 9825B Calculator System which receives data from the Neil Brown Mark IIIB deck unit through an IEEE-488-1978 interface (HBIB). At a lowering speed of 50 m per minute, the 0.5 dbar increments usually represent the average of about three data cycles. These pressure, conductivity, temperature and fluorescence averages were used to produce the preliminary data plots presented in this report.

As the averaging technique described above is not sufficient to produce the quality of CTD data required for dynamic height calculations, a second method of data storage was utilized to provide a high quality digital data set from each CTD station. The serial data sent to the ship from the CTD probe were recorded on analog tape during the cast and the full data stream was simultaneously sent to a Neil Brown Instruments, Inc. Model 1150 Data Terminal. The full data stream was digitized and displayed by this unit and transmitted to a Digi-Data, Inc. 9-track tape recorder for simultaneous digital data recording. These 9-track tapes will be processed to provide high quality temperature and salinity profiles and these data will be used to calculate dynamic height.

The averaged data collected on the ship are of equal quality to the 9-track digital data, only the number of points averaged are fewer. These averaged data were used to produce a matrix of data including pressure, temperature, conductivity and relative fluorescence. The data were collected in 0.5 dbar averages to a depth of 500 dbars and then in 1.0 dbar averages to the maximum cast depth, usually 900 dbars.

Parameter Calculations

From the pressure, temperature and conductivity averages, depth, salinity, potential temperature, and potential density were calculated based on the algorithms given in UNESCO Report 44 (UNESCO 1983). This report provides FORTRAN functions and subroutines which can be used to calculate

Table 2. Neil Brown CTD Calibration Data, S/N: 2301-01, Pre-Cruise 14 April 1987.

SAMPLE NO.	NO. DATA POINTS	PAVG (DECIBARS)	PDEV	TAVG (DEGREES C)	TDEV	CAVG (MMHOS/CM)	CDEV	ATB TEMP
1	32	.5	.071	7.7888	.00025	35.7680	.00002	7.7910
2	32	.5	.061	7.7889	.00020	35.7680	.00002	7.7909
3	32	.5	.071	7.7889	.00017	35.7680	.00002	7.7909
4	32	.5	.078	7.7890	.00012	35.7680	.00002	7.7909
5	32	.5	.075	7.7891	.00022	35.7680	.00002	7.7909
6	32	.5	.055	7.7890	.00009	35.7680	.00002	7.7908
7	32	.5	.063	7.7889	.00043	35.7680	.00002	7.7908
8	32	.5	.066	7.7886	.00021	35.7680	.00002	7.7907
9	32	.5	.061	7.7886	.00022	35.7680	.00002	7.7907
10	32	.5	.071	7.7886	.00026	35.7680	.00002	7.7906
11	32	.5	.078	7.7888	.00025	35.7680	.00002	7.7905
12	32	.5	.071	7.7889	.00029	35.7680	.00002	7.7905
13	32	.5	.055	7.7889	.00022	35.7680	.00002	7.7906
14	32	.5	.068	7.7886	.00022	35.7680	.00002	7.7907
15	32	.5	.084	7.7886	.00021	35.7679	.00025	7.7907

TOTAL VALUES FOR 15 SECONDS OF DATA:

TOTAL NO. OF SYNC WORDS FOUND = 480
TOTAL NO. OF DATA POINTS = 480
SAMPLES LOST = 0

P AVG = .5 T AVG = 7.7888 C AVG = 35.7680 ATB AVE = 7.7907

*****USING PSS78*****

TEMPERATURES (°C): (T1) STANDARD T = 7.7907 (T2) CTD AVE T = 7.7888

STANDARD CONDUCTIVITY RATIO = .99335

CONDUCTIVITIES (MMHO/CM): (C1) STANDARD ABS C = 35.7728 (C2) STANDARD BIASED C = 35.7711
(C3) CTD AVE COND = 35.7680 (C4) STD TEMP CORR C = 35.7697

SALINITIES (PPT): (S1) STANDARD S = 34.7380 (S2) STD TEMP CORR CTD S = 34.7346 (S3) CTD S = 34.7365

ERRORS: TEMP ERROR (T2-T1) = -.0019
ABS C ERROR (C4-C1) = -.0032
BIASED ERROR (C3-C2) = -.0032
STD SALINITY ERROR (S2-S1) = -.0034 CTD SALINITY ERROR (S3-S1) = -.0015

NOTE: THE DECK UNIT DISPLAYED CONDUCTIVITY MUST BE ADJUSTED USING THE BIASED C ERROR!!!!!!

NOTES: NBIS CELL CORRECTIONS USING T1
C2 CALCULATED FROM C1 BIASED USING NBIS CELL CORRECTION
C4 CALCULATED FROM C3 USING NBIS CELL CORRECTION
S2 CALCULATED USING C4 AND T1
AUTOSAL ASSUMED TO BE OPERATING AT 27°C

these parameters accurately. Appendix A gives the FORTRAN routines used in these calculations. Depth is calculated from pressure based on the algorithm of Saunders and Fofonoff (1976) with the formula refitted for the 1980 Equation of State. This algorithm (Appendix A) requires measurements of only pressure and latitude. Before calculating salinity, the conductivity data from the CTD was corrected based on the pre-cruise calibration data. Temperature differences for the CTD were less than 0.01°C and thus no temperature correction was required. The CTD conductivity offset at 15.3°C (-0.0018 mmhos), 7.8°C (-0.0032) and 0.7°C (-0.0055) was fitted to a linear ($r = 0.9875$) equation of the form.

$$\text{delta C} = 0.00025332 * t(^{\circ}\text{C}) - 0.00551340. \quad (1)$$

The CTD temperature (t) values were then used to calculate a CTD conductivity correction (delta C) and this correction was made to conductivity before salinity was calculated. Salinity is calculated from conductivity, temperature and pressure and is reported on the practical salinity scale 1978 (PSS-78). References for the method are found in UNESCO Report No. 37 (1981). Potential temperature (θ) is calculated using Bryden's (1973) polynomial for adiabatic lapse rate and Runge-Kutta 4th order integration algorithm (Bryden 1973; Fofonoff 1977). Density (or potential density; σ_{θ}) was calculated as a function of practical salinity (S), and potential temperature (t , $^{\circ}\text{C}$) to yield density in kilograms per cubic meter. The international high pressure equation of state (Millero et. al. 1980, Millero and Poisson 1981) is used along with the density of pure water at atmospheric pressure (Bigg 1967) in the calculation. The algorithms are given in Appendix A and the rationale for the method is described in UNESCO Report No. 38 (1981). $\sigma_{\theta} = (\text{potential density} - 1) \times 1000$.

Navigation Positions

Position locations were determined using either the Decca positioning system aboard WFS PLANET or the NRL GPS-LORAN system which was installed aboard PLANET for this cruise. If enough GPS satellites were in position to allow an accurate navigation fix to be calculated, the GPS fix was accepted for the CTD stations and recorded for the cast. GPS fixes have a nominal accuracy of ± 10 meters and GPS was the method of choice for determining position. If GPS was not available, then either LORAN-C or Decca was used to obtain the correct position. The Decca system gave very precise positions near the coast. Further from the coast, however, the quality of the Decca positions deteriorated and LORAN-C was used to fix positions far from the coast, when GPS was not available. All positions reported are believed to be accurate to ± 0.5 kilometer.

RESULTS

Station Locations

Table 3 provides complete summary data on each CTD station and cast. Date, time, location, fluorometer scale and number of water samples taken (ST) are provided for each cast. Both date and time are given in Greenwich Mean Time (GMT). Local time was +2 hours relative to GMT. Also listed on the table is the bottom depth (MAX) measured acoustically at each station and the maximum depth (DEPTH) of the CTD cast. The bottom depth is in meters and

Table 3. Station and location description WFS PLANET NORDMEER 87

STATION	CAST	MAX	DEPTH	ST	DATE	TIME	LATITUDE	LONGITUDE	SENSOR
1	1	98	104	0	03 June 87	1942	60 14.26N	002 25.83W	Fluor5
2	1	153	166	0	03 June 87	2144	60 29.01N	002 51.50W	Fluor5
3	1	500	553	0	03 June 87	2351	60 44.64N	003 18.67W	Fluor4
4	1	916	1124	0	04 June 87	0159	60 59.53N	003 45.10W	Fluor3
5	1	609	1100	0	04 June 87	0426	61 14.54N	004 11.49W	Fluor3
6	1	540	612	0	04 June 87	0658	61 29.44N	004 37.71W	Fluor3
7	1	203	230	0	04 June 87	0908	61 44.13N	005 04.05W	Fluor3
8	1	200	220	0	04 June 87	1113	61 59.04N	005 30.15W	Fluor3
9	1	166	180	0	04 June 87	1612	62 39.47N	006 50.05W	Fluor3
10	1	924	3350	0	06 June 87	1443	65 48.61N	001 30.59W	Fluor3
11	1	929	3100	0	06 June 87	1733	65 33.19N	000 49.10W	Fluor3
12	1	926	3010	0	06 June 87	2130	65 15.35N	000 05.04W	Fluor3
13	1	914	2770	0	07 June 87	0035	64 58.88N	000 39.87E	Fluor3
14	1	915	3000	0	07 June 87	0336	64 41.69N	001 23.28E	Fluor3
15	1	912	2500	0	07 June 87	0638	64 24.92N	002 07.35E	Fluor3
16	1	910	1760	0	07 June 87	0949	64 07.32N	002 52.03E	Fluor3
16	2	100	1760	0	07 June 87	1044	64 07.23N	002 51.57E	Fluor3
17	1	910	1510	0	07 June 87	1327	63 47.73N	003 36.16E	Fluor3
18	1	909	1280	0	07 June 87	1647	63 25.73N	004 25.45E	Fluor3
19	1	137	150	0	09 June 87	2153	65 15.79N	010 14.82E	Fluor3
20	1	356	390	0	10 June 87	0037	65 31.95N	009 31.29E	Fluor3
21	1	377	415	0	10 June 87	0335	65 48.20N	008 46.04E	Fluor3
22	1	358	380	0	10 June 87	0707	66 03.13N	008 03.29E	Fluor3
23	1	336	365	0	10 June 87	0959	66 17.71N	007 18.60E	Fluor3
24	1	635	678	0	10 June 87	1241	66 31.34N	006 31.31E	Fluor3

Table 3(Cont.) Station and location description WFS PLANET NORDMEER 87

STATION	CAST	MAX	DEPTH	ST	DATE	TIME	LATITUDE	LONGITUDE	SENSOR
25	1	902	1150	0	10 June 87	1524	66 44.96N	005 50.32E	Fluor3
26	1	909	1325	0	10 June 87	1821	66 58.08N	005 04.36E	Fluor3
27	1	906	1600	0	10 June 87	2106	67 10.68N	004 23.95E	Fluor3
28	1	909	1350	0	10 June 87	2351	67 23.50N	003 36.88E	Fluor3
29	1	882	1410	0	11 June 87	0237	67 35.04N	002 57.28E	Fluor3
30	1	921	1830	0	11 June 87	0526	67 47.44N	002 13.42E	Fluor3
31	1	910	2100	0	11 June 87	0638	67 51.12N	001 58.11E	Fluor3
32	1	912	2650	0	11 June 87	0835	67 58.01N	001 22.65E	Fluor3
33	1	916	2920	0	11 June 87	1116	68 10.56N	000 50.02E	Fluor3
34	1	910	2680	0	11 June 87	1344	68 20.03N	000 04.55W	Fluor3
34	2	110	2680	0	11 June 87	1420	68 19.96N	000 04.54W	Fluor3
35	1	900	3340	0	15 June 87	1746	63 56.50N	005 17.77W	Fluor3
36	1	920	3475	0	15 June 87	2106	64 20.30N	004 59.44W	Fluor3
36	2	100	3475	0	15 June 87	2141	64 20.34N	004 59.24W	Fluor2
37	1	913	3450	0	16 June 87	0014	64 43.65N	004 34.00W	Fluor2
38	1	908	3460	0	16 June 87	0313	65 07.28N	004 08.25W	Fluor3
39	1	910	3350	0	16 June 87	0612	65 31.30N	003 36.81W	Fluor3
39	2	100	3350	0	16 June 87	0645	65 31.09N	003 36.99W	Fluor2
40	1	913	3300	0	16 June 87	0856	65 14.90N	002 56.71W	Fluor2
41	1	911	3140	0	16 June 87	1151	64 59.18N	002 17.13W	Fluor2
42	1	912	2950	0	16 June 87	1438	64 42.80N	001 32.23W	Fluor2
43	1	913	2700	0	16 June 87	1730	64 24.77N	000 48.80W	Fluor2
44	1	904	2500	0	16 June 87	2030	64 06.80N	000 04.07W	Fluor2
45	1	913	2250	0	16 June 87	2337	63 47.11N	000 40.87E	Fluor2
46	1	903	1650	0	17 June 87	0239	63 27.67N	001 24.59E	Fluor2
47	1	881	1125	0	17 June 87	0550	63 07.65N	002 08.18E	Fluor2

Table 3(Cont.) Station and location description WFS PLANET NORDMEER 87

STATION	CAST	MAX DEPTH	ST	DATE	TIME	LATITUDE	LONGITUDE	SENSOR
48	1	592	620	0	17 June 87	0917	62 46.55N 002 54.92E	Fluor3
48	2	100	625	0	17 June 87	0952	62 46.68N 002 51.88E	Fluor3
49	1	328	360	0	17 June 87	1136	62 35.89N 003 14.85E	Fluor3
50	1	170	200	0	17 June 87	1334	62 25.37N 003 36.75E	Fluor3
51	1	177	210	0	17 June 87	1650	62 04.21N 004 21.32E	Fluor3

the CTD depths is given in decibars. Due to cable and time limitations, the maximum sampling depth was limited to about 920 dbars or to within 50 meters of the bottom on shallower stations.

CTD Data Plots

A plot of potential temperature, salinity (PSS78), sigma theta, and relative fluorescence for each station is given in Appendix B. A plot of potential temperature versus salinity is also provided for each station. All plots are not all on the same scale as there were large variations in surface salinity between stations. Near the coast, salinities of less than 33 were recorded, with 35 at depth at the same station. In other stations, salinity variations of less than 0.1 were recorded. To plot all stations on the same salinity scale (32-36) would reduce one's ability to examine any small-scale features on many of the stations. Likewise, all stations were not plotted on the same depth scale. Two scales were used. Stations shallower than 400 m were plotted on a 0-400 m depth scale. All other stations were plotted on a 0-900 m depth scale.

Fluorescence Profiles

The fluorescence data on these plots is presented on a relative scale. The CTD fluorescence output recorded by the CTD varies from 0 to 4096 data bits. The data were divided by 100 and plotted on a 0-45 relative scale in all plots. Without actual extracted chlorophyll determinations collected simultaneously, it is difficult to determine chlorophyll biomass from in situ chlorophyll fluorescence measurements. The fluorescence profiles presented here should thus be used only to examine relative changes between stations, and as a method of determining how the phytoplankton have distributed themselves in the water column in accordance with the temperature or salinity profiles and changes in mixed layer depth.

Temperature and Salinity Transects

To examine the transect data in a more meaningful way, contour maps of temperature and salinity with depth have been produced for the Shetland Faeroe Transect (Figures 2 and 3) which encompasses Stations 1 to 8, and GEOSAT Transect 1 (Station 10-18, Figures 4 and 5), GEOSAT Transect 2 (Stations 19-34, Figures 6 and 7) and GEOSAT Transect 3 (Stations 39-51, Figures 8 and 9). The contour plots are located after the REFERENCES section (p. 14-21). These contour plots were produced aboard the PLANET from the same averaged data used to produce the plots in Appendix B. Total distance was determined along a given CTD transect and stations were located accordingly on the plots. The station locations are given along the bottom of each plot and the transect distance is given in kilometers on the upper scale. The average data was plotted at 10 decibar intervals and contoured by hand to produce the temperature and salinity contour plots. We feel that the fully processed CTD contour plots will have no noticeable difference from those presented here.

DISCUSSION

The CTD stations and part of thermistor chain and batfish data taken from WFS PLANET were positioned along nadir tracks of GEOSAT altimeter. Except for the Shetland-Faeroe transect, all stations were taken below a

GEOSAT satellite pass, +/- 1 day. The Shetland-Faeroe Transect was taken 9 days after the satellite pass. The main purpose of these measurements was to correlate satellite data (IR and altimeter) with in situ oceanographic measurements in the mesoscale range.

CTD transects were made while crossing the major current inflow into the Norwegian Sea, the Norwegian Atlantic Current. This current is the continuation of the North Atlantic Current. It passes through the Faeroe-Shetland channel and transports into the Norwegian basin relatively warm (about 9°C) and saline (>35) Atlantic Water (AW). It is present in all transects with salinity greater than 35.00 and variable temperature. The strongest flux is near the Norwegian slope with maximum salinity of 35.3 near the Shetland Island and diminishing to 35.15 in GEOSAT Transect 2. Underlying the Atlantic water mass are two stratified layers. The upper layer is primarily Arctic Intermediate water (AIW), defined in accordance with Stefansson (1962) as a water mass with a temperature between 0° and 2°C and salinity between 34.80 and 35.00. Below the AIW is the Norwegian Sea Deep Water (NSDW) with salinity about 34.92 and temperature below 0°C. While AW flows northward, AIW and NSDW flow southward through Faeroe-Shetland channel and are the source for the North Eastern Atlantic Bottom Water. Clearly noticeable is also Norwegian Coastal Water (NCW) carried by the Norwegian Coastal Current. This water has a salinity of less than 35.00 and in summer less than 32.00. It originates in Baltic Sea with contributions from fjords. The NCW is described as a wedge of coastal water extending out from the shore and onto the Atlantic water of the Norwegian Atlantic Current (Johannessen 1986) and is seen in GEOSAT Transects 1, 2, and 3. It is interesting to notice that in GEOSAT Transect 3 this water extends as a 30 m slab about 200 km offshore.

The different systems of warm and cold currents in Nordic Seas causes the formation of ocean fronts. The frontal boundaries are convergence zones of cold, less saline water with warm saline water such that the strong changes in the temperature and salinity compensate each other with regard to density, thereby reducing the density gradients. A very strong front is visible in transects where Norwegian Atlantic and Norwegian Coastal Currents meet. They create the Norwegian Coastal front with large, seasonal salinity gradients. A much weaker front was observed on the west side of Norwegian Atlantic current where Atlantic water encounters the East Icelandic Current, approximately between the Faeroe and Jan Mayen Islands.

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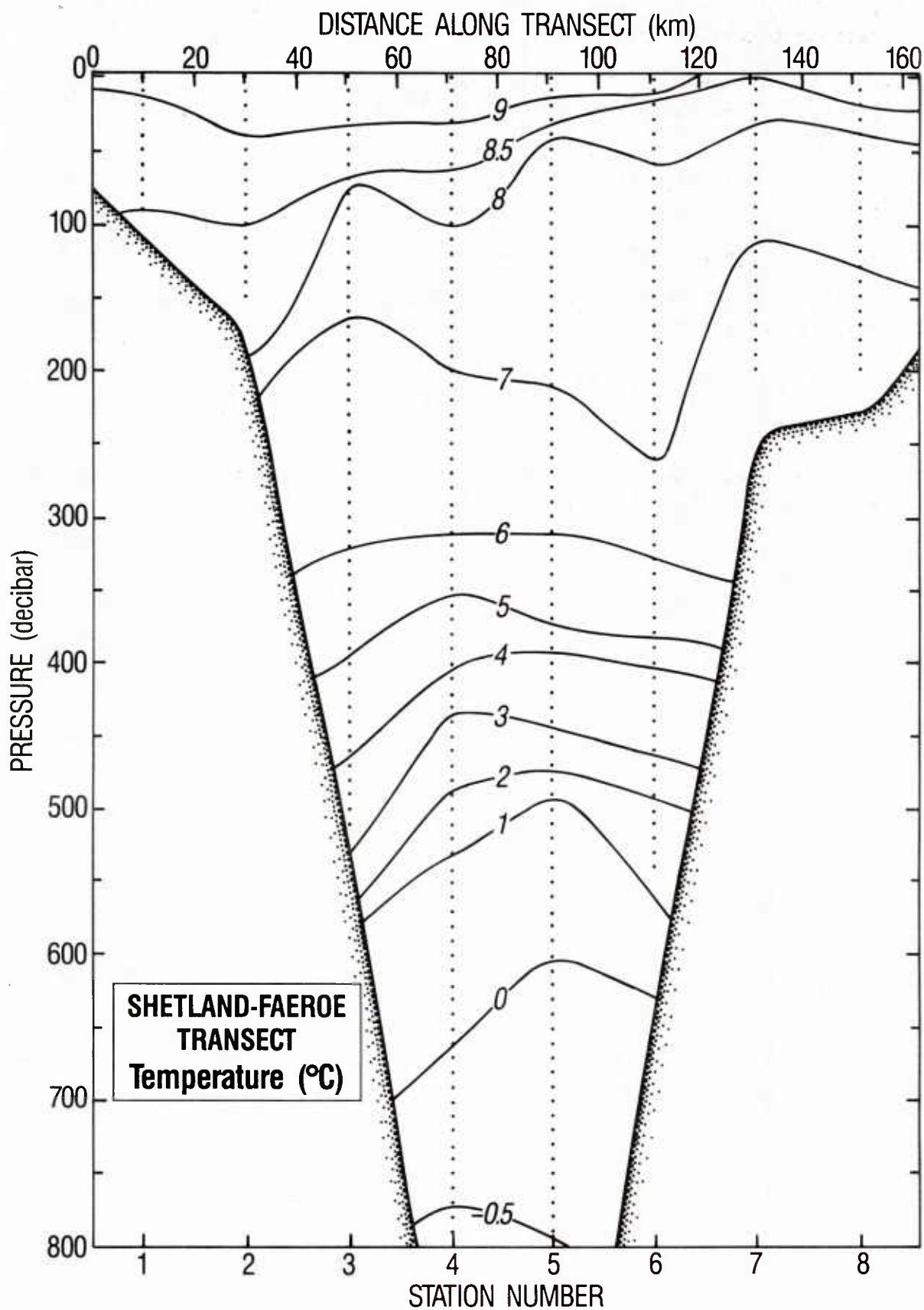


Figure 2. Temperature contours along the Shetland-Faeroe Transect, Stations 1-8.

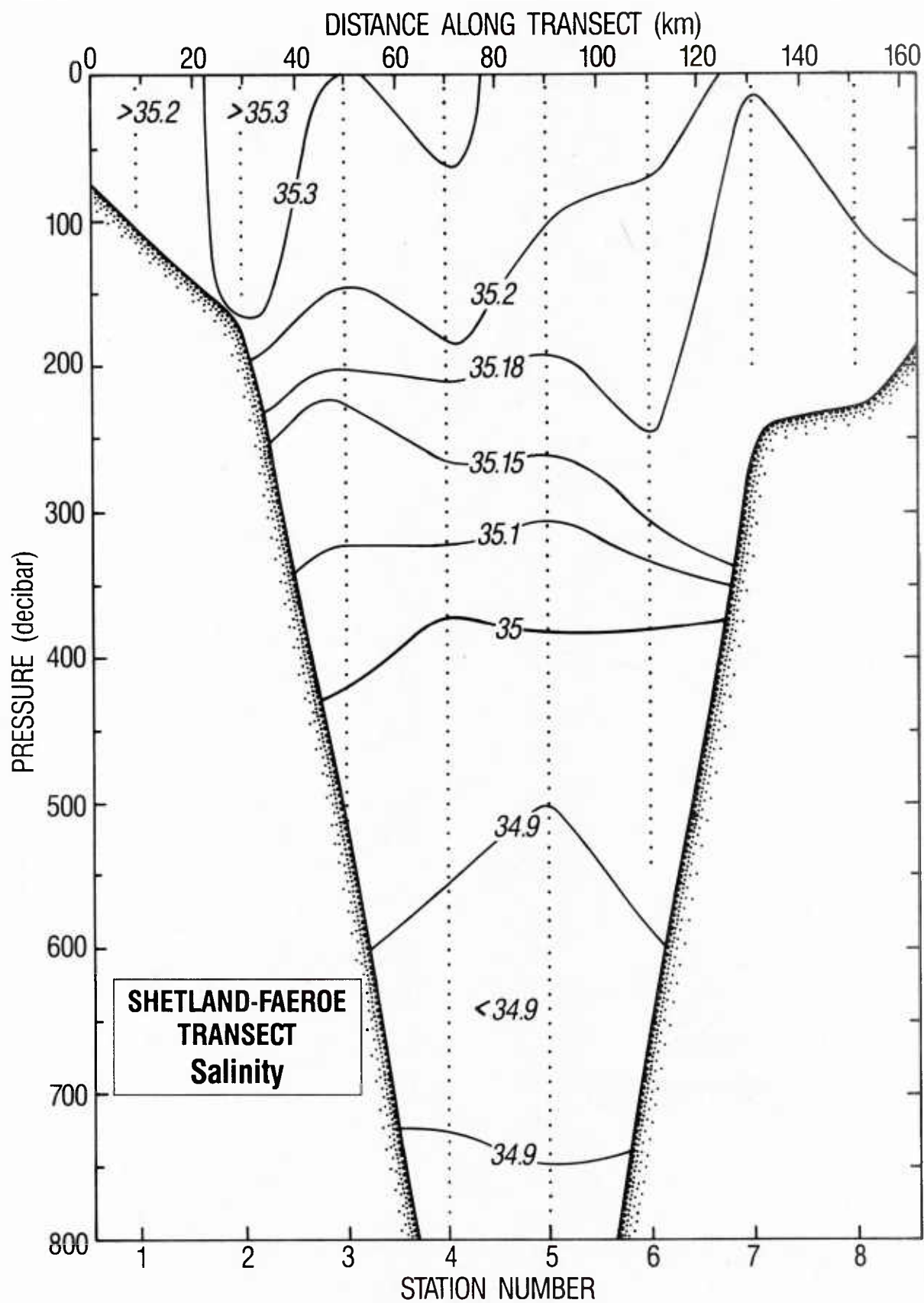


Figure 3. Salinity contours along the Shetland-Faeroe Transect, Stations 1-8.

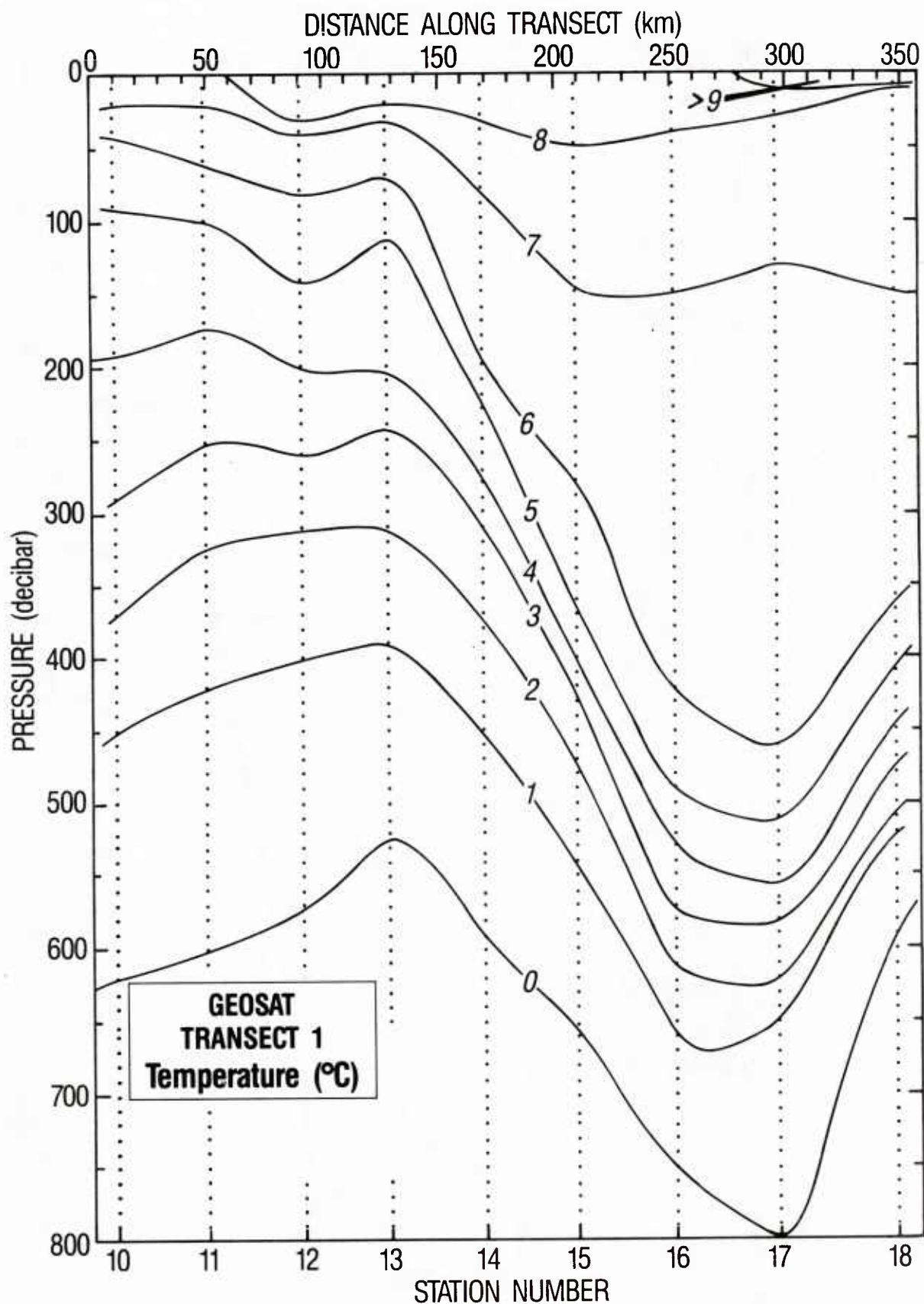


Figure 4. Temperature contours along GEOSAT Transect 1, Stations 10-18.

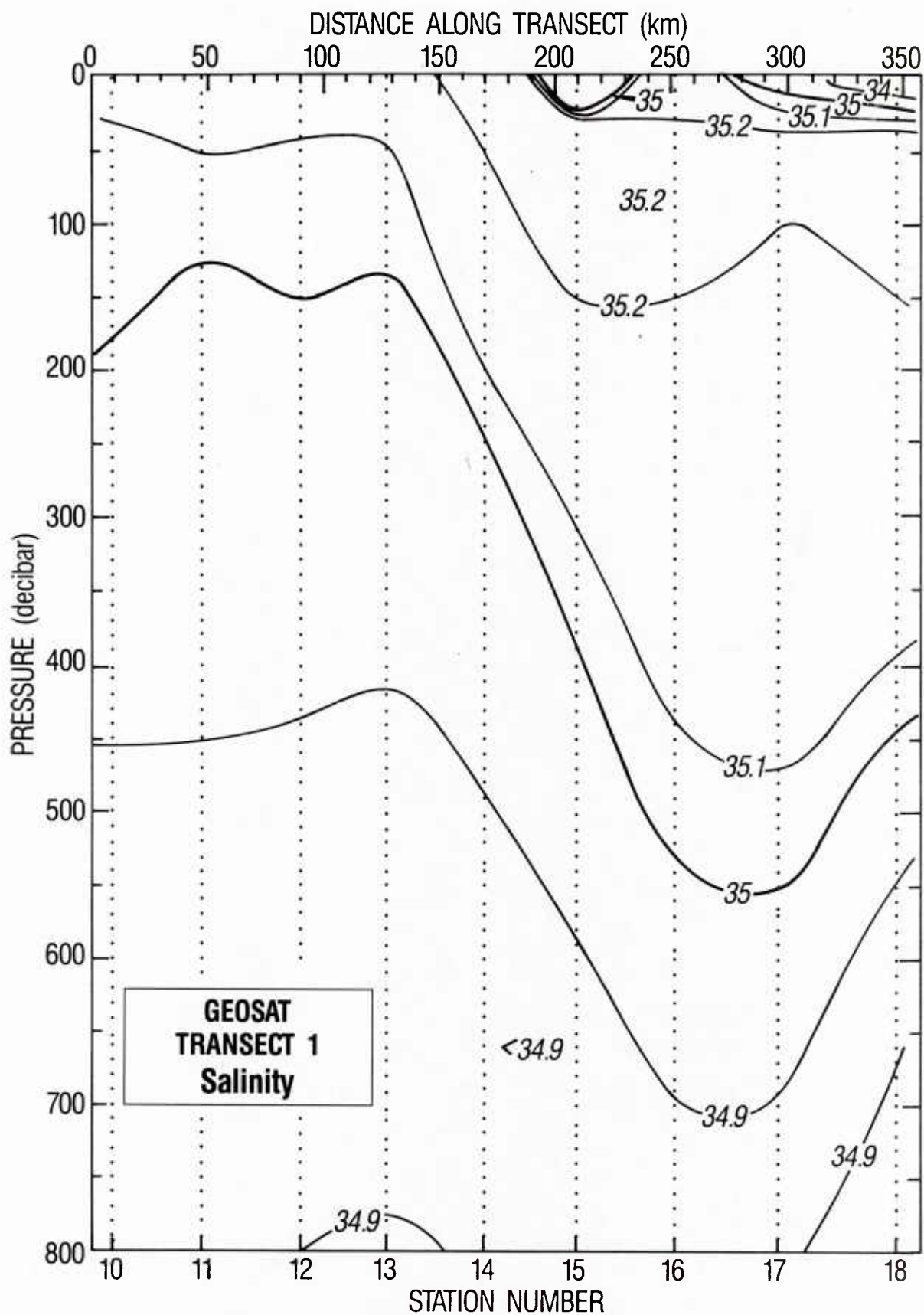


Figure 5. Salinity contours along GEOSAT Transect 1, Stations 10-18.

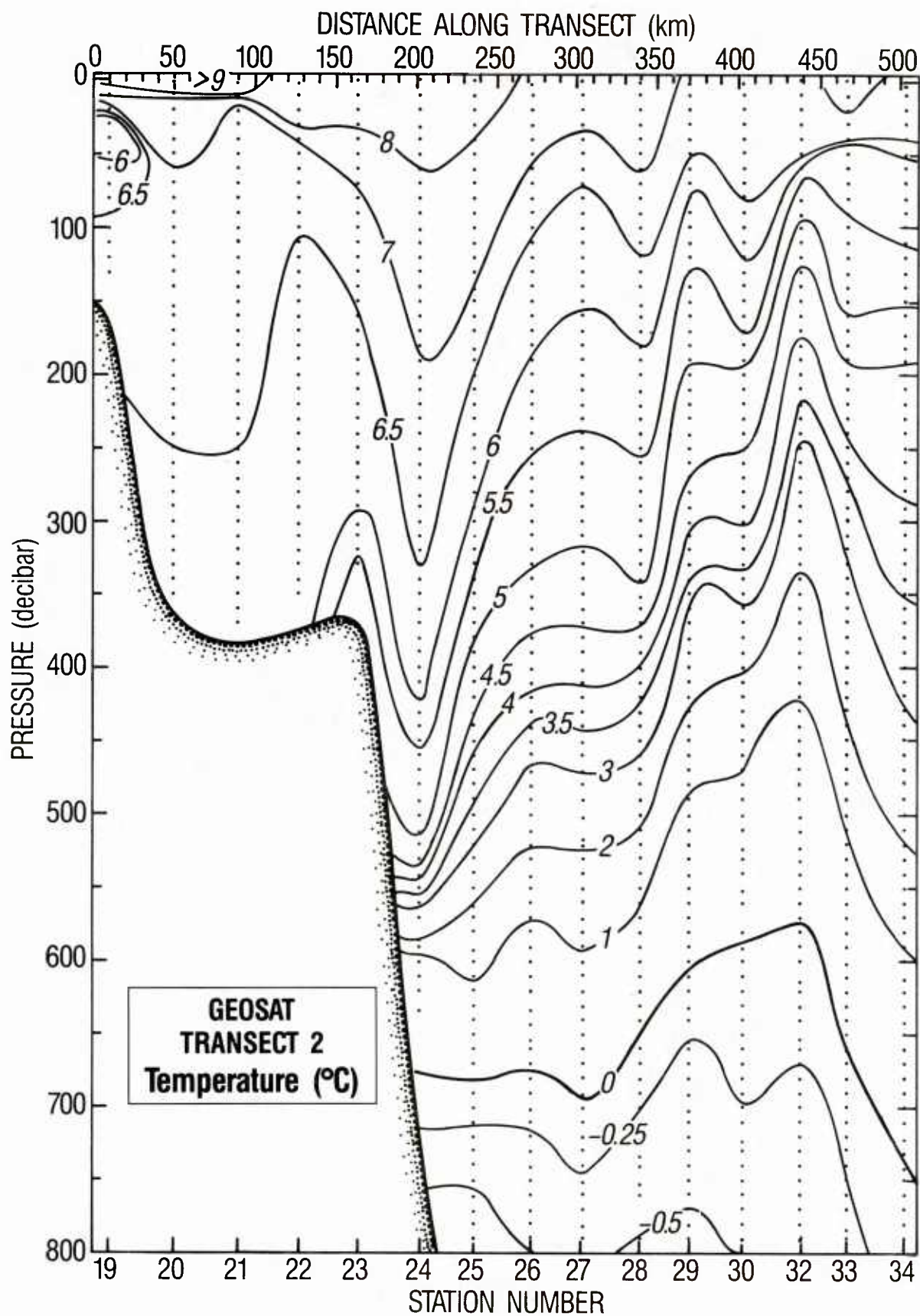


Figure 6. Temperature contours along GEOSAT Transect 2, Stations 19-34.

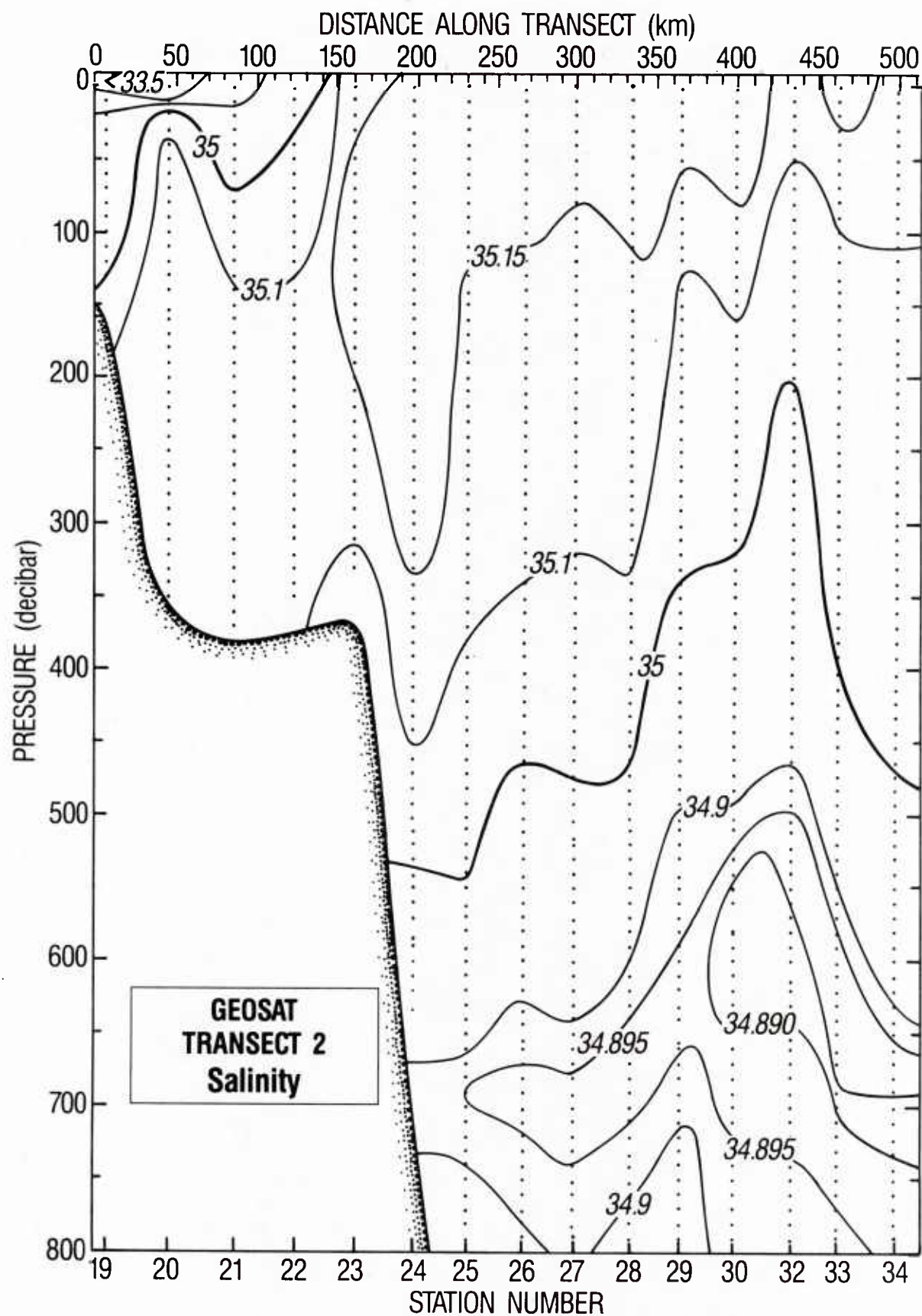


Figure 7. Salinity contours along GEOSAT Transect 2, Stations 19-34.

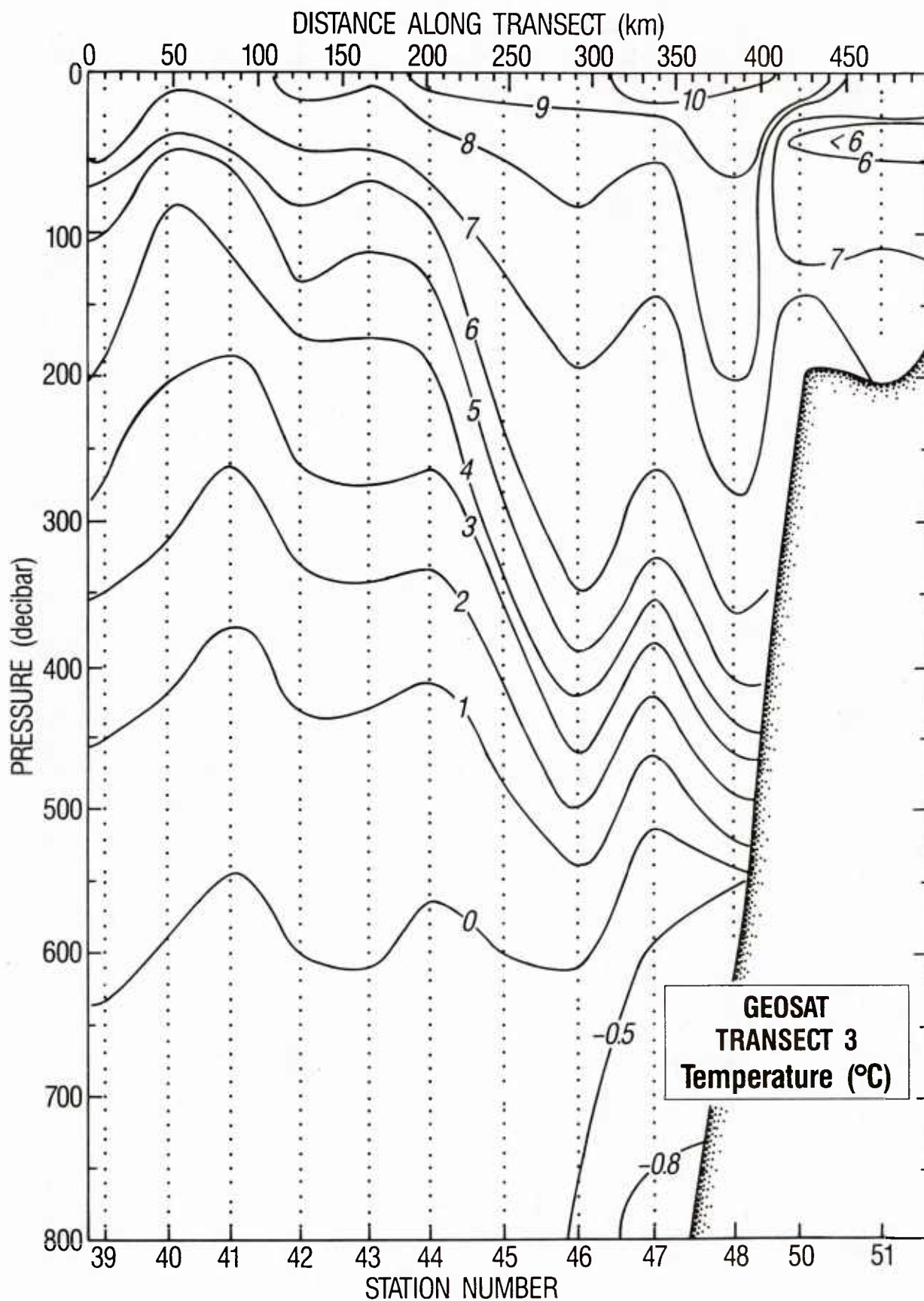


Figure 8. Temperature contours along GEOSAT Transect 3, Stations 39-51.

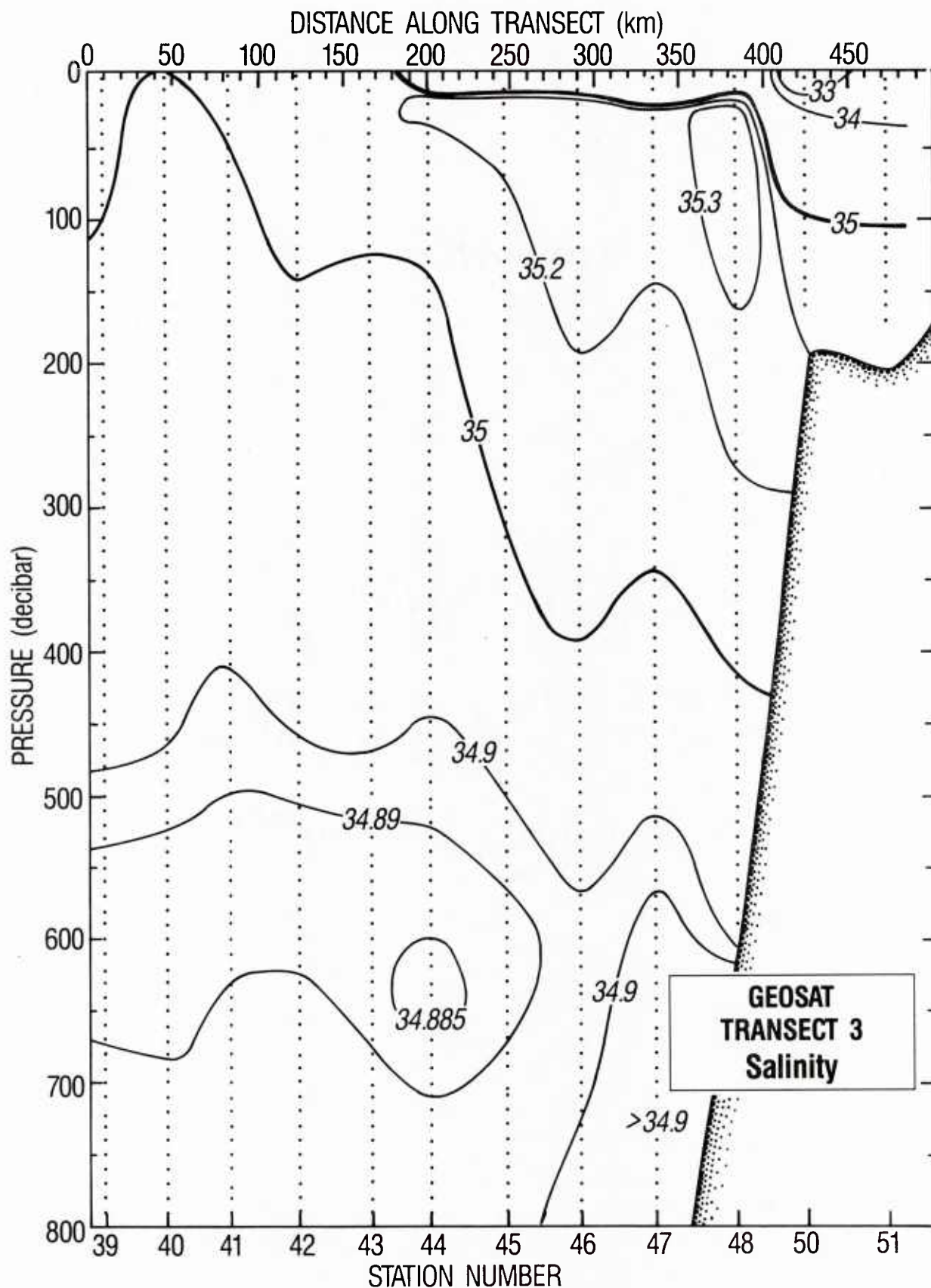


Figure 9. Salinity contours along GEOSAT Transect 3, Stations 39-51.

APPENDIX A

CTD DATA
CALCULATION
PROGRAMS

```

C SAL78 FCN ***** MAR 28 1983 *****
  REAL FUNCTION SAL78(CND,T,P,M)
C *****
C   THE CONDUCTIVITY RATIO (CND) = 1.0000000 FOR SALINITY = 35 PSS-78
C   TEMPERATURE = 15.0 DEG. CELSIUS , AND ATMOSPHERIC PRESSURE.
C *****
C
C FUNCTION TO CONVERT CONDUCTIVITY RATIO TO SALINITY (M = 0)
C SALINITY TO CONDUCTIVITY RATIO (M = 1,CND BECOMES INPUT SALINITY)
C *****
C REFERENCES:  ALSO LOCATED IN UNESCO REPORT # 37 1981
C PRACTICAL SALINITY SCALE 1978: E.L. LEWIS IEEE OCEAN ENG. JAN. 1980
C *****
C UNITS:
C   PRESSURE      P      DECIBARS
C   TEMPERATURE   T      DEG CELSIUS (IPTS-68)
C   CONDUCTIVITY  CND     RATIO      (M=0)
C   SALINITY      SAL78   (PSS-78)  (M=0)
C CHECKVALUES:
C   SAL78=1.888091 :CND= 40.0000,T=40 DEG C,P= 10000 DECIBARS:  M= 1
C   SAL78=40.00000 :CND=1.888091,T=40 DEG C,P=10000 DECIBARS:  M=0
C *****
C SAL78 RATIO: RETURNS ZERO FOR CONDUCTIVITY RATIO:  < 0.0005
C SAL78: RETURNS ZERO FOR SALINITY:  < 0.02
C *****
C INTERNAL FUNCTIONS
C *****
C PRACTICAL SALINITY SCALE 1978 DEFINITION WITH TEMPERATURE CORRECTION
C XT=T-15.0 : XR=SQRT(RT)
  SAL(XR,XT) = (((2.7081*XR-7.0261)*XR+14.0941)*XR+25.3851)*XR
  X-0.1692)* XR+0.0080
  X +(XT/(1.0+0.0162*XT))*(((((-0.0144*XR+
  X 0.0636)*XR-0.0375)*XR-0.0066)*XR-0.0056)*XR+0.0005)
C DSAL(XR,XT) FUNCTION FOR DERIVATIVE OF SAL(XR,XT) WITH XR.
  DSAL(XR,XT) = (((13.5405*XR-28.1044)*XR+42.2823)*XR+50.7702)*XR
  X -0.1692)+(XT/(1.0+0.0162*XT))*(((((-0.0720*XR+0.2544)*XR
  X -0.1125)*XR-0.0132)*XR-0.0056)
C FUNCTION RT35 : C(35,T,0)/C(35,15,0) VARIATION WITH TEMPERATURE
C WITH TEMPERATURE.
  RT35(XT) = (((1.0031E-9*XT-6.9698E-7)*XT+1.104259E-4)*XT
  X + 2.00564E-2)*XT + 0.6766097
C POLYNOMIALS OF RP: C(S,T,P)/C(S,T,0) VARIATION WITH PRESSURE
C C(XP) POLYNOMIAL CORRESPONDS TO A1-A3 CONSTANTS: LEWIS 1980
  C(XP) = ((3.989E-15*XP-6.370E-10)*XP+2.070E-5)*XP
  B(XT) = (4.464E-4*XT+3.426E-2)*XT + 1.0
C A(XT) POLYNOMIAL CORRESPONDS TO B3 AND B4 CONSTANTS: LEWIS 1980
  A(XT) = -3.107E-3*XT + 0.4215
C *****
C ZERO SALINITY/CONDUCTIVITY TRAP
  SAL78=0.0
  IF((M.EQ.0).AND.(CND.LE.5E-4)) RETURN
  IF((M.EQ.1).AND.(CND.LE.0.02)) RETURN
C *****
  DT = T - 15.0

```

```

C SELECT BRANCH FOR SALINITY (M=0) OR CONDUCTIVITY (M=1)
  IF(M.EQ.1) GO TO 10
C *****
C CONVERT CONDUCTIVITY TO SALINITY
  R = CND
  RT = R/(RT35(T)*(1.0 + C(P)/(B(T) + A(T)*R)))
  RT = SQRT(ABS(RT))
  SAL78 = SAL(RT,DT)
  RETURN
C ***** END OF CONDUCTIVITY TO SALINITY SECTION *****
C *****
C INVERT SALINITY TO CONDUCTIVITY BY THE
C NEWTON-RAPHSON ITERATIVE METHOD.
C *****
C FIRST APPROXIMATION
  10 RT = SQRT(CND/35.0)
  SI = SAL(RT,DT)
  N = 0

C
C ITERATION LOOP BEGINS HERE WITH A MAXIMUM OF 10 CYCLES
C
  15 RT = RT + (CND - SI)/DSAL(RT,DT)
  SI = SAL(RT,DT)
  N = N + 1
  DELS = ABS(SI - CND)
  IF((DELS.GT.1.0E-4).AND.(N.LT.10))GO TO 15
C
C *****END OF ITERATION LOOP *****
C
C COMPUTE CONDUCTIVITY RATIO
  RTT = RT35(T)*RT*RT
  AT = A(T)
  BT = B(T)
  CP = C(P)
  CP = RTT*(CP + BT)
  BT = BT - RTT*AT
C
C SOLVE QUADRATIC EQUATION FOR R:  $R=RT35*RT*(1+C/AR+B)$ 
C
  R = SQRT(ABS(BT*BT + 4.0*AT*CP)) - BT
C CONDUCTIVITY RETURN
  SAL78 = 0.5*R/AT
  RETURN
  END

```

```

      REAL FUNCTION THETA(S,TO,PO,PR)
C *****
C TO COMPUTE LOCAL POTENTIAL TEMPERATURE AT PR
C USING BRYDEN 1973 POLYNOMIAL FOR ADIABATIC LAPSE RATE
C AND RUNGE-KUTTA 4-TH ORDER INTEGRATION ALGORITHM.
C REF: BRYDEN,H.,1973,DEEP-SEA RES.,20,401-408
C FOFONOFF,N.,1977,DEEP-SEA RES.,24,489-491
C UNITS:
C      PRESSURE      PO      DECIBARS
C      TEMPERATURE   TO      DEG CELSIUS (IPSS-68)
C      SALINITY       S      (IPSS-78)
C      REFERENCE PRS  PR      DECIBARS
C      POTENTIAL TMP. THETA   DEG CELSIUS
C CHECKVALUE: THETA= 36.89073 C,S=40 (IPSS-78),TO=40 DEG C,
C PO=10000 DECIBARS,PR=0 DECIBARS
C
C      SET-UP INTERMEDIATE TEMPERATURE AND PRESSURE VARIABLES
      P=PO
      T=TO
C *****
      H = PR - P
      XK = H*ATG(S,T,P)
      T = T + 0.5*XK
      Q = XK
      P = P + 0.5*H
      XK = H*ATG(S,T,P)
      T = T + 0.29289322*(XK-Q)
      Q = 0.58578644*XK + 0.121320344*Q
      XK = H*ATG(S,T,P)
      T = T + 1.707106781*(XK-Q)
      Q = 3.414213562*XK - 4.121320344*Q
      P = P + 0.5*H
      XK = H*ATG(S,T,P)
      THETA = T + (XK-2.0*Q)/6.0
      RETURN
      END

```

```

      REAL FUNCTION ATG(S,T,P)
C *****
C ADIABATIC TEMPERATURE GRADIENT DEG C PER DECIBAR
C REF: BRYDEN,H.,1973,DEEP-SEA RES.,20,401-408
C UNITS:
C      PRESSURE      P      DECIBARS
C      TEMPERATURE   T      DEG CELSIUS (IPSS-68)
C      SALINITY       S      (IPSS-78)
C      ADIABATIC      ATG     DEG. C/DECIBAR
C CHECKVALUE: ATG=3.255976E-4 C/DBAR FOR S=40 (IPSS-78),
C T=40 DEG C,PO=10000 DECIBARS
      DS = S - 35.0
      ATG = (((-2.1687E-16*T+1.8676E-14)*T-4.6206E-13)*P
X+((2.7759E-12*T-1.1351E-10)*DS+((-5.4481E-14*T
X+8.733E-12)*T-6.7795E-10)*T+1.8741E-8))*P
X+(-4.2393E-8*T+1.8932E-6)*DS
X+((6.6228E-10*T-6.836E-8)*T+8.5258E-6)*T+3.5803E-5
      RETURN
      END

```

```

C *****
      REAL FUNCTION DEPTH(P,LAT)
C *****
C DEPTH IN METERS FROM PRESSURE IN DECIBARS USING
C SAUNDERS AND FOFONOFF'S METHOD.
C DEEP-SEA RES., 1976,23,109-111.
C FORMULA REFITTED FOR 1980 EQUATION OF STATE
C UNITS:
C      PRESSURE      P      DECIBARS
C      LATITUDE      LAT     DEGREES
C      DEPTH          DEPTH   METERS
C CHECKVALUE: DEPTH = 9712.653 M FOR P=10000 DECIBARS, LATITUDE=30 DEG
C      ABOVE FOR STANDARD OCEAN: T=0 DEG. CELSUIS ; S=35 (IPSS-78)
C
      REAL LAT
C
      X = SIN(LAT/57.29578)
C *****
      X = X*X
C GR= GRAVITY VARIATION WITH LATITUDE: ANON (1970) BULLETIN GEODESIQUE
      GR = 9.780318*(1.0+(5.2788E-3+2.36E-5*X)*X) + 1.092E-6*P
      DEPTH = (((-1.82E-15*P+2.279E-10)*P-2.2512E-5)*P+9.72659)*P
      DEPTH=DEPTH/GR
      RETURN
      END

```

```

      REAL FUNCTION SVAN(S,T,PO,SIGMA)
C   MODIFIED RCM
C   *****
C   SPECIFIC VOLUME ANOMALY (STERIC ANOMALY) BASED ON 1980 EQUATION
C   OF STATE FOR SEAWATER AND 1978 PRACTICAL SALINITY SCALE.
C   REFERENCES
C   MILLERO, ET AL (1980) DEEP-SEA RES., 27A, 255-264
C   MILLERO AND POISSON 1981, DEEP-SEA RES., 28A PP 625-629.
C   BOTH ABOVE REFERENCES ARE ALSO FOUND IN UNESCO REPORT 38 (1981)
C   UNITS:
C       PRESSURE      PO      DECIBARS
C       TEMPERATURE   T      DEG CELSIUS (IPSS-68)
C       SALINITY      S      (IPSS-78)
C       SPEC. VOL. ANA. SVAN   M**3/KG *1.0E-8
C       DENSITY ANA.  SIGMA   KG/M**3
C   *****
C   CHECK VALUE: SVAN=981.3021 E-8 M**3/KG.  FOR S = 40 (IPSS-78) ,
C   T = 40 DEG C, PO= 10000 DECIBARS.
C   CHECK VALUE: SIGMA = 59.82037 KG/M**3 FOR S = 40 (IPSS-78) ,
C   T = 40 DEG C, PO= 10000 DECIBARS.
C   *****
      REAL P,T,S,SIG,SR,R1,R2,R3,R4
      REAL A,B,C,D,E,A1,B1,AW,BW,K,KO,KW,K35
C   EQUIV
      EQUIVALENCE (E,D,B1),(BW,B,R3),(C,A1,R2)
      EQUIVALENCE (AW,A,R1),(KW,KO,K)
C   *****
C   DATA
      DATA R3500,R4/1028.1063,4.8314E-4/
      DATA DR350/28.106331/
C   R4 IS REFERED TO AS C IN MILLERO AND POISSON 1981
C   CONVERT PRESSURE TO BARS AND TAKE SQUARE ROOT SALINITY.
      P=PO/10.
      SR = SQRT(ABS(S))
C   *****
C   PURE WATER DENSITY AT ATMOSPHERIC PRESSURE
C   BIGG P.H.,(1967) BR. J. APPLIED PHYSICS 8 PP 521-537.
C
      R1 = (((6.536332E-9*T-1.120083E-6)*T+1.001685E-4)*T
      X-9.095290E-3)*T+6.793952E-2)*T-28.263737
C   SEAWATER DENSITY ATM PRESS.
C   COEFFICIENTS INVOLVING SALINITY
C   R2 = A IN NOTATION OF MILLERO AND POISSON 1981
      R2 = (((5.3875E-9*T-8.2467E-7)*T+7.6438E-5)*T-4.0899E-3)*T
      X+8.24493E-1
C   R3 = B IN NOTATION OF MILLERO AND POISSON 1981
      R3 = (-1.6546E-6*T+1.0227E-4)*T-5.72466E-3
C   INTERNATIONAL ONE-ATMOSPHERE EQUATION OF STATE OF SEAWATER
      SIG = (R4*S + R3*SR + R2)*S + R1
C   SPECIFIC VOLUME AT ATMOSPHERIC PRESSURE
      V350P = 1.0/R3500
      SVA = -SIG*V350P/(R3500+SIG)
      SIGMA=SIG+DR350

```

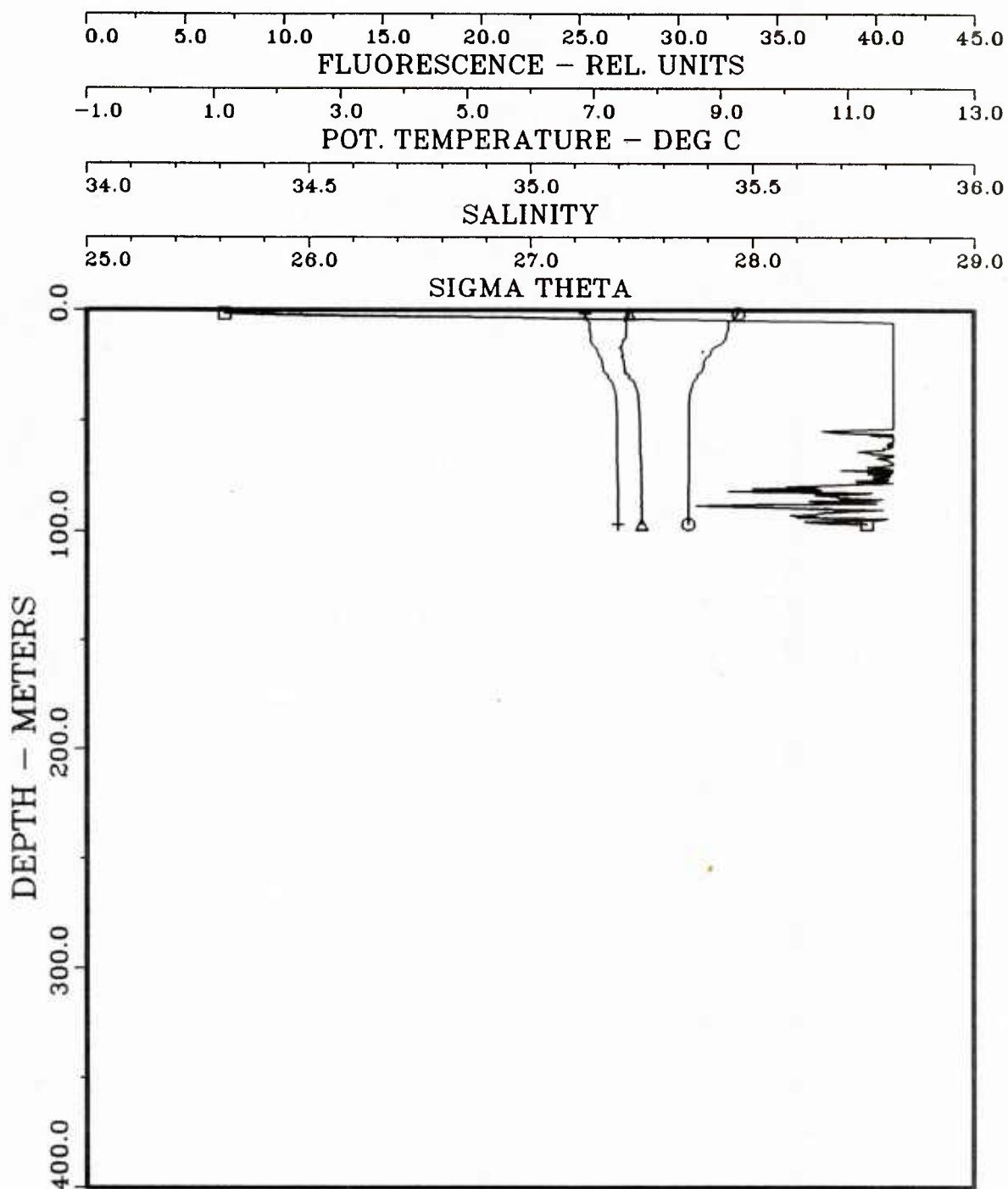
```

C SCALE SPECIFIC VOL. ANAMOLY TO NORMALLY REPORTED UNITS
  SVAN=SVA*1.0E+8
  IF(P.EQ.0.0) RETURN
C *****
C ***** NEW HIGH PRESSURE EQUATION OF STATE FOR SEAWATER *****
C *****
C MILLERO, ET AL , 1980 DSR 27A, PP 255-264
C CONSTANT NOTATION FOLLOWS ARTICLE
C *****
C COMPUTE COMPRESSION TERMS
  E = (9.1697E-10*T+2.0816E-8)*T-9.9348E-7
  BW = (5.2787E-8*T-6.12293E-6)*T+3.47718E-5
  B = BW + E*S
C
  D = 1.91075E-4
  C = (-1.6078E-6*T-1.0981E-5)*T+2.2838E-3
  AW = ((-5.77905E-7*T+1.16092E-4)*T+1.43713E-3)*T
  X-0.1194975
  A = (D*SR + C)*S + AW
C
  B1 = (-5.3009E-4*T+1.6483E-2)*T+7.944E-2
  A1 = ((-6.1670E-5*T+1.09987E-2)*T-0.603459)*T+54.6746
  KW = (((-5.155288E-5*T+1.360477E-2)*T-2.327105)*T
  X+148.4206)*T-1930.06
  K0 = (B1*SR + A1)*S + KW
C EVALUATE PRESSURE POLYNOMIAL
C *****
C K EQUALS THE SECANT BULK MODULUS OF SEAWATER
C DK=K(S,T,P)-K(35,0,P)
C K35=K(35,0,P)
C *****
  DK = (B*P + A)*P + K0
  K35 = (5.03217E-5*P+3.359406)*P+21582.27
  GAM=P/K35
  PK = 1.0 - GAM
  SVA = SVA*PK + (V350P+SVA)*P*DK/(K35*(K35+DK))
C SCALE SPECIFIC VOL. ANAMOLY TO NORMALLY REPORTED UNITS
  SVAN=SVA*1.0E+8
  V350P = V350P*PK
C *****
C COMPUTE DENSITY ANAMOLY WITH RESPECT TO 1000.0 KG/M**3
C 1) DR350: DENSITY ANAMOLY AT 35 (IPSS-78), 0 DEG. C AND 0 DECIBARS
C 2) DR35P: DENSITY ANAMOLY 35 (IPSS-78), 0 DEG. C , PRES. VARIATION
C 3) DVAN : DENSITY ANAMOLY VARIATIONS INVOLVING SPECIFIC VOL. ANAMOLY
C *****
C CHECK VALUE: SIGMA = 59.82037 KG/M**3 FOR S = 40 (IPSS-78),
C T = 40 DEG C, P0= 10000 DECIBARS.
C *****
  DR35P=GAM/V350P
  DVAN=SVA/(V350P*(V350P+SVA))
  SIGMA=DR350+DR35P-DVAN
  RETURN
  END

```

APPENDIX B

CTD DATA PLOTS

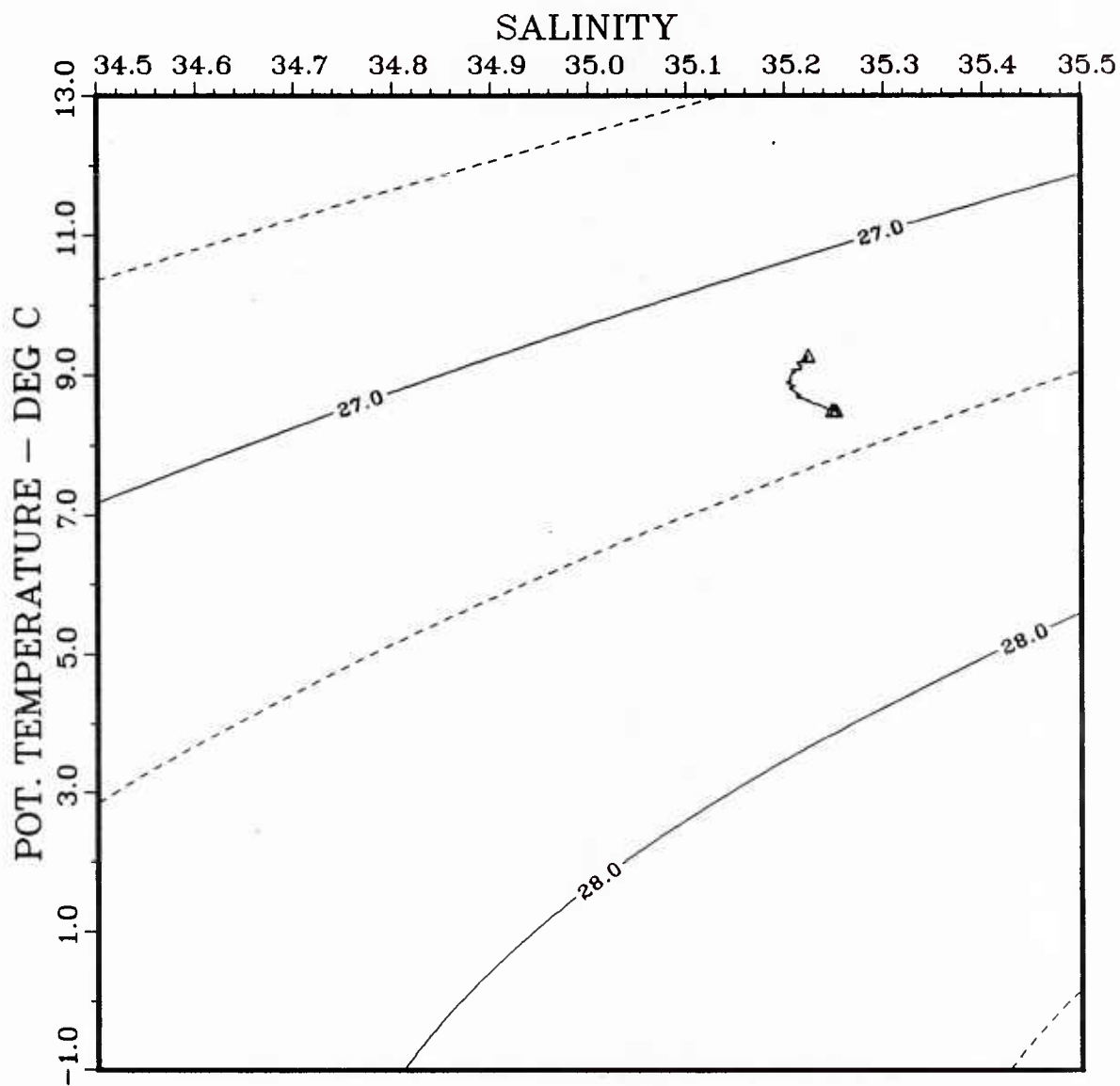


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

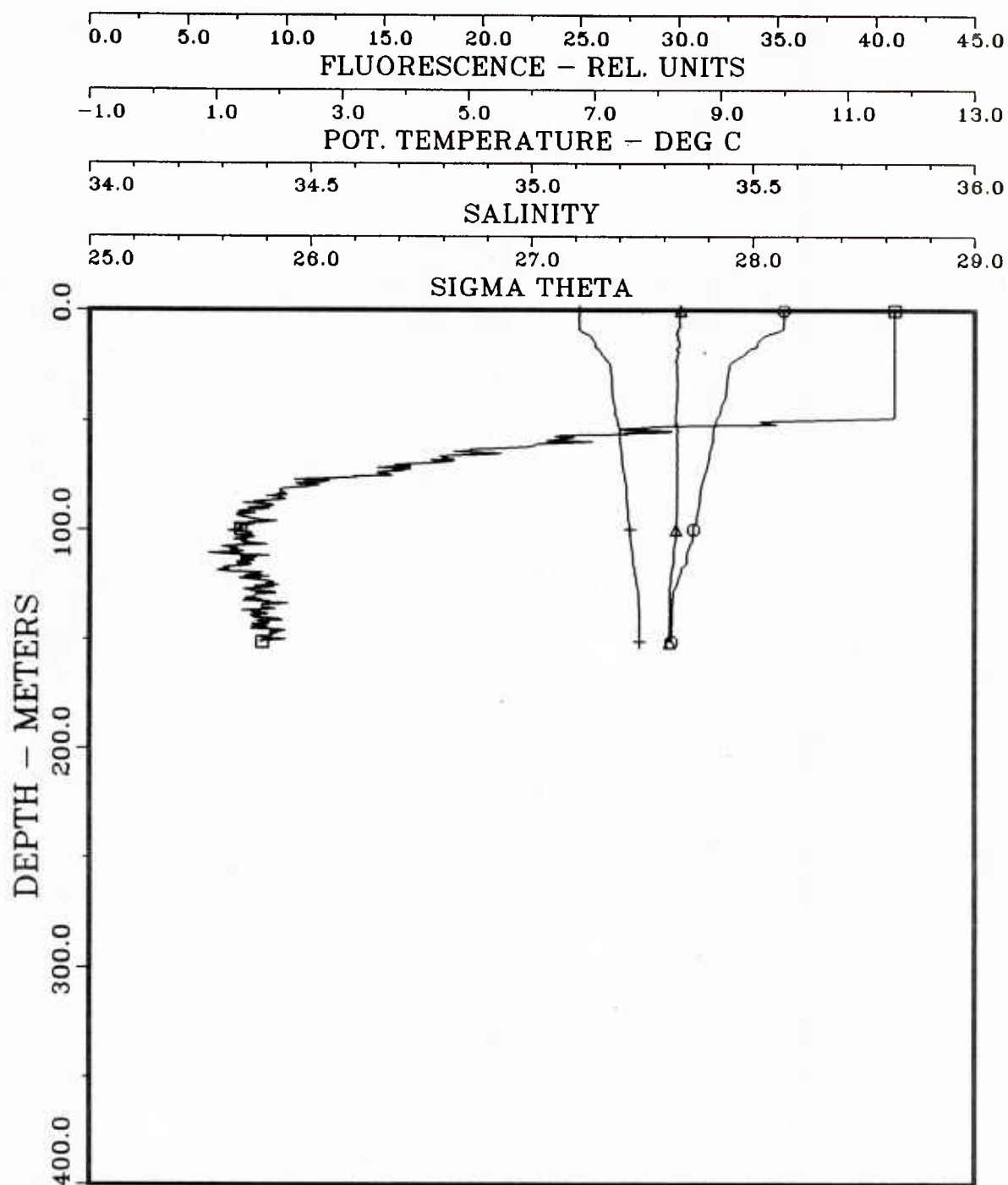
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1
154.1940
60 14.26N
002 25.83W

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
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CAST NUMBER	1	
JULIAN DATE	154.1940	
LATITUDE	60 14.26N	
LONGITUDE	002 25.83W	

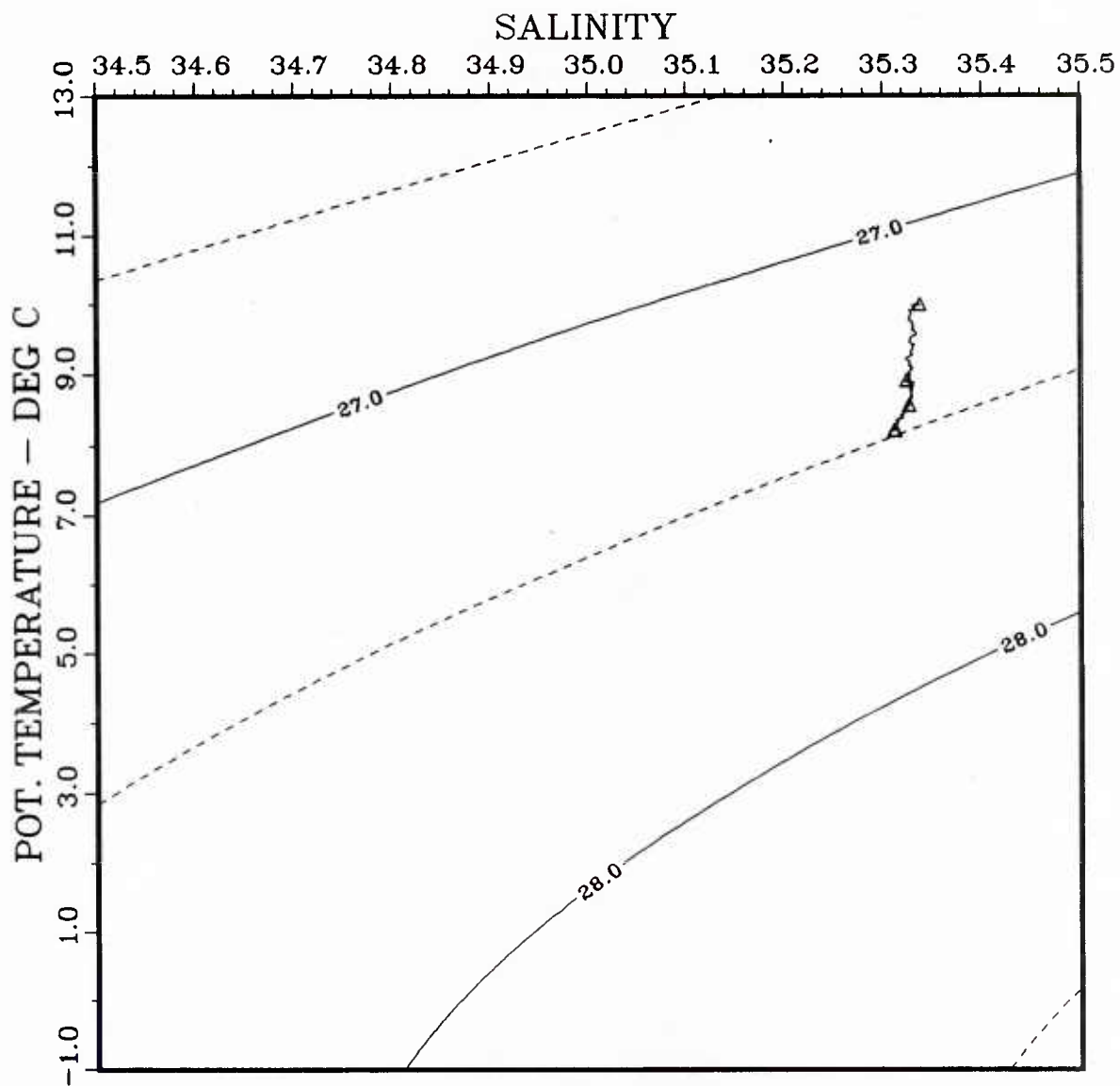


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CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

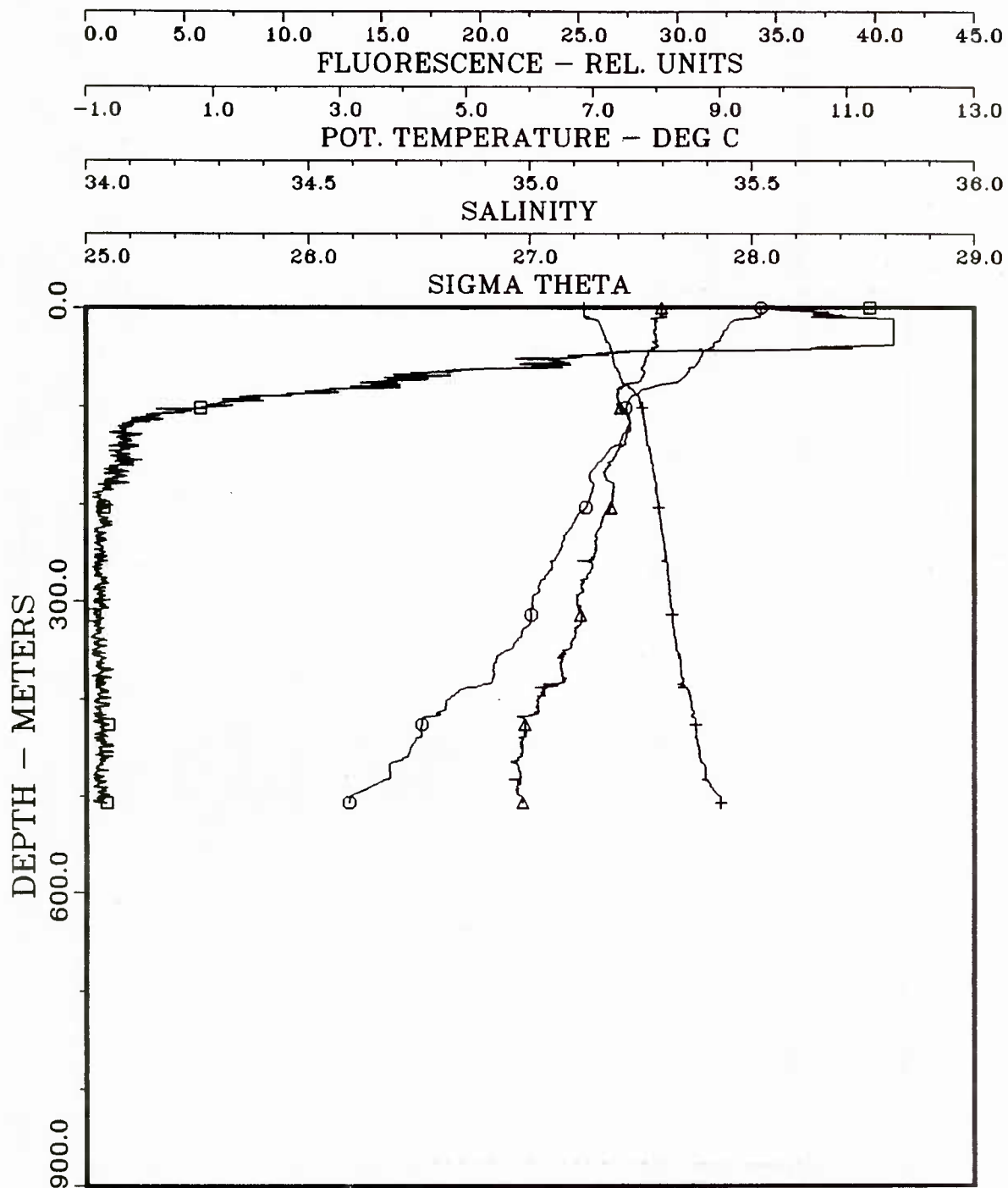
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JUNE 1987

LEGEND
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○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
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LONGITUDE	002 51.50W	

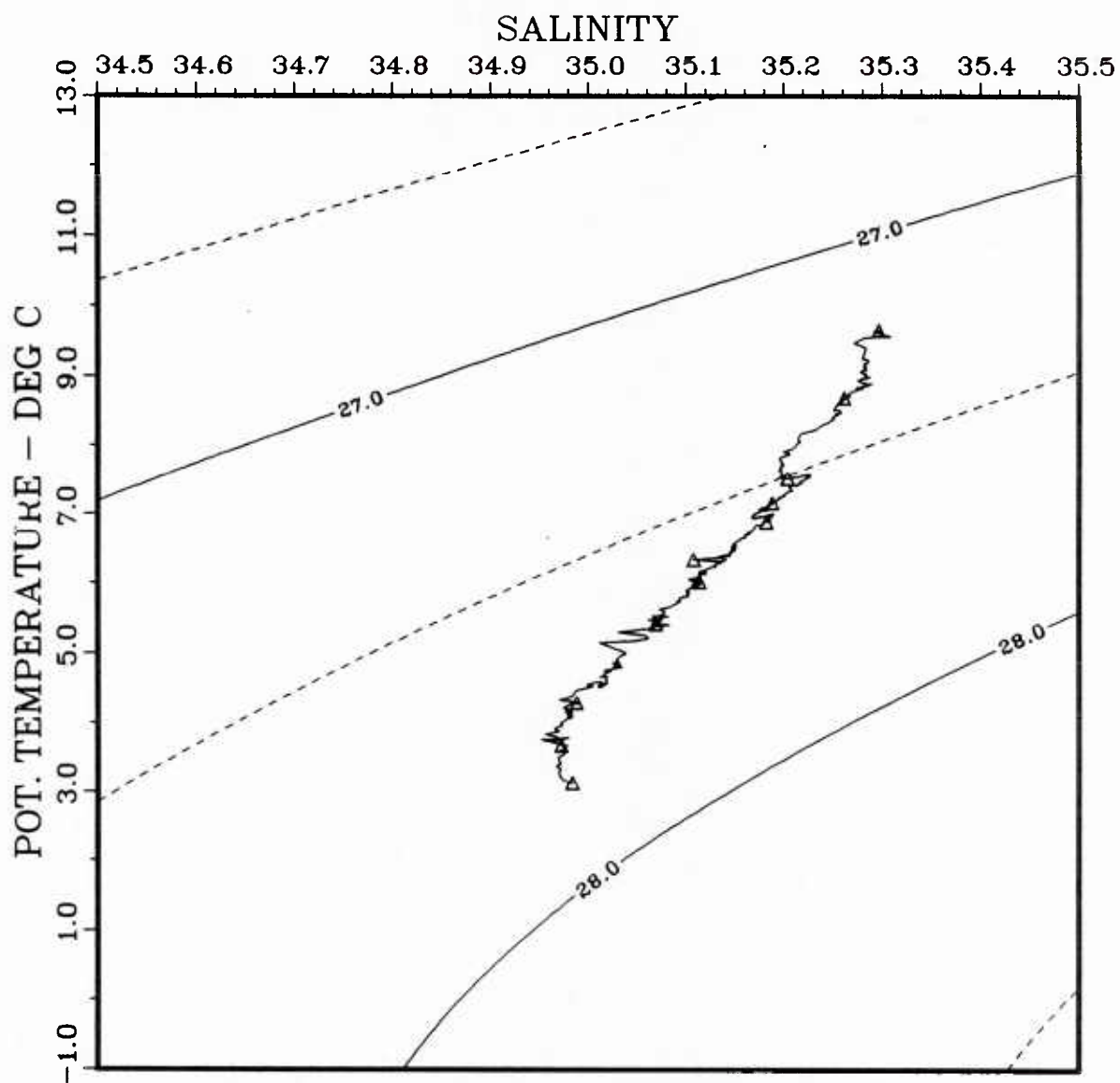


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

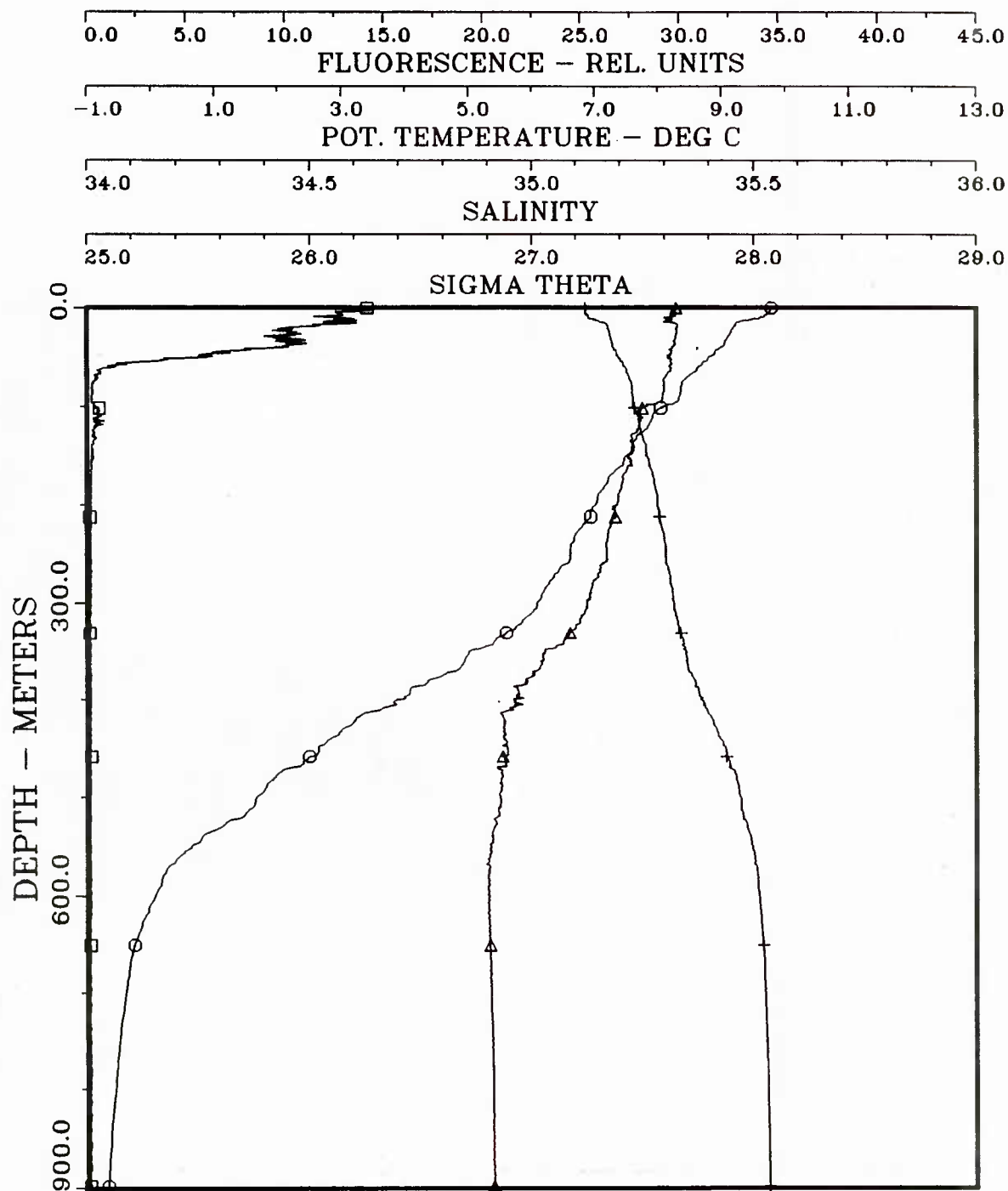
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JUNE 1987

LEGEND
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○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
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LATITUDE	60 44.64N	
LONGITUDE	003 18.67W	

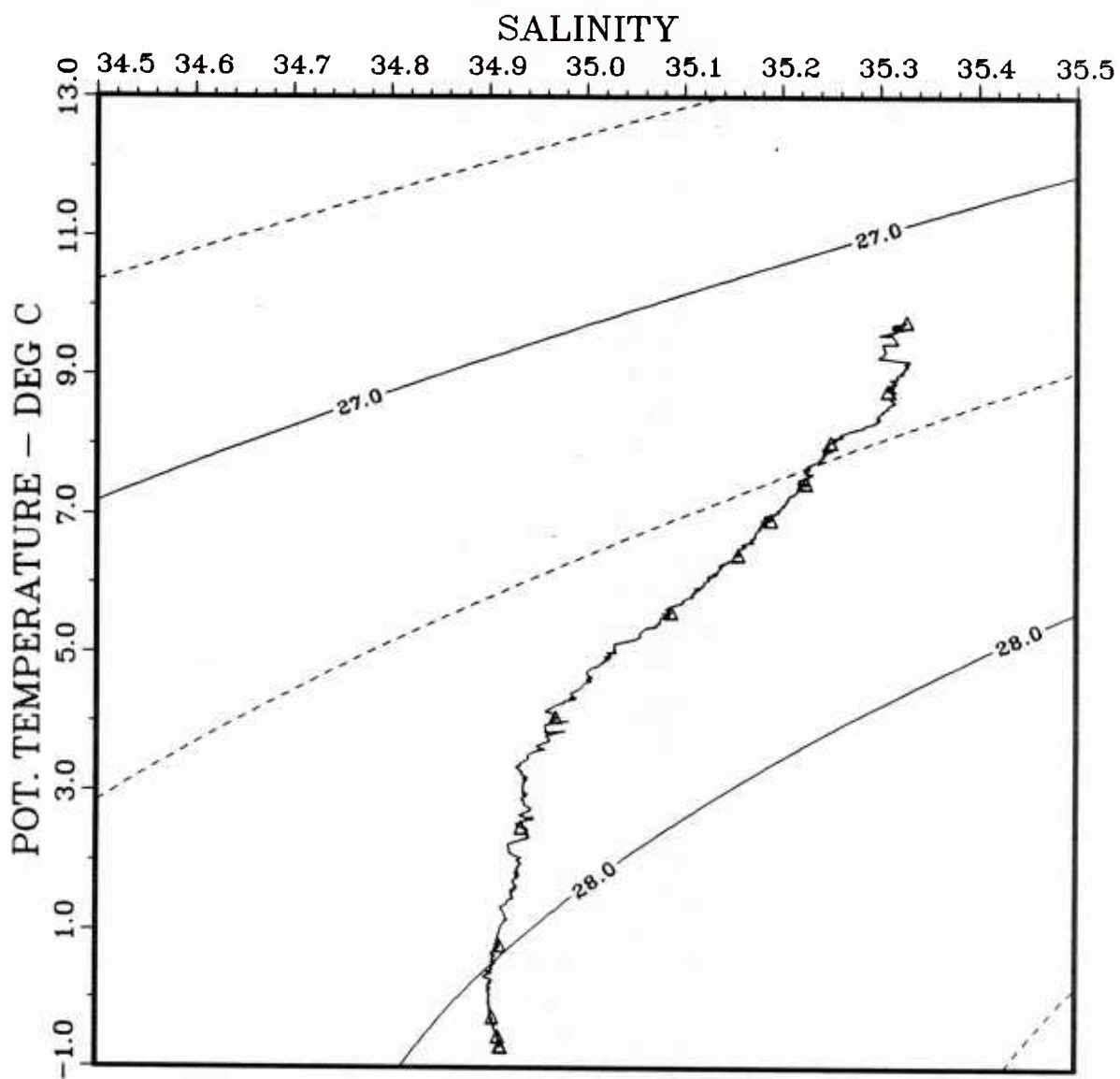


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

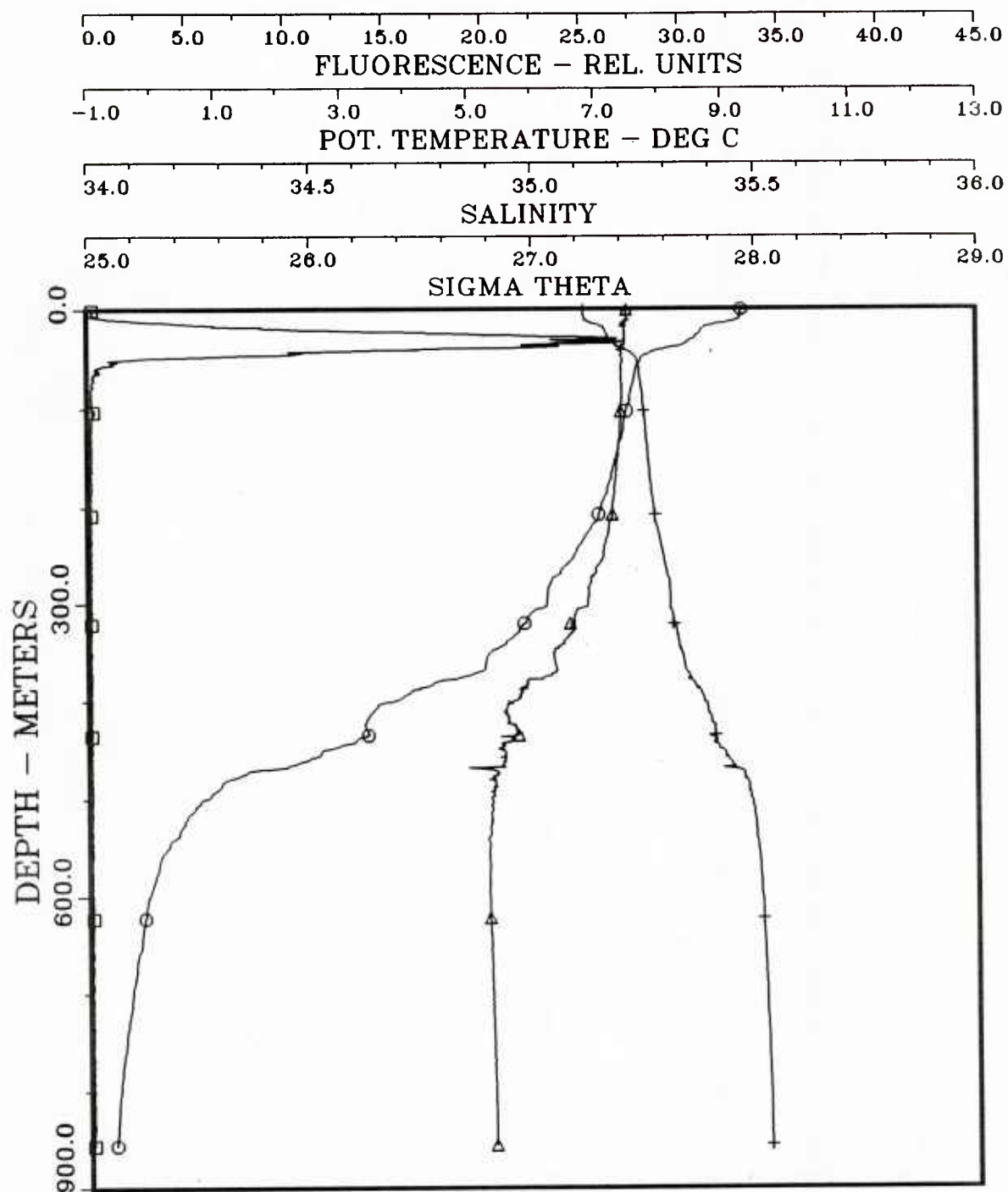
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JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
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CAST NUMBER	1	
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LONGITUDE	003 45.10W	

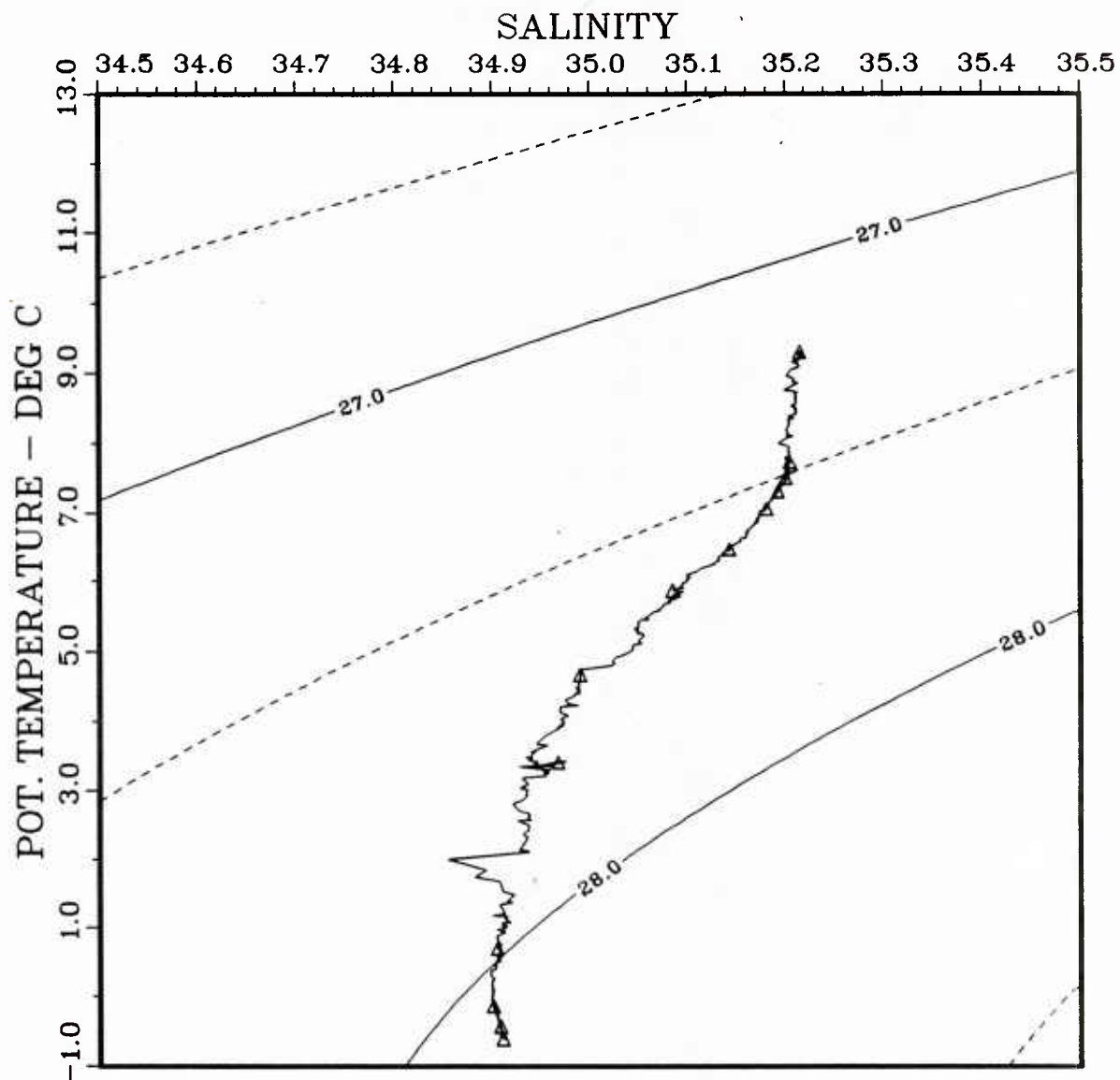


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

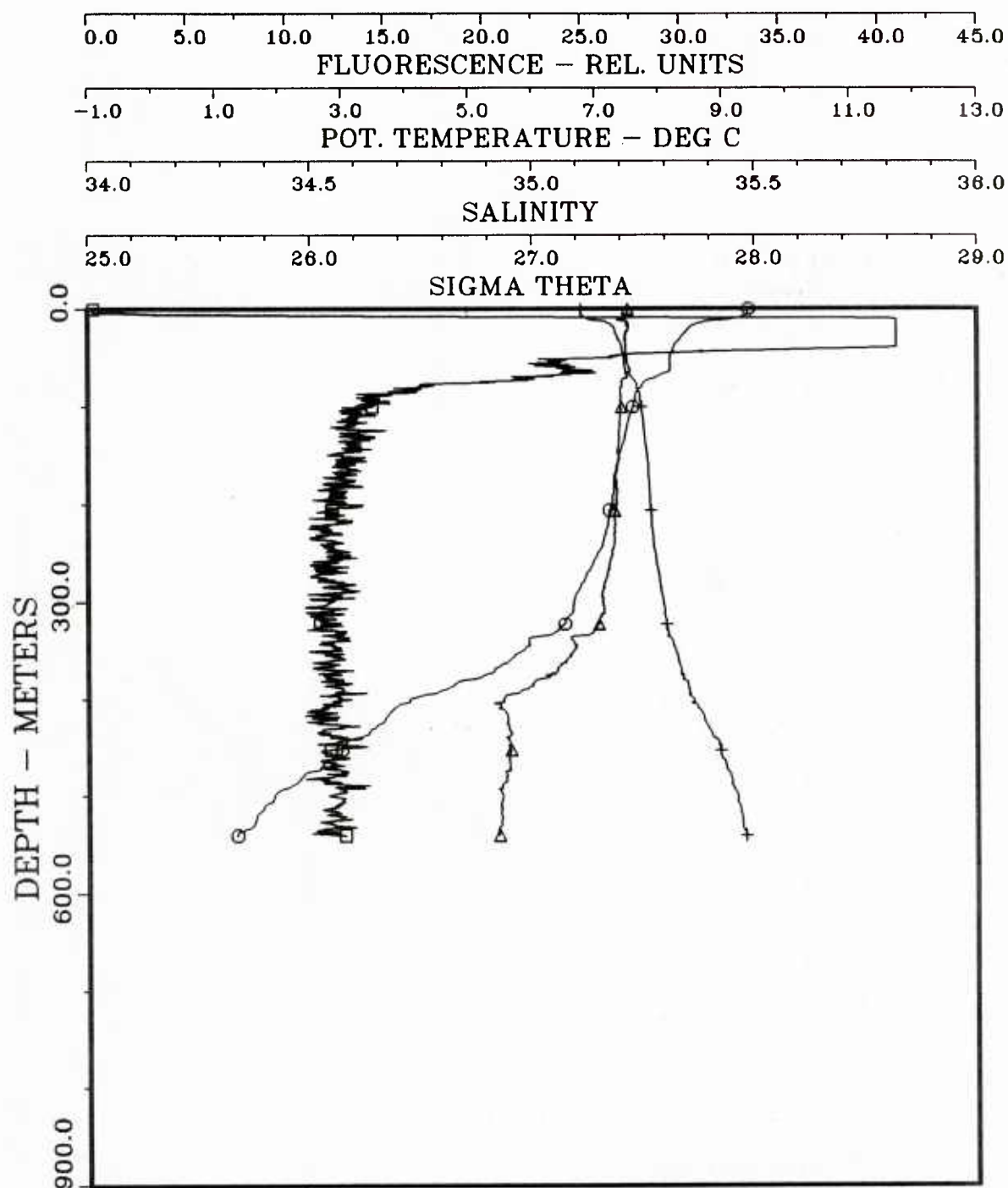
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61 14.54N
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JUNE 1987

LEGEND
□ - FLUORESCENCE
○ - POT. TEMPERATURE
△ - SALINITY
+ - SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
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CAST NUMBER	1	
JULIAN DATE	155.0420	
LATITUDE	61 14.54N	
LONGITUDE	004 11.49W	

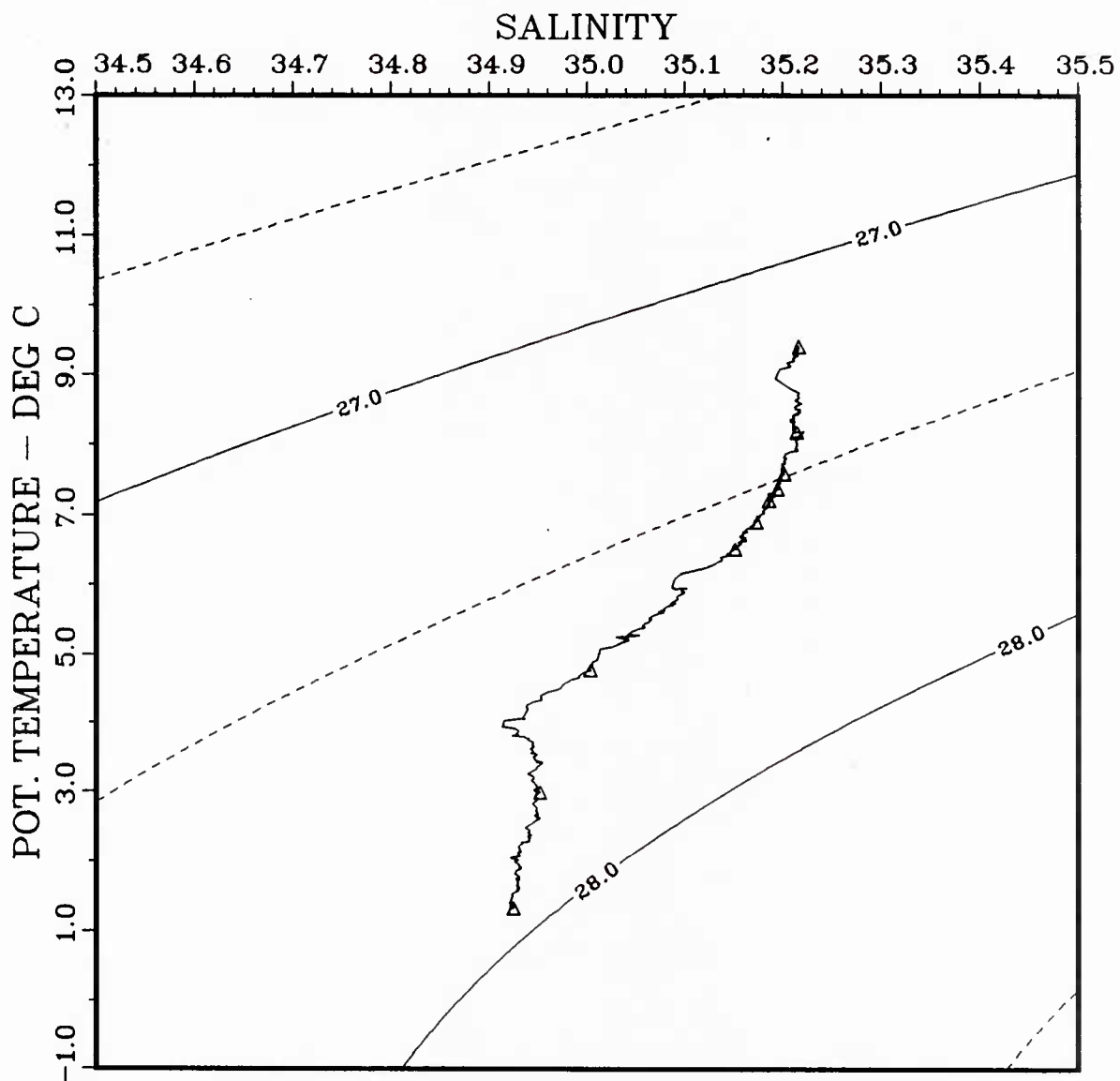


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

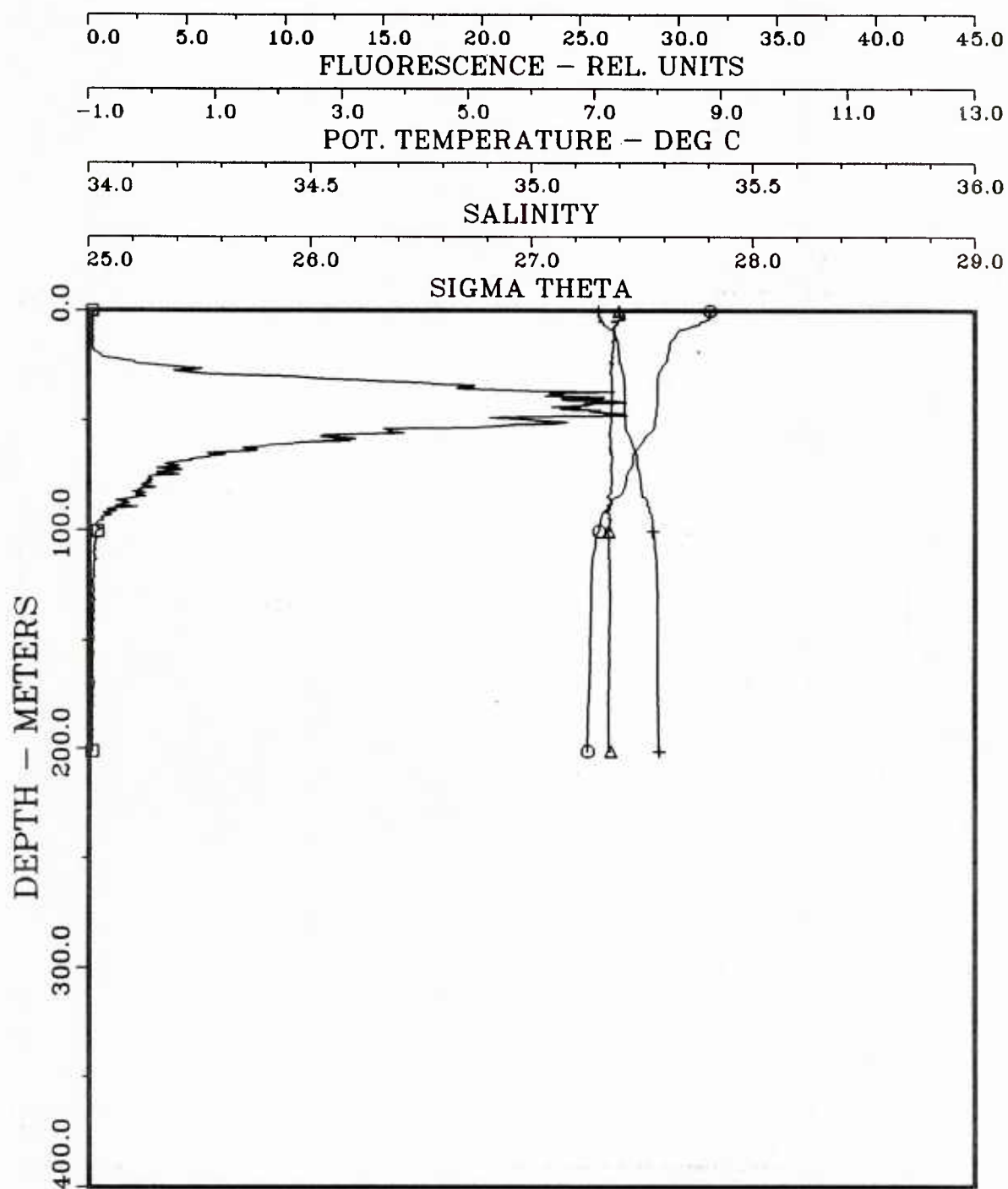
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JUNE 1987

LEGEND
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○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
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CAST NUMBER	1	
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LONGITUDE	004 37.71W	

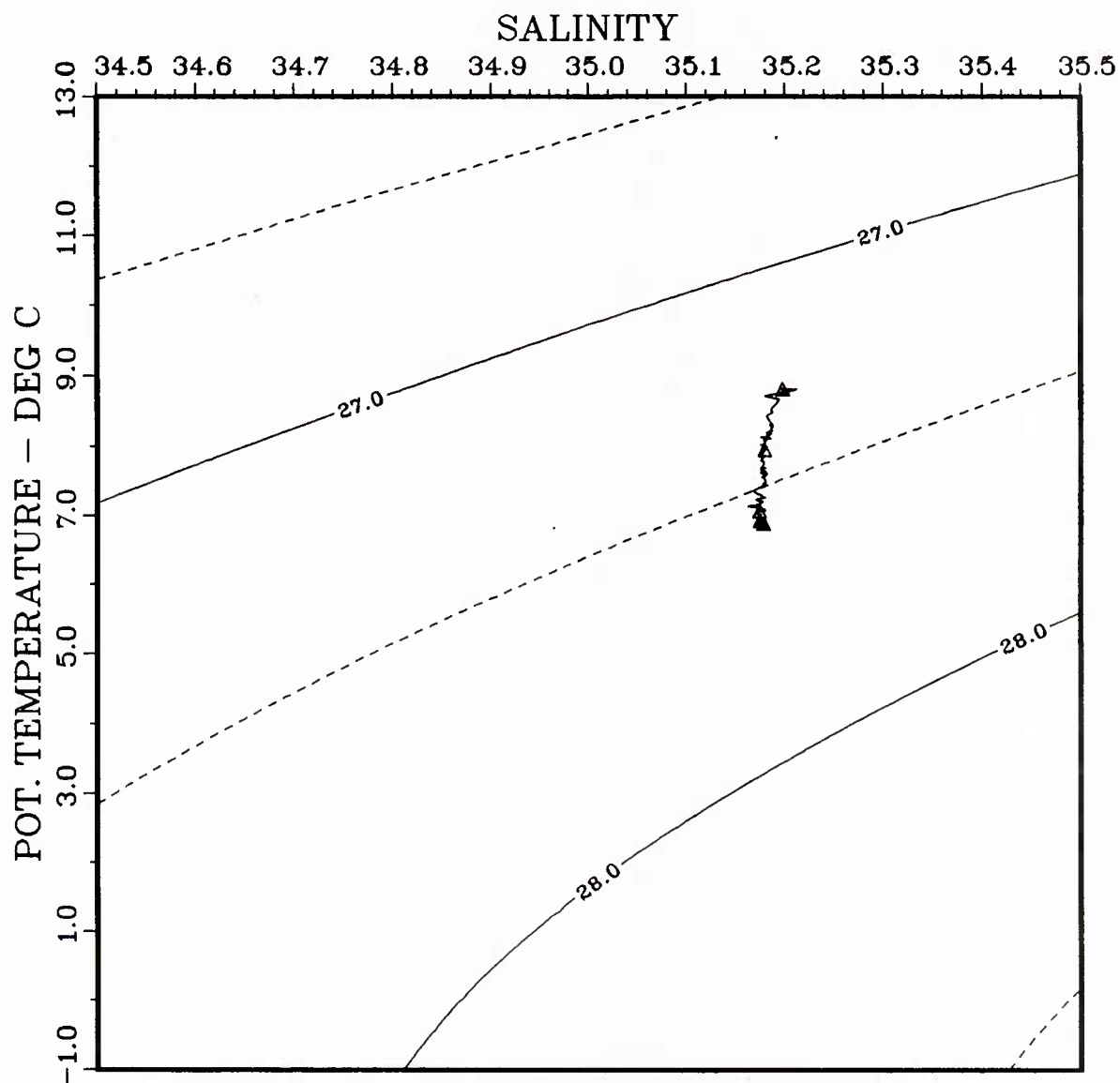


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

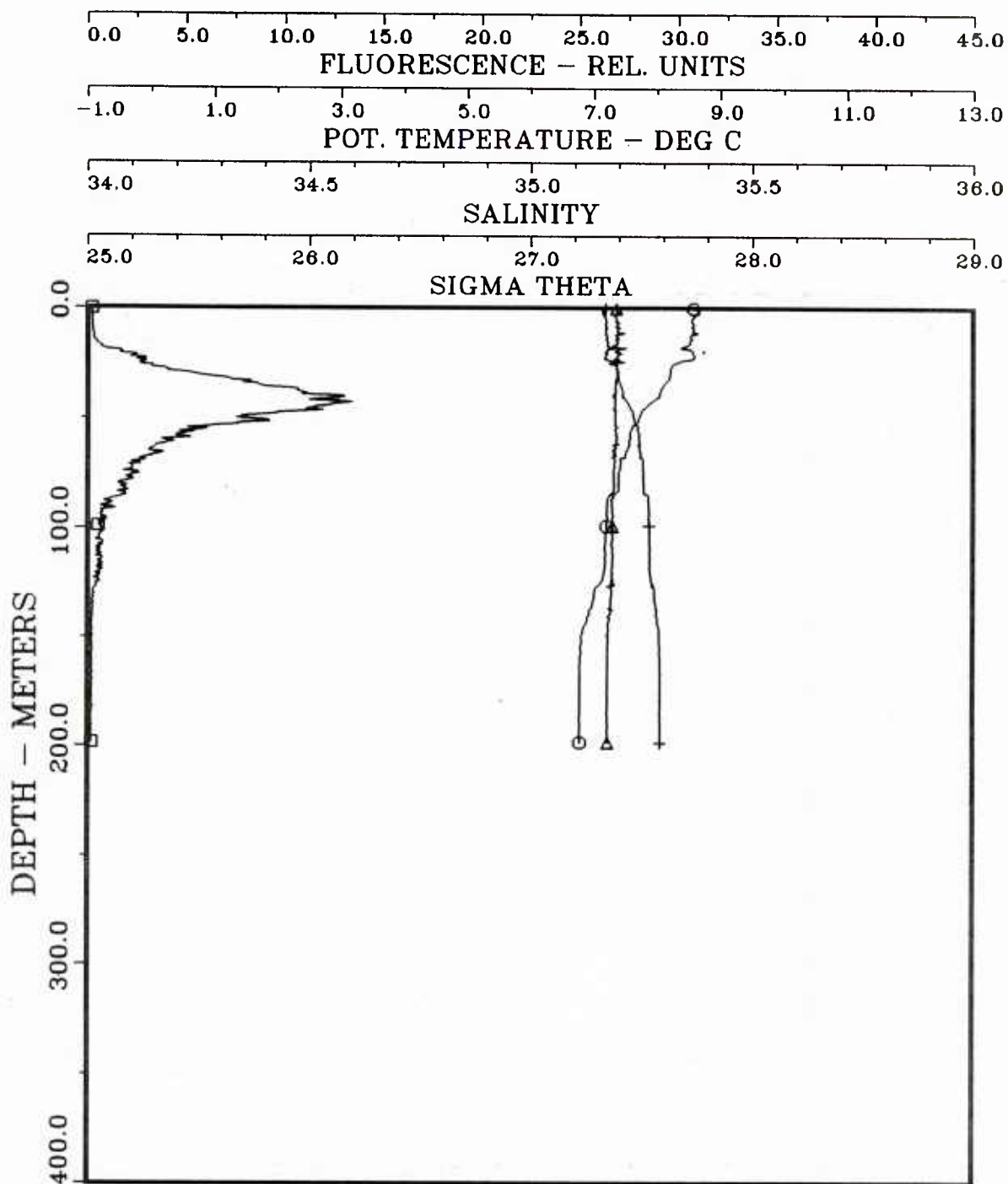
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JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
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LONGITUDE	005 04.05W	

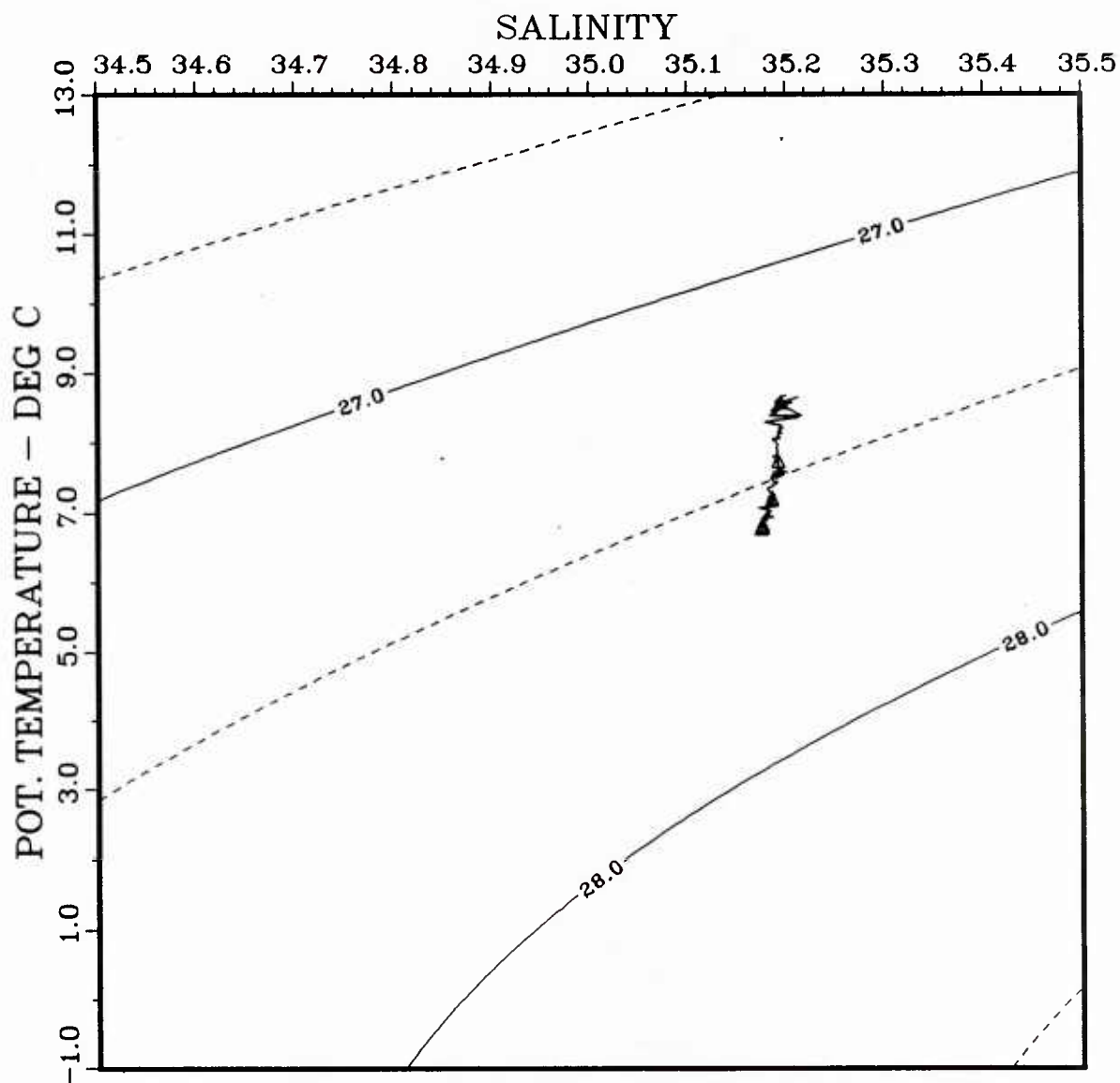


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JULIAN DATE
LATITUDE
LONGITUDE

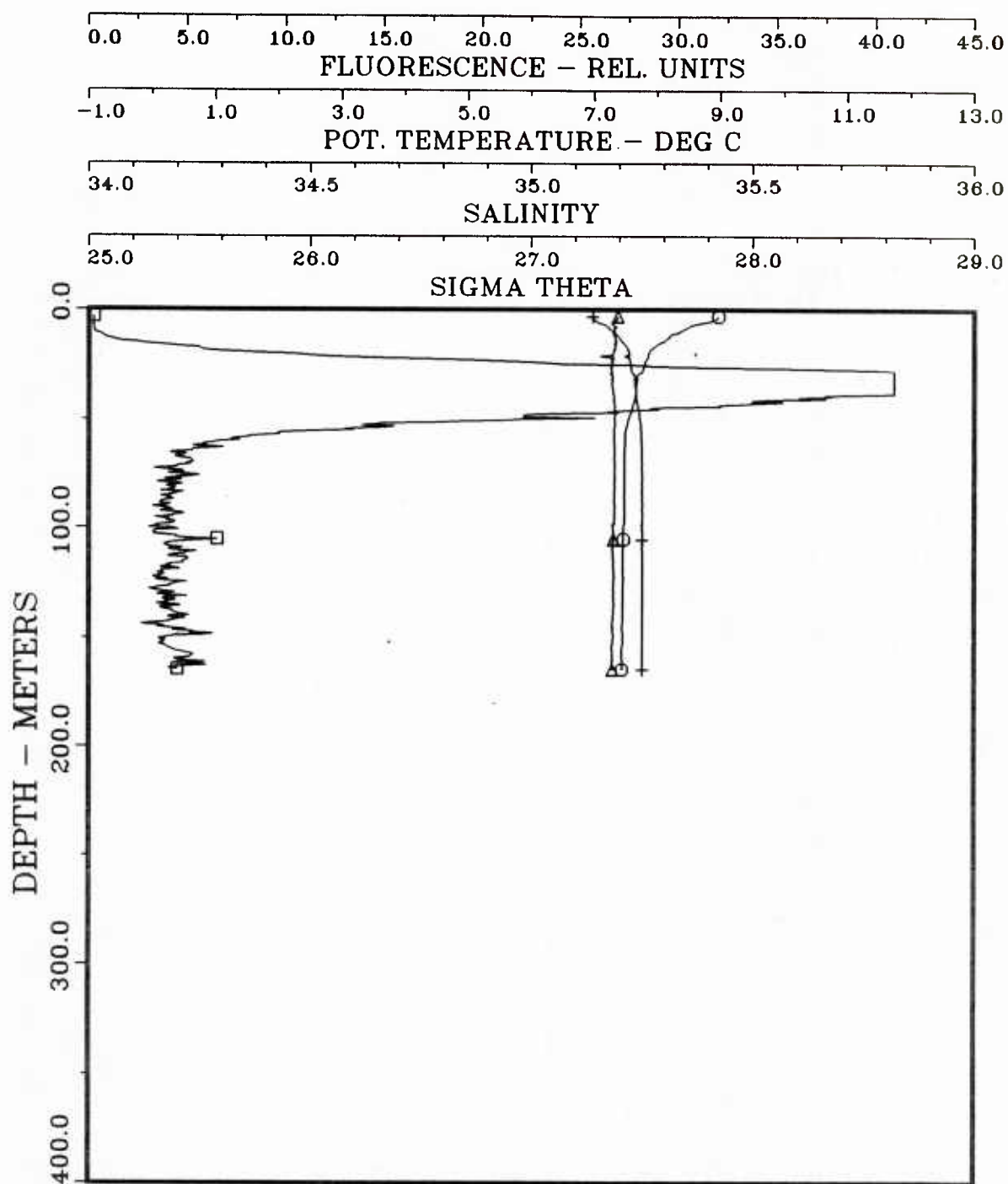
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JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	8	
CAST NUMBER	1	
JULIAN DATE	155.1110	
LATITUDE	61 59.04N	
LONGITUDE	005 30.15W	



WFS PLANET

NORDMEER 87

JUNE 1987

STATION

9

CAST NUMBER

1

JULIAN DATE

155.1610

LATITUDE

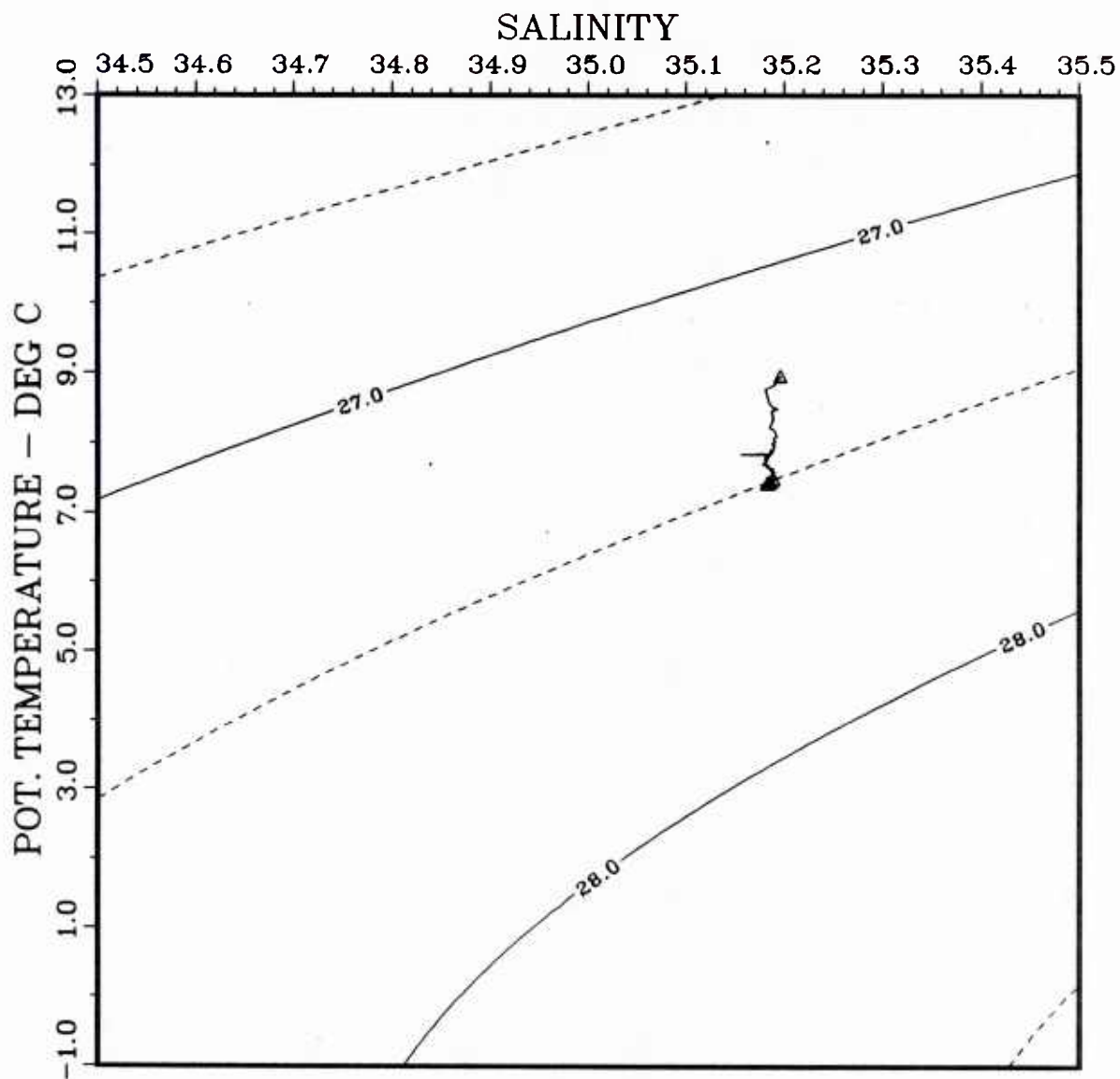
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LONGITUDE

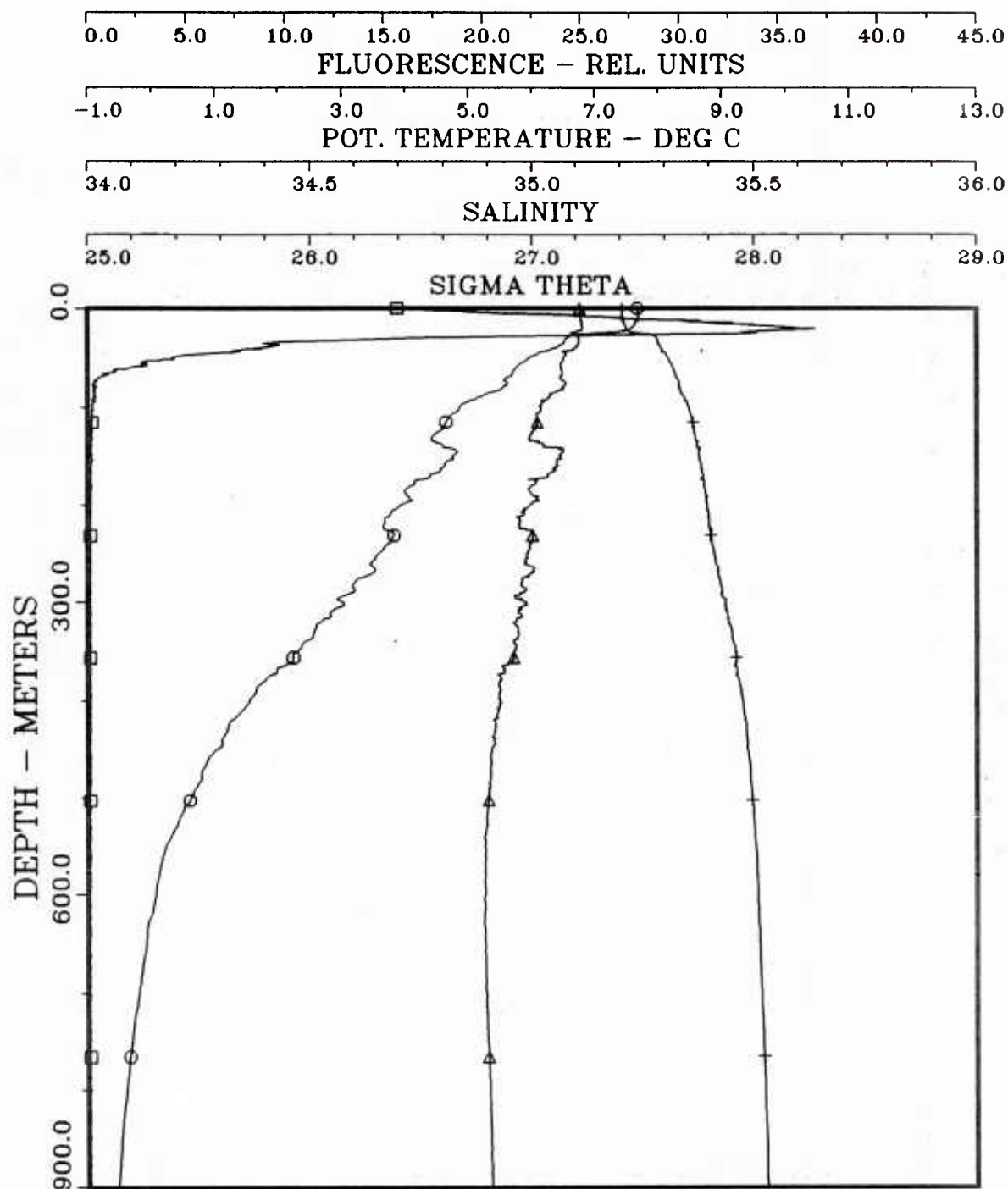
006 50.05W

LEGEND

- = FLUORESCENCE
- = POT. TEMPERATURE
- △ = SALINITY
- + = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	9	
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LONGITUDE	006 50.05W	

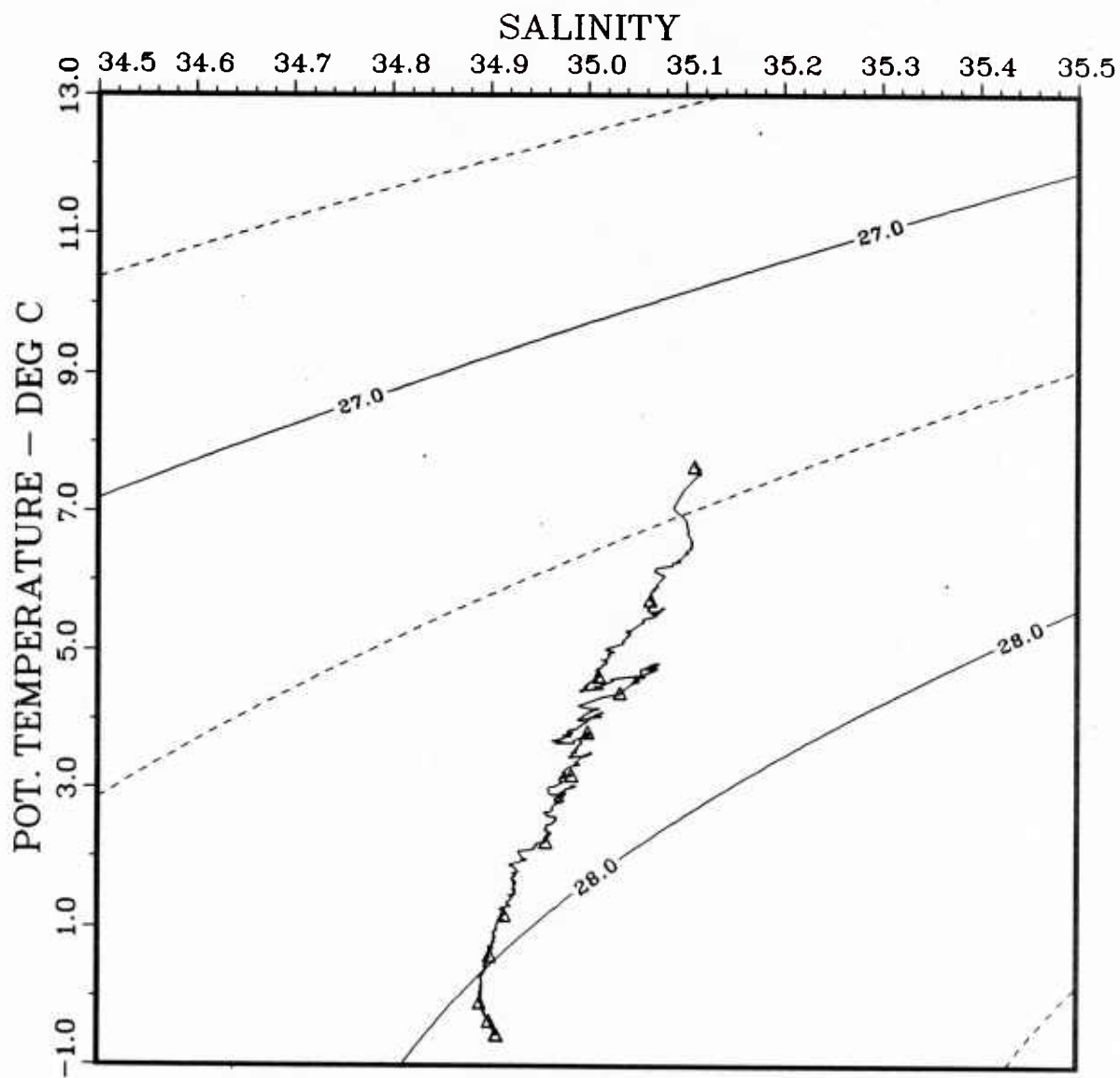


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

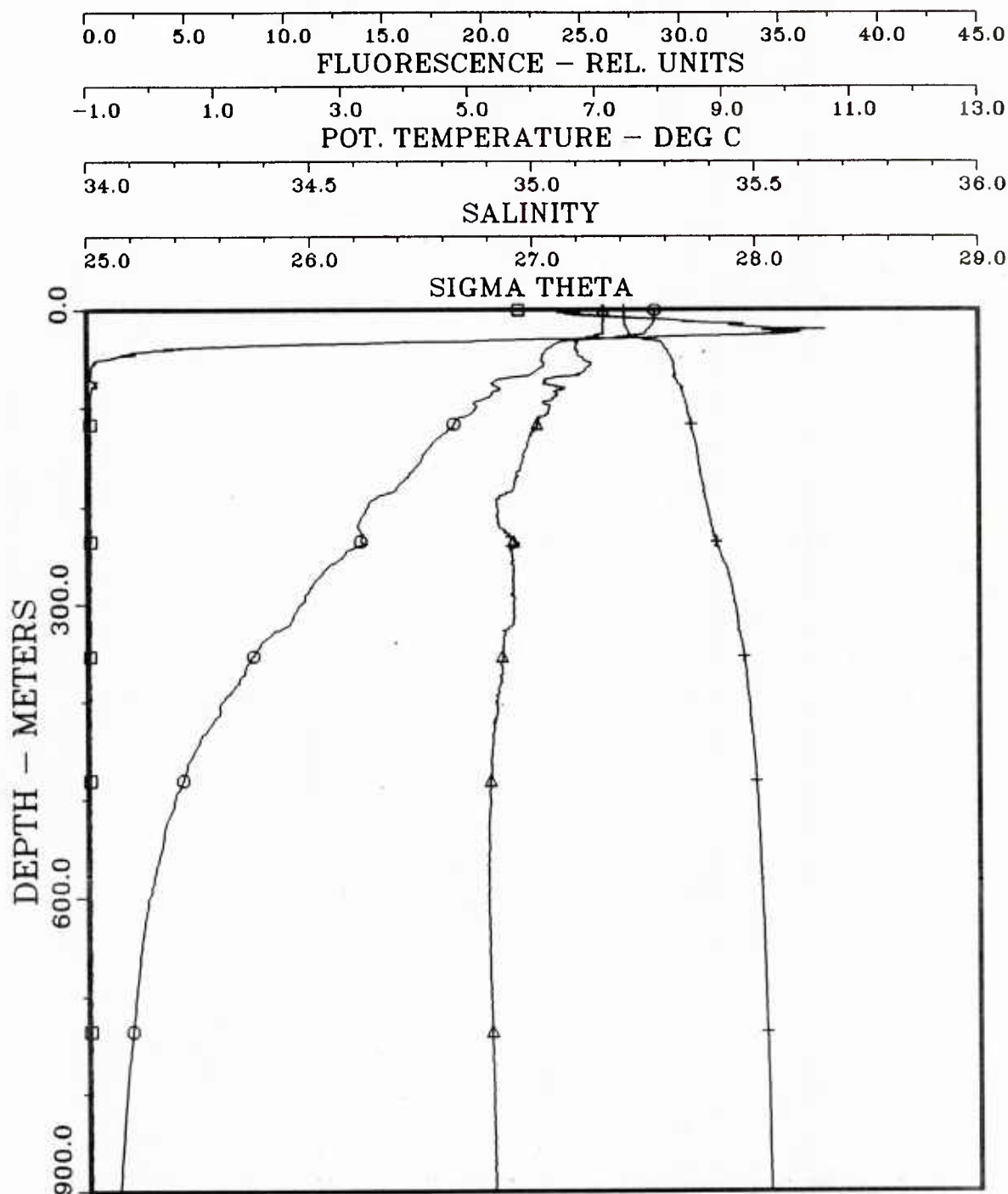
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65 48.61N
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JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
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LONGITUDE	001 30.59W	

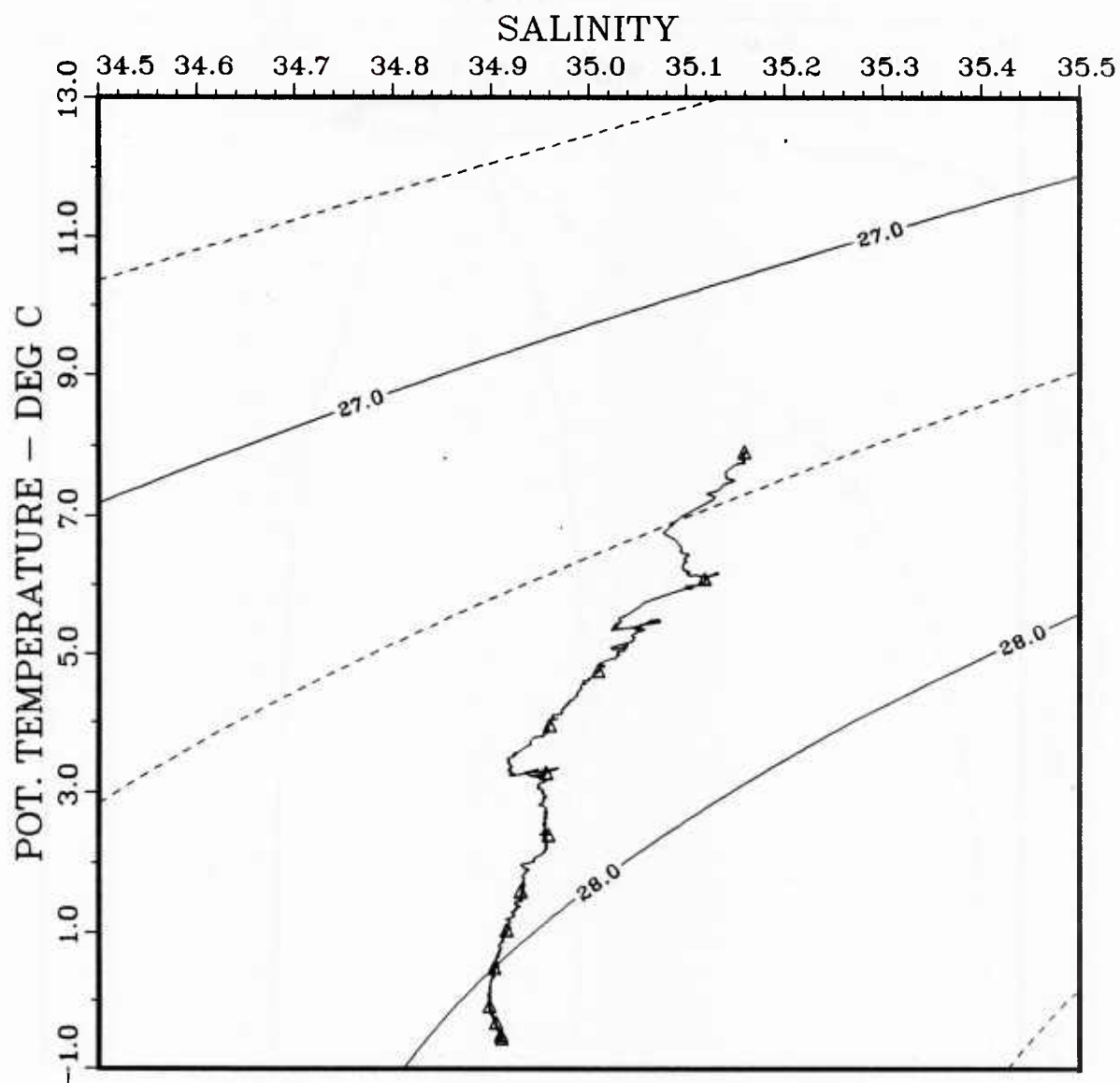


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

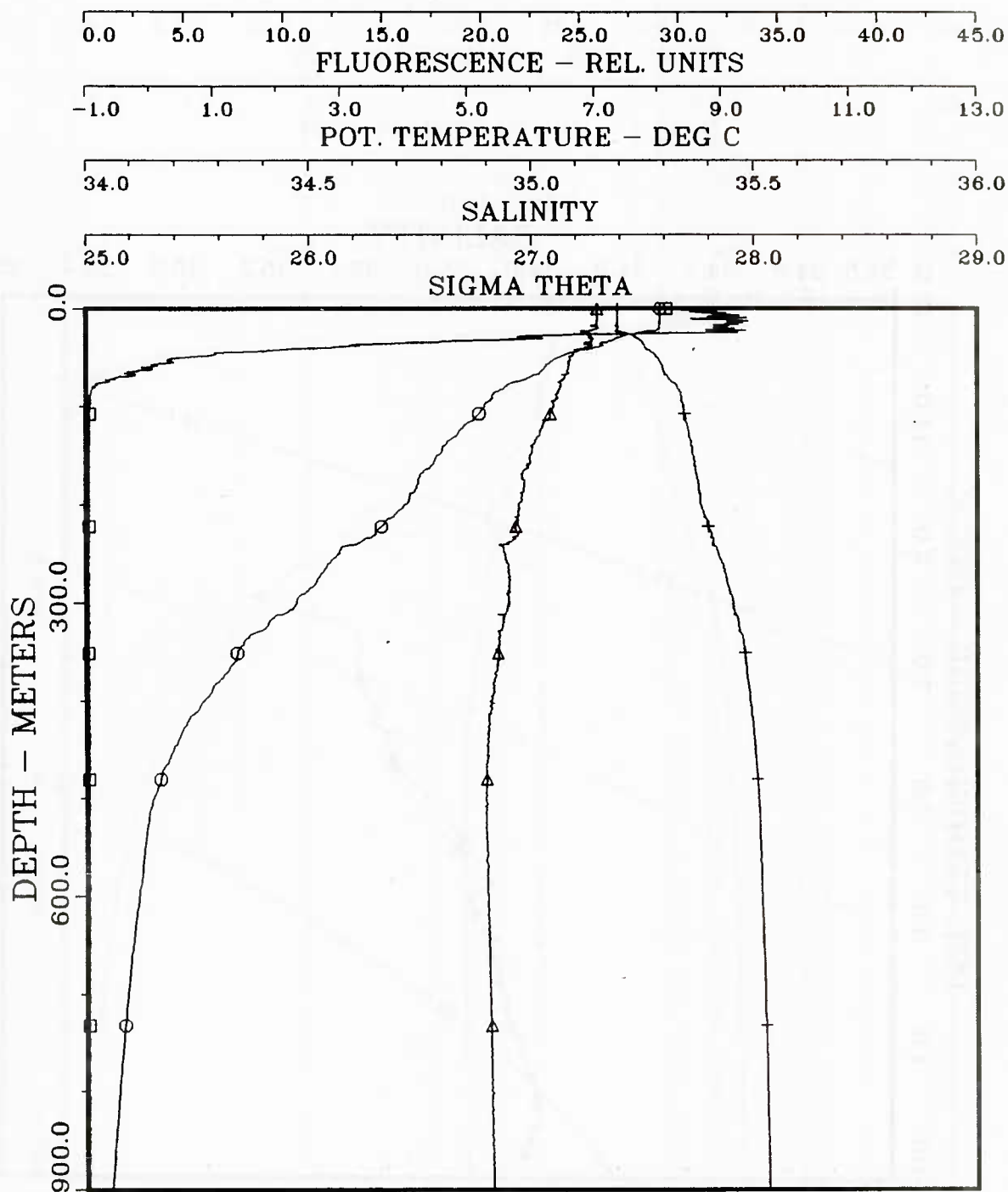
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11
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65 33.19N
000 49.10W

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
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CAST NUMBER	1	
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LONGITUDE	000 49.10W	

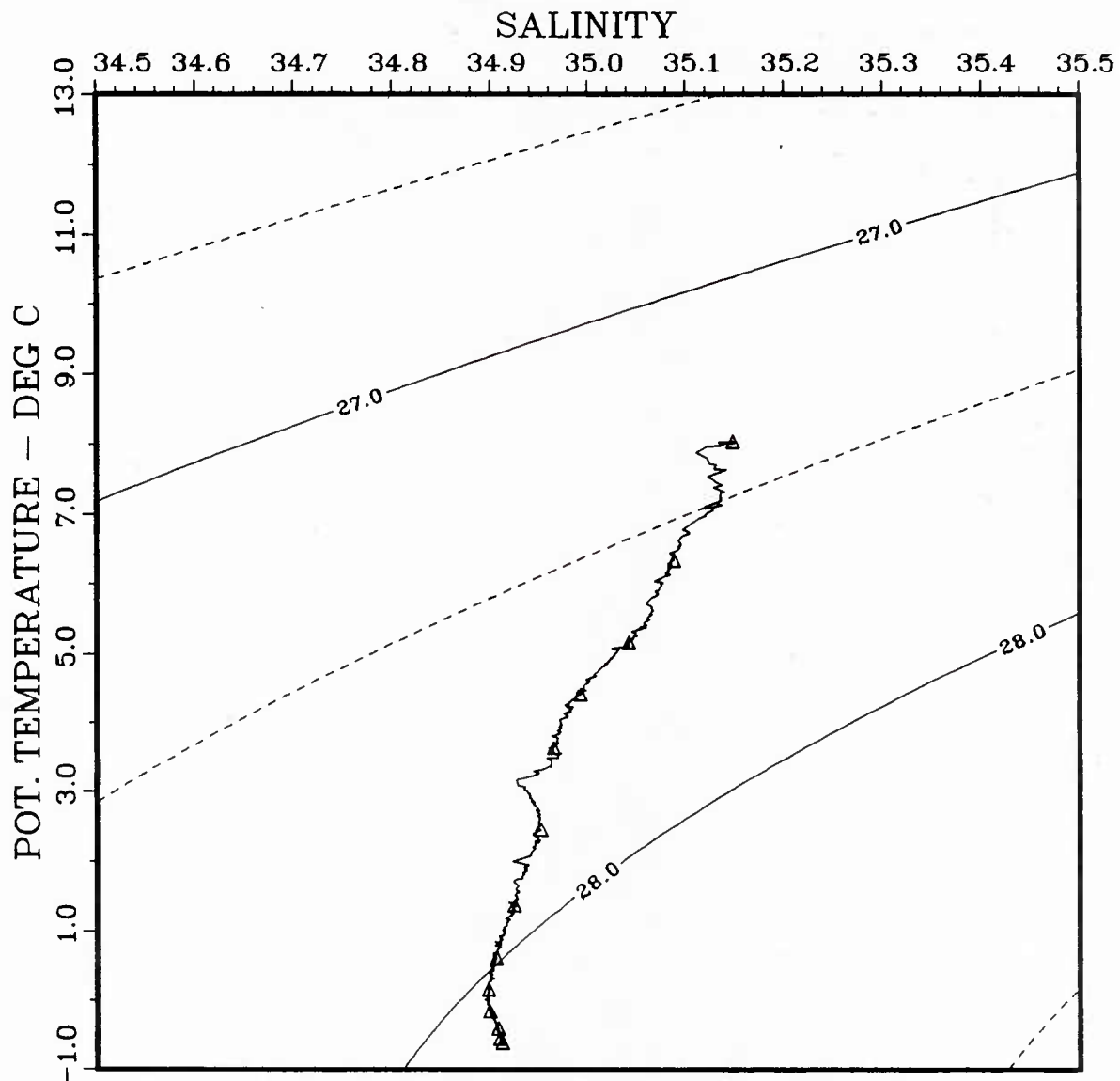


WFS PLANET
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CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

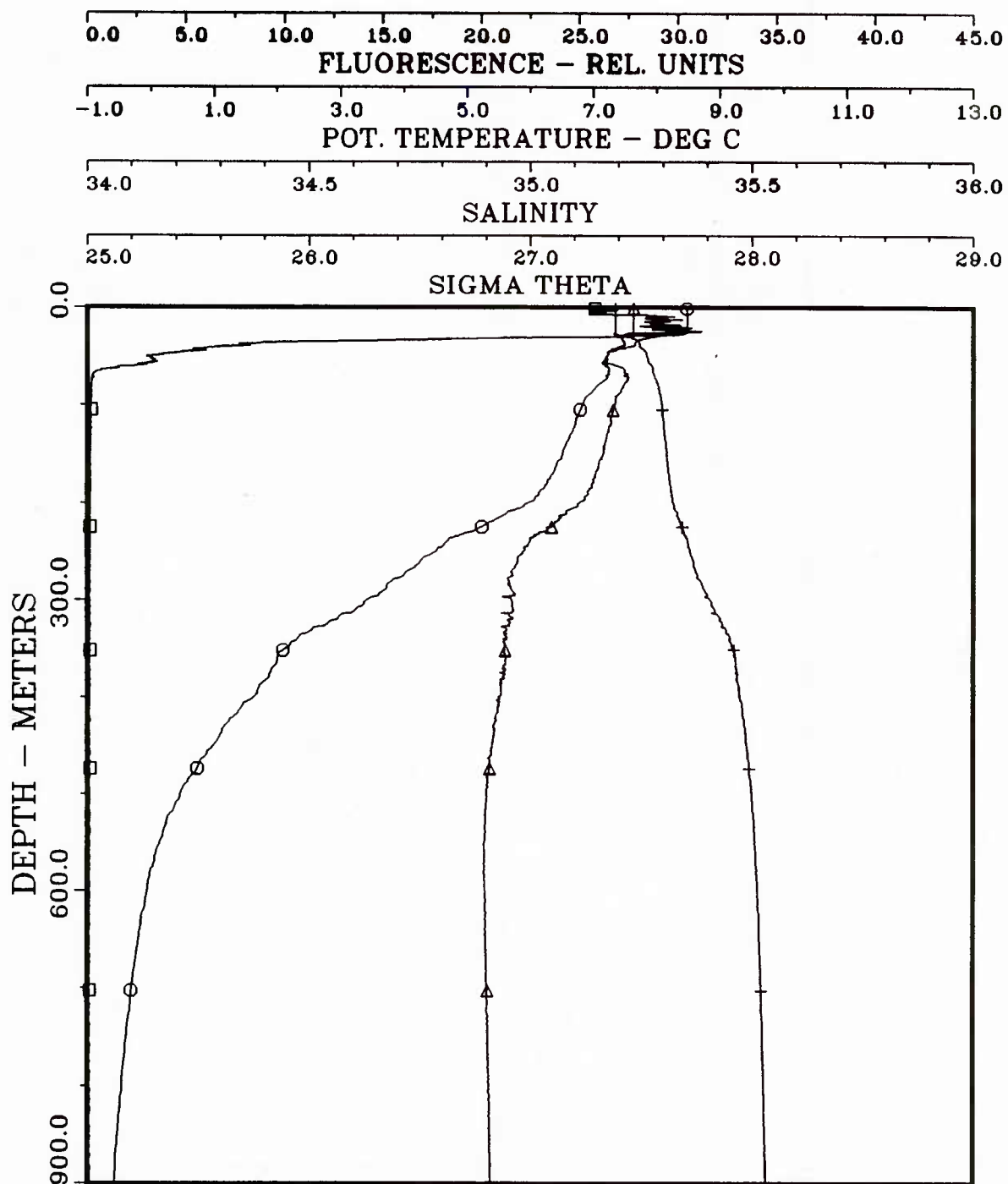
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JUNE 1987

LEGEND
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○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
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CAST NUMBER	1	
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LATITUDE	65 58.88N	
LONGITUDE	000 39.87W	

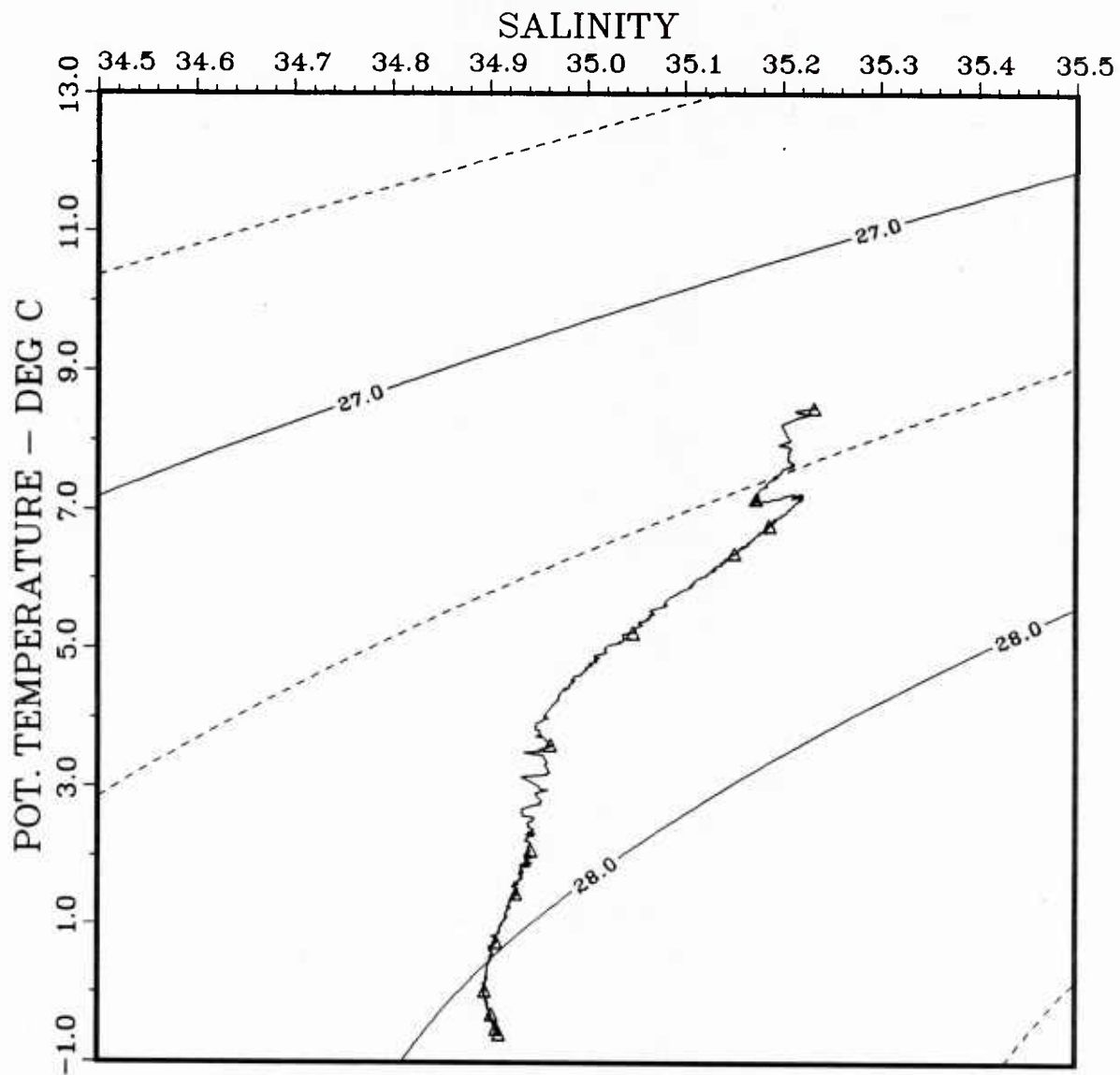


WFS PLANET
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CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

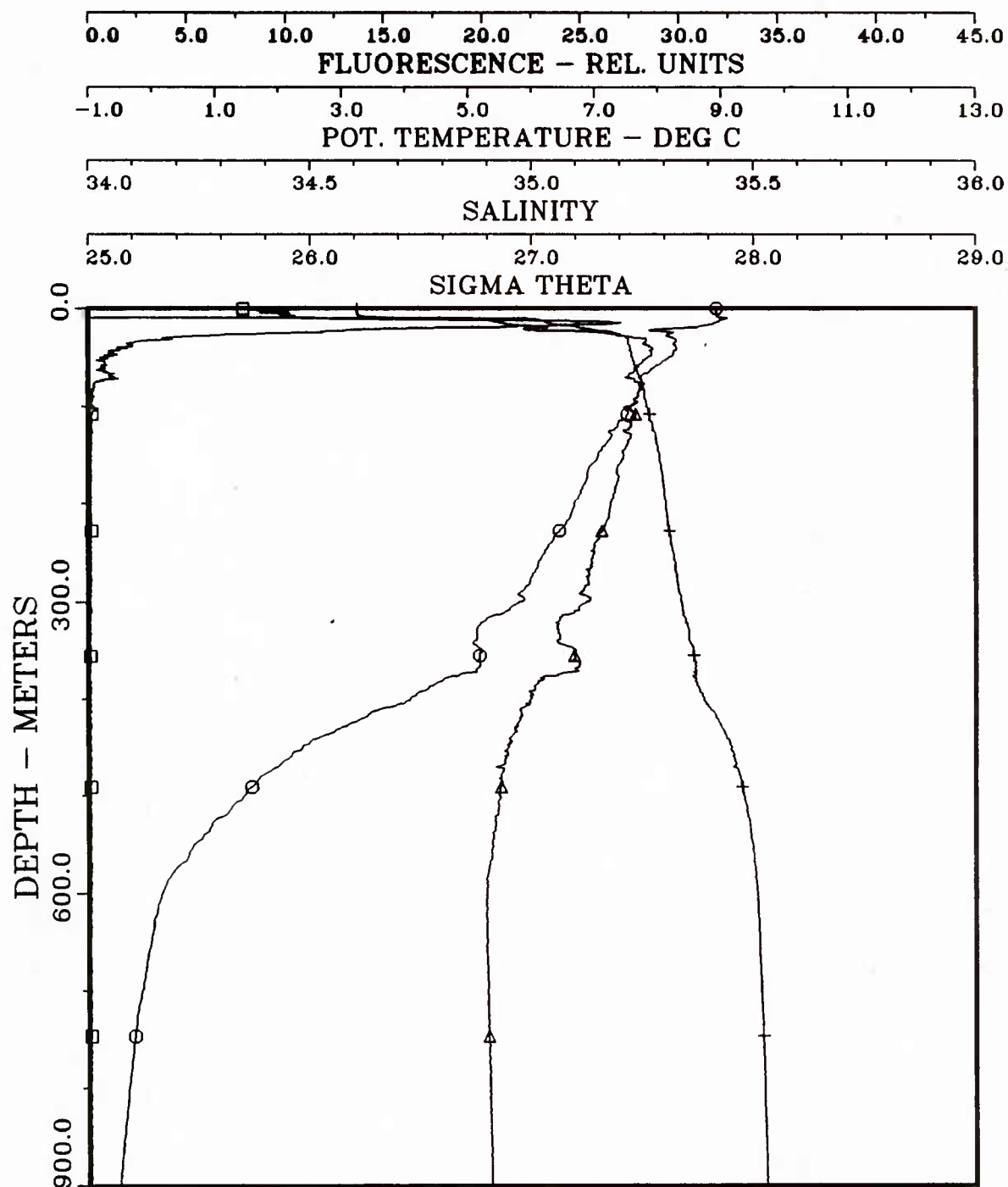
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14
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64 41.69N
001 23.28E

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	14	
CAST NUMBER	1	
JULIAN DATE	158.0330	
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LONGITUDE	001 23.28E	

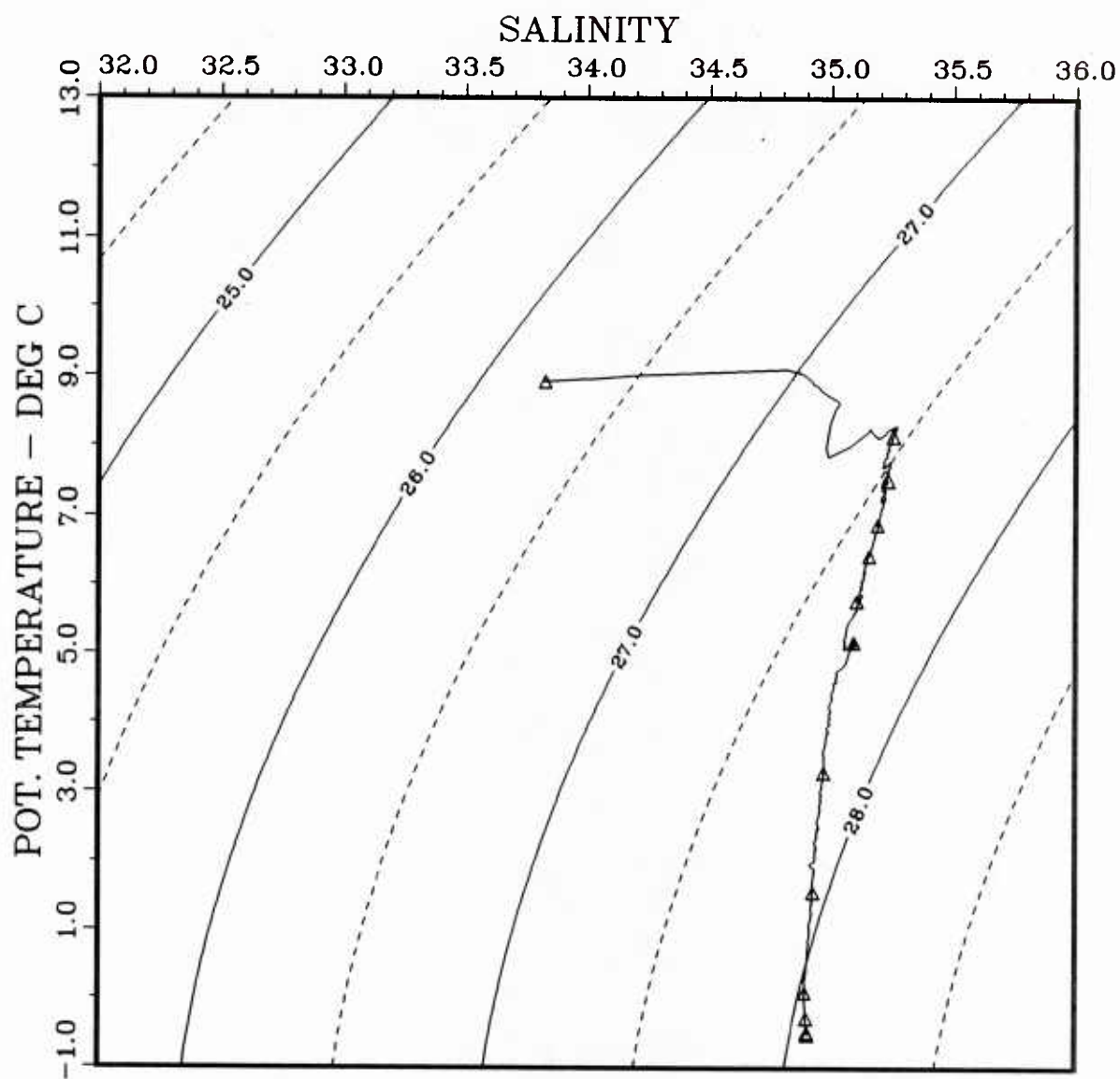


WFS PLANET
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CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

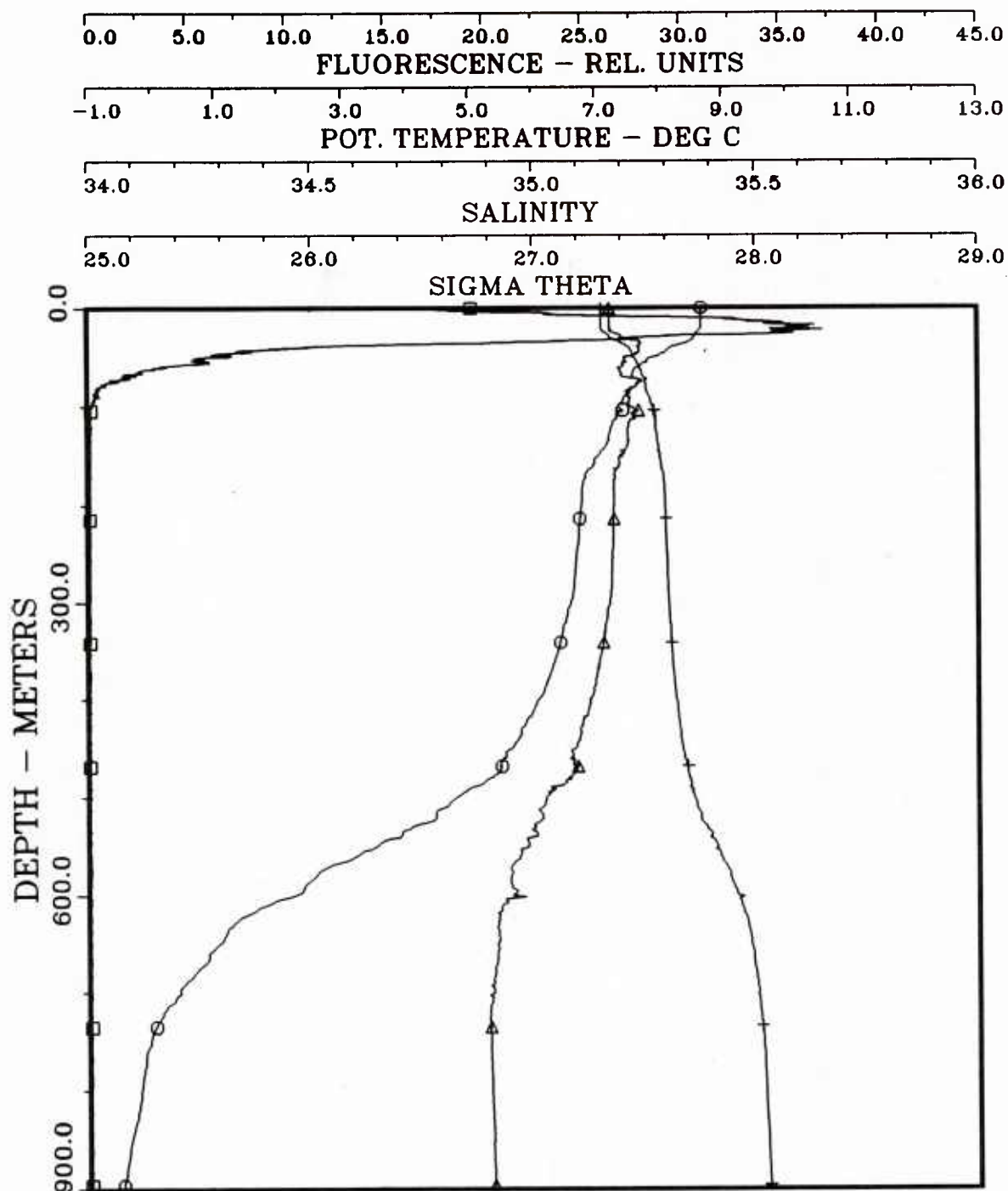
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JUNE 1987

LEGEND
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○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	15	
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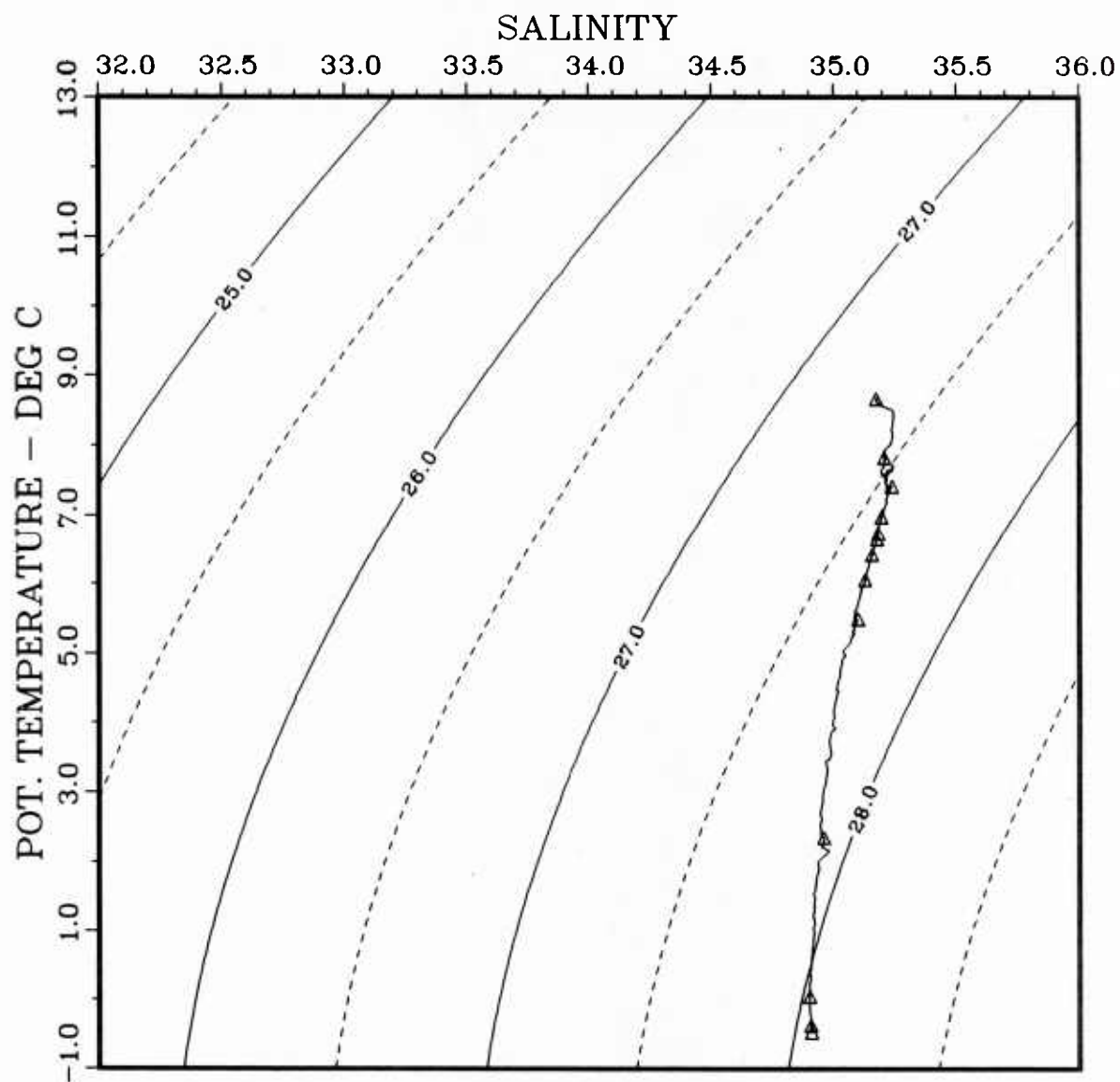


WFS PLANET
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CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

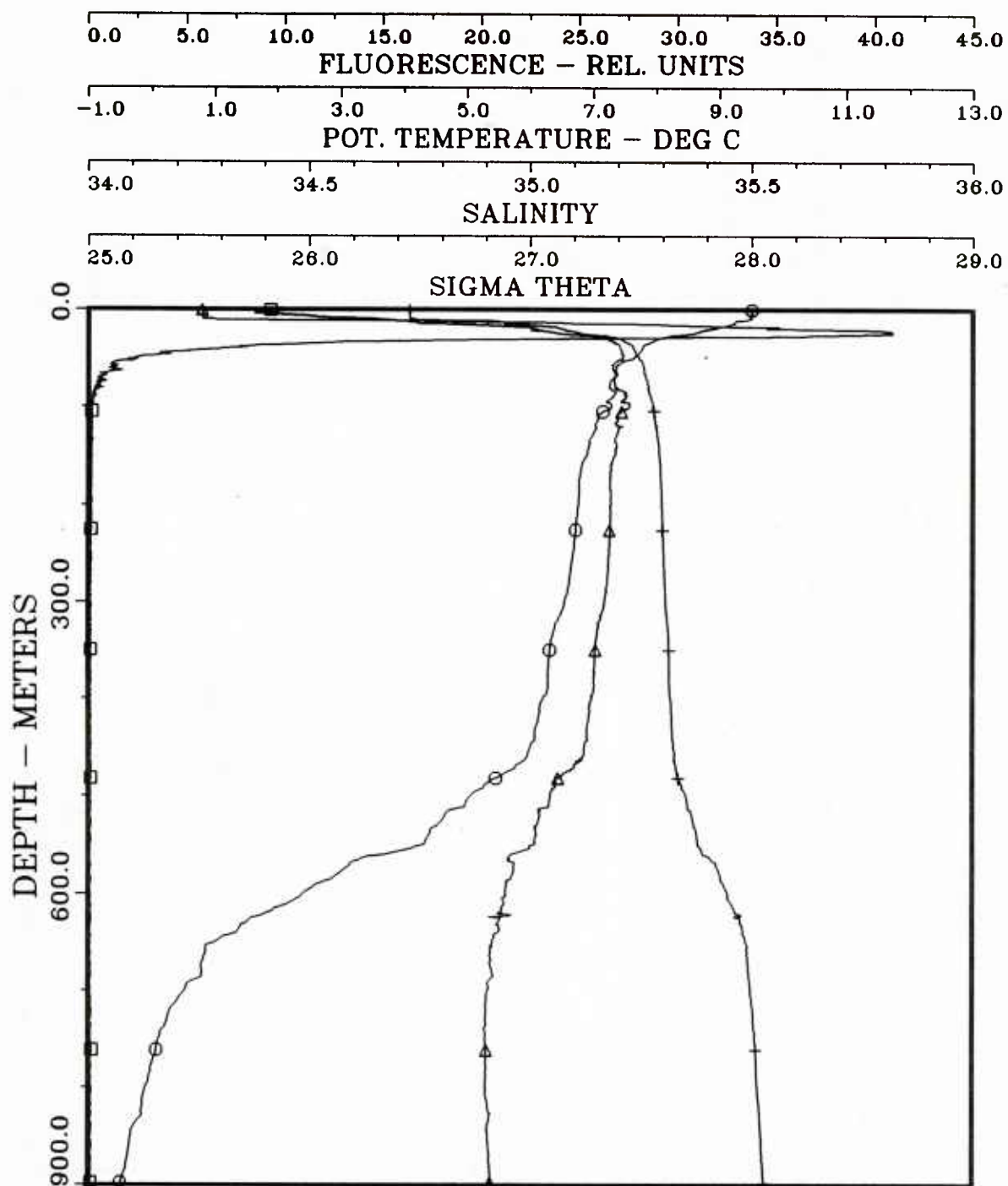
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JUNE 1987

LEGEND
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○ - POT. TEMPERATURE
△ - SALINITY
+ - SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
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CAST NUMBER	1	
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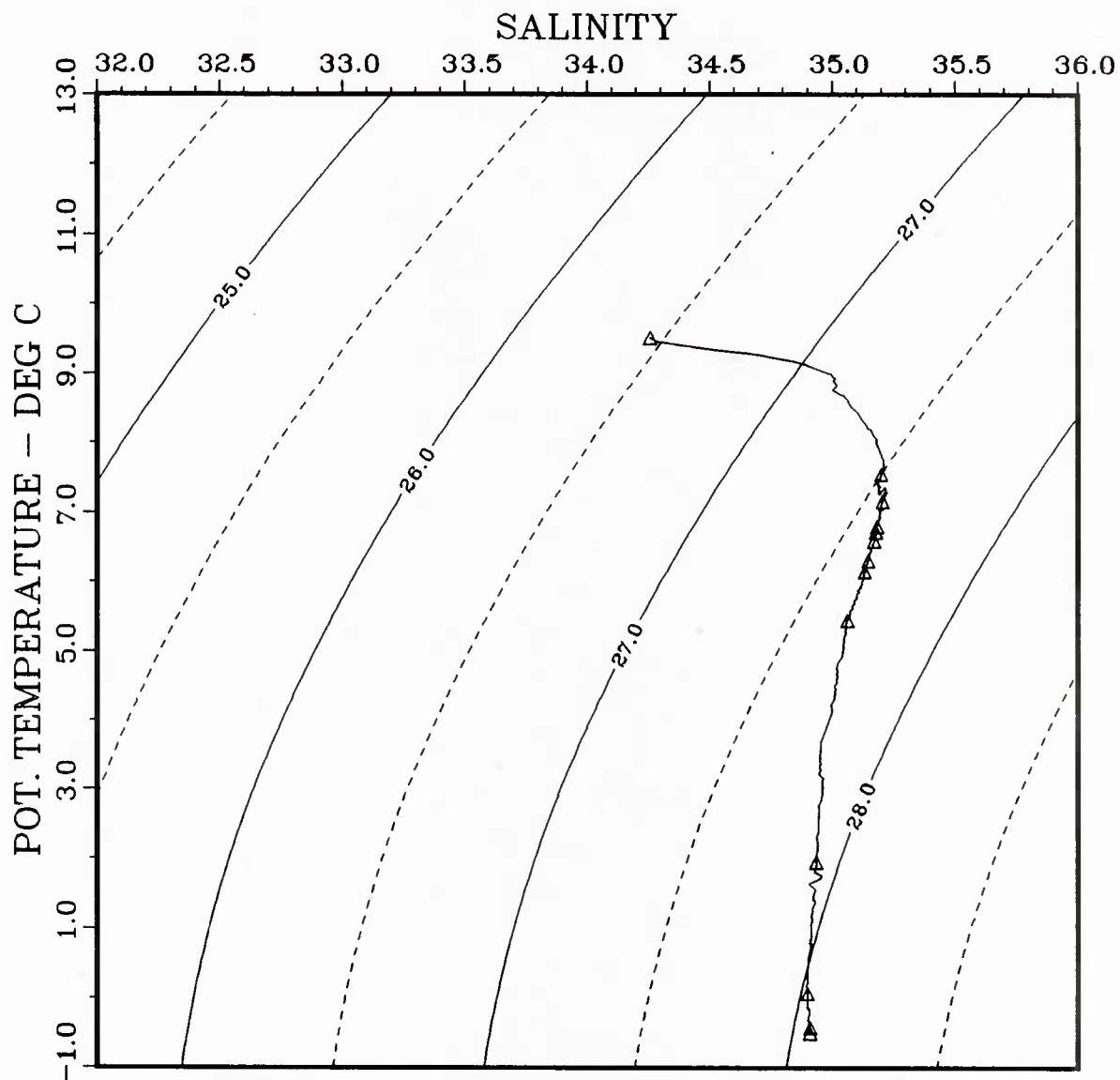


WFS PLANET
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JULIAN DATE
LATITUDE
LONGITUDE

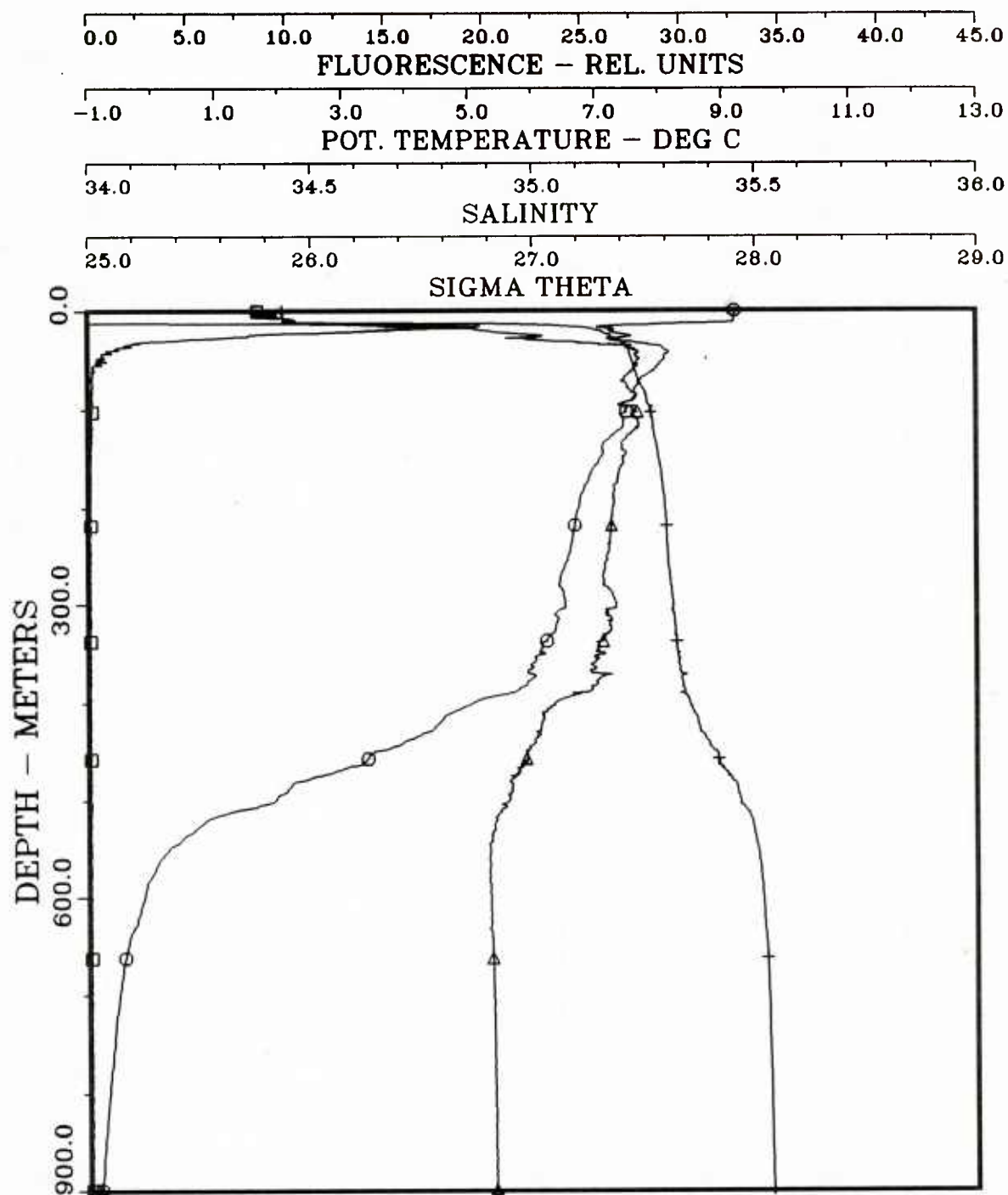
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JUNE 1987

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○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
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CAST NUMBER	1	
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LONGITUDE	003 36.16E	

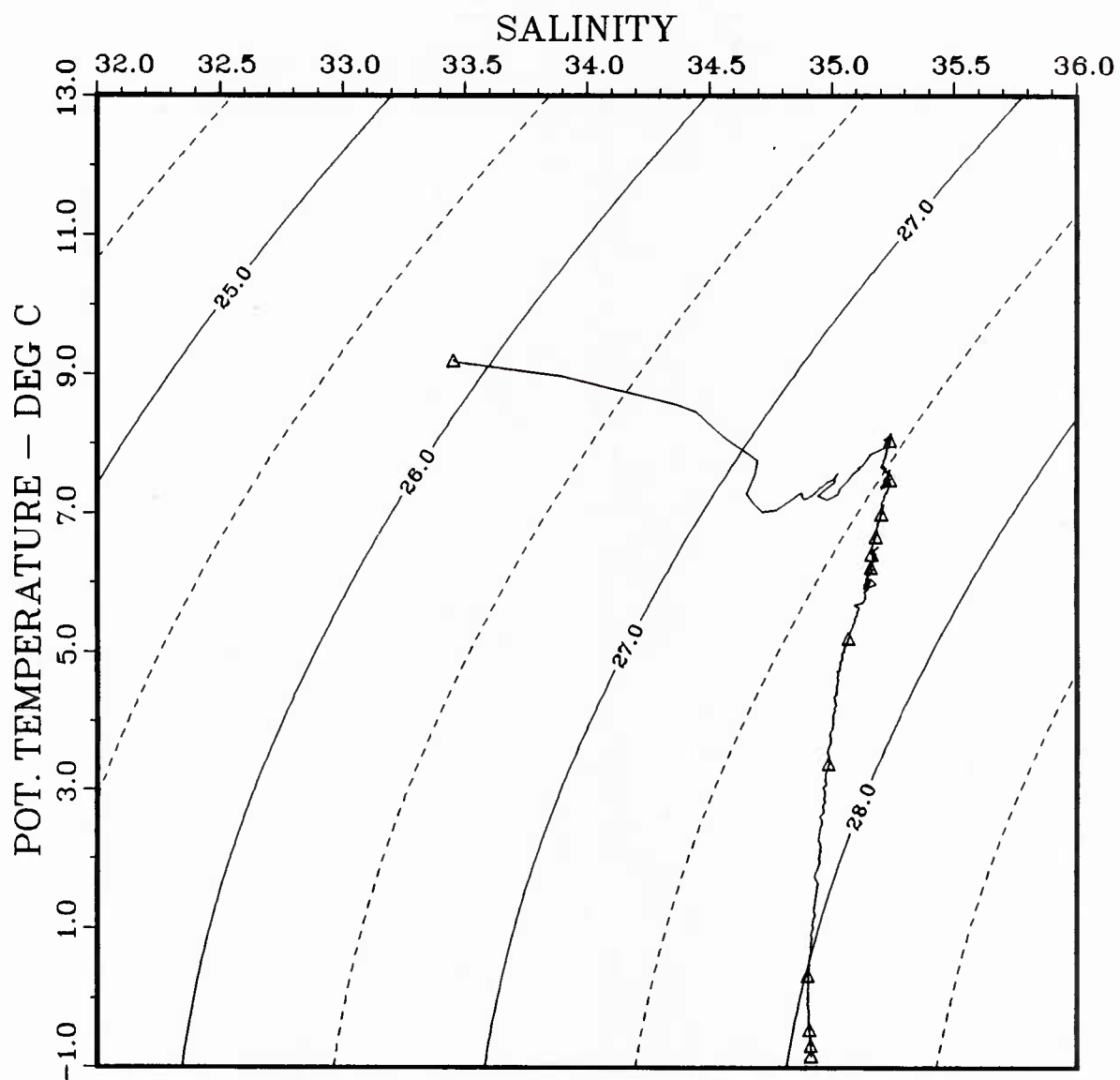


WFS PLANET
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CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

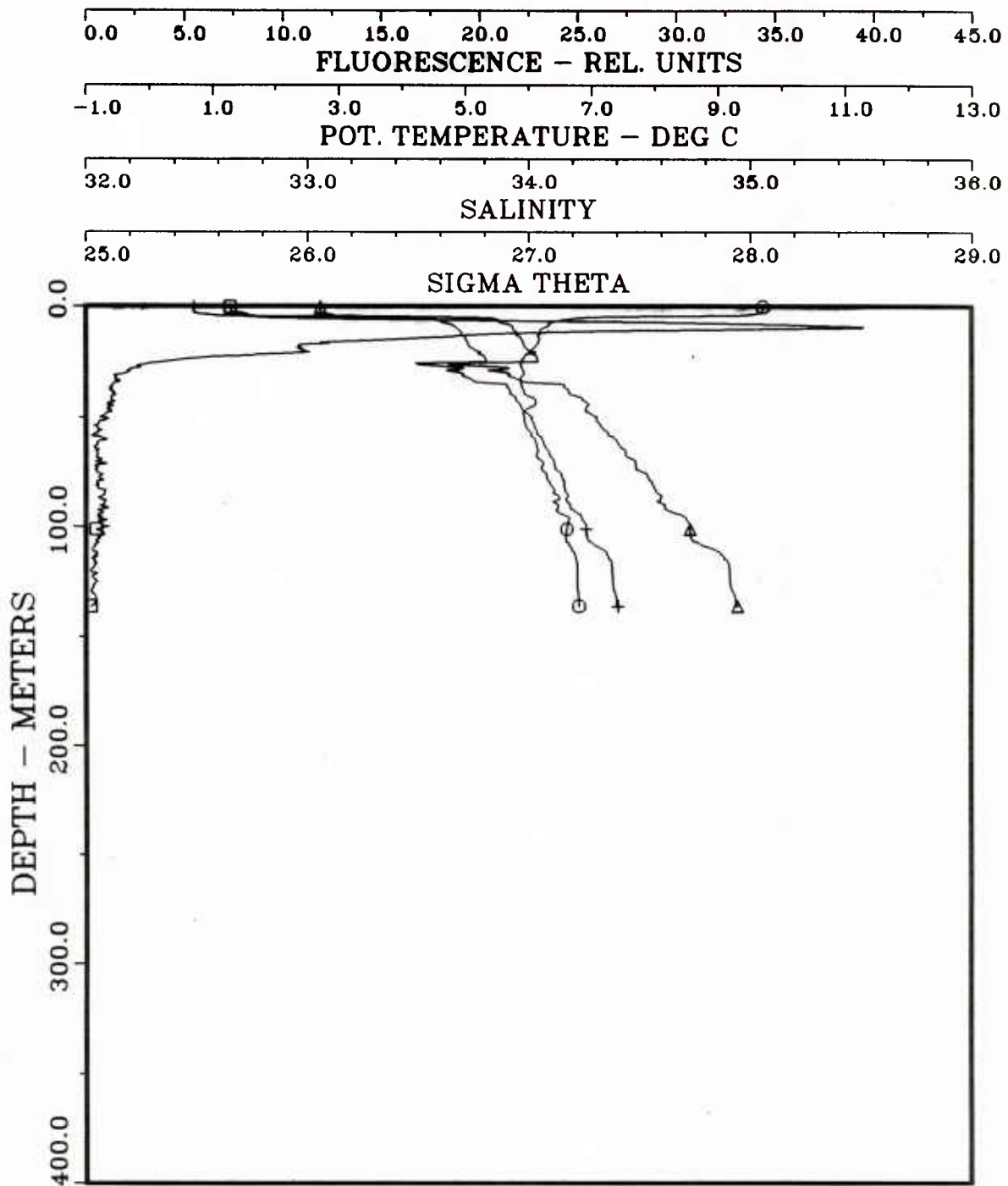
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JUNE 1987

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○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
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CAST NUMBER	1	
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LONGITUDE	004 25.45E	

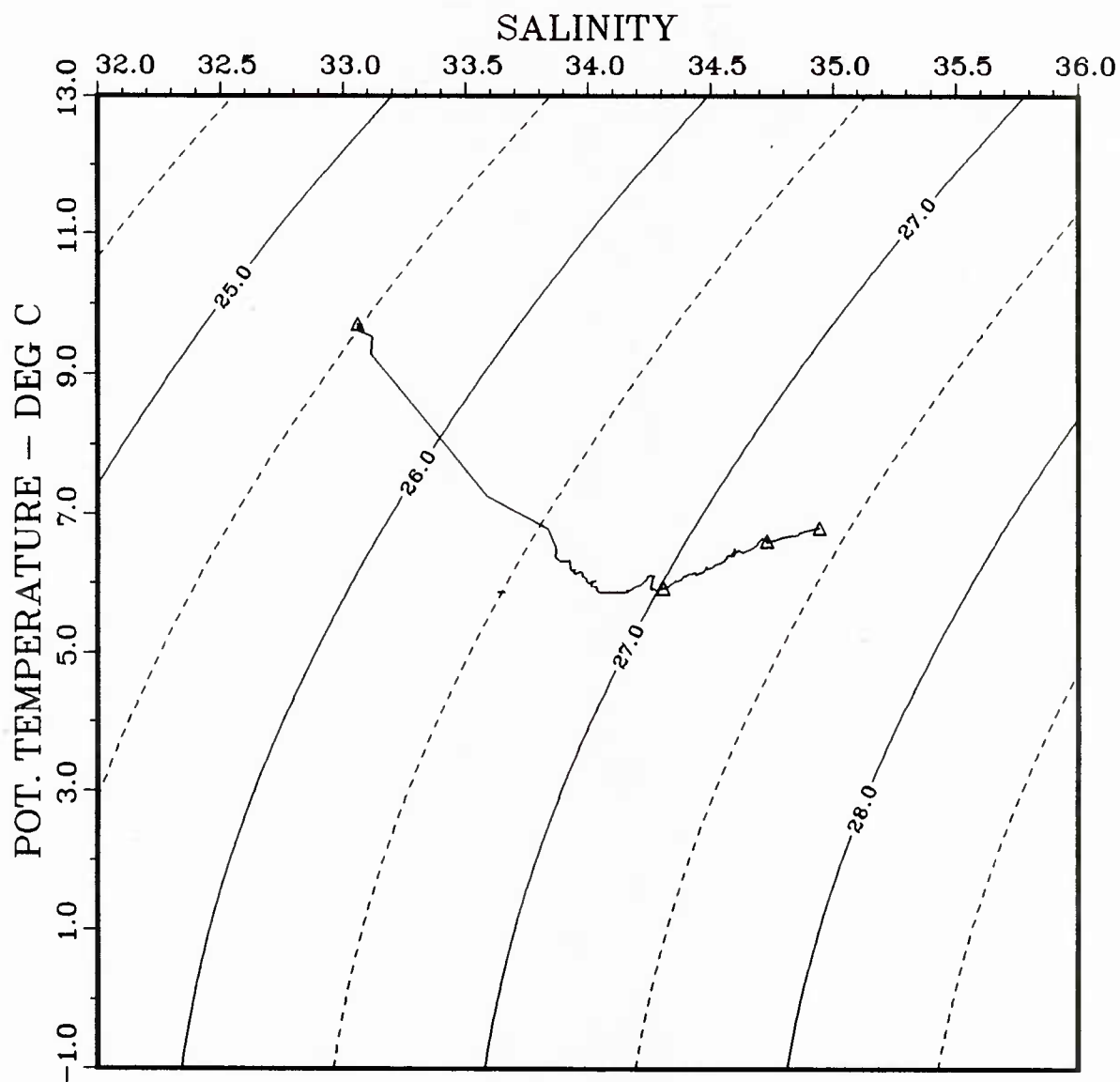


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CAST NUMBER
JULIAN DATE
LATITUDE
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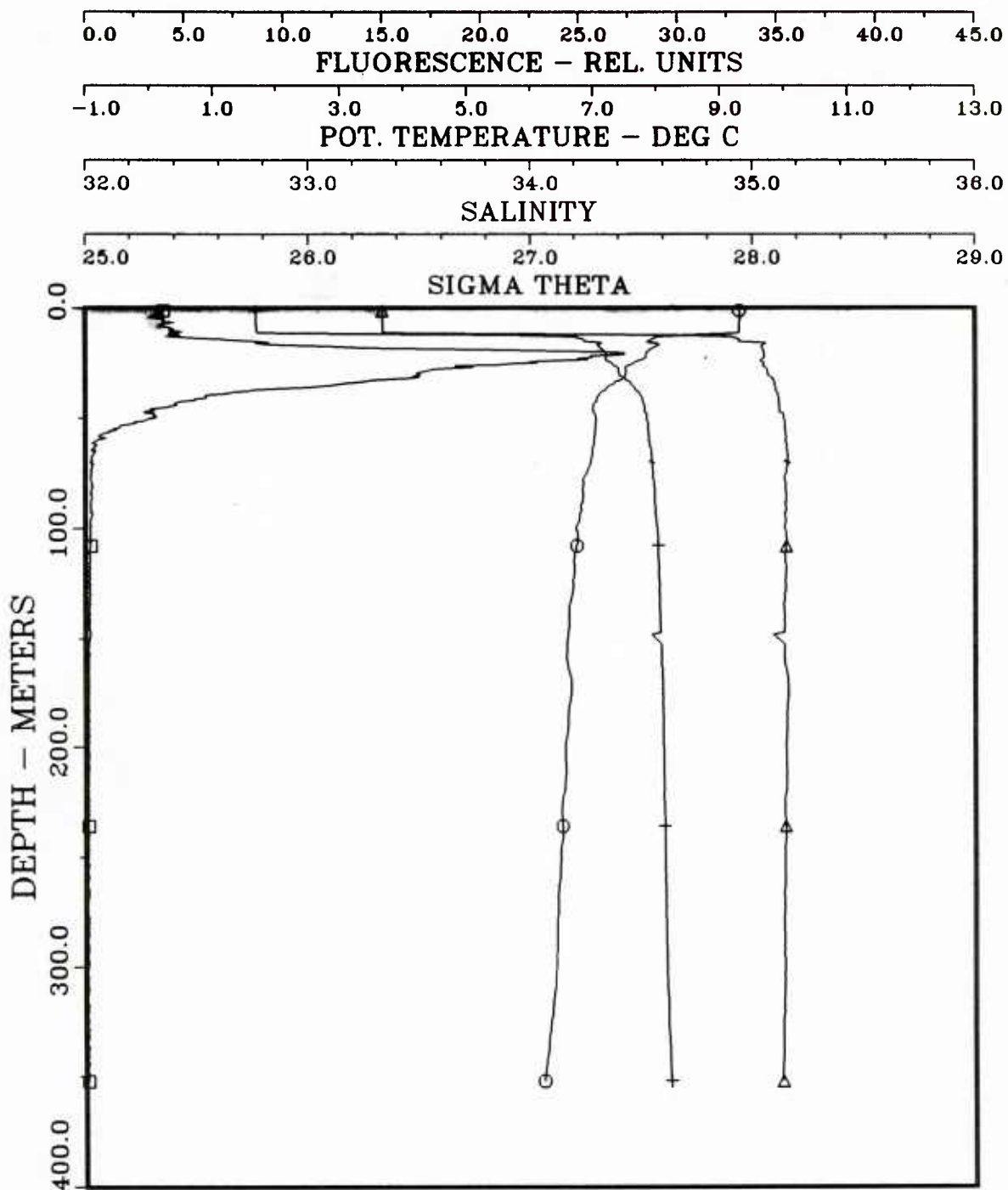
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19
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JUNE 1987

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○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	19	
CAST NUMBER	1	
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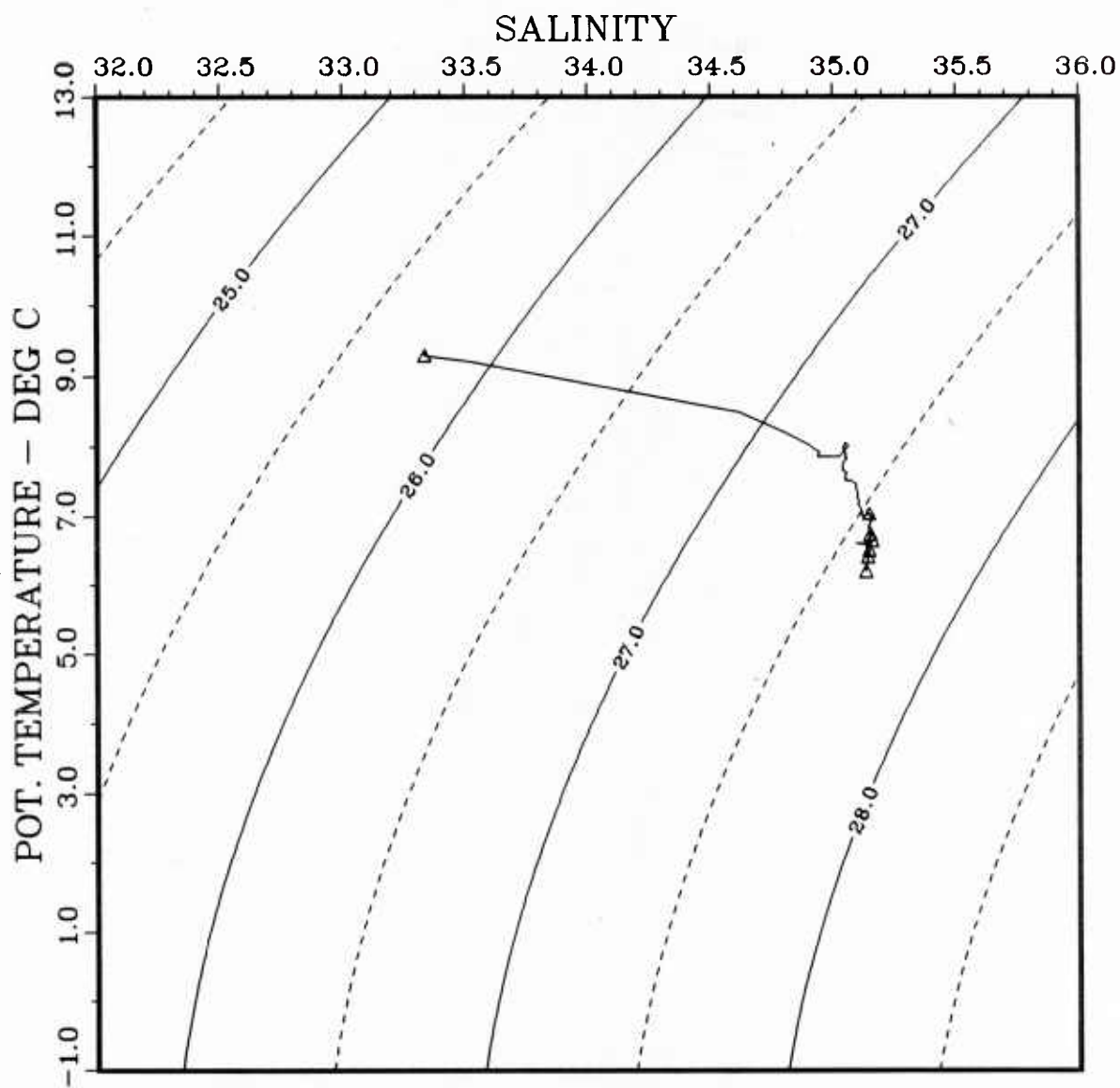


WFS PLANET
STATION
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JULIAN DATE
LATITUDE
LONGITUDE

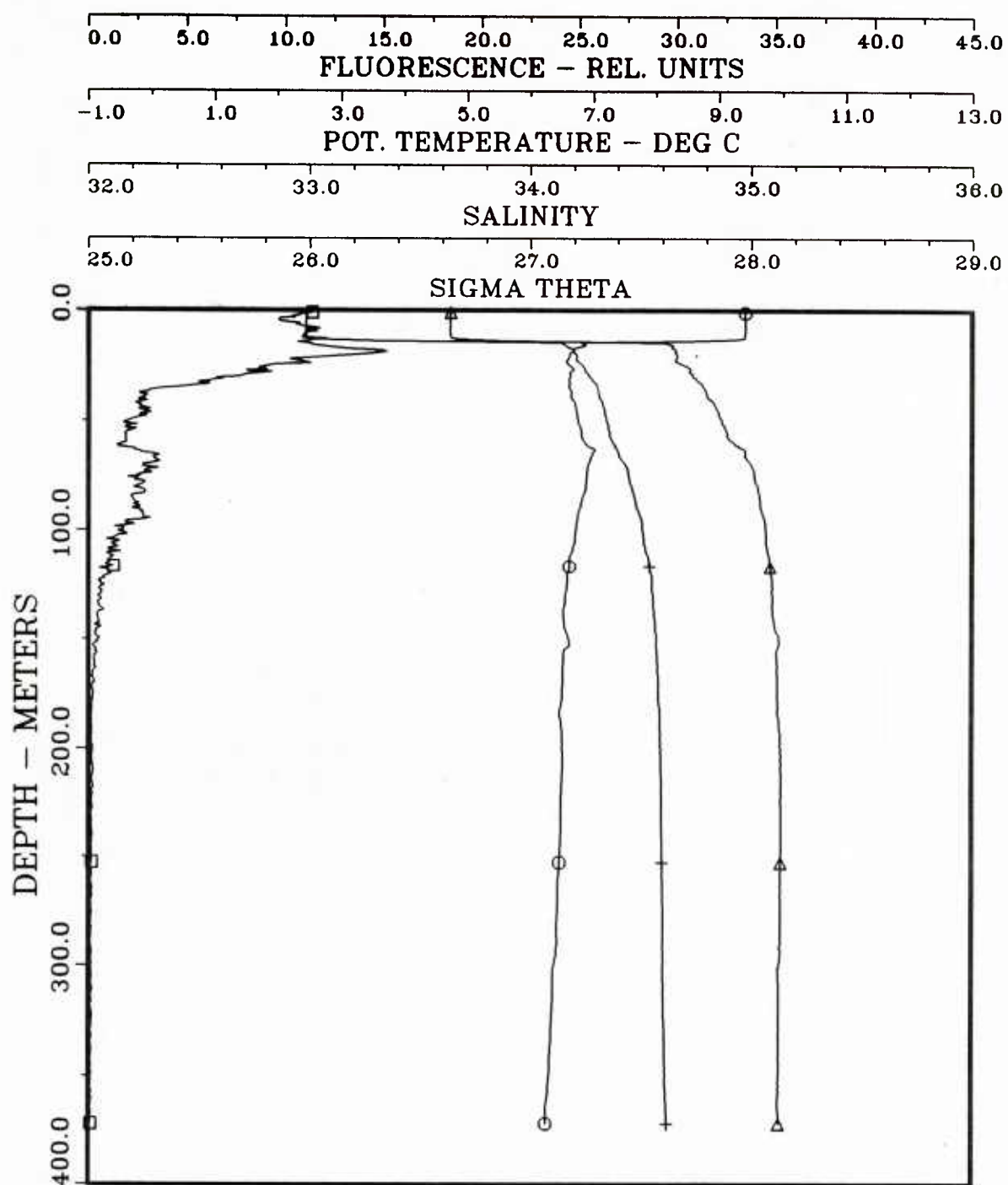
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65 31.95N
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JUNE 1987

LEGEND
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○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	20	
CAST NUMBER	1	
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LONGITUDE	009 31.29E	

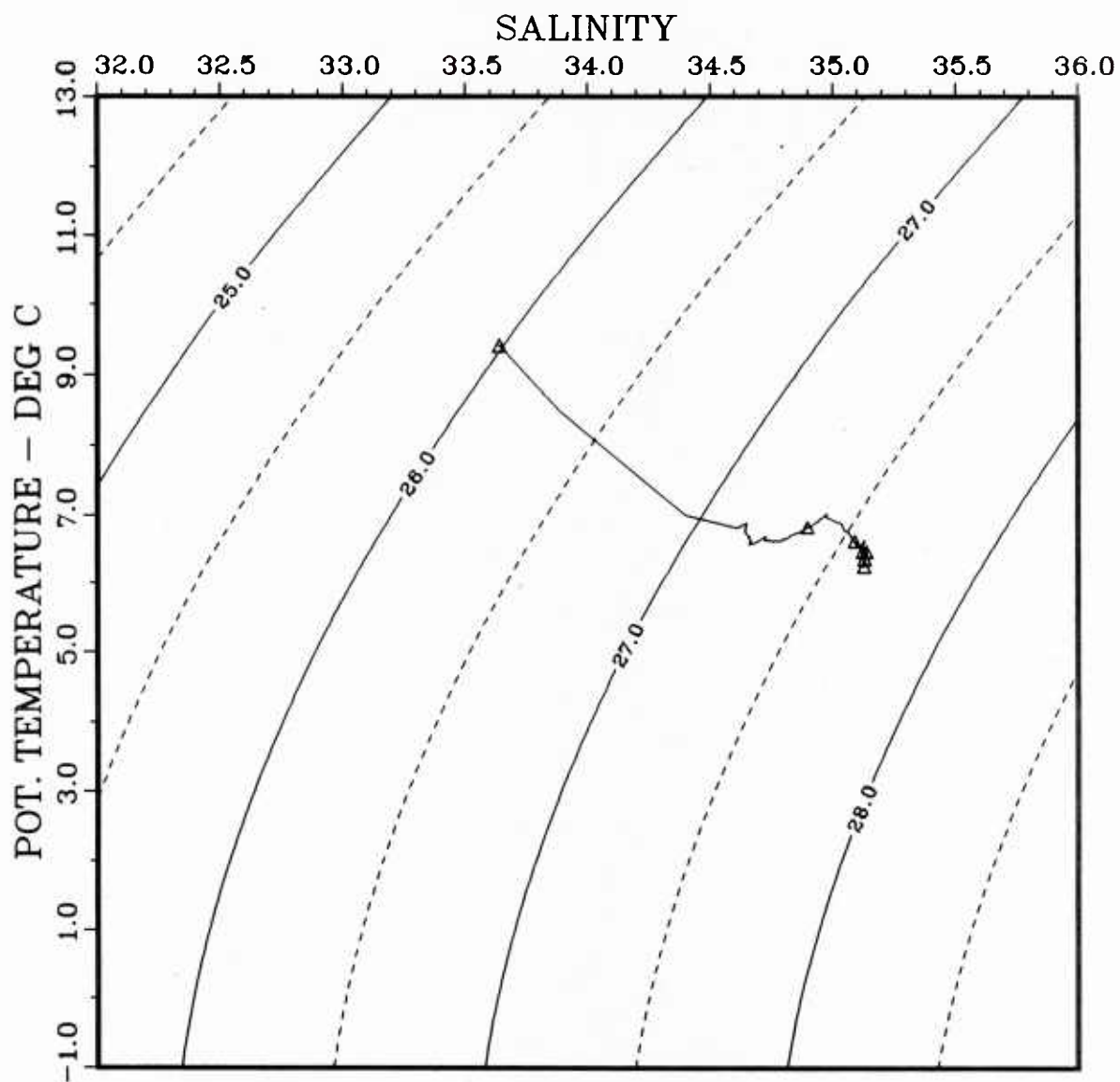


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

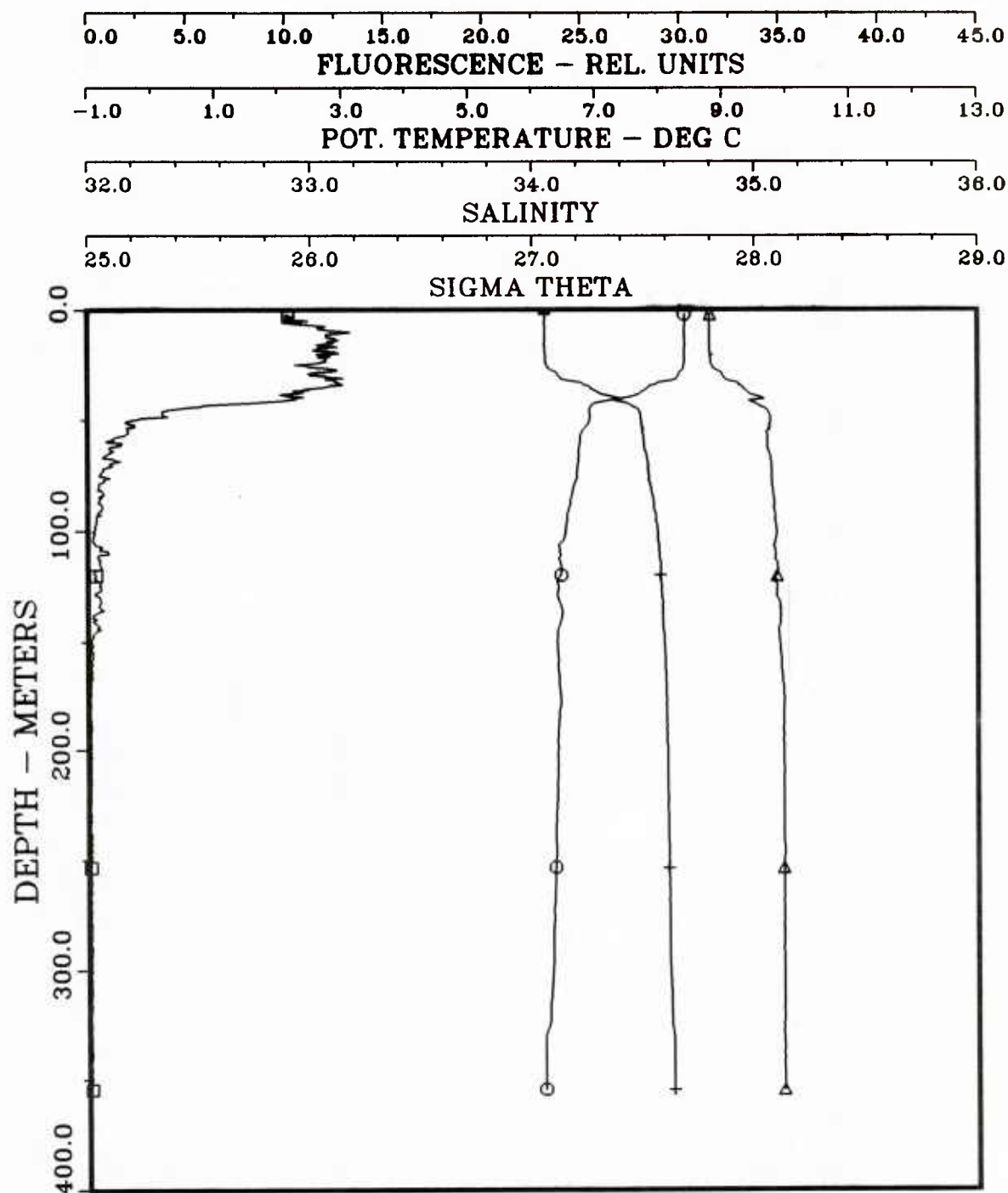
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JUNE 1987

LEGEND
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○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
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CAST NUMBER	1	
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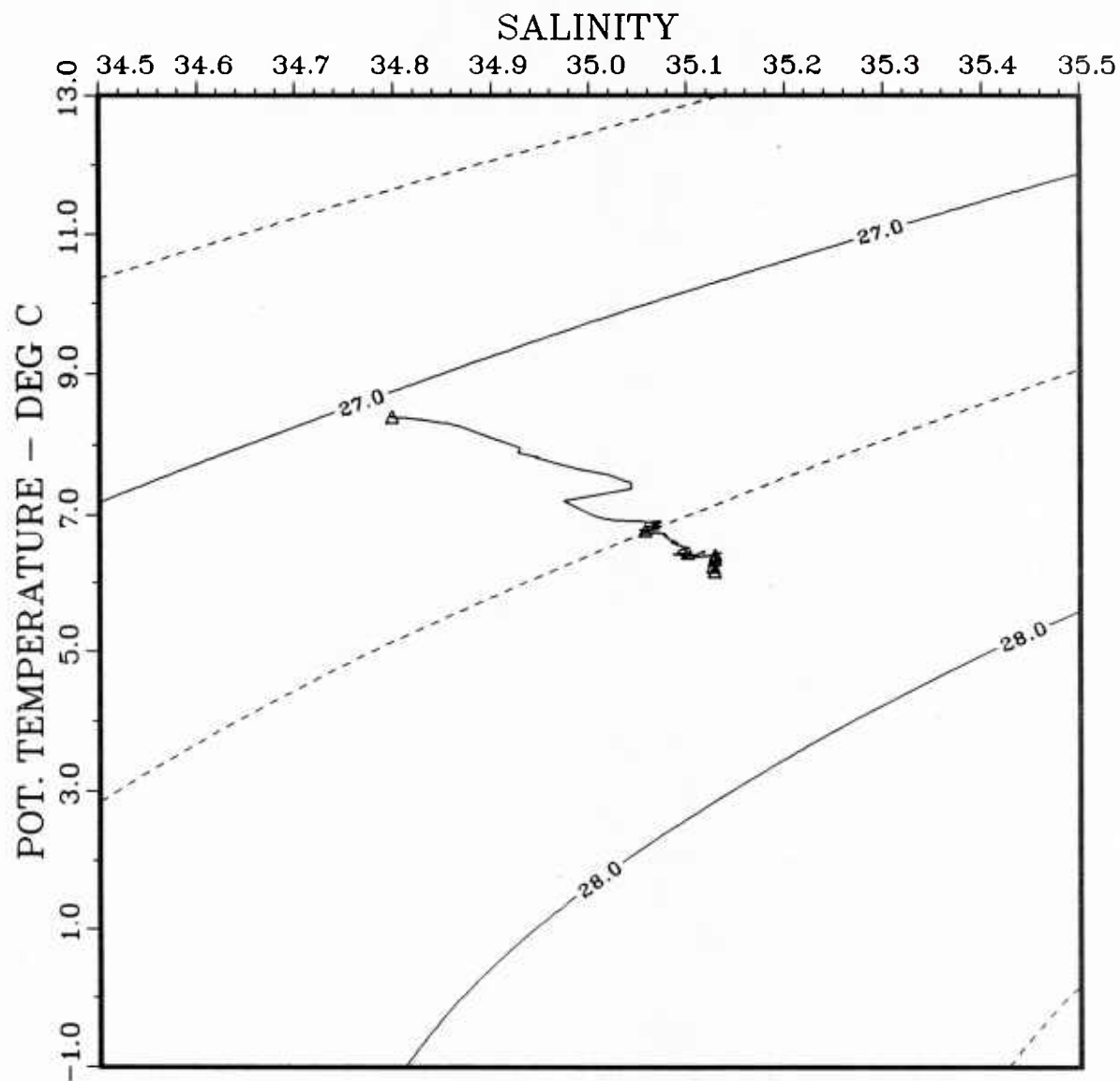


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

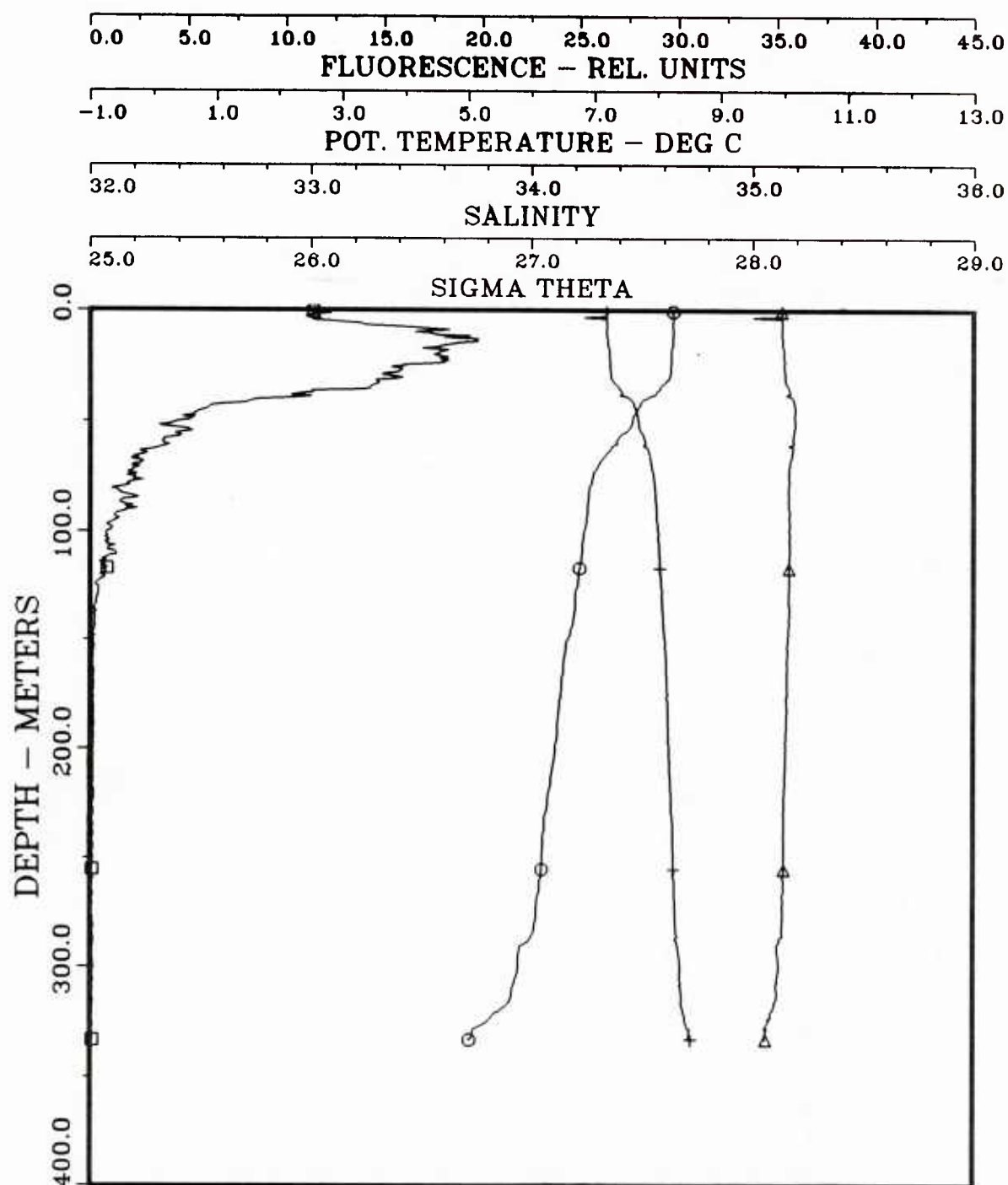
NORDMEER 87
22
1
161.0700
66 03.13N
008 03.29E

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	22	
CAST NUMBER	1	
JULIAN DATE	161.0700	
LATITUDE	66 03.13N	
LONGITUDE	008 03.29E	

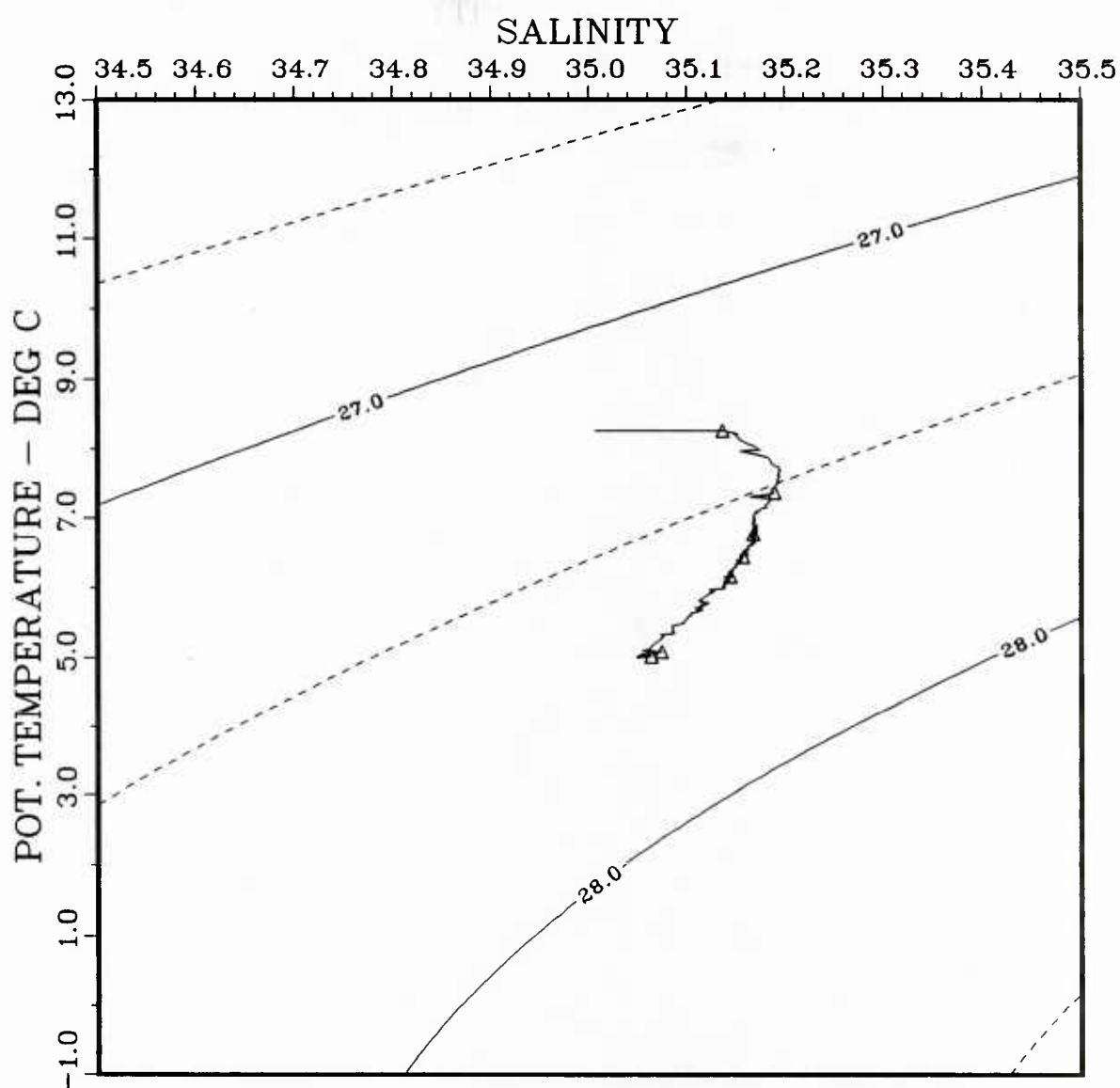


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

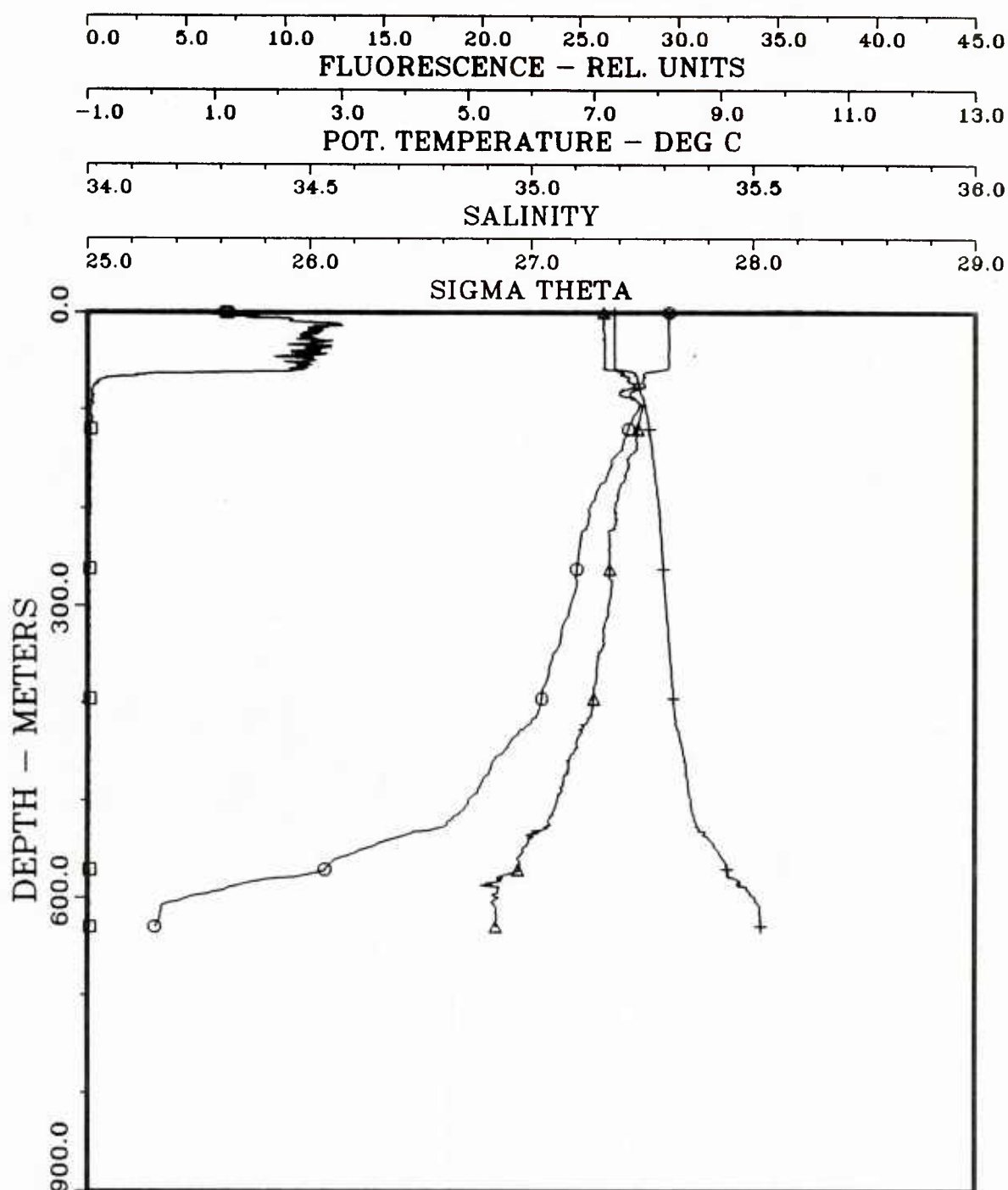
NORDMEER 87
23
1
161.0950
66 17.71N
007 18.60E

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	23	
CAST NUMBER	1	
JULIAN DATE	161.0950	
LATITUDE	66 17.71N	
LONGITUDE	007 18.60E	

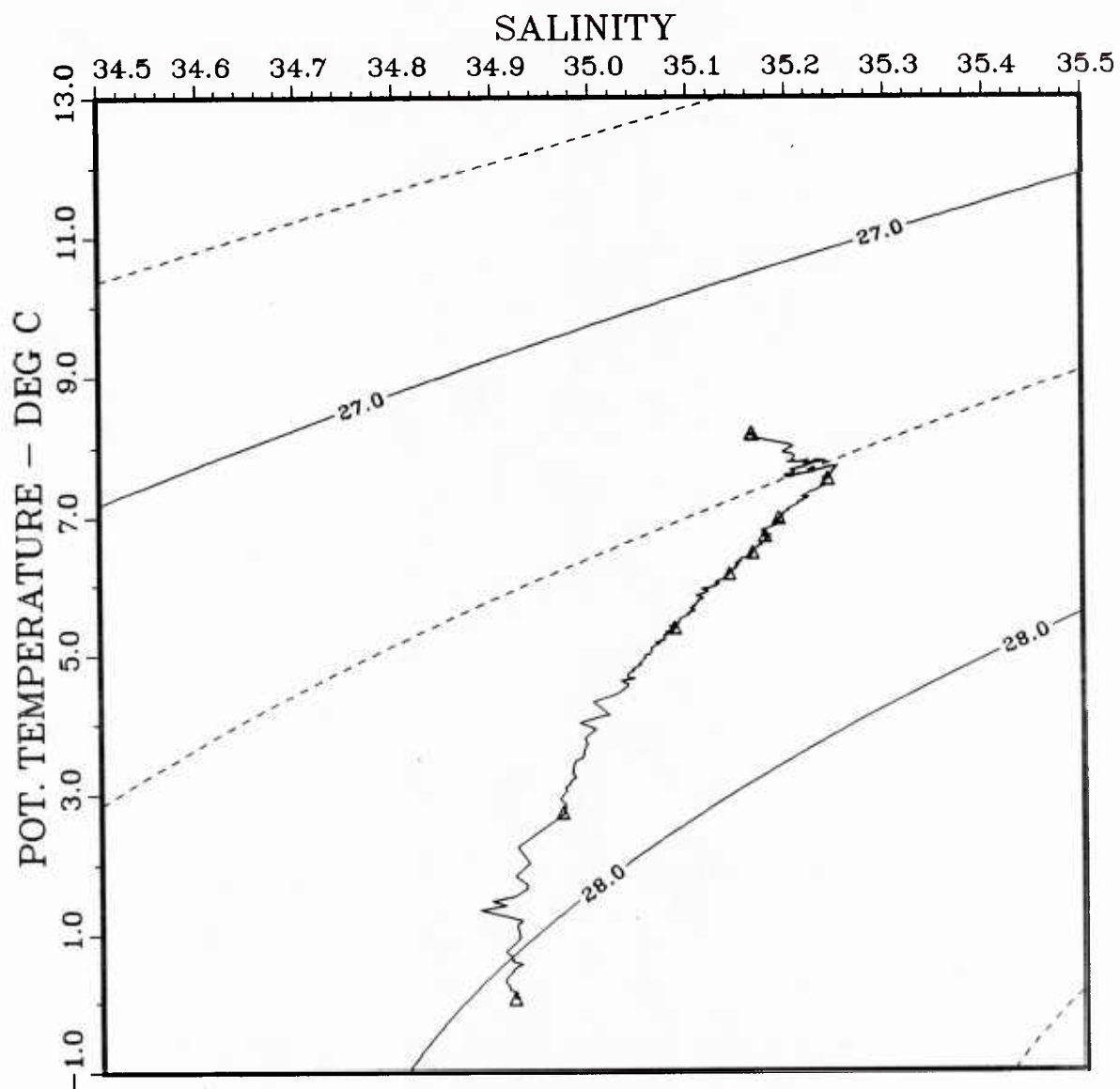


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

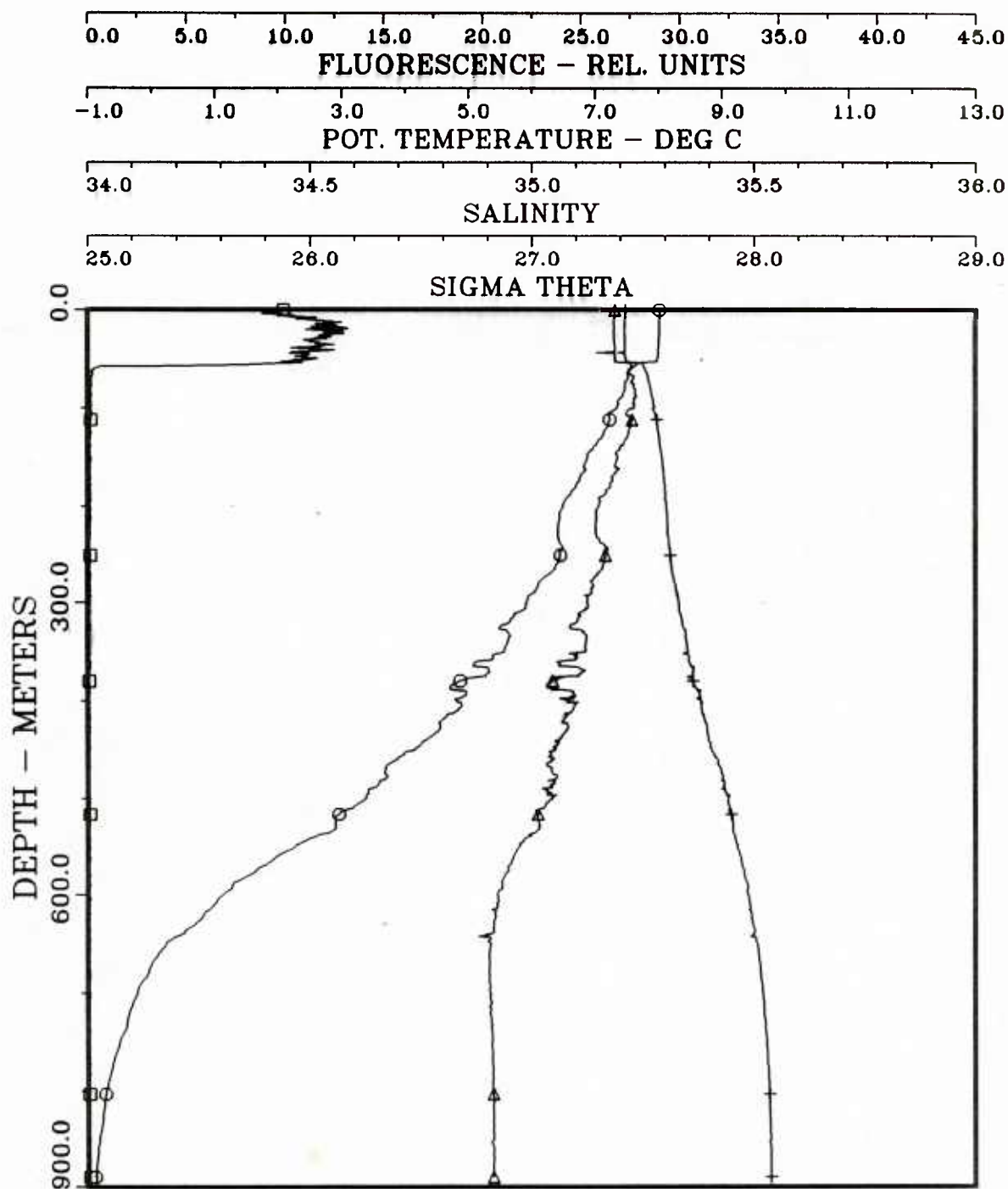
NORDMEER 87
24
1
161.1240
66 31.34N
006 31.31E

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	24	
CAST NUMBER	1	
JULIAN DATE	161.1240	
LATITUDE	66 31.34N	
LONGITUDE	006 31.31E	

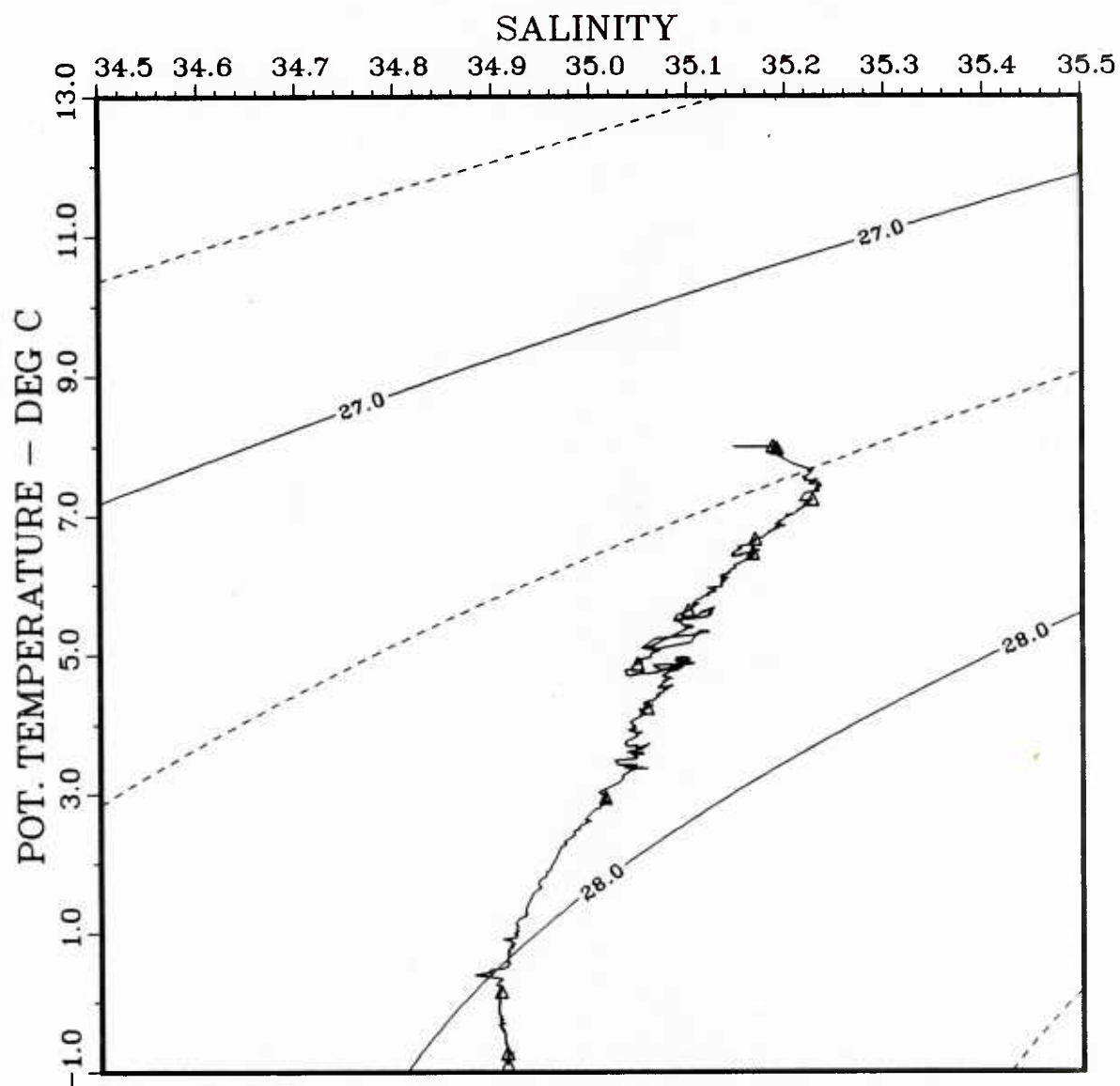


WFS PLANET
 STATION
 CAST NUMBER
 JULIAN DATE
 LATITUDE
 LONGITUDE

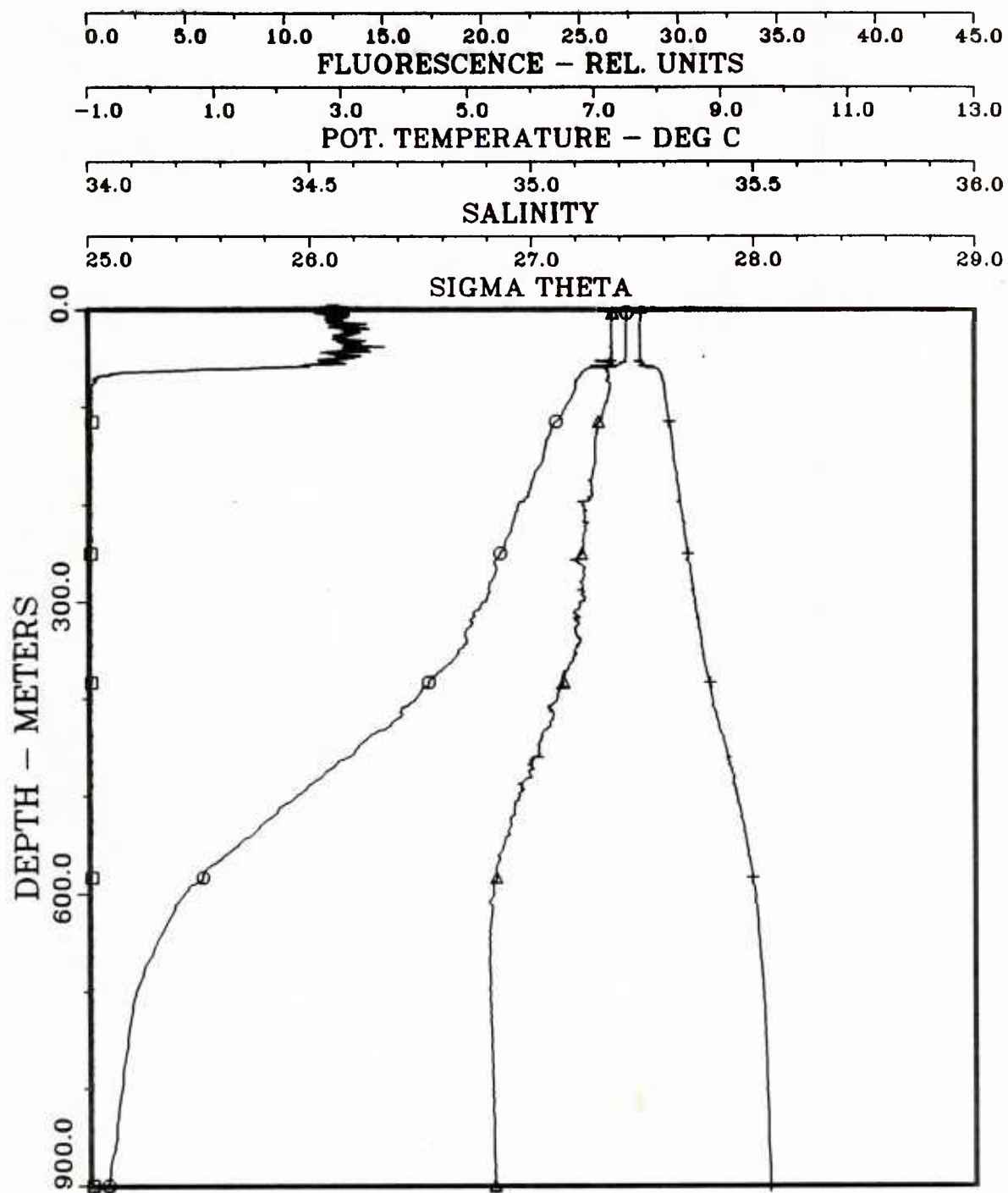
NORDMEER 87
 25
 1
 161.1520
 66 44.96N
 005 50.32E

JUNE 1987

LEGEND
 □ = FLUORESCENCE
 ○ = POT. TEMPERATURE
 △ = SALINITY
 + = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	25	
CAST NUMBER	1	
JULIAN DATE	161.1520	
LATITUDE	66 44.96N	
LONGITUDE	005 50.32E	

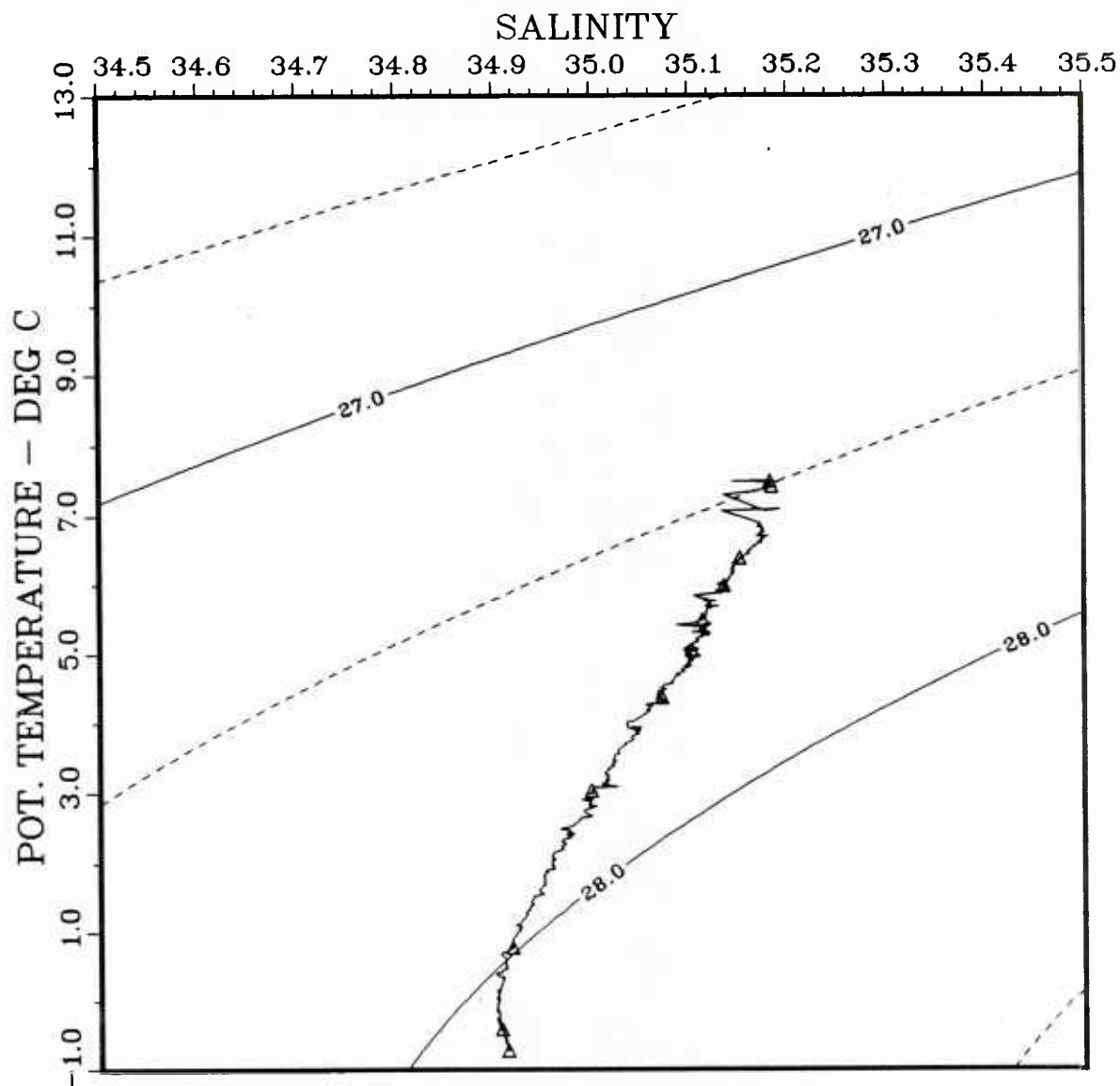


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

NORDMEER 87
26
1
161.1820
66 58.08N
005 04.36E

JUNE 1987

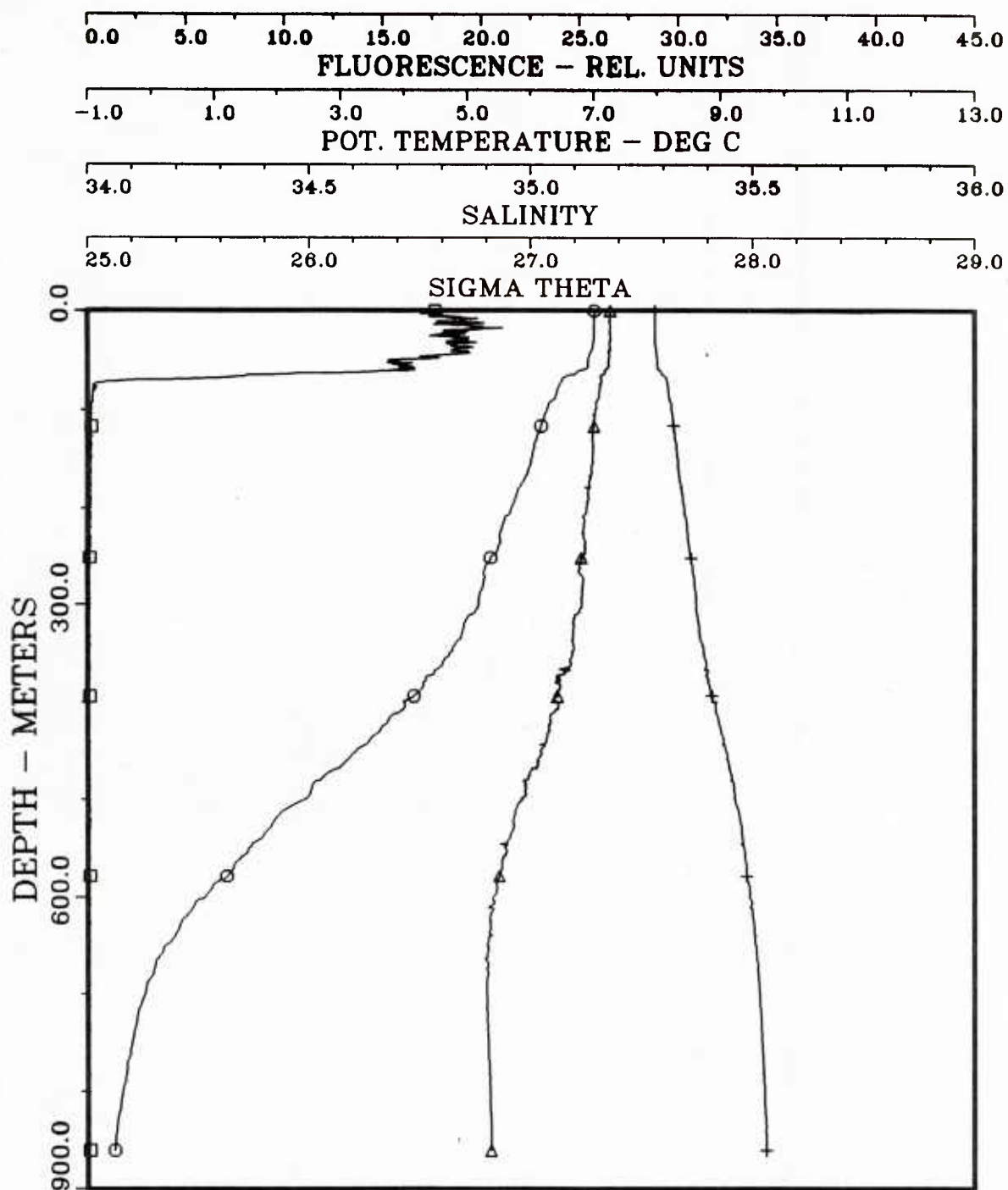
LEGEND
□ - FLUORESCENCE
○ - POT. TEMPERATURE
△ - SALINITY
+ - SIGMA THETA



WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

NORDMEER 87
26
1
161.1820
66 58.08N
005 04.36E

JUNE 1987

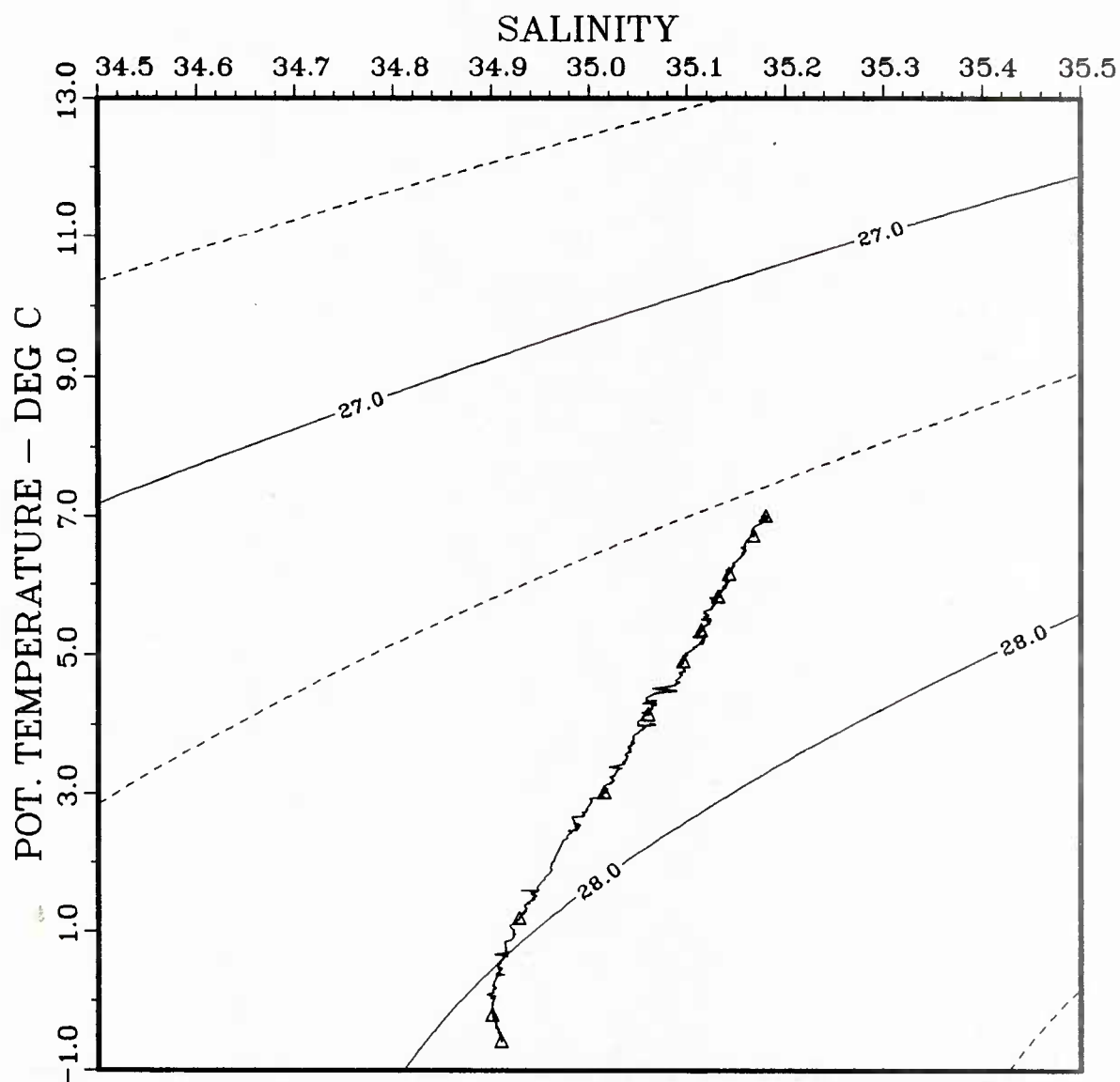


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

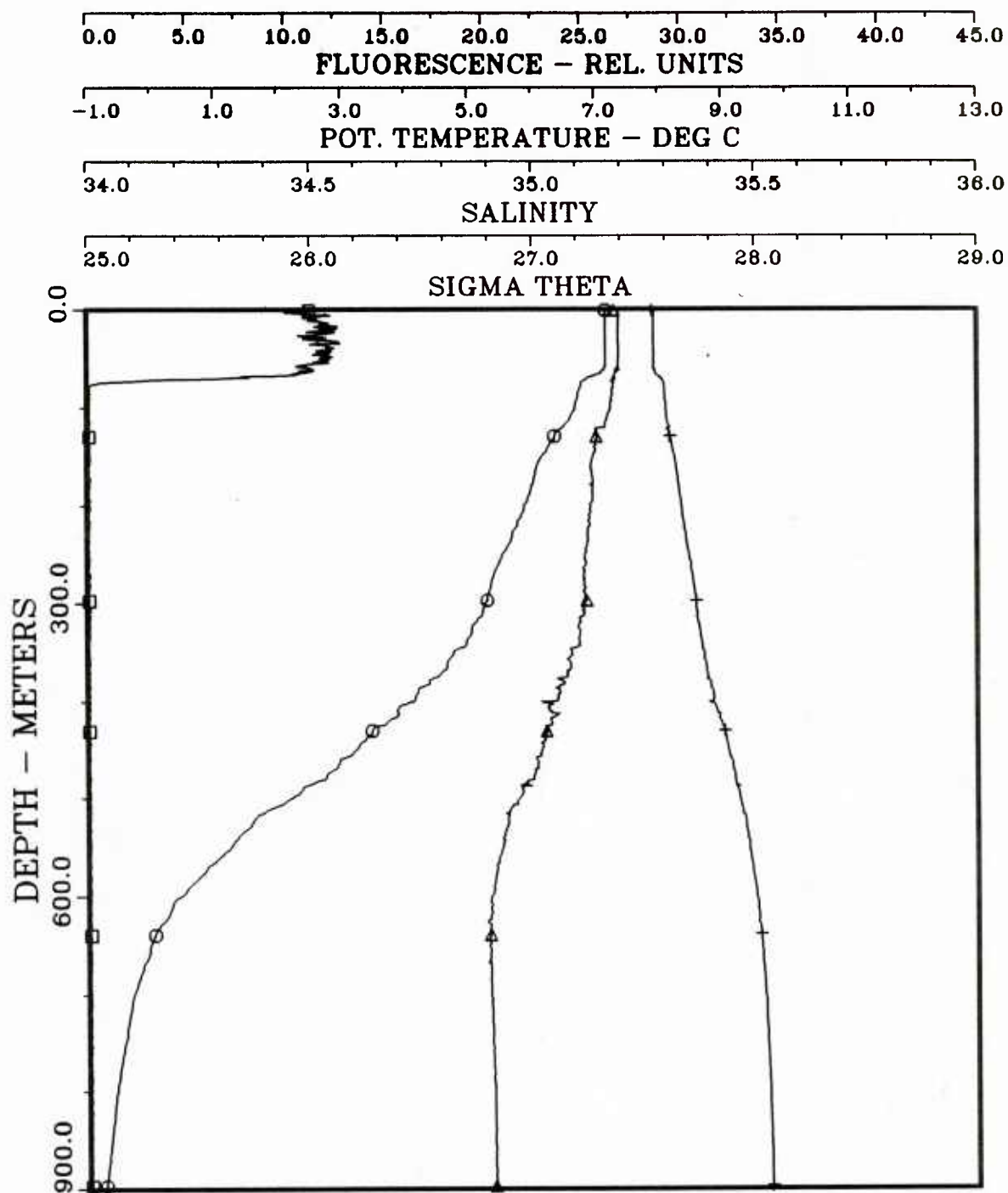
NORDMEER 87
27
1
161.2100
67 10.68N
004 23.95E

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	27	
CAST NUMBER	1	
JULIAN DATE	161.2100	
LATITUDE	67 10.68N	
LONGITUDE	004 23.95E	

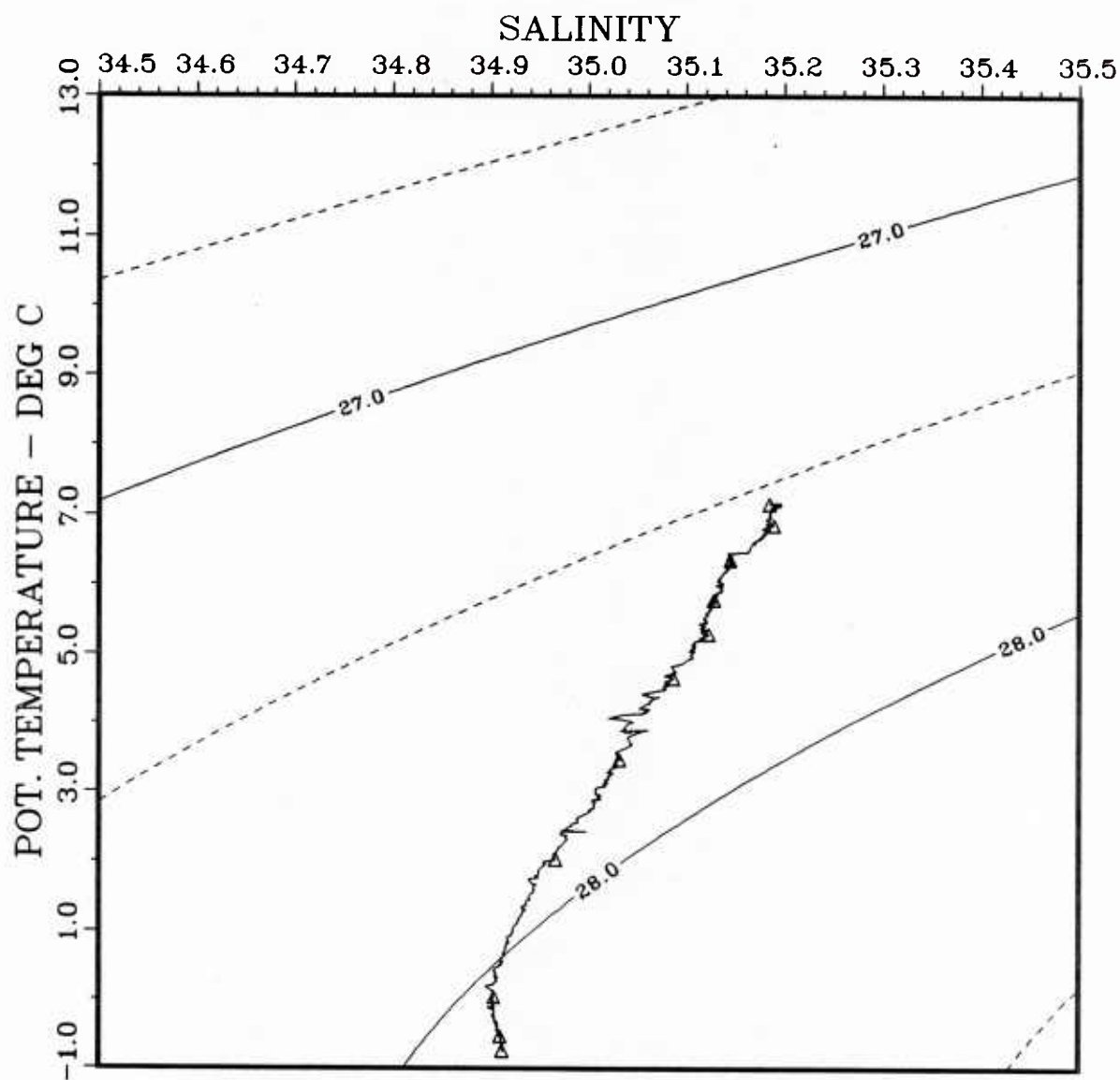


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

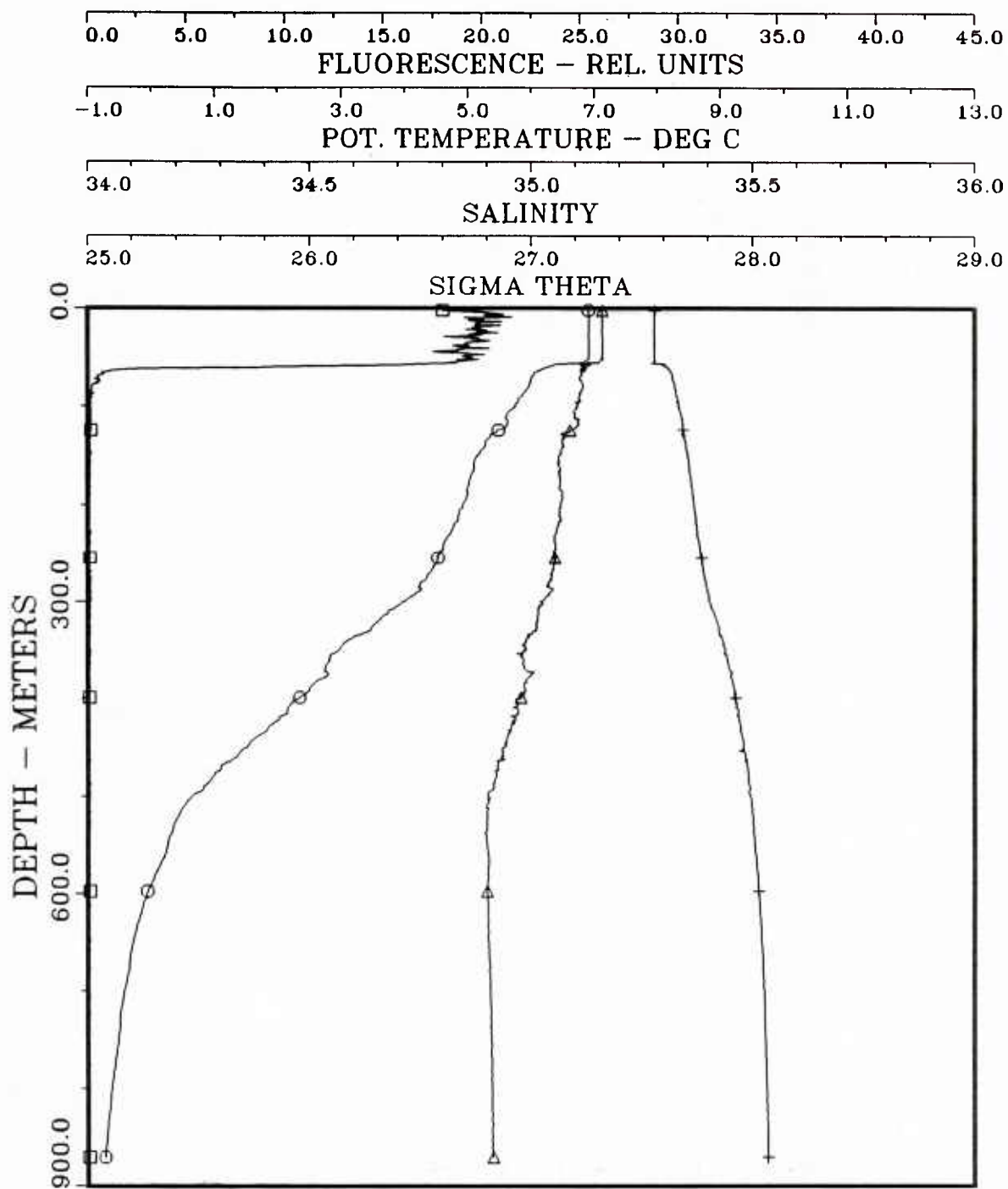
NORDMEER 87
28
1
161.2350
66 23.50N
003 36.88E

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	28	
CAST NUMBER	1	
JULIAN DATE	161.2350	
LATITUDE	66 23.50N	
LONGITUDE	003 36.88E	

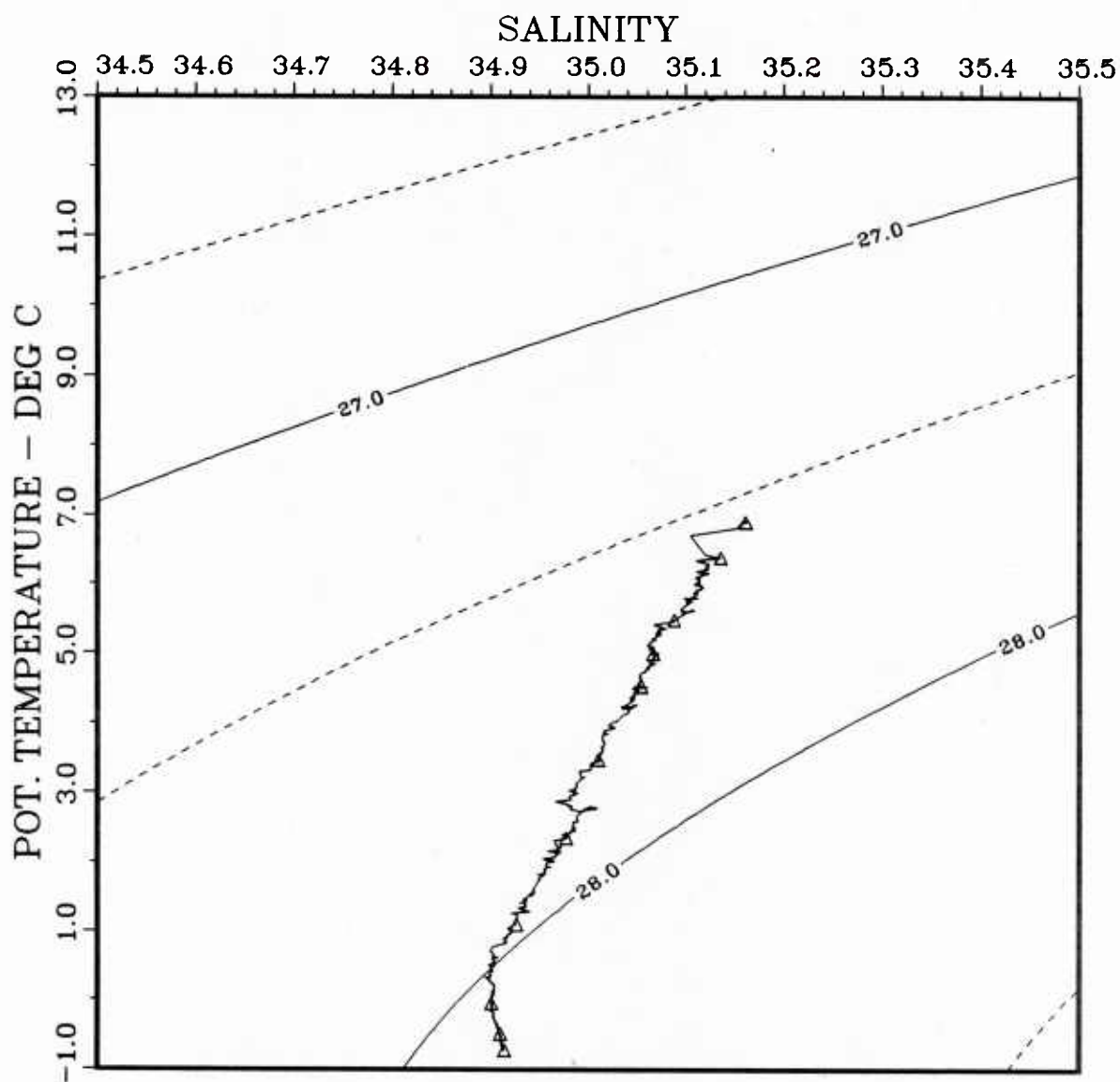


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

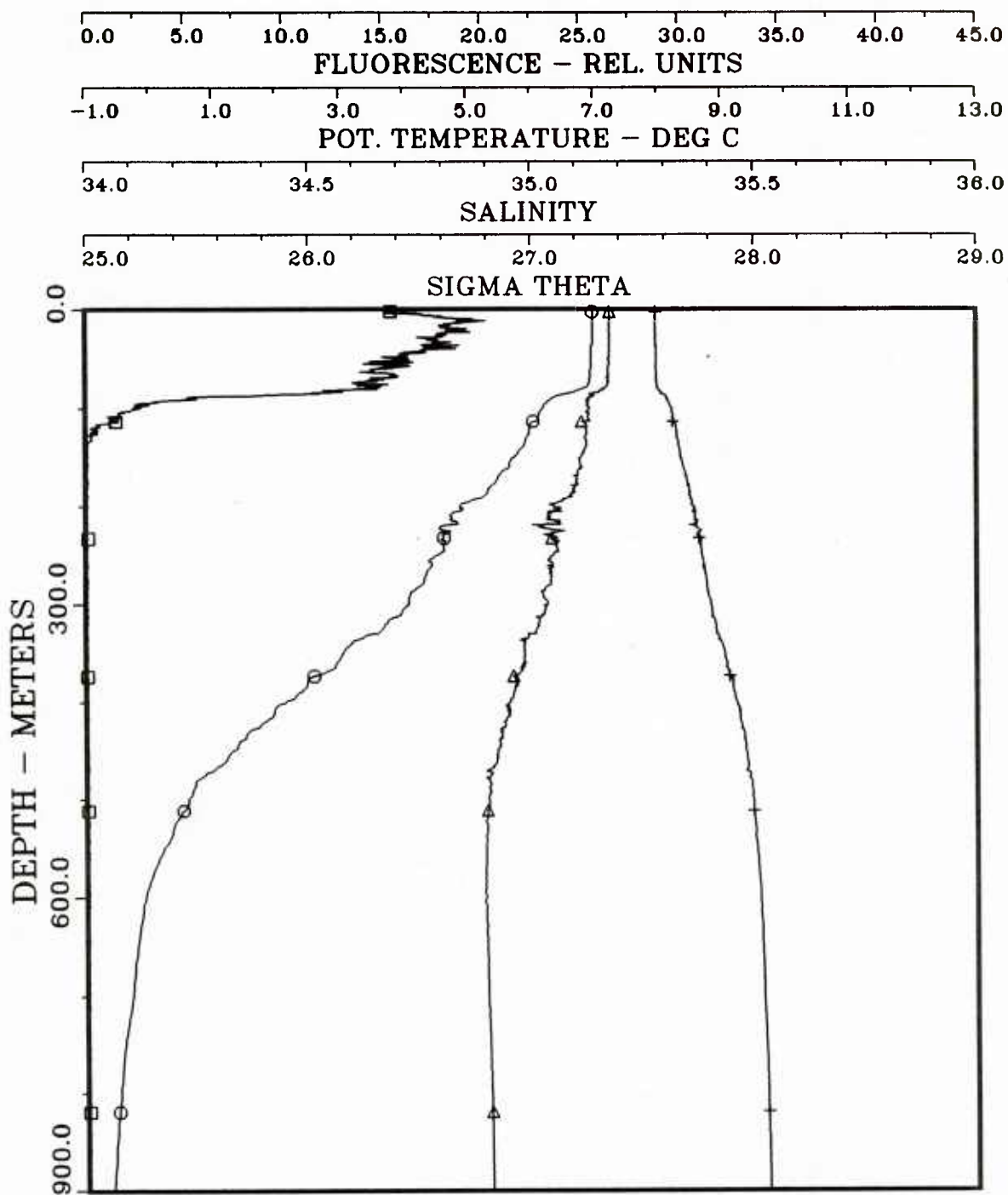
NORDMEER 87
29
1
162.0230
67 35.04N
002 57.28E

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	29	
CAST NUMBER	1	
JULIAN DATE	162.0230	
LATITUDE	67 35.04N	
LONGITUDE	002 57.28E	

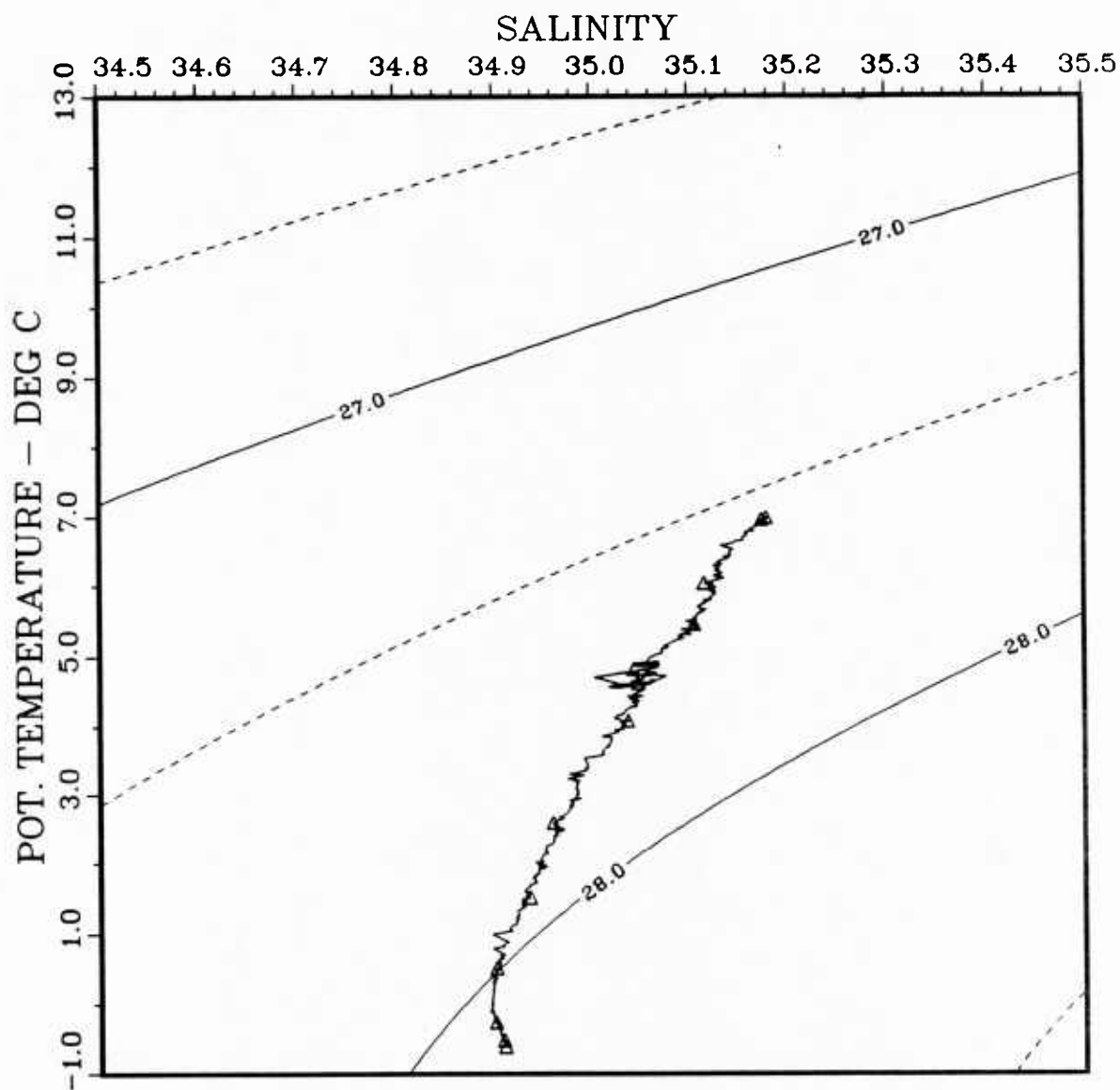


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

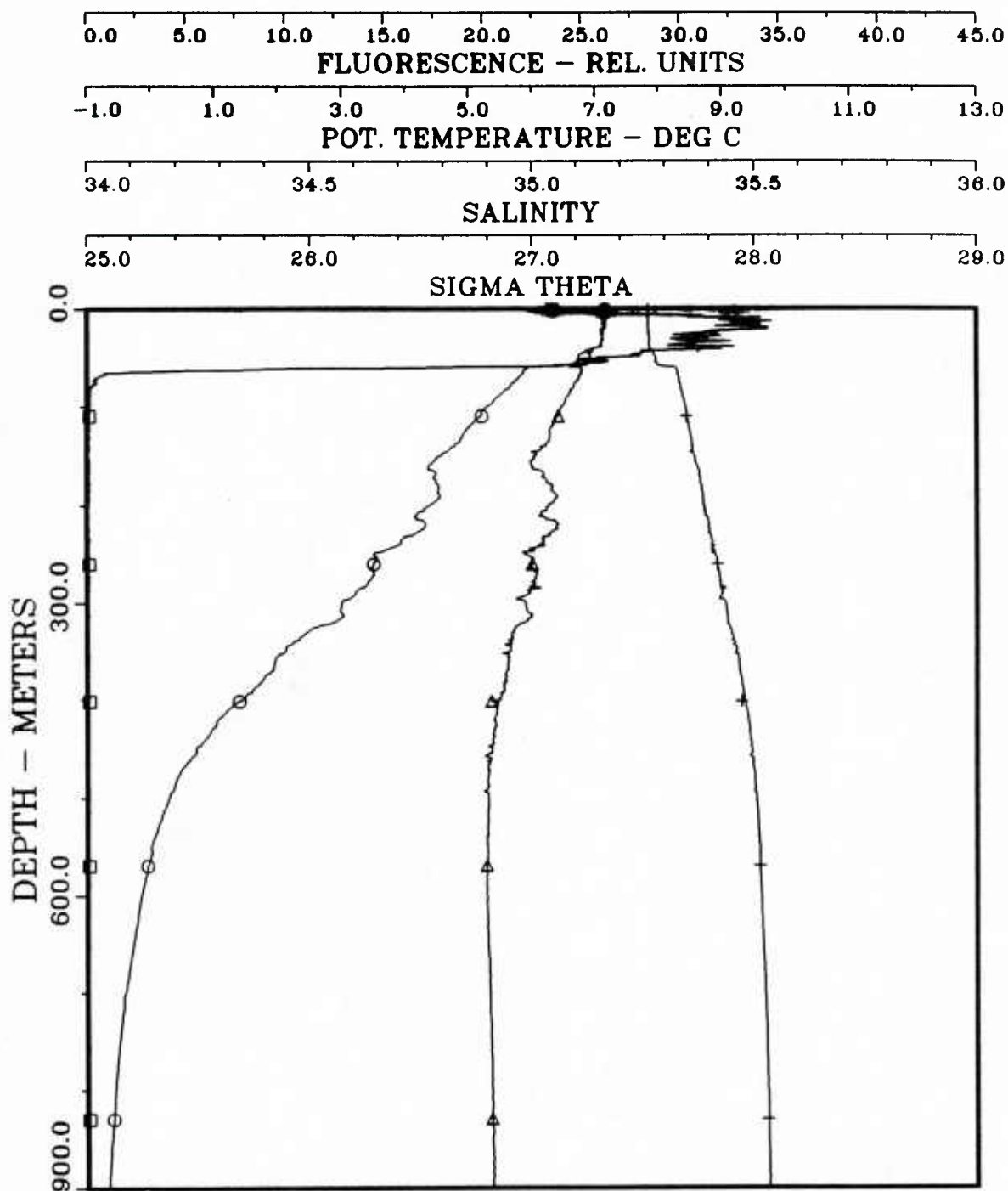
NORDMEER 87
30
1
162.0520
67 47.44N
002 13.42E

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	30	
CAST NUMBER	1	
JULIAN DATE	162.0520	
LATITUDE	67 47.44N	
LONGITUDE	002 13.42E	

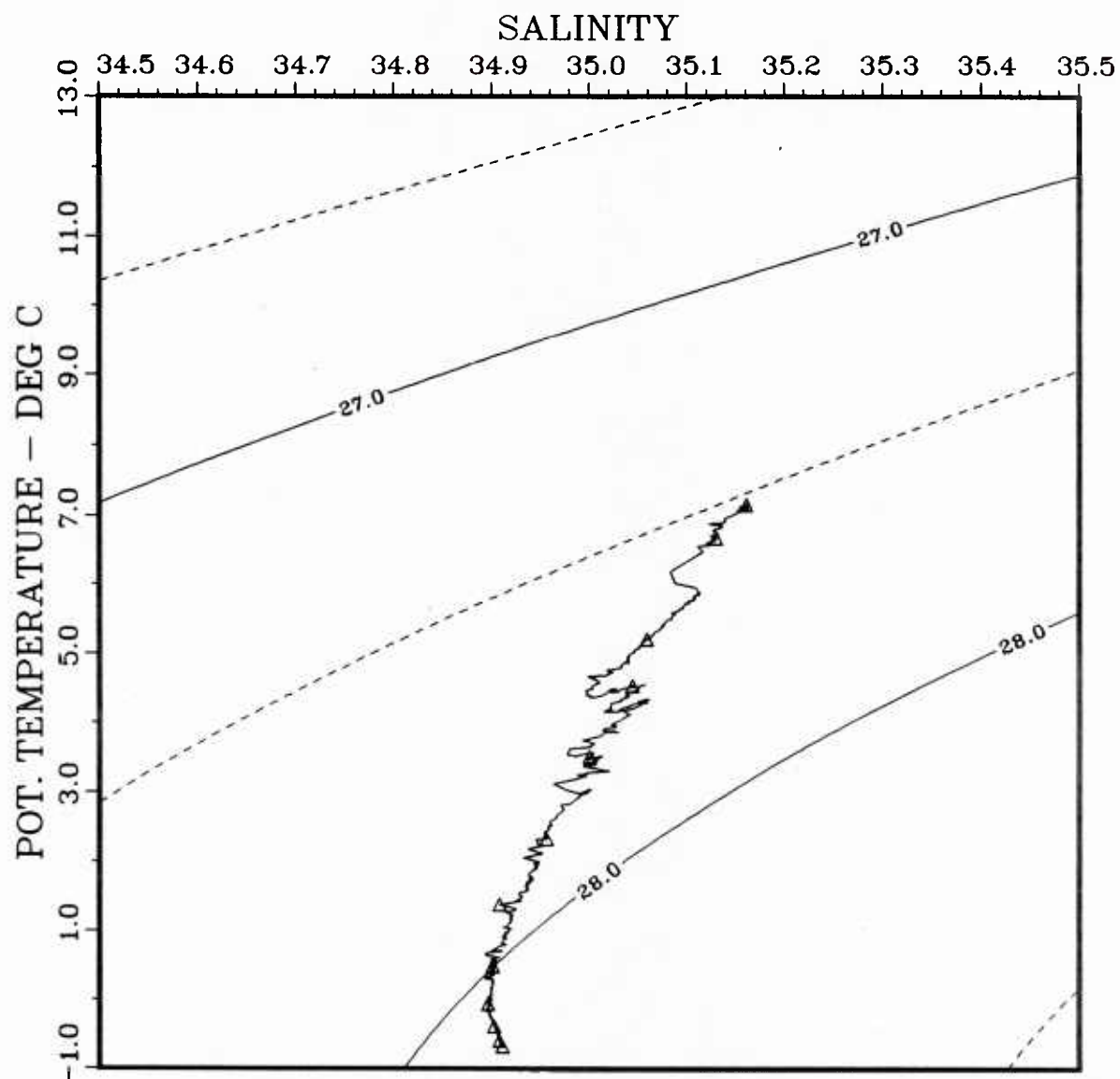


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

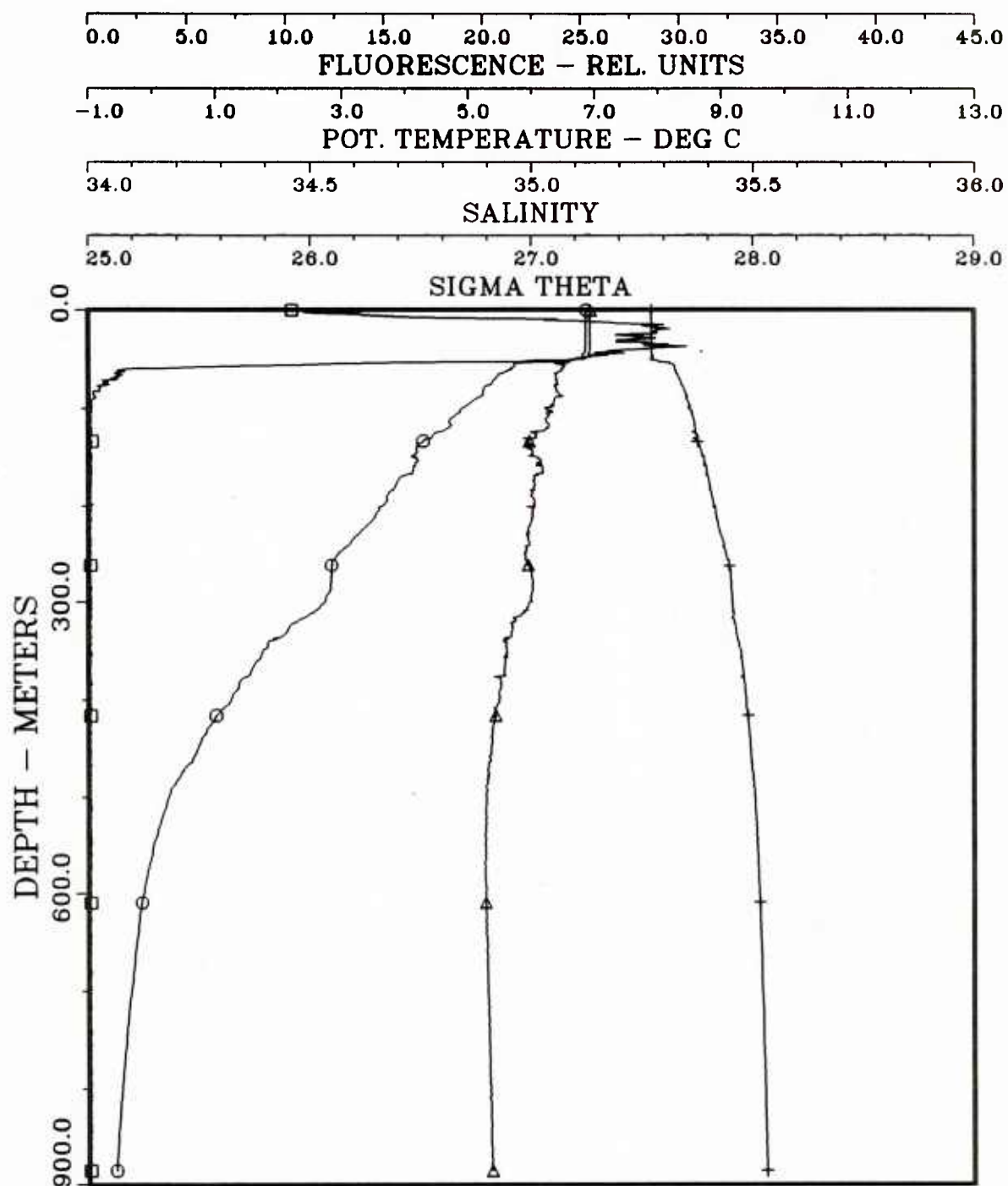
NORDMEER 87
31
1
162.0630
67 51.12N
001 58.11E

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	31	
CAST NUMBER	1	
JULIAN DATE	162.0630	
LATITUDE	67 51.12N	
LONGITUDE	001 58.11E	

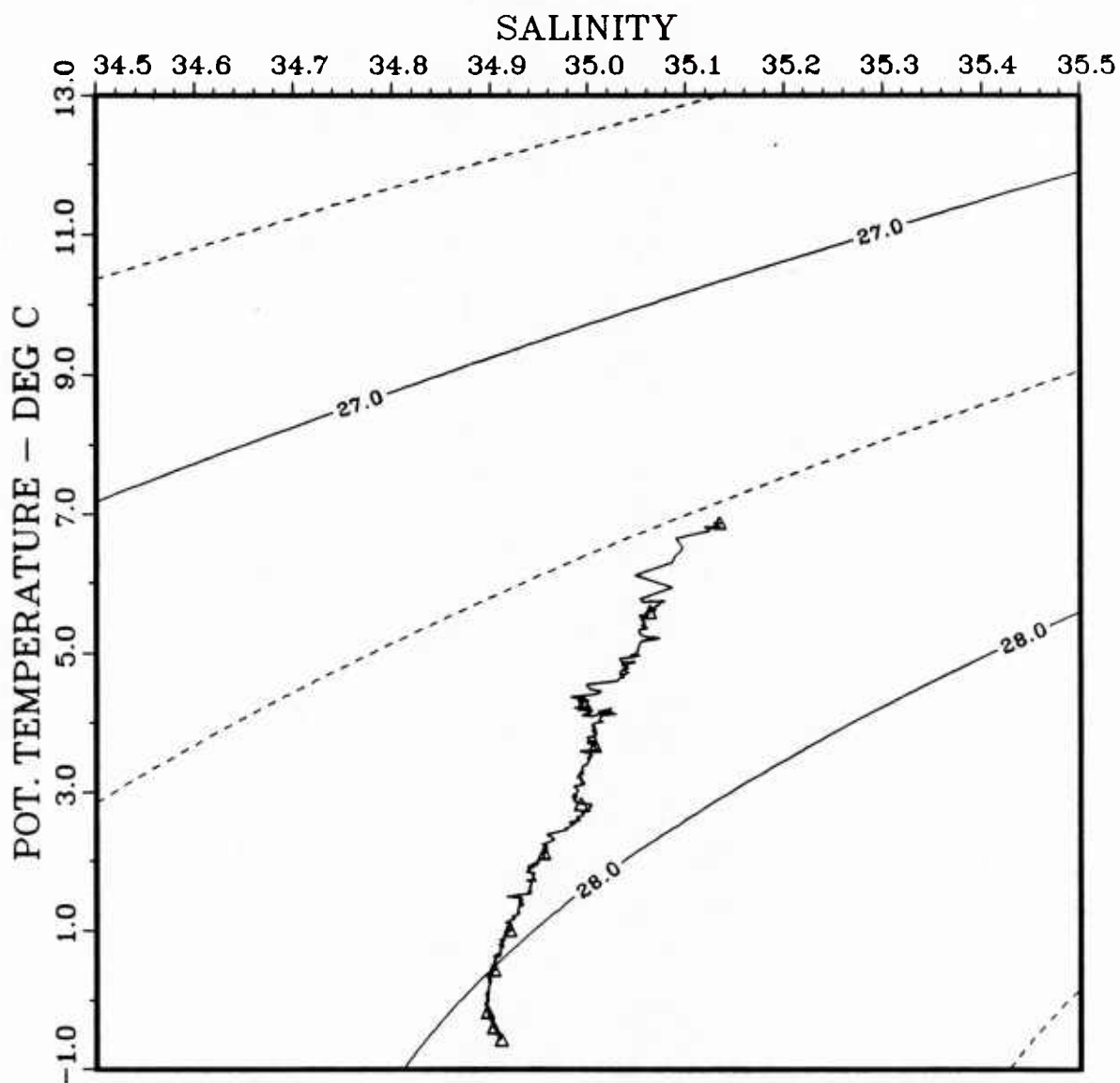


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

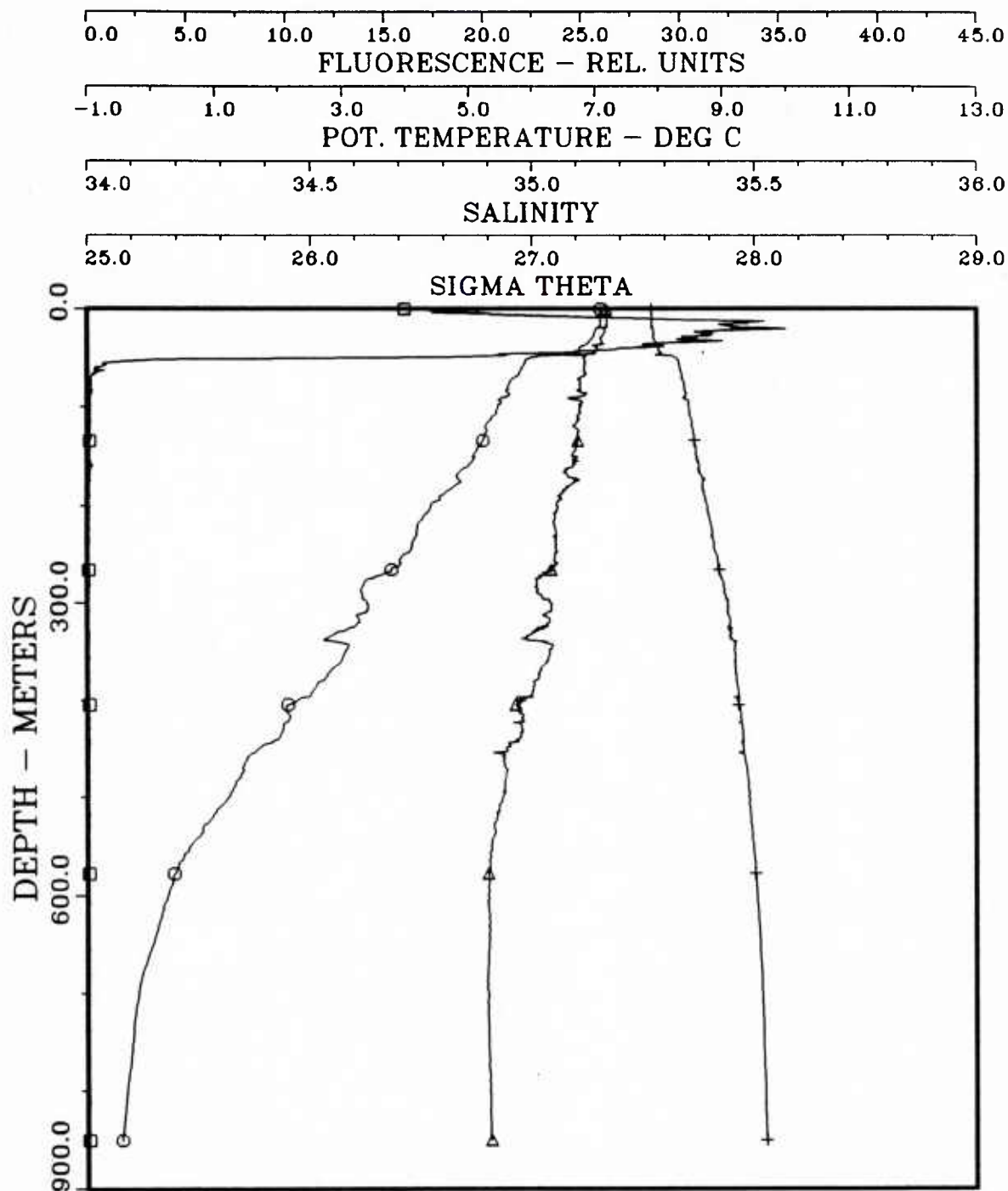
NORDMEER 87
32
1
162.0830
67 58.01N
001 22.65E

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	32	
CAST NUMBER	1	
JULIAN DATE	162.0830	
LATITUDE	67 58.01N	
LONGITUDE	001 22.65E	

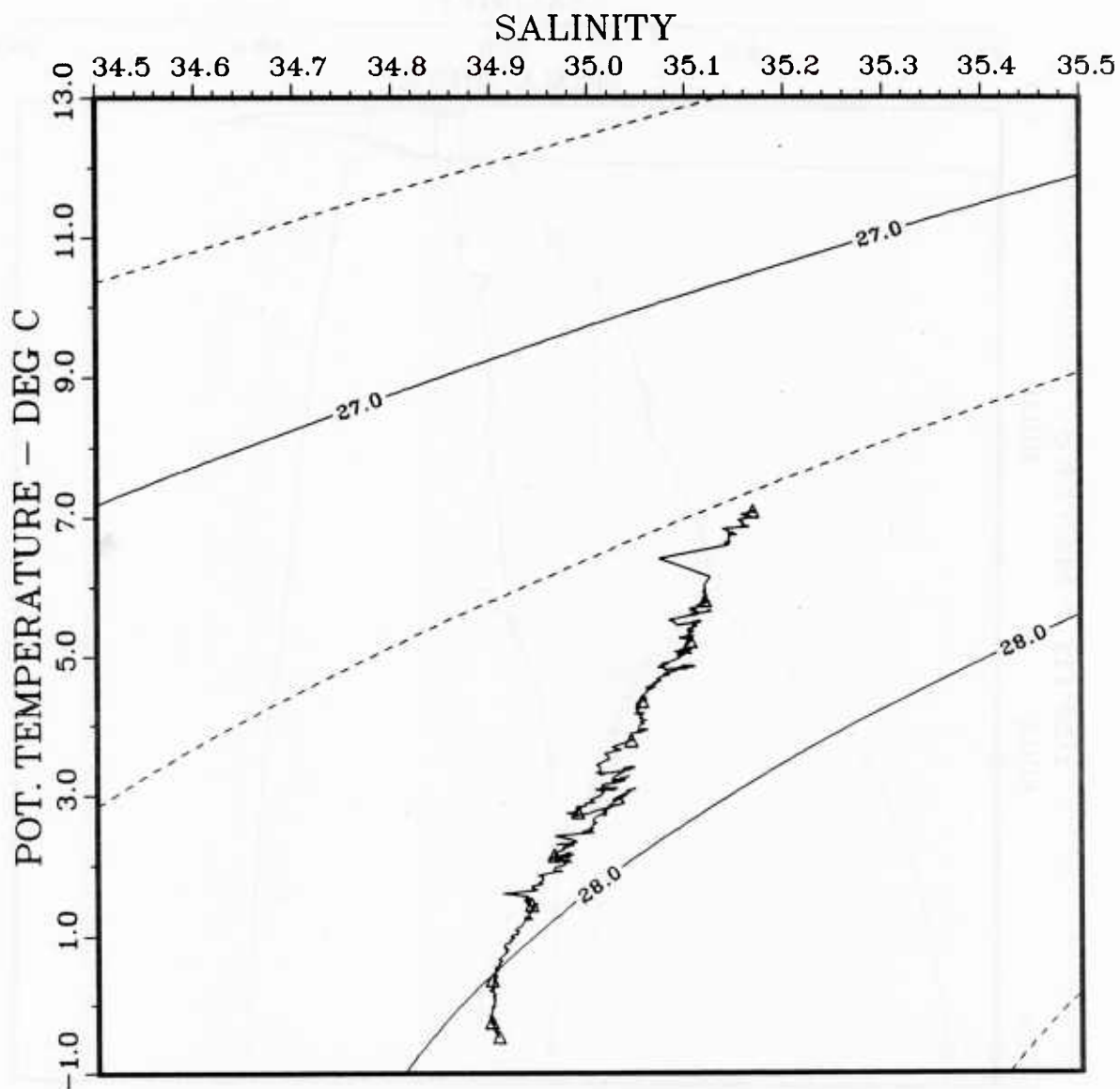


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

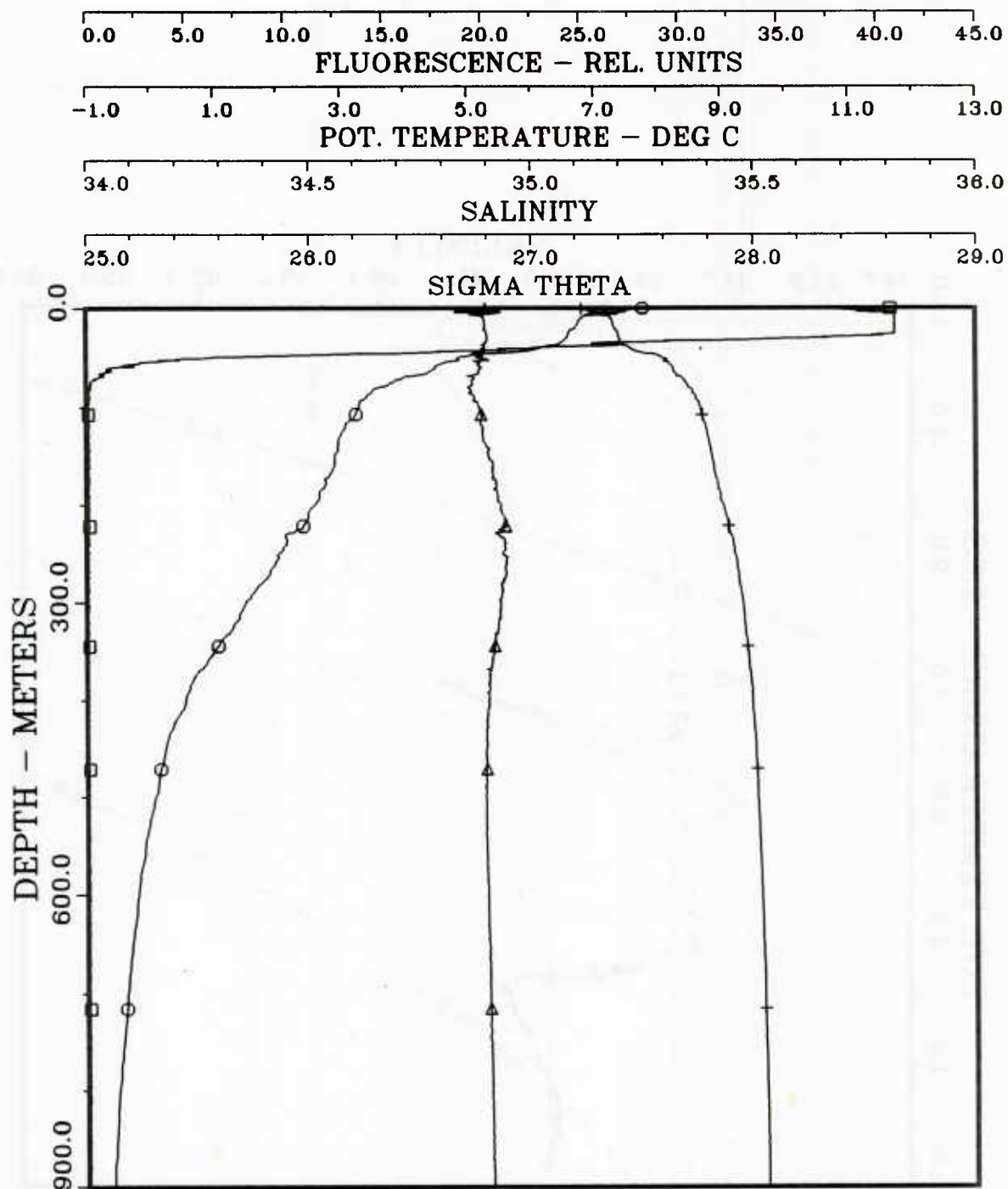
NORDMEER 87
33
1
162.1110
68 10.56N
000 50.02E

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	33	
CAST NUMBER	1	
JULIAN DATE	162.1110	
LATITUDE	68 10.56N	
LONGITUDE	000 50.02E	

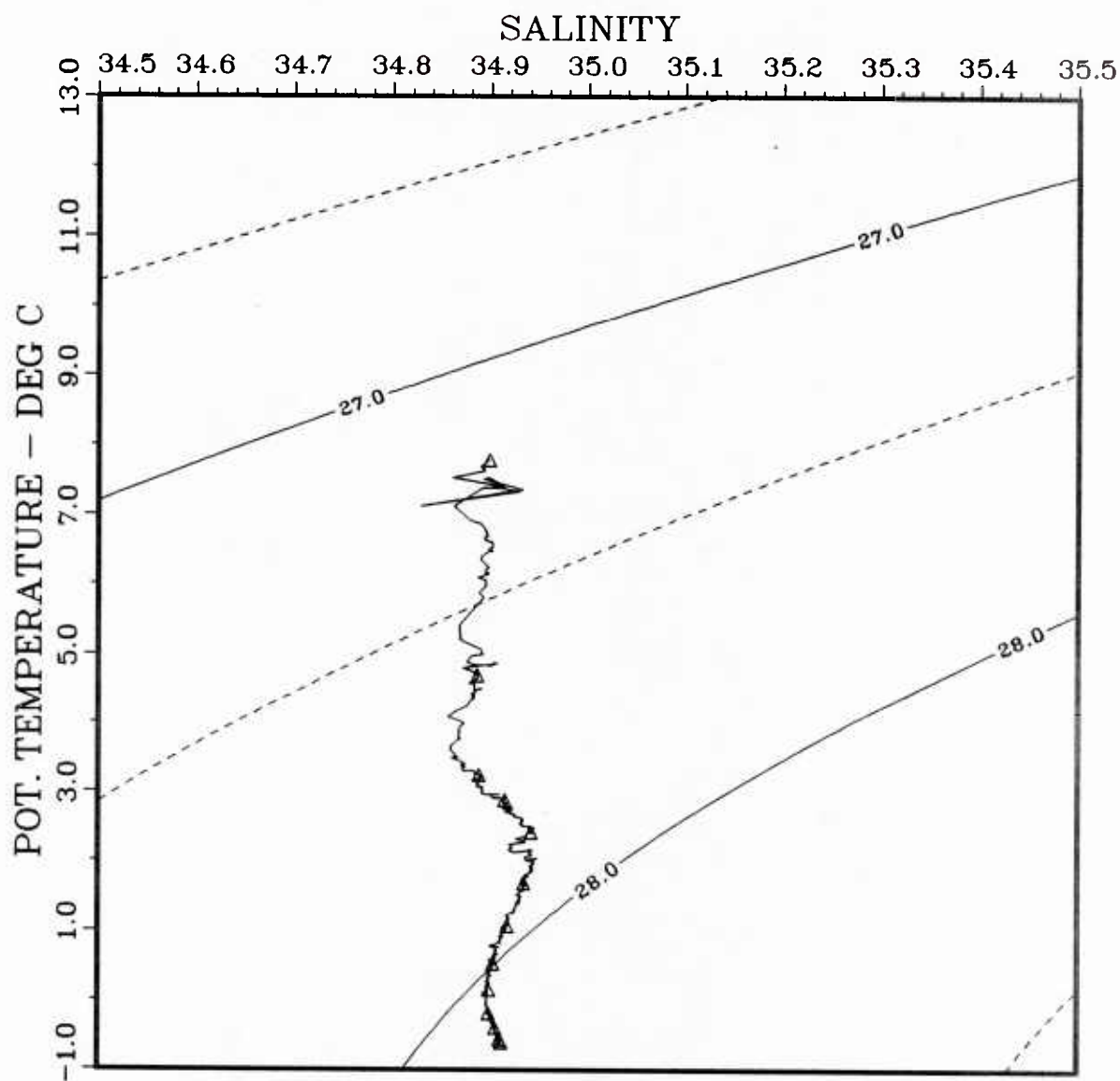


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

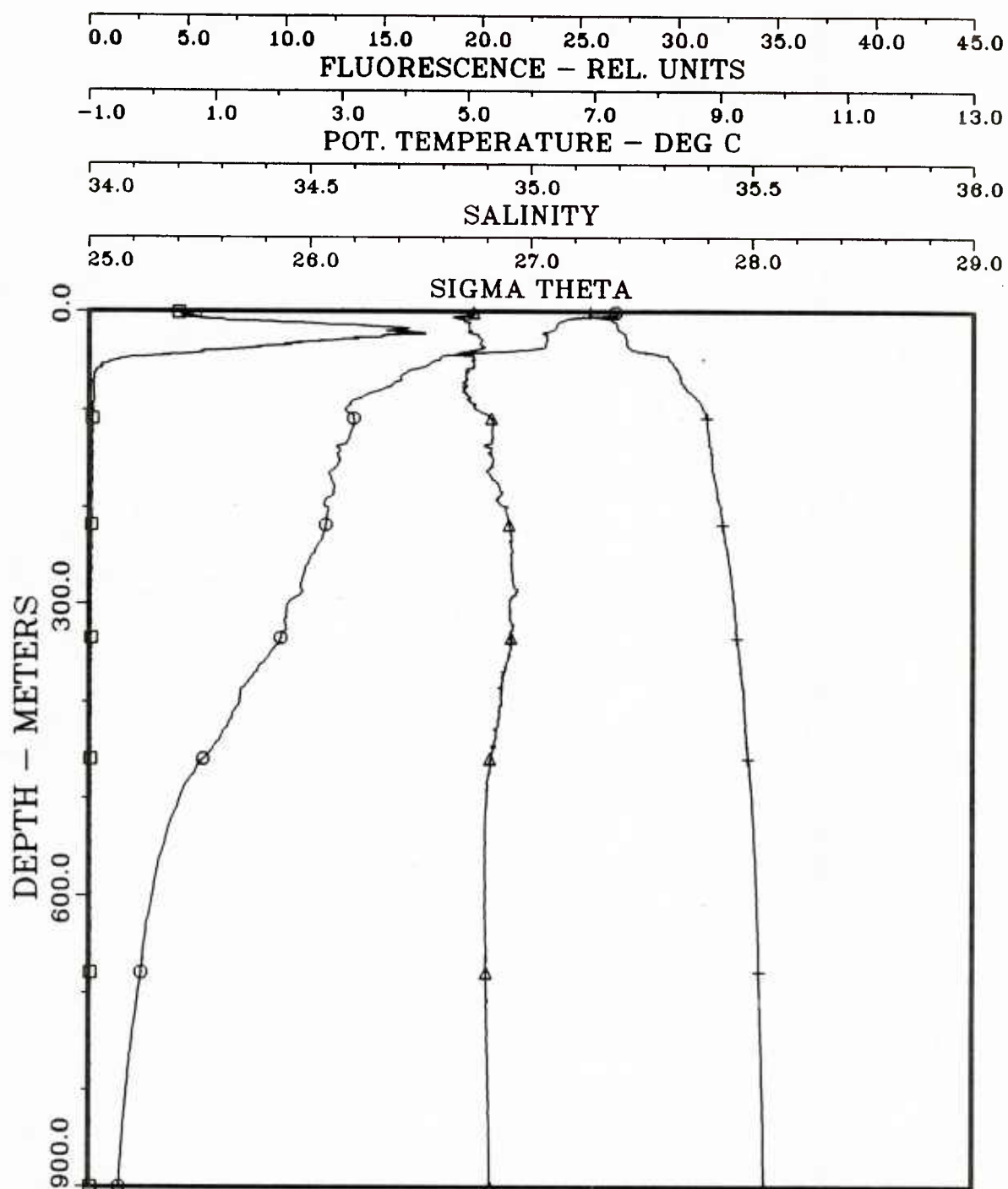
NORDMEER 87
36
1
166.2100
64 20.30N
004 59.44W

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	36	
CAST NUMBER	1	
JULIAN DATE	166.2100	
LATITUDE	64 20.30N	
LONGITUDE	004 59.44W	

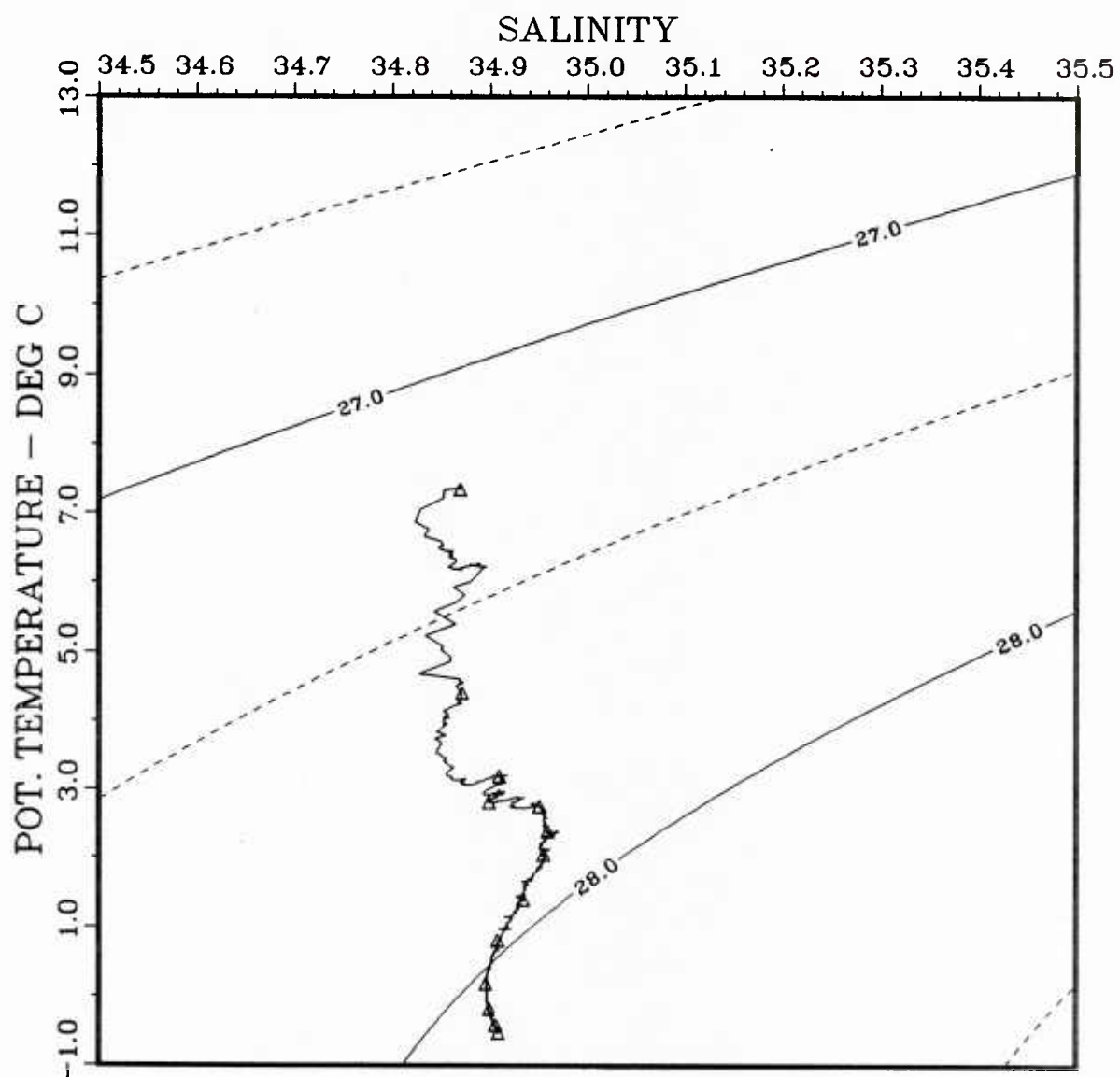


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

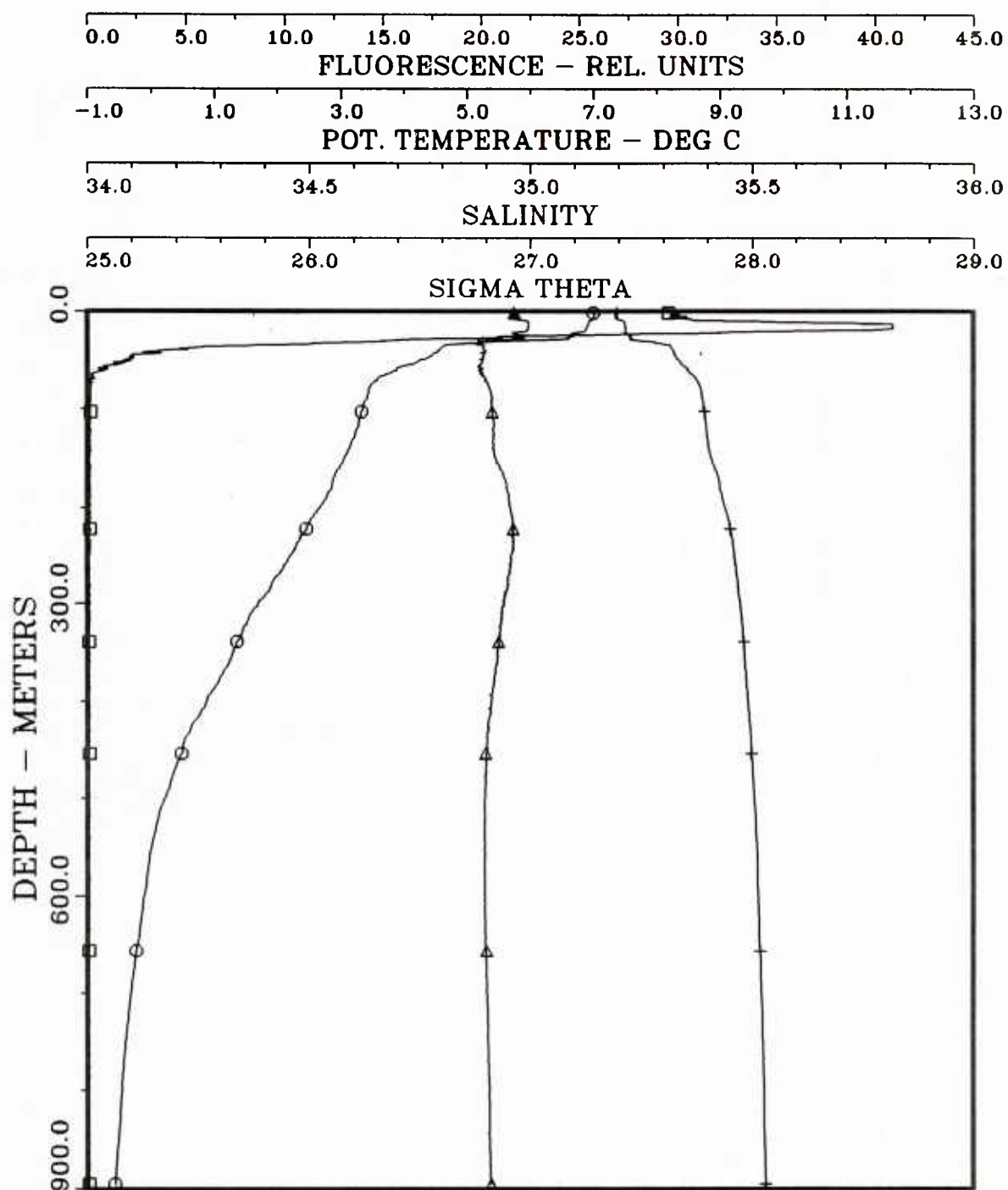
NORDMEER 87
37
1
167.0010
64 43.65N
004 34.00W

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	37	
CAST NUMBER	1	
JULIAN DATE	167.0010	
LATITUDE	64 43.65N	
LONGITUDE	004 34.00W	

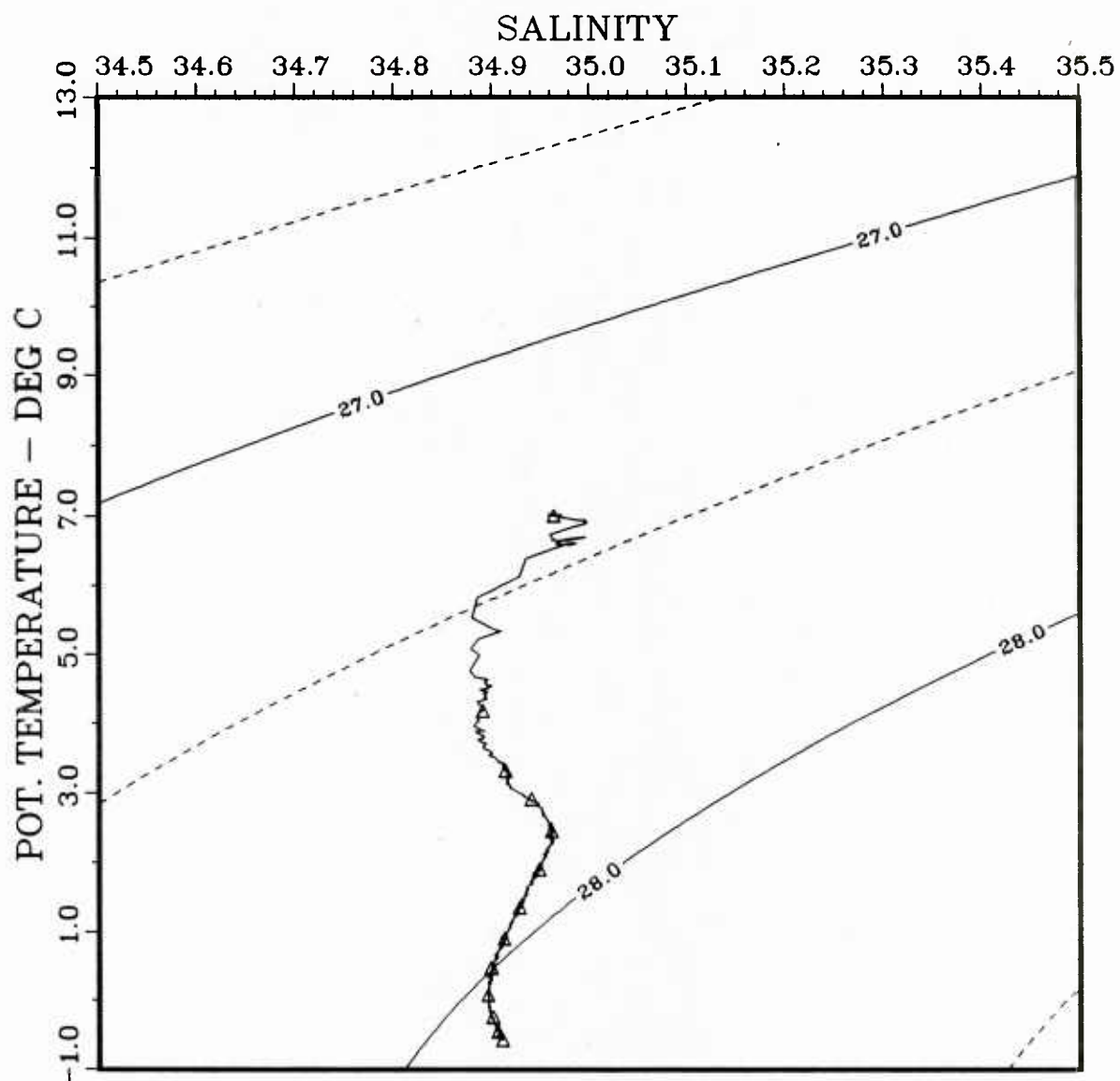


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

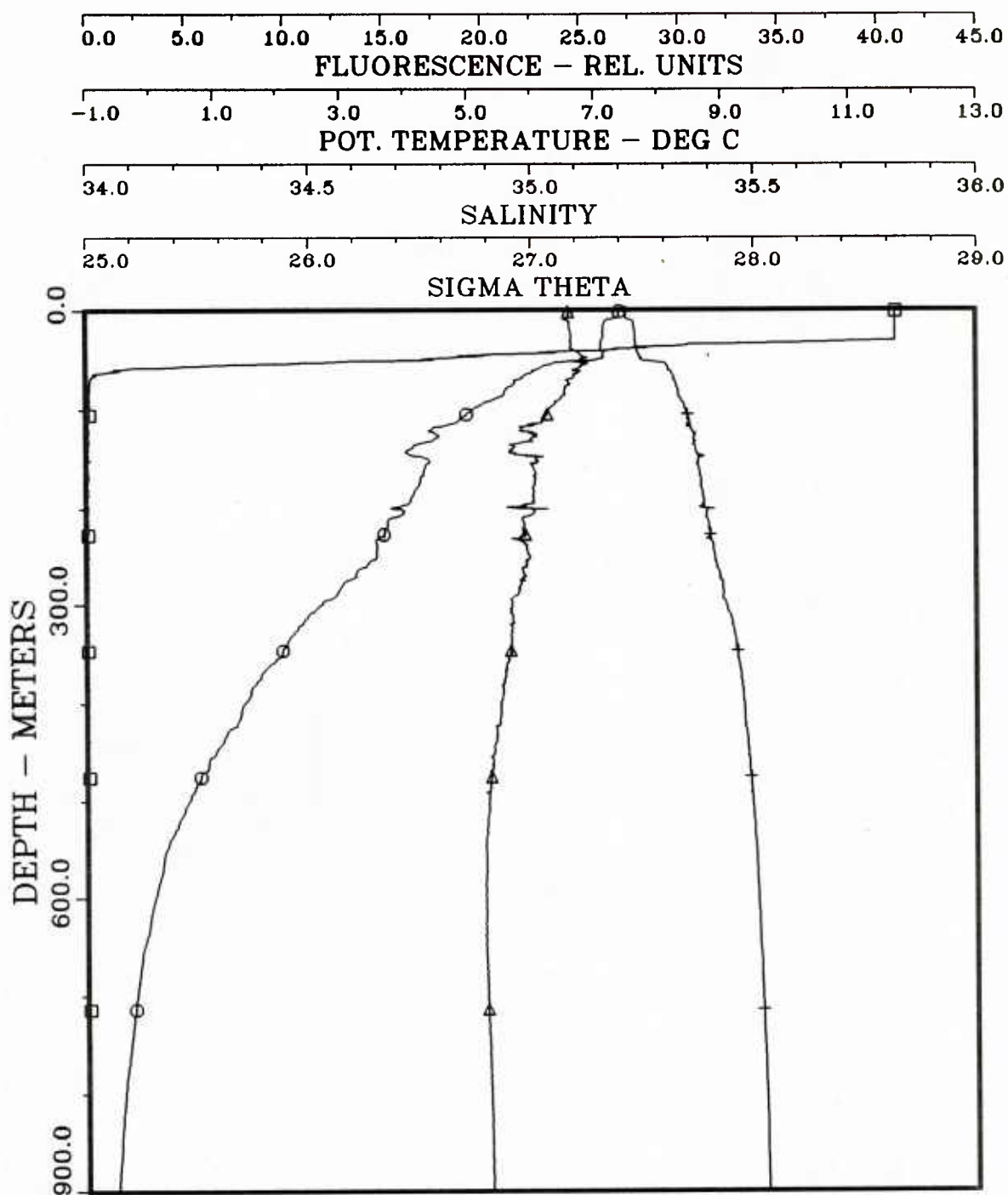
NORDMEER 87
38
1
167.0310
65 07.28N
004 08.25W

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	38	
CAST NUMBER	1	
JULIAN DATE	167.0310	
LATITUDE	65 07.28N	
LONGITUDE	004 08.25W	

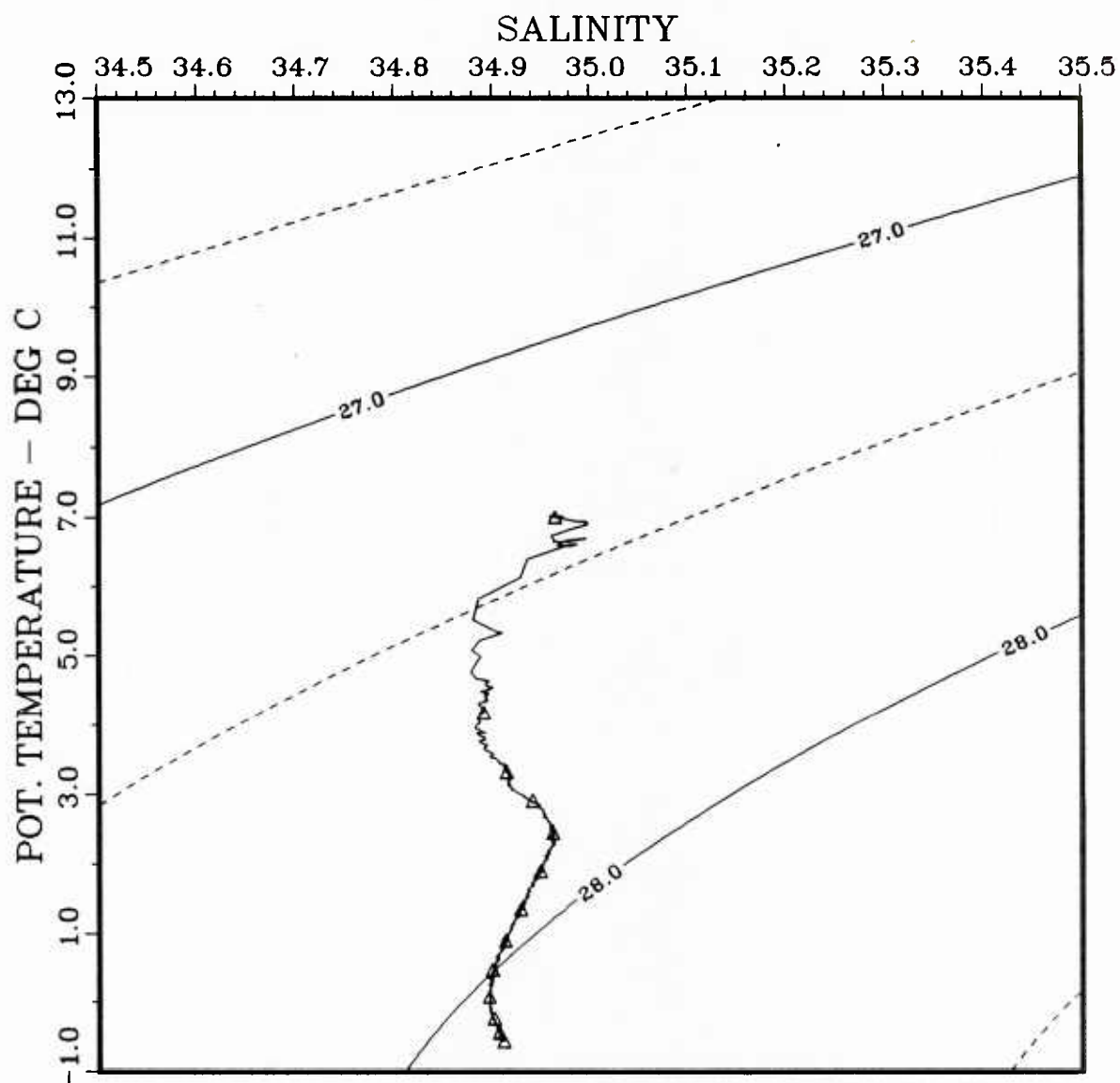


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

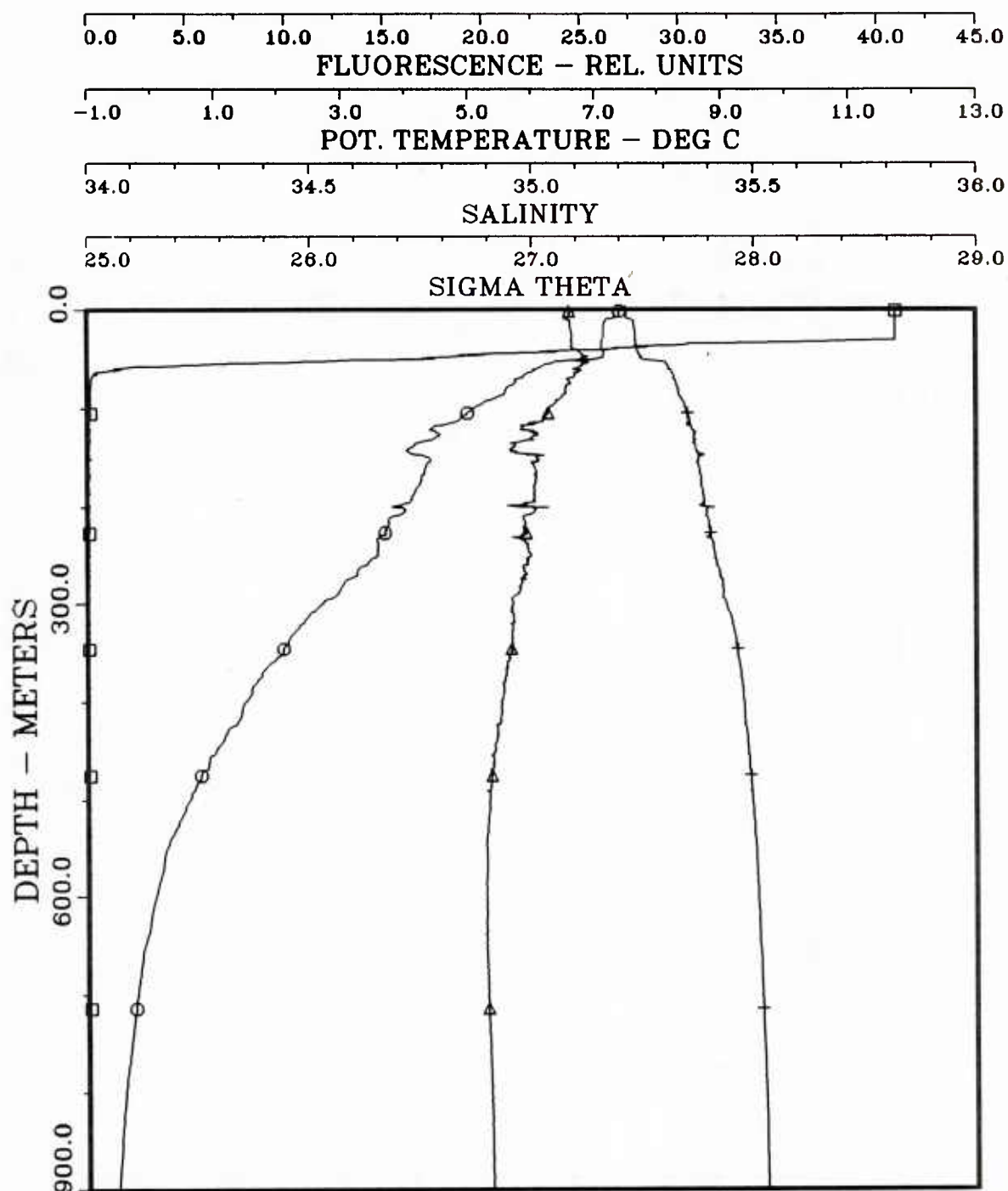
NORDMEER 87
39
1
167.0610
65 31.30N
003 36.81W

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	38	
CAST NUMBER	1	
JULIAN DATE	167.0310	
LATITUDE	65 07.28N	
LONGITUDE	004 08.25W	

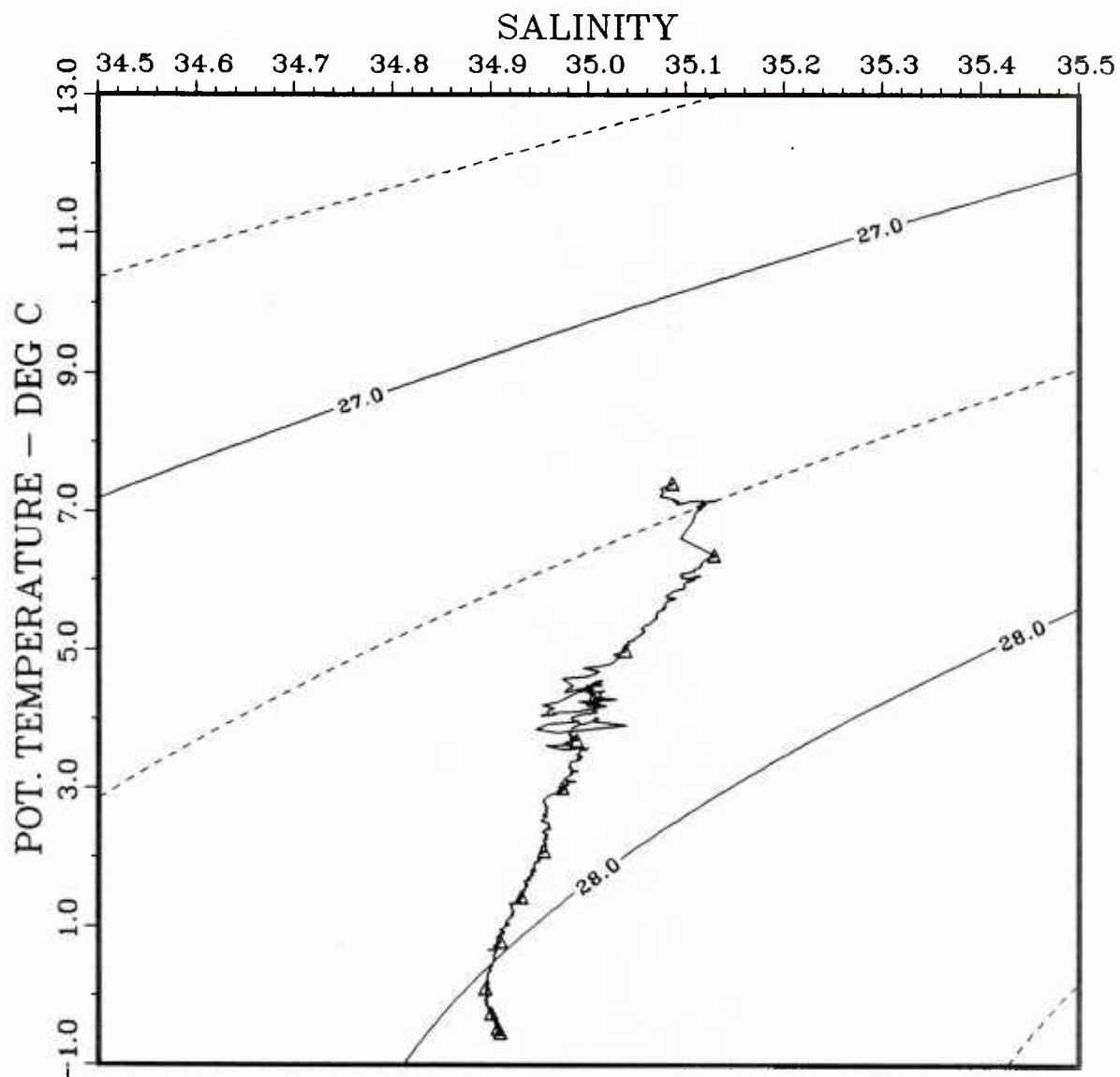


WFS PLANET
 STATION
 CAST NUMBER
 JULIAN DATE
 LATITUDE
 LONGITUDE

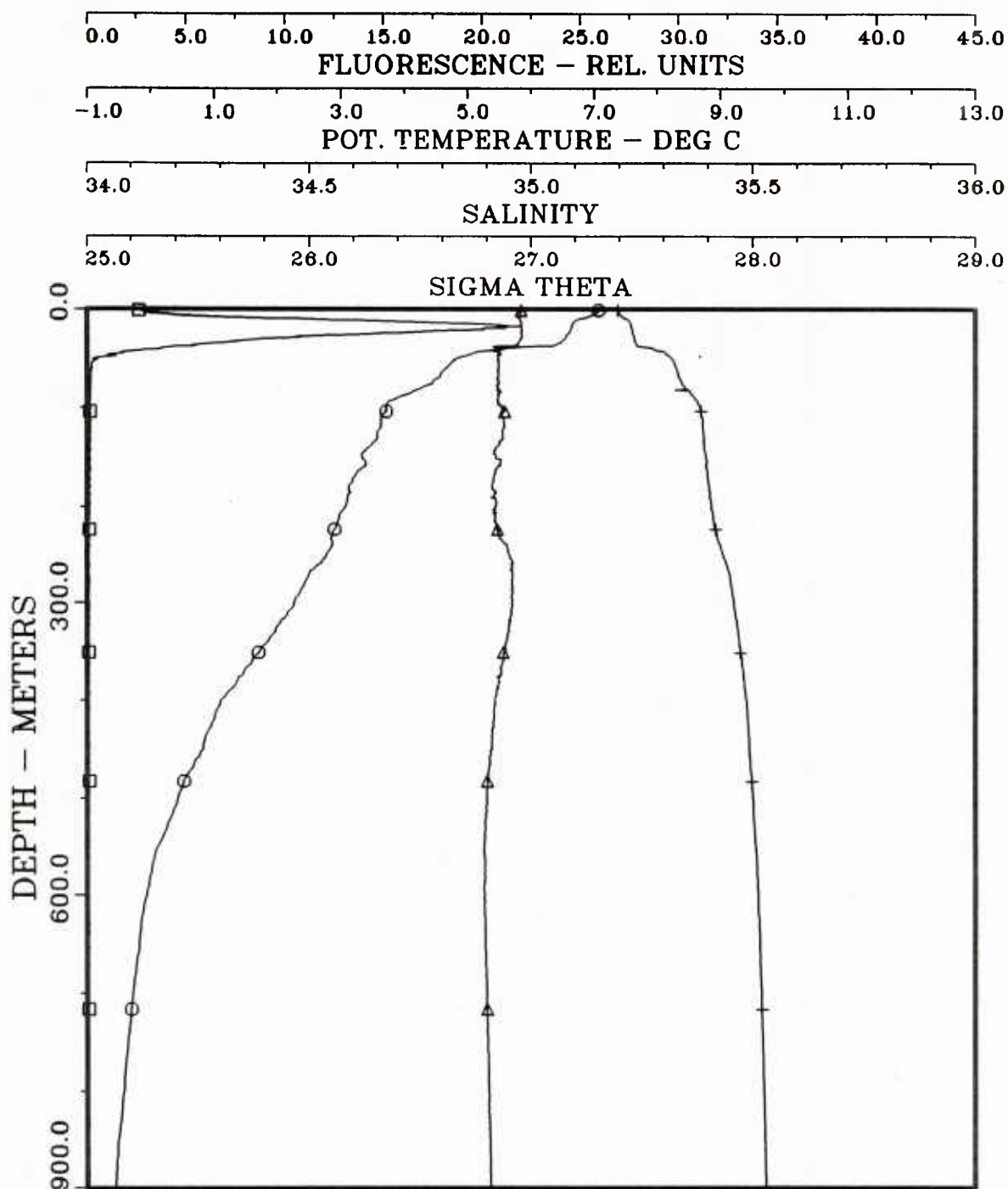
NORDMEER 87
 39
 1
 167.0610
 65 31.30N
 003 36.81W

JUNE 1987

LEGEND
 □ = FLUORESCENCE
 ○ = POT. TEMPERATURE
 △ = SALINITY
 + = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	39	
CAST NUMBER	1	
JULIAN DATE	167.0610	
LATITUDE	65 31.30N	
LONGITUDE	003 36.81W	

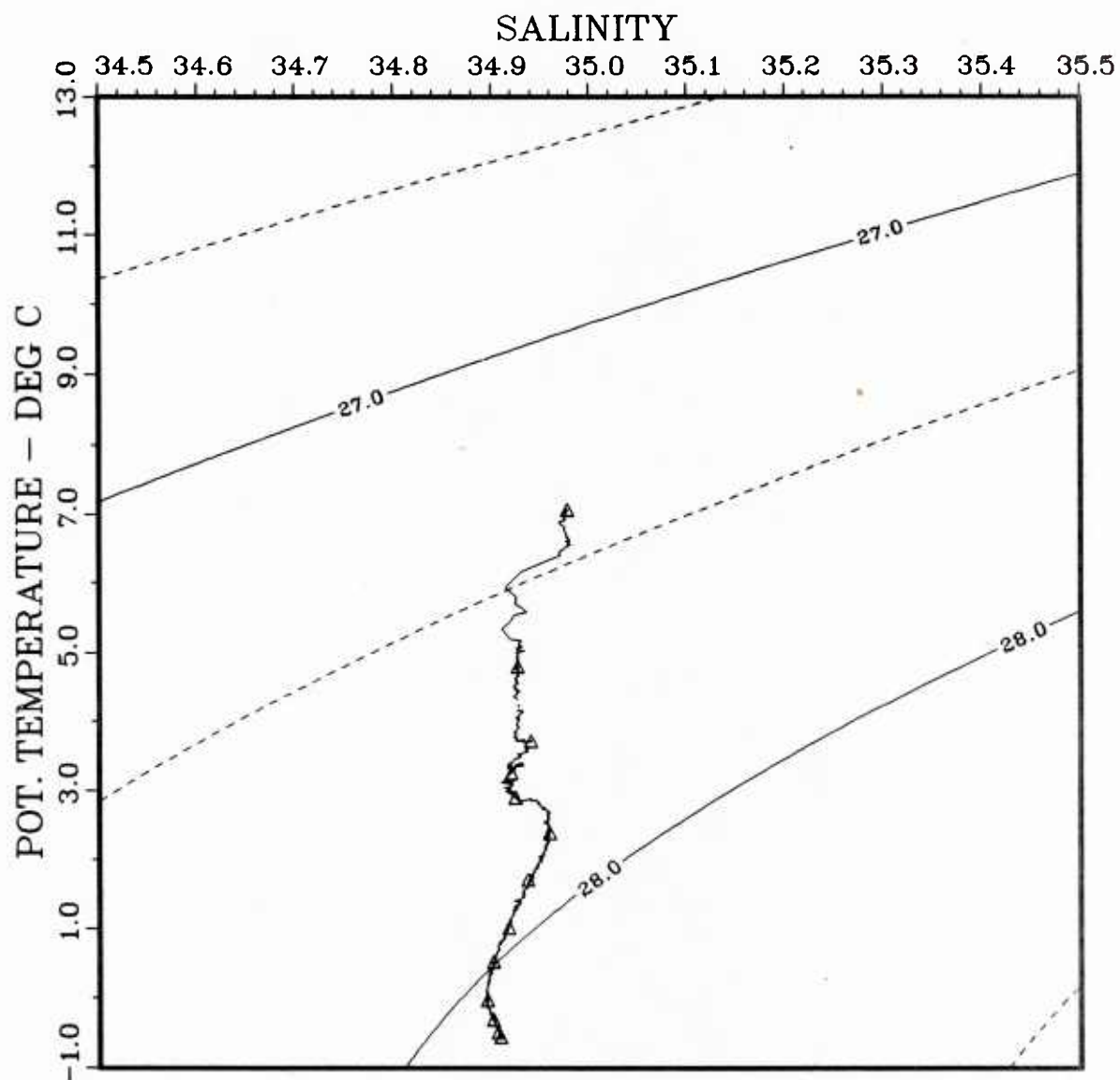


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

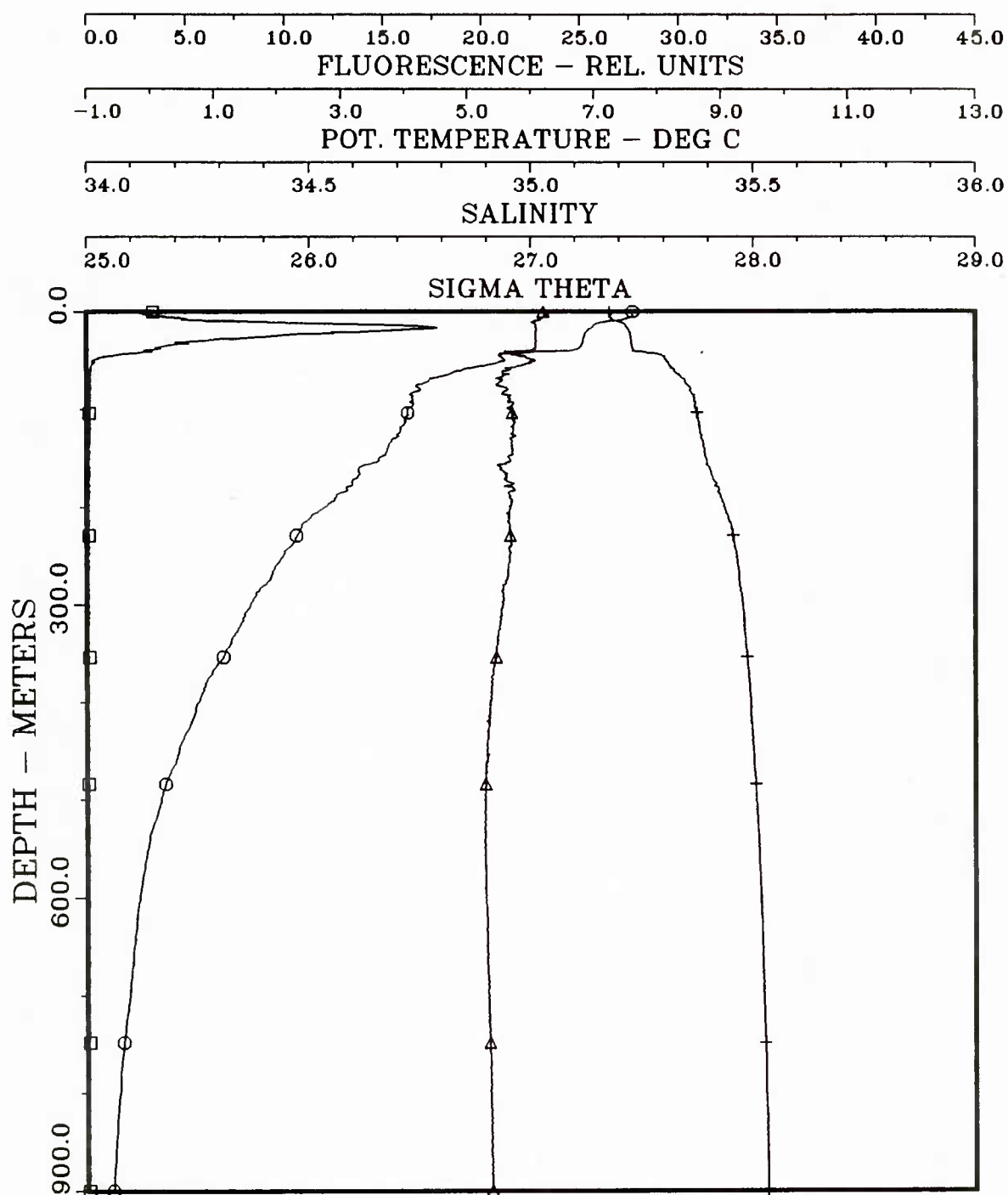
NORDMEER 87
40
1
167.0850
65 14.90N
002 56.71W

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	40	
CAST NUMBER	1	
JULIAN DATE	167.0850	
LATITUDE	65 14.90N	
LONGITUDE	002 56.71W	

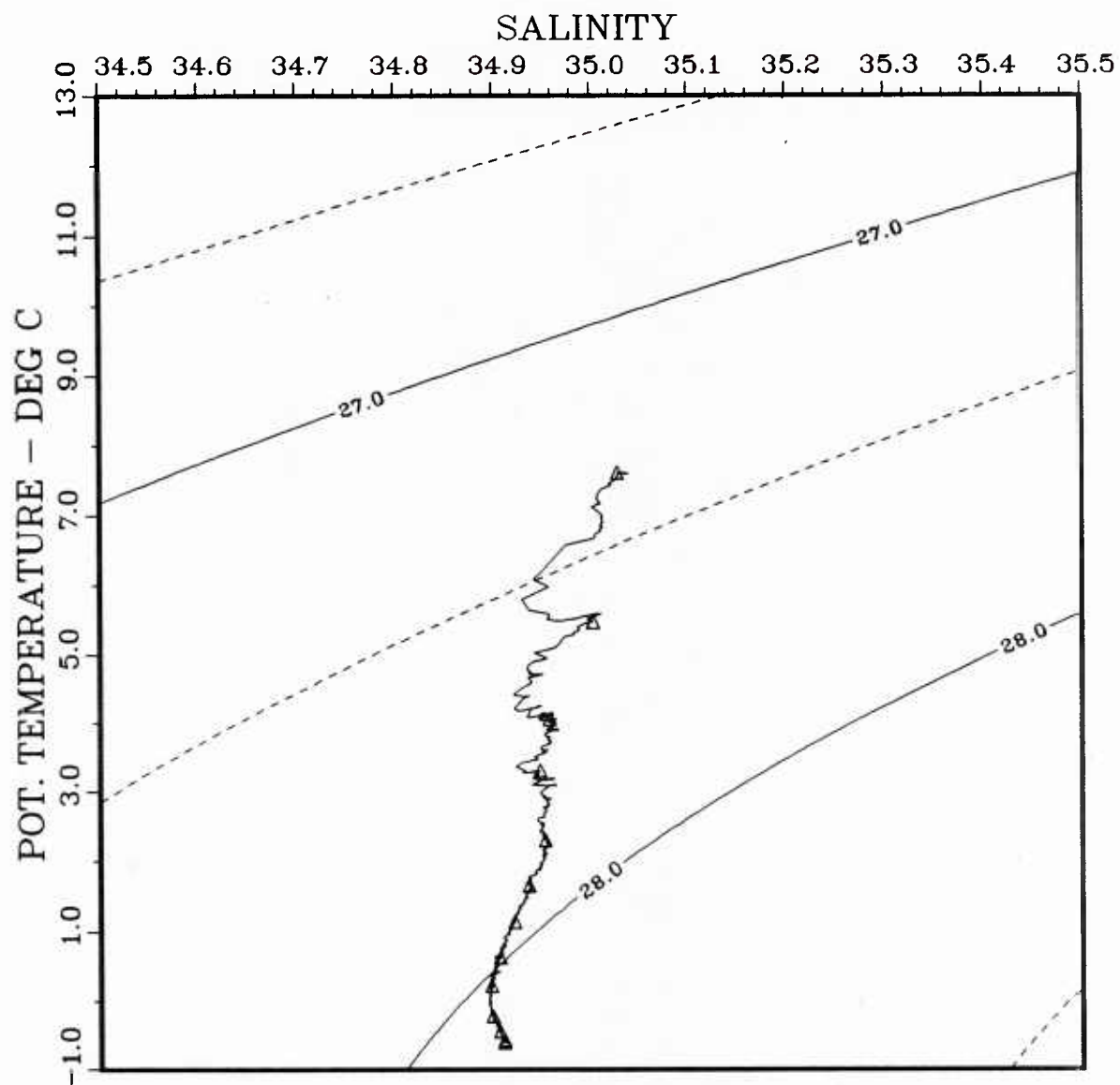


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

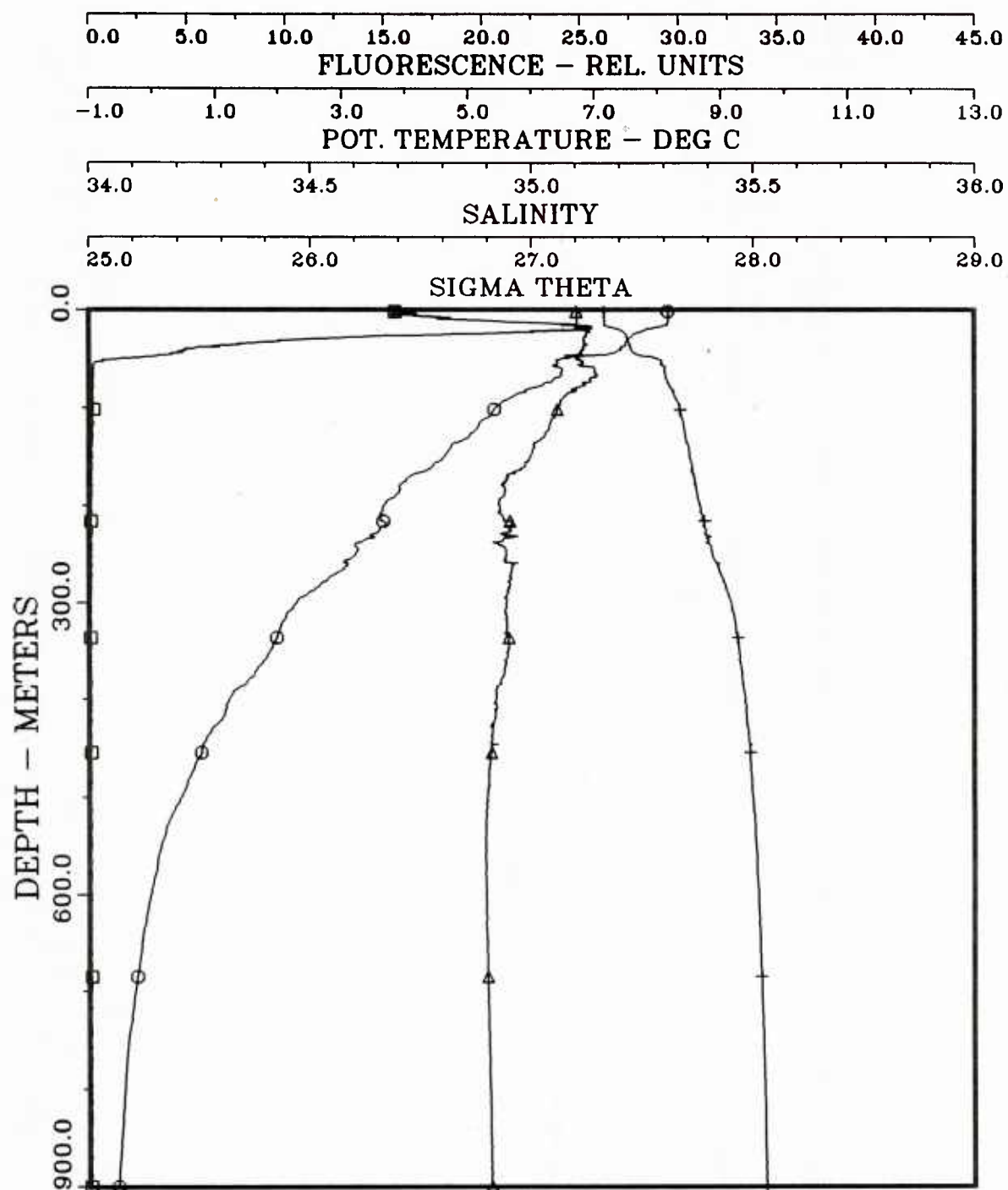
NORDMEER 87
41
1
167.1150
64 59.18N
002 17.13W

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	41	
CAST NUMBER	1	
JULIAN DATE	167.1150	
LATITUDE	64 59.18N	
LONGITUDE	002 17.13W	

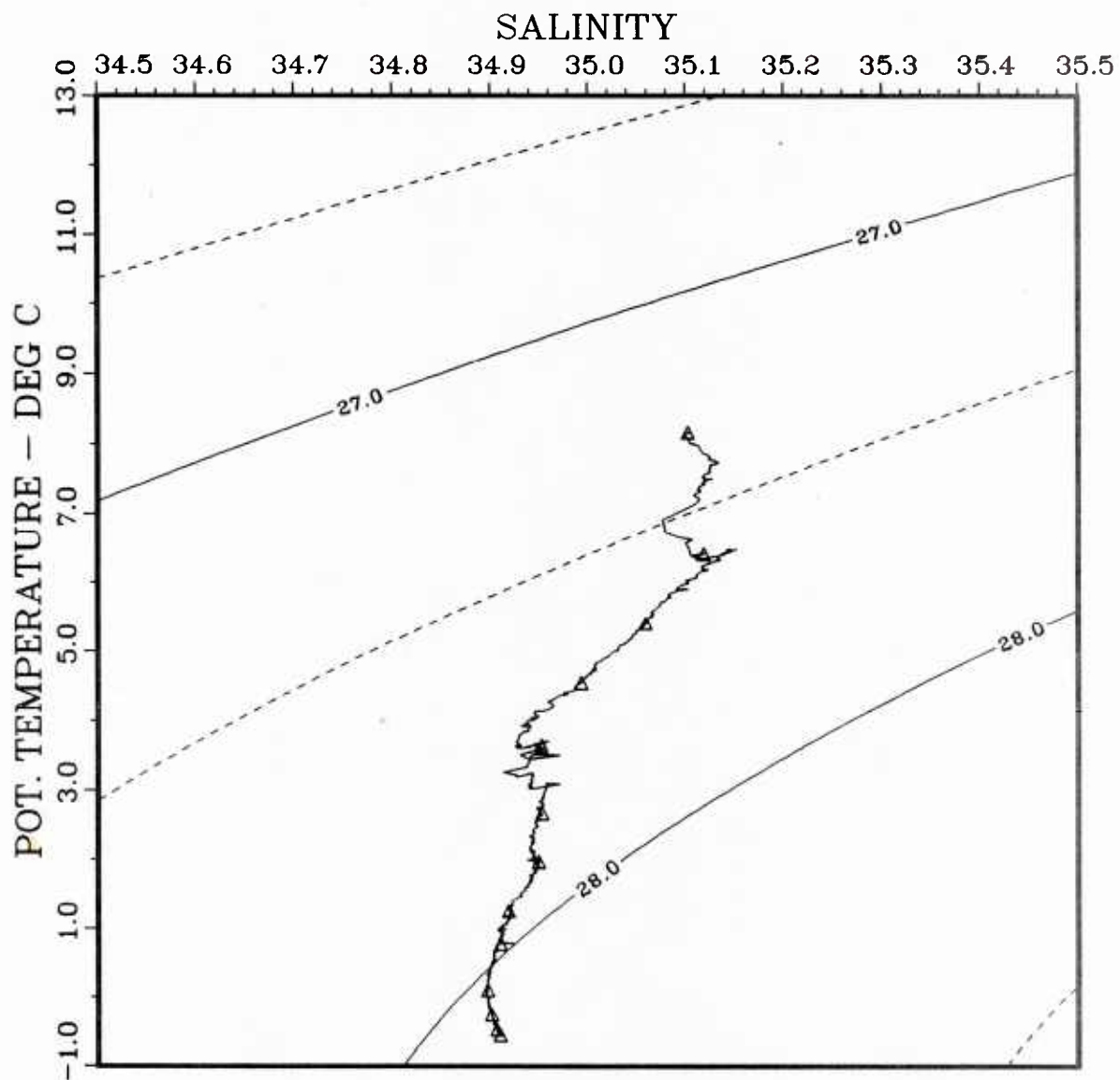


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

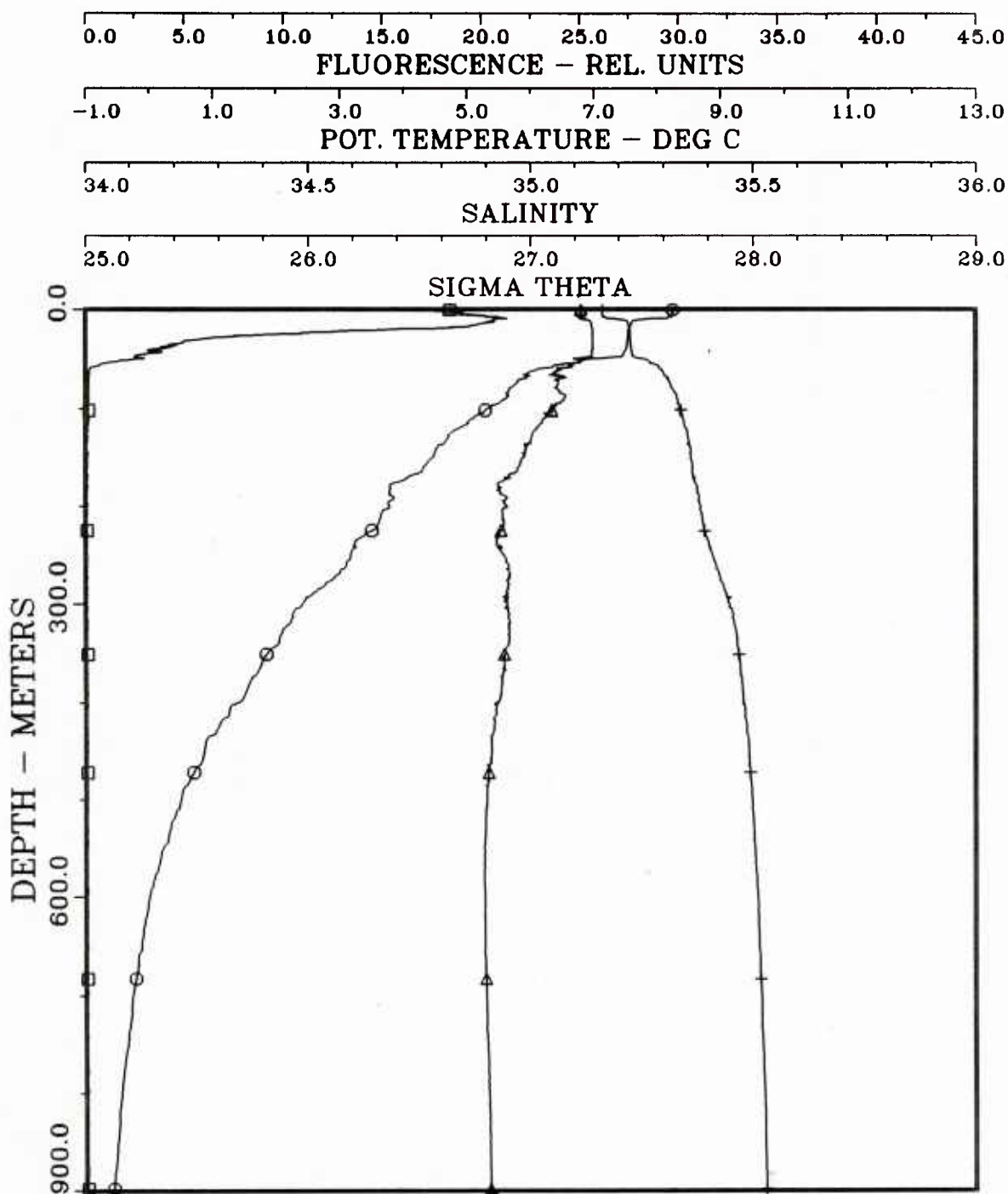
NORDMEER 87
42
1
167.1430
64 42.80N
001 32.23W

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	42	
CAST NUMBER	1	
JULIAN DATE	167.1430	
LATITUDE	64 42.80N	
LONGITUDE	001 32.23W	

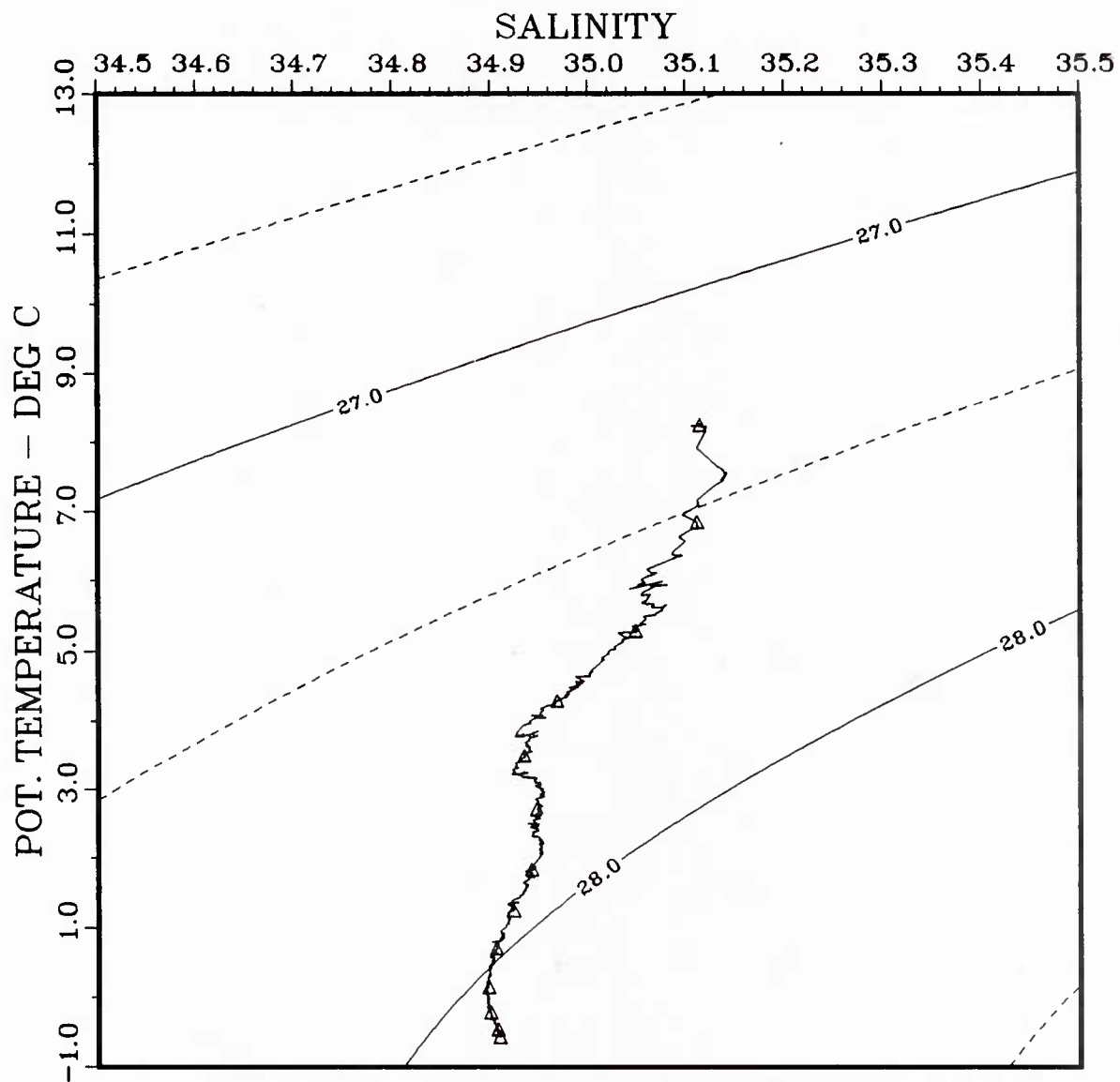


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

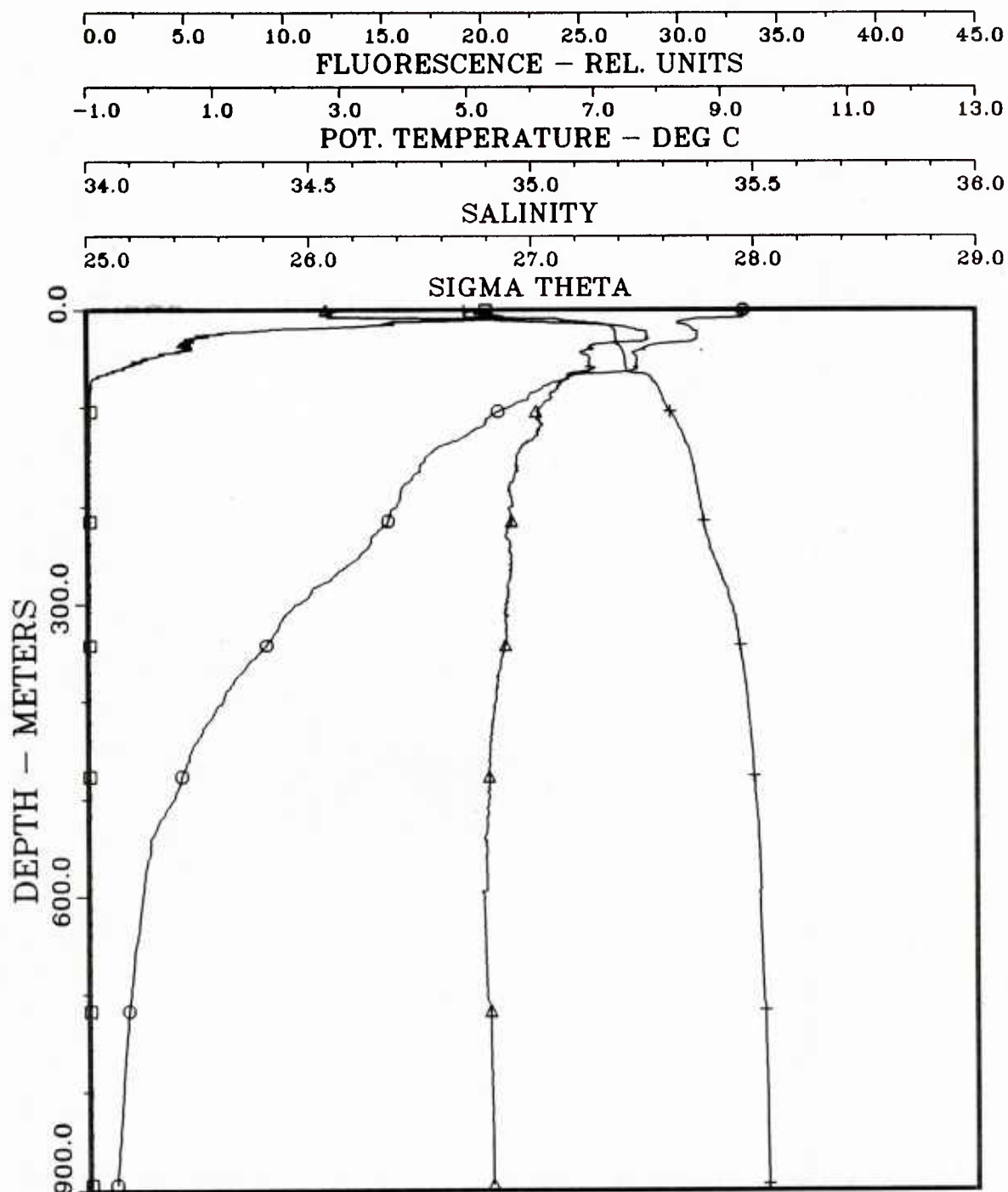
NORDMEER 87
43
1
167.1730
64 24.77N
000 48.80W

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	43	
CAST NUMBER	1	
JULIAN DATE	167.1730	
LATITUDE	64 24.77N	
LONGITUDE	000 48.80W	

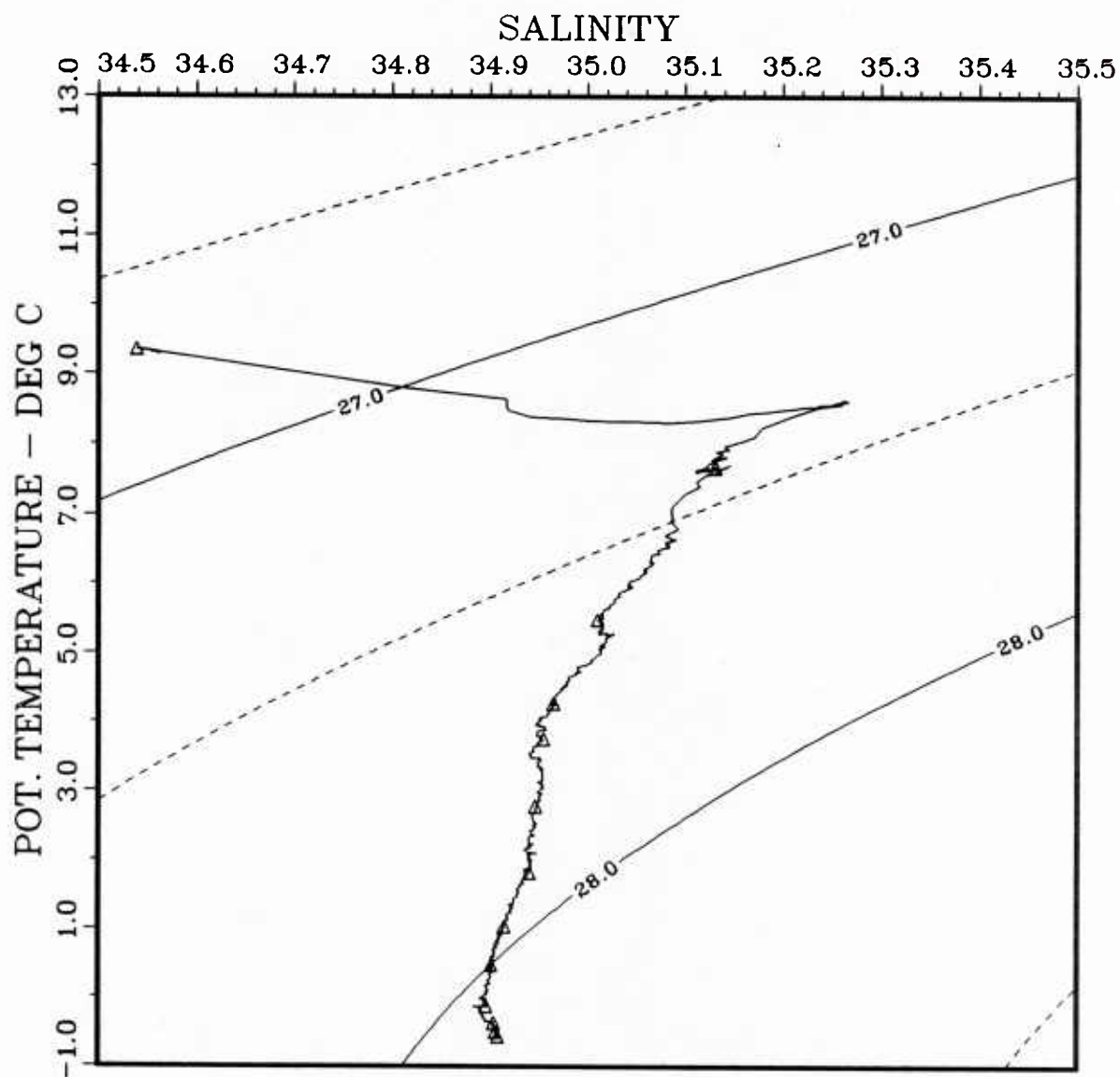


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

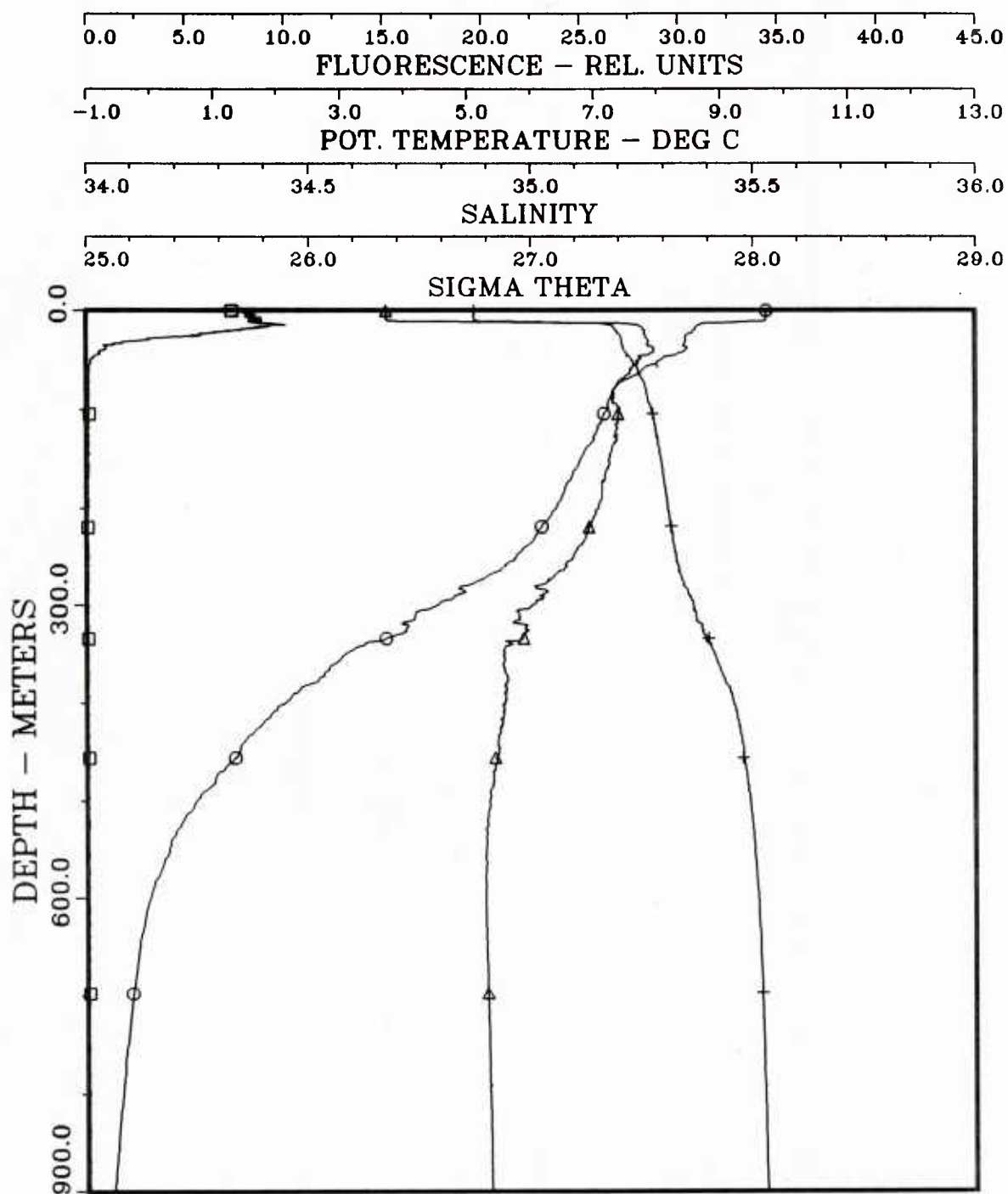
NORDMEER 87
44
1
167.2030
64 06.80N
000 04.07W

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	44	
CAST NUMBER	1	
JULIAN DATE	167.2030	
LATITUDE	64 06.80N	
LONGITUDE	000 04.07W	

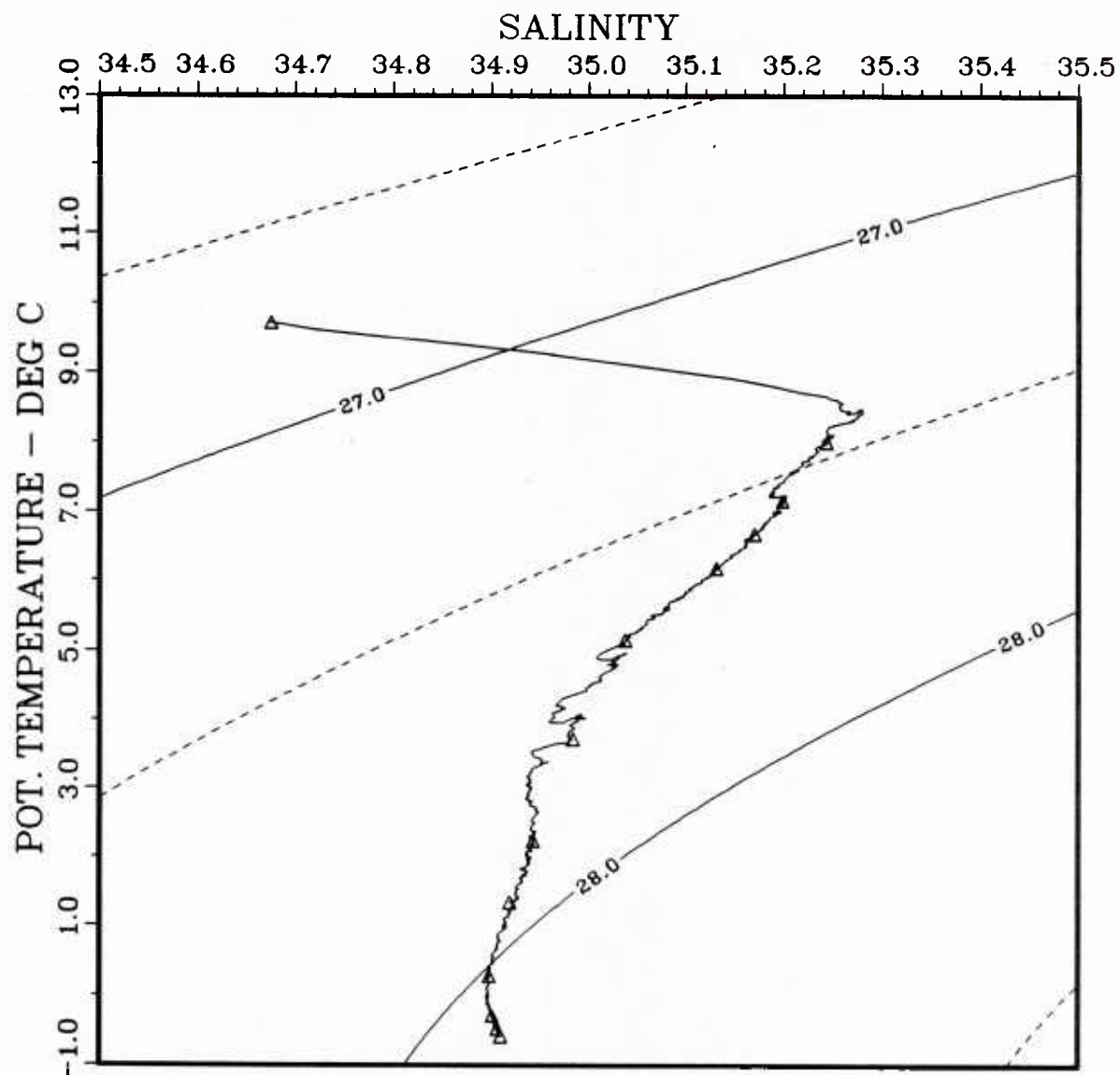


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

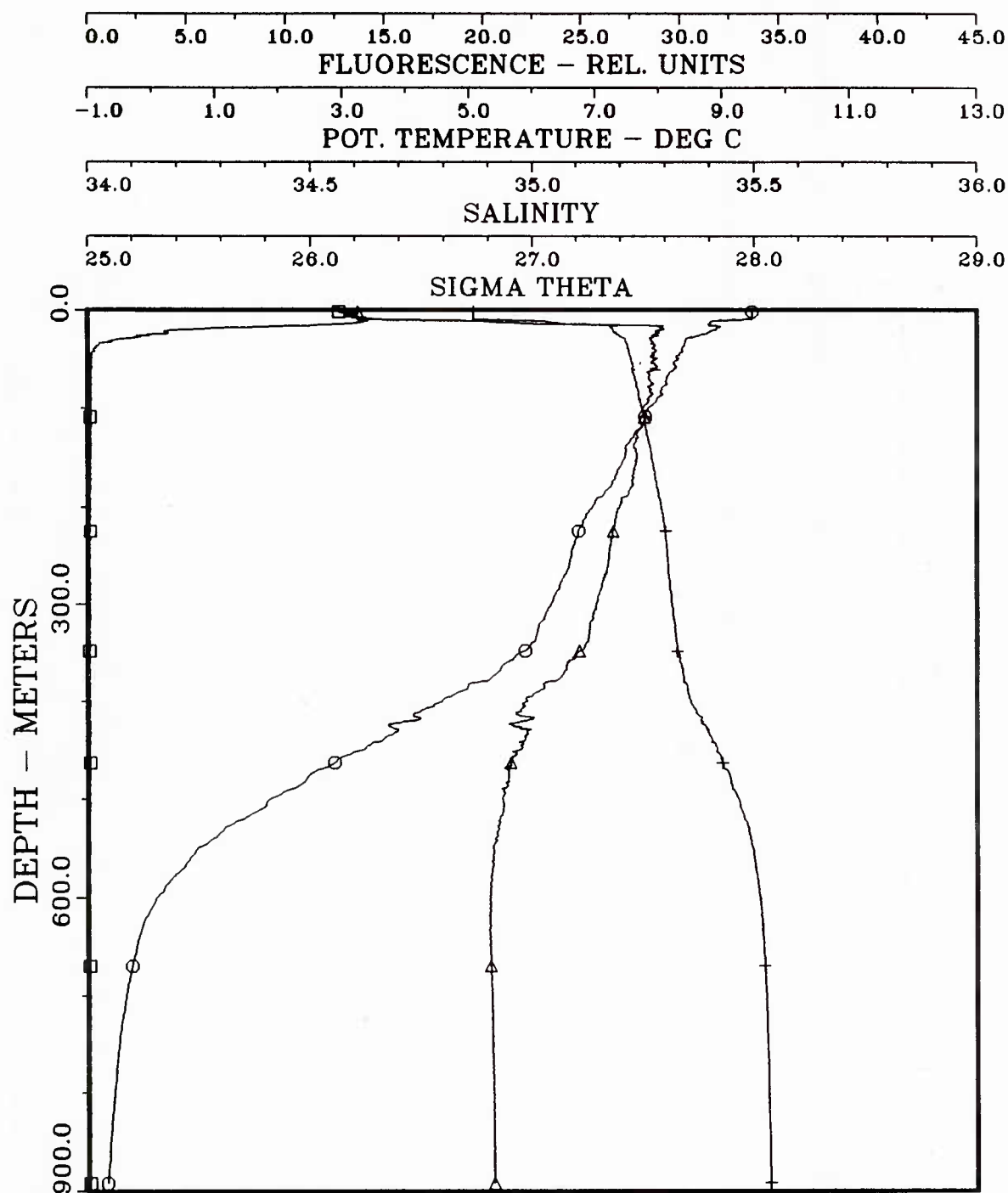
NORDMEER 87
45
1
167.2330
63 47.11N
000 40.87E

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	45	
CAST NUMBER	1	
JULIAN DATE	167.2330	
LATITUDE	63 47.11N	
LONGITUDE	000 40.87E	

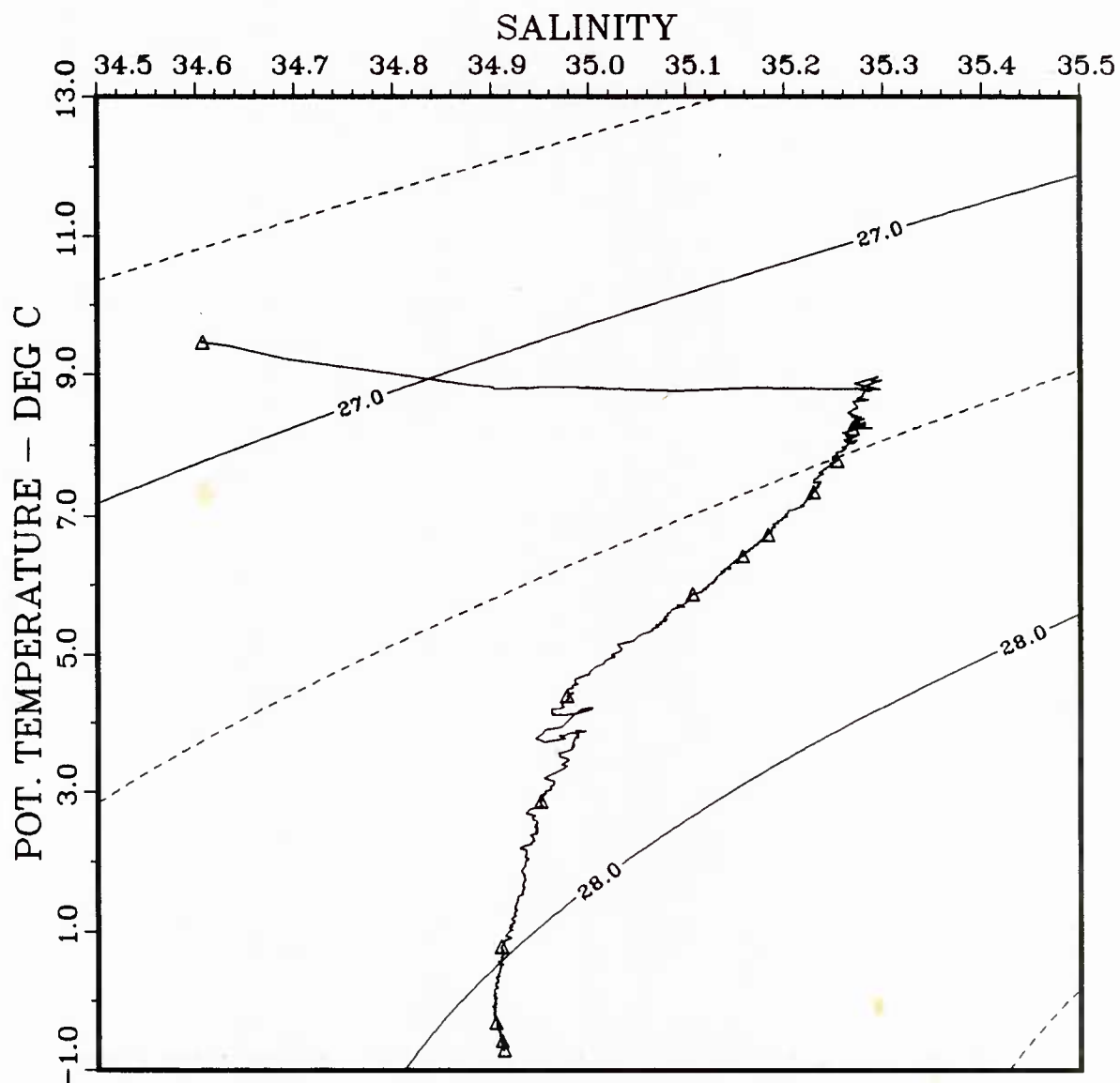


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

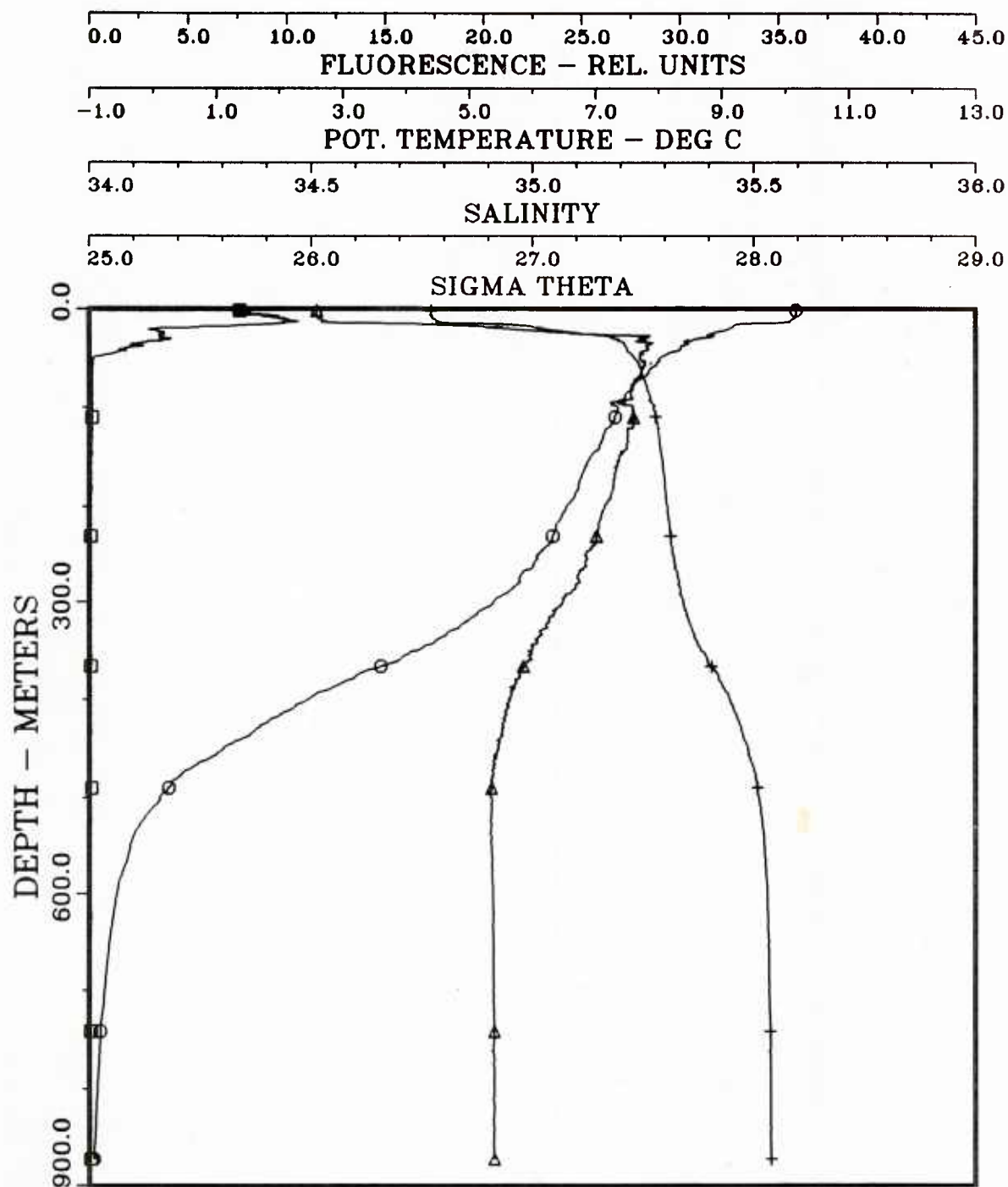
NORDMEER 87
46
1
168.0230
63 27.67N
001 24.59E

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	46	
CAST NUMBER	1	
JULIAN DATE	168.0230	
LATITUDE	63 27.67N	
LONGITUDE	001 24.59E	

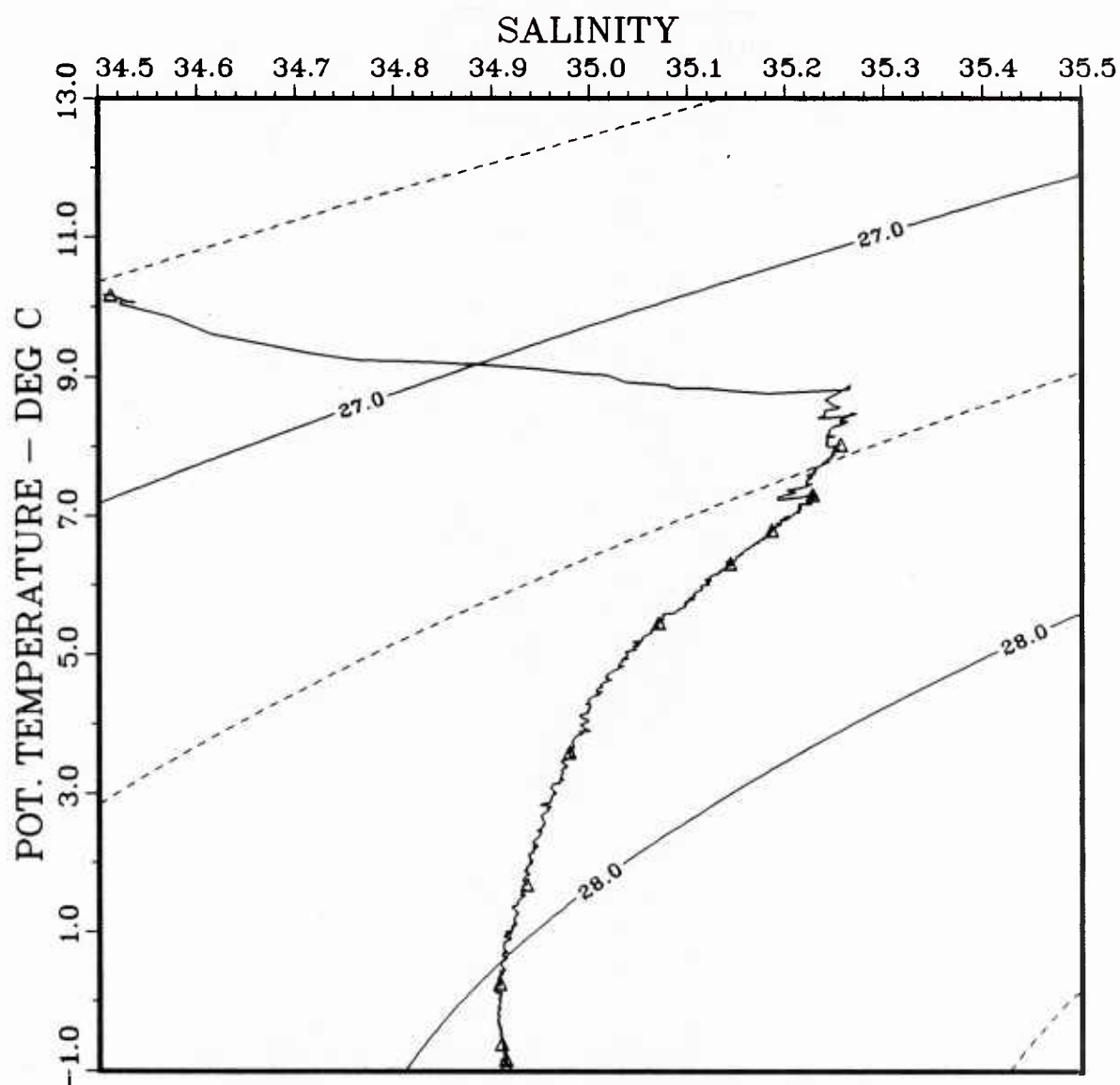


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

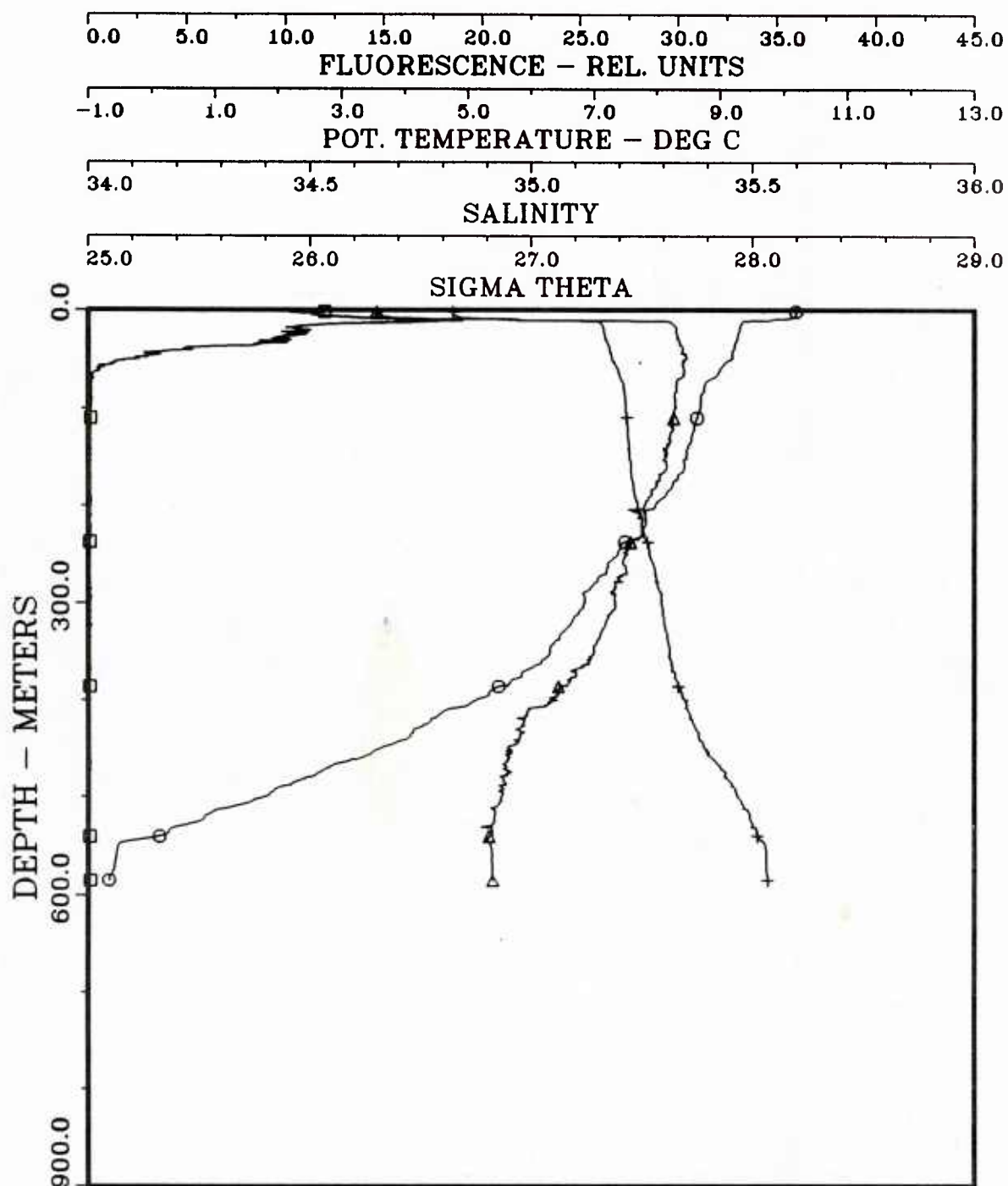
NORDMEER 87
47
1
168.0550
63 07.65N
002 08.18E

JUNE 1987

LEGEND
□ - FLUORESCENCE
○ - POT. TEMPERATURE
△ - SALINITY
+ - SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	47	
CAST NUMBER	1	
JULIAN DATE	168.0550	
LATITUDE	63 07.65N	
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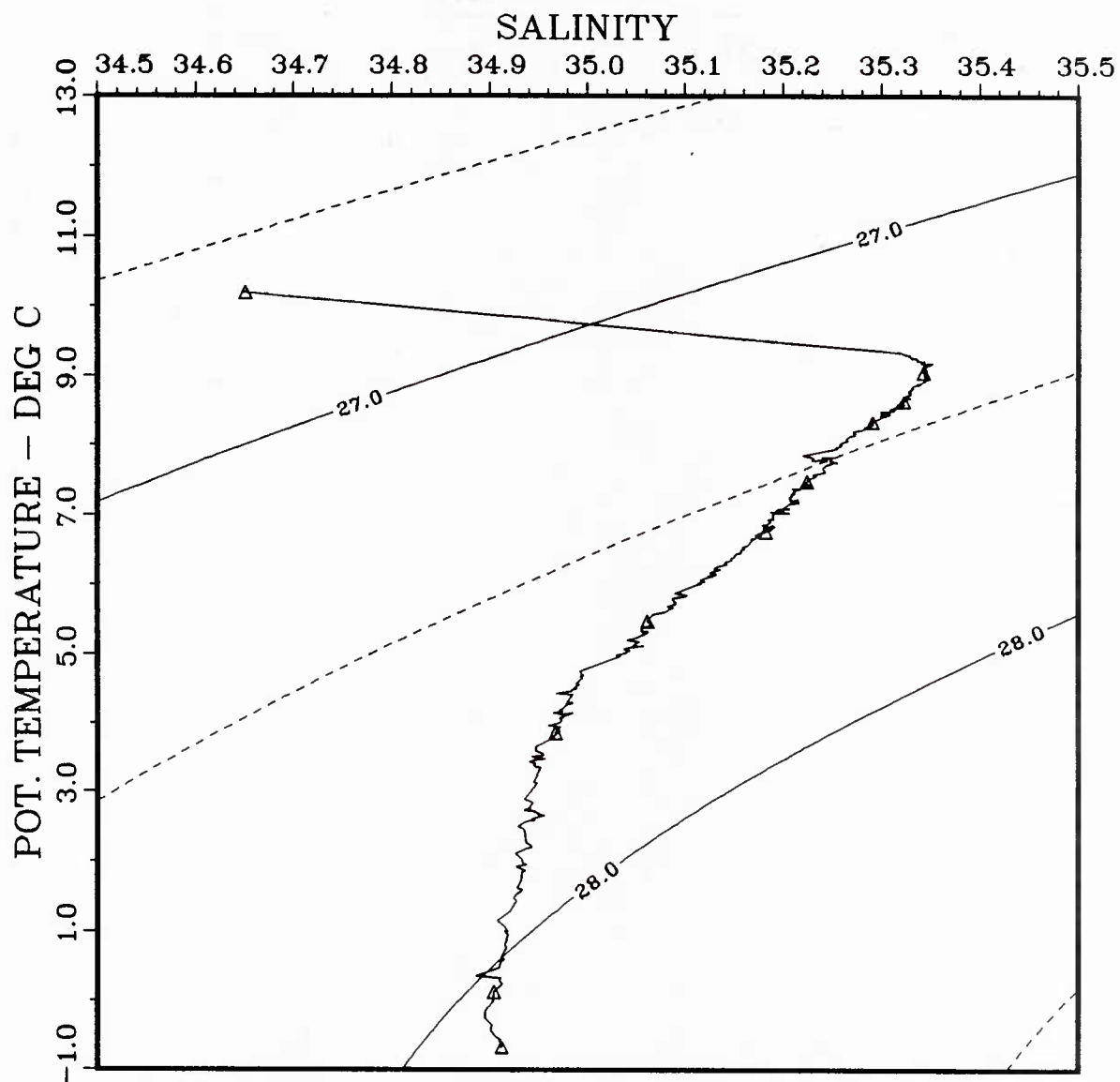


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

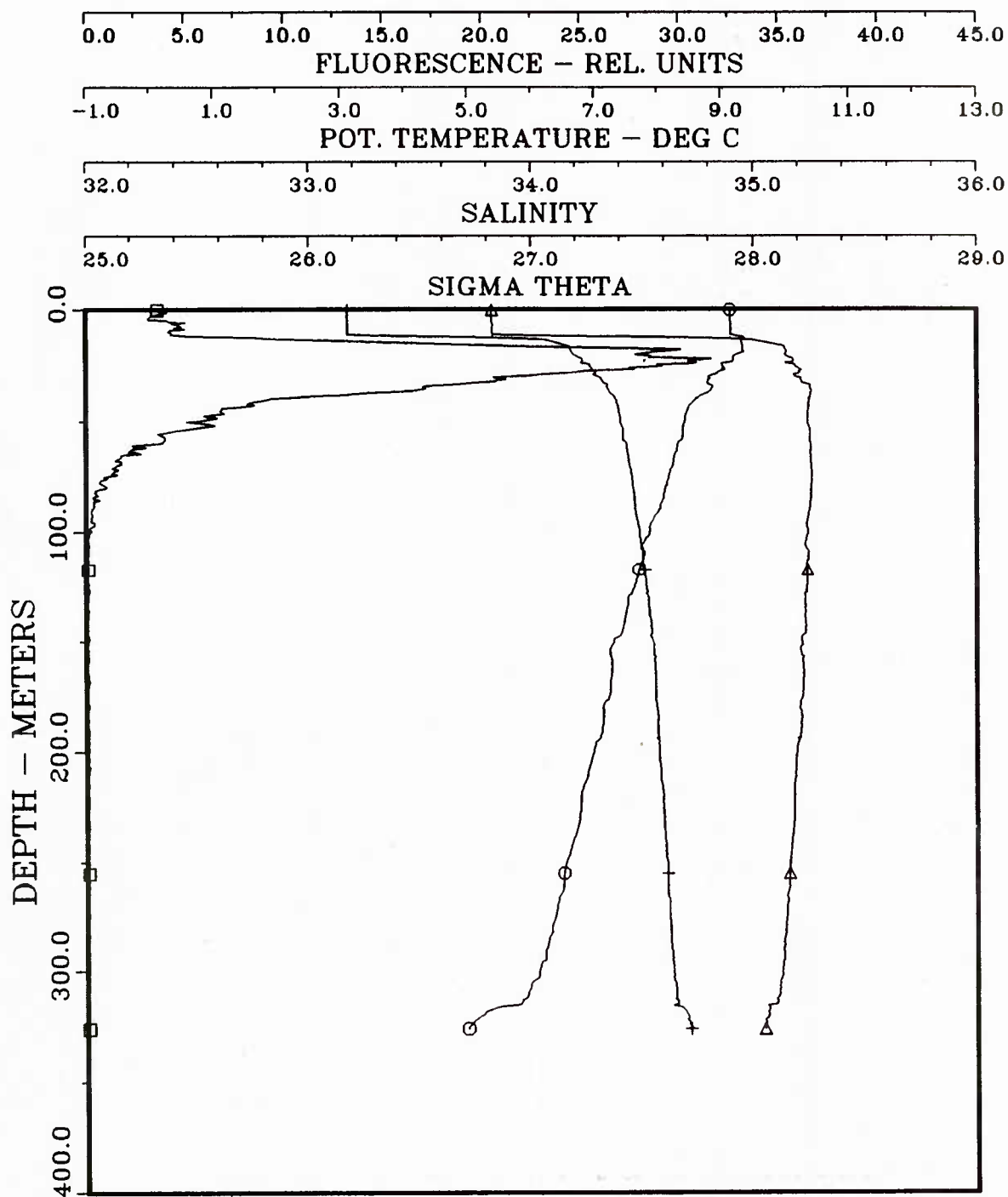
NORDMEER 87
48
1
168.0910
62 46.55N
002 54.92E

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	48	
CAST NUMBER	1	
JULIAN DATE	168.0910	
LATITUDE	62 46.55N	
LONGITUDE	002 54.92E	

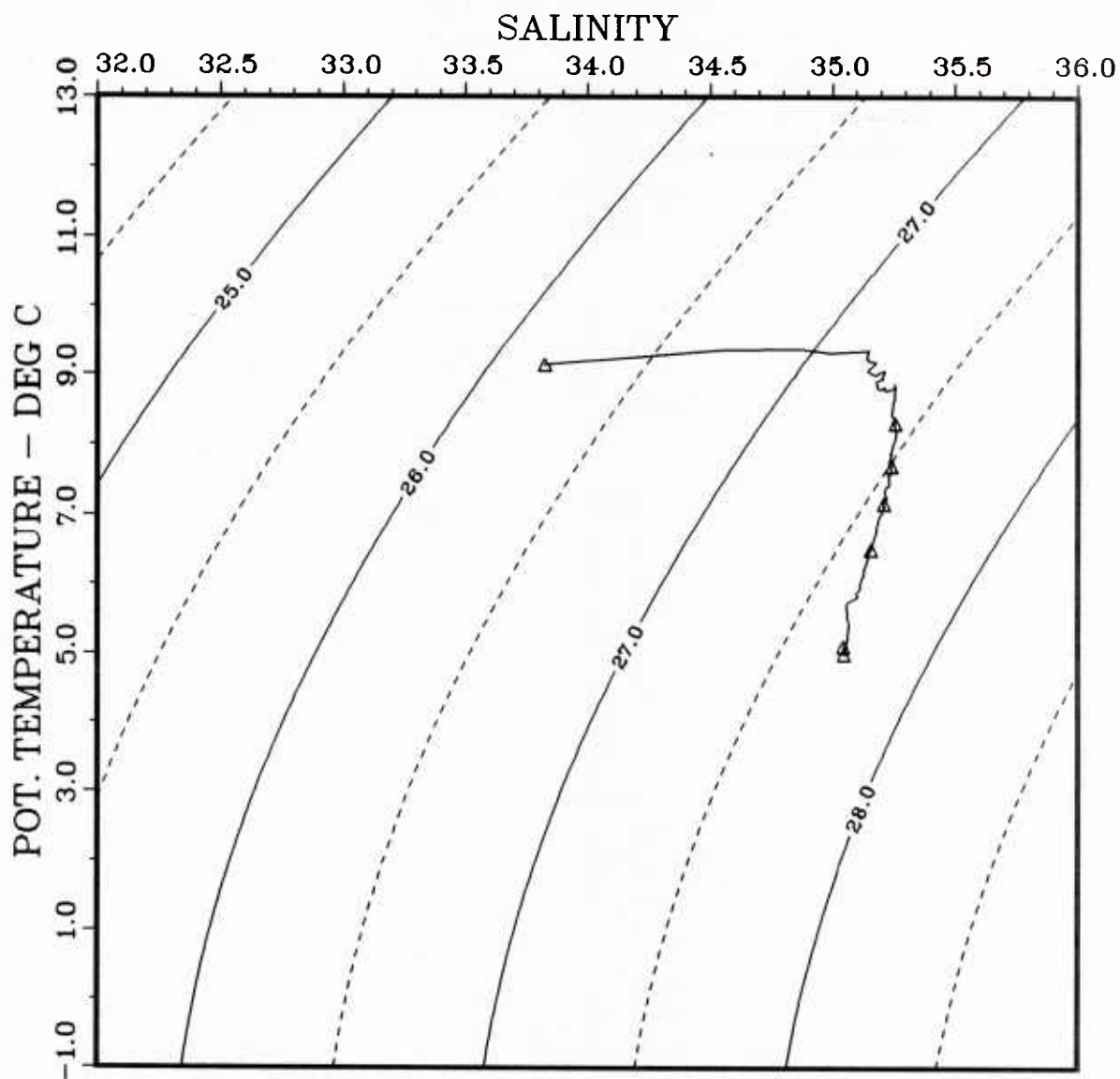


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

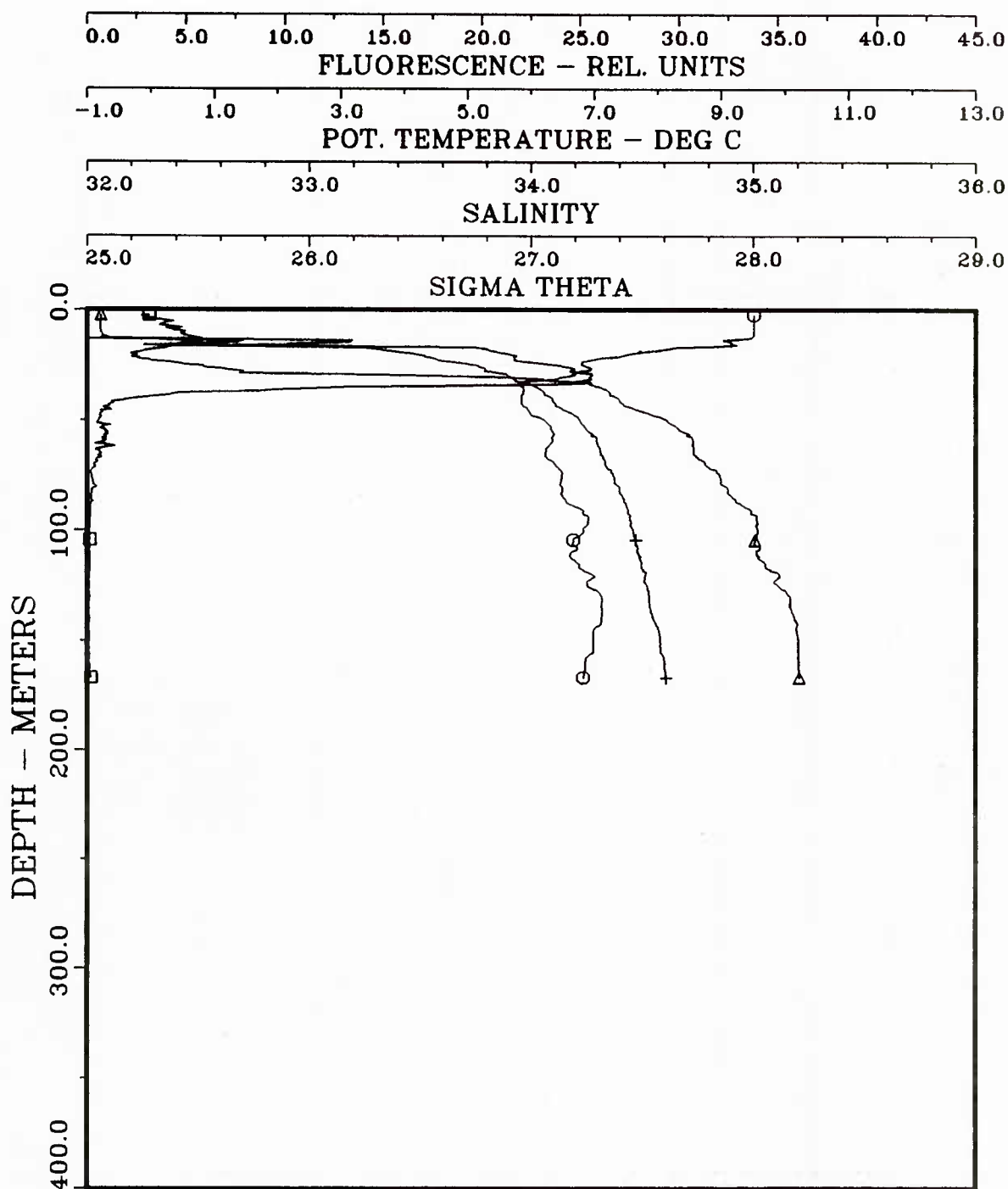
NORDMEER 87
49
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168.1130
62 35.89N
003 14.85E

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	49	
CAST NUMBER	1	
JULIAN DATE	168.1130	
LATITUDE	62 35.89N	
LONGITUDE	003 14.85E	

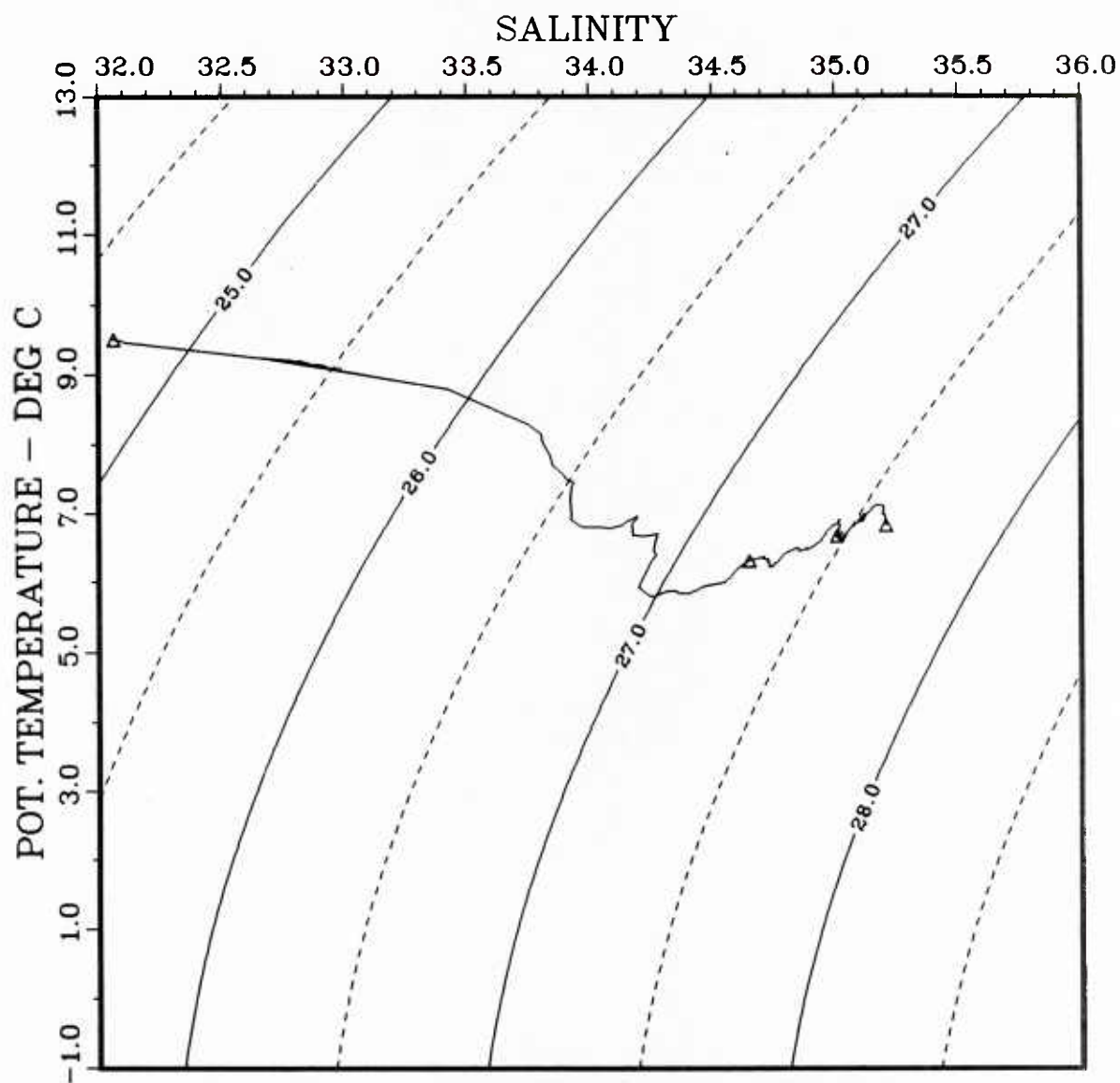


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

NORDMEER 87
50
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168.1330
62 25.37N
003 36.75E

JUNE 1987

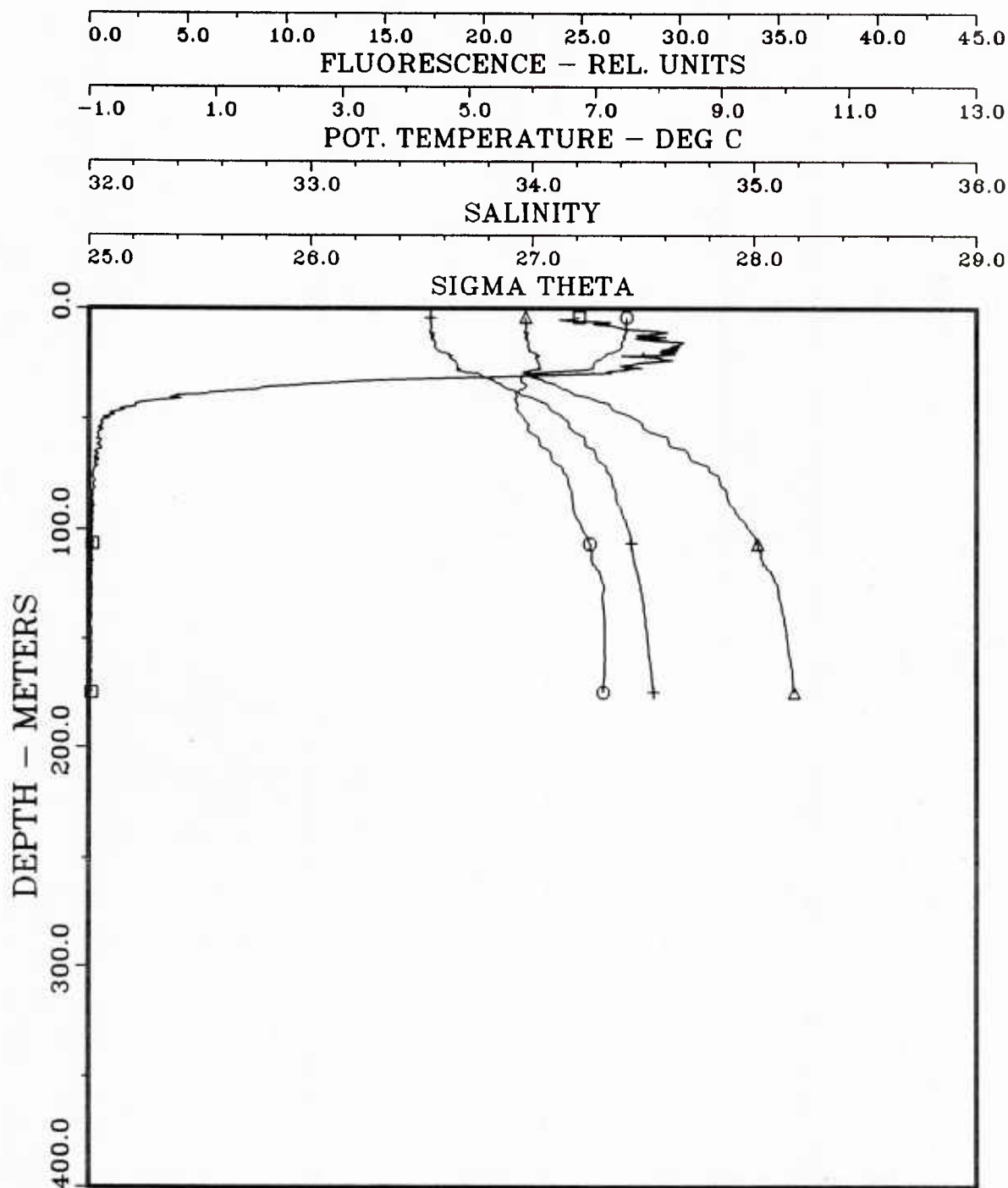
LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

NORDMEER 87
50
1
168.1330
62 25.37N
003 36.75E

JUNE 1987

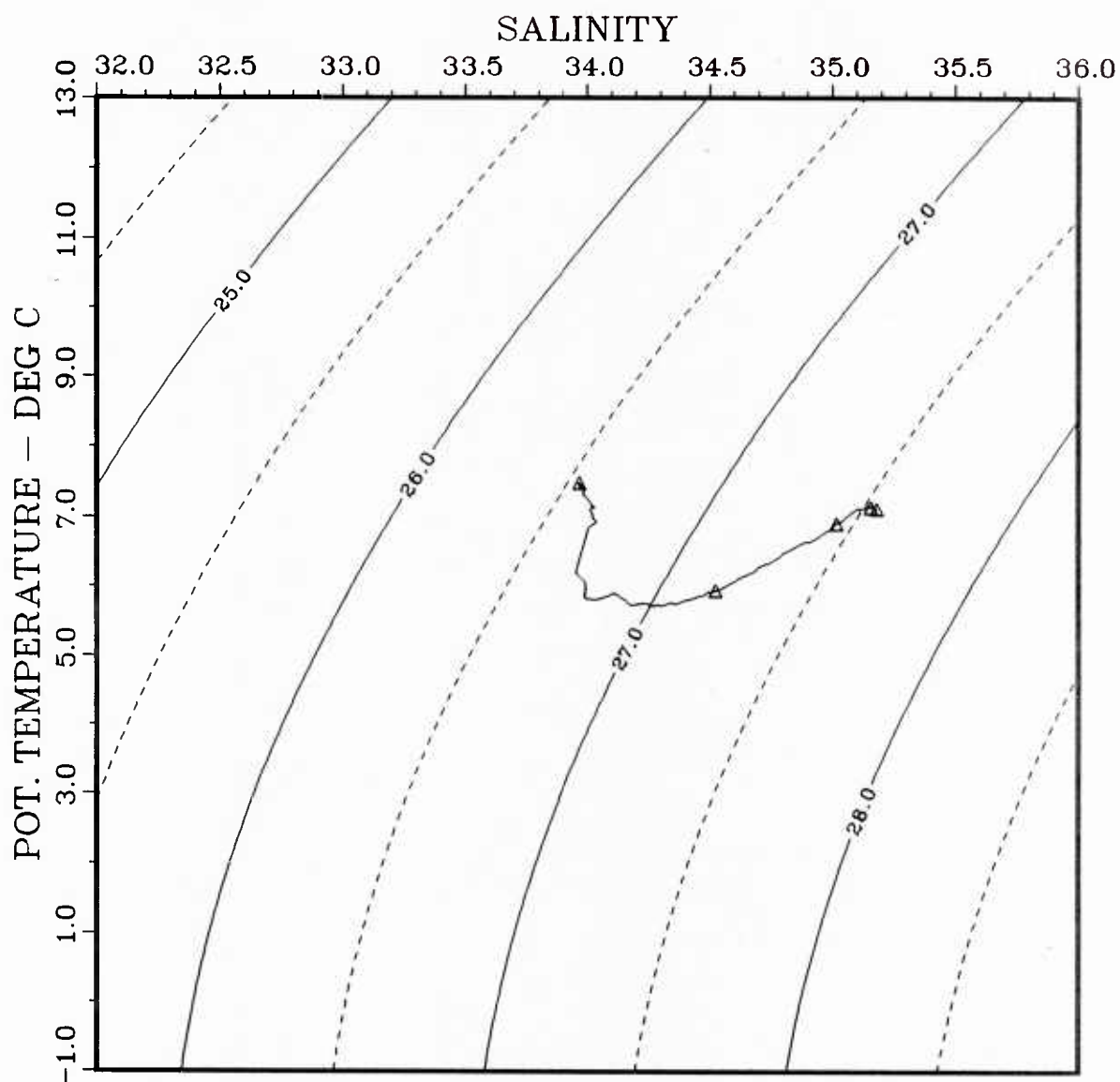


WFS PLANET
STATION
CAST NUMBER
JULIAN DATE
LATITUDE
LONGITUDE

NORDMEER 87
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168.1650
62 04.21N
004 21.32E

JUNE 1987

LEGEND
□ = FLUORESCENCE
○ = POT. TEMPERATURE
△ = SALINITY
+ = SIGMA THETA



WFS PLANET	NORDMEER 87	JUNE 1987
STATION	51	
CAST NUMBER	1	
JULIAN DATE	168.1650	
LATITUDE	62 04.21N	
LONGITUDE	004 21.32E	

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