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TEMPERATURE, SALINITY AND DENSITY ALONG THE STANDARD BONAVISTA TRANSECT

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ABSTRACT

Colbourne, E., and D. R. Senciall. 1993. Temperature, salinity and density along the standard Bonavista transect. Can. Tech. Rep. Hydrogr. Ocean Sci. 150: v + 331 p.

Synoptic, monthly average and annual time-series of temperature, salinity and density (sigma-t) are presented for the NAFO Cape Bonavista standard transect based on all data available from 1930 to 1992. A review of the spatial and temporal distribution of the data in the Cape Bonavista area is also presented. A brief descriptive analysis of various indices describing the temperature and salinity field along the transect is presented, including a discussion of the 1948 to 1992 time series of the cross-sectional area of the Cold Intermediate Layer (CIL). Finally, summer temperature and salinity anomalies (referenced to a July-August average for 1948 to 1992) are presented for 1984 to 1992.

RÉSUMÉ

Colbourne, E., and D. R. Senciall. 1993. Temperature, salinity and density along the standard Bonavista transect. Can. Tech. Rep. Hydrogr. Ocean Sci. 150: v + 331 p.

Des donnnées synoptiques, des moyennes mensuelles et des séries chronologiques annuelles de température, de salinité et de densité (sigma-t) pour le transct standard de l'OPANO de la zone du cap Bonavista ont été rassemblées à partir de l'ensemble des données recueillies entre 1930 et 1992. Un examen de la répartition spatiale et temporelle des données de la zone du cap Bonavista est également présenté. Une brève analyse descriptive des divers indices caractérisant les champs de température et de salinité le long du transect est présentée, de mêmo qu'une analyse de la série chronologique de 1948 à 1992 de l'aire transversale de la couche intermédiaire froide (CIF). Enfin, les anomalies estivales de température et de salinité (par rapport aux moyennes de juillet et d'août entre 1948 et 1992) sont présentées pour la période de 1984 à 1992.

1. INTRODUCTION

The trough between the northern Grand Bank and the Funk Island Bank (Fig. 1) has recently been identified as a likely corridor along which a significant biomass of northern cod migrate to the inshore areas along the east coast of Newfoundland during late spring and early summer (Rose, 1993). As a result there is an immediate need for increased knowledge of the physical oceanography of this area. A first step in this process is to make available all historical data in the region in a form where it can be easily referenced and used by the scientific community.

In 1976 the International Commission for the Northwest Atlantic Fisheries (ICNAF) adopted a suite of standard oceanographic stations along transects in the Northwest Atlantic ocean from Cape Cod (USA) to Egedesminde (West Greenland) (Anon. 1978). One of these standards was the Bonavista transect which lies along the center of the cod migration corridor (Fig. 1). A considerable amount of oceanographic data dating back to the early 1930s is available for this particular area.

Previous studies of the oceanography off the east coast of Newfoundland have included analyses of temperature and salinity data at Station 27 located about 4.0 km east of St. John's Newfoundland (Keeley, 1981a, Bailey, 1966, Huyer and Verney, 1975) and along the ICNAF standard Flemish Cap transect (Keeley, 1981b). The International Ice Patrol of the U.S. Coast Guard have also conducted studies concentrated mainly in the offshore branch of the Labrador current along the southeast slopes of the Grand Bank (Kollmeyer et. al., 1965). Additional studies have included extensive analysis of temperature and salinity variability along the east and northeast Newfoundland shelves (Petrie et. al. 1991, Petrie et. al., 1992, Petrie et. al. 1986, Templeman, 1975). Drinkwater and Trites (1986) have compiled monthly averaged temperature and salinity for standard areas over the entire Grand Bank and most of the northeast Newfoundland shelf up to 1982.

Most of the above studies describing the physical oceanography on the Newfoundland and Labrador shelves are becoming dated and there is now a need for a complete and up-to-date data set, particularly in the Cape Bonavista area where the oceanography is not generally represented by data from other regions; for example, along the Flemish Cap transect cold water extends from below the seasonal mixed layer to the ocean bottom for up to 300 to 400 km offshore throughout most of the year. This report complements these earlier studies by providing the first detailed presentation of data from a deep shelf transect off Newfoundland.

2. ORGANIZATION OF THE REPORT

The results presented here are based on an analyses of all available bottle, mechanical bathythermograph (MBT), expendable bathythermograph (XBT) and conductivity-temperature-depth recorder (CTD) data collected along the standard Bonavista transect from 1930 to 1992. The report includes a brief summary of the data sources, the spatial and temporal distribution of the data, analysis, and a brief discussion of the temperature, salinity and density (sigma-t) fields off Cape Bonavista, Newfoundland. Time series of the monthly average temperature, salinity and density are discussed first as functions of depth and time for selected positions along the transect (Appendix A). Appendices B to D contain monthly averaged vertical distributions of temperature, salinity and density along the transect derived from all data available for the month. Appendices E to G contain all completed transects since 1948. A discussion of various indices calculated from the horizontal transects (eg. cross-sectional area at various temperatures; maximum thickness, offshore extent of the cold intermediate layer (CIL); minimum core temperatures or CIL intensities; offshore bottom positions of various isotherms) is included. Finally, summer anomalies of temperature and salinity are presented in Appendices H and I, based on a July-August average (from 1930 to 1992) for the years 1984 to 1992. Due to the seasonal bias in the available data, anomalies were calculated only for the summer months.

3. THE STUDY AREA

This report includes all available data within a box with boundaries at ± 25 minutes of latitude of a line connecting 48 44.0 N, 52 58.0 W and 50 0.0 N, 49 0.0 W (the end points of the standard Bonavista transect). The positions and water depths of the standard oceanographic stations along the transect are listed in Table 1 and shown in Fig. 1. The standard transect consists of 12 stations beginning about 10 km NE of Cape Bonavista at depths of 70 m and ending 330 km offshore near the shelf slope at depths of 2000 m. Most of the temperature and salinity observations utilized in this report are scattered around these positions within the boundaries of the box defined above.

It is apparent from Fig. 1 that the Bonavista transect bisects the trough between the Northern Grand Bank and the Southern Funk Island Bank indicated by the 300 meter isobath. The trough runs from the edge of the continental shelf indicated by the 1000 m isobath, to within 50 km of Cape Bonavista Newfoundland.

4. DATA SOURCES AND ANALYSIS

Most of the data contained in this report were obtained from the Marine Environmental Data Service (MEDS) in Ottawa, Canada. Data after the early 1980s were available from archives at the Northwest Atlantic Fisheries Center (NAFC) in St. John's Newfoundland. About 34 % of the data, mainly before the late 1970s were collected at standard oceanographic depths (0,10,20,30,50, 75,100,125,150,200,250,300 and 400 m) using water sampling bottles fitted with reversing thermometers. Since the 1960s and up to the present a considerable amount of data were also collected using mechanical and electronic bathythermographs and since the late 1970s conductivity-temperature-depth (CTD) recorders have become common place. The historical data set consists of data collected by all of these instruments and have expected accuracies ranging from ± 0.2 °C in temperature for bathythermographs to ± 0.02 for reversing thermometers and ± 0.005 °C for CTDs. Accuracies in salinities range from ± 0.02 from bottle titrations to ± 0.005 from CTD measurements. Densities are reported as sigma-t values calculated using the UNESCO equation of state for seawater (Millero, et. al. 1980).

The earliest complete occupation of the Bonavista transect occurred in July 1948, after 1950 the transect has been occupied on a regular basis in July or August except for the period 1965 to 1968. Observations along the transect during other months, particularly the winter months (December to March) were irregular. The total number of profiles measured along the transect in the selected corridor from all sources for the years 1948 to 1992 are shown in Table 2 by month. The transect has been occupied 43 times in the July-August period between 1948 and 1992 comprising a total of 1169 profiles.

The spatial distribution of all observations within ± 25 minutes of latitude of the standard transect over all years for each month are shown in Fig 2a to 2l. The symbols on these maps indicate a station occupation, as either a standard bottle cast, BT or CTD; both temperature and salinity may not be available for each

station. These results indicate a reasonably well distributed data set along the transect for all months except January and February, when it can be considered marginal for the calculation of mean conditions.

The distribution of data collected among years is multi modal with 4 % collected from 1930 to 1950, 25 % from 1950 to 1970, 41 % from 1970 to 1990 and 30 % from 1990 to 1992 (Fig. 3a). Noticeable gaps in the historical record are apparent during 1936 to 1946 and 1966 to 1968. There has been an exponential increase in data collection in the Bonavista area since 1975. As a result the means calculated here will be biased towards later years. A strong seasonal bias in the historical data is apparent with 59 % of the data collected in the summer (June, July and August), 15 % in the spring (April, May), 16 % in the fall (September, October and November) and 10 % in the winter (December, January, February and March) (Fig. 3b).

Temporal biasing in the calculation of monthly averages is likely when there are variations in the amount of data collected from year to year and when the data for a particular month are not distributed evenly throughout the month. No attempts were made to adjust the data for possible temporal biasing arising from the sample distribution. Spatial biasing of the monthly averages may also occur when there is a significant amount of data confined to a particular area of the region under consideration, however as mention above Figure 2 indicates that there are ample data along the complete transect for most months. In addition, the N-S variations in the bathymetry within the selected box are small which indicates that alongshore gradients in temperature and salinity are probably weak.

The station positions of all observations in the corridor along the transect, for the purposes of the analysis, were assumed to lie along a straight line with offshore distance calculated from Cape Bonavista. The data were then quality controlled for obvious spikes, range restricted and linearly interpolated or decimated if necessary to 5.0 m depth intervals. The profiles were not extrapolated beyond their depth range. In cases where a particular cast was repeated on the same station on the same day the duplicate data were discarded keeping CTD and Bottle data over BTs. The data were then projected onto a 5.0 km horizontal by 5.0 m vertical grid and a simple arithmetic mean computed. In general there was a sufficient amount of data collected during each month to approximate the monthly means along the transect throughout the year. The analysis makes no attempt to estimate any error in the calculated means.

5. TEMPERATURE, SALINITY AND DENSITY TIME SERIES

Time series of the monthly mean temperature, salinity and density versus depth are shown in Appendix A for the inshore (50 km offshore), mid-shelf (100 km offshore) and shelf edge (250 km offshore) areas off Cape Bonavista. The time series were formed by averaging all data for each month in a 5 km horizontal bin along the transect (centered at 50,100 and 250 km offshore) over all years (from 1930 to 1992). These plots shows the seasonal variations in the CIL; its winter formation, spring capping, gradual decay over the summer and rapid erosion during the autumn.

In the inshore areas the whole water column is below 0.0 °C from January until the end of April. The seasonal warming in the upper layer commences in mid May and continues to warm at a rate of about 0.1 °C per day until late August to early September when it reaches its maximum of about 10.0 °C. The thickness of the mixed layer reaches a maximum of about 50 m by mid October by which time the surface layer is already cooling down. The temperature from mid depths to the bottom remain below 0.0 °C throughout the year.

The salinities in the inshore areas range from 32.75 in the upper water column to 33.75 near the bottom from January to April after which the upper layers experience a gradual freshening with salinities reaching a minimum of 31.5 by late August to September. In the deeper water (below 100 m) the salinities remain above 33.0 over the entire year. At cold water temperatures the density field is mainly determined by salinity and so the isopycnals generally follow isohalines.

At mid shelf about 100 km offshore, the temperature structure is very similar to near shore values except near the bottom at depths of 300 m where the warmer shelf-slope water starts to flood the deep troughs between the banks. Temperatures here range from 1.0 to 2.0 °C throughout the year. Salinities are generally higher (up to 1.0) than the inshore values over most of the water column with minimum values of 32.0 in the upper layers in September, to 34.5 near the bottom throughout the year.

At the edge of the continental shelf (about 250 km offshore) in a water depth of about 500 m the temperature structure is quite different from that at mid shelf and inshore. A thin surface layer of water with temperatures ranging from 0.0 to -1.0 °C and from 0.0 to 2.0 °C in water depths down to 150 m exist during the winter months. Below 200 m depth the temperature remains between 3.0 to 4.0 °C. By early April the upper layer warms to a maximum of about 8.0 °C by August while at depths of 50 m to the bottom the

temperature remains between 3.0 and 4.0 °C. Salinities range from 33.50 near the surface during the winter and summer periods to about 34.75 near the bottom throughout the year. Again the density field generally follows salinity.

6. TEMPERATURE, SALINITY AND DENSITY TRANSECTS

Presented in Appendices B to D are the monthly average vertical distributions of temperature, salinity and density versus horizontal distance from Cape Bonavista based on all available data, followed by specific occupations of the transect by month beginning in 1948 (Appendices E to G).

A dominant feature of the temperature structure along the east coast of Newfoundland on the continental shelves is the cold intermediate layer (CIL) (Petrie et. al., 1988). The CIL is most apparent in summer when spring ice melt and seasonal heating has increased the stratification in the upper layers to a point when heat transfer to the lower layers is inhibited. The result is a cold layer of water confined to the continental shelf with temperatures ranging from 0.0 to -1.8 °C sandwiched between the warm seasonal upper layer and warmer slope water near the bottom.

In the winter months the intermediate layer effectively disappears as the upper layers cool down to between -1.0 and 0.0 °C from January to March due to winter cooling and strong surface mixing. By late April and early May the warming of the surface layer commences and the cross-sectional area of ≤ 0.0 °C water decreases from the winter maximum to a minimum in the fall due to summer heating.

Figure 4a to 4c shows time series of the CIL cross-sectional area of water less than 1.0, 0.0, and -1.0 °C from 1948 to 1992 for July and August together with the mean (dashed line). In general the time series shows for all temperatures presented a gradual warming trend starting in 1950 and lasting until the mid 1960s. During this period the cross-sectional area of the CIL decreased at a rate of approximately 1.0 km^2 per year. A gap exists in the data from 1966 to 1968. Since the early 1970s the time series is characterized by three major cold periods with peaks in 1972, 1984 and in 1990/91. The area anomaly during these cold periods range from 60 % to 88 % above the mean with 1984 showing the greatest areal extent of sub-zero water. The warmest years were the mid 1960s, mid 1970s and the late 1980s when the cross-sectional areas were from 30 % to 50 % below the mean. The average cross-sectional area for water less than -1.0, 0.0 and 1.0 °C are 12.4, 26.4 and 37.7 km^2 with standard deviations of 7.1, 8.7 and 9.4 km^2 respectively.

The areal extent and shape of the CIL bounded by the 0.0 °C isotherm for 1984, a cold year, and for 1986 a relatively warm year together with the July-August mean is shown in Fig. 5a. In 1984 the offshore extent of the CIL reached about 325 km off Cape Bonavista with a cross-sectional area of near 50 km^2, more than 80 % above normal. The thickness of the CIL during cold years is also above normal with 0.0 °C water reaching close to the bottom at mid-shelf. The CIL shape and area during 1991 and 1992 is shown in Fig. 5b. In 1991 the cross-sectional area was about 44 km^2 close to the maximum while in 1992 it was close to the mean with an area of 28 km^2. The main difference between 1984 and 1991 was in the offshore extent of the cold water.

The temperature along the bottom across the northeast Newfoundland shelf ranges from -1.0 °C near the coast to 2.0 to 4.0 °C in water depths greater than 200 m to the shelf edge throughout the year. The average bottom position (Fig. 6a) of the 1.0, 2.0 and 3.0 °C isotherm in July and August is located about 42, 70 and 160 km offshore respectively. The bottom positions of the 2.0 and 3.0 °C isotherms are in general highly variable from one year to the next and even from one month to the next within the same year, for example in July 1991 the 3.0 °C isotherm was about 125 km offshore where as in July 1992 it was about 225 km offshore. The position of the 1.0 °C isotherm has remained relatively constant during the summer months with only a 15 km standard deviation from the mean. Warmer slope water is further offshore during the cold periods of the early 1970s, mid 1980s and early 1990s corresponding to high CIL areas. The mean offshore extent (Fig. 6b) of the CIL is about 220 km with a standard deviation of 44 km, centered at approximately 100 m depth and a mean thickness about 200 m with a standard deviation of 35 m, occurring at approximately 50 km offshore.

Minimum temperatures at the core of the CIL (Fig. 7) range from -1.84 °C in a cold year (1984 and 1991) to -1.4 °C in a warm year (1986). The average core temperature from 1948 to 1992 is -1.64 °C centered at about 70 km offshore at approximately 80 to 100 m depth. The freezing point of seawater at salinities typically found on the continental shelf along this transect (ie. between 32.50 to 34.25) ranges from -1.78 to -1.88 °C.

For convenience a summary of the various CIL summer indices discussed above for the Bonavista transect, are presented in Table 3.

7. TEMPERATURE AND SALINITY ANOMALIES

Presented in Appendices H and I are the summer temperature and salinity anomalies for the years 1984 to 1992 based on the average for the July-August period (from 1948 TO 1992). These anomalies were calculated by projecting the transect data for each year on a 5 km horizontal by 5.0 m vertical grid and subtracting the temperature and salinity values from the corresponding values of the summer averaged grid. The results were then smoothed and contoured at 1.0 °C intervals. Thus the results presented here show only significant anomalies along the transect over the entire water column.

The results show significant negative temperature anomalies ranging from -1.0 to -3.0 °C in July of 1984 over most of the water column with the most intense anomalies in the upper layer. The strong negative anomalies near the surface in 1984 had moderated by August of 1985. From 1986 to 1989 the anomalies were generally positive with amplitudes ranging from 1.0 to 4.0 °C above average, again the most significant anomalies occurred in the upper mixed layer. From 1990 to 1992 the temperature anomalies were again negative with amplitudes ranging from -1.0 to -3.0 °C below average. During 1992 the negative anomalies were restricted entirely to a thin upper layer of about 25 m thick, whereas in 1991 significant negative anomalies were observed over the entire water column of the northeast Newfoundland shelf.

The corresponding salinity anomalies from 1984 to 1985 show slightly fresher than normal conditions with anomalies ranging from -0.25 to -0.50 over most of the water column. From 1986 to 1989 the anomalies range from about normal in 1986 to generally positive (saltier than normal) in other years. In 1990 the salinity anomalies remained above average in the upper layer but had reversed to slightly fresher in deeper water and over the entire water column by 1991.

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ICNAF #	Latitude	Longitude	Depth (M)
62	50 00.0	49 00.0	2,047
63	49 51.0	49 30.0	1,618
64	49 41.0	50 01.0	570
65	49 31.0	50 32.0	331
66	49 22.0	51 01.0	314
67	49 11.4	51 32.5	284
68	49 06.0	51 49.8	307
69 (46)	49 01.5	52 04.0	294
70	48 55.0	52 24.0	342
71 (45)	48 50.0	52 39.0	79
72 (44)	48 48.0	52 45.0	72
73 (43)	48 44.0	52 58.0	68

Table 1. The standard oceanographic stations along the Bonavista transect. The figures in () represent old station numbers with position and depths same or very similar to the standard ICNAF stations (from Anom. 1978).

YEAR	MONTH											
	J	F	M	A	M	J	J	A	S	O	N	D
1930	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	0	0	4	2	0	0	0	0
1932	0	0	0	0	1	0	0	0	0	0	0	0
1933	0	0	0	0	0	3	1	0	1	0	0	0
1934	0	0	0	0	0	1	2	0	1	0	0	0
1935	0	0	0	0	0	0	6	0	1	0	0	0
1936	0	0	0	0	0	0	0	0	0	0	0	0
1937	0	0	0	0	0	0	0	0	0	0	0	0
1938	0	0	0	0	0	0	0	0	0	0	0	0
1939	0	0	0	0	0	0	0	0	0	0	0	0
1940	0	0	0	0	0	0	0	0	0	0	0	0
1941	0	0	0	0	0	0	0	0	0	0	0	0
1942	0	0	0	0	0	0	0	0	0	0	0	0
1943	0	0	0	0	0	0	0	0	0	0	0	0
1944	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	0	0	0	0	0	0	0	0
1946	0	0	0	0	0	0	0	1	0	0	0	0
1947	0	0	0	0	0	0	0	0	0	0	0	0
1948	0	0	0	0	0	0	16	0	0	0	0	0
1949	0	0	0	0	0	29	0	0	0	0	0	0
1950	0	0	0	0	14	0	36	2	1	0	0	0
1951	0	0	0	5	10	0	21	0	0	0	0	0
1952	0	0	0	15	0	0	23	1	0	0	0	0
1953	4	2	3	0	14	1	23	0	8	0	0	0
1954	0	0	0	0	0	15	11	15	0	1	4	0
1955	0	0	0	2	0	15	24	0	7	6	0	0
1956	0	0	0	0	0	14	23	0	8	0	0	0
1957	0	0	0	0	0	0	15	9	0	0	0	0
1958	0	0	13	15	0	28	0	9	1	0	20	0
1959	0	0	0	0	0	15	3	37	1	0	0	0
1960	0	0	1	0	0	15	27	7	0	0	0	0
1961	0	0	0	0	2	15	35	4	0	0	0	0
1962	0	0	0	0	15	15	27	0	0	12	1	0
1963	1	0	0	15	15	4	15	16	0	0	0	0
1964	0	0	0	10	14	0	29	0	0	0	0	0
1965	0	0	0	0	0	0	9	9	0	0	0	0
1966	0	0	0	0	0	0	3	0	1	0	0	0
1967	0	0	5	0	0	0	0	0	0	0	2	0
1968	0	0	0	0	0	1	0	0	0	0	0	0
1969	0	5	0	12	2	0	0	17	1	1	0	0
1970	0	12	0	11	11	0	11	11	0	4	0	0
1971	0	0	0	0	1	1	1	20	0	0	1	0
1972	0	0	0	0	0	0	19	0	1	0	0	0
1973	0	0	0	0	2	14	20	13	0	0	0	0
1974	0	0	0	0	0	0	0	21	0	0	1	0
1975	0	0	0	0	1	16	15	0	1	0	0	0
1976	0	0	0	4	0	0	0	15	1	0	0	0
1977	0	1	0	0	7	0	0	20	1	0	0	0
1978	0	0	0	0	2	3	13	27	1	0	0	0
1979	0	0	7	0	14	0	8	15	14	1	0	8
1980	0	0	7	0	28	9	3	1	8	25	7	8
1981	3	0	11	32	3	11	4	16	27	3	13	3
1982	0	0	25	5	7	3	0	0	0	0	9	0
1983	5	0	0	0	20	0	21	0	0	13	15	0
1984	9	0	0	0	0	37	26	0	7	0	17	5
1985	11	0	1	0	10	85	3	31	0	13	41	0
1986	11	0	0	0	22	18	0	24	0	0	18	1
1987	0	0	0	0	24	31	1	30	1	3	12	10
1988	0	4	0	9	18	9	0	30	15	15	12	6
1989	0	1	0	2	16	25	13	2	0	14	20	11
1990	8	33	10	0	17	105	17	16	0	10	0	33
1991	0	18	1	6	15	134	17	17	1	4	32	0
1992	7	3	4	0	63	142	186	0	43	7	17	36

Table 2. Summary of the total number of oceanographic profiles available along and near the Bonavista transect from 1930 to 1992.

Cape Bonavista CIL Indices							
YEAR	Cross Sectional Area. $(KM)^2$				Min. Temp.	Thickness	Extent
	1.0 ^oC	0.0 ^oC	-1.0 ^oC	-1.5 ^oC	(^oC)	(M)	(KM)
1948	27.6	17.5	7.6	0.0	-1.548	210	153
1950	42.3	28.7	16.0	5.9	-1.768	217	233
1951	38.0	23.9	6.2	0.0	-1.818	189	256
1952	43.3	32.0	11.5	0.4	-1.630	203	254
1953	35.4	21.9	10.4	1.2	-1.648	168	228
1954	37.8	28.1	16.1	4.3	-1.665	213	207
1955	44.1	28.8	11.3	0.0	-1.660	192	249
1956	28.4	19.1	9.8	0.0	-1.620	192	165
1957	33.0	16.3	4.4	0.0	-1.620	192	151
1958	31.9	20.4	8.6	1.8	-1.620	168	218
1959	36.4	25.1	12.0	0.0	-1.660	185	228
1960	32.5	22.8	10.6	0.7	-1.618	178	216
1961	29.3	18.7	9.1	0.0	-1.564	175	158
1962	27.5	15.8	7.2	0.0	-1.573	157	155
1963	28.1	18.0	6.8	0.0	-1.467	206	209
1964	28.7	20.9	11.8	4.0	-1.669	224	164
1965	19.5	12.7	2.7	0.0	-1.430	147	136
1969	41.3	27.7	7.0	0.0	-1.510	203	251
1970	44.1	28.7	13.4	2.1	-1.840	175	279
1971	40.8	27.2	4.3	0.0	-1.630	203	266
1972	55.1	43.2	17.5	3.0	-1.720	224	287
1973	47.4	36.0	20.7	1.0	-1.760	248	246
1974	31.9	18.8	6.4	0.0	-1.600	175	212
1975	35.7	27.1	17.9	4.0	-1.798	227	204
1976	34.0	27.8	16.9	4.5	-1.840	231	169
1977	33.5	21.1	11.6	2.0	-1.710	227	207
1978	23.9	15.3	6.8	0.0	-1.520	133	151
1979	36.6	23.7	6.4	0.0	-1.470	175	270
1981	34.4	23.5	8.8	0.0	-1.400	182	195
1983	47.0	37.6	22.1	0.0	-1.840	227	286
1984	63.8	49.6	29.0	10.6	-1.798	255	322
1985	52.7	36.3	21.2	8.4	-1.700	210	239
1986	30.8	20.5	9.9	0.0	-1.500	178	212
1987	31.8	19.3	1.0	0.0	-1.500	122	225
1988	41.9	29.1	12.0	0.0	-1.494	192	249
1989	36.4	28.7	17.4	7.3	-1.716	210	199
1990	53.7	43.3	26.9	11.9	-1.701	280	244
1991	52.3	44.4	31.7	18.3	-1.745	266	247
1992	38.7	28.4	13.0	3.8	-1.682	220	226

Table 3. Summary of selected Bonavista transect summer CIL indices.

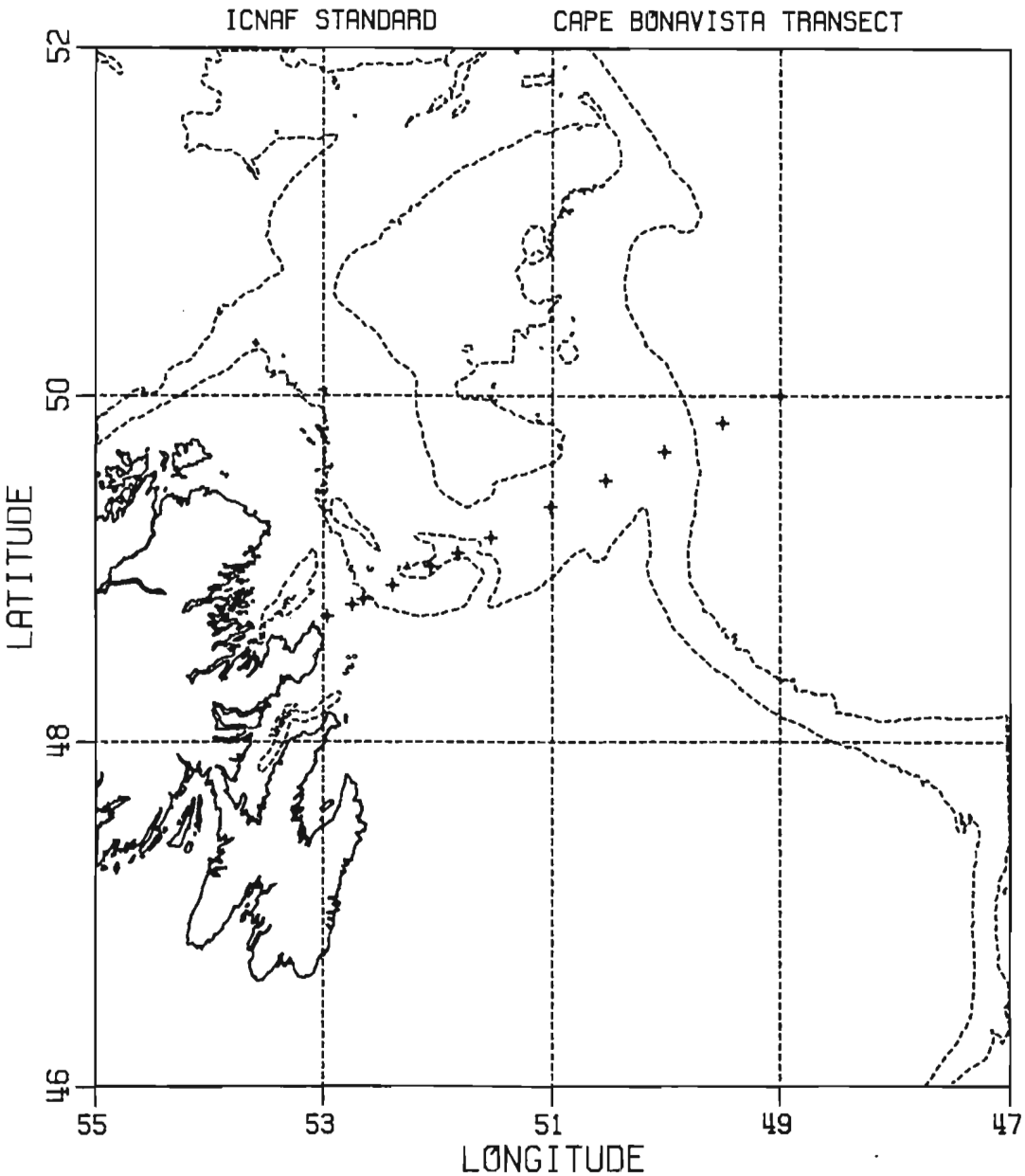


Fig. 1. Location map showing the position of the standard stations along the Bonavista transect. The bathymetry lines are 300 and 1000 m.

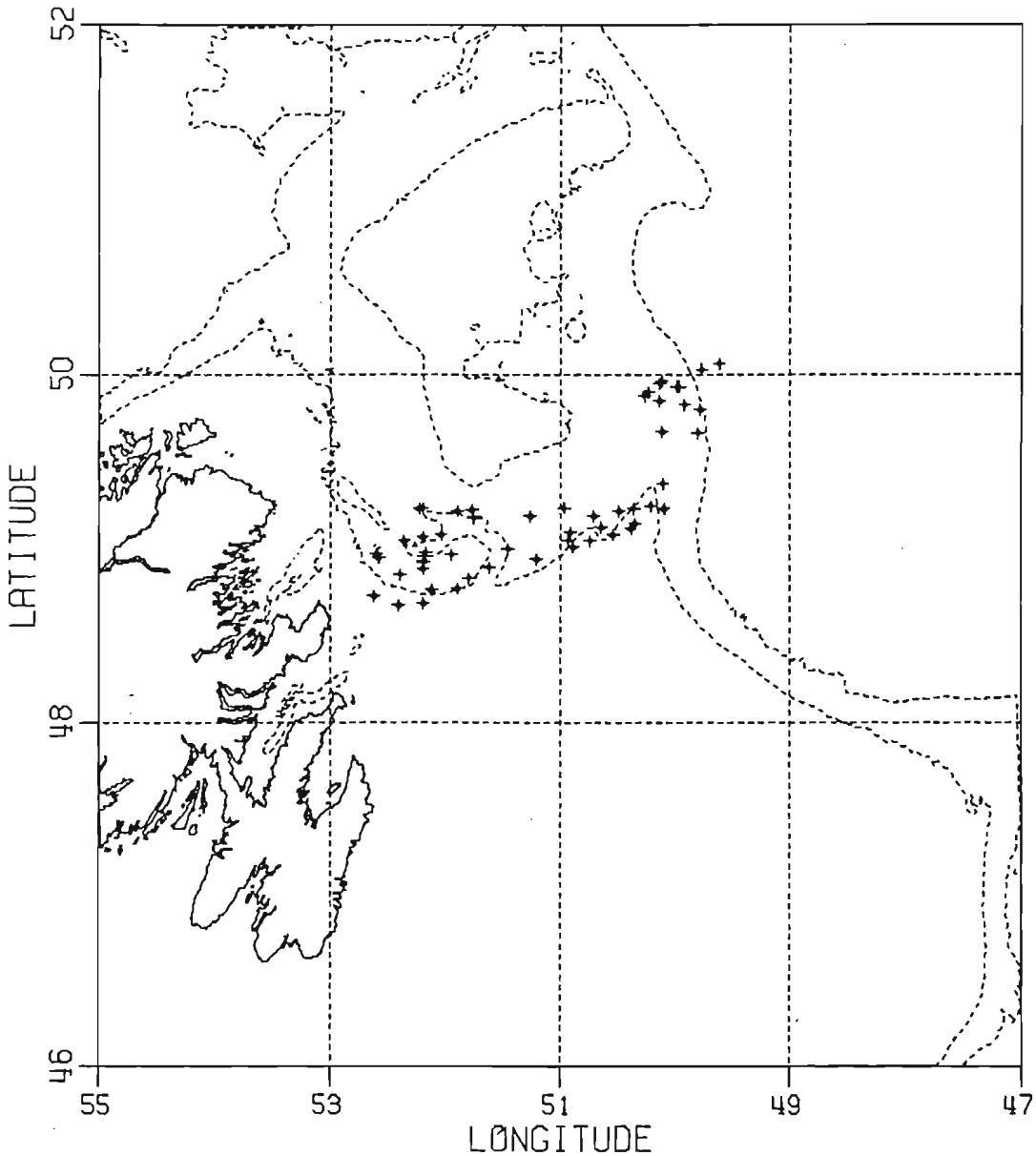


Fig. 2a. Location map showing the position of all stations occupied along and near the Bonavista transect since 1930 for the month of January.

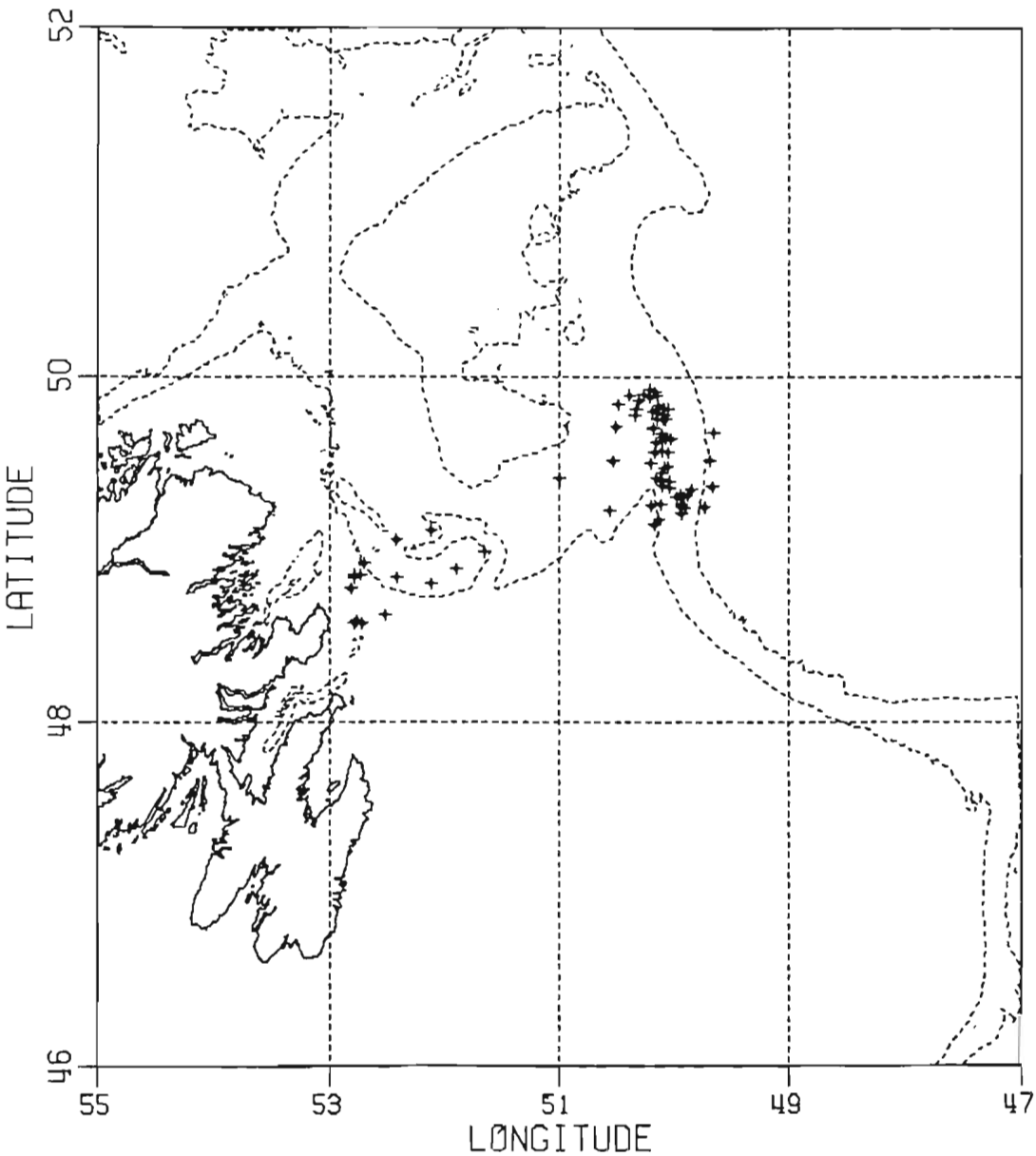


Fig. 2b. Location map showing the position of all stations occupied along and near the Bonavista transect since 1930 for the month of February.

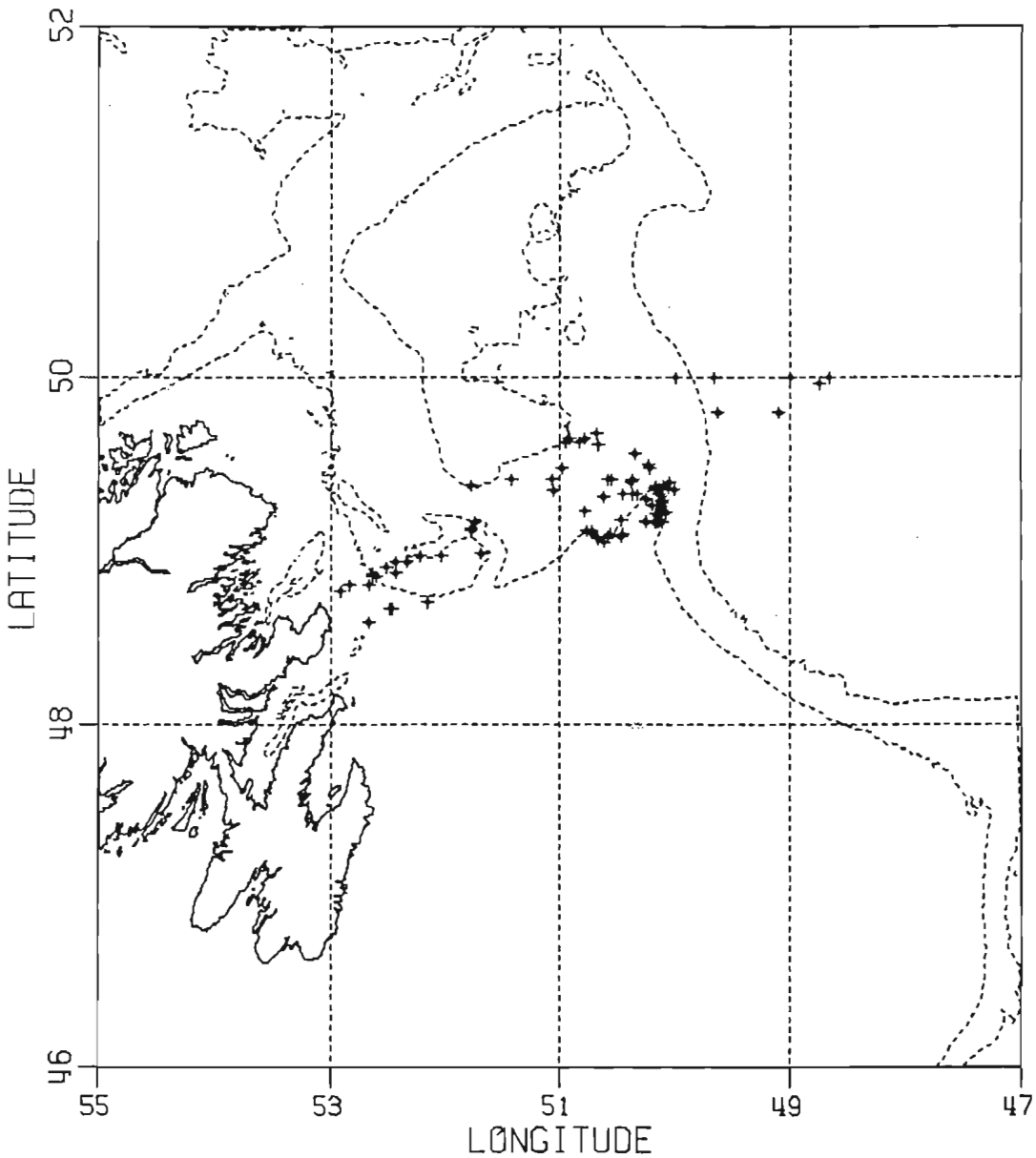


Fig. 2c. Location map showing the position of all stations occupied along and near the Bonavista transect since 1930 for the month of March.

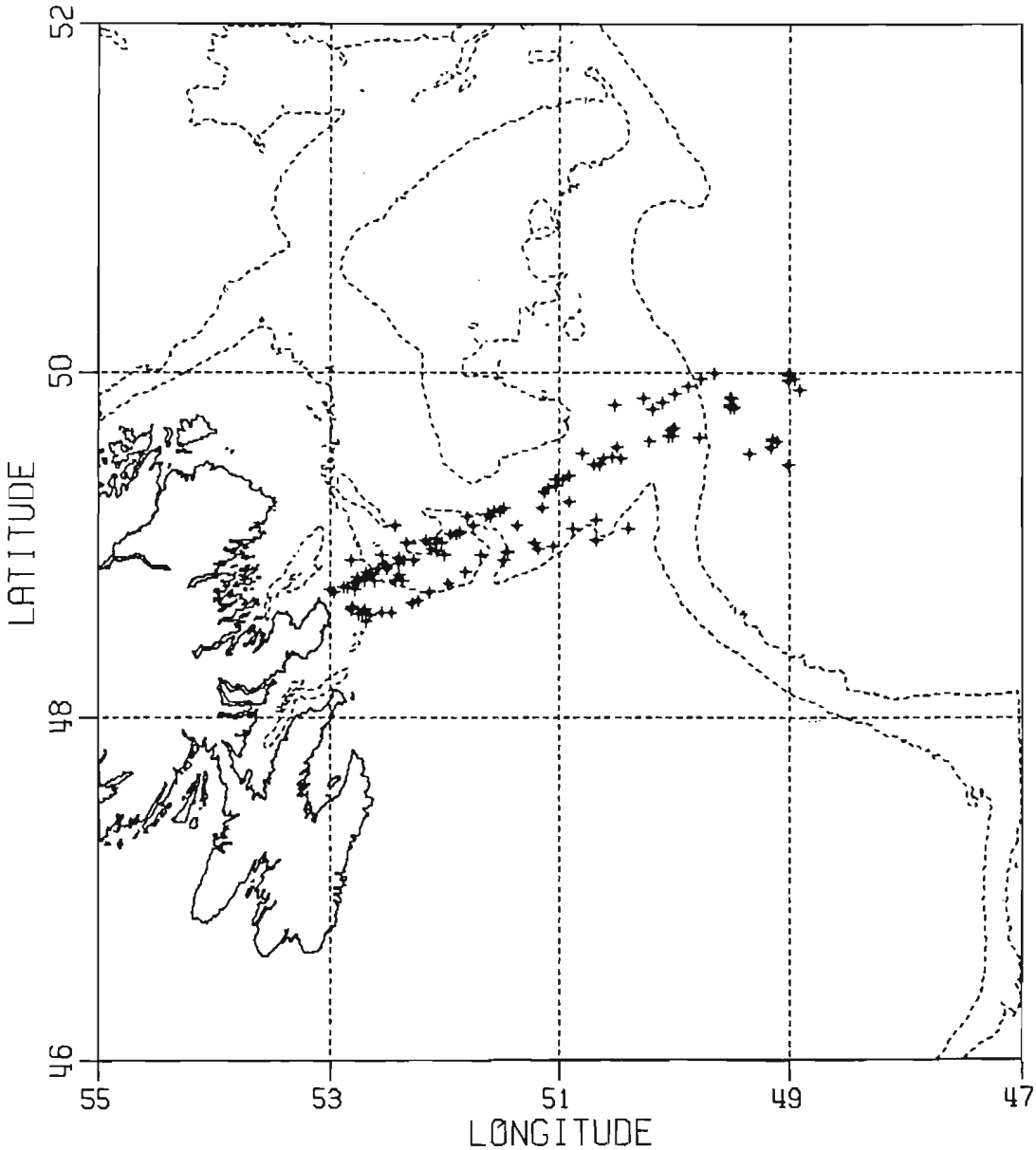


Fig. 2d. Location map showing the position of all stations occupied along and near the Bonavista transect since 1930 for the month of April.

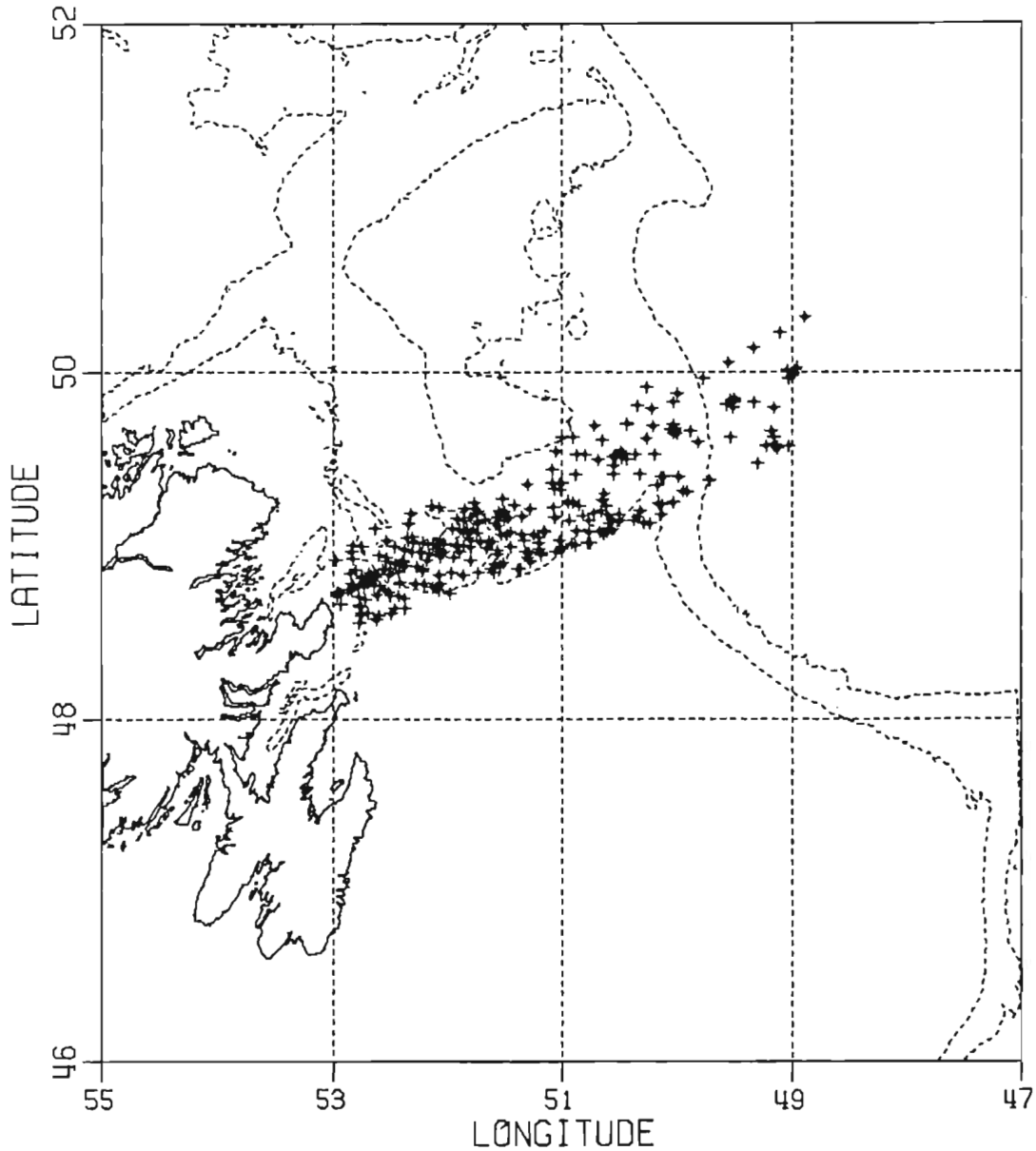


Fig. 2e. Location map showing the position of all stations occupied along and near the Bonavista transect since 1930 for the month of May.

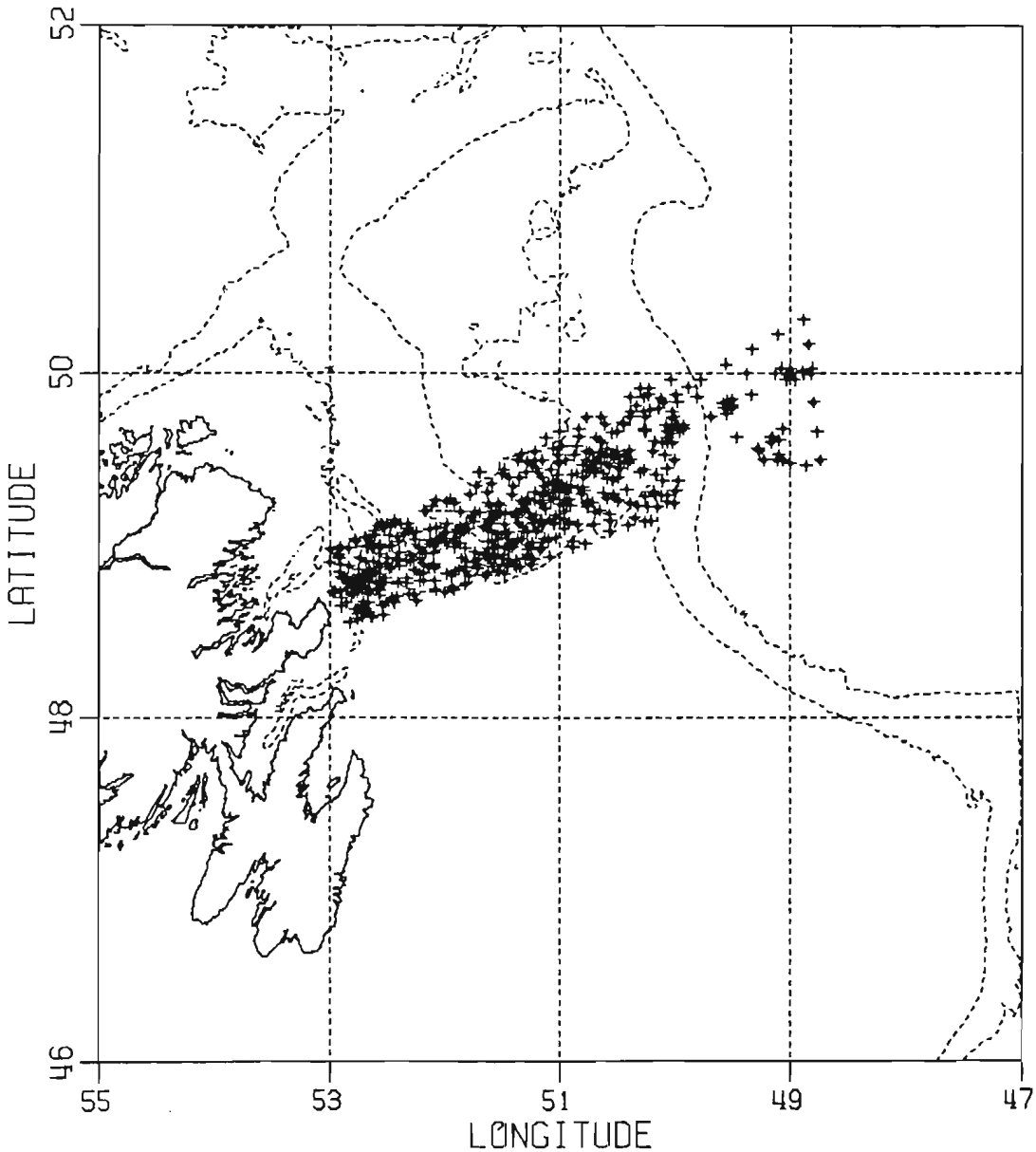


Fig. 2f. Location map showing the position of all stations occupied along and near the Bonavista transect since 1930 for the month of June.

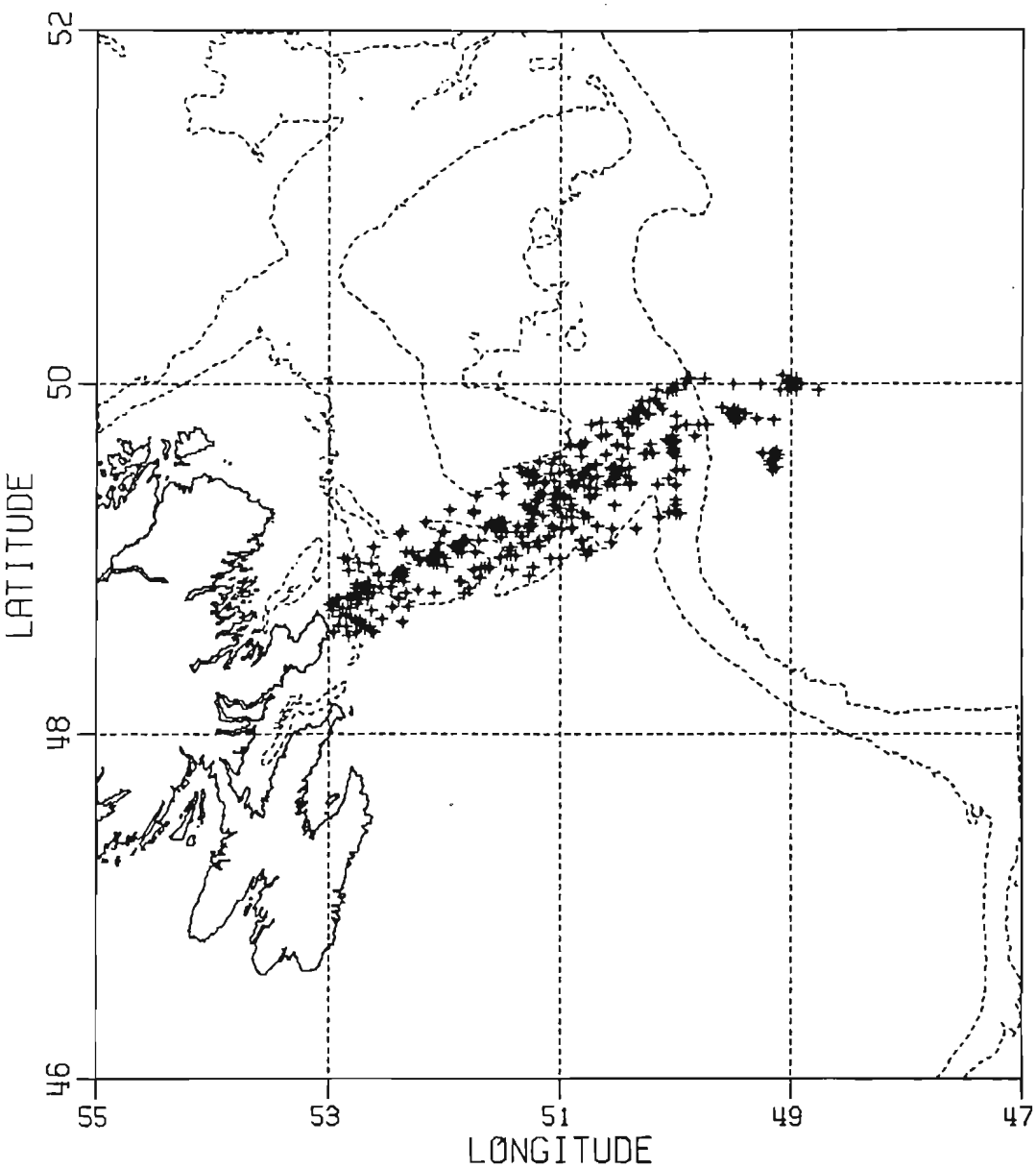


Fig. 2g. Location map showing the position of all stations occupied along and near the Bonavista transect since 1930 for the month of July.

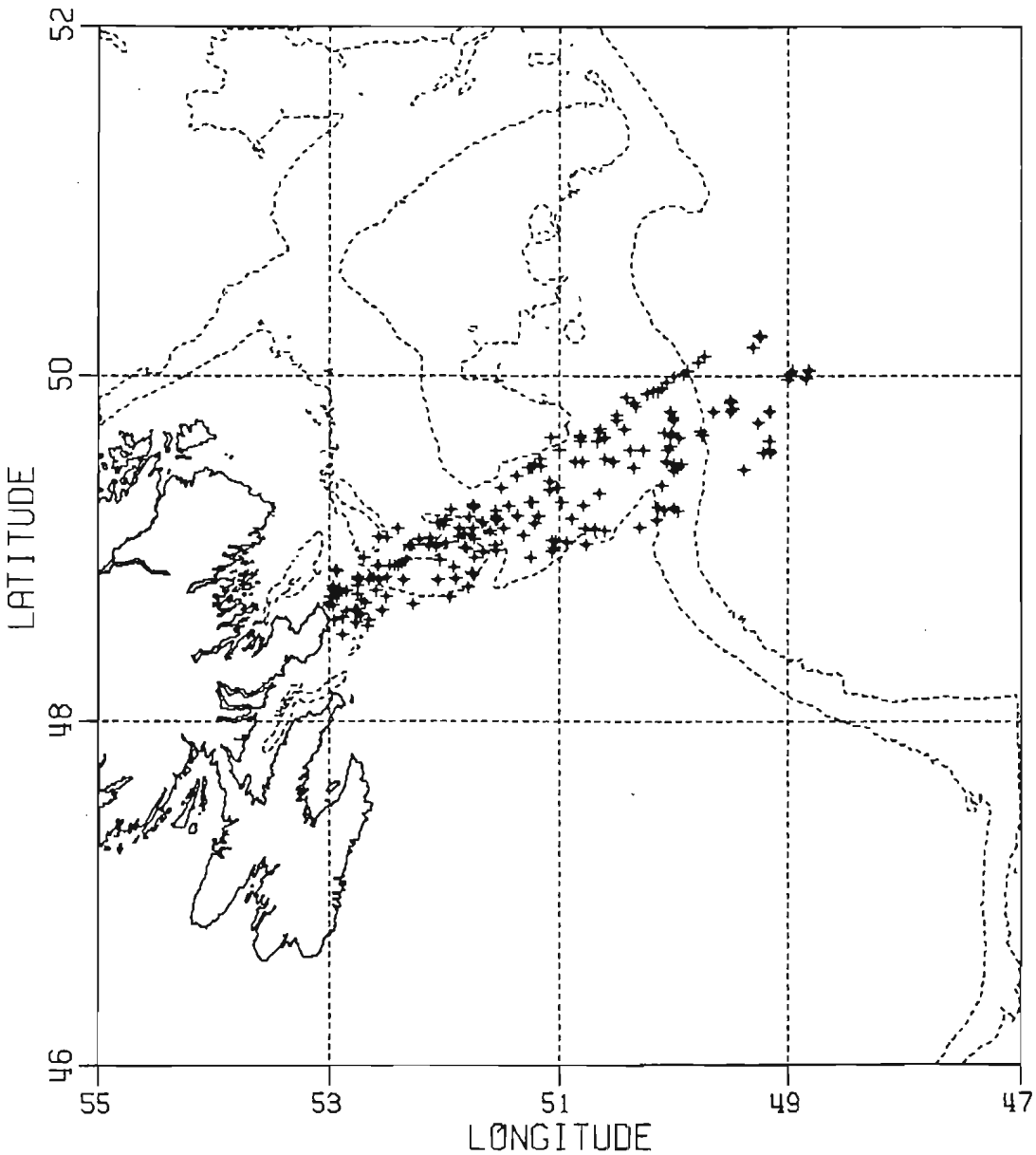


Fig. 2h. Location map showing the position of all stations occupied along and near the Bonavista transect since 1930 for the month of August.

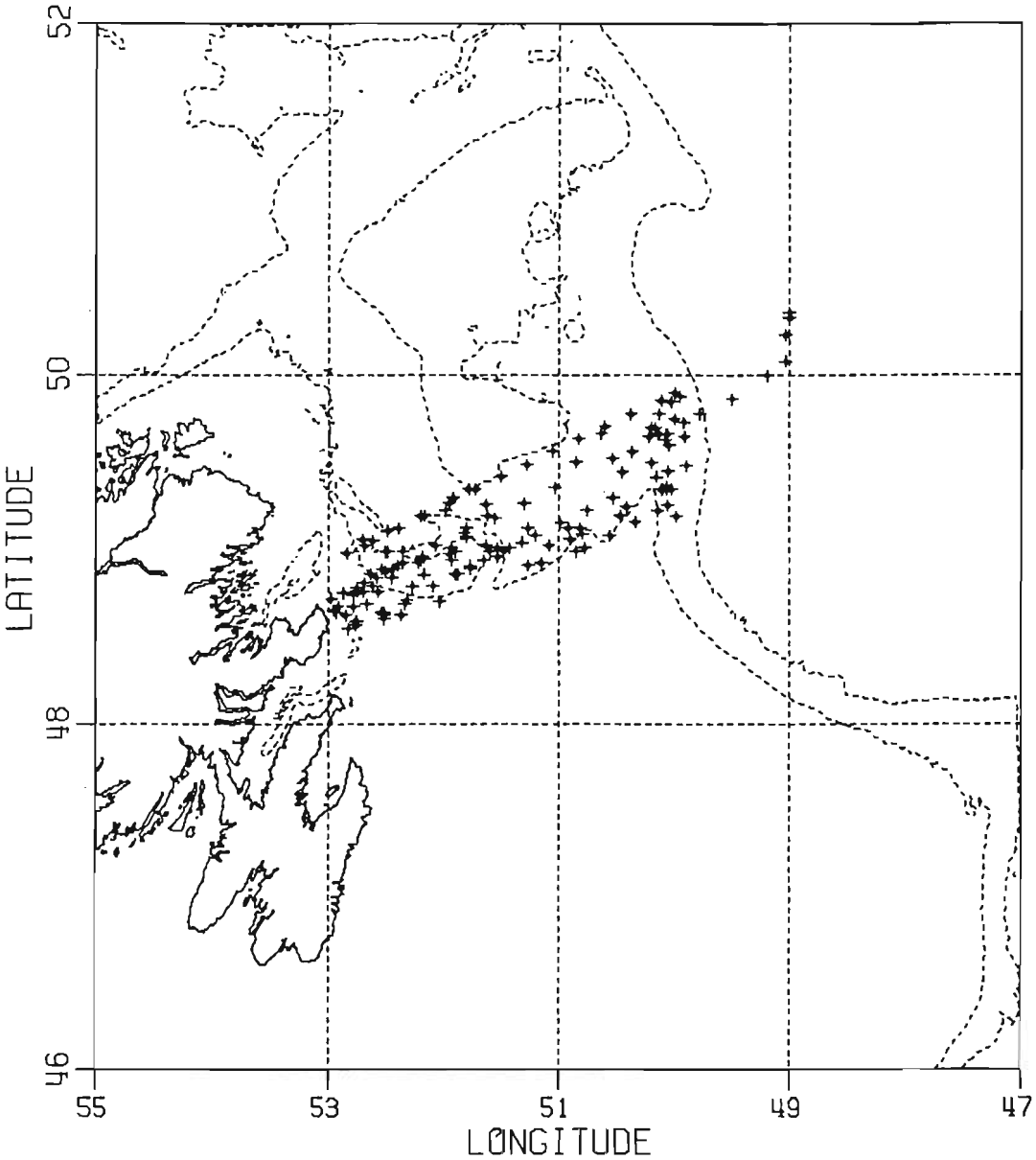


Fig. 2i. Location map showing the position of all stations occupied along and near the Bonavista transect since 1930 for the month of September.

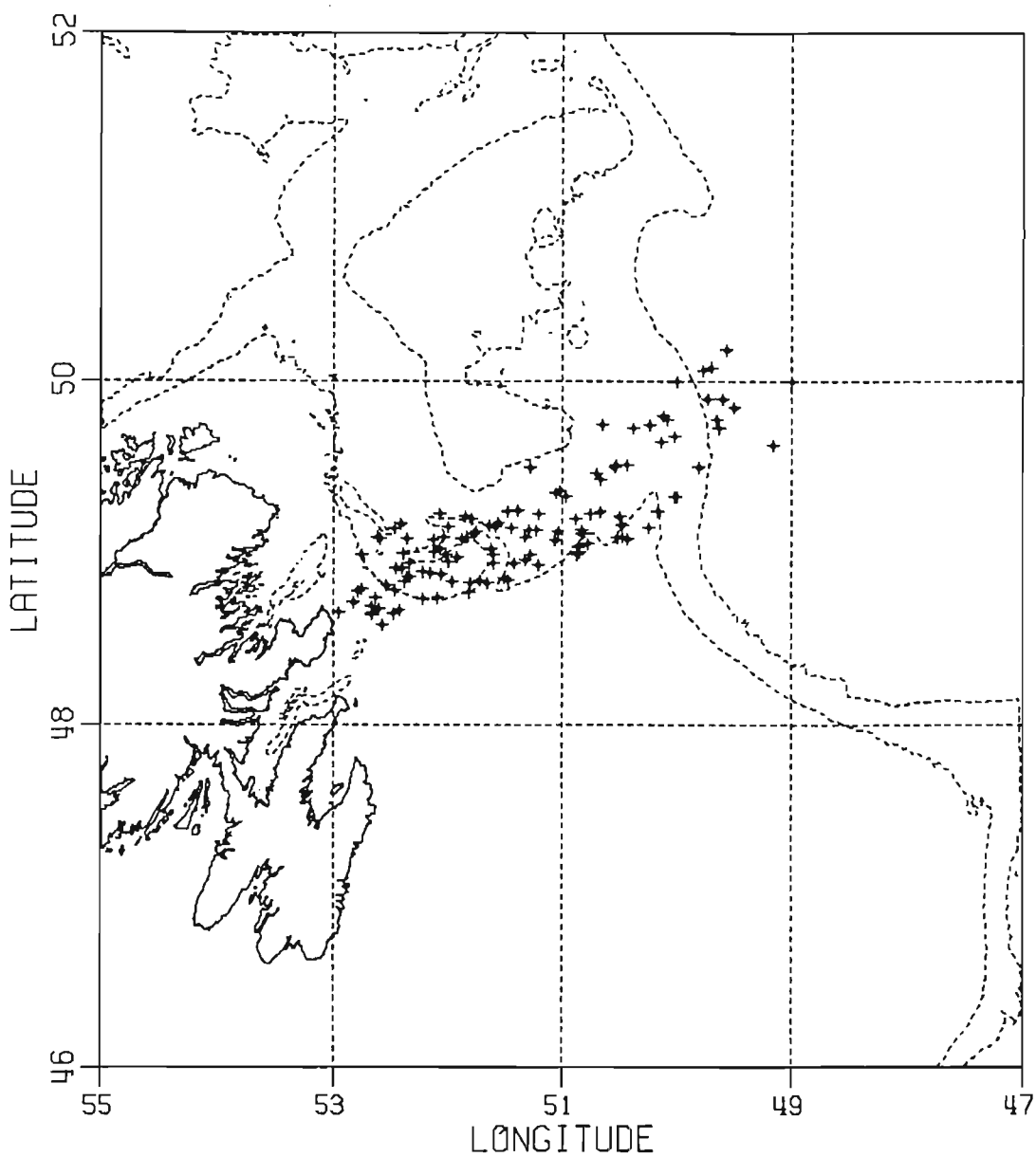


Fig. 2j. Location map showing the position of all stations occupied along and near the Bonavista transect since 1930 for the month of October.

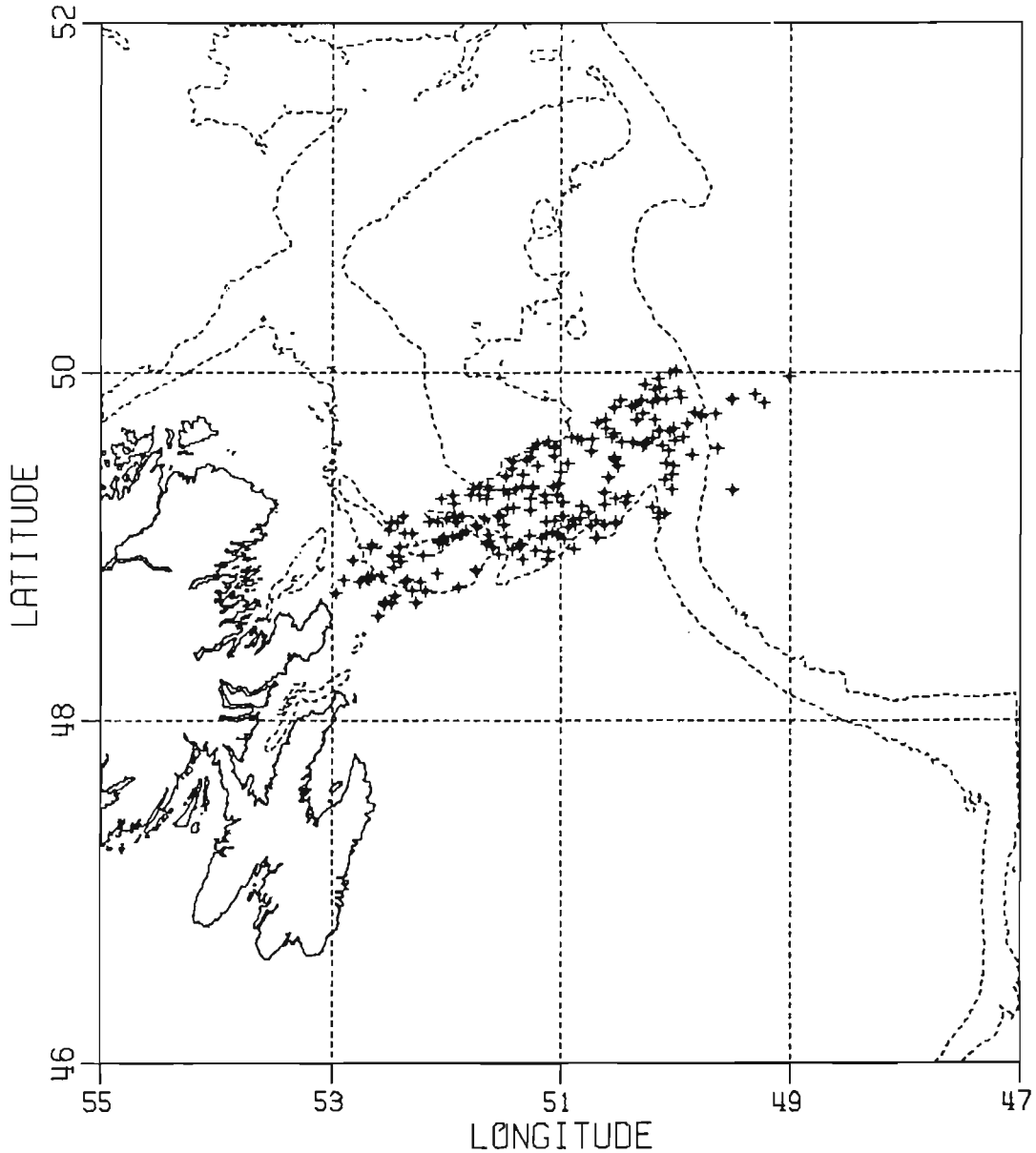


Fig. 2k. Location map showing the position of all stations occupied along and near the Bonavista transect since 1930 for the month of November.

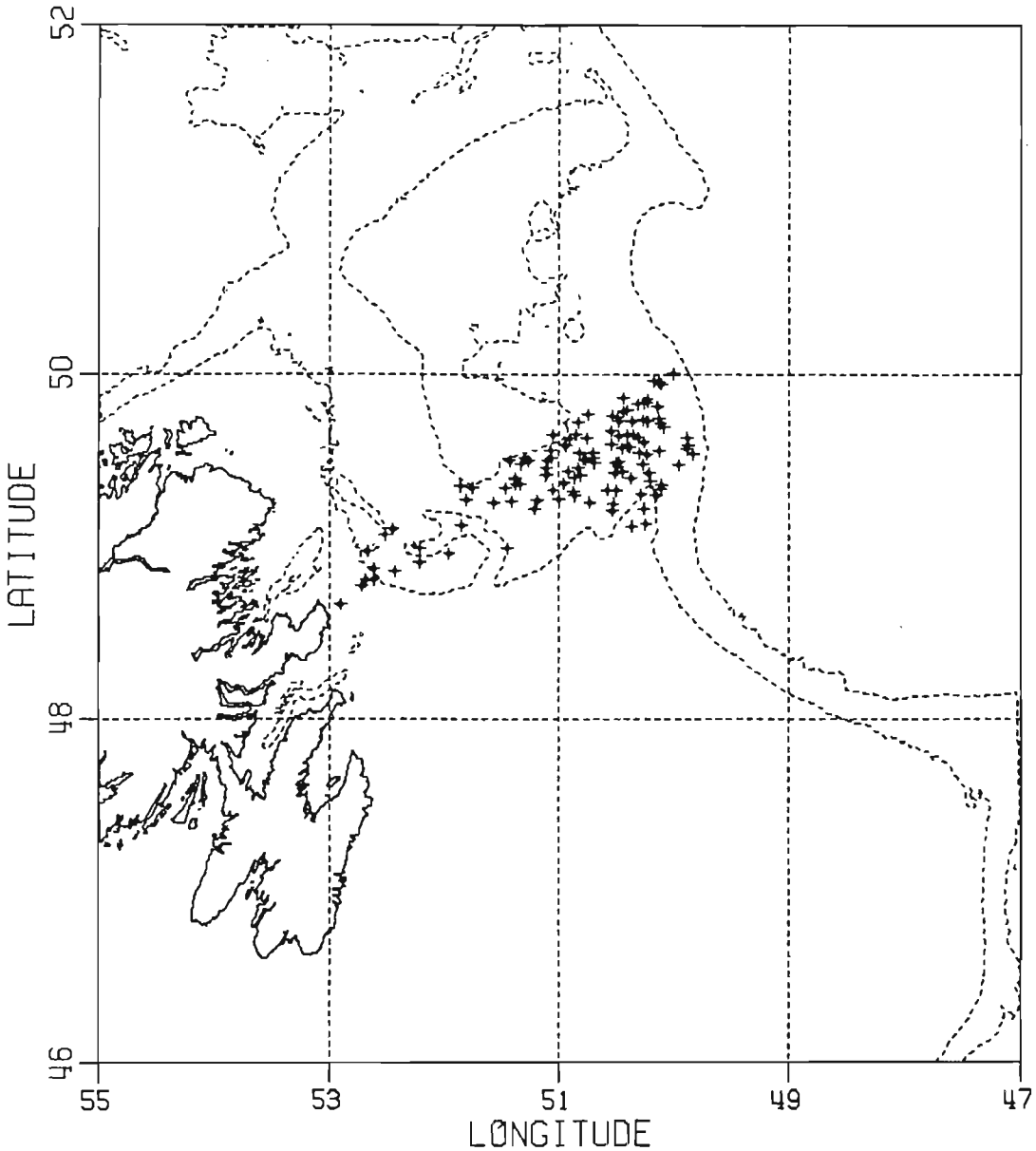


Fig. 21. Location map showing the position of all stations occupied along and near the Bonavista transect since 1930 for the month of December.

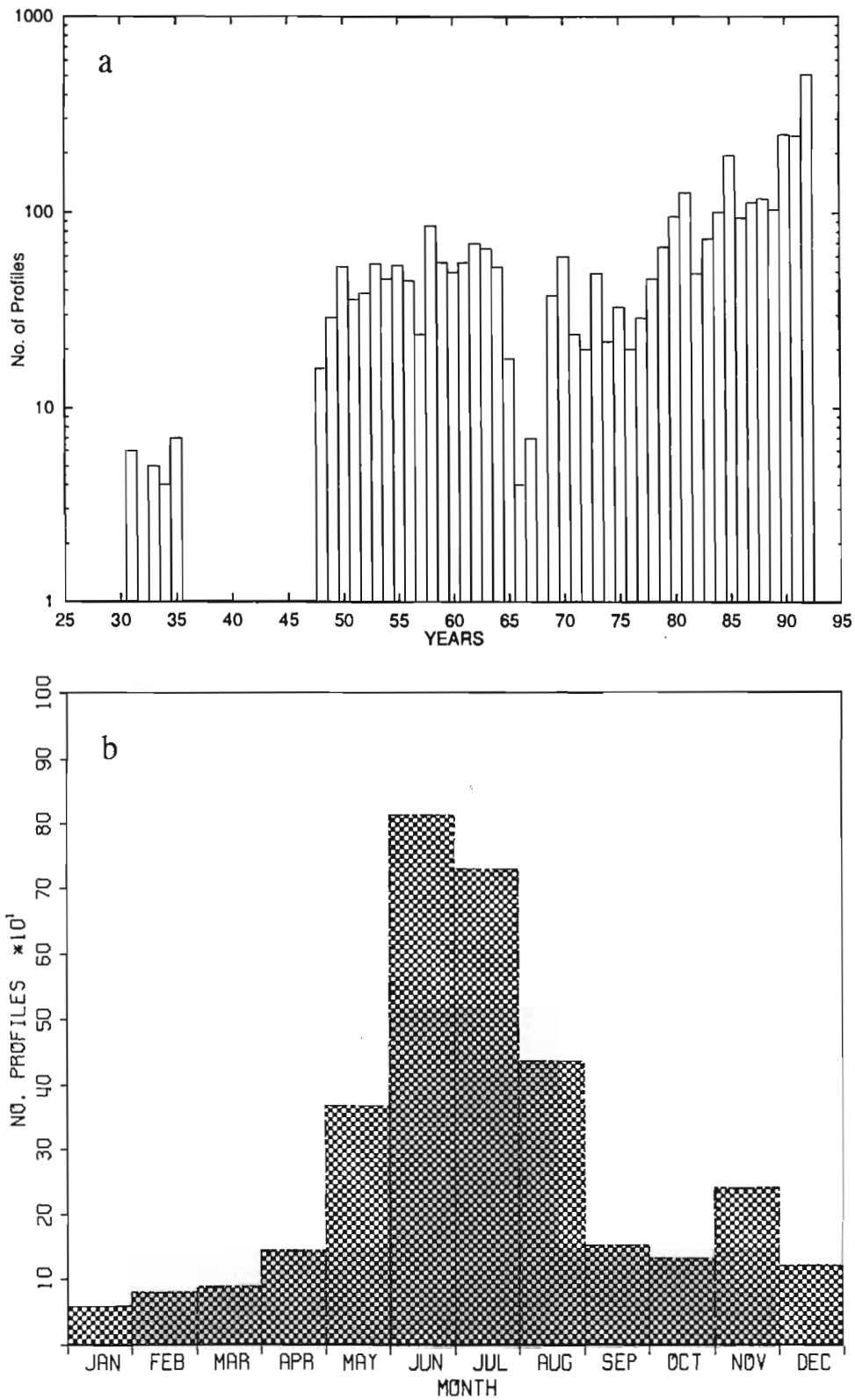


Fig. 3. (a) The total number of stations by year and (b) by month occupied along and near the Bonavista transect since 1930.

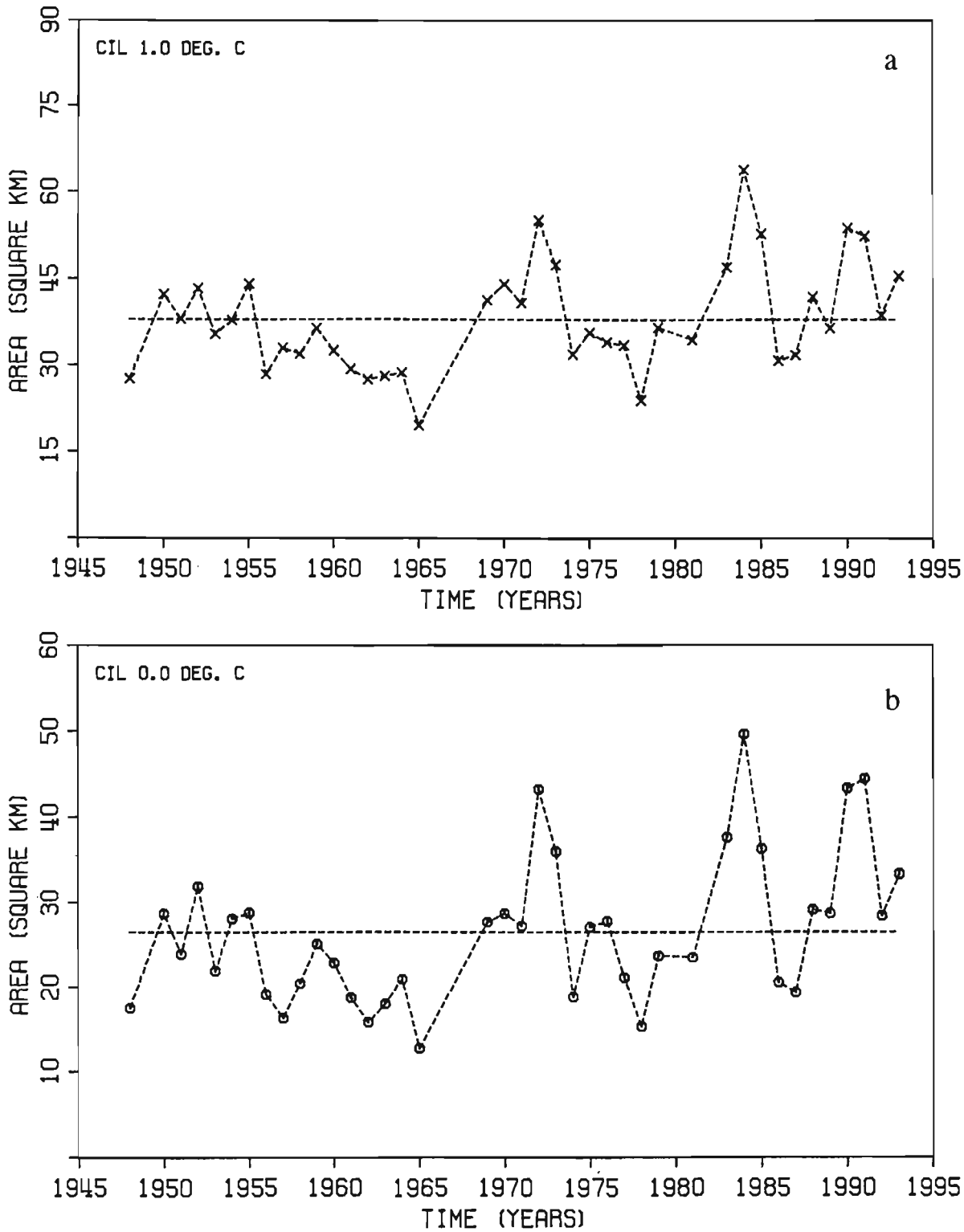


Fig. 4. (a) Time series of Bonavista transect CIL area less than 1.0 °C and (b) less than 0.0 °C in km^2.

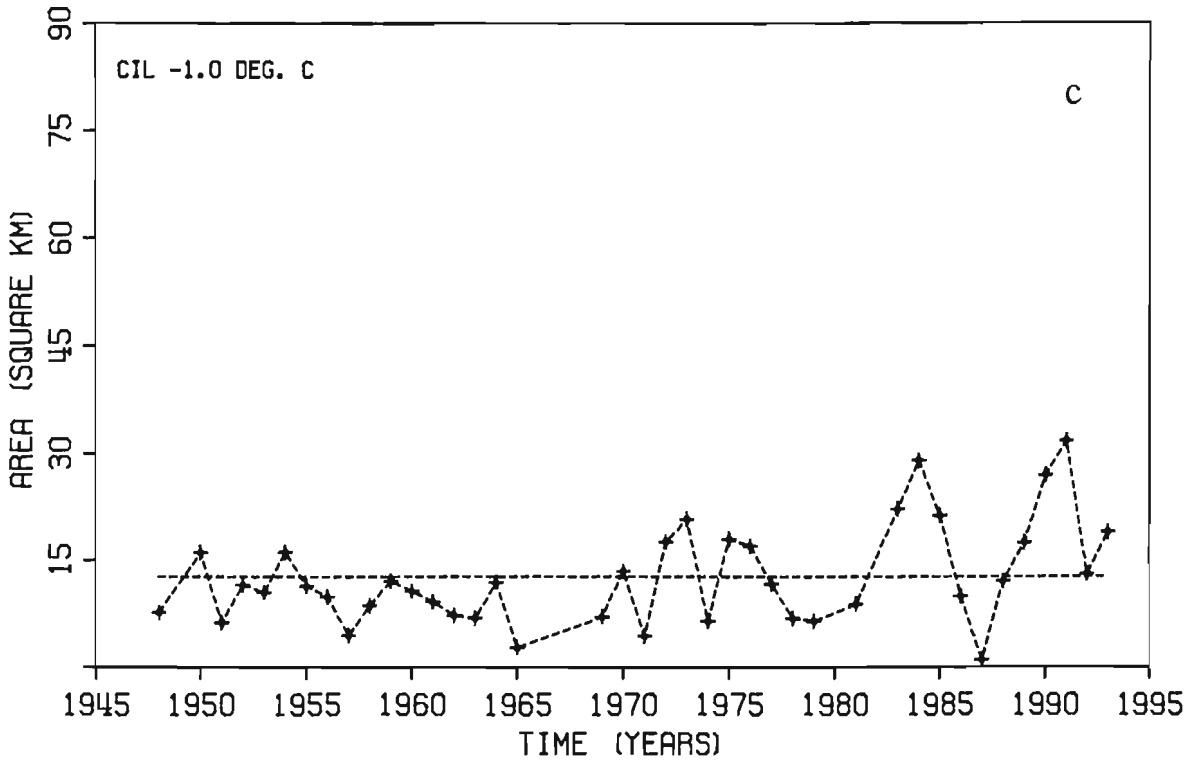


Fig. 4. (c) Time series of Bonavista transect CIL area less than -1.0 °C in km^2.

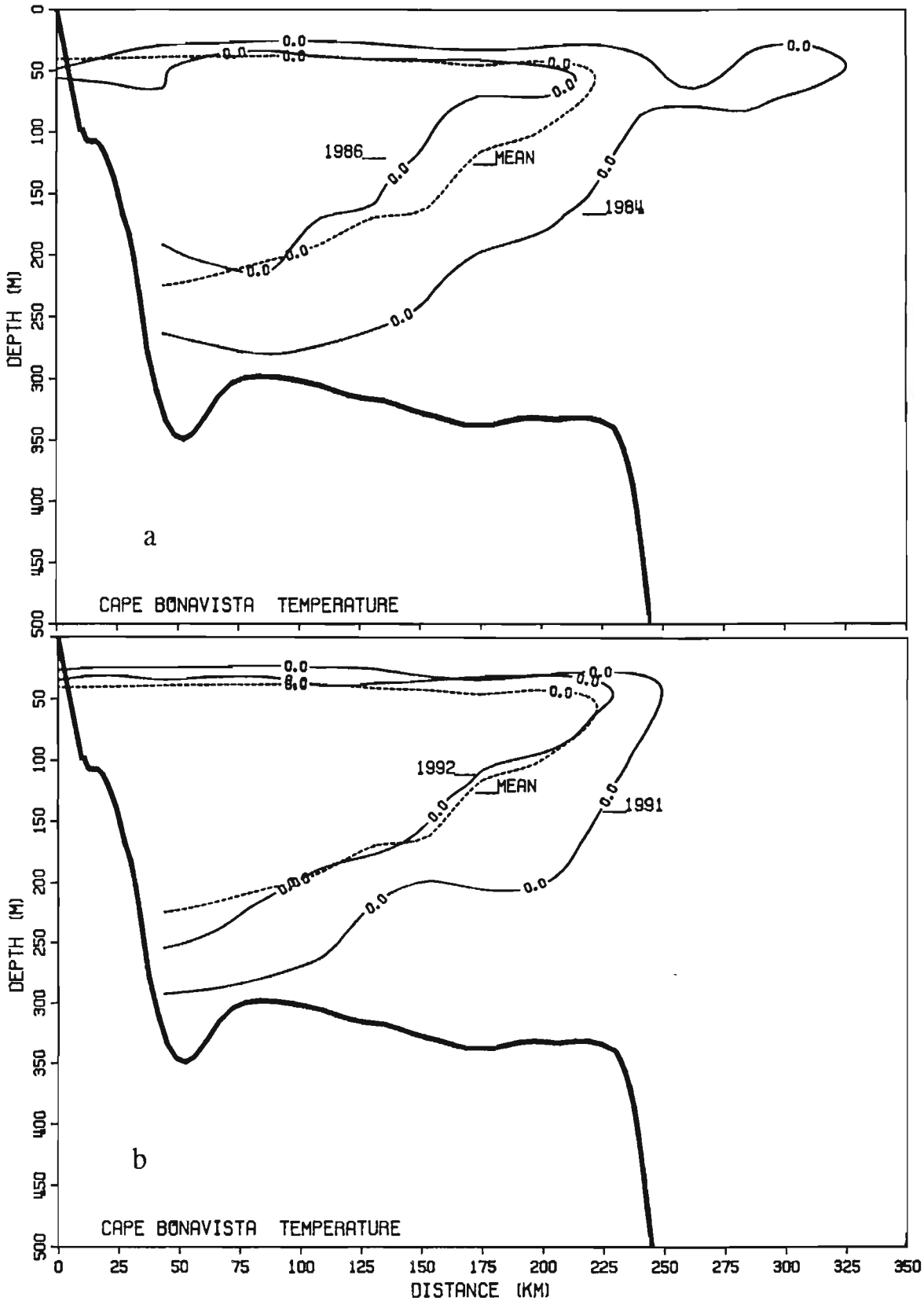


Fig. 5. (a) The shape and extent of the CIL area less than 0.0 °C along the Bonavista transect for 1984 and 1986 and (b) for 1991 and 1992. The mean is shown as the dashed line.

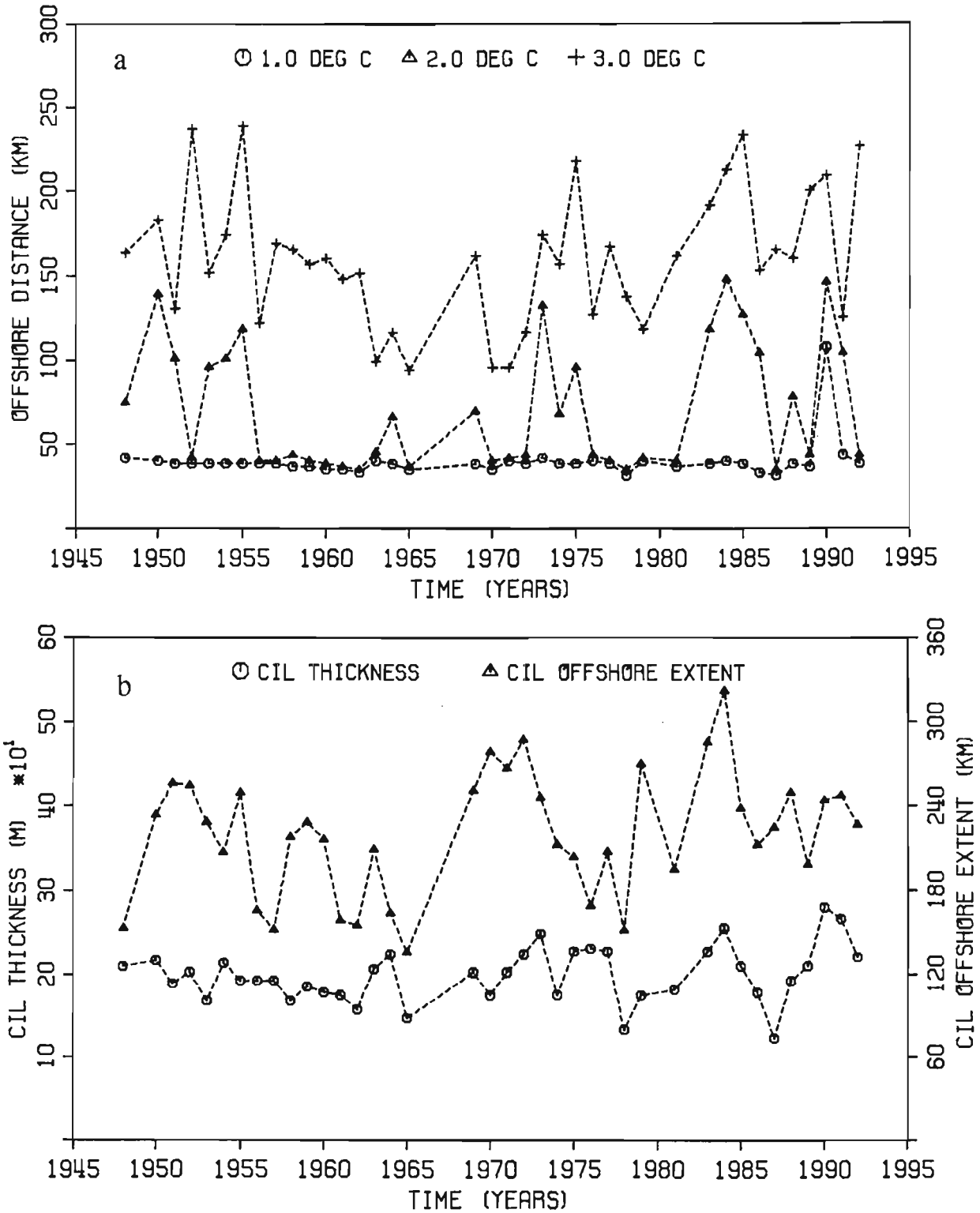


Fig. 6. (a) Offshore distance from Cape Bonavista of the bottom location of the 1.0, 2.0 and 3.0 °C isotherms and (b) the CIL thickness and offshore extent

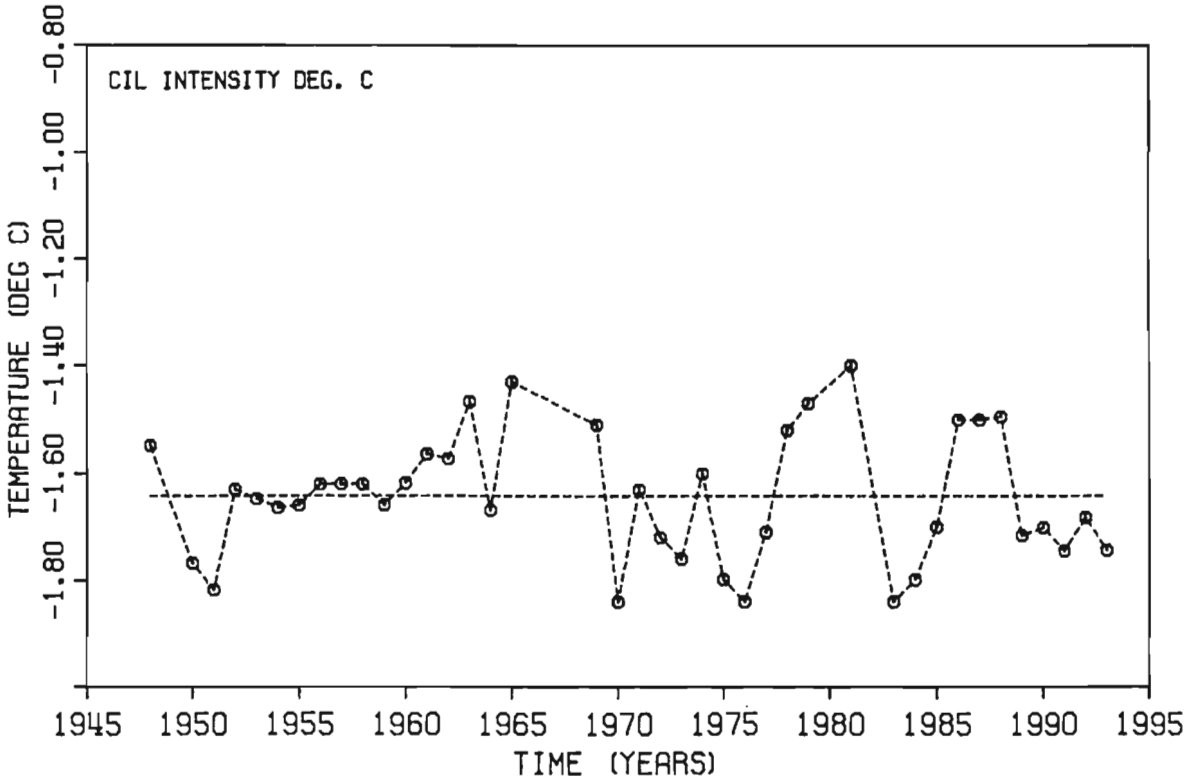
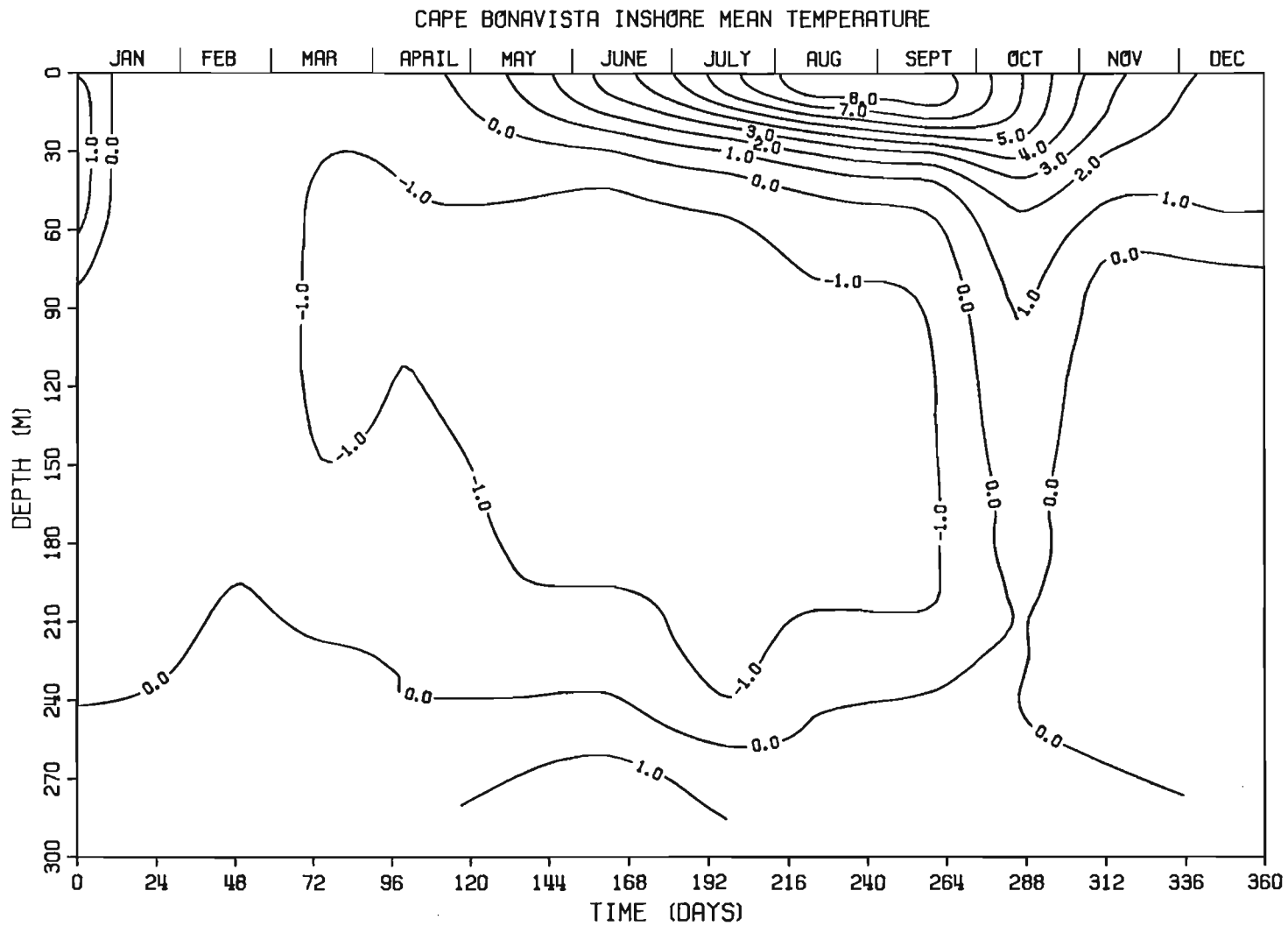
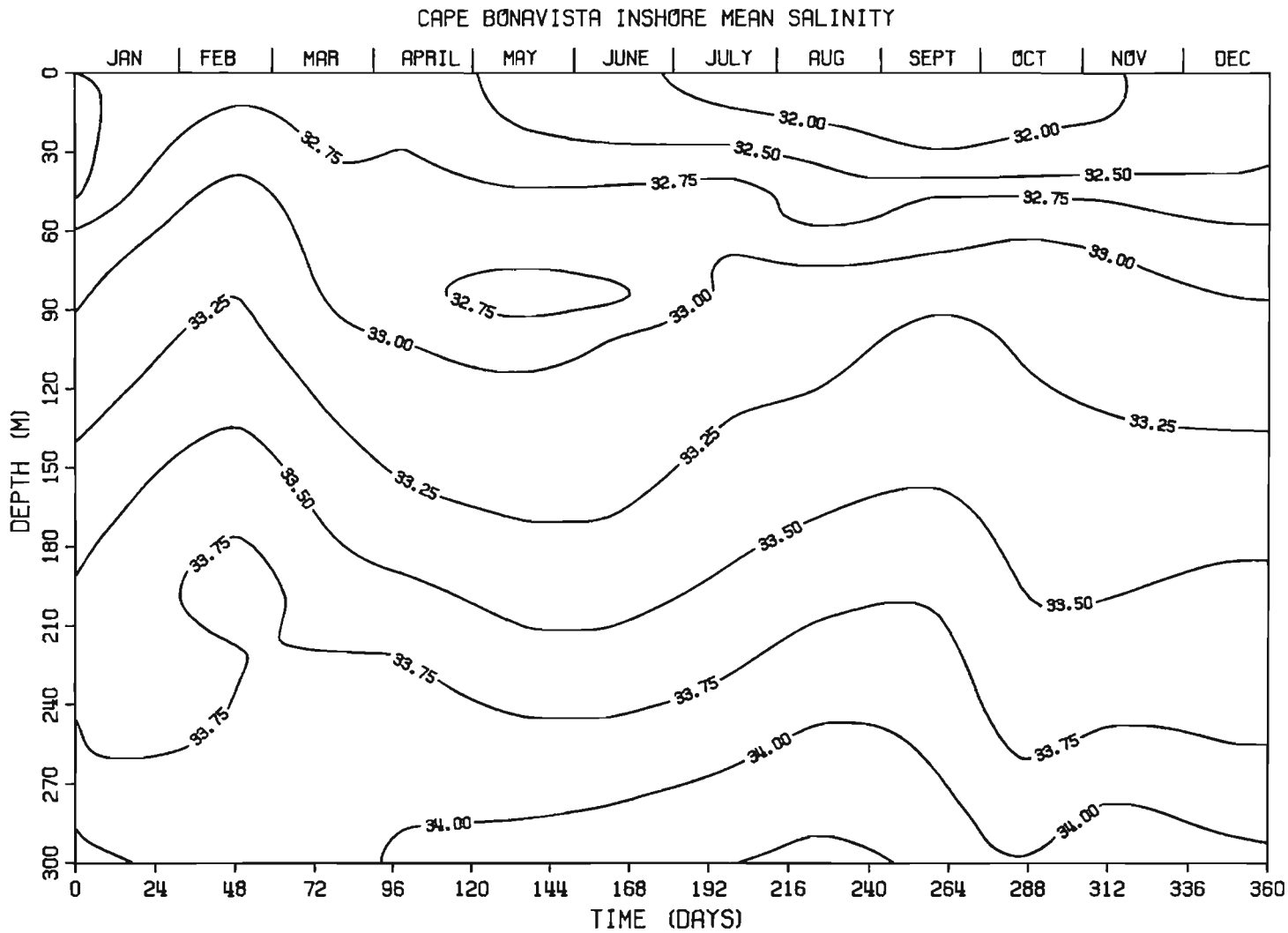
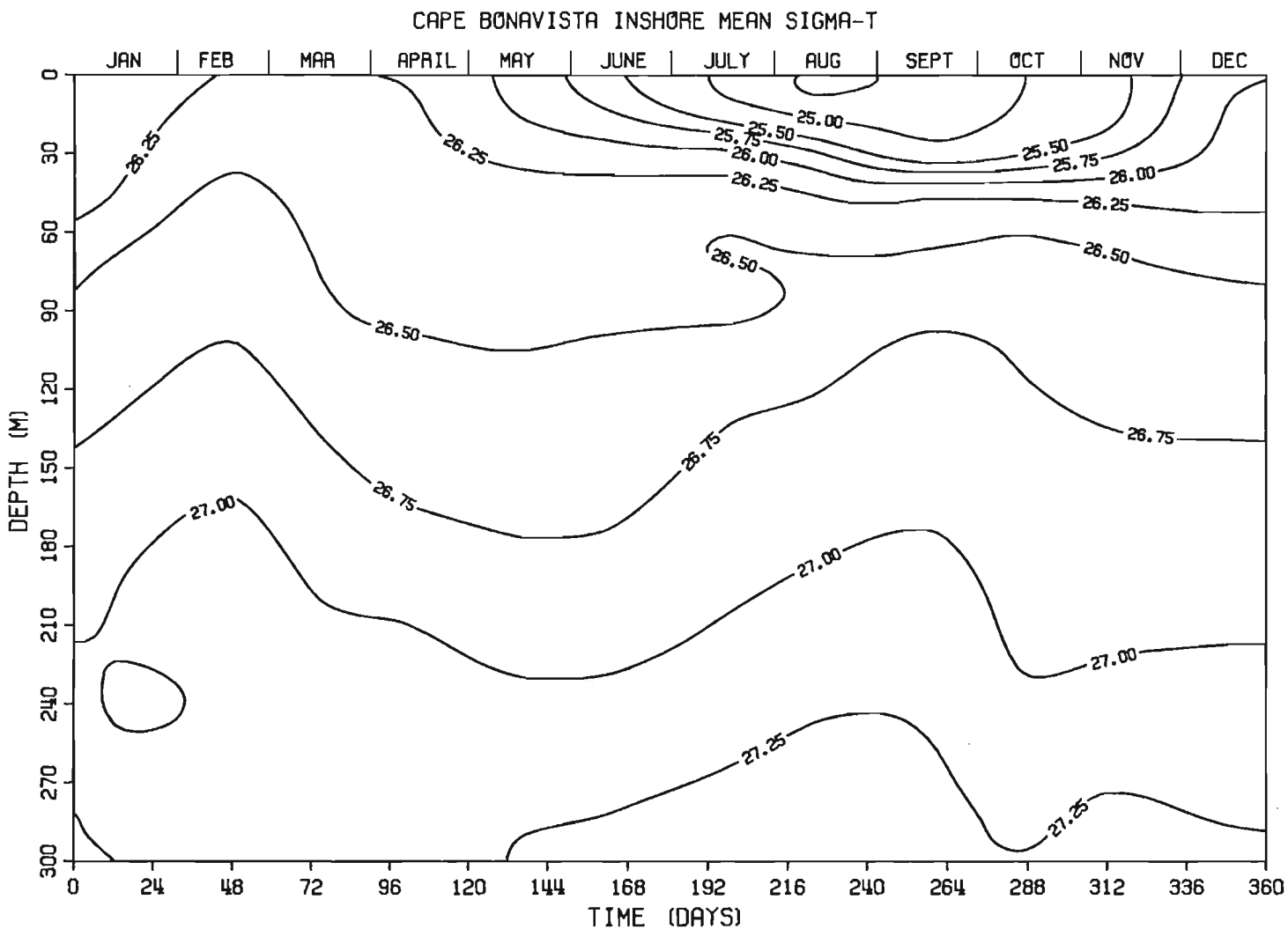


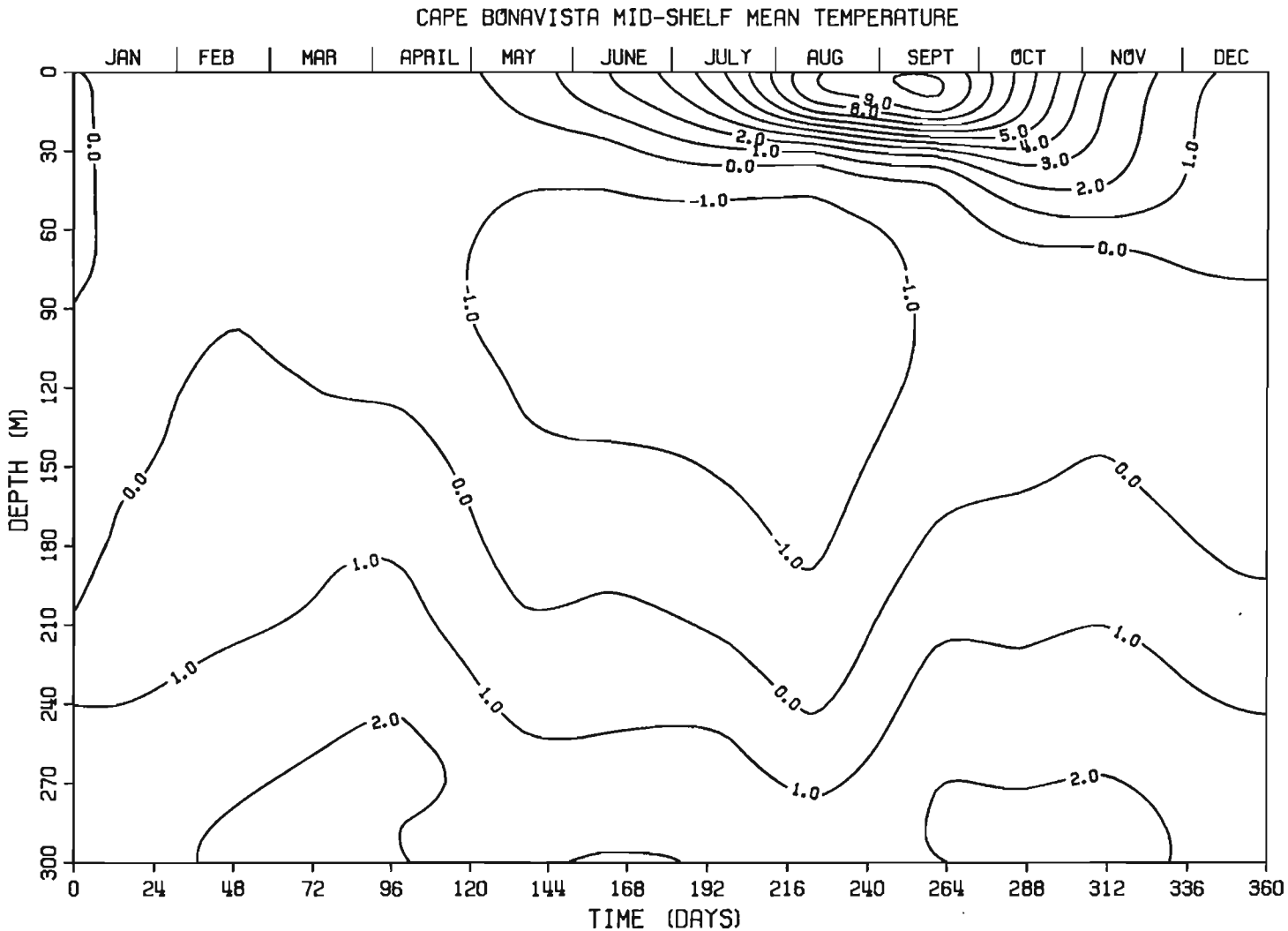
Fig. 7. Time series of the CIL intensities or minimum core temperatures.

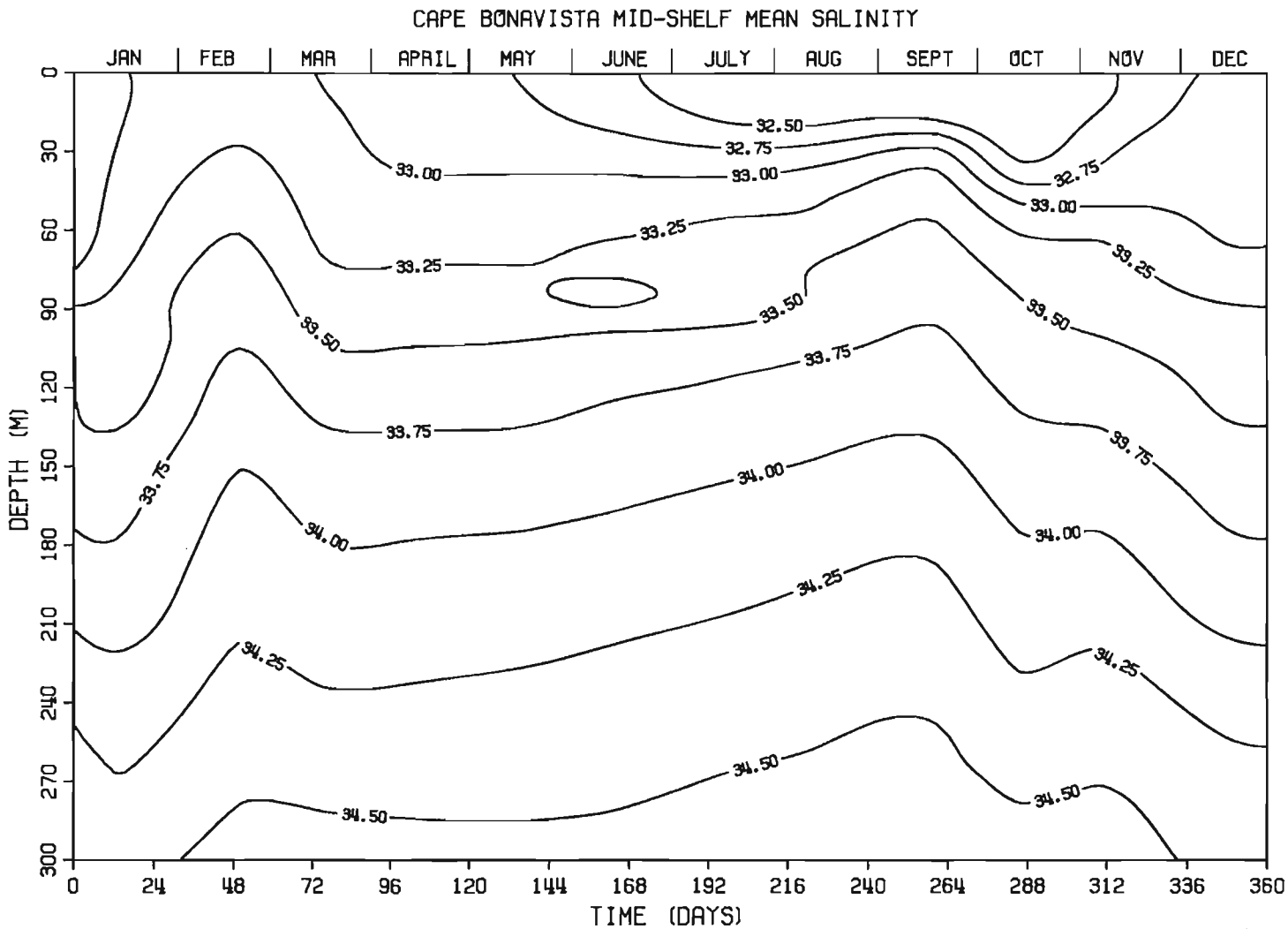
APPENDIX A. Time series of monthly mean temperature, salinity and density versus depth for the inshore, mid-shelf and shelf-edge areas off Cape Bonavista.

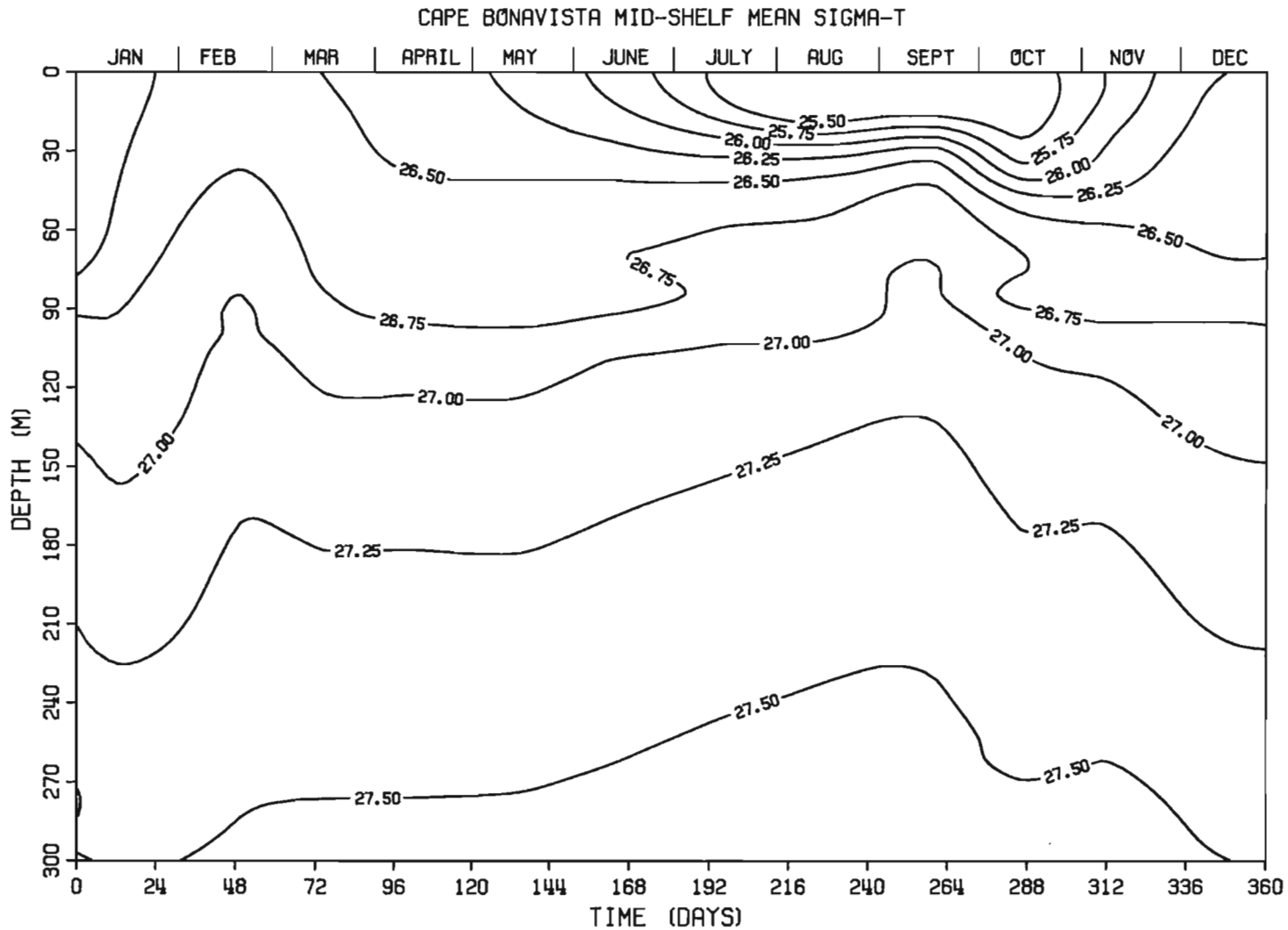

CAPE BONAVISTA INSHORE MEAN TEMPERATURE
JAN
FEB
MAR
APRIL
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
DEPTH (M)
0
30
60
90
120
150
180
210
240
270
300
TIME (DAYS)
0
24
48
72
96
120
144
168
192
216
240
264
288
312
336
360
8.0
7.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0

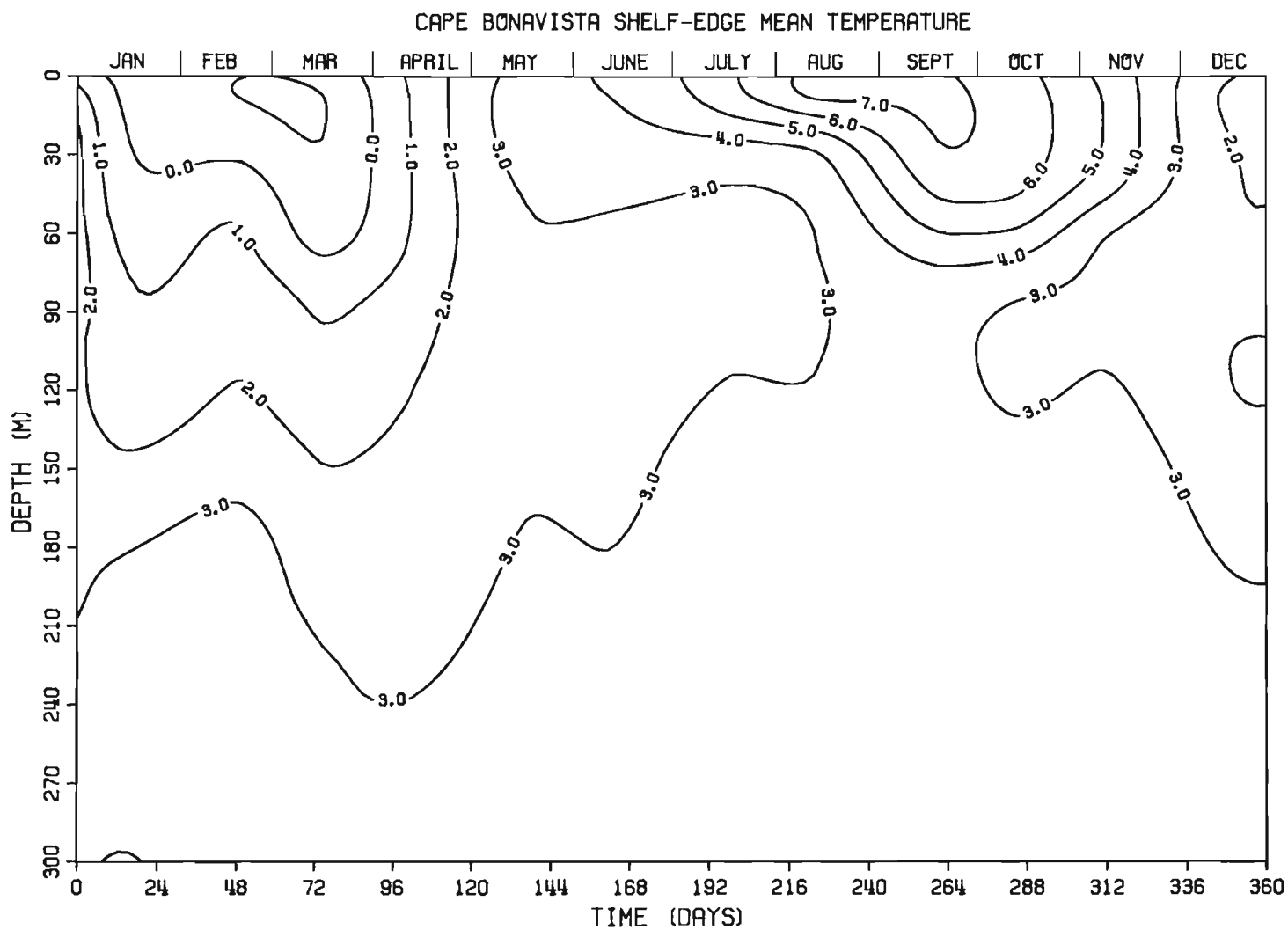

CAPE BONAVISTA INSHORE MEAN SALINITY
JAN
FEB
MAR
APRIL
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
DEPTH (M)
0
30
60
90
120
150
180
210
240
270
300
TIME (DAYS)
0
24
48
72
96
120
144
168
192
216
240
264
288
312
336
360
32.00
32.50
32.75
33.00
33.25
33.50
33.75
34.00

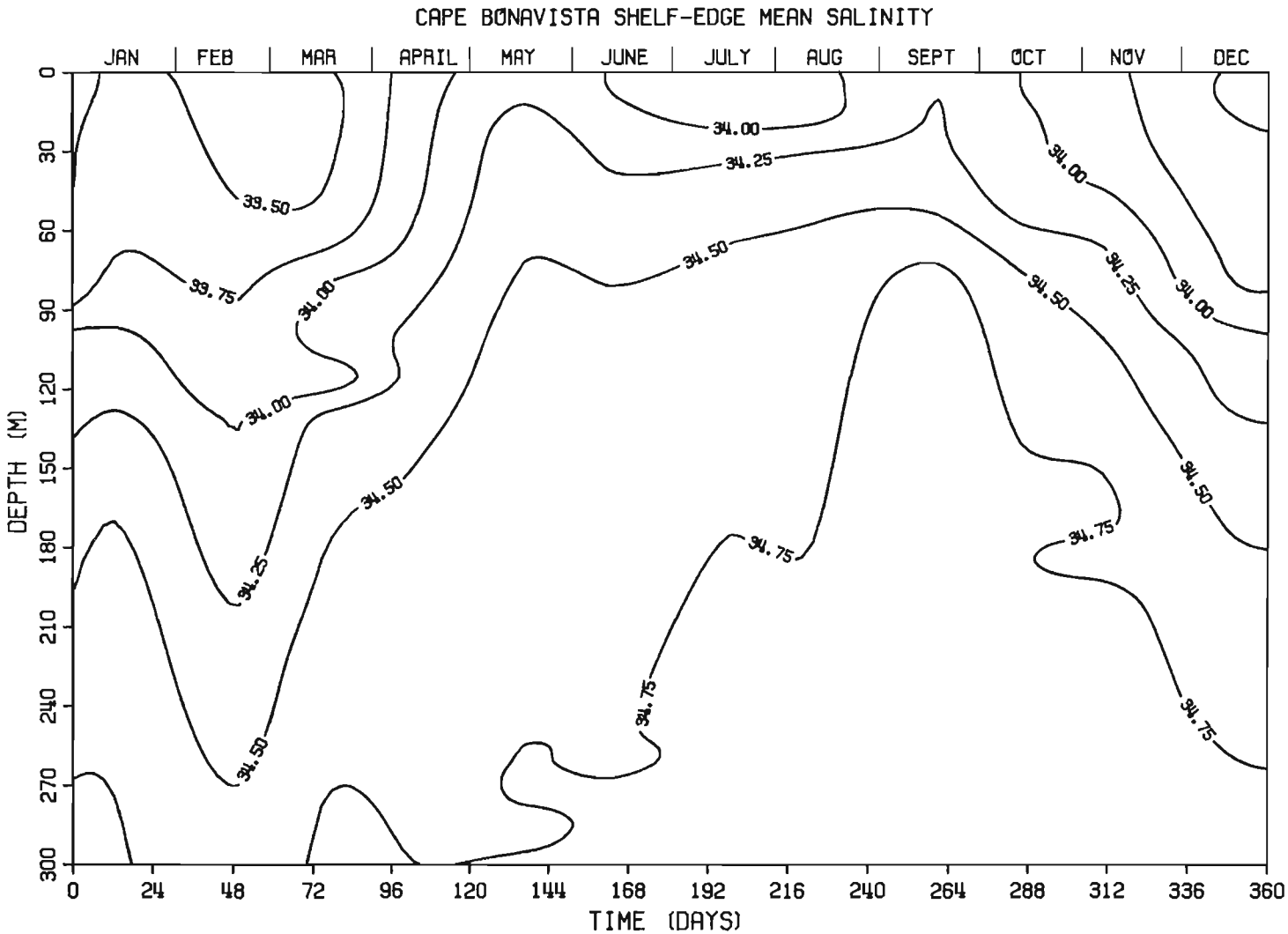

CAPE BONAVISTA INSHORE MEAN SIGMA-T
JAN
FEB
MAR
APRIL
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
DEPTH (M)
0
30
60
90
120
150
180
210
240
270
300
TIME (DAYS)
0
24
48
72
96
120
144
168
192
216
240
264
288
312
336
360
25.00
25.50
25.75
26.00
26.25
26.50
26.75
27.00
27.25

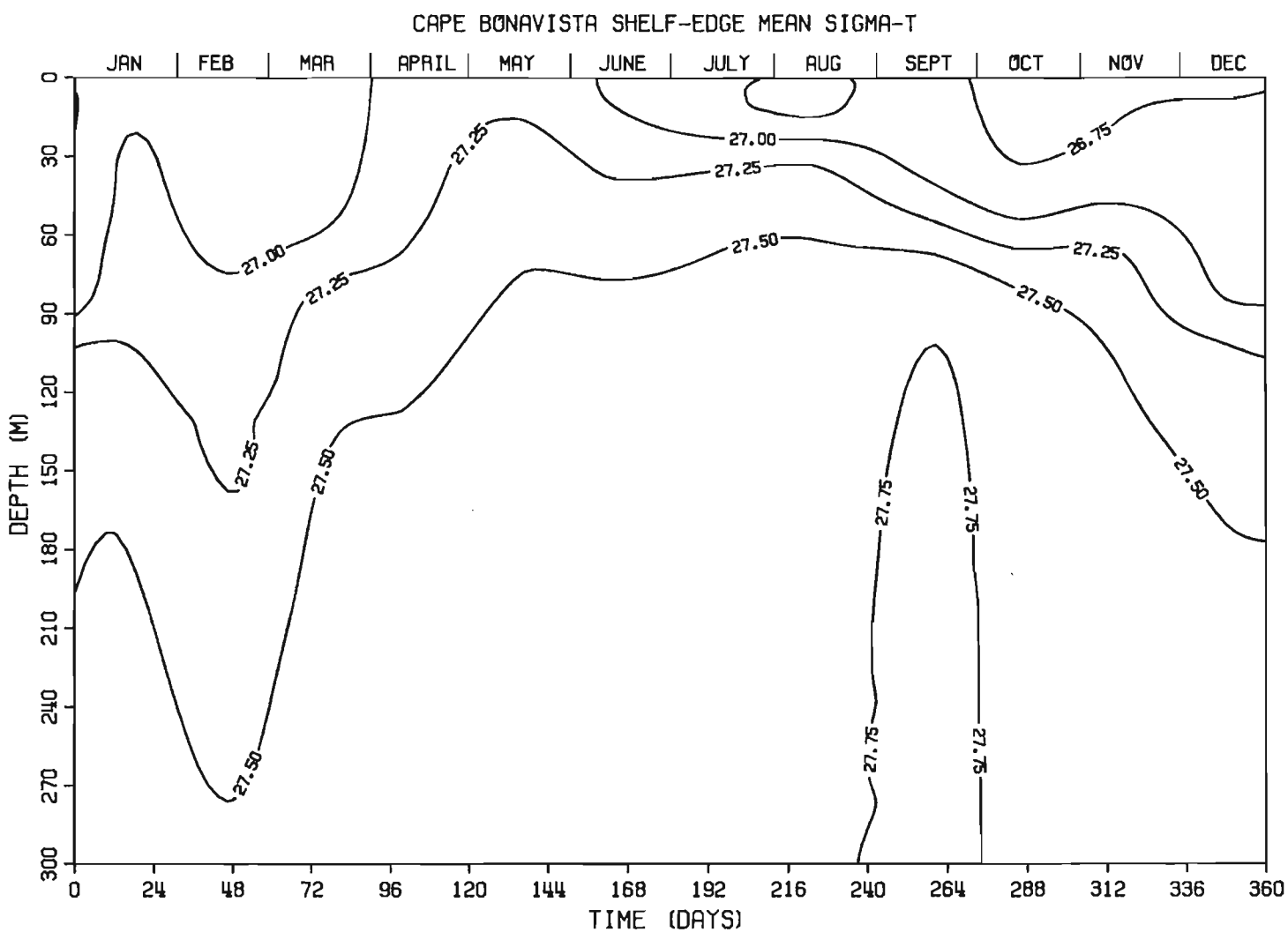

CAPE BONAVISTA MID-SHELF MEAN TEMPERATURE
JAN
FEB
MAR
APRIL
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
DEPTH (M)
0
30
60
90
120
150
180
210
240
270
300
TIME (DAYS)
0
24
48
72
96
120
144
168
192
216
240
264
288
312
336
360
9.0
8.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
2.0
1.0
0.0
-1.0
-1.0
-1.0
-1.0
0.0
0.0
0.0
0.0
1.0
1.0
1.0
1.0
1.0
2.0
2.0


CAPE BONAVISTA MID-SHELF MEAN SALINITY
JAN
FEB
MAR
APRIL
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
DEPTH (M)
0
30
60
90
120
150
180
210
240
270
300
TIME (DAYS)
0
24
48
72
96
120
144
168
192
216
240
264
288
312
336
360
32.50
32.75
33.00
33.25
33.50
33.75
34.00
34.25
34.50

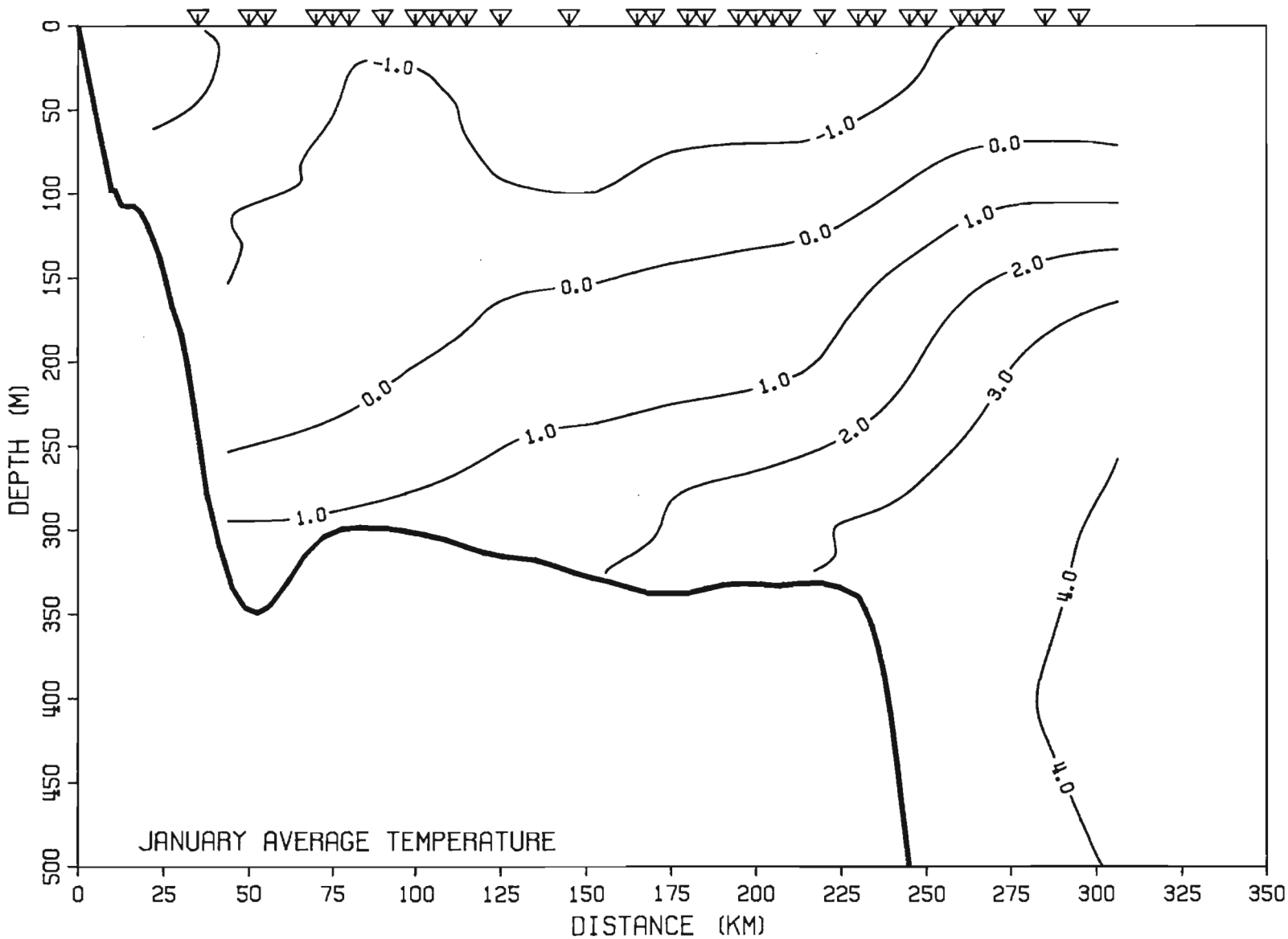

CAPE BONAVISTA MID-SHELF MEAN SIGMA-T
JAN
FEB
MAR
APRIL
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
DEPTH (M)
0
30
60
90
120
150
180
210
240
270
300
TIME (DAYS)
0
24
48
72
96
120
144
168
192
216
240
264
288
312
336
360
25.50
25.75
26.00
26.25
26.50
26.75
27.00
27.25
27.50


CAPE BONAVISTA SHELF-EDGE MEAN TEMPERATURE
JAN
FEB
MAR
APRIL
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
DEPTH (M)
0
30
60
90
120
150
180
210
240
270
300
TIME (DAYS)
0
24
48
72
96
120
144
168
192
216
240
264
288
312
336
360
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0


CAPE BONAVISTA SHELF-EDGE MEAN SALINITY
JAN
FEB
MAR
APRIL
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
DEPTH (M)
0
30
60
90
120
150
180
210
240
270
300
TIME (DAYS)
0
24
48
72
96
120
144
168
192
216
240
264
288
312
336
360
33.50
33.75
34.00
34.25
34.50
34.75


CAPE BONAVISTA SHELF-EDGE MEAN SIGMA-T
JAN
FEB
MAR
APRIL
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
DEPTH (M)
0
30
60
90
120
150
180
210
240
270
300
TIME (DAYS)
0
24
48
72
96
120
144
168
192
216
240
264
288
312
336
360
27.00
27.25
27.50
27.75
26.75

APPENDIX B. The monthly average vertical distributions of temperature.


JANUARY AVERAGE TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
-1.0
-1.0
0.0
0.0
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1.0
2.0
2.0
3.0
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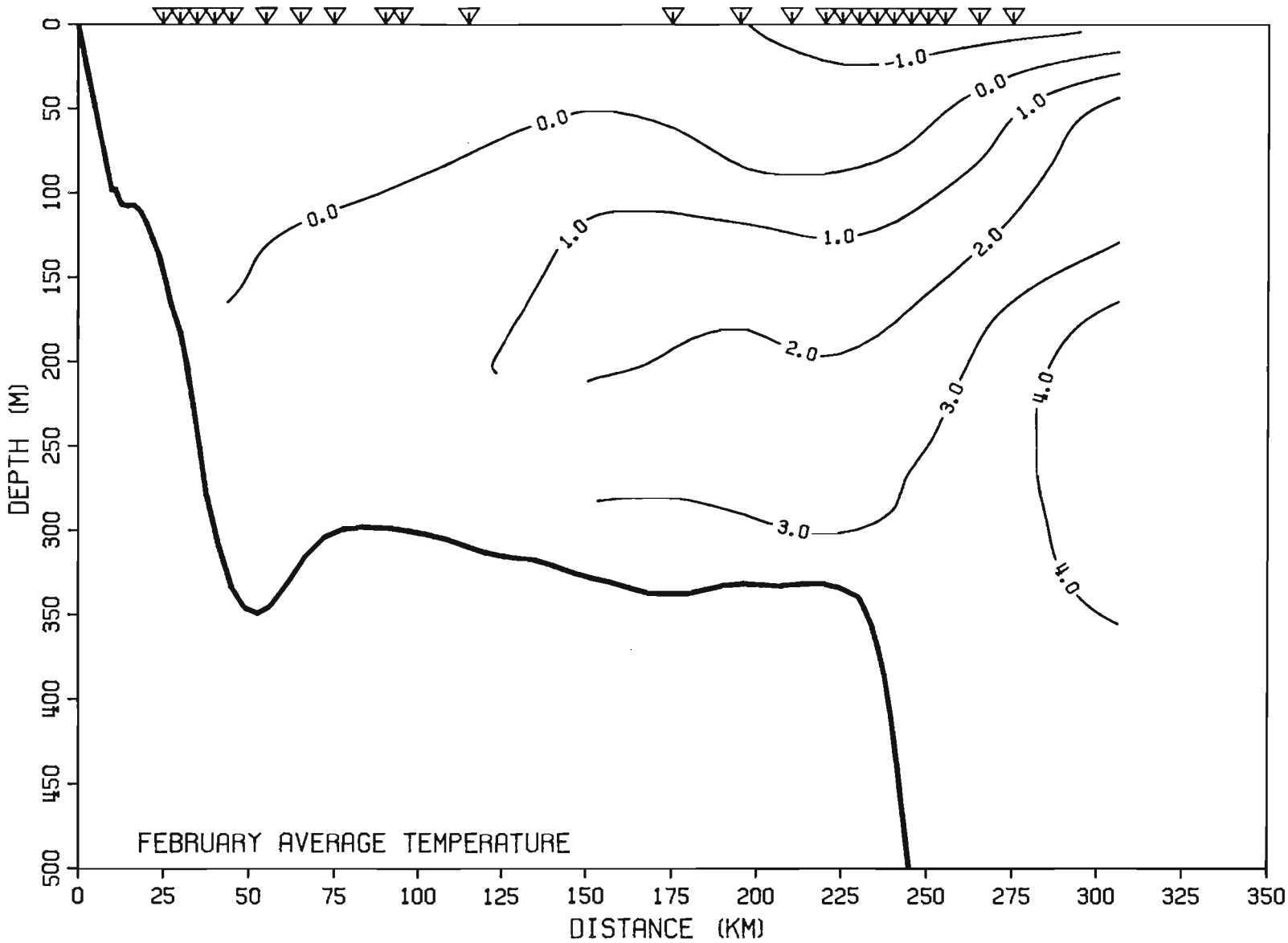
4.0


FEBRUARY AVERAGE TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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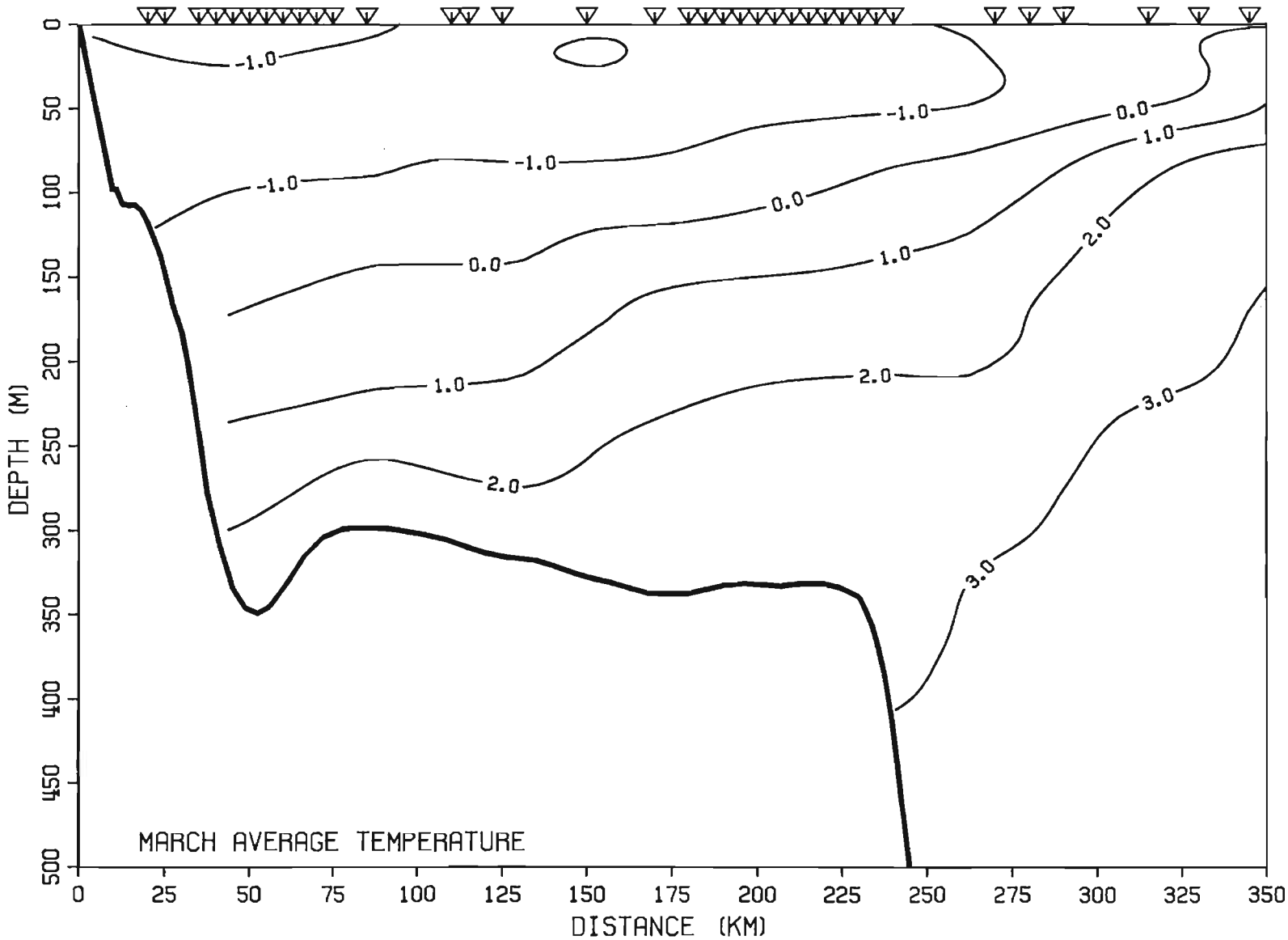
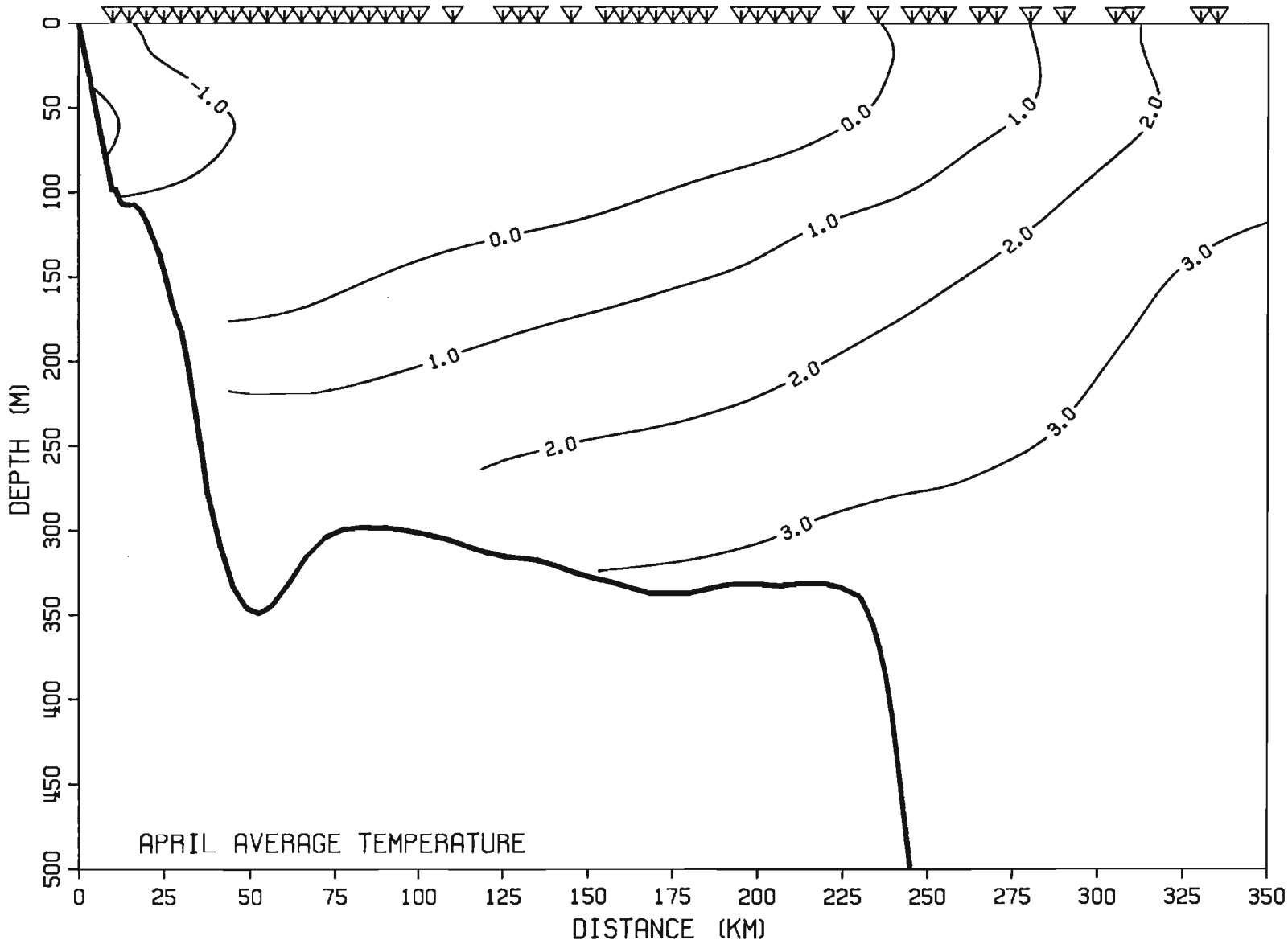
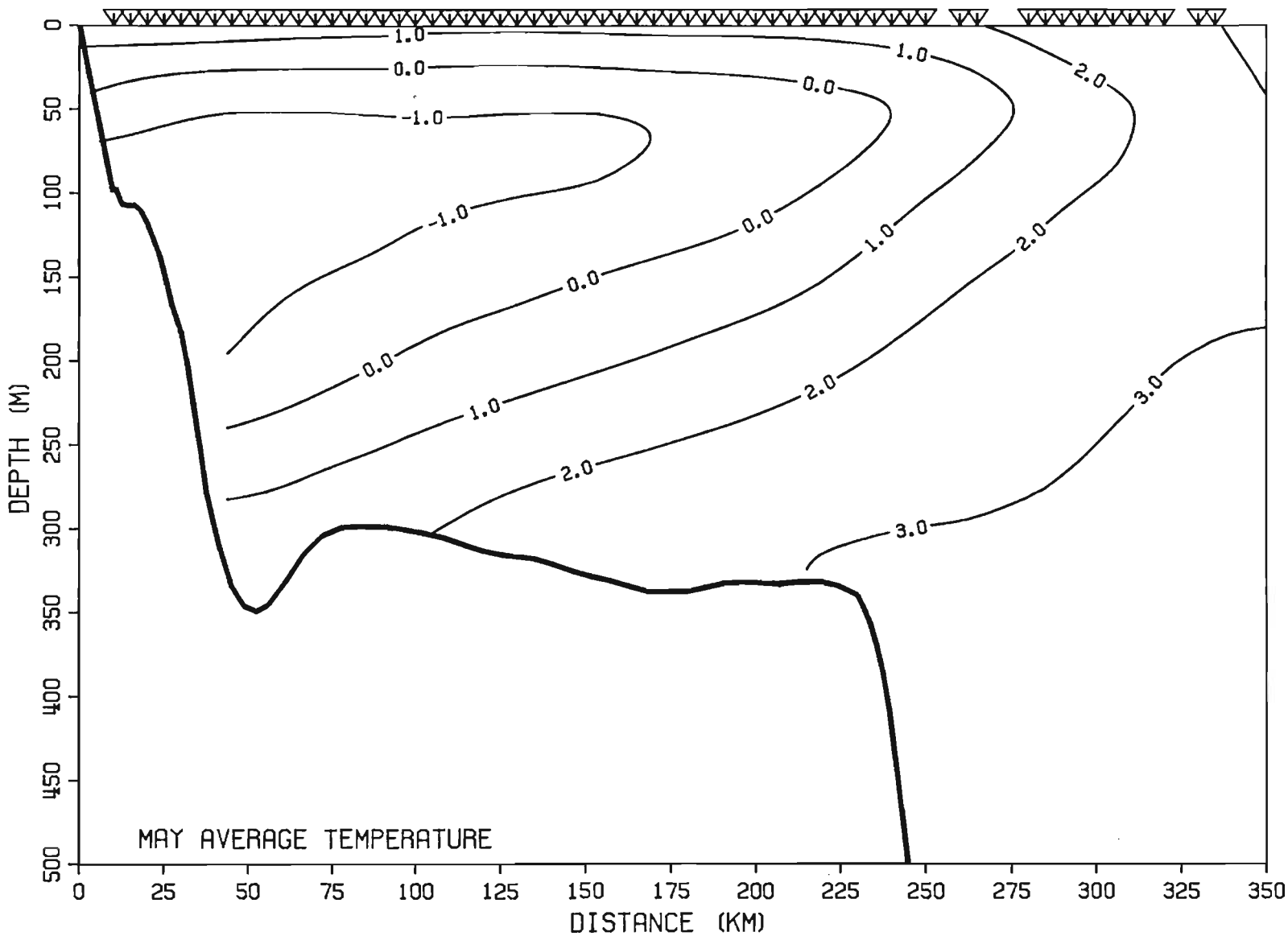
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
-1.0
0.0
1.0
2.0
3.0
4.0


MARCH AVERAGE TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
-1.0
0.0
1.0
2.0
3.0


APRIL AVERAGE TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
-1.0
0.0
1.0
2.0
3.0


MAY AVERAGE TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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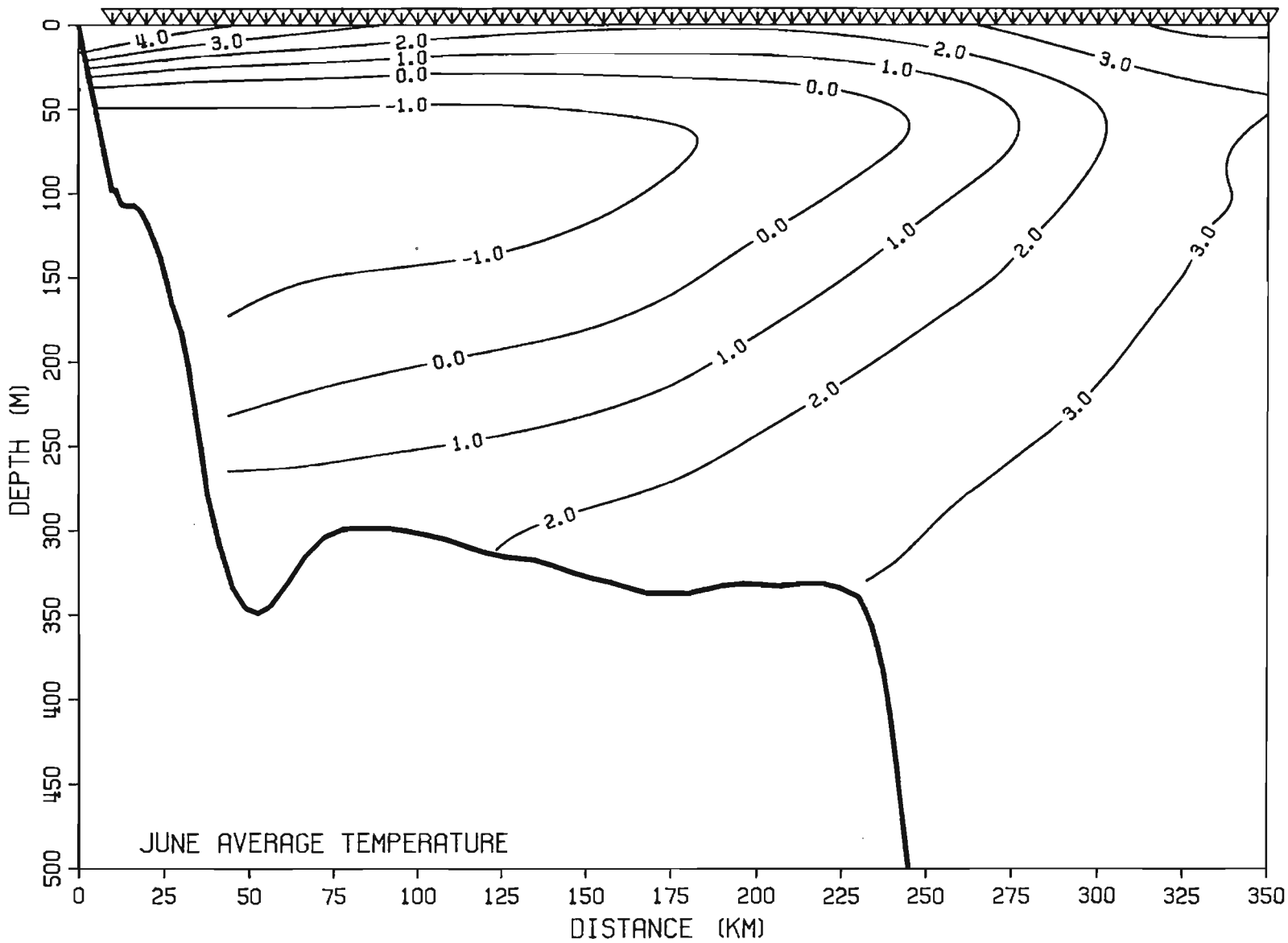
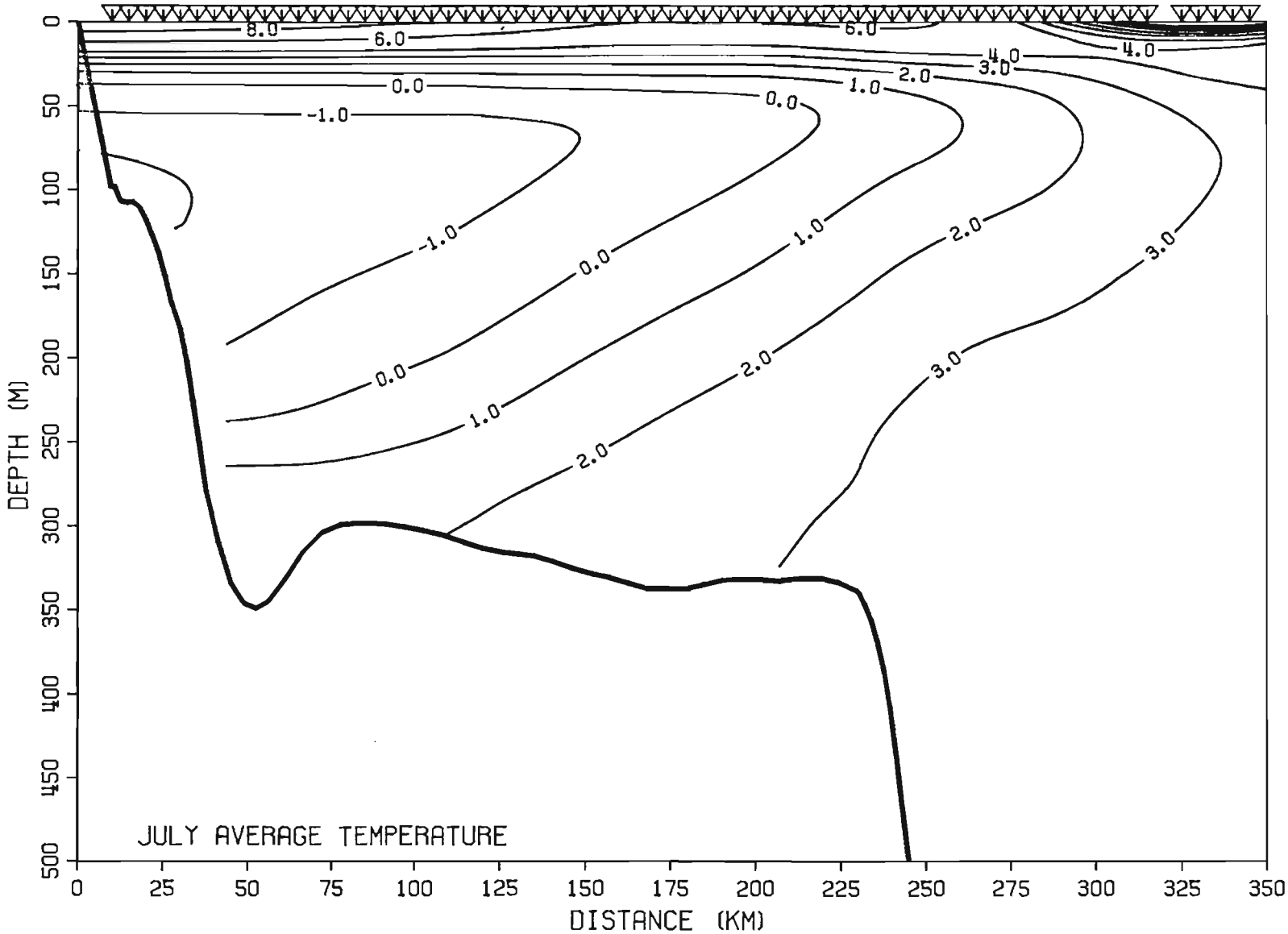
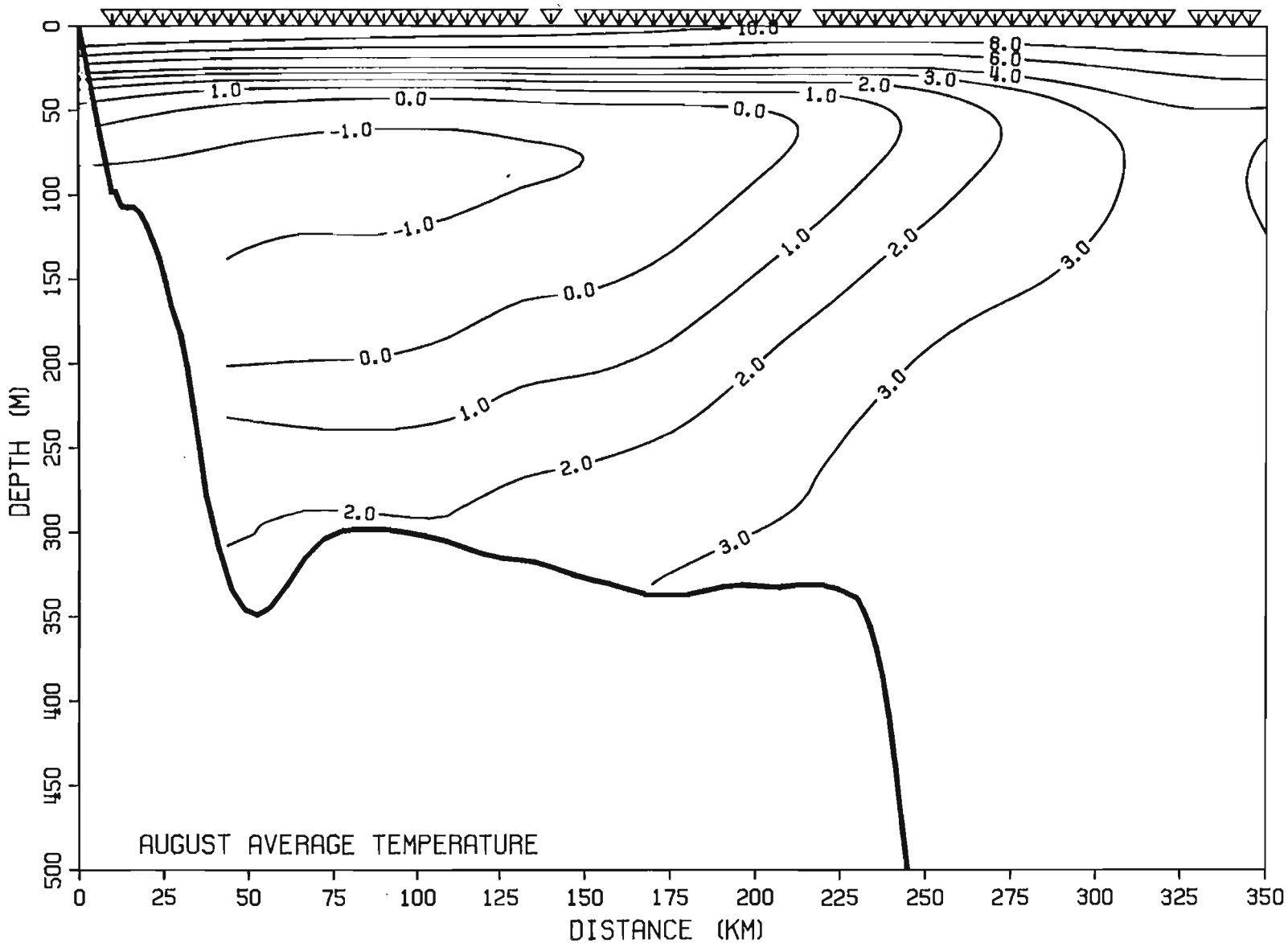
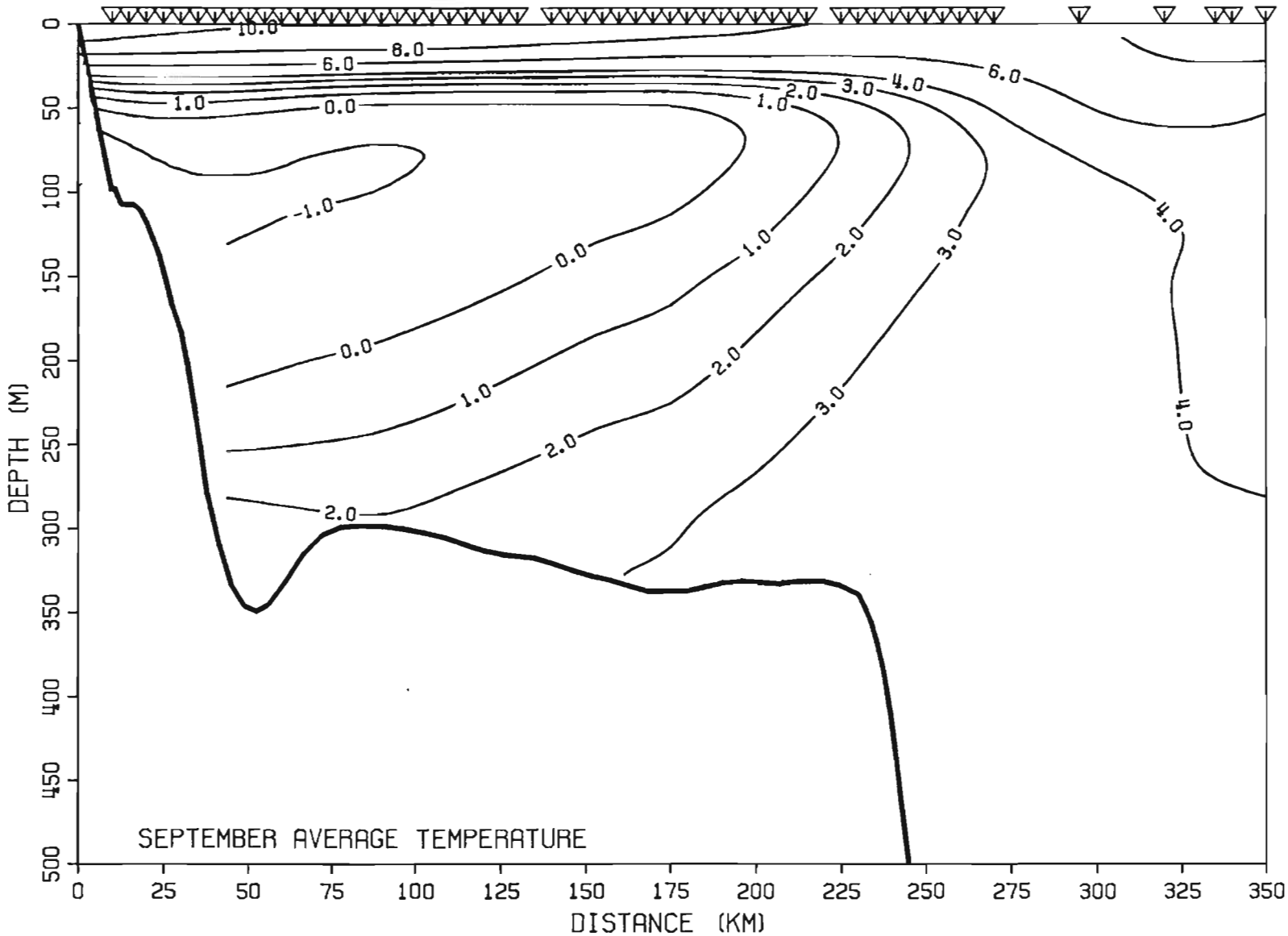
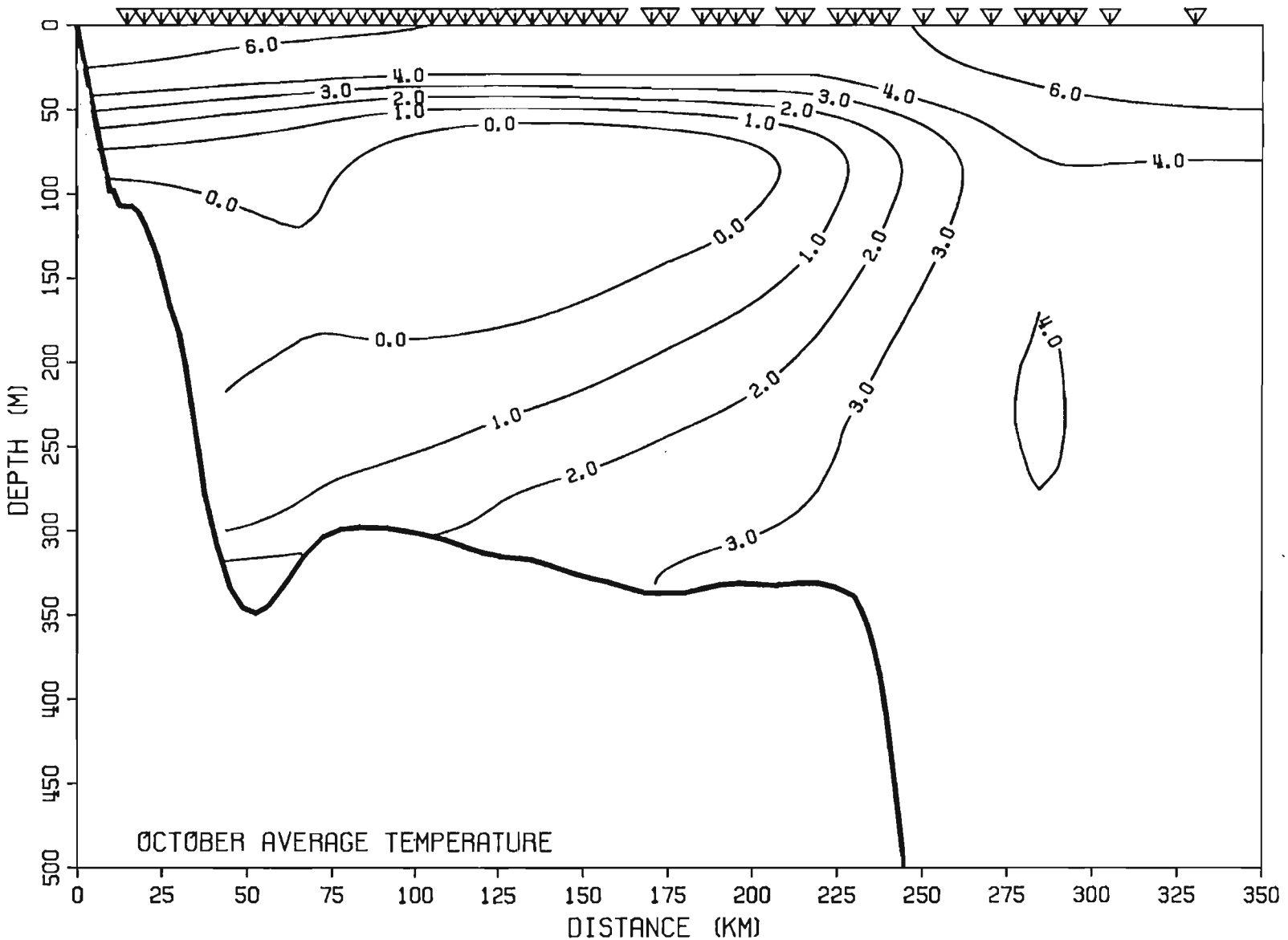
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
1.0
0.0
-1.0
2.0
3.0

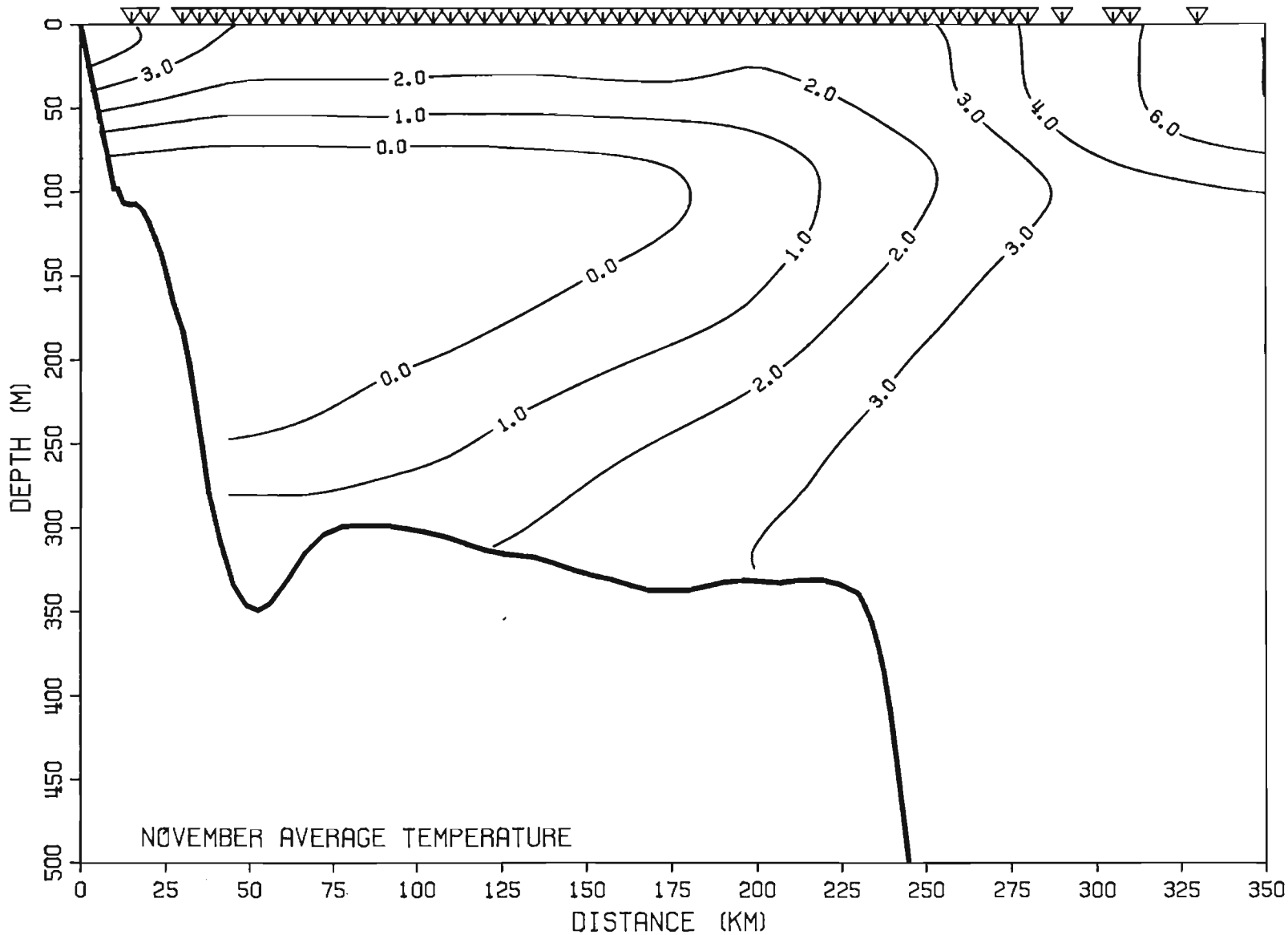

JUNE AVERAGE TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
4.0
3.0
2.0
1.0
0.0
-1.0

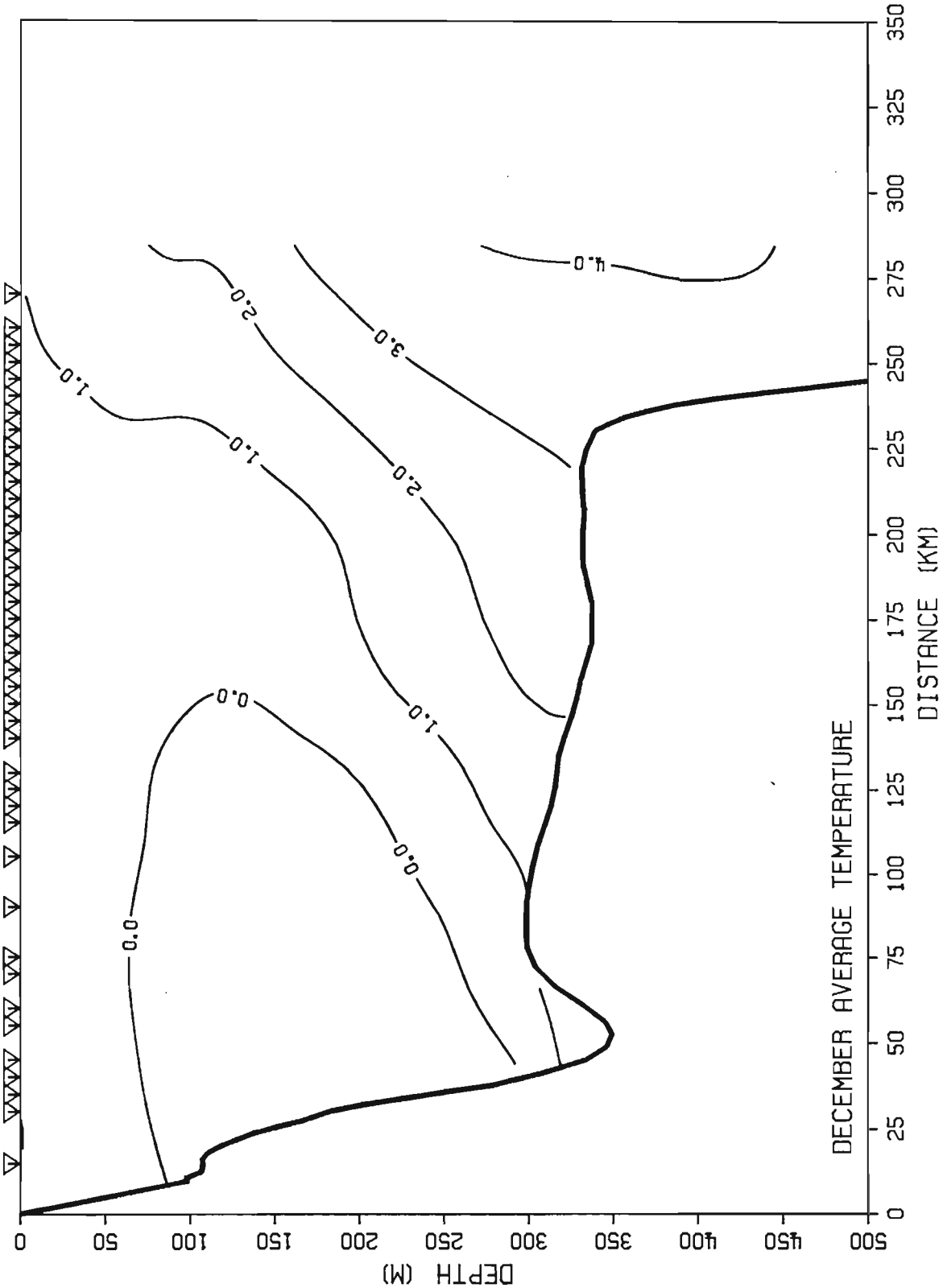

JULY AVERAGE TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
8.0
6.0
6.0
4.0
4.0
3.0
2.0
1.0
0.0
0.0
-1.0
-1.0
0.0
1.0
2.0
3.0
0.0
1.0
2.0
3.0
2.0


AUGUST AVERAGE TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
10.0
8.0
6.0
4.0
3.0
2.0
1.0
0.0
-1.0

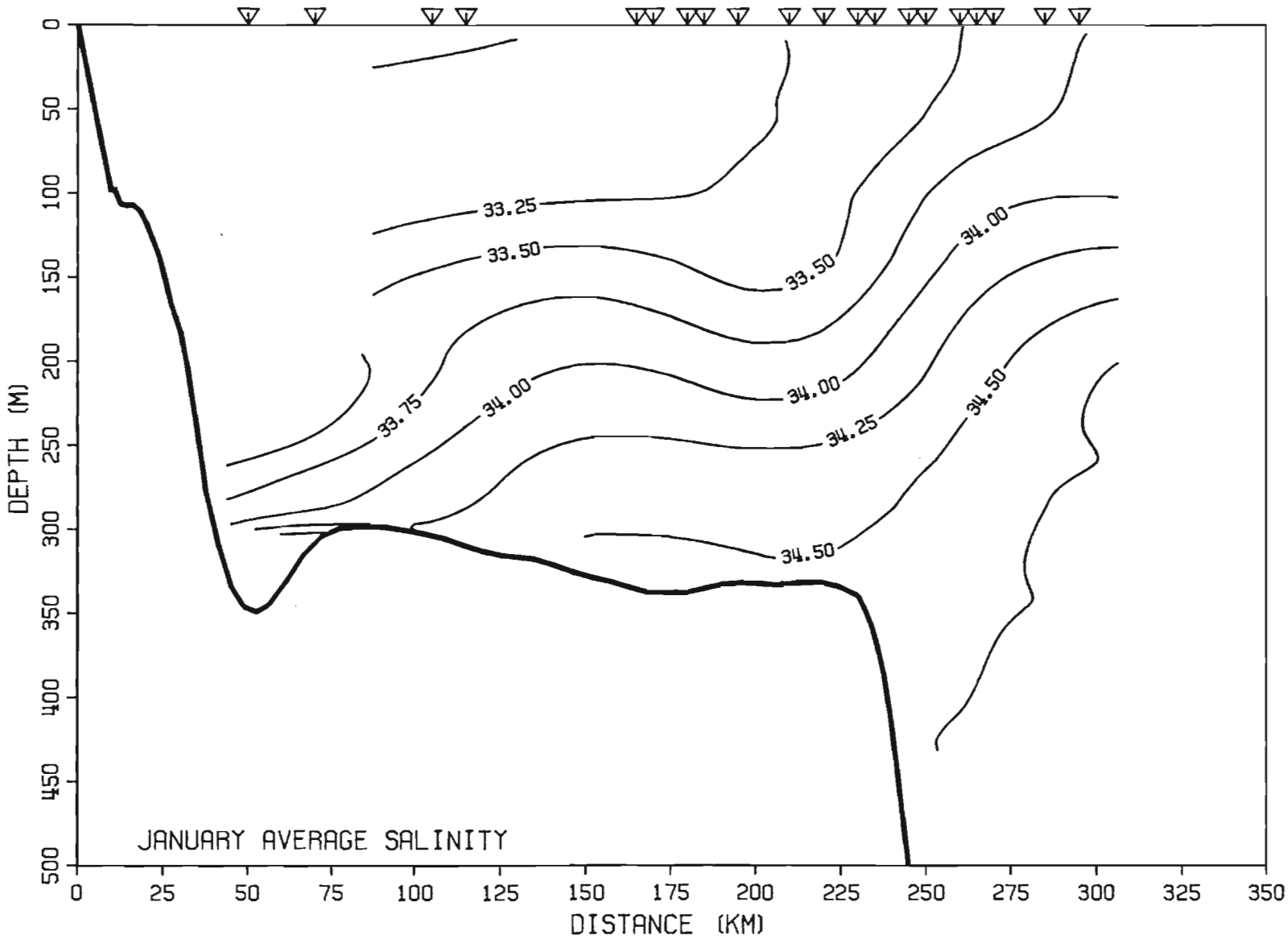

SEPTEMBER AVERAGE TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
10.0
8.0
6.0
4.0
3.0
2.0
1.0
0.0
-1.0

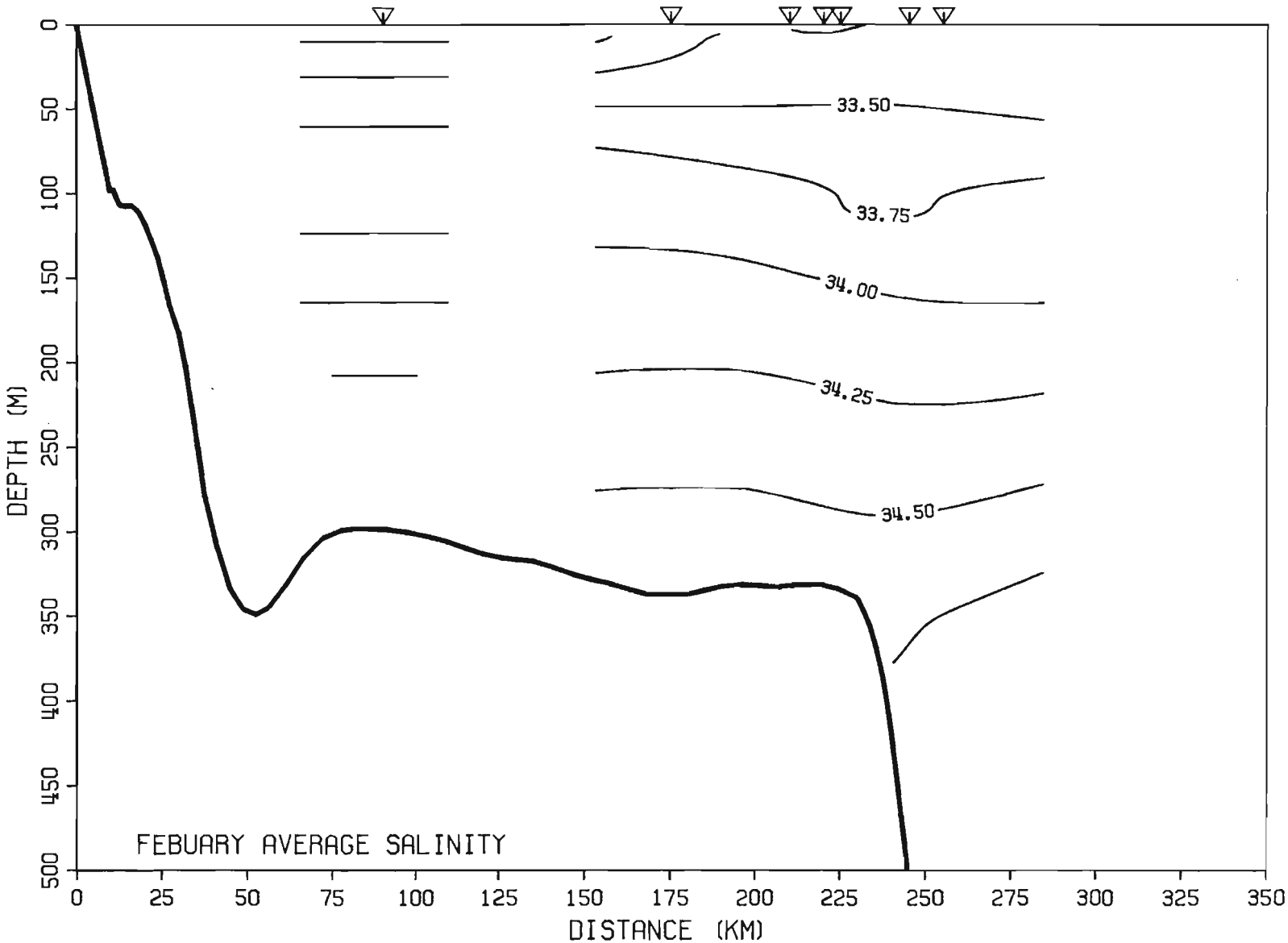

OCTOBER AVERAGE TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
6.0
4.0
3.0
2.0
1.0
0.0

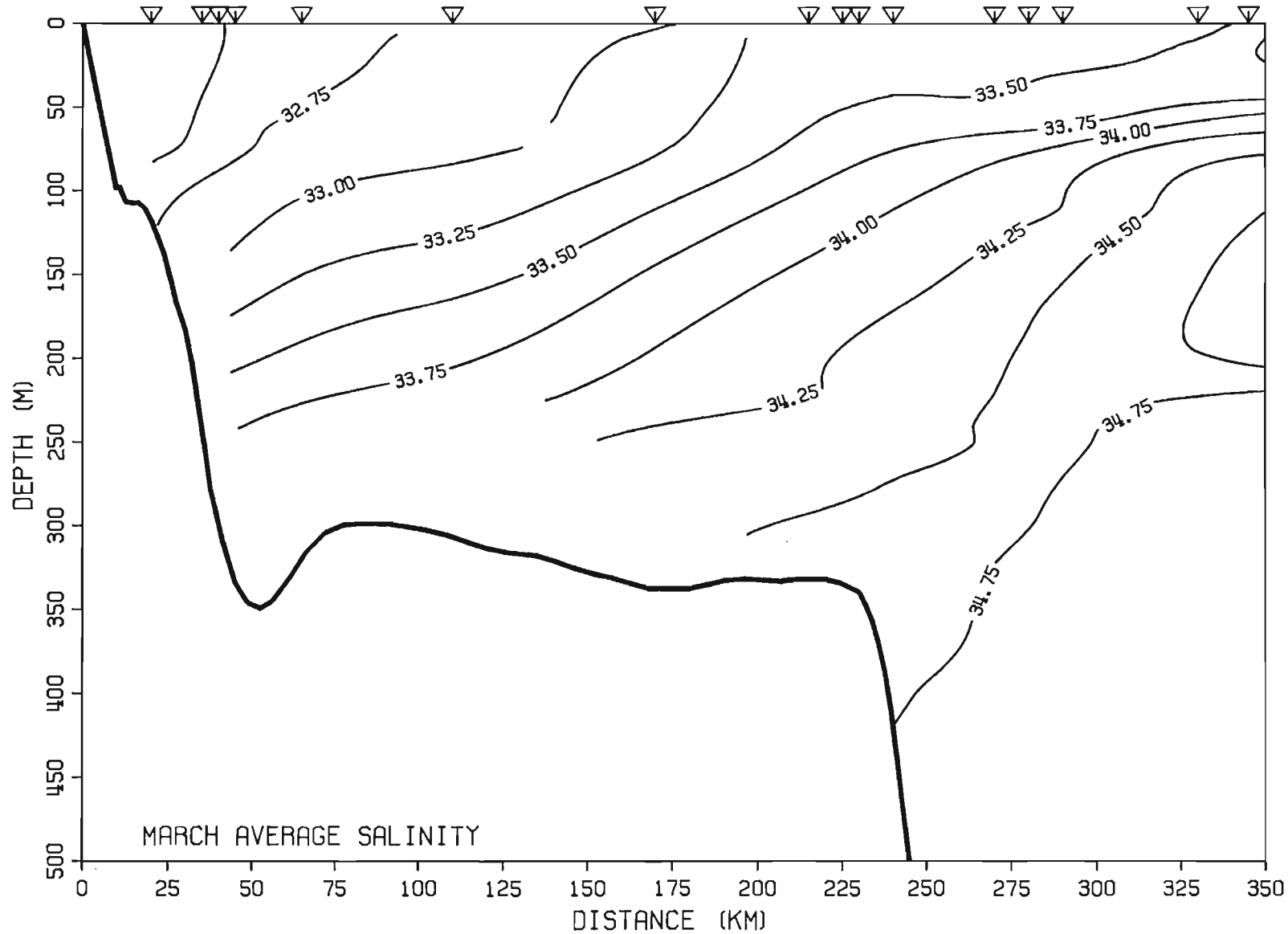

NOVEMBER AVERAGE TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
3.0
2.0
1.0
0.0
2.0
3.0
4.0
6.0
0.0
1.0
2.0
3.0
0.0
1.0
2.0
3.0

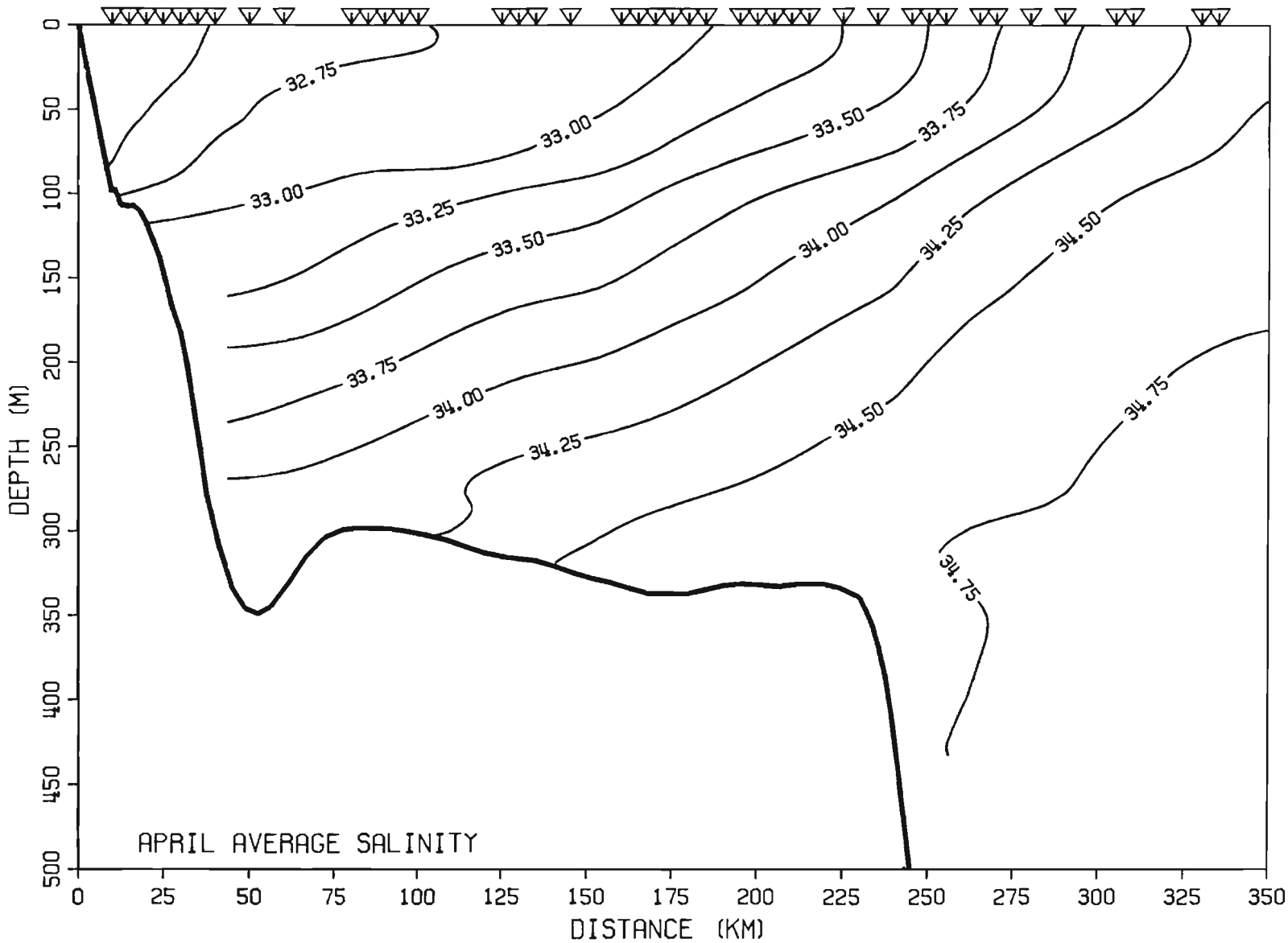

DECEMBER AVERAGE TEMPERATURE
DISTANCE (KM)
DEPTH (M)
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
0
50
100
150
200
250
300
350
400
450
500
0.0
0.0
0.0
1.0
1.0
1.0
2.0
2.0
3.0
4.0

APPENDIX C. The monthly average vertical distributions of salinity.


JANUARY AVERAGE SALINITY
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
33.25
33.50
33.50
33.75
34.00
34.00
34.00
34.25
34.50
34.50


FEBUARY AVERAGE SALINITY
33.50
33.75
34.00
34.25
34.50
DEPTH (M)
0
50
100
150
200
250
300
350
400
450
500
DISTANCE (KM)
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350


MARCH AVERAGE SALINITY
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
32.75
33.00
33.25
33.50
33.75
34.00
34.25
34.50
34.75


APRIL AVERAGE SALINITY
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
32.75
33.00
33.00
33.25
33.50
33.50
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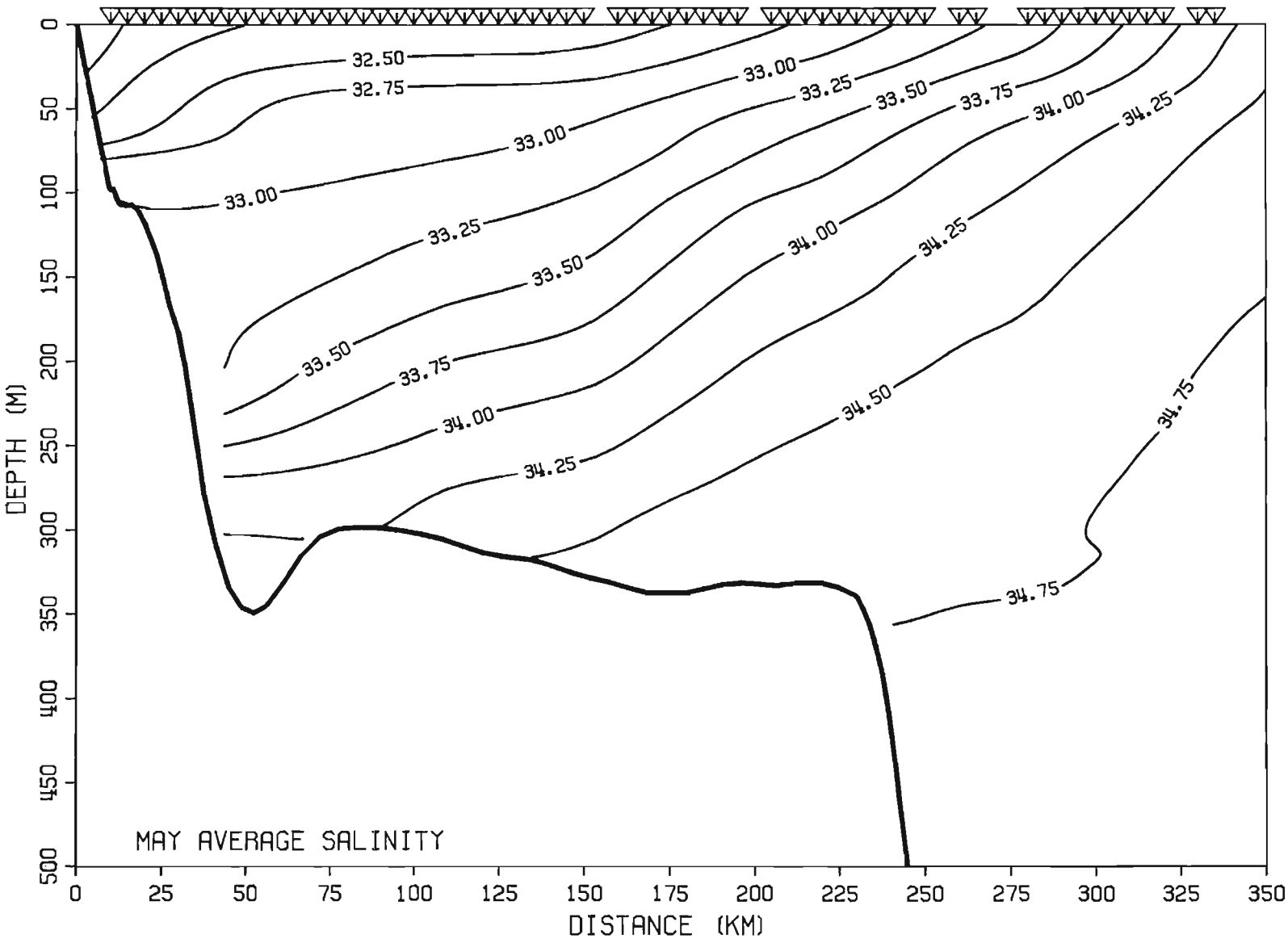
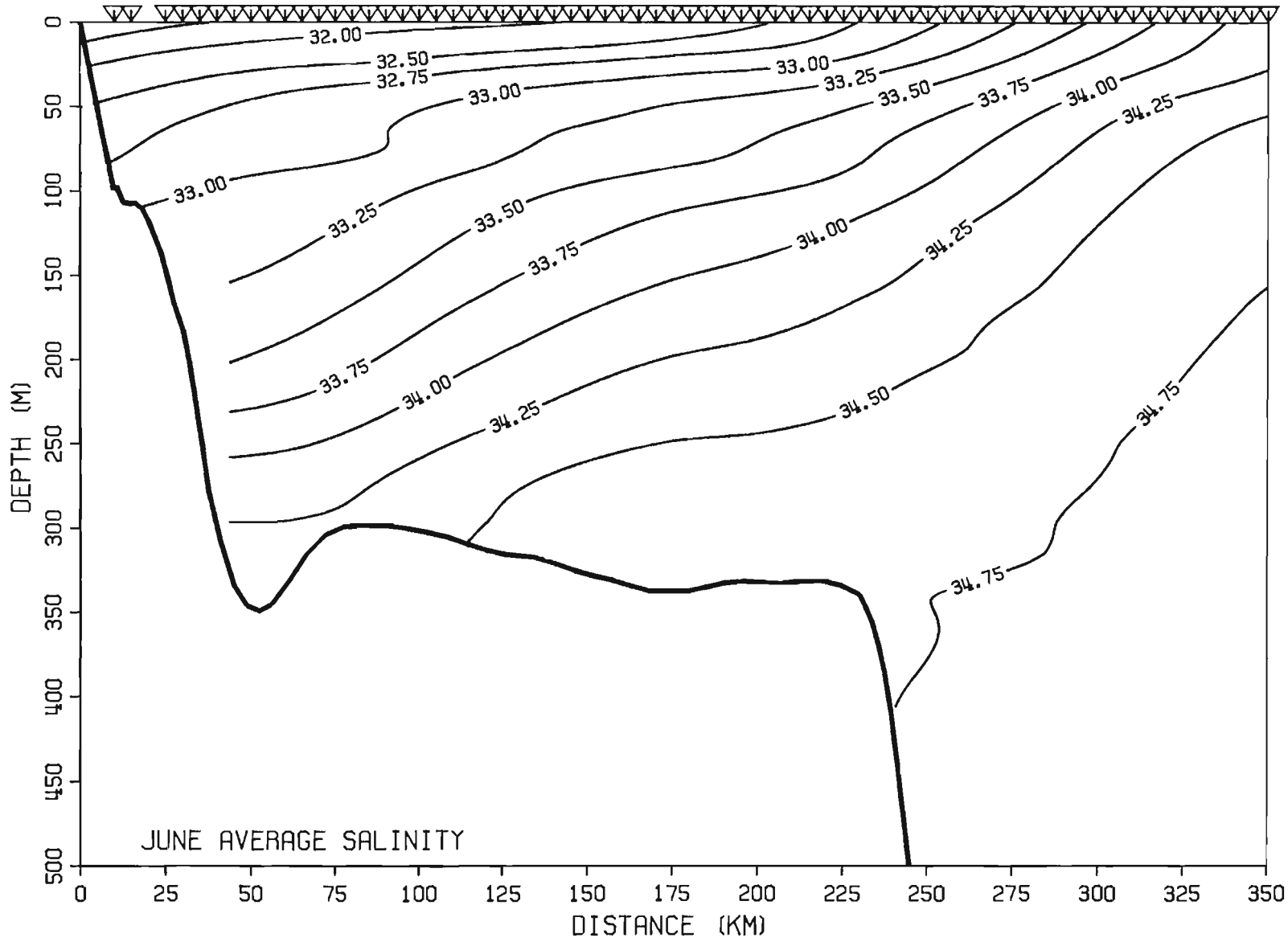
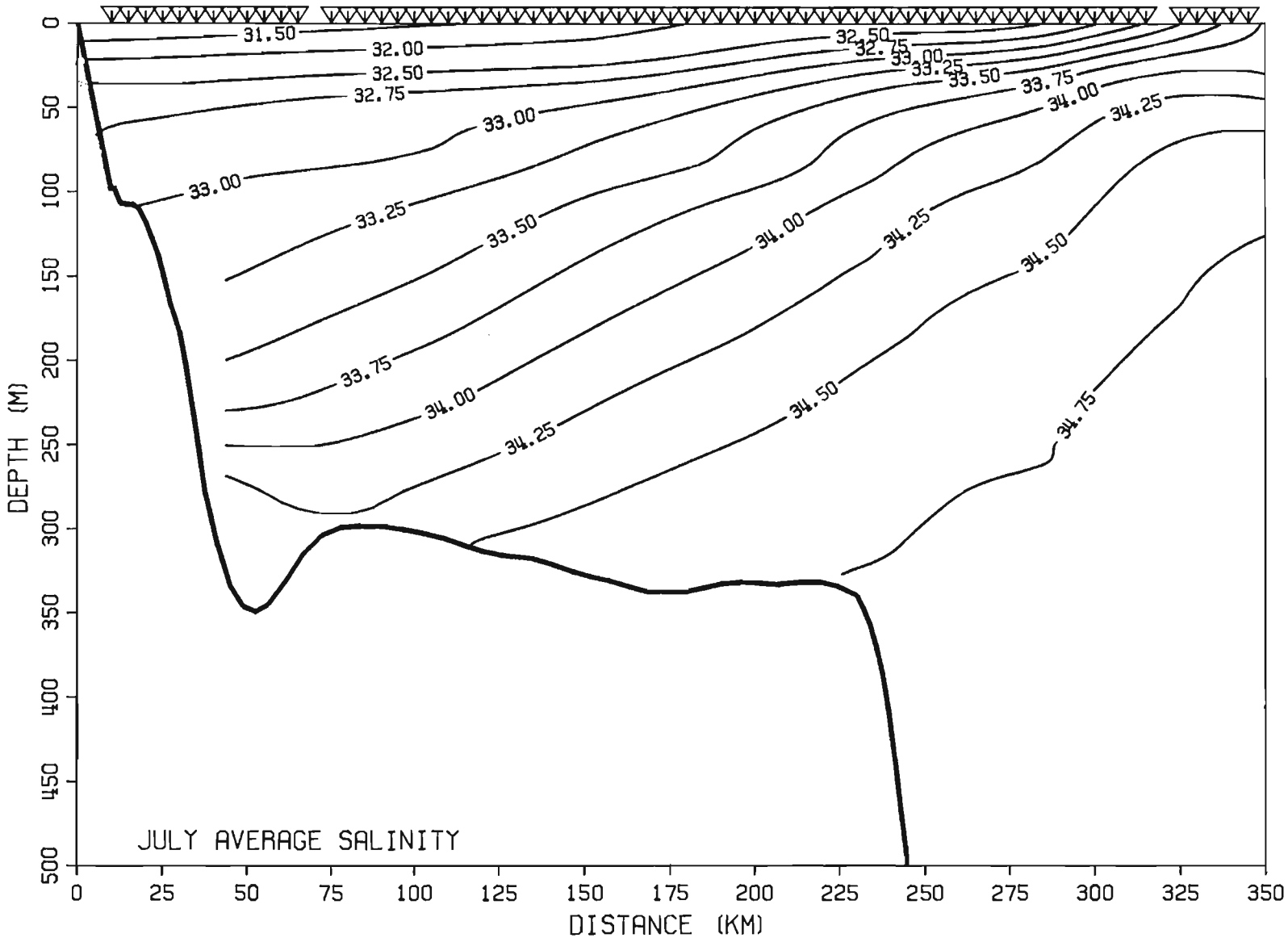
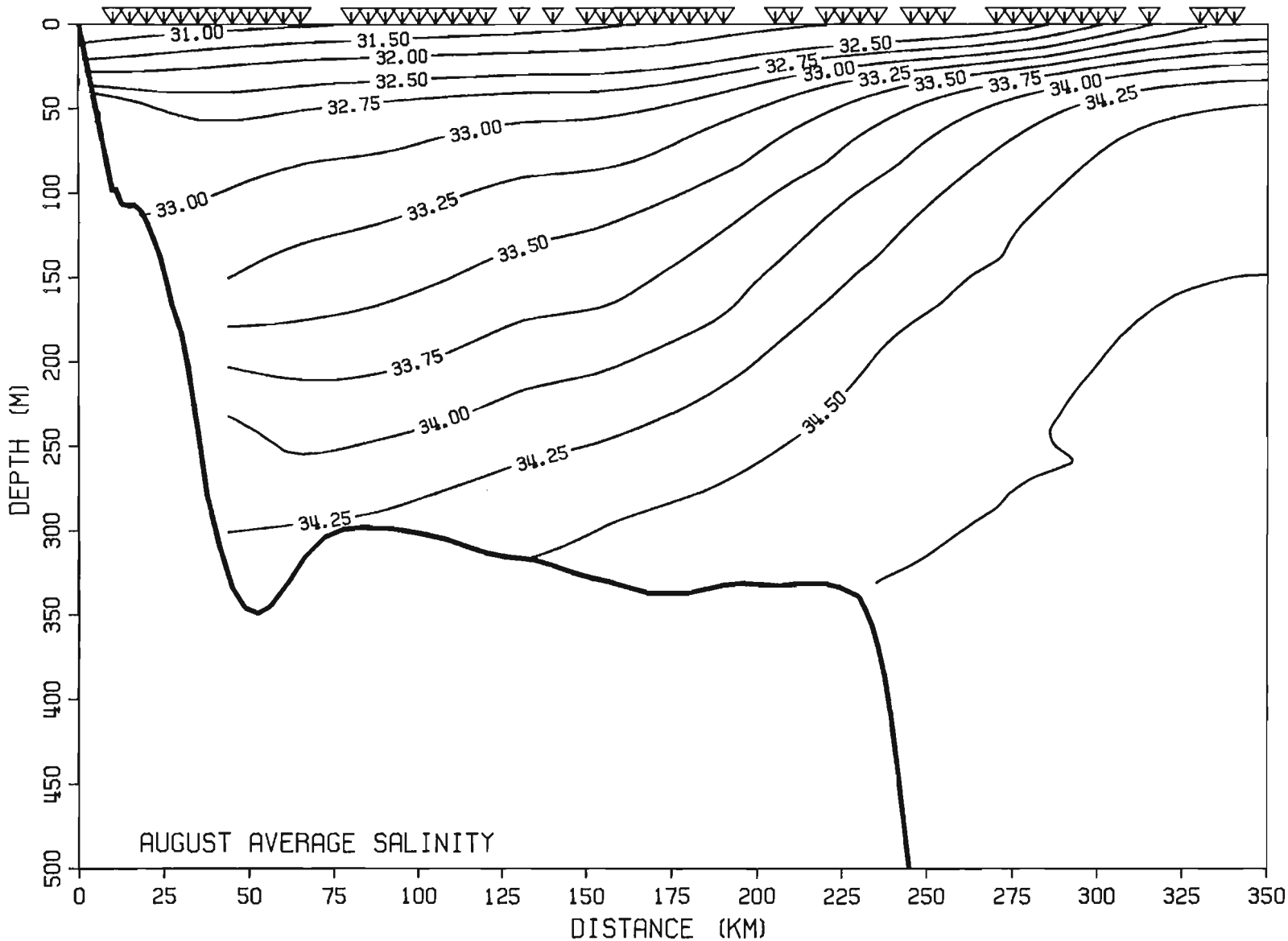
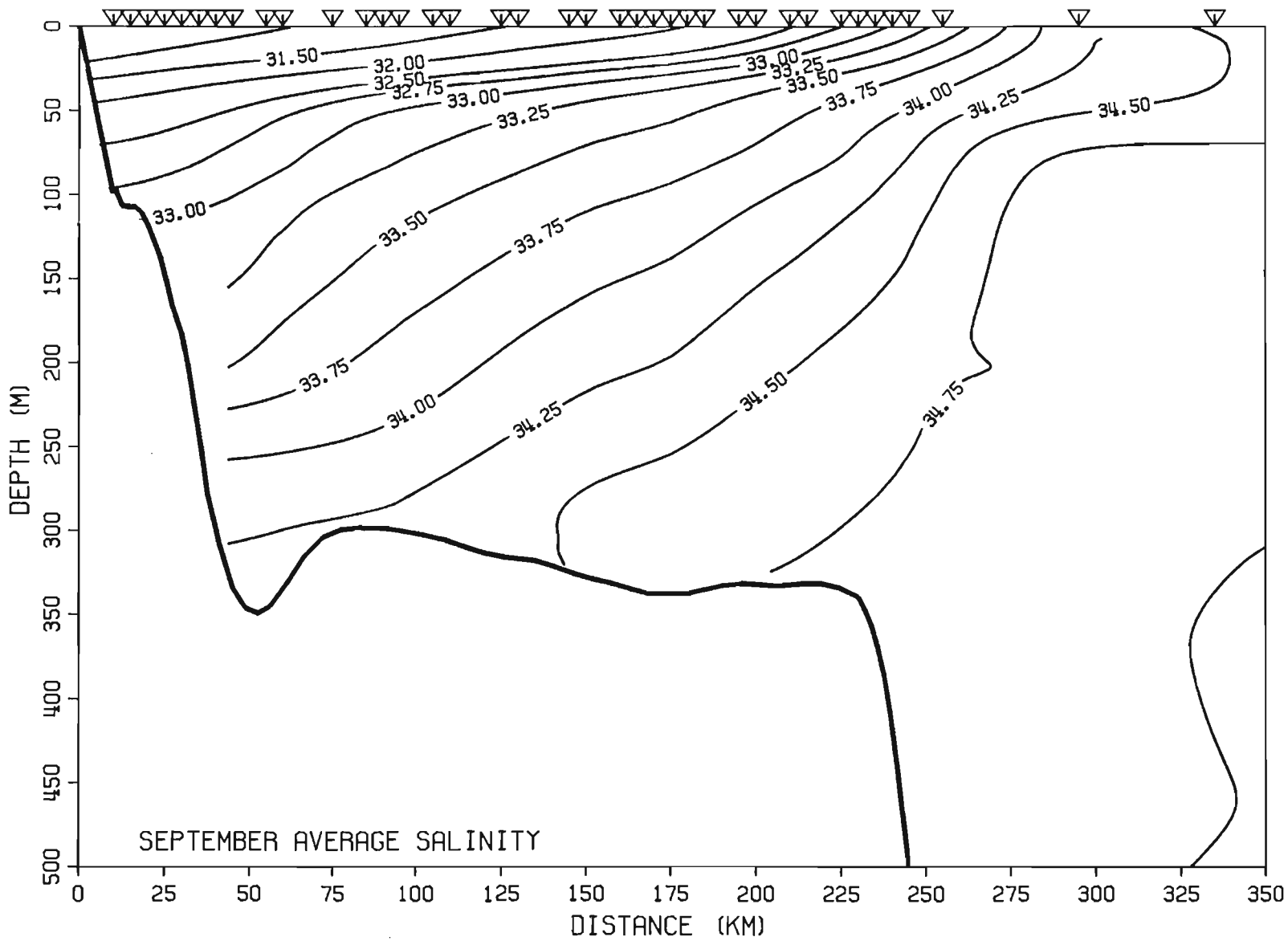
34.25
34.25
34.50
34.50
34.75
34.75


MAY AVERAGE SALINITY
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
32.50
32.75
33.00
33.25
33.50
33.75
34.00
34.25
34.50
34.75


JUNE AVERAGE SALINITY
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
32.00
32.50
32.75
33.00
33.25
33.50
33.75
34.00
34.25
34.50
34.75


JULY AVERAGE SALINITY
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
31.50
32.00
32.50
32.75
33.00
33.25
33.50
33.75
34.00
34.25
34.50
34.75


AUGUST AVERAGE SALINITY
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
31.00
31.50
32.00
32.50
32.75
33.00
33.25
33.50
33.75
34.00
34.25
34.50


SEPTEMBER AVERAGE SALINITY
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
31.50
32.00
32.50
32.75
33.00
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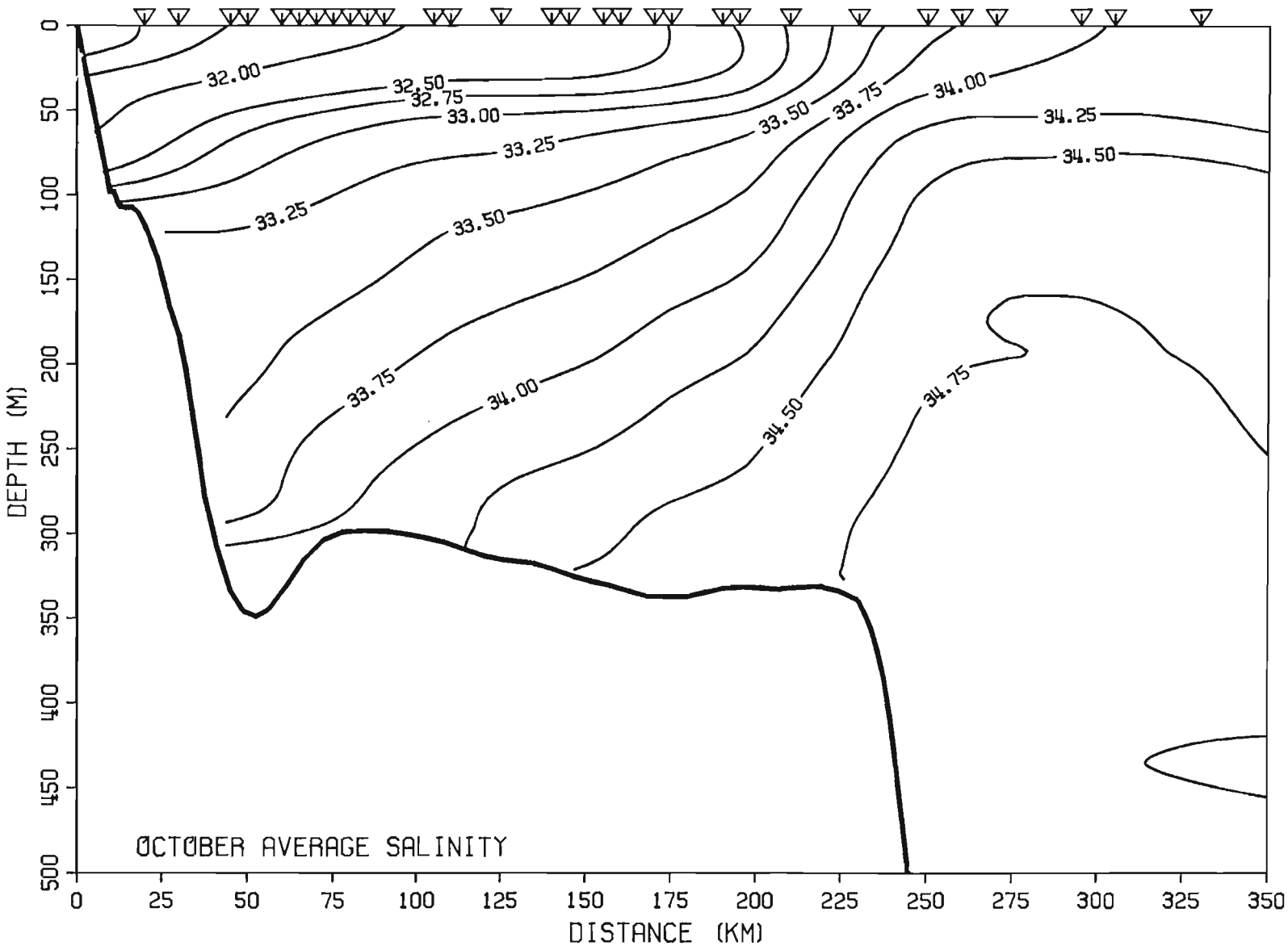
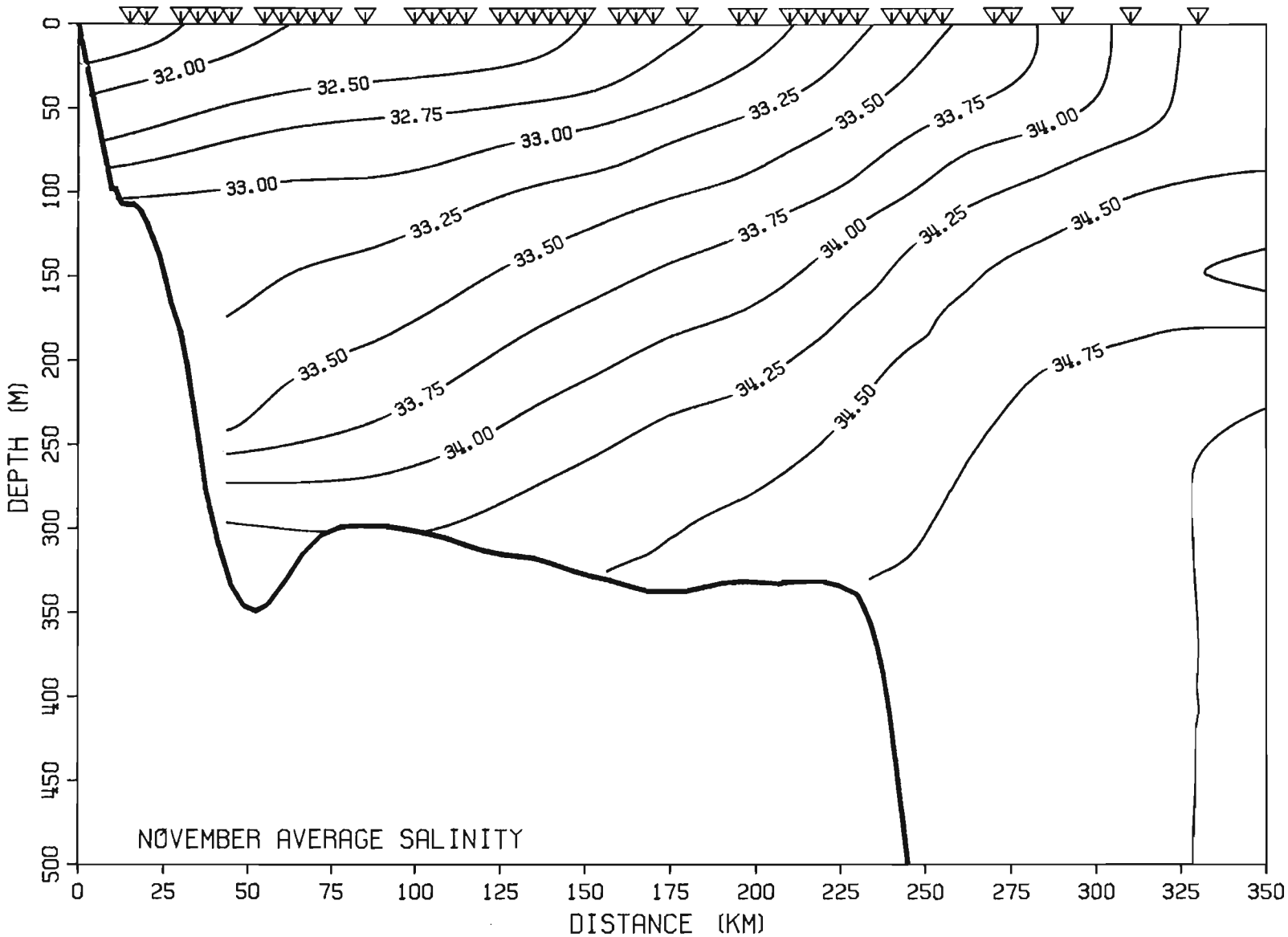
33.50
33.75
34.00
34.25
34.50
34.75


OCTOBER AVERAGE SALINITY
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
32.00
32.50
32.75
33.00
33.25
33.25
33.50
33.50
33.75
33.75
34.00
34.00
34.25
34.50
34.50
34.75


NOVEMBER AVERAGE SALINITY
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
32.00
32.50
32.75
33.00
33.00
33.25
33.50
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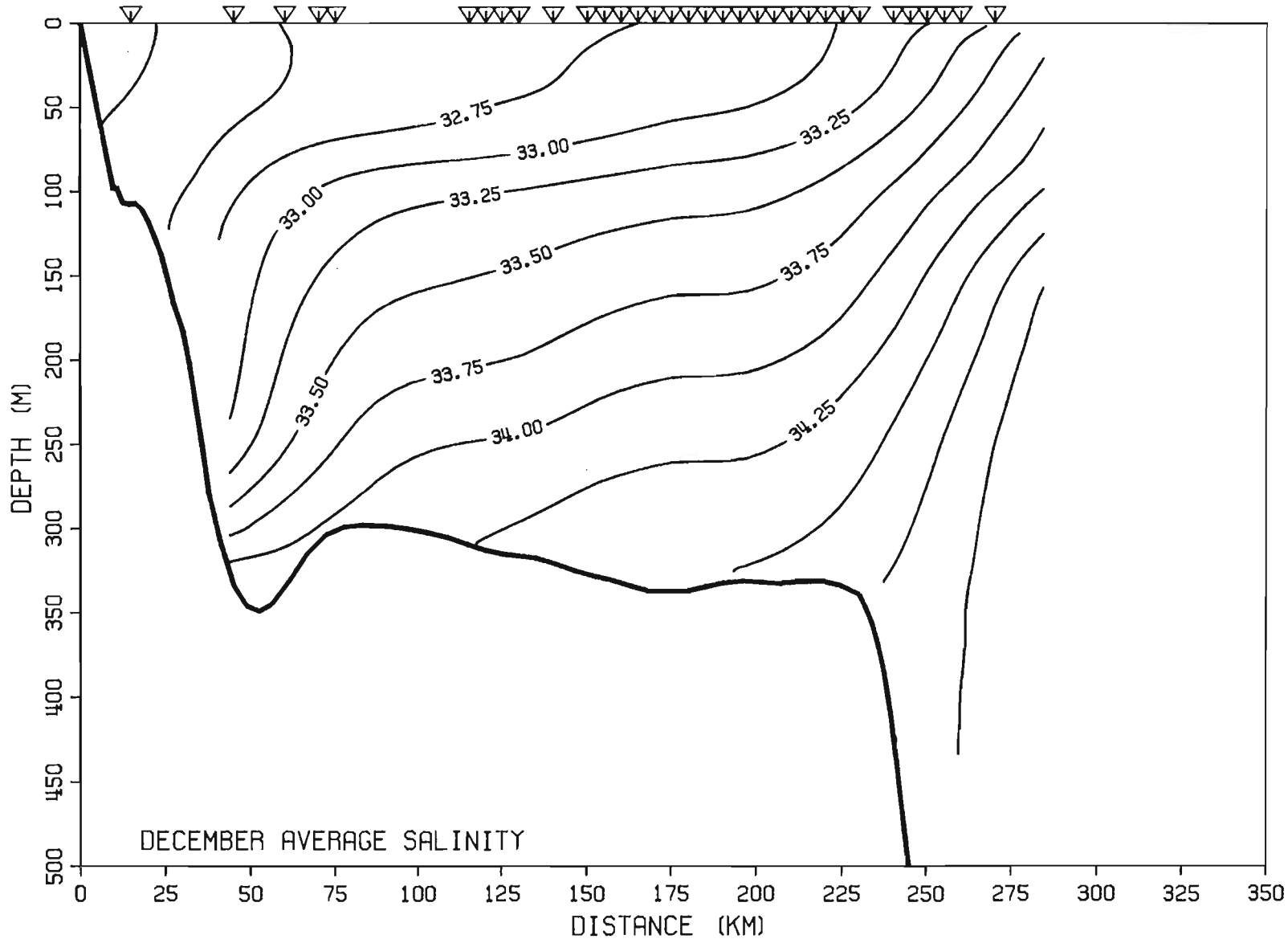
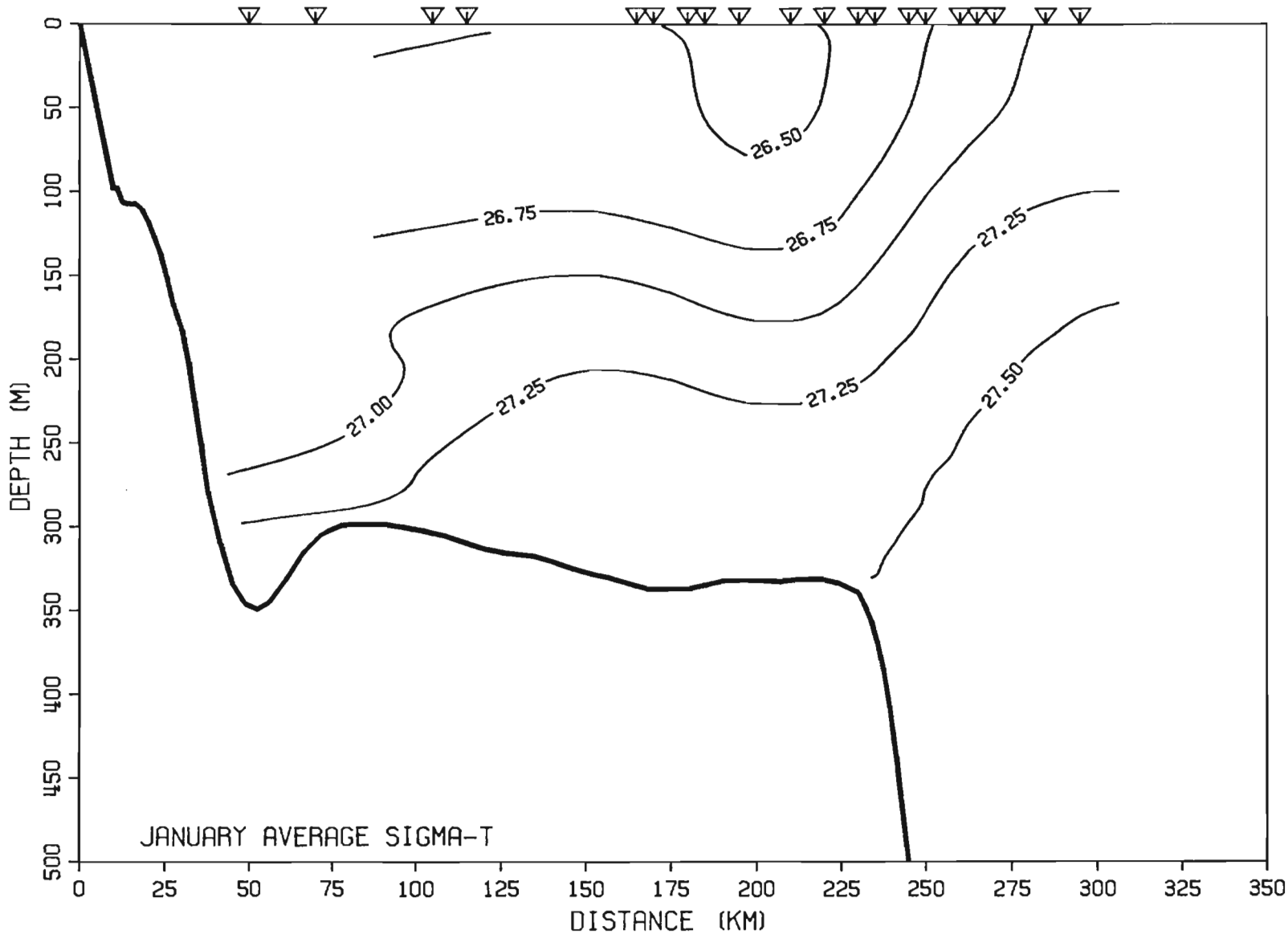
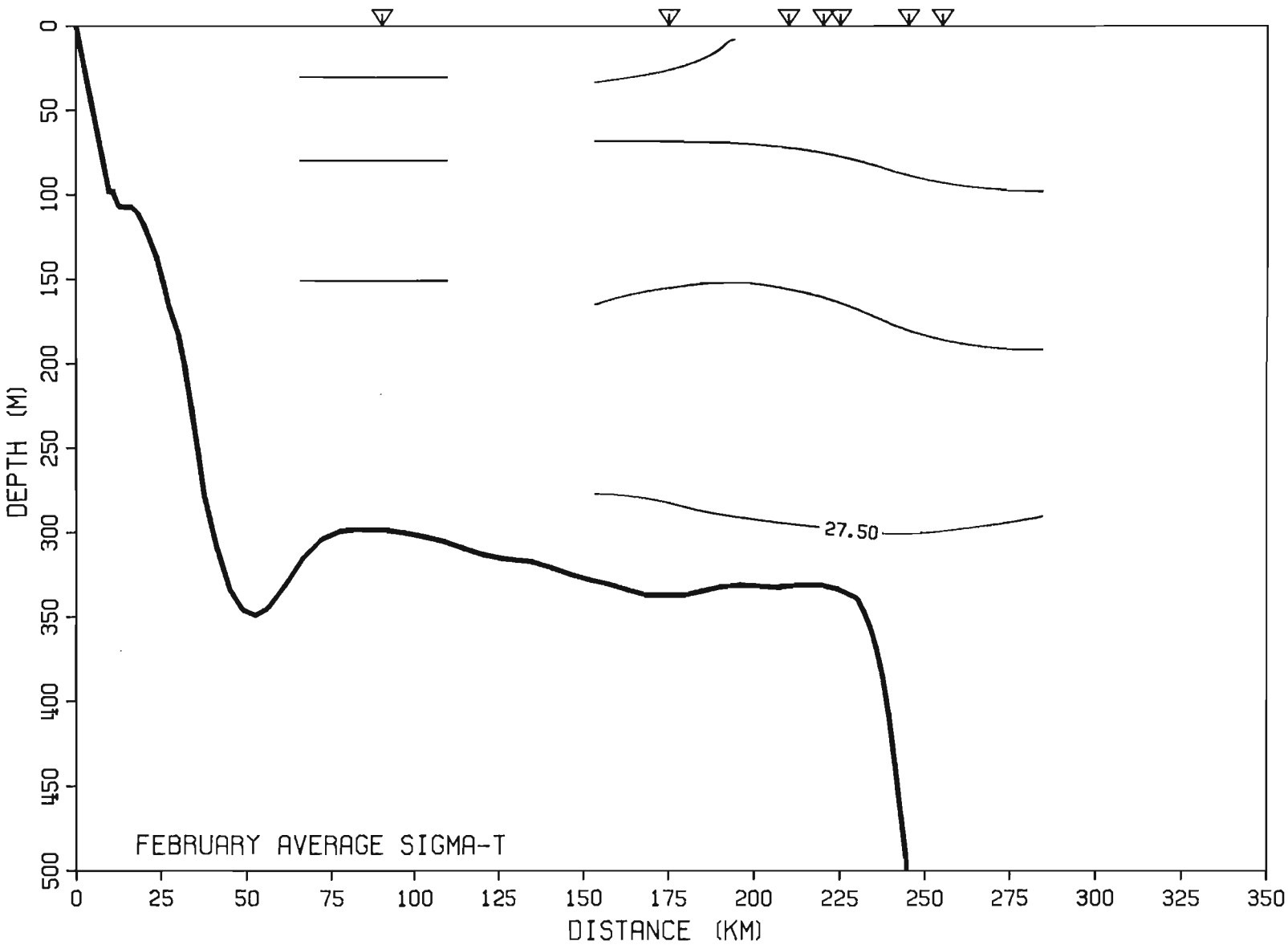
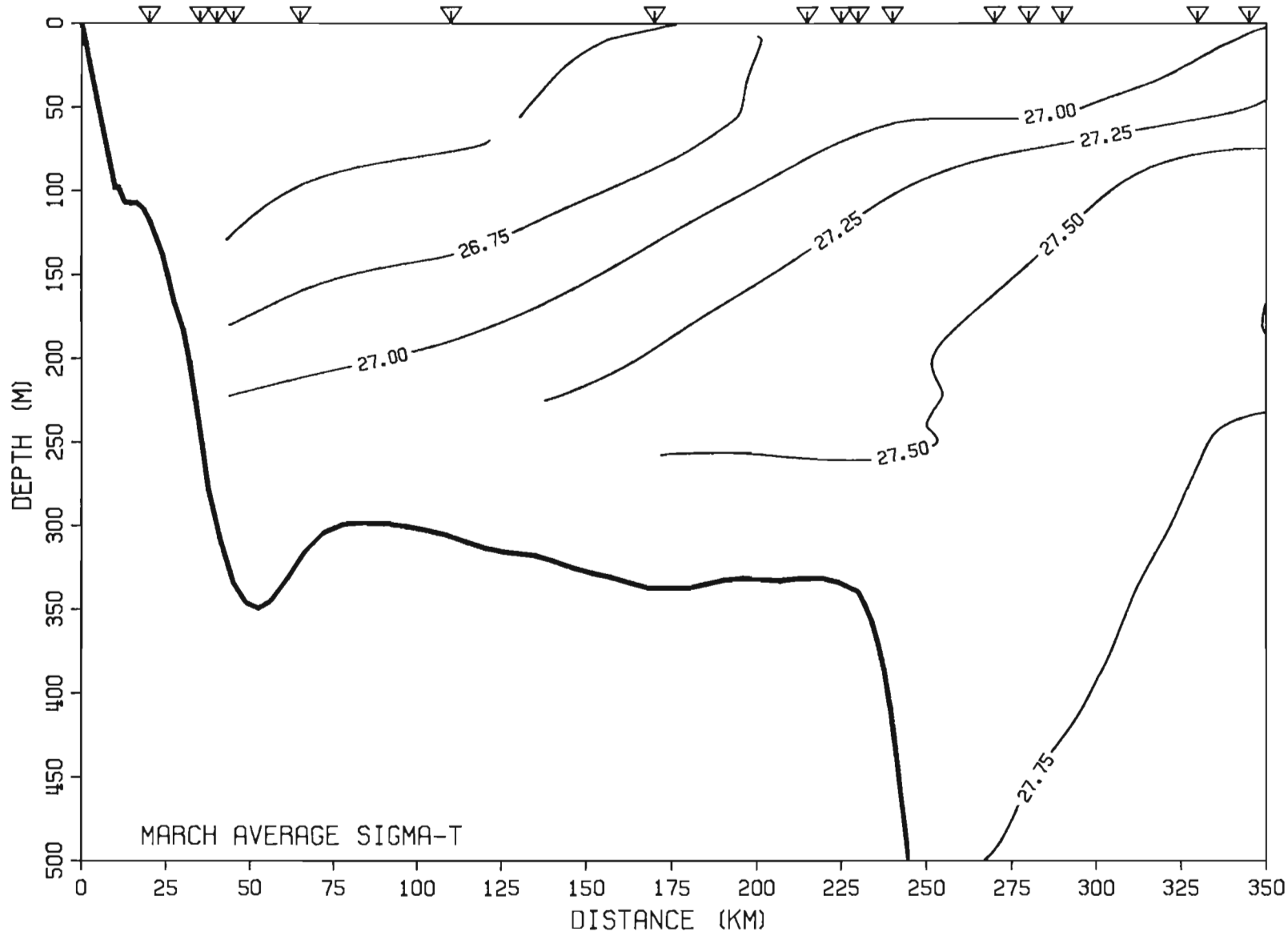
33.75
33.75
34.00
34.00
34.25
34.25
34.50
34.50
34.75

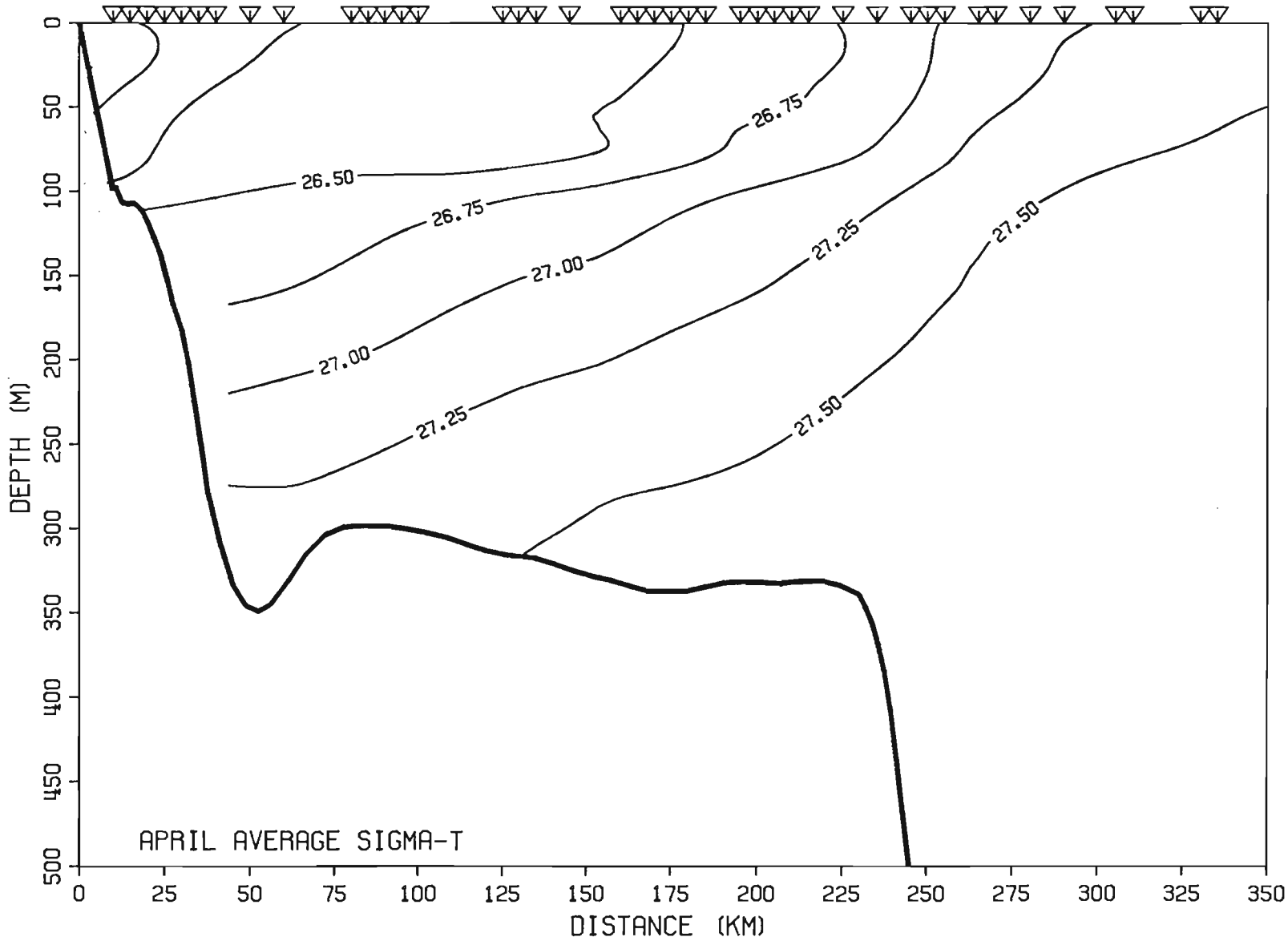

DECEMBER AVERAGE SALINITY
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
32.75
33.00
33.25
33.50
33.75
34.00
34.25

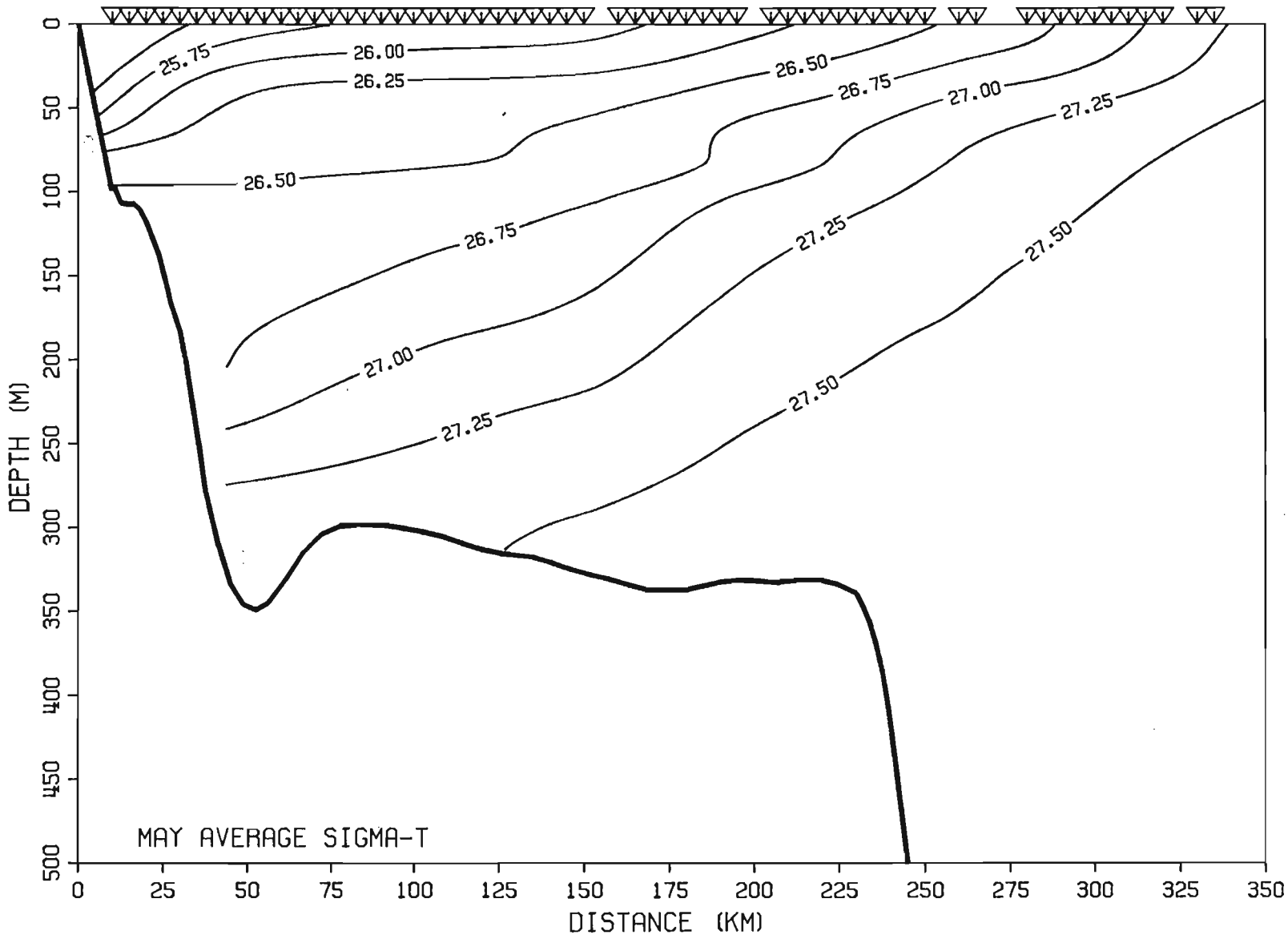
APPENDIX D. The monthly average vertical distributions of density.

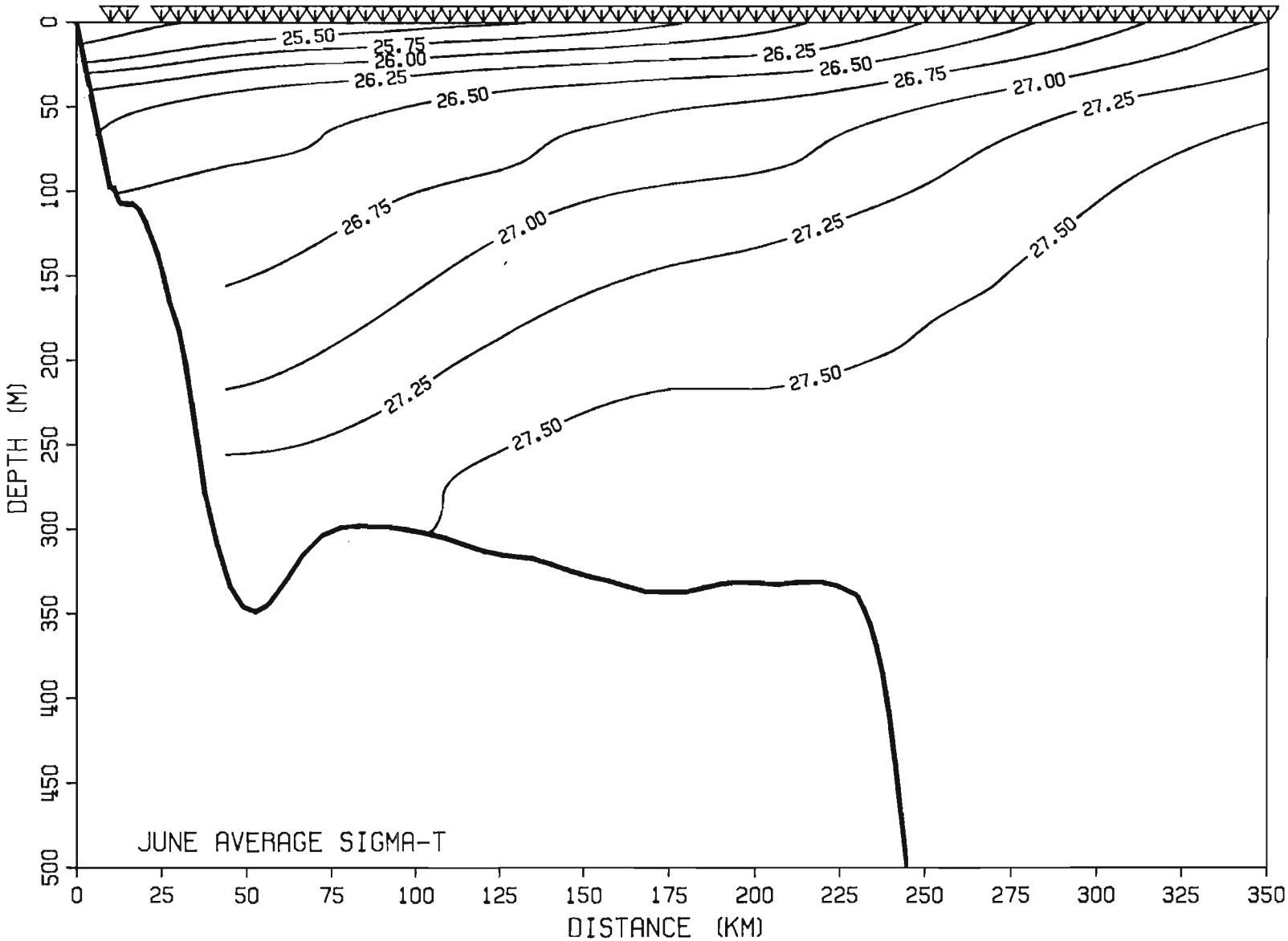

JANUARY AVERAGE SIGMA-T
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
26.50
26.75
26.75
27.00
27.25
27.25
27.25
27.50

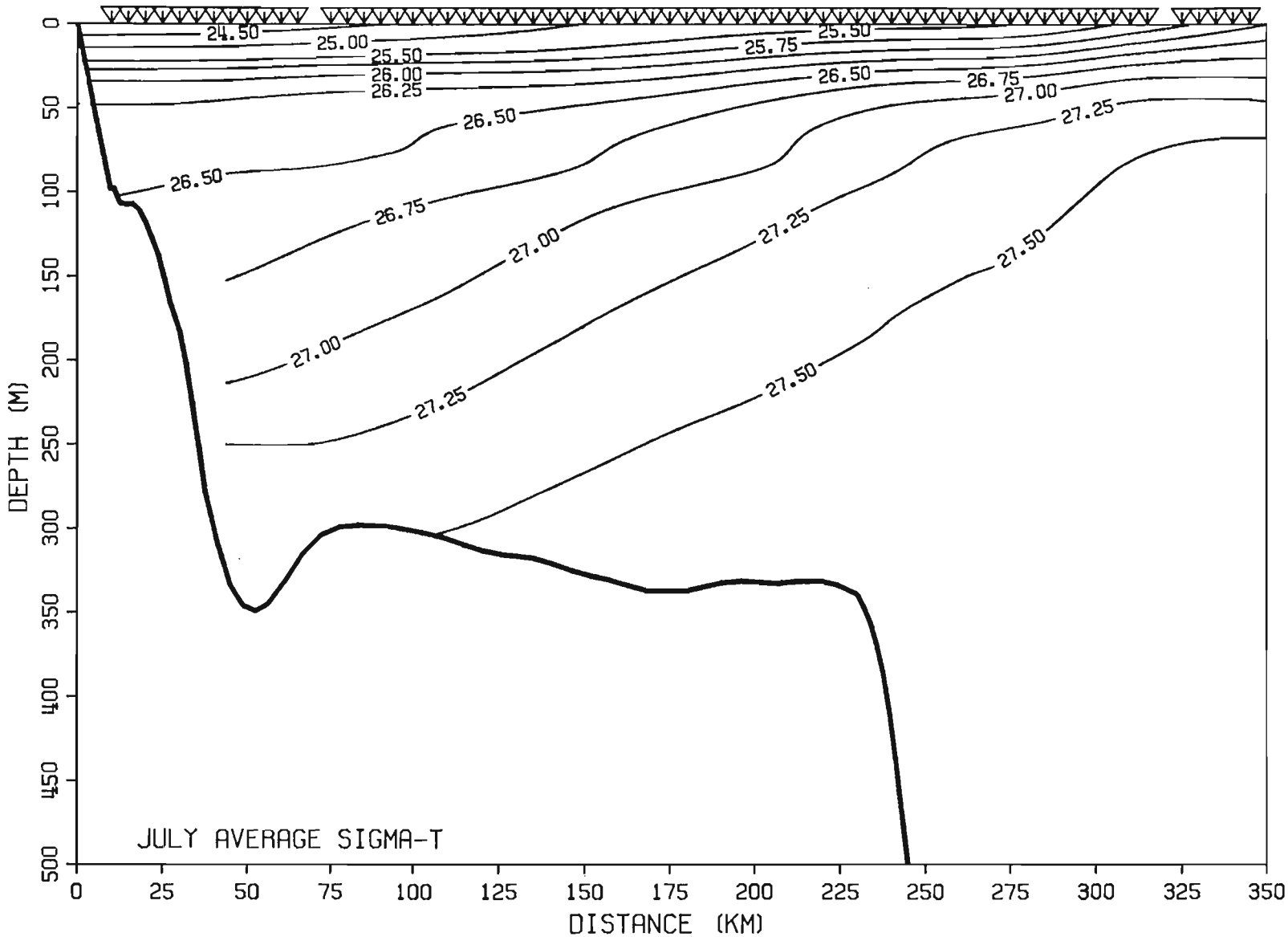

FEBRUARY AVERAGE SIGMA-T
DEPTH (M)
DISTANCE (KM)
27.50
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350

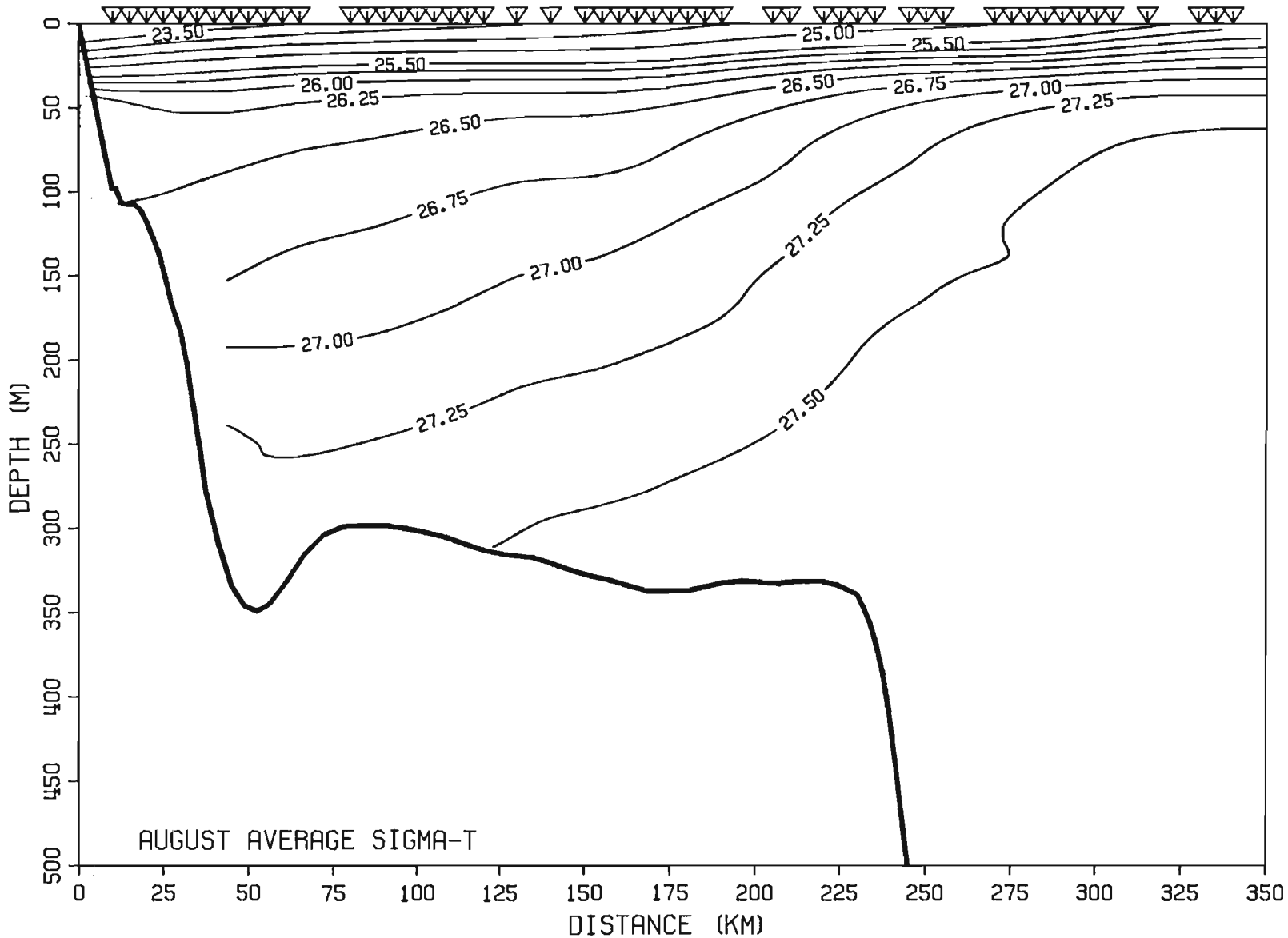

MARCH AVERAGE SIGMA-T
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
26.75
27.00
27.00
27.25
27.25
27.50
27.50
27.75


APRIL AVERAGE SIGMA-T
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
26.50
26.75
26.75
27.00
27.00
27.25
27.25
27.50
27.50


MAY AVERAGE SIGMA-T
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
25.75
26.00
26.25
26.50
26.50
26.75
26.75
27.00
27.00
27.25
27.25
27.25
27.50
27.50


JUNE AVERAGE SIGMA-T
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
25.50
25.75
26.00
26.25
26.50
26.75
27.00
27.25
27.50


JULY AVERAGE SIGMA-T
DEPTH (M)
DISTANCE (KM)
24.50
25.00
25.50
26.00
26.25
25.75
26.50
26.75
27.00
27.25
27.50
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350


AUGUST AVERAGE SIGMA-T
DEPTH (M)
DISTANCE (KM)
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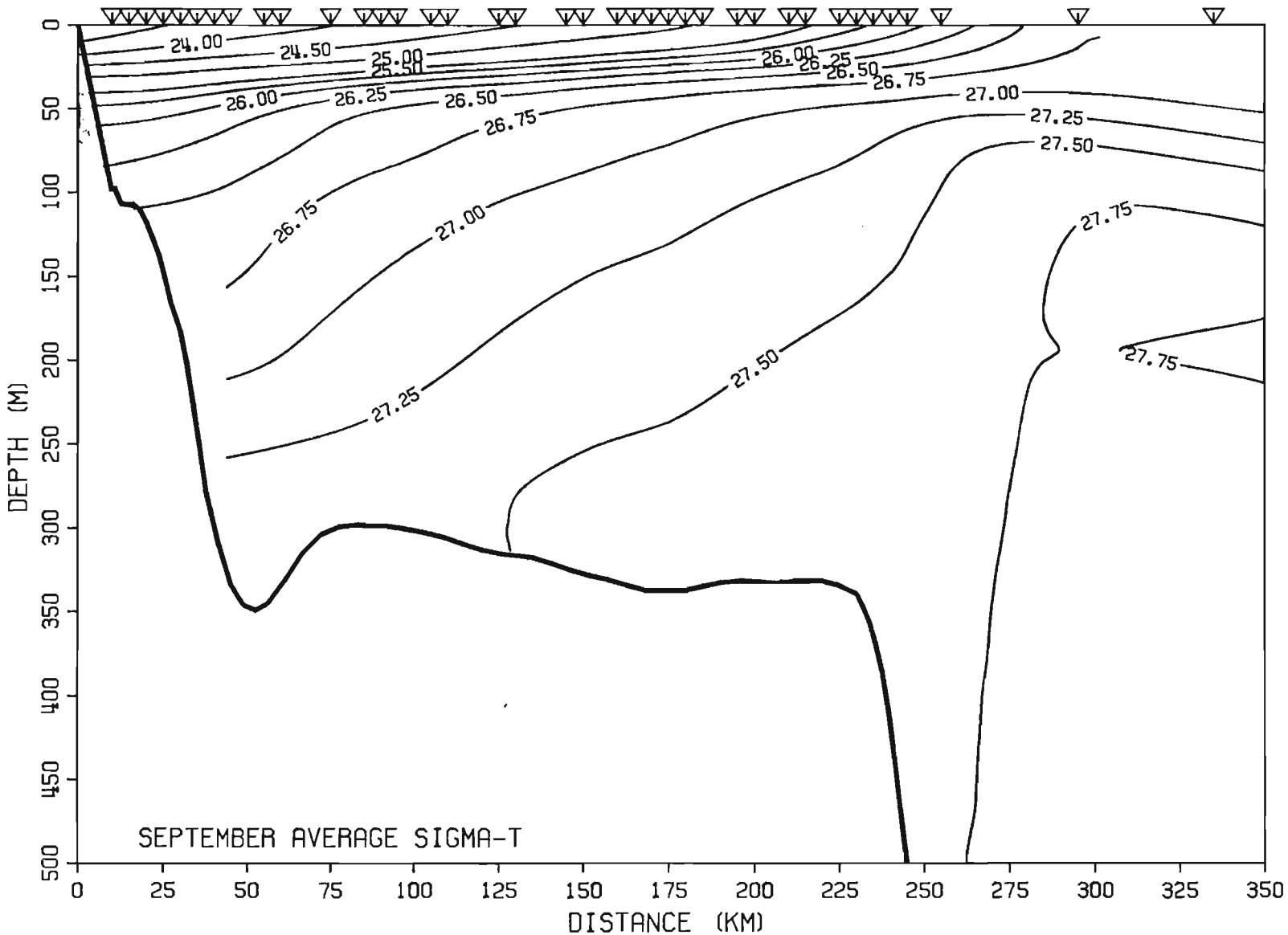
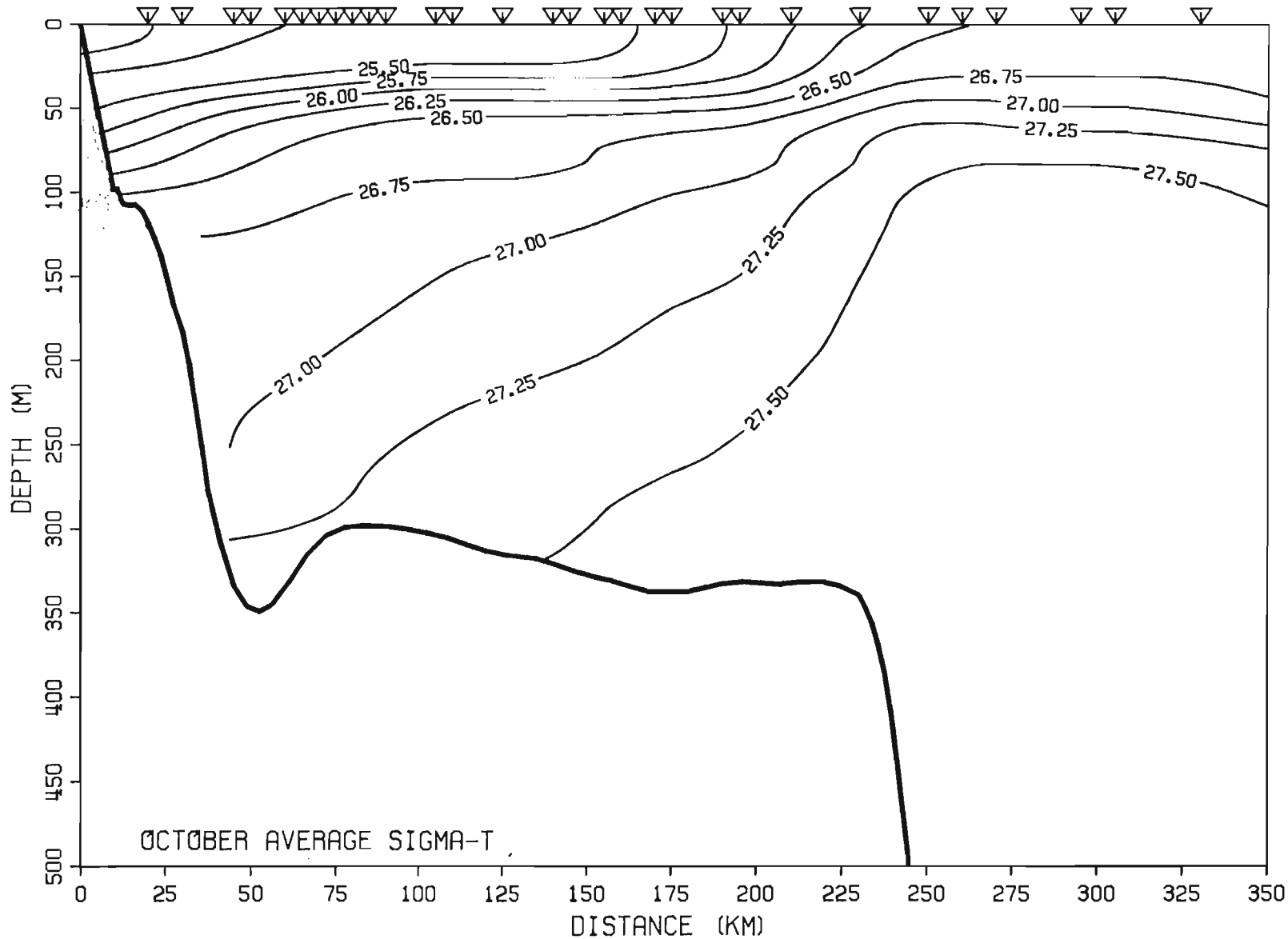
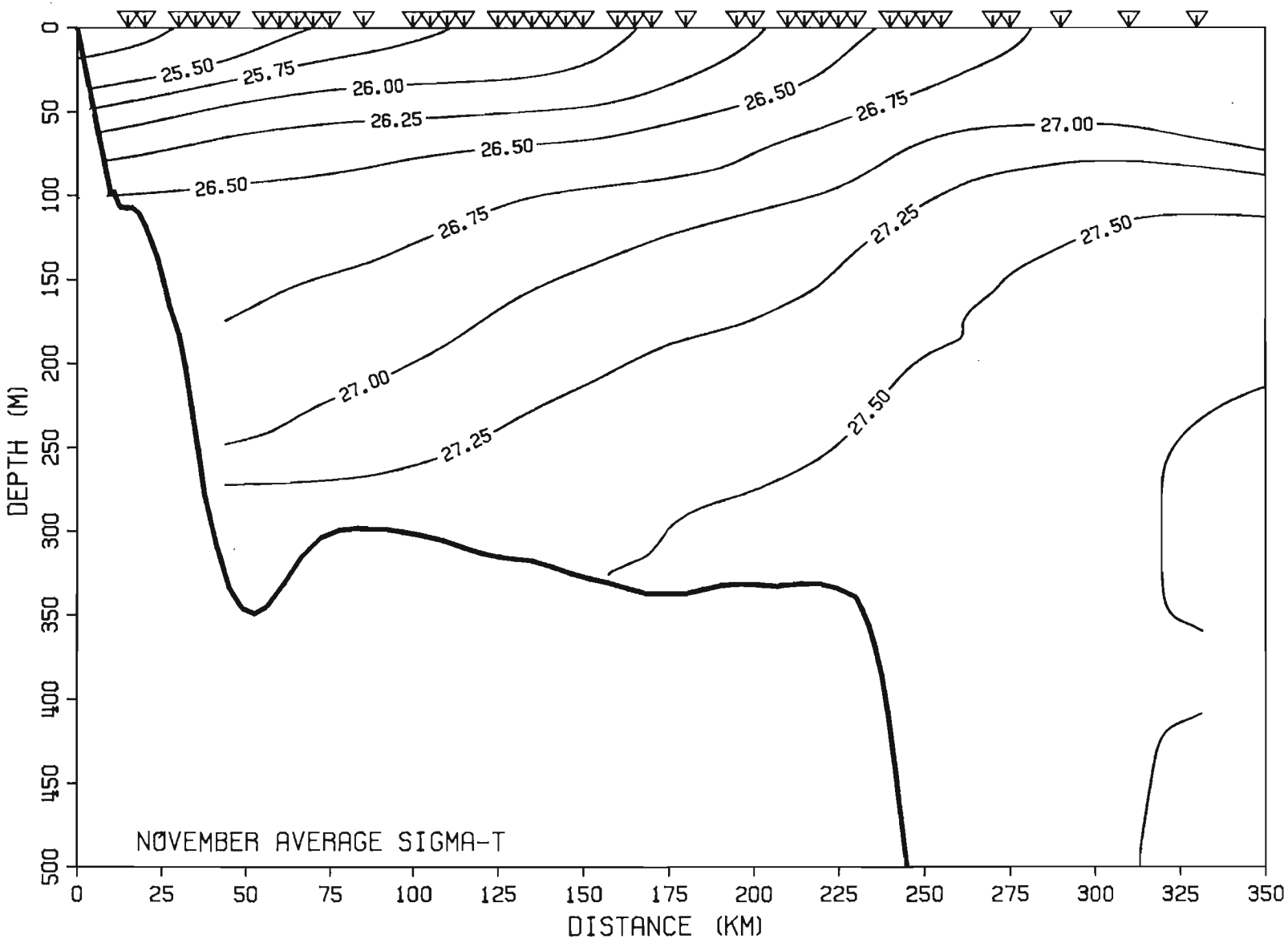
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
23.50
25.00
25.50
25.50
26.00
26.25
26.50
26.50
26.75
27.00
27.25
26.75
27.00
27.25
27.00
27.25
27.50


SEPTEMBER AVERAGE SIGMA-T
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
24.00
24.50
25.00
25.50
26.00
26.25
26.50
26.75
27.00
27.25
27.50
27.75


OCTOBER AVERAGE SIGMA-T
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
25.50
25.75
26.00
26.25
26.50
26.75
27.00
27.25
27.50


NOVEMBER AVERAGE SIGMA-T
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
25.50
25.75
26.00
26.25
26.50
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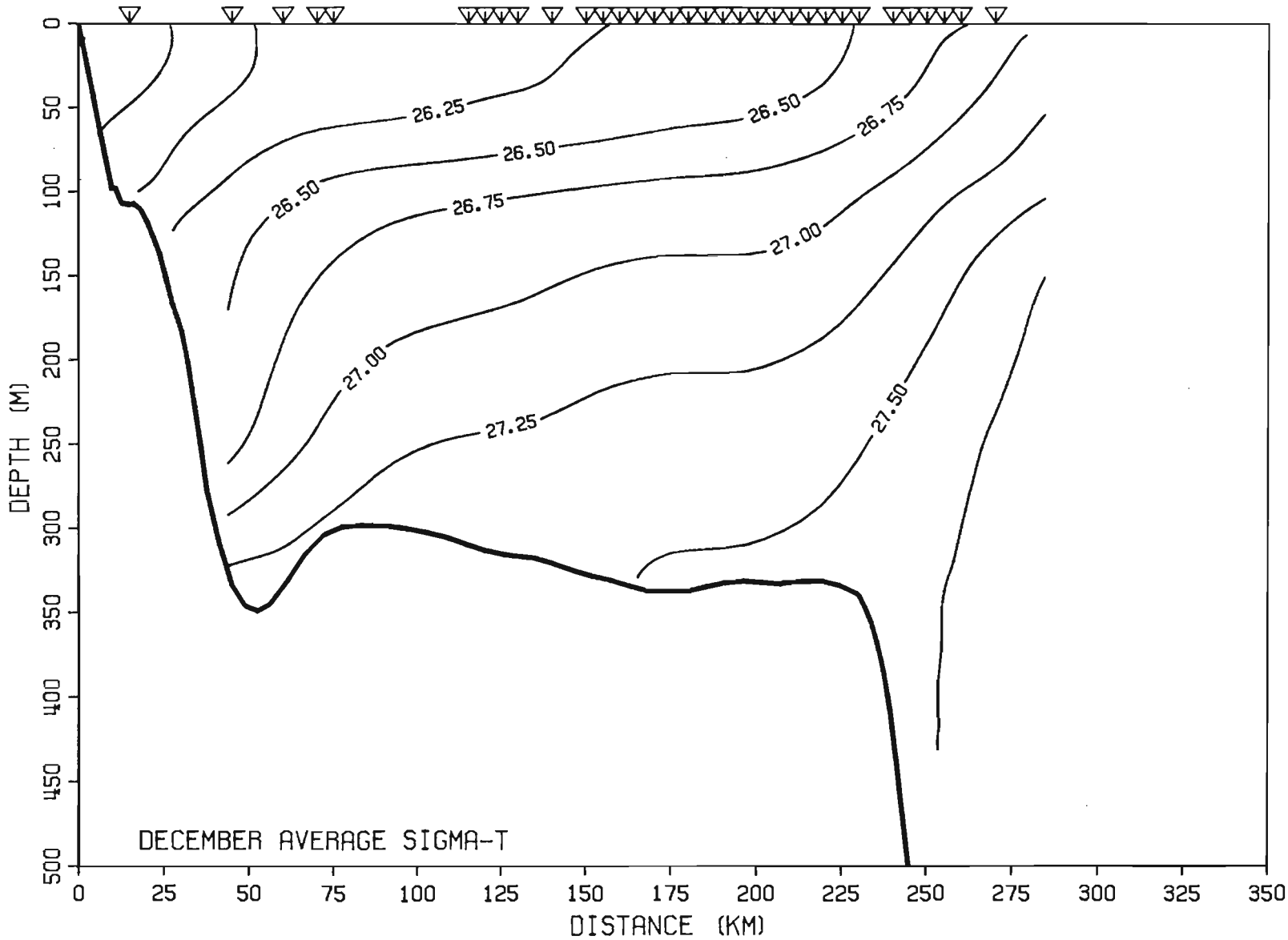
27.00
27.00
27.25
27.25
27.50
27.50


DECEMBER AVERAGE SIGMA-T
DEPTH (M)
DISTANCE (KM)
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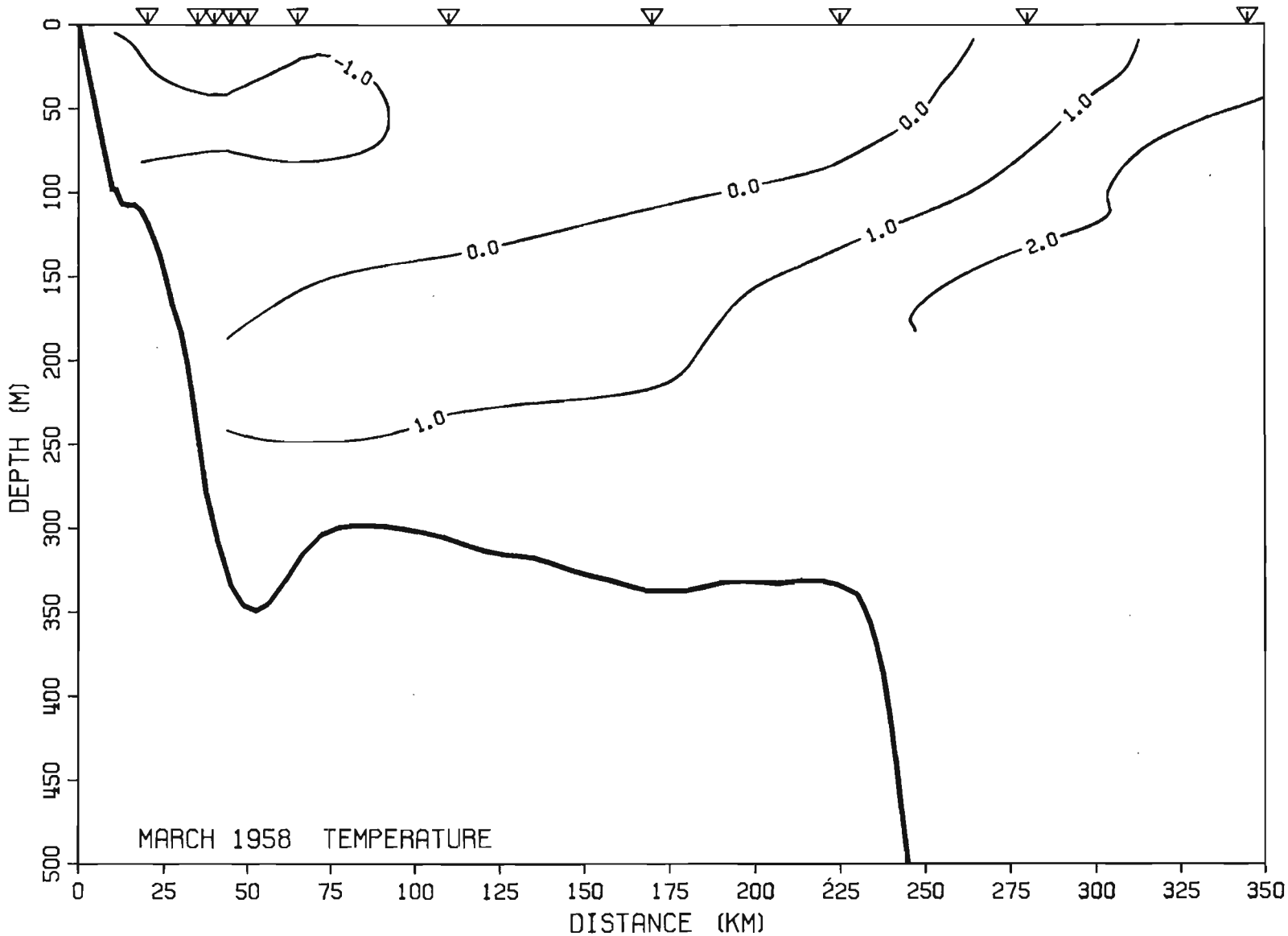
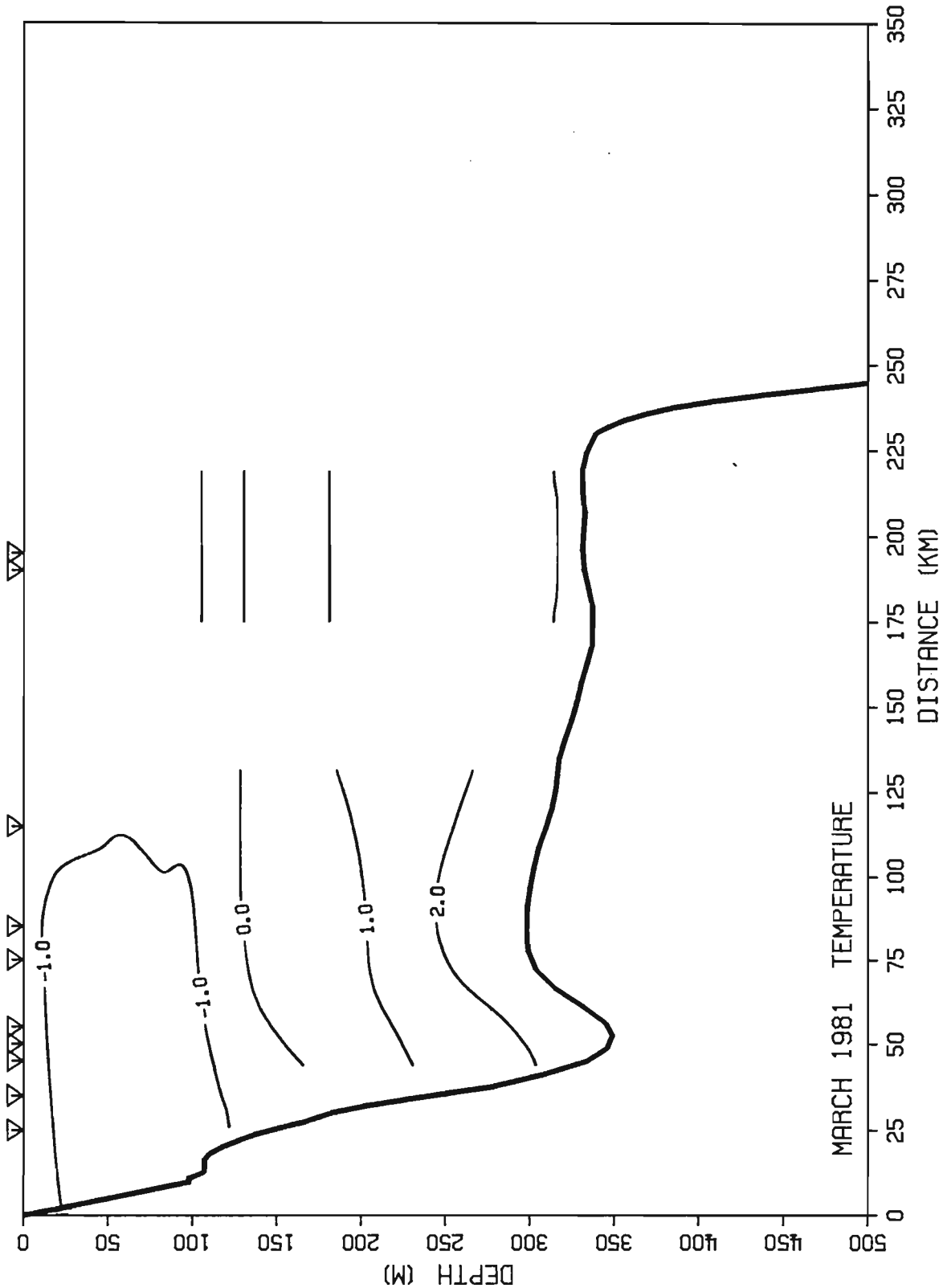
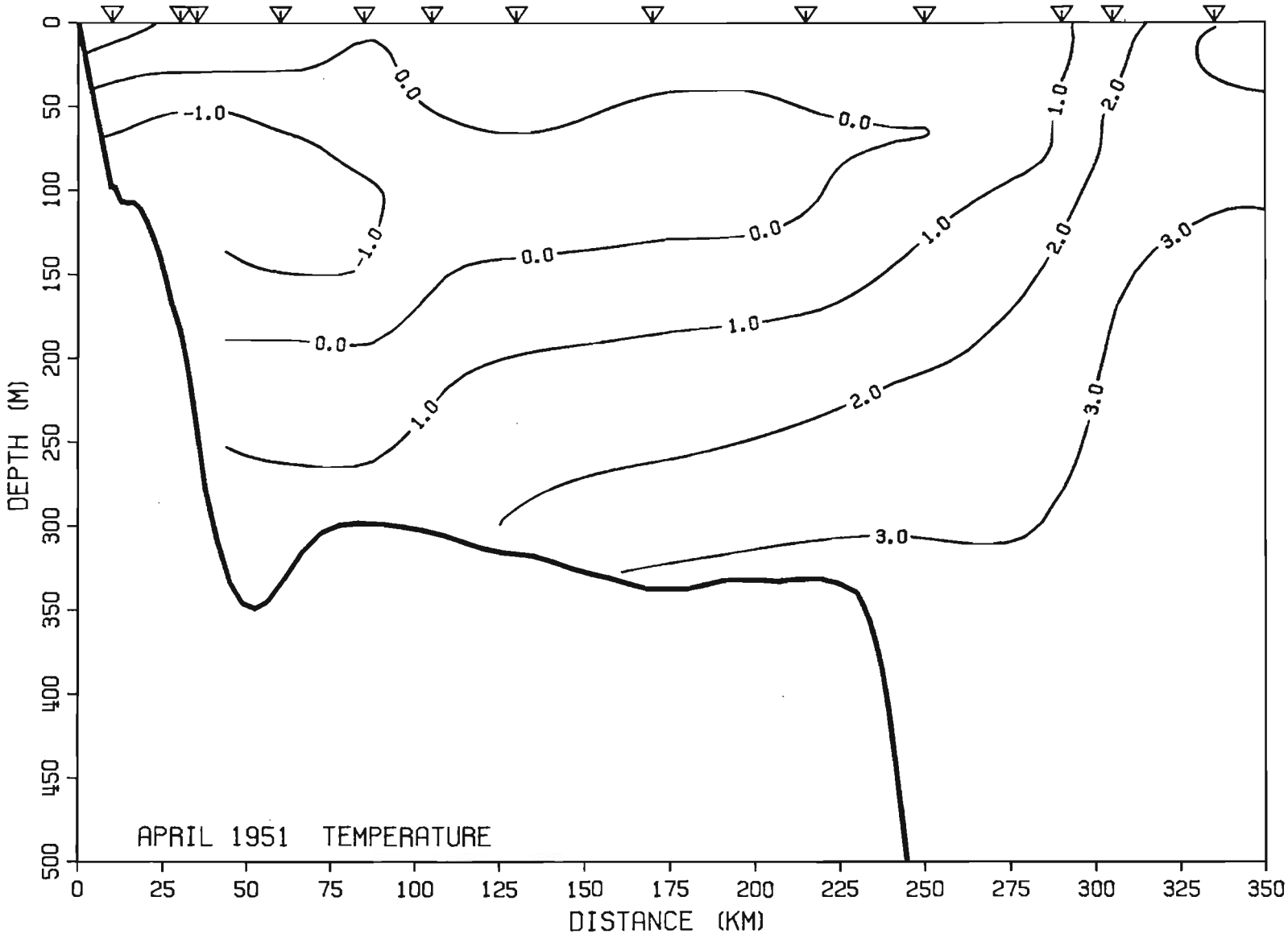
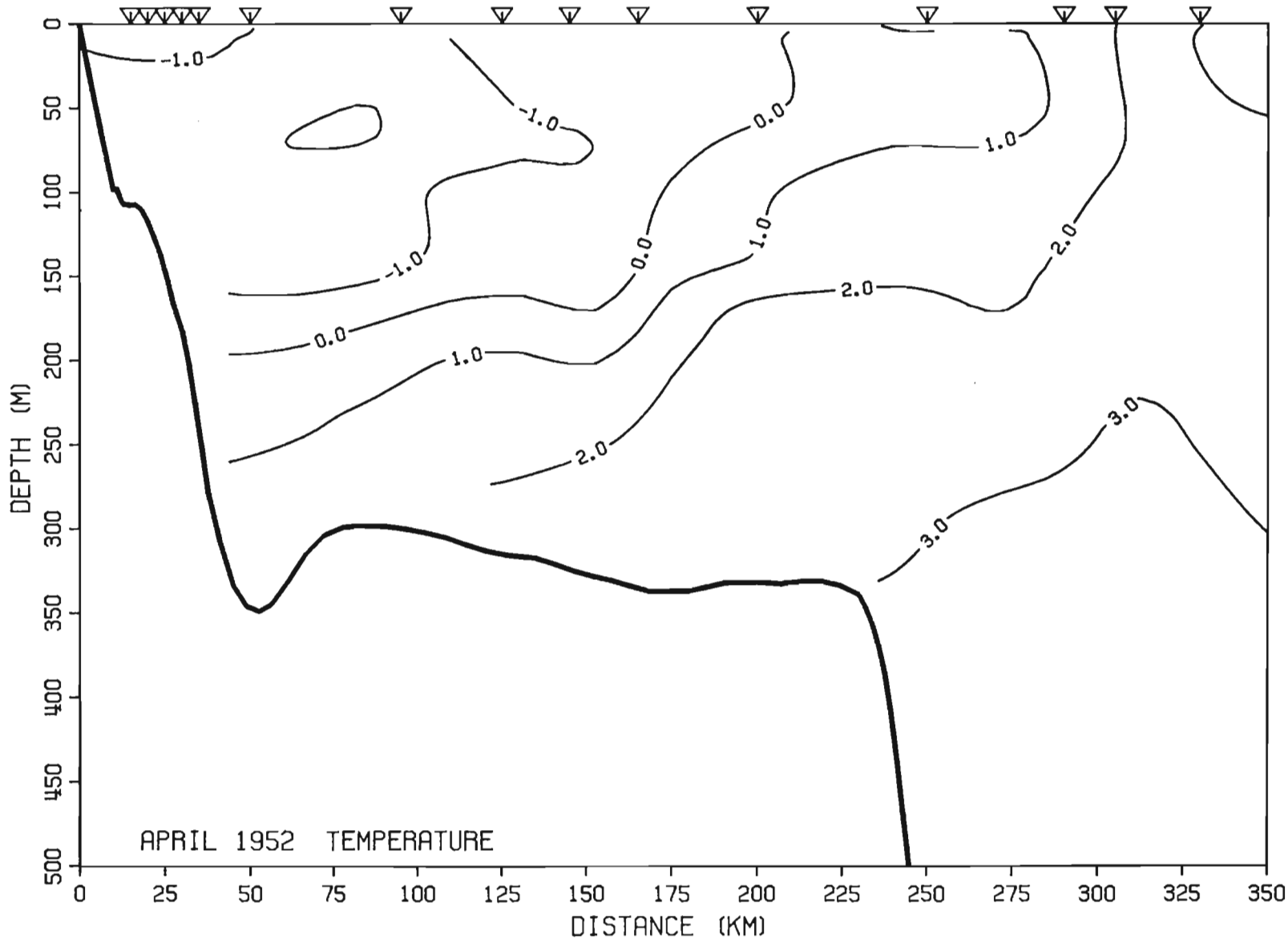
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
26.25
26.50
26.50
26.50
26.75
26.75
27.00
27.00
27.25
27.50

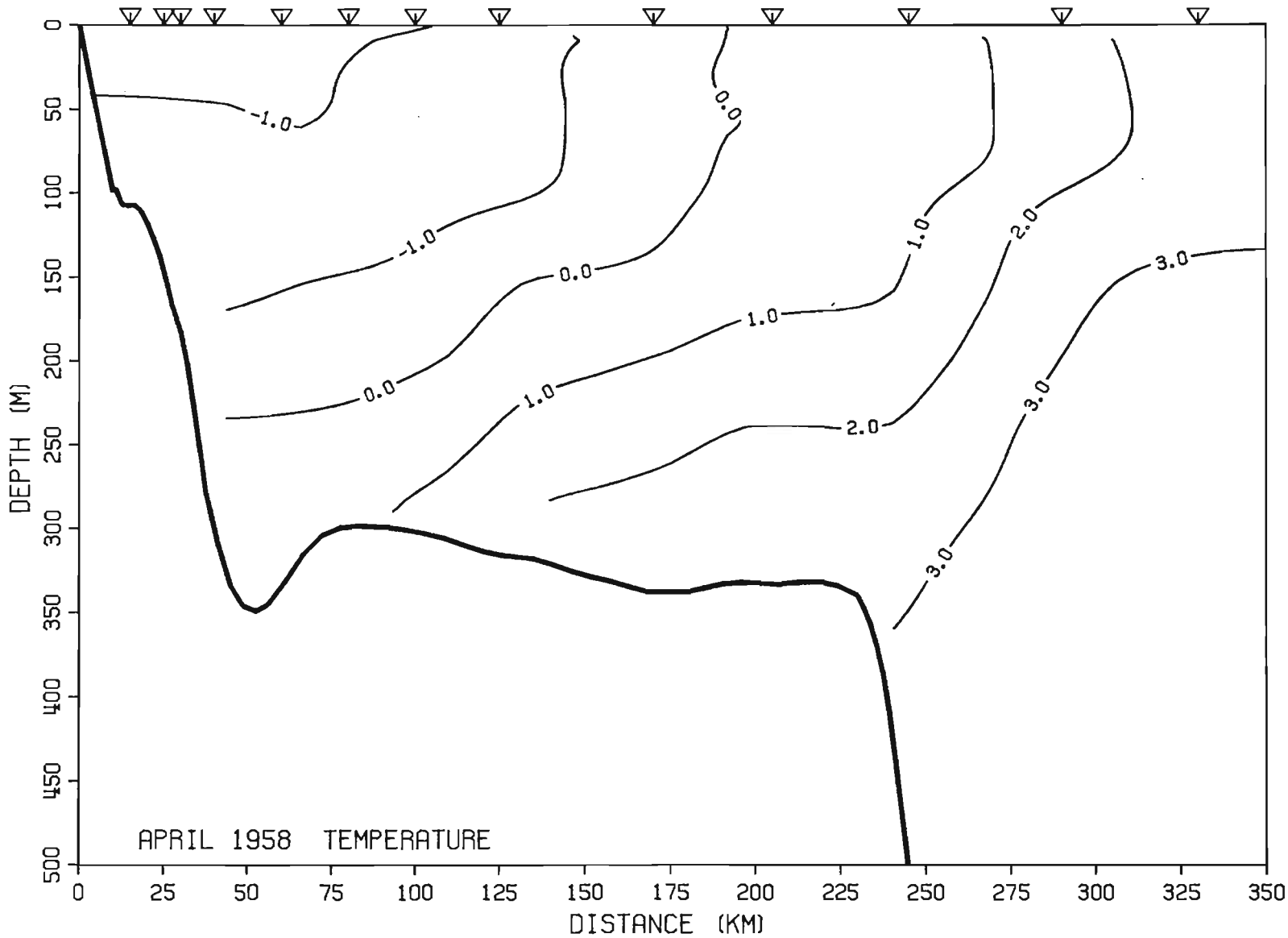
APPENDIX E. Cape Bonavista Temperature.

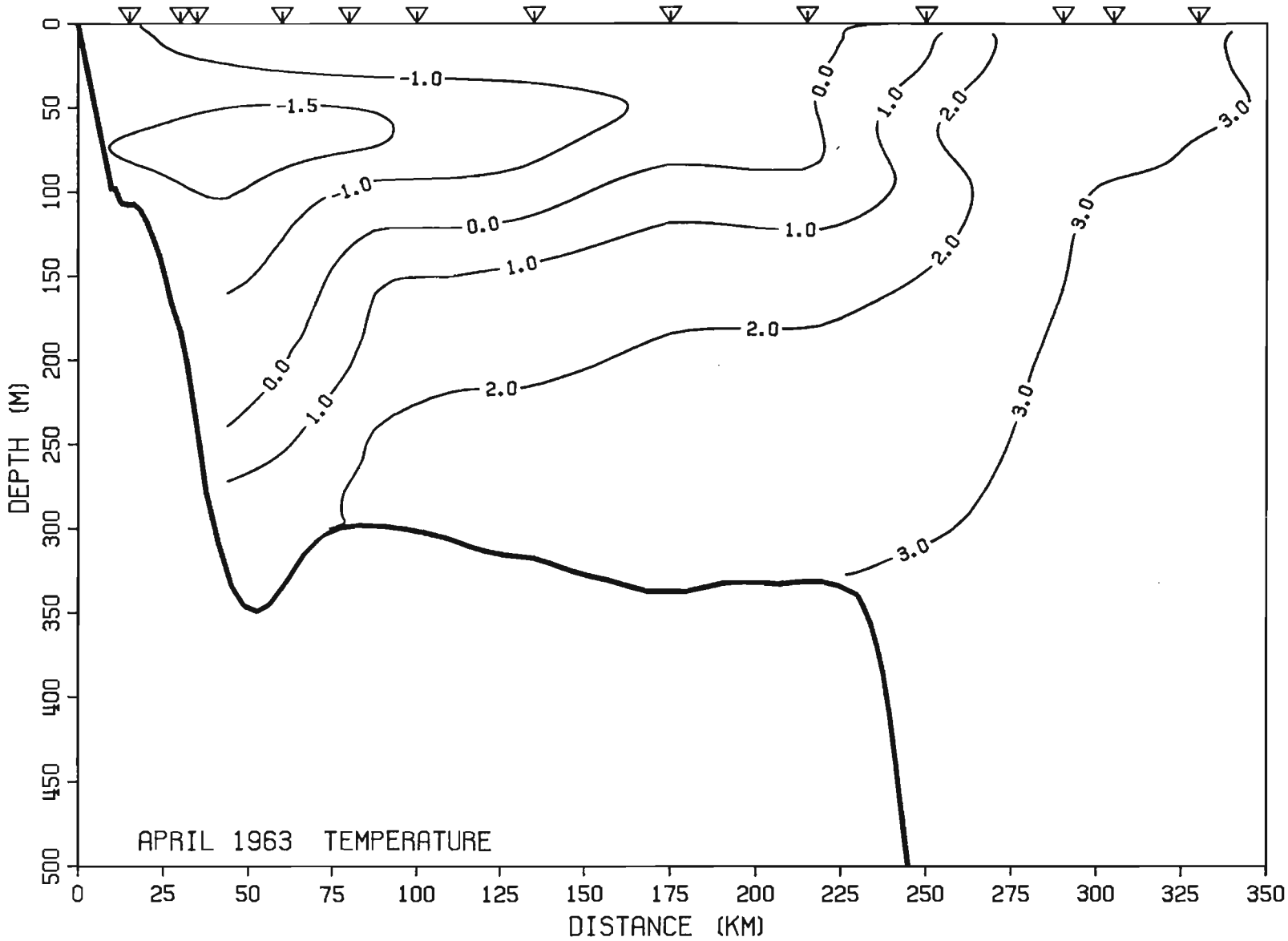

MARCH 1958 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
-1.0
0.0
0.0
0.0
1.0
1.0
1.0
2.0

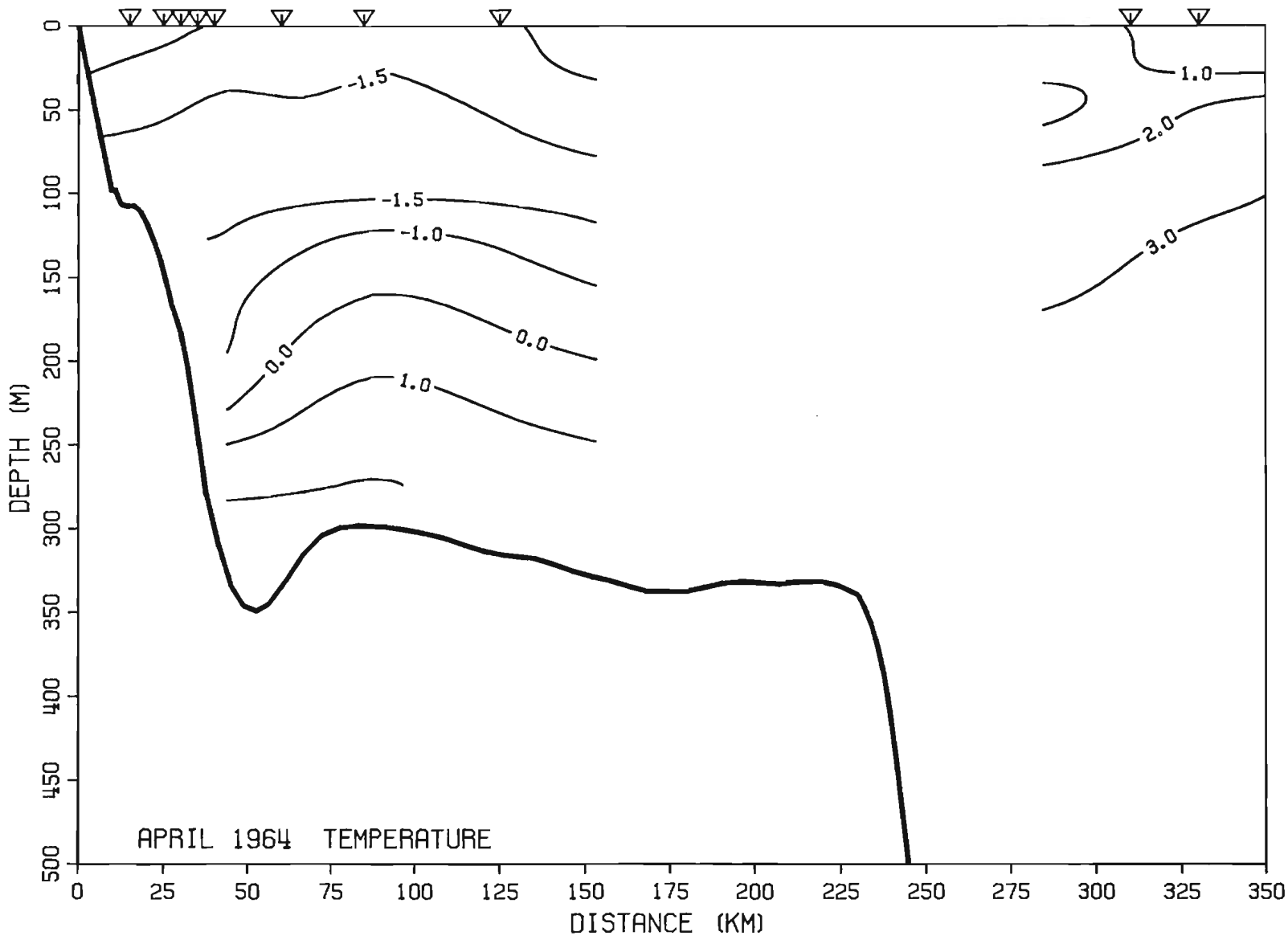

MARCH 1981 TEMPERATURE
-1.0
-1.0
0.0
1.0
2.0
DISTANCE (KM)
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
DEPTH (M)
0
50
100
150
200
250
300
350
400
450
500

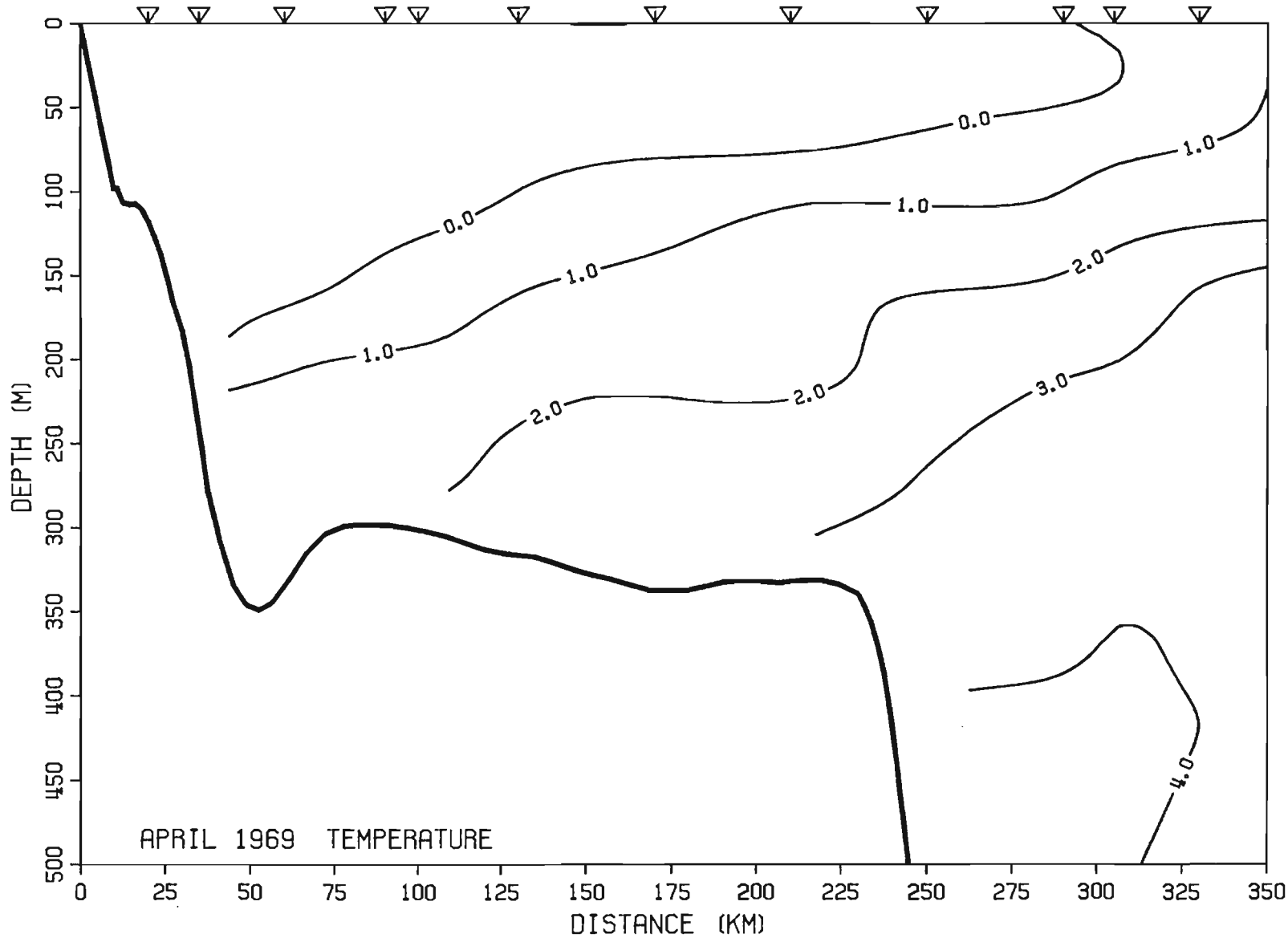

APRIL 1951 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
-1.0
0.0
1.0
2.0
3.0


APRIL 1952 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
-1.0
-1.0
-1.0
0.0
0.0
0.0
1.0
1.0
1.0
2.0
2.0
2.0
3.0
3.0


APRIL 1958 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
-1.0
-1.0
0.0
0.0
0.0
1.0
1.0
1.0
2.0
2.0
3.0
3.0
3.0


APRIL 1963 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
-1.0
-1.5
-1.0
0.0
1.0
0.0
1.0
2.0
1.0
2.0
2.0
3.0
3.0
3.0
3.0


APRIL 1964 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
-1.5
-1.5
-1.0
0.0
0.0
1.0
1.0
2.0
3.0


APRIL 1969 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
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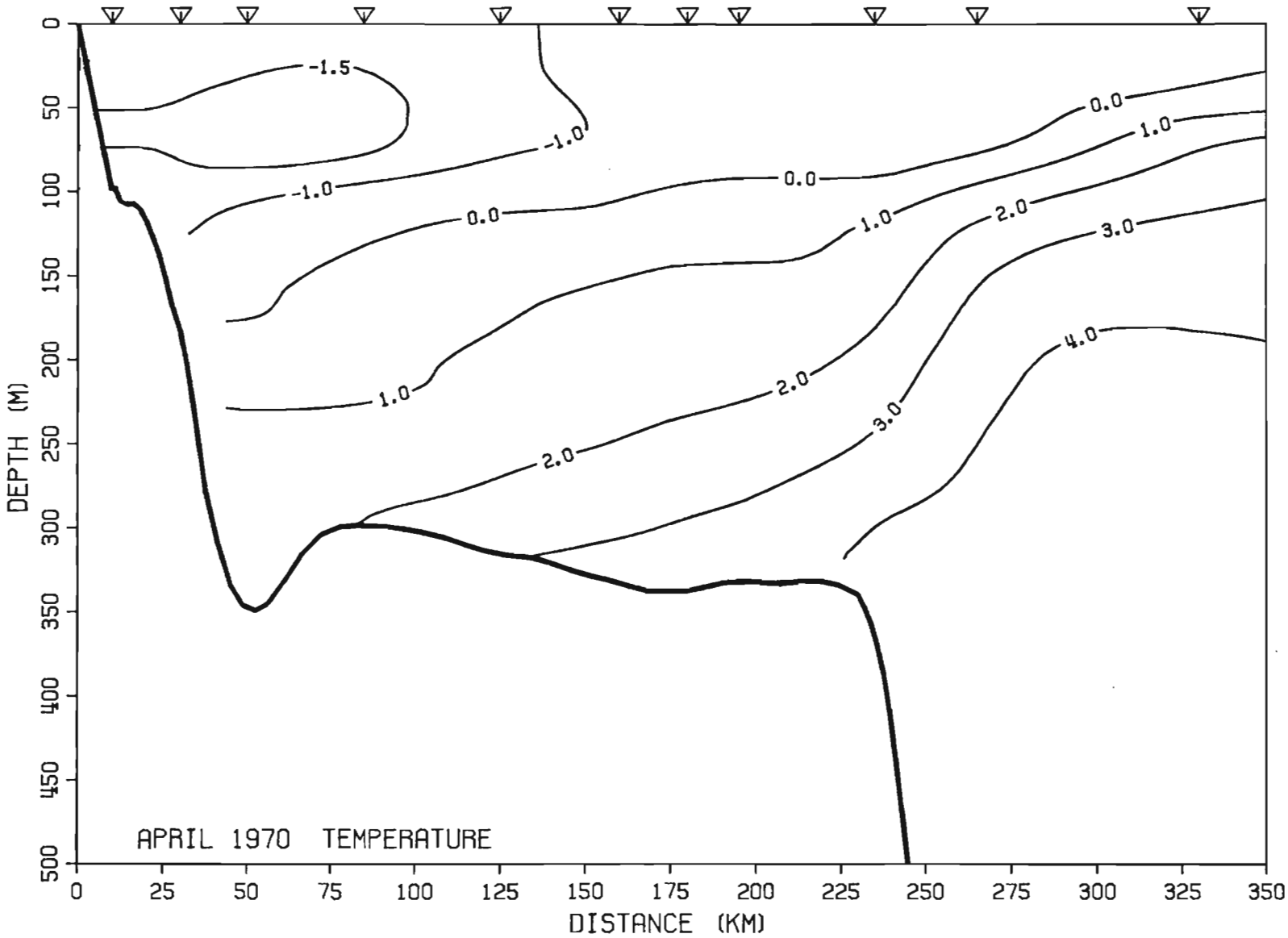
0.0
1.0
2.0
3.0
4.0


APRIL 1970 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
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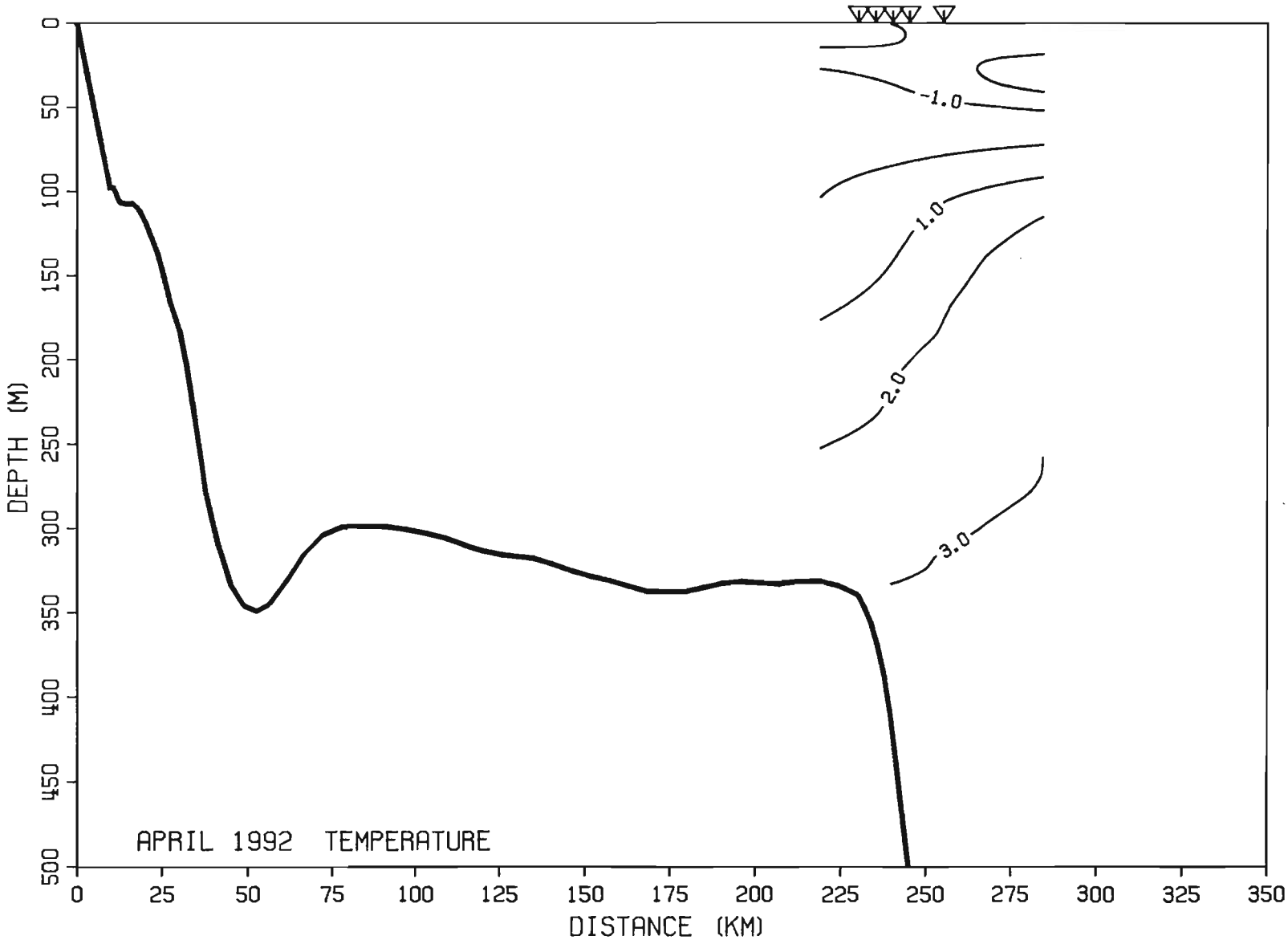
-1.0
0.0
0.0
1.0
1.0
2.0
2.0
3.0
3.0
4.0


APRIL 1992 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
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350
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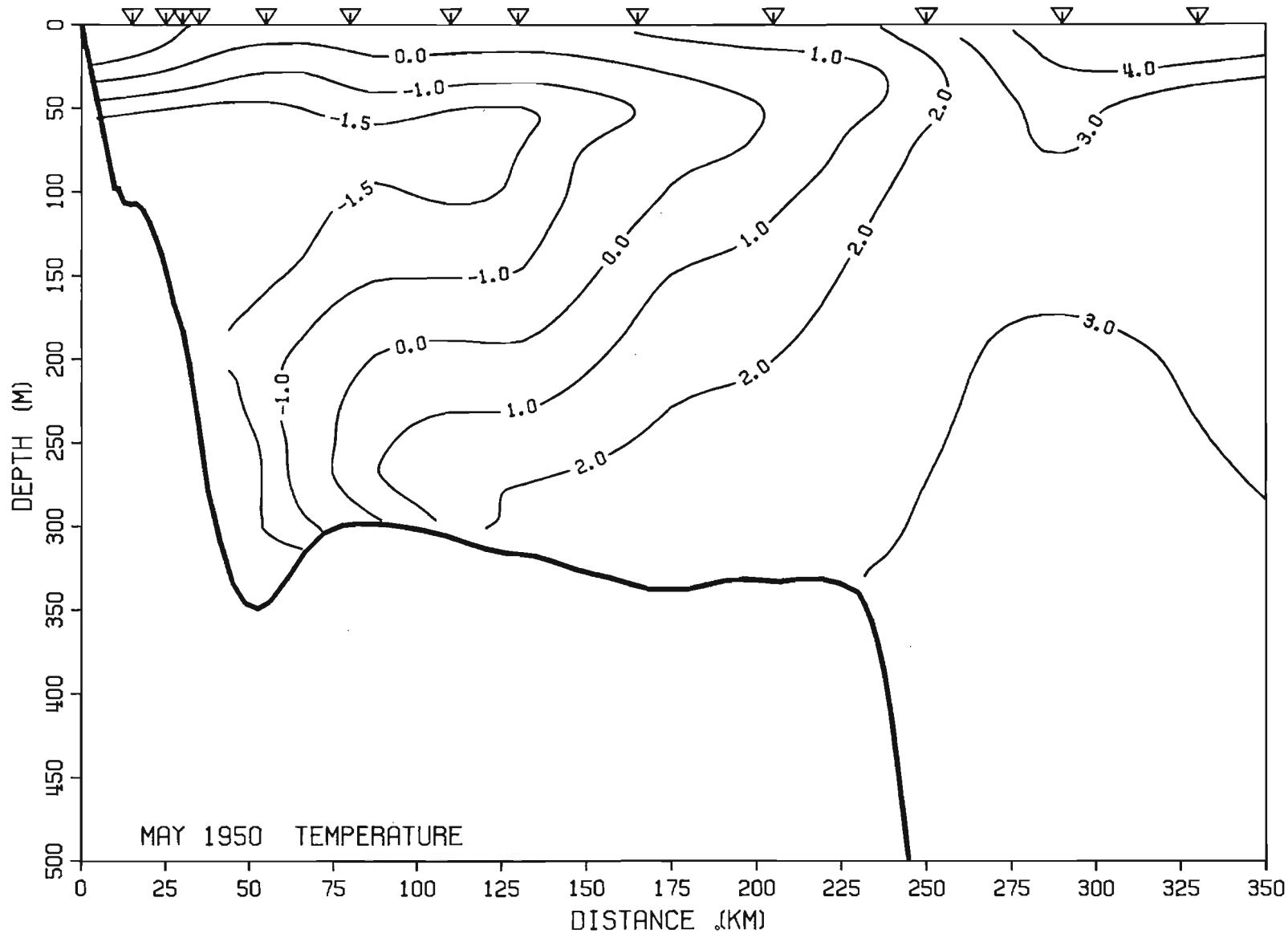
3.0


MAY 1950 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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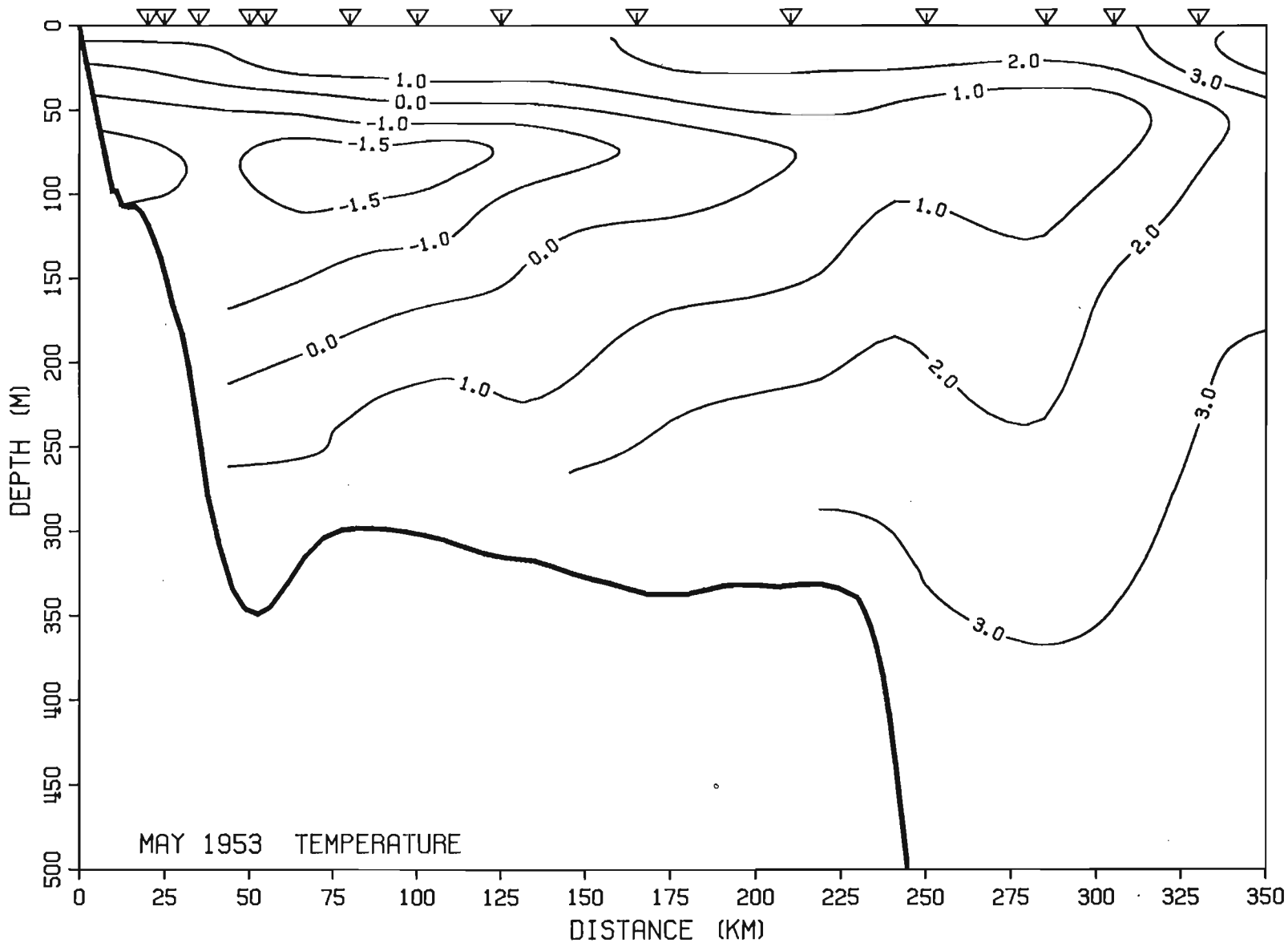
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
0.0
-1.0
-1.5
1.0
2.0
3.0
4.0


MAY 1953 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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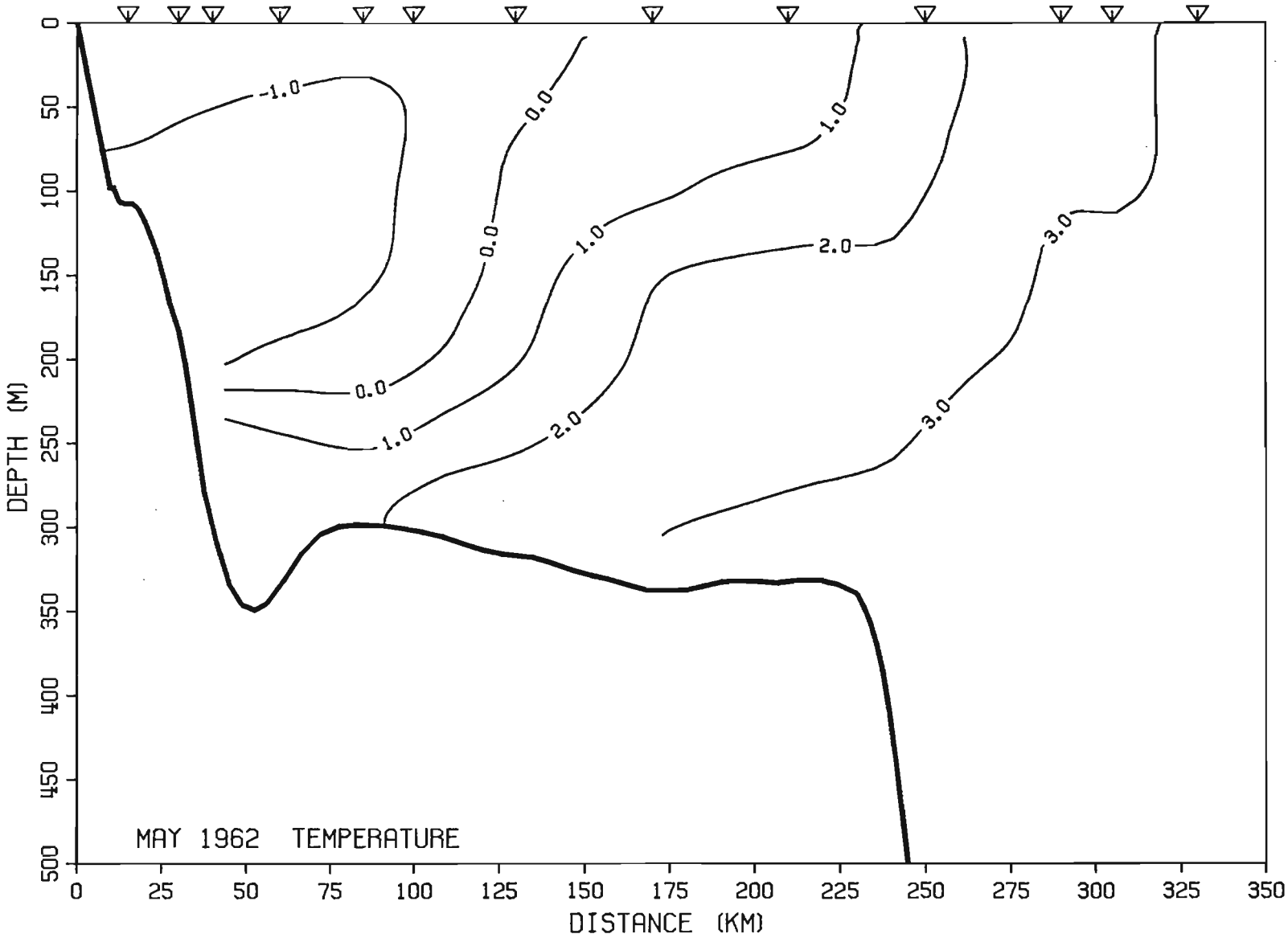
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
1.0
0.0
-1.0
-1.5
-1.5
-1.0
0.0
0.0
1.0
2.0
1.0
1.0
2.0
2.0
3.0
3.0
3.0


MAY 1962 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
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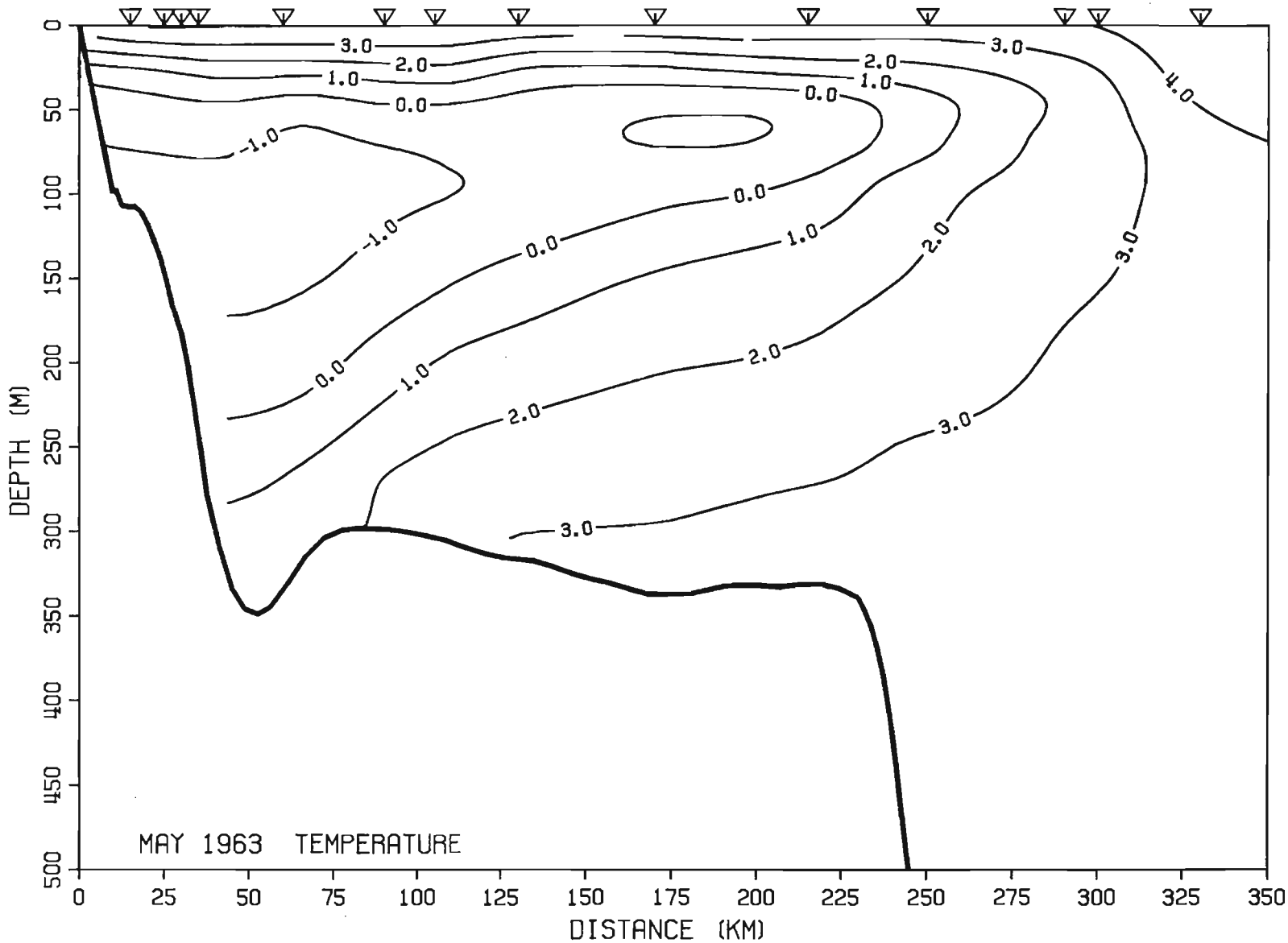
0.0
1.0
2.0
3.0


MAY 1963 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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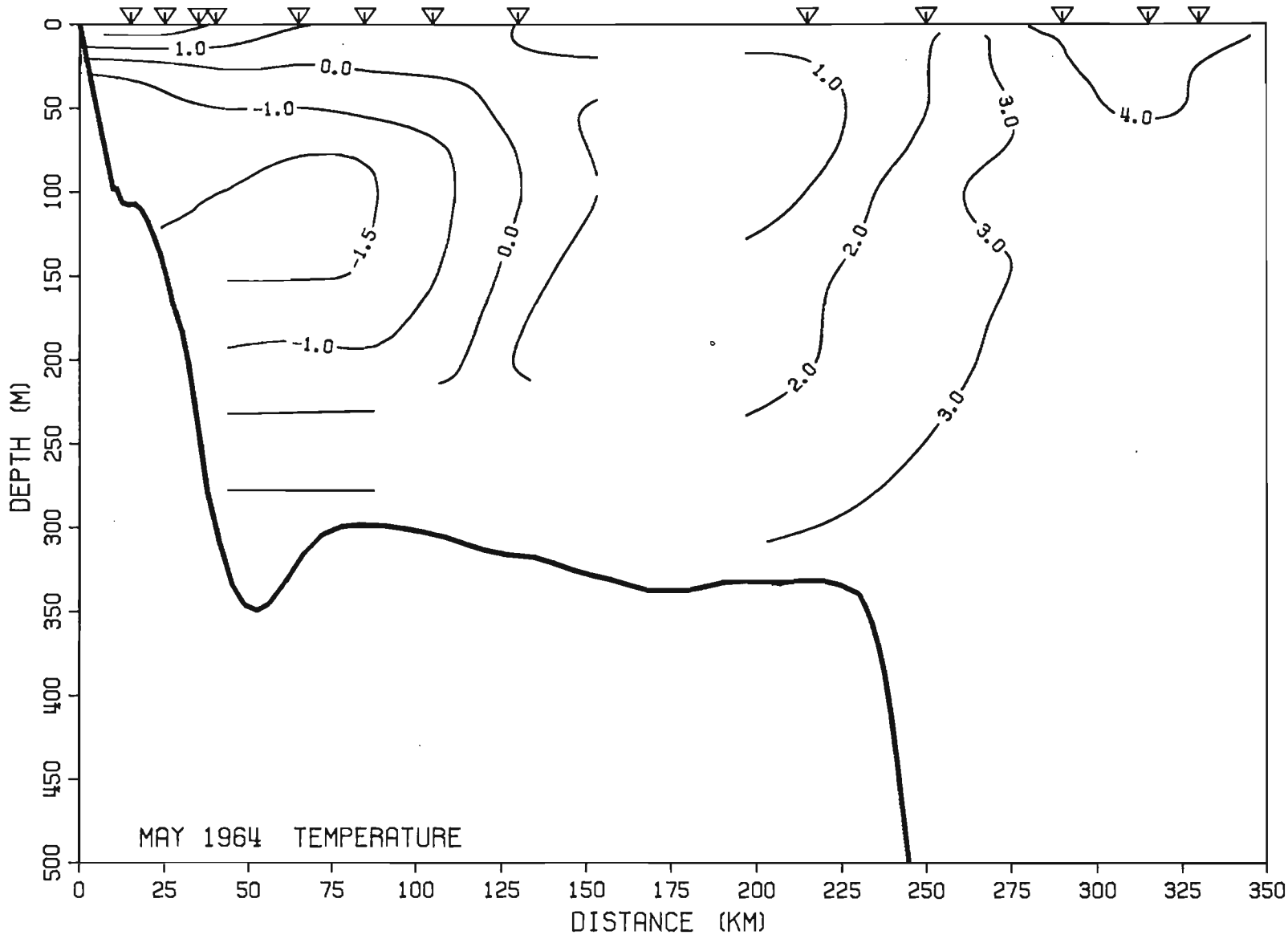
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
3.0
2.0
1.0
0.0
-1.0
4.0


MAY 1964 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
1.0
0.0
-1.0
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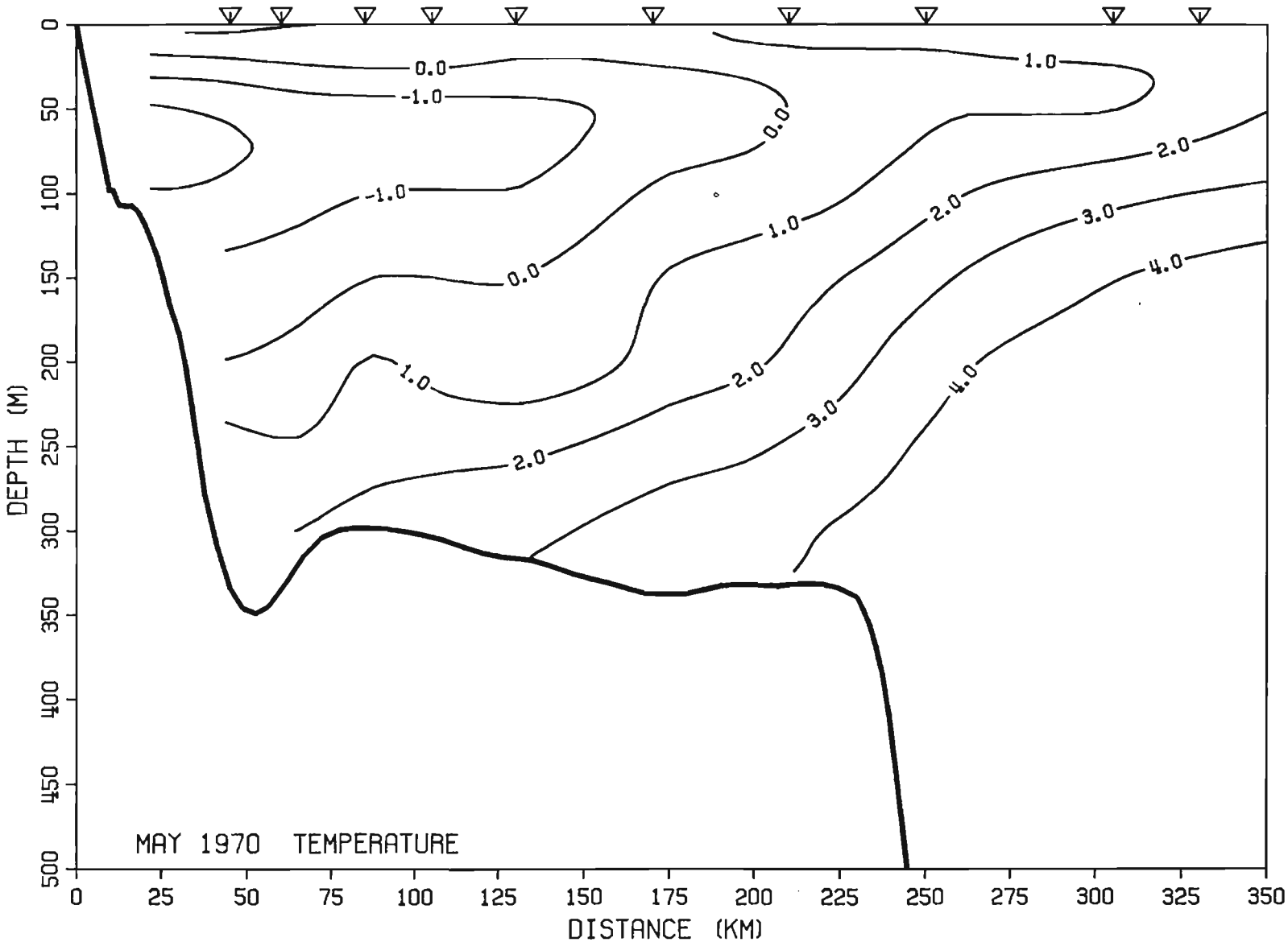
-1.0
0.0
1.0
2.0
2.0
3.0
3.0
3.0
4.0


MAY 1970 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
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-1.0
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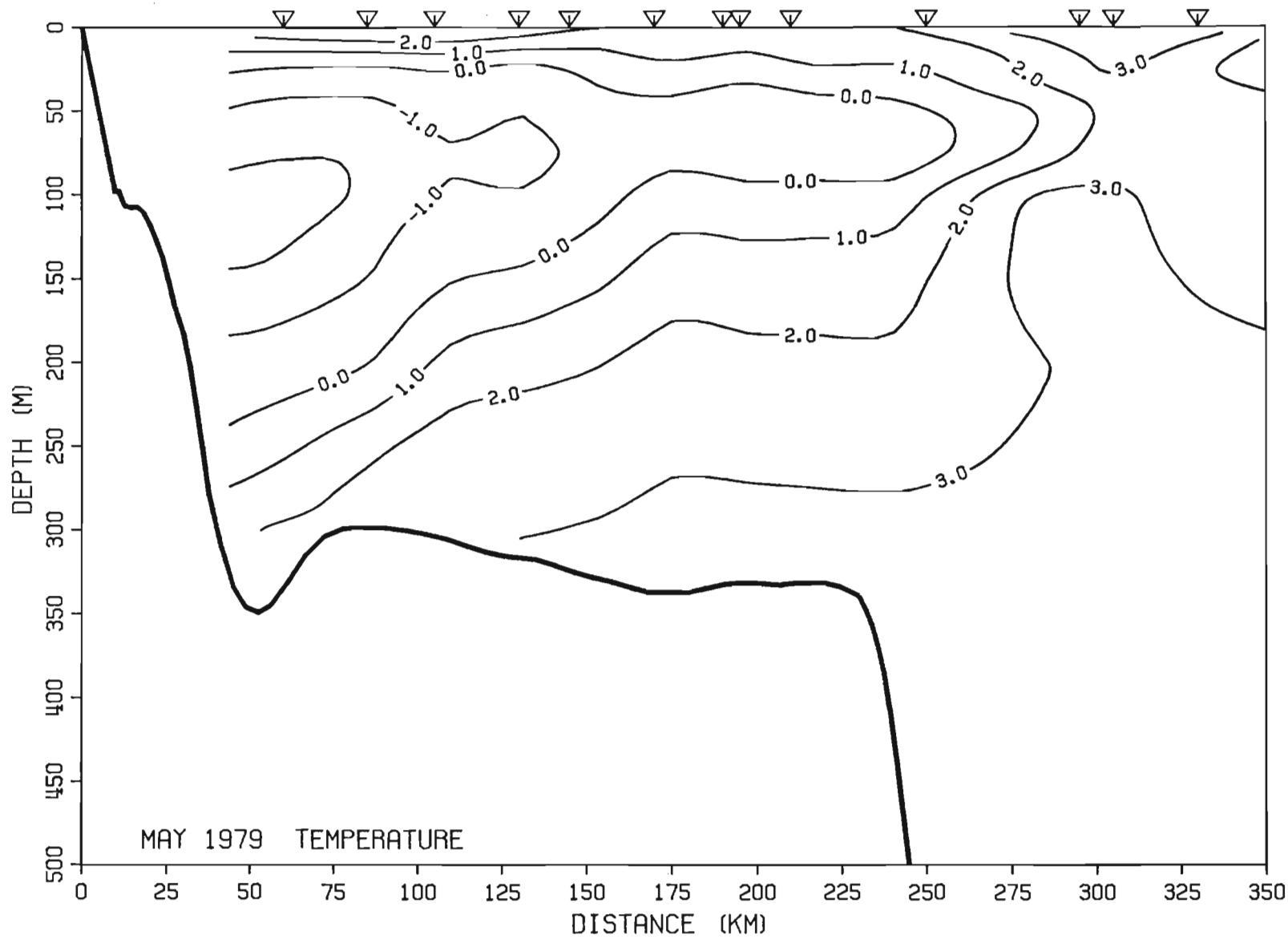
3.0
4.0


MAY 1979 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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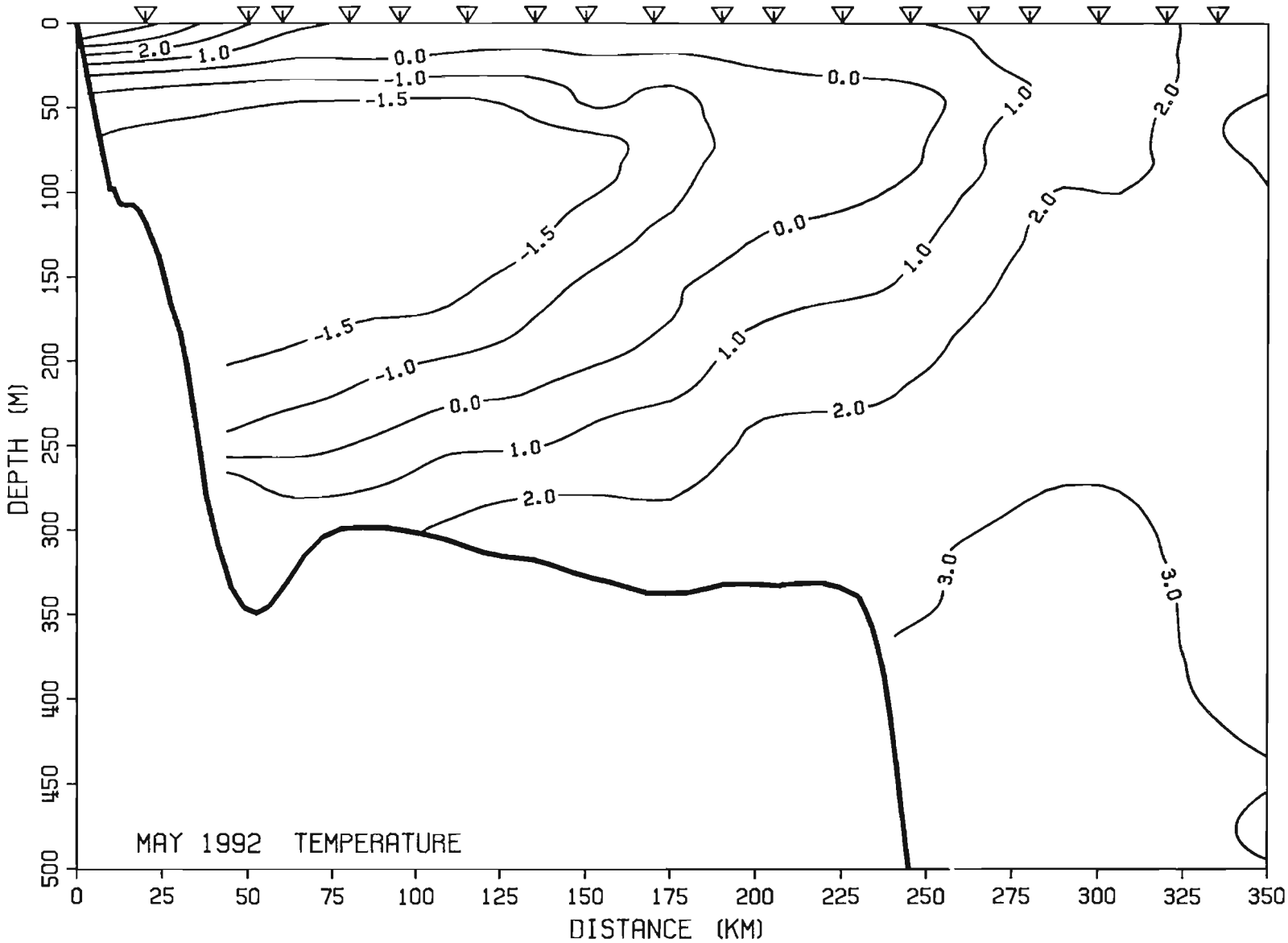
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
2.0
1.0
0.0
-1.0
3.0


MAY 1992 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
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175
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225
250
275
300
325
350
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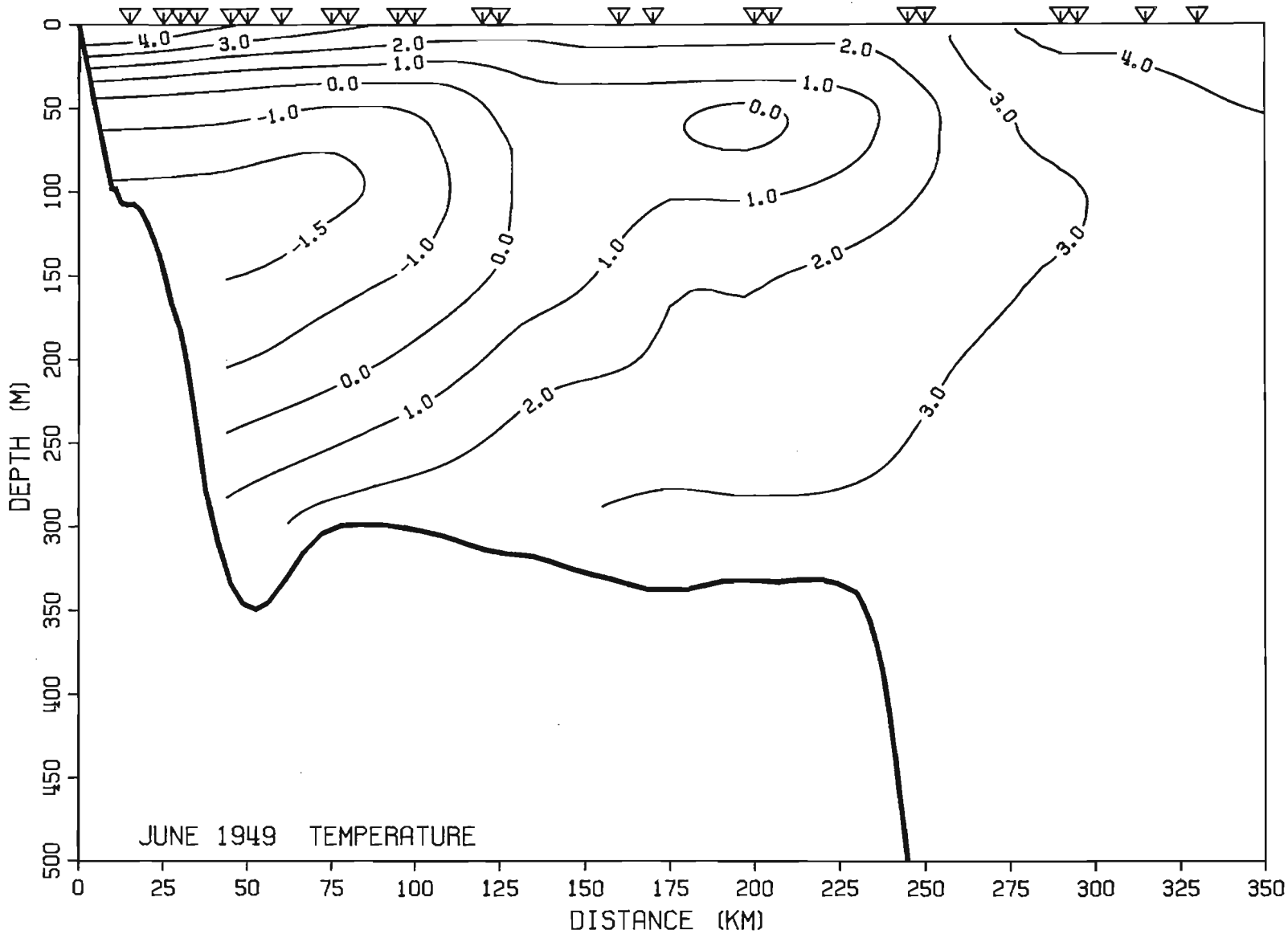
0.0
-1.0
-1.5
3.0


JUNE 1949 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
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100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
4.0
3.0
2.0
1.0
0.0
-1.0
-1.5
-1.0
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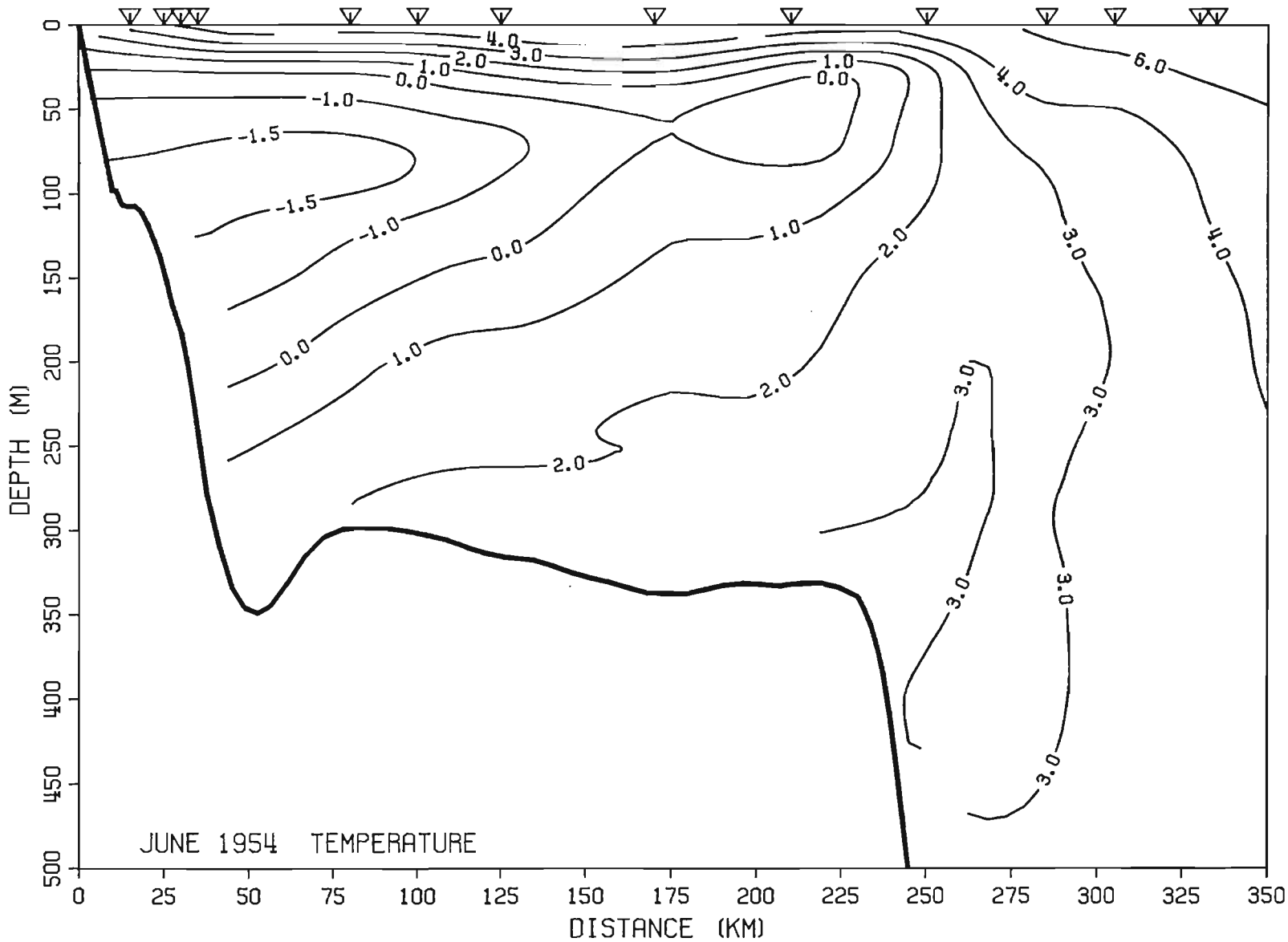
0.0
1.0
2.0
3.0
4.0
1.0
2.0
3.0
3.0


JUNE 1954 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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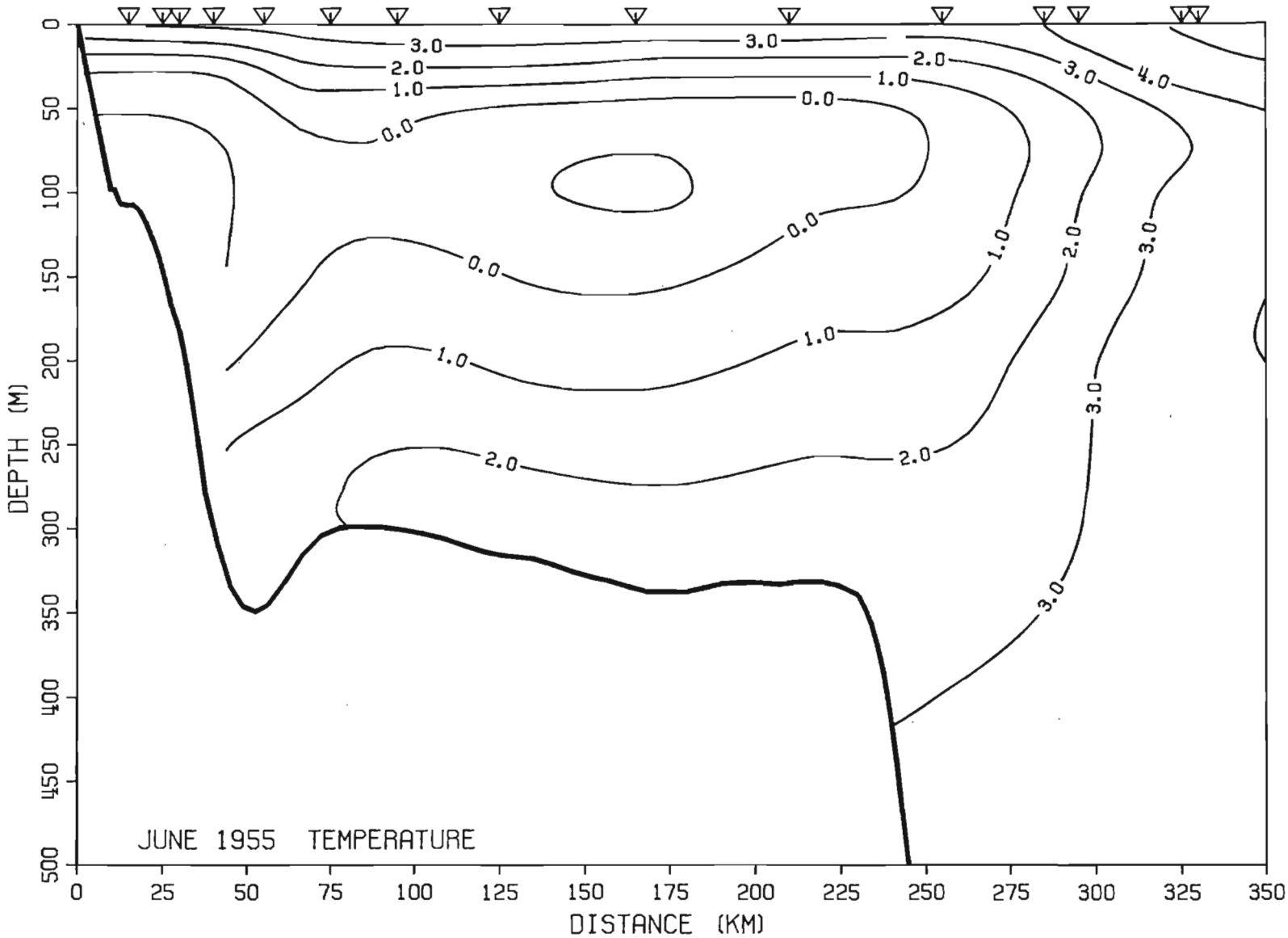
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
4.0
3.0
2.0
1.0
0.0
-1.0
-1.5
-1.5
-1.0
0.0
0.0
1.0
2.0
2.0
1.0
0.0
4.0
6.0
4.0
3.0
3.0
3.0
3.0
3.0
2.0


JUNE 1955 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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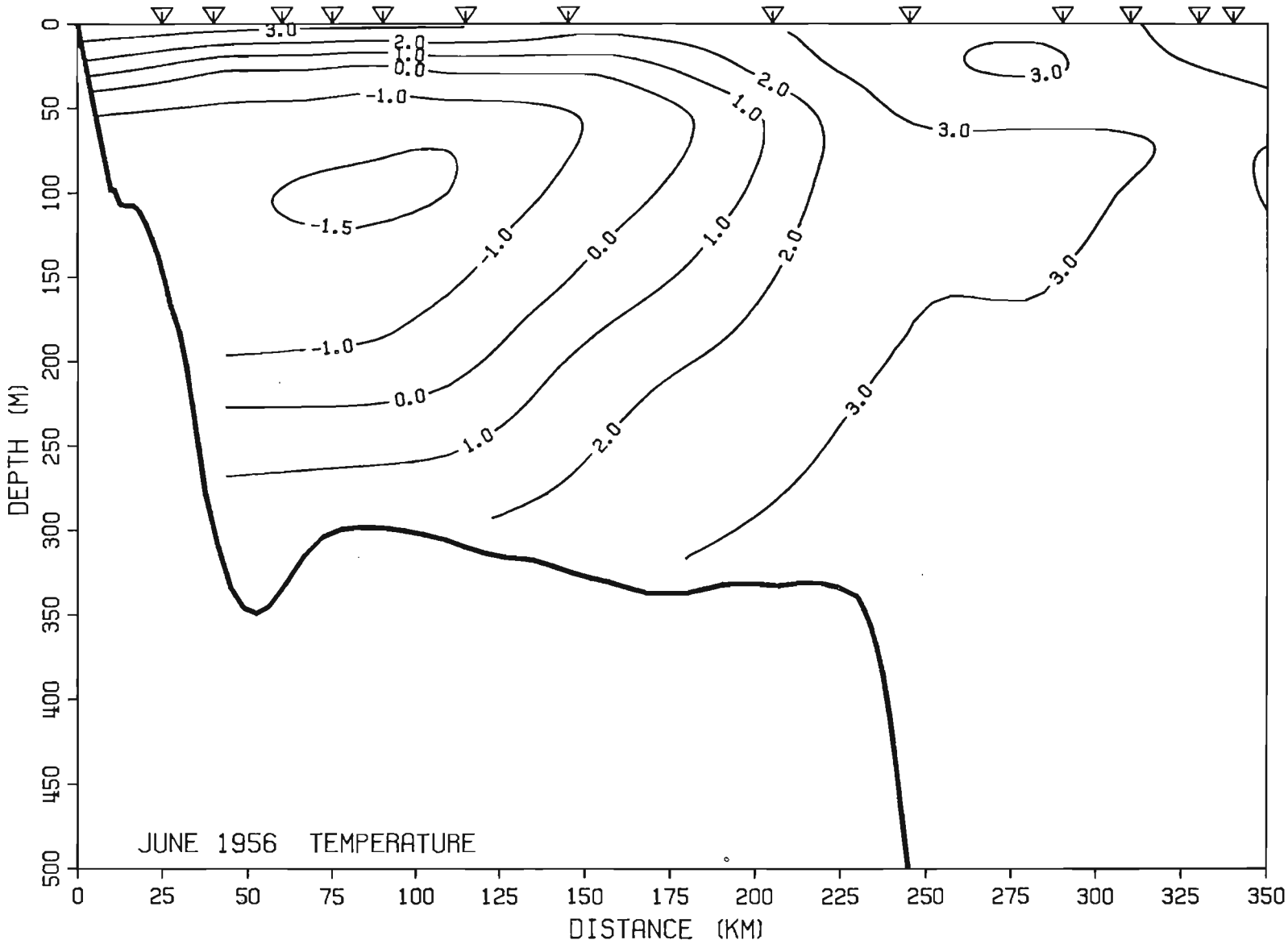
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
3.0
2.0
1.0
0.0
4.0


JUNE 1956 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
3.0
2.0
1.0
0.0
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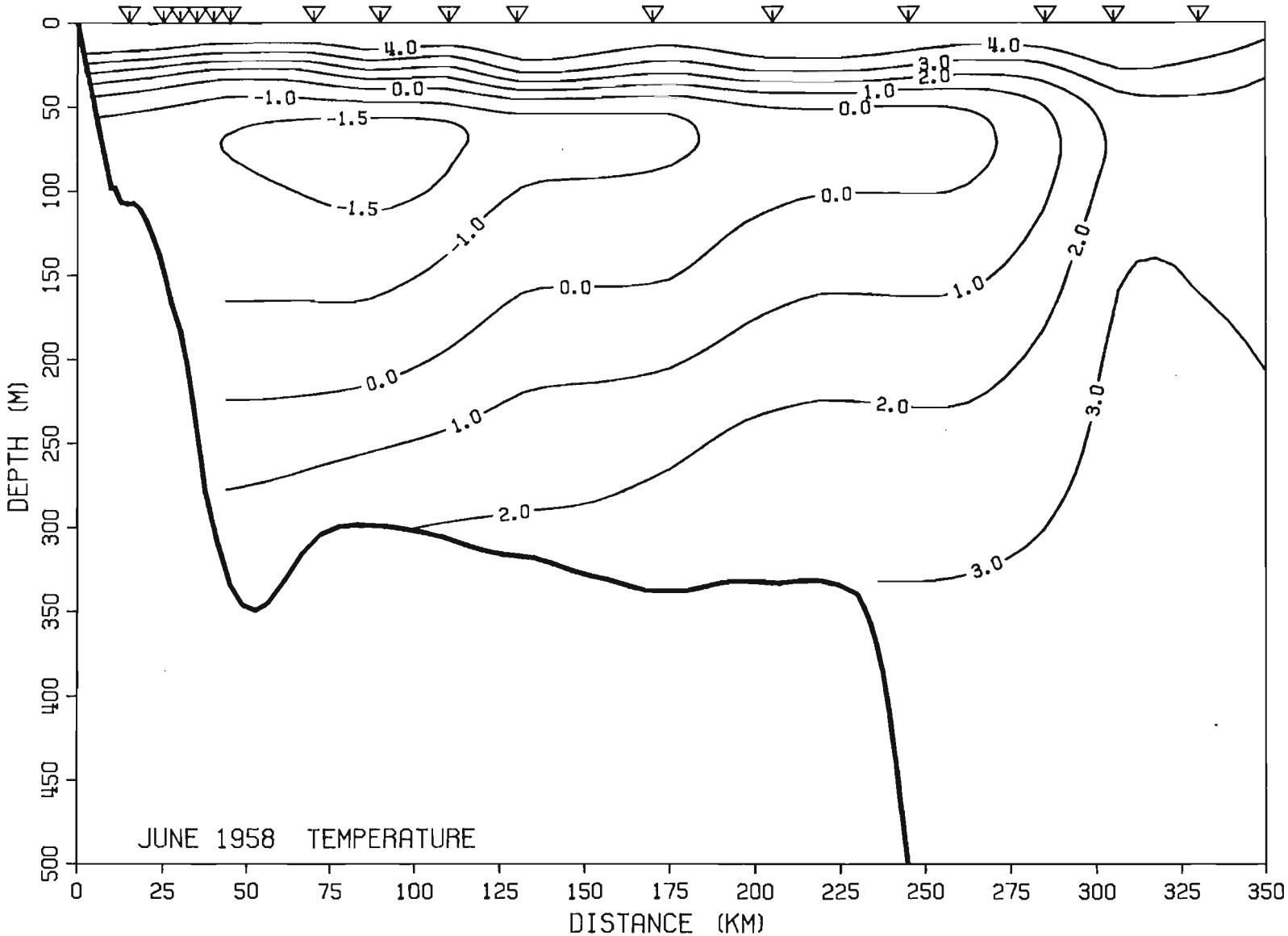
-1.5


JUNE 1958 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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50
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100
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150
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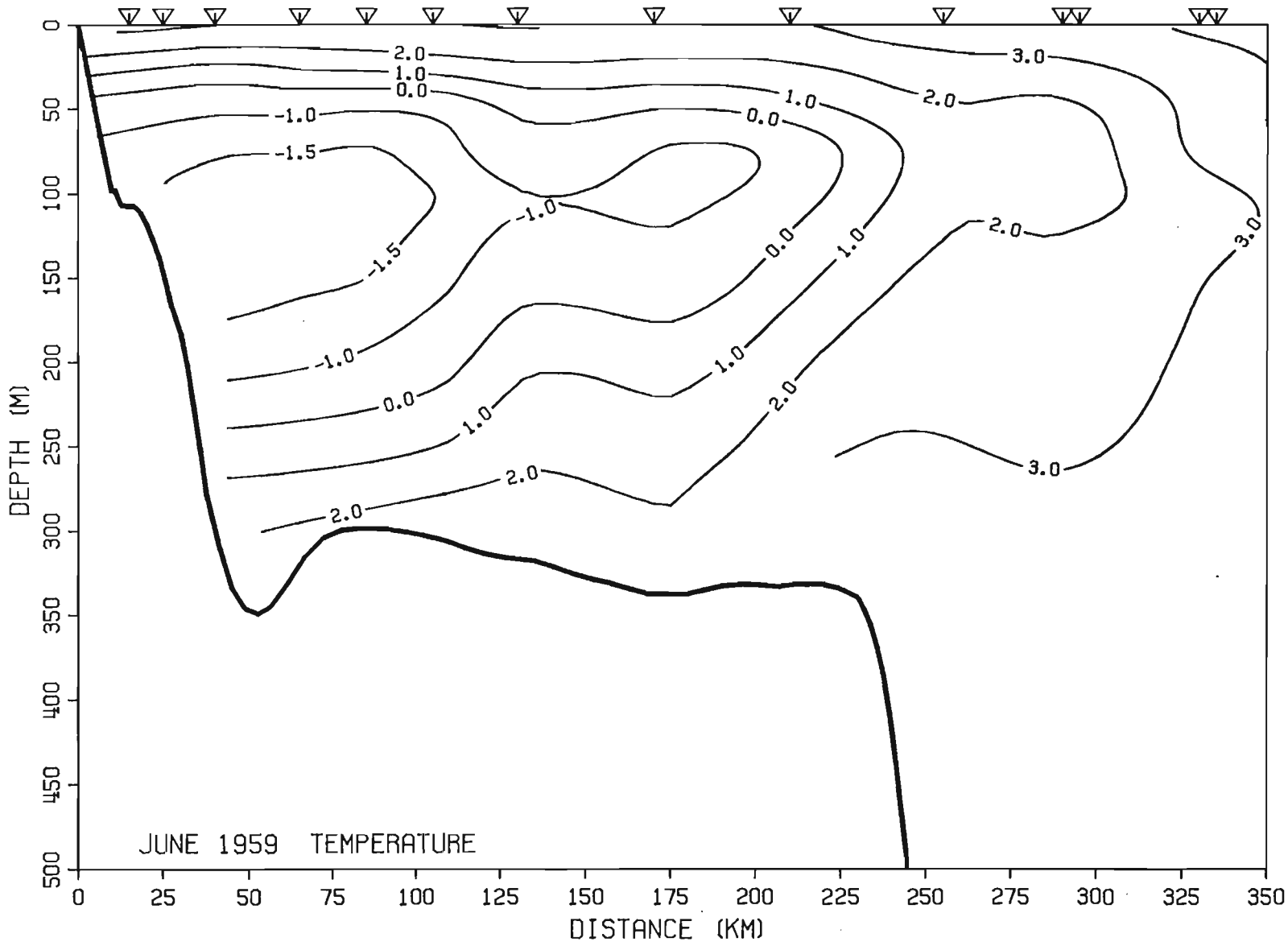
JUNE 1959 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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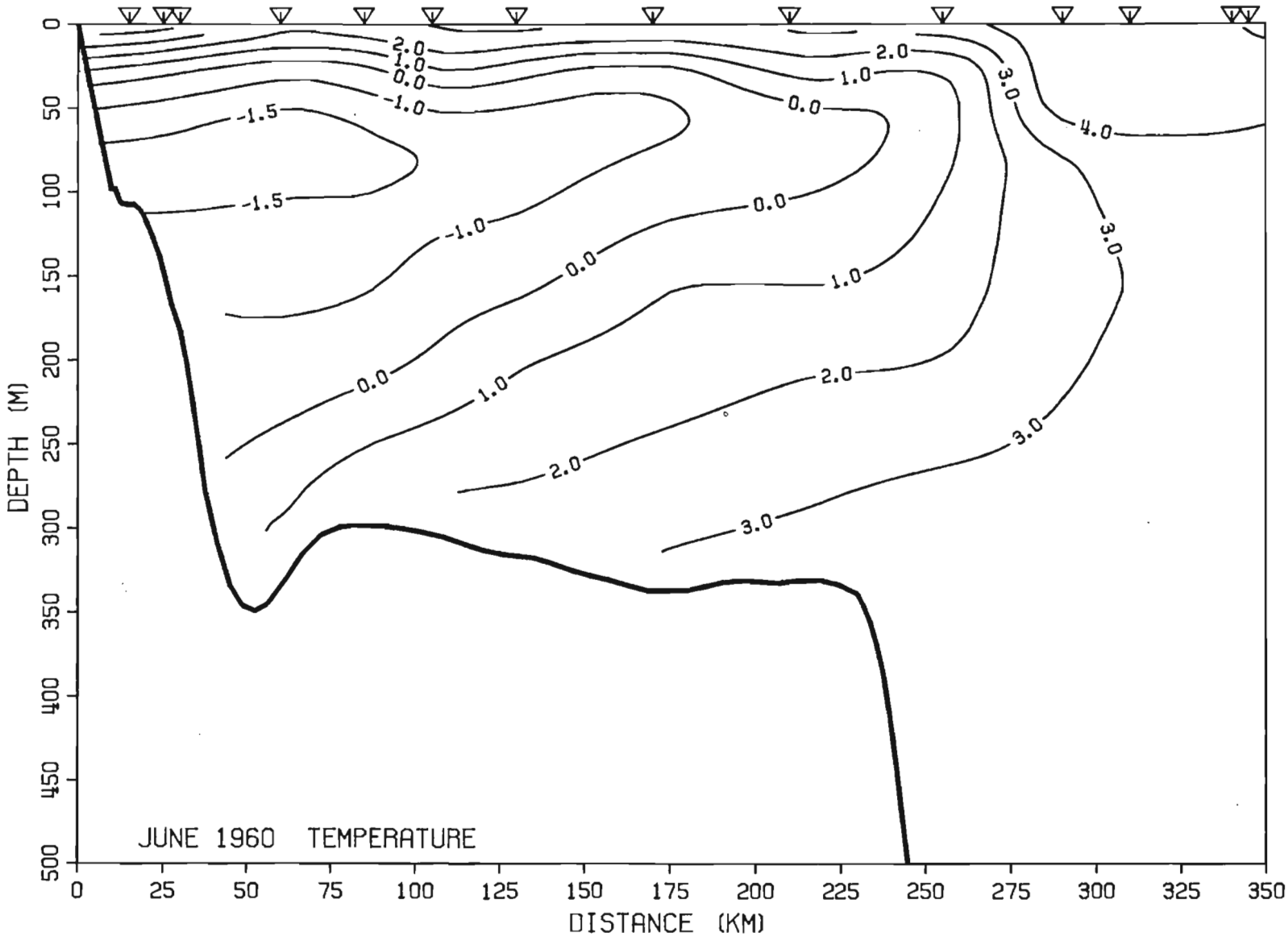
JUNE 1960 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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50
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300
325
350
2.0
1.0
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-1.0
-1.5
-1.5
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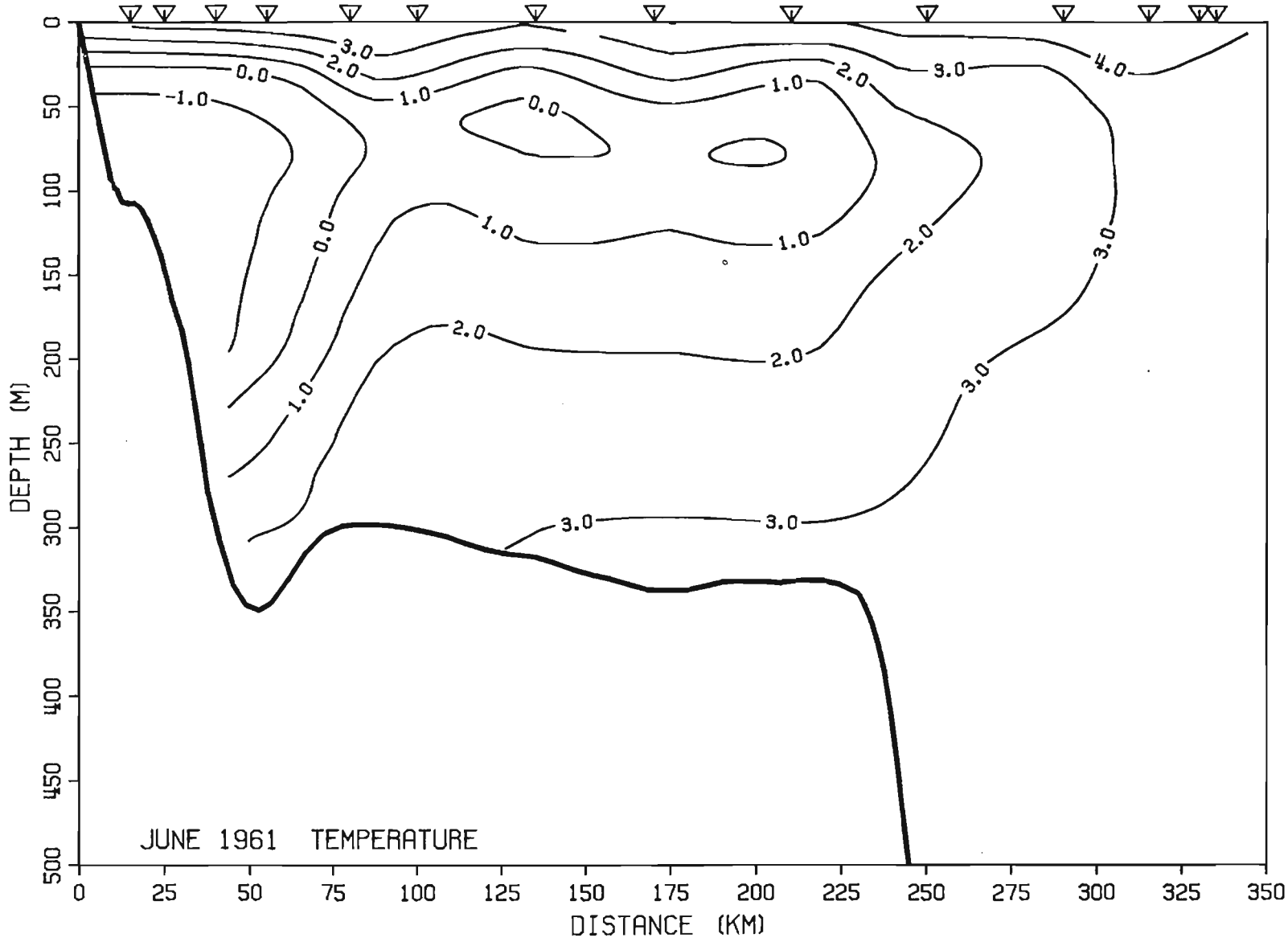
JUNE 1961 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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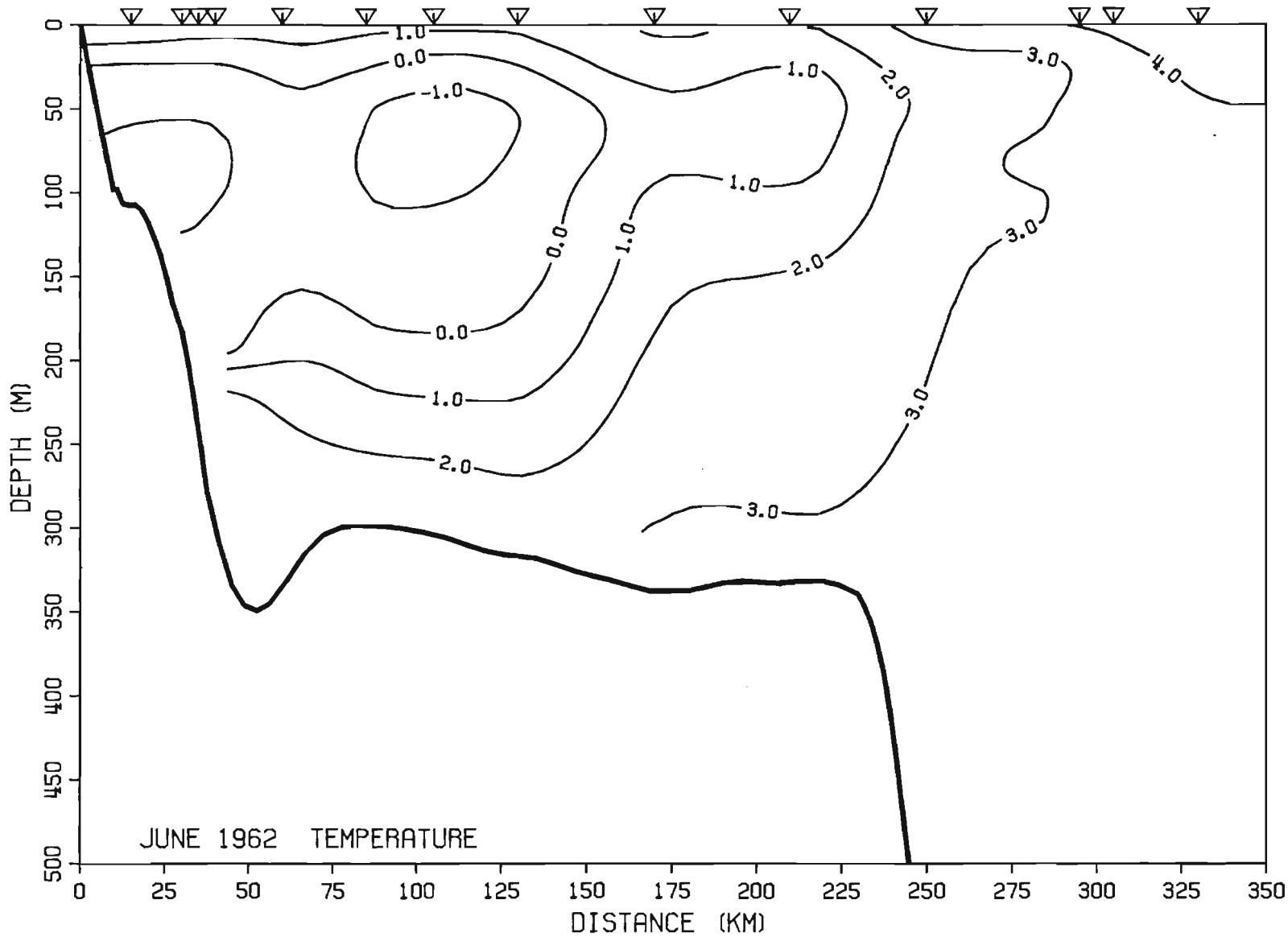
JUNE 1962 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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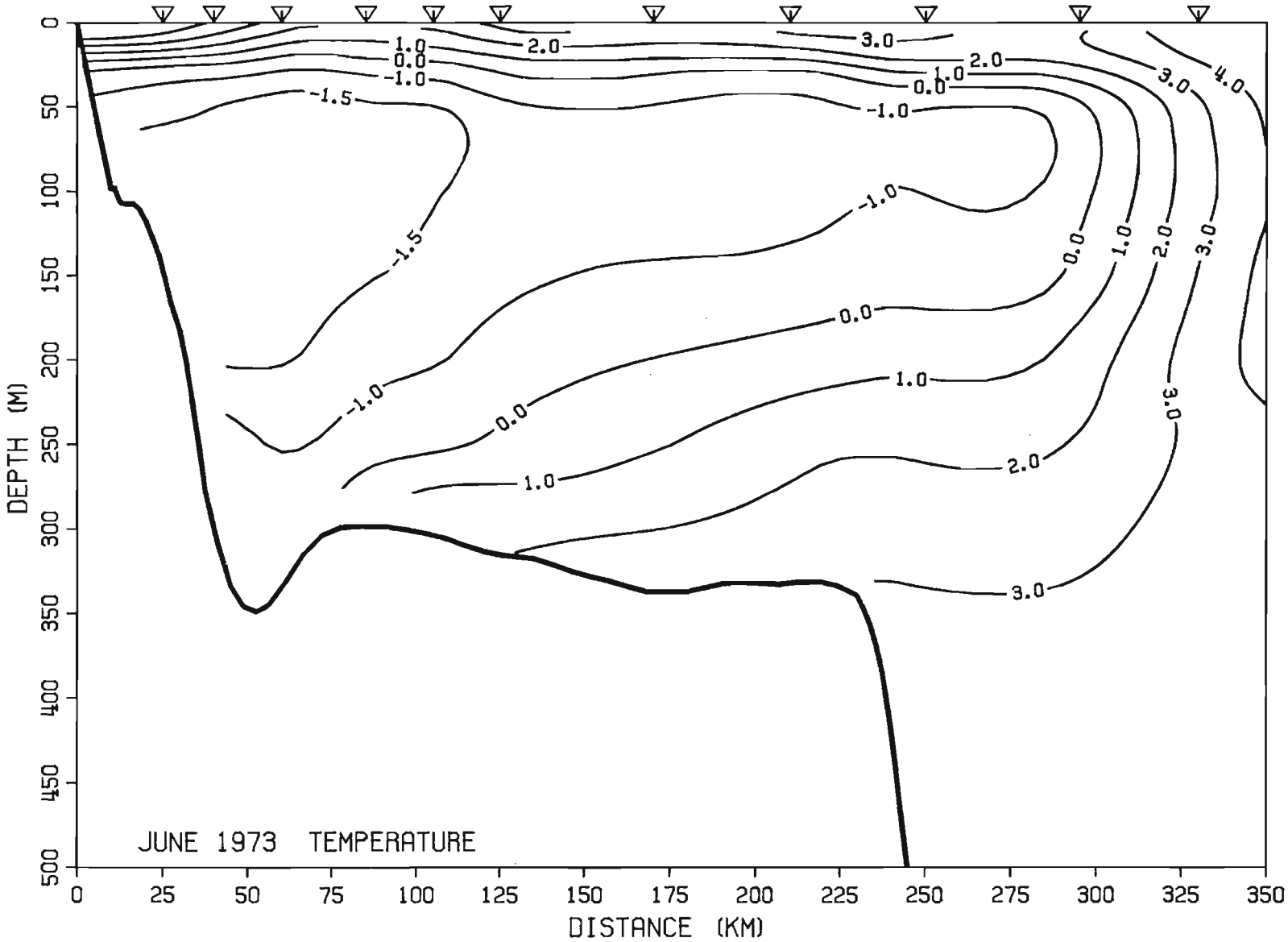
JUNE 1973 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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100
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400
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0
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50
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-1.5
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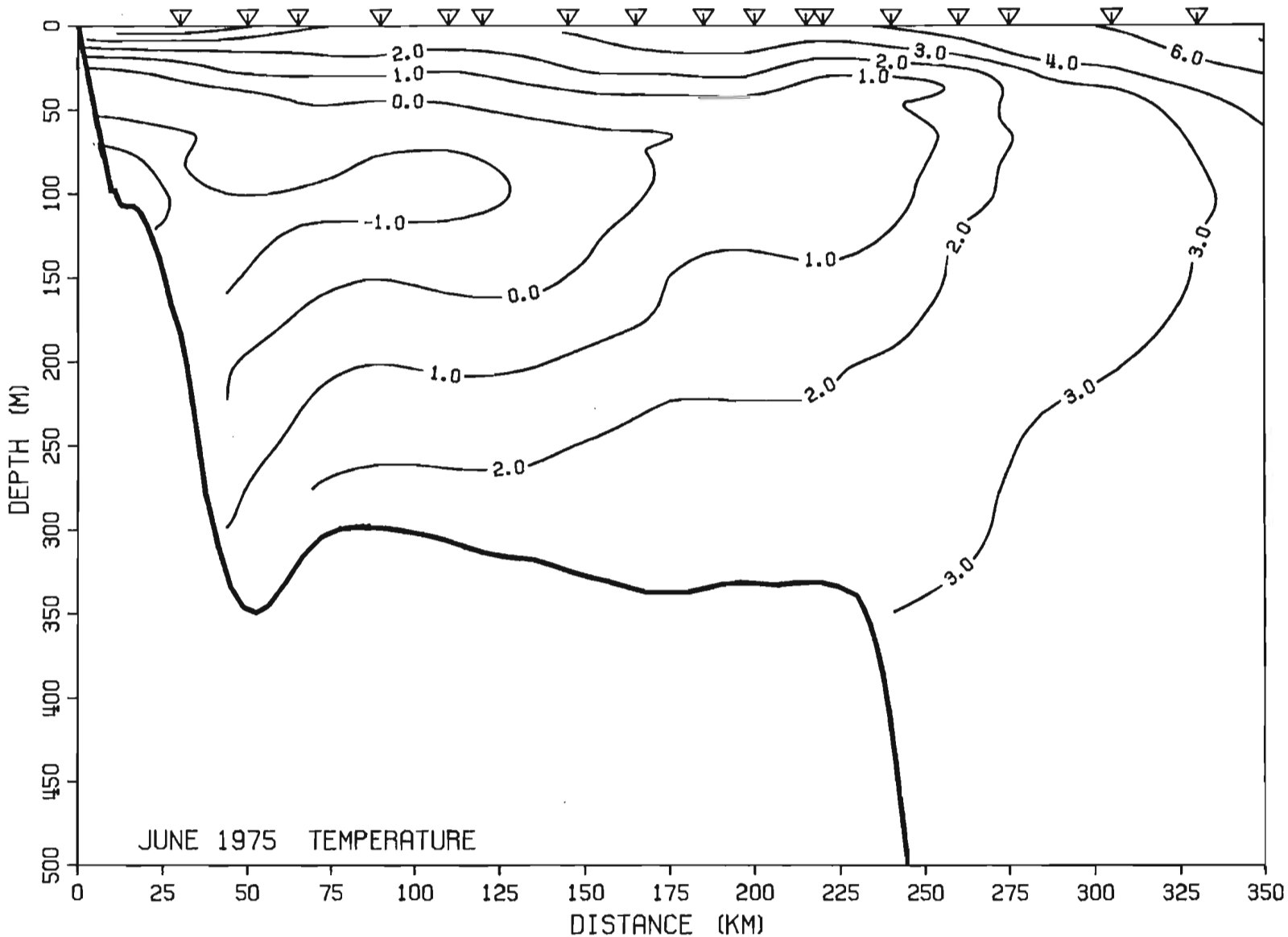
JUNE 1975 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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100
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0
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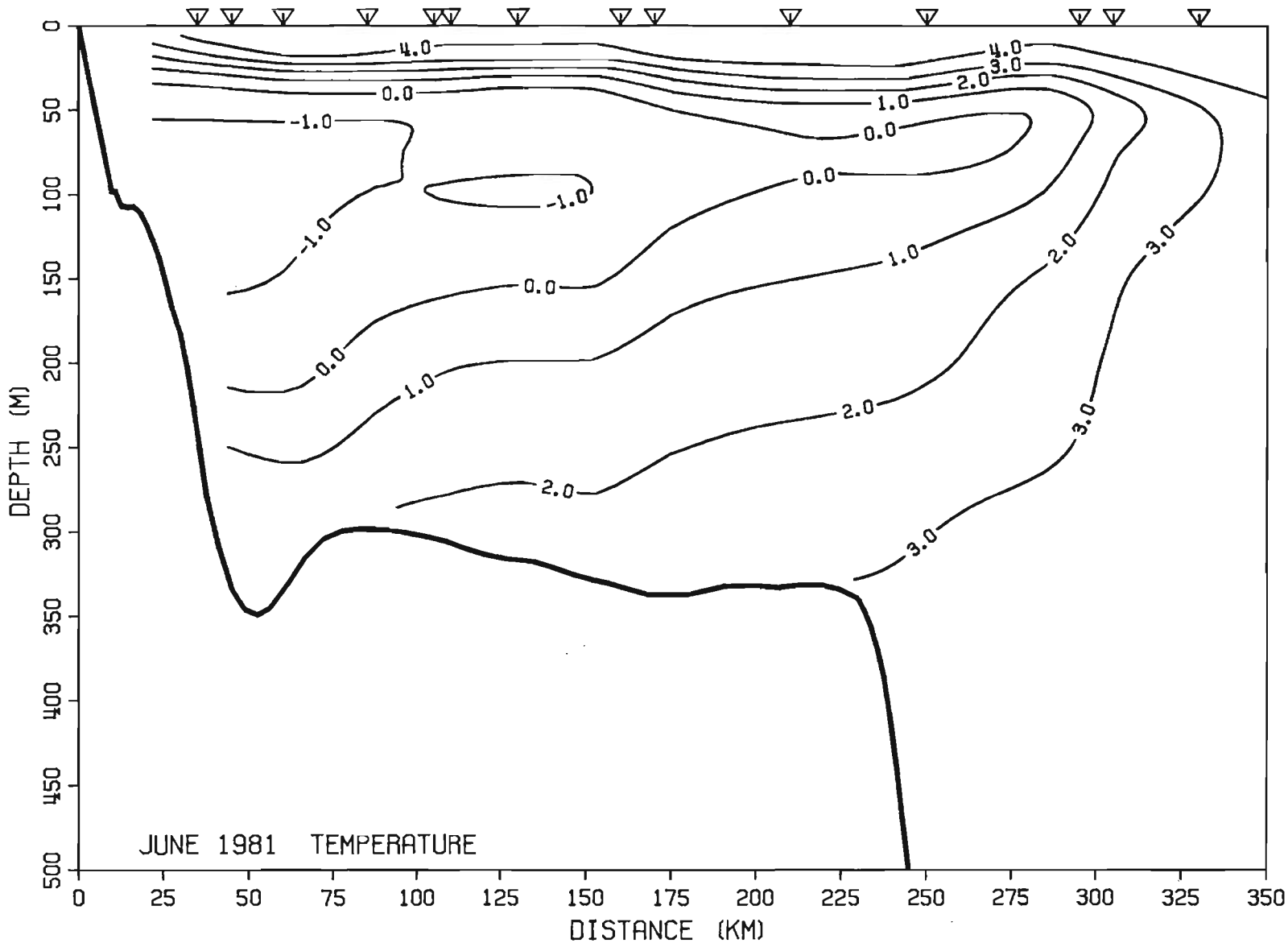
JUNE 1981 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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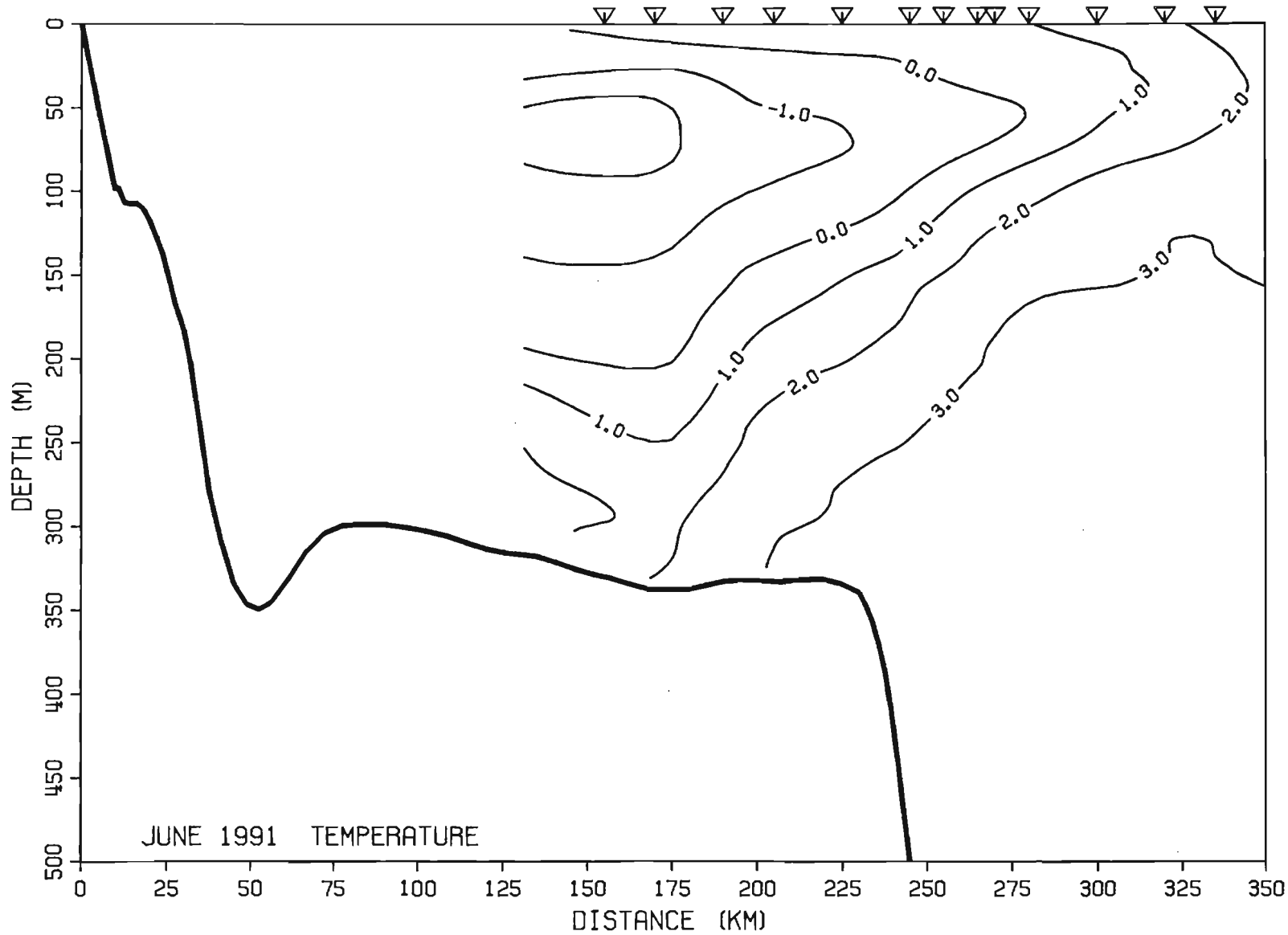
JUNE 1991 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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0
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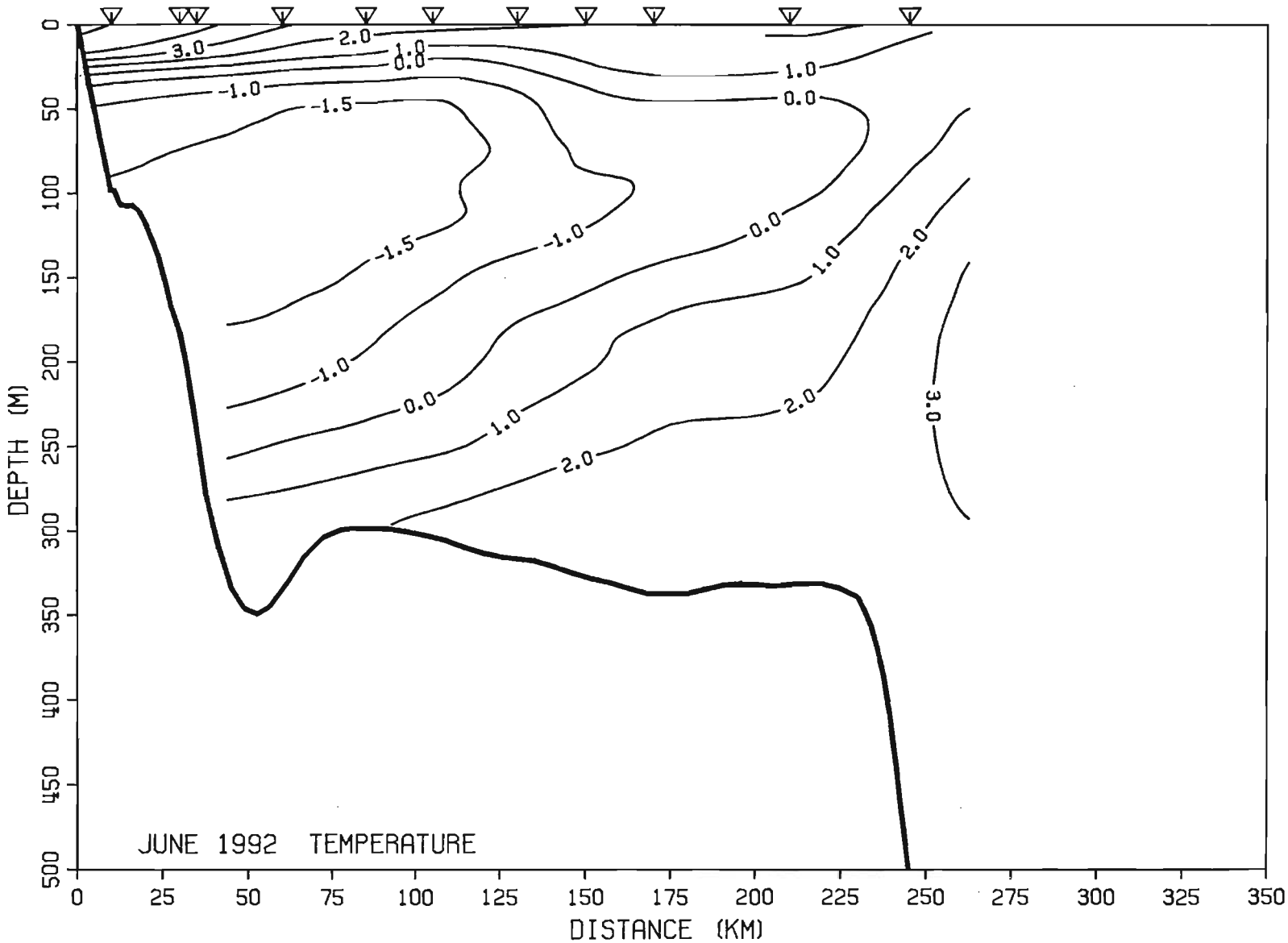
JUNE 1992 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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0
25
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75
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125
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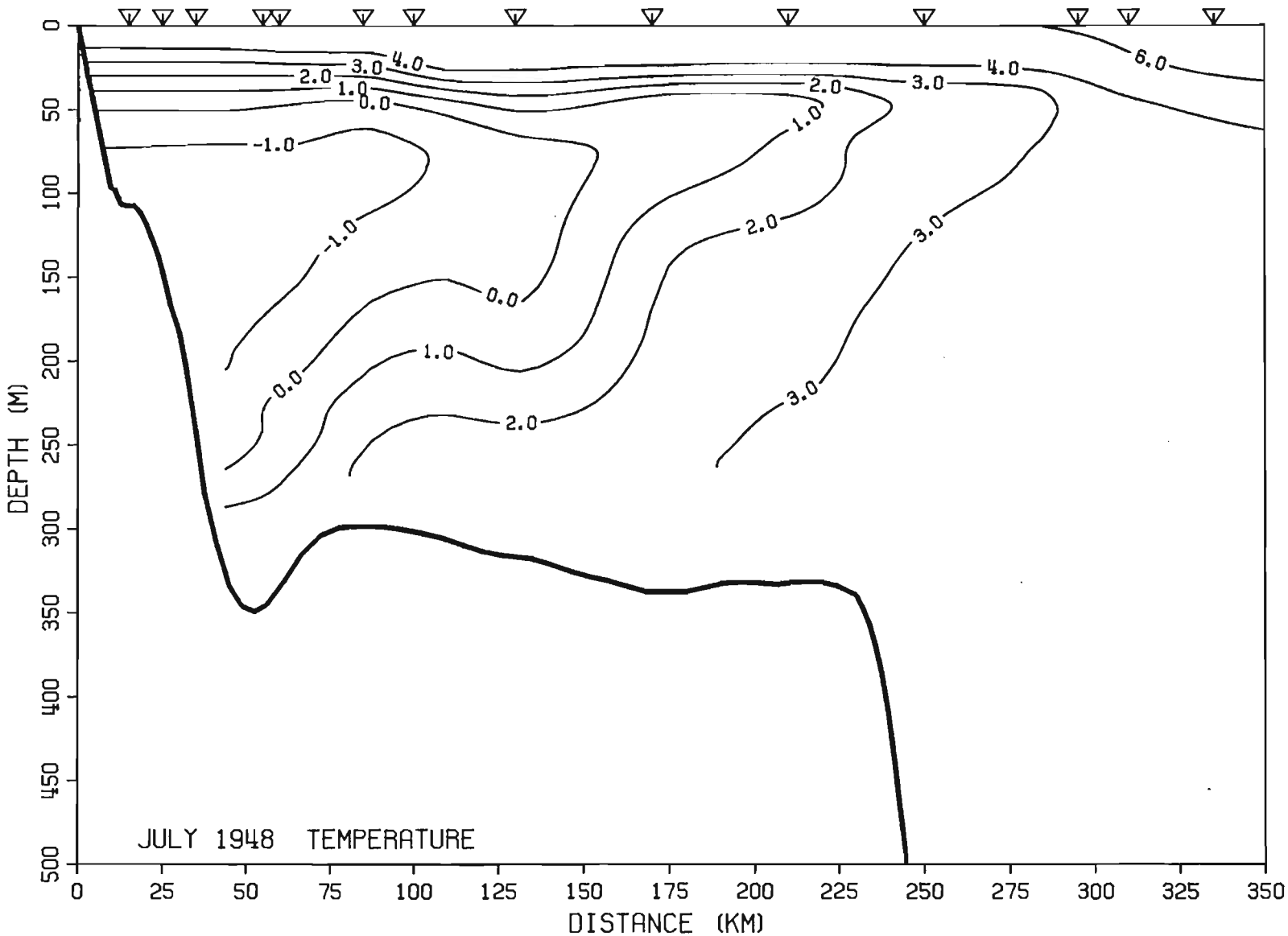
-1.0
-1.5


JULY 1948 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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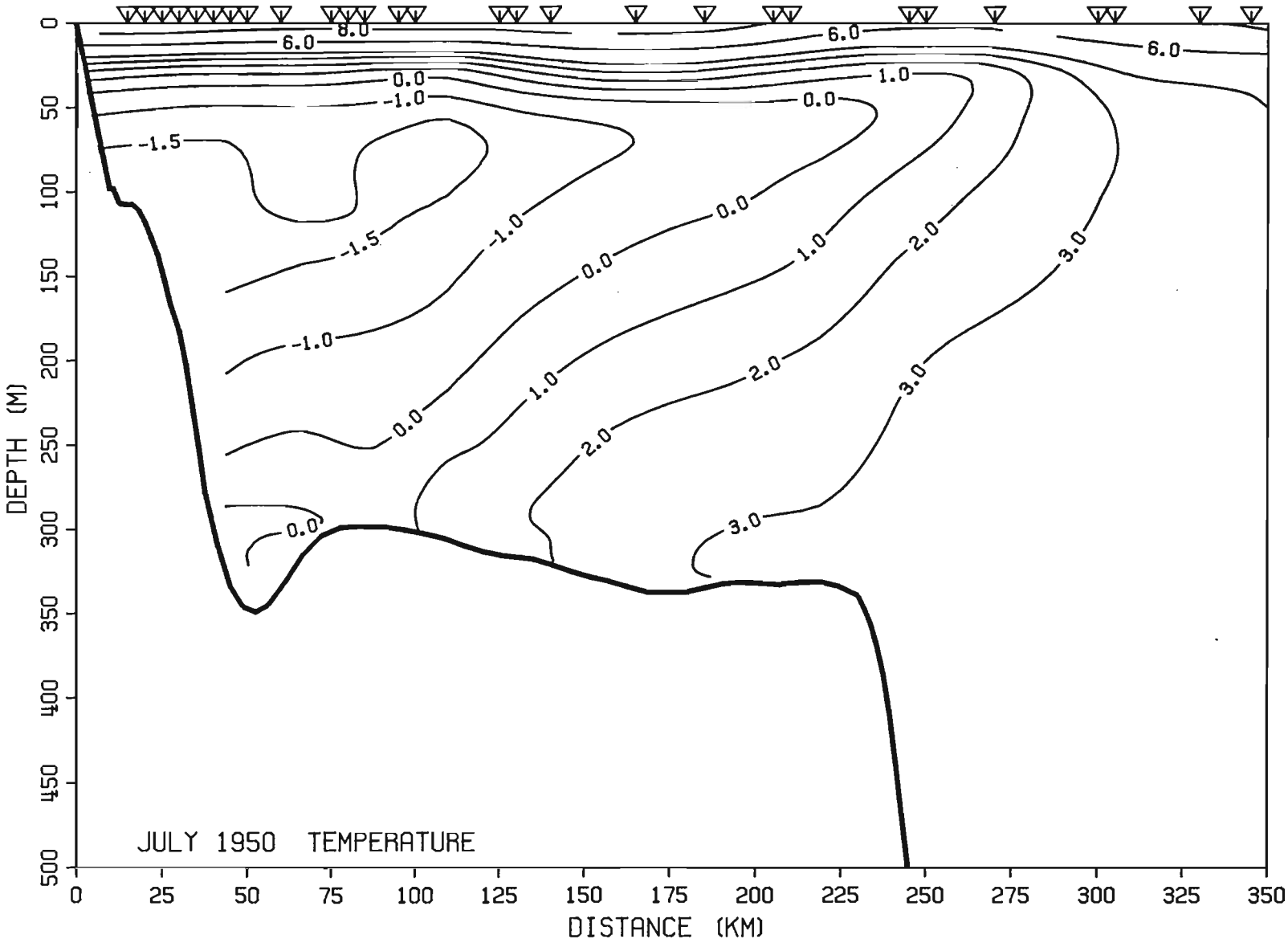
JULY 1950 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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1.0
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-1.5
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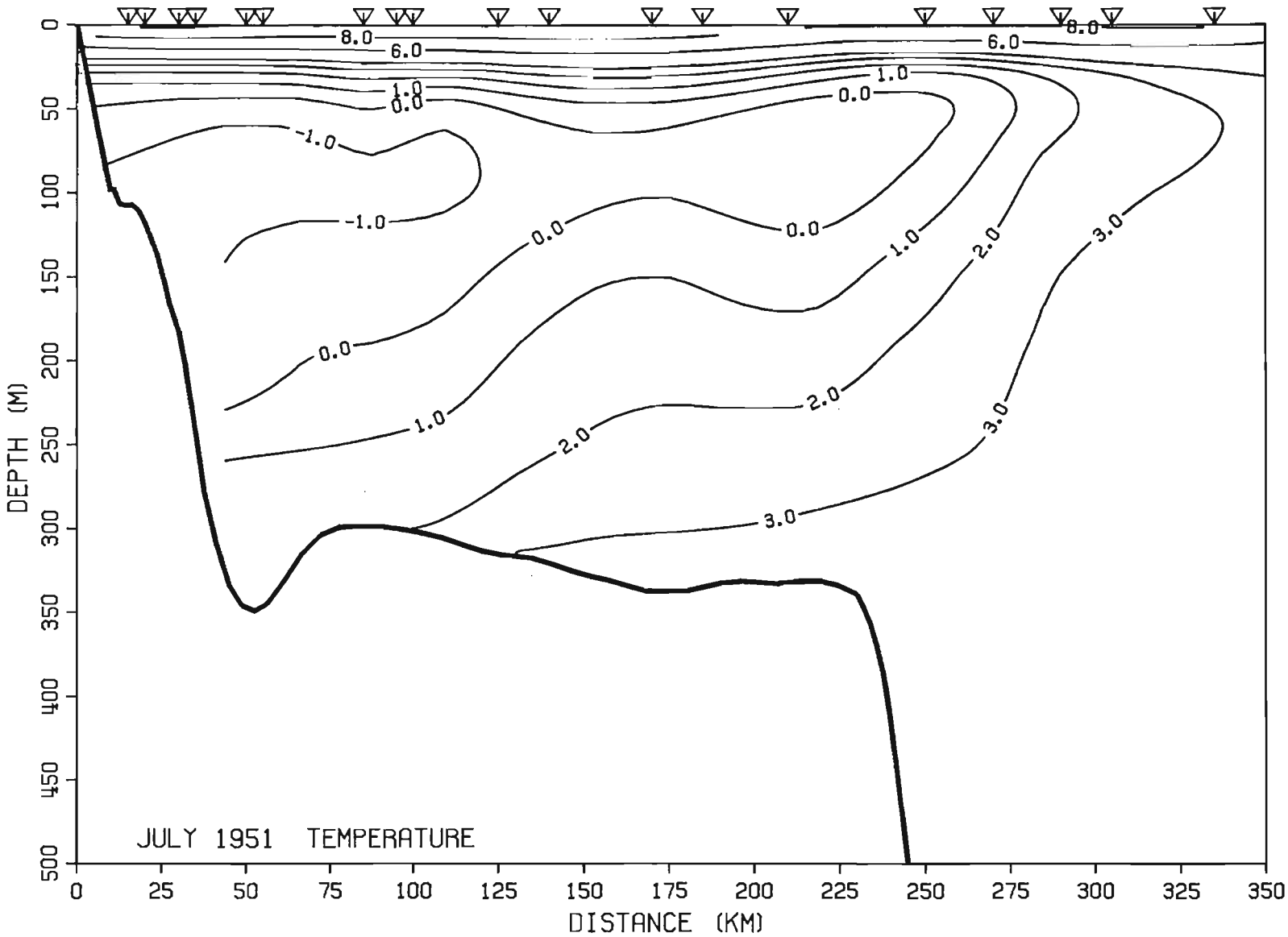
JULY 1951 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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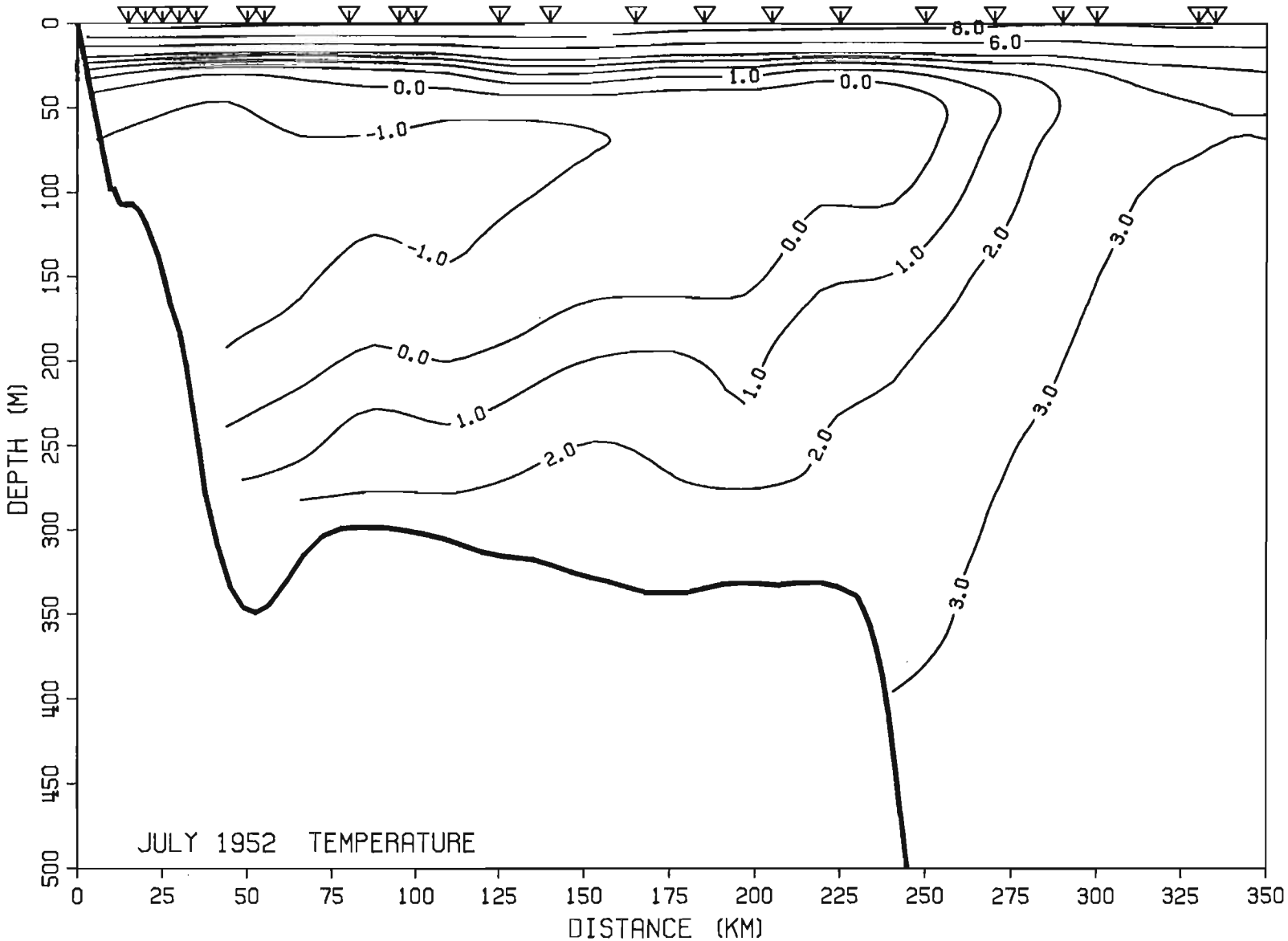
JULY 1952 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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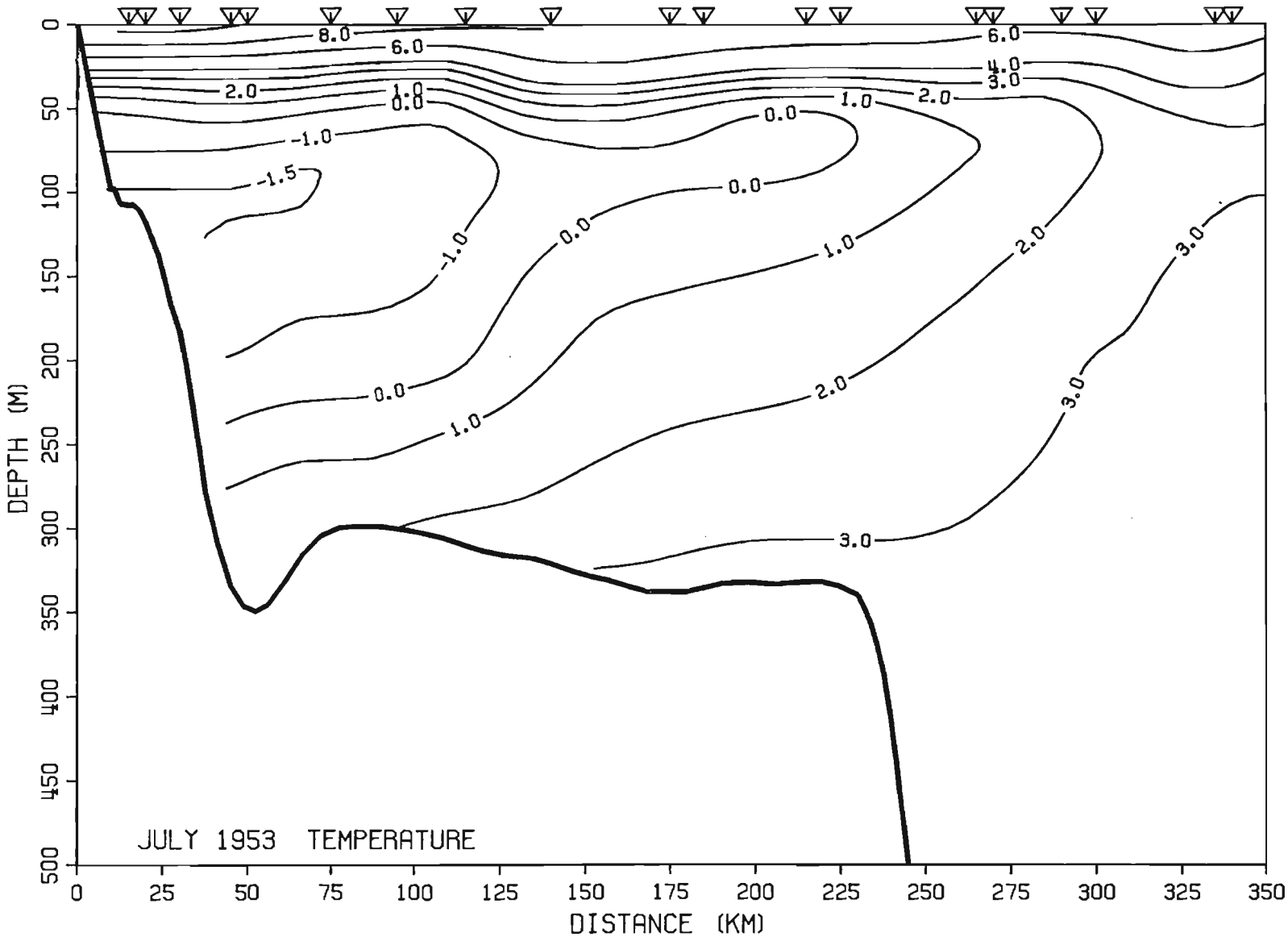
JULY 1953 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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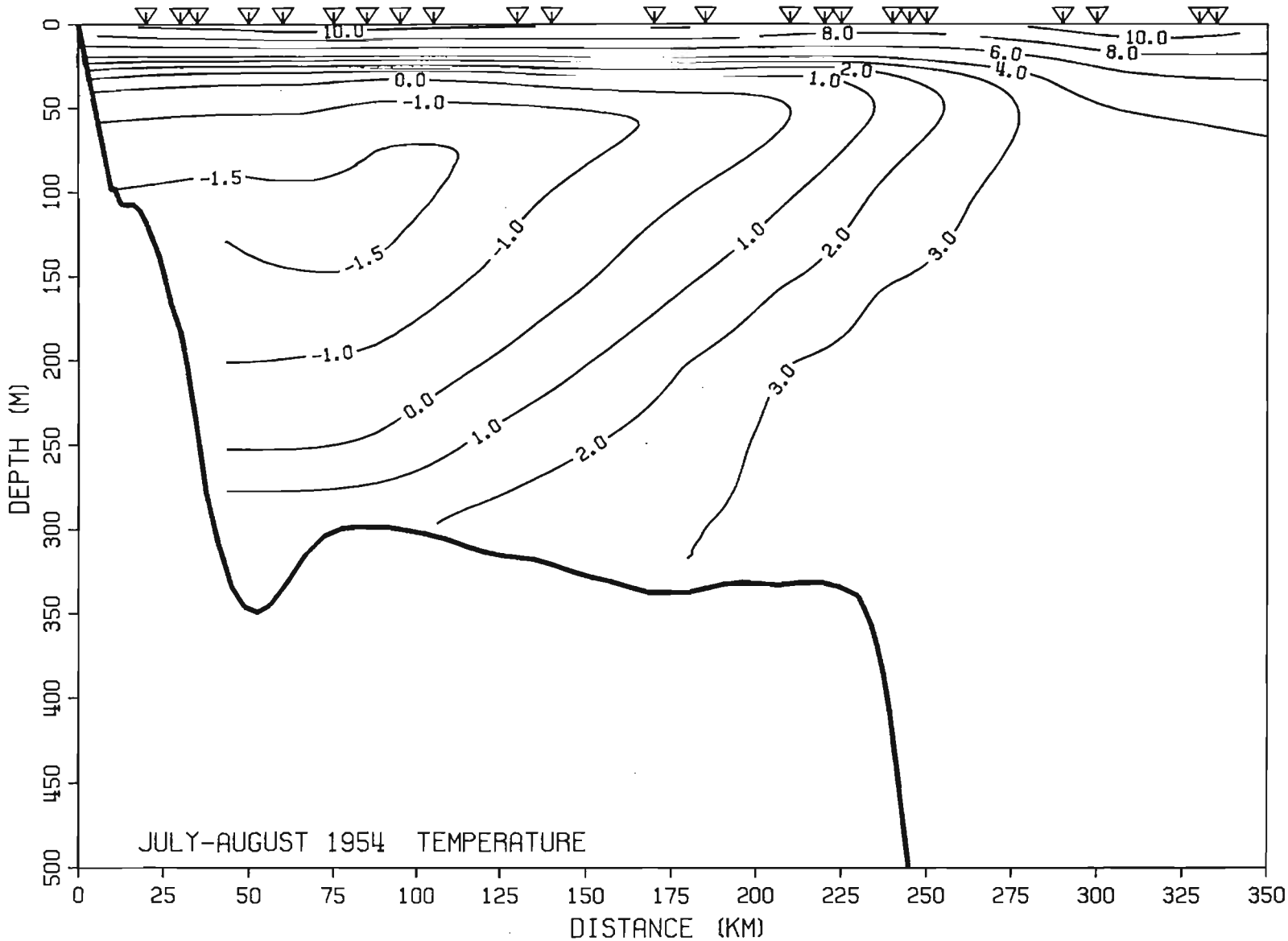
JULY-AUGUST 1954 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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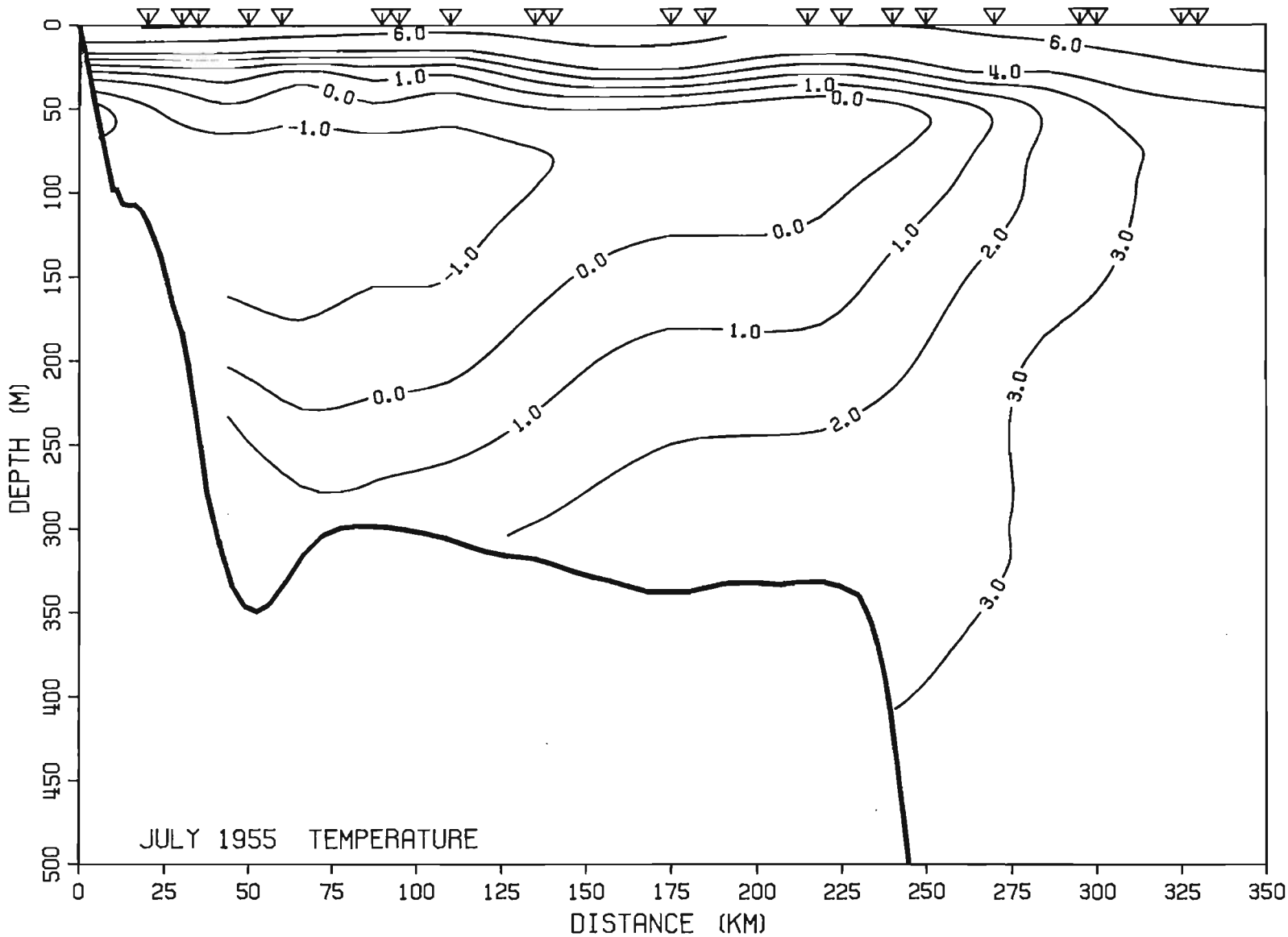
JULY 1955 TEMPERATURE
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DISTANCE (KM)
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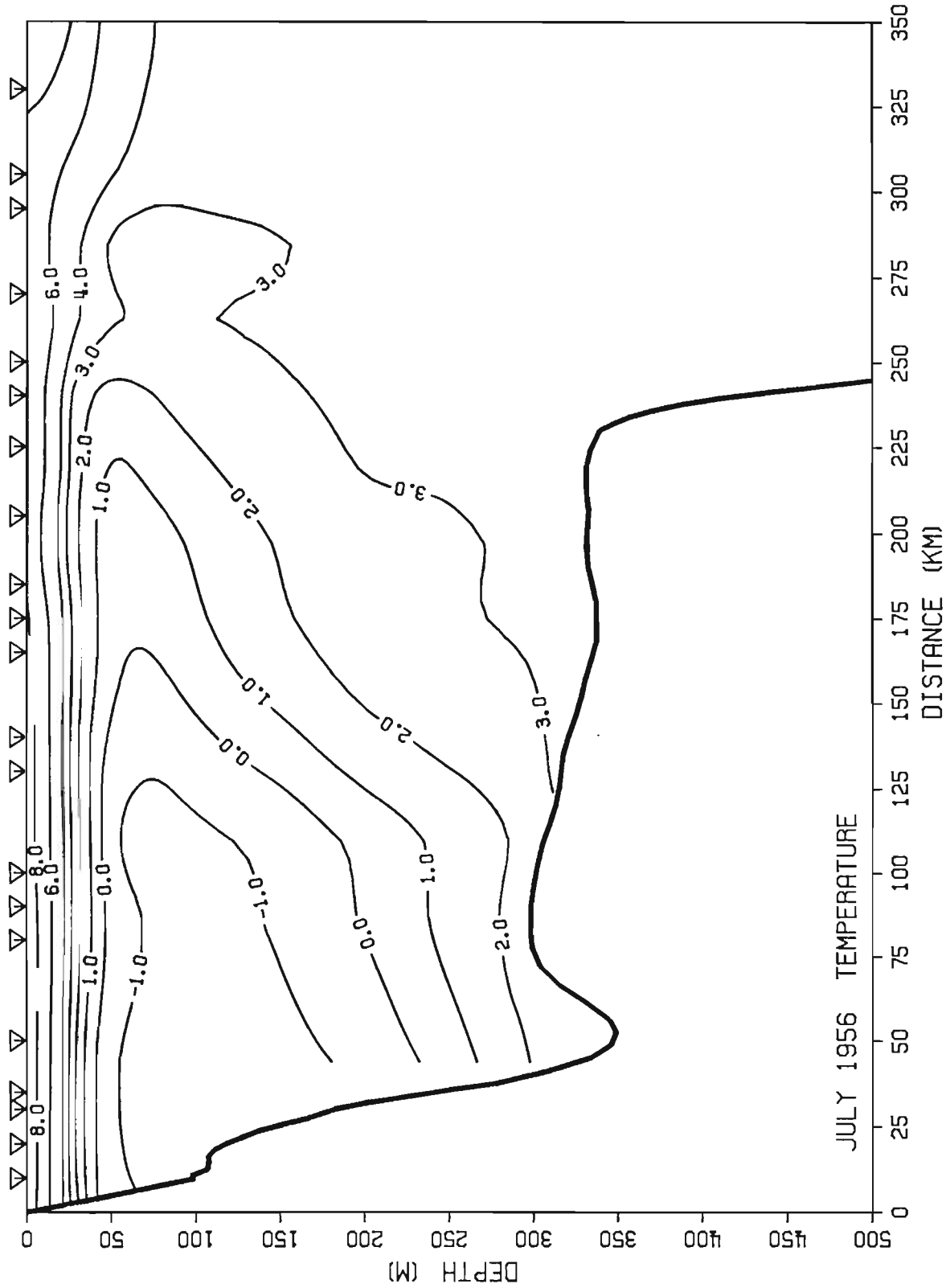
JULY 1956 TEMPERATURE
DISTANCE (KM)
DEPTH (M)
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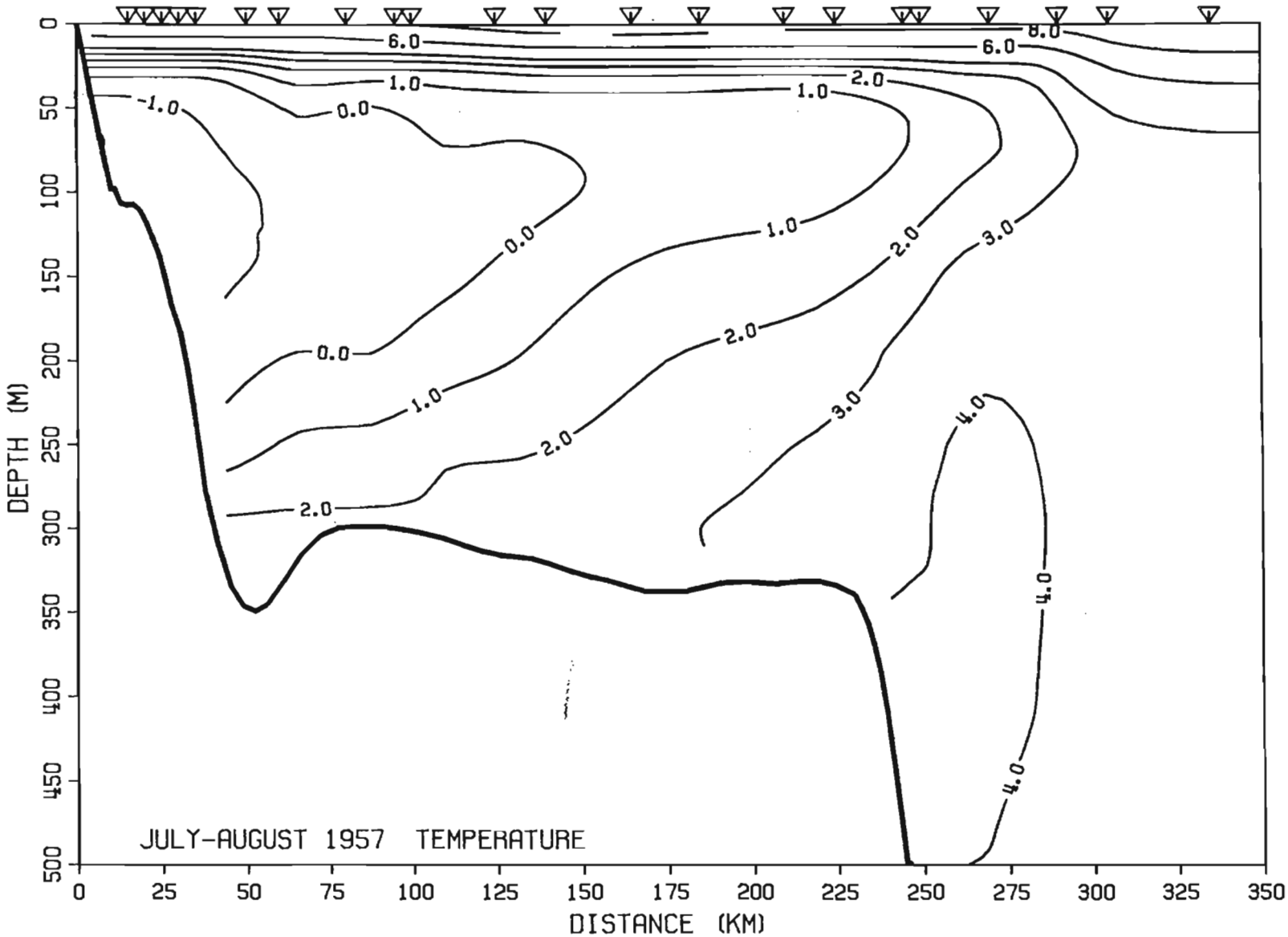
JULY-AUGUST 1957 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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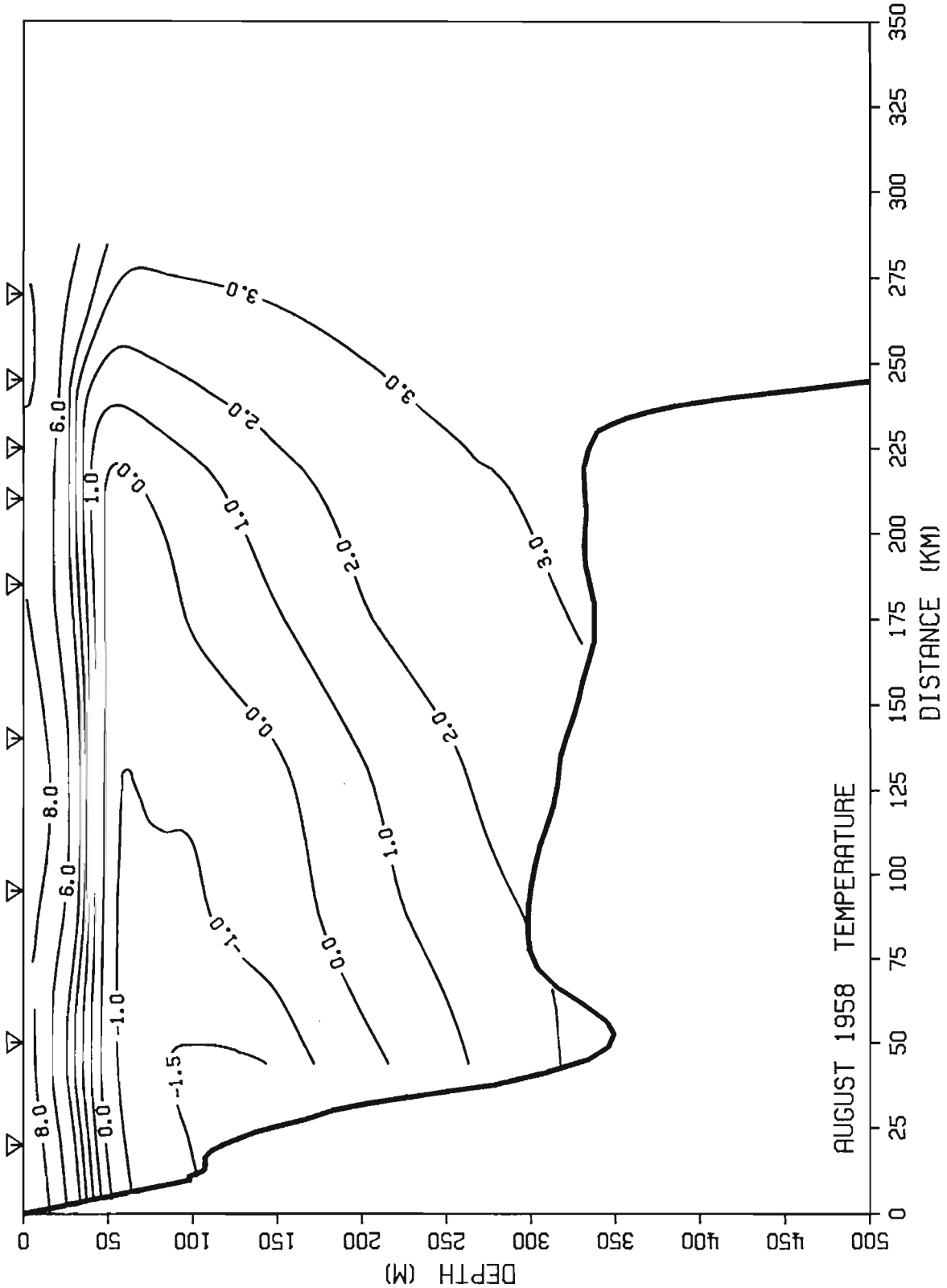
AUGUST 1958 TEMPERATURE
DISTANCE (KM)
DEPTH (M)
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175
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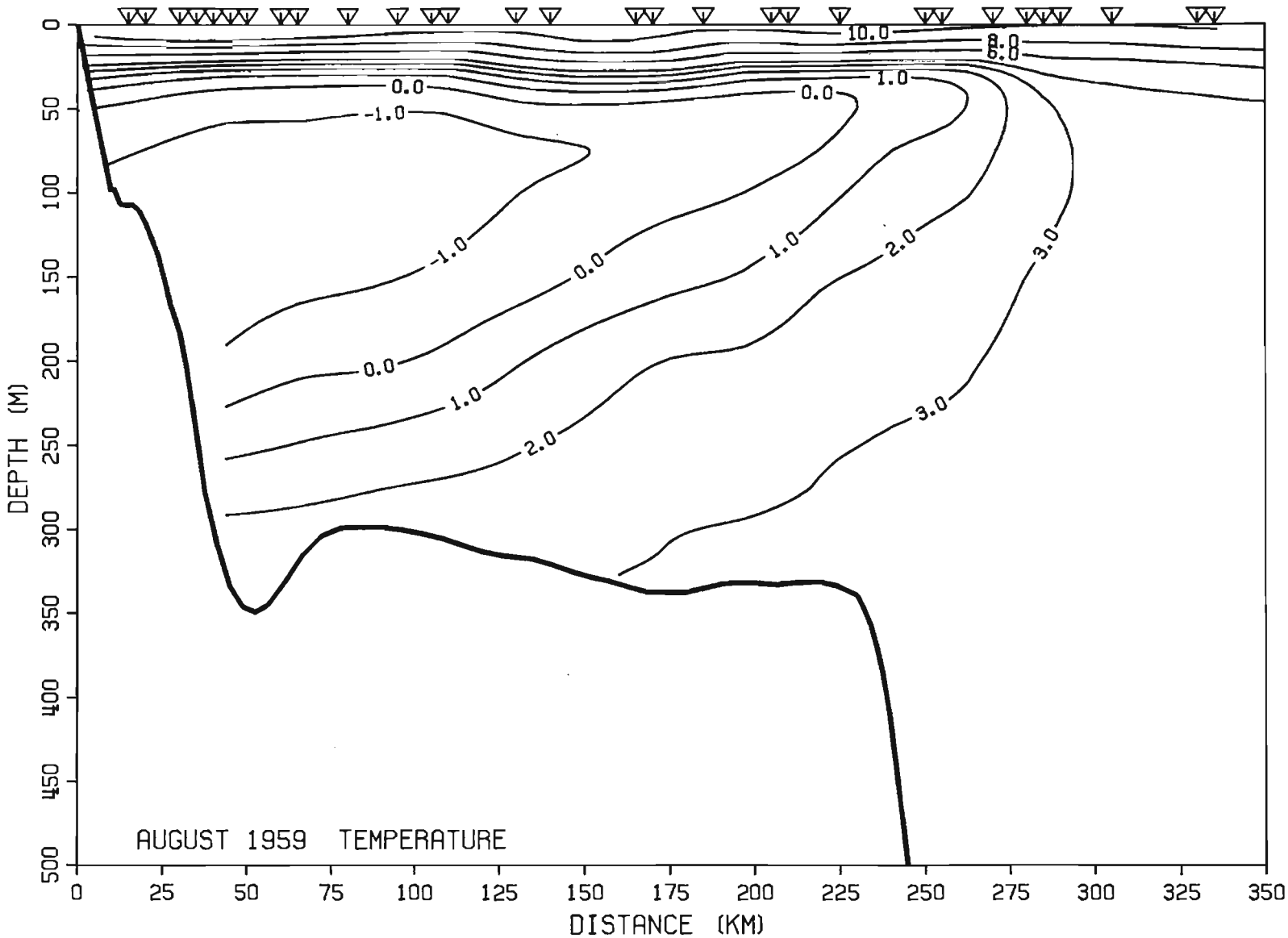
AUGUST 1959 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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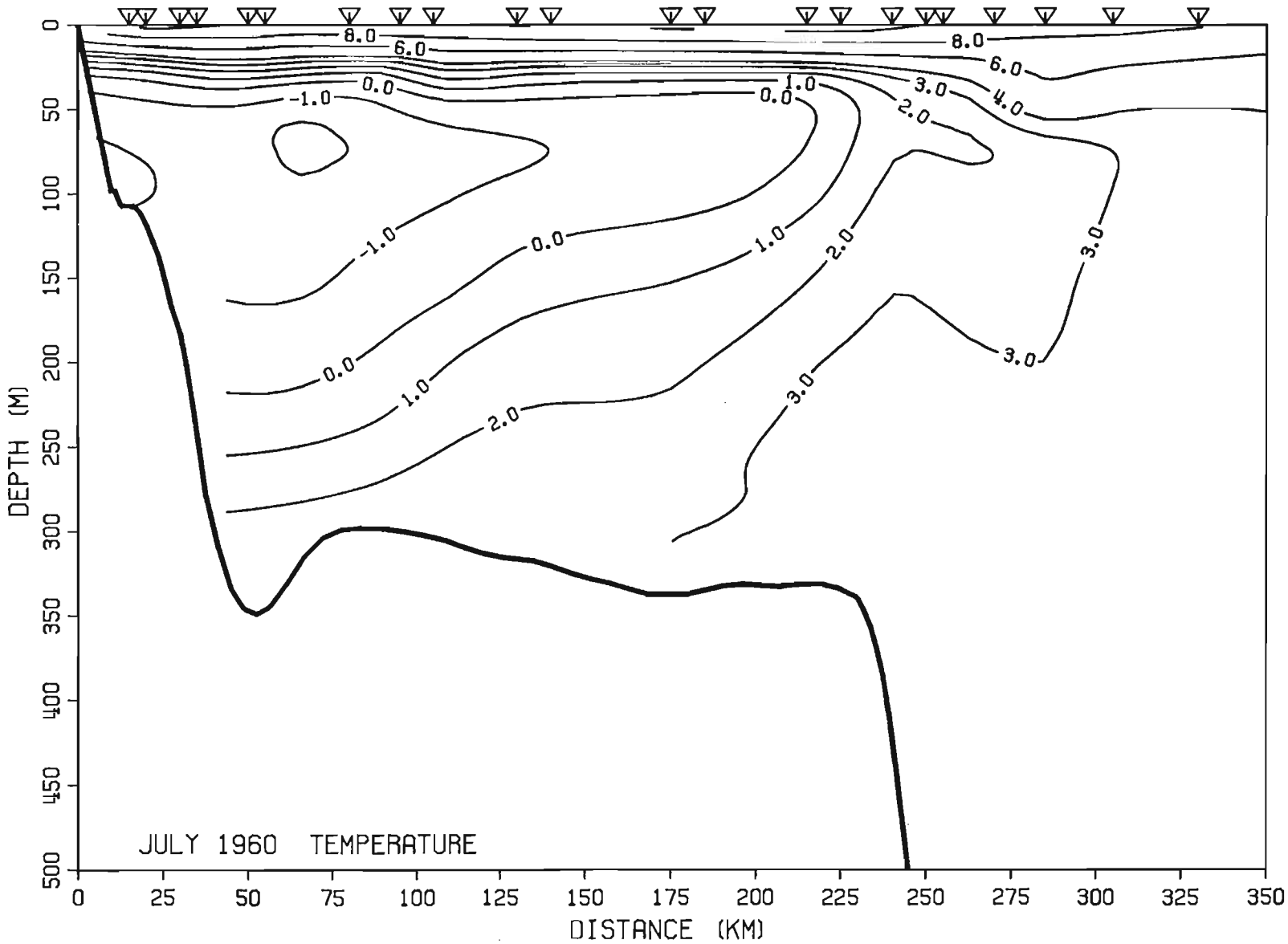
JULY 1960 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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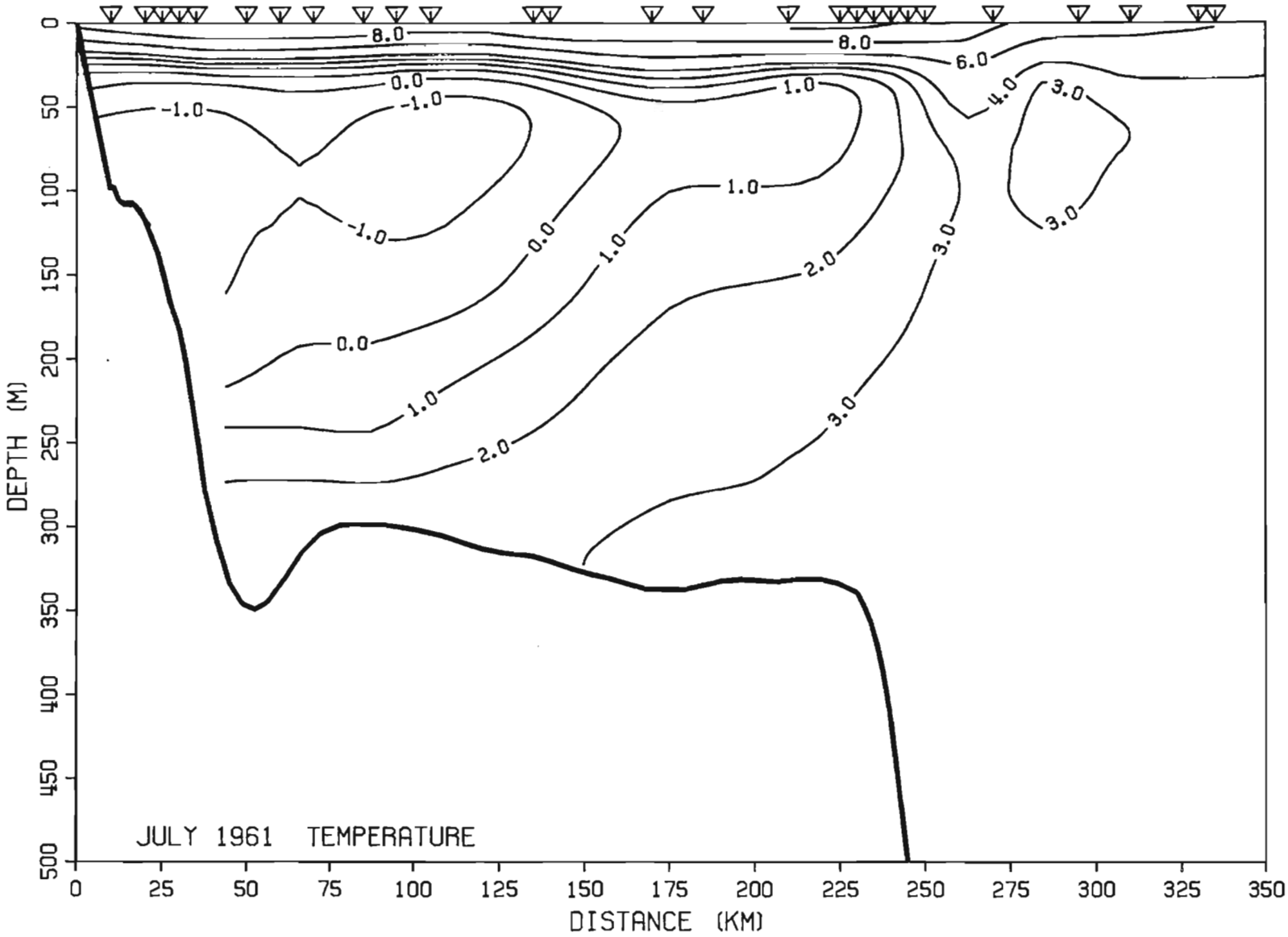
JULY 1961 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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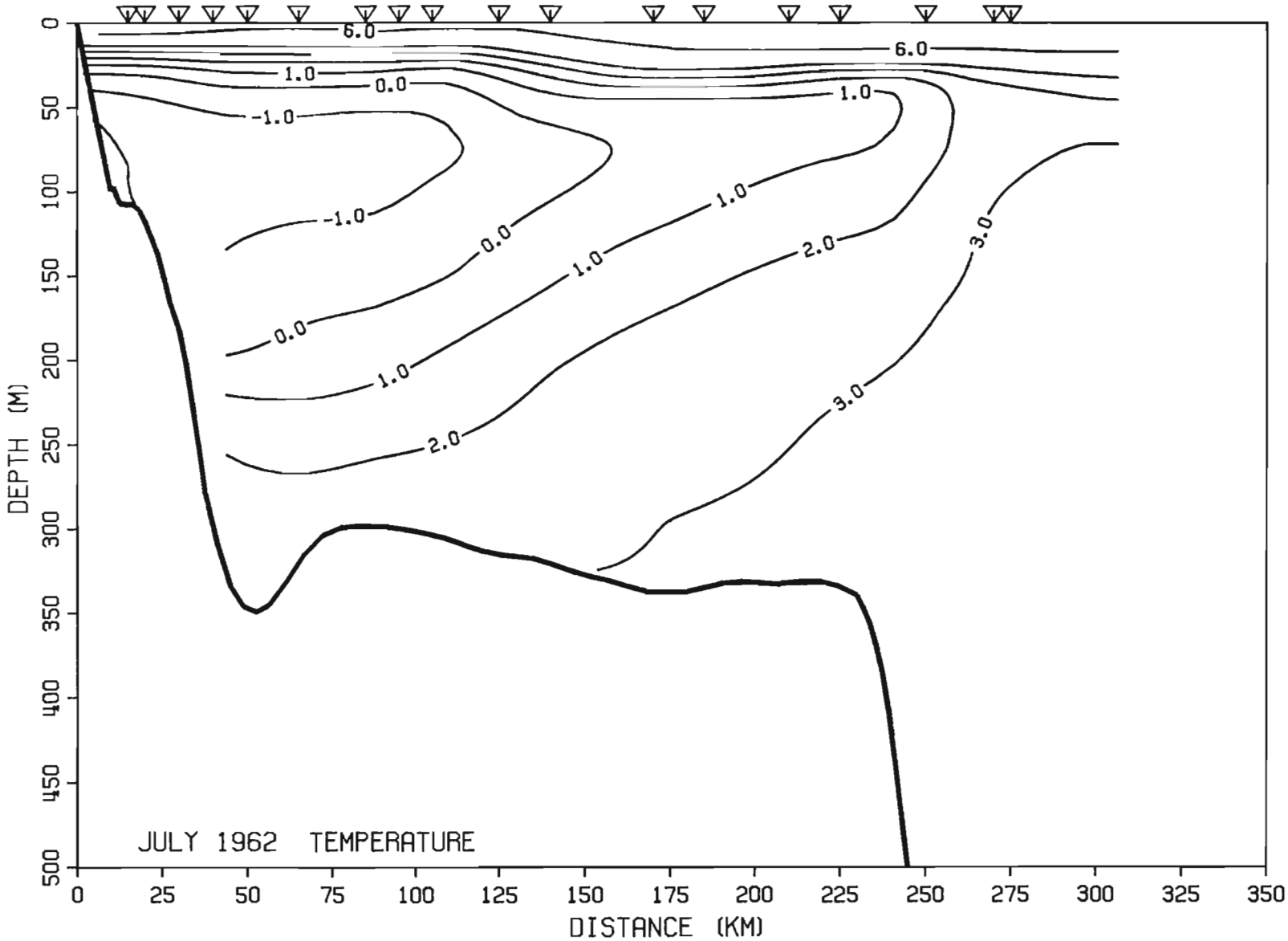
JULY 1962 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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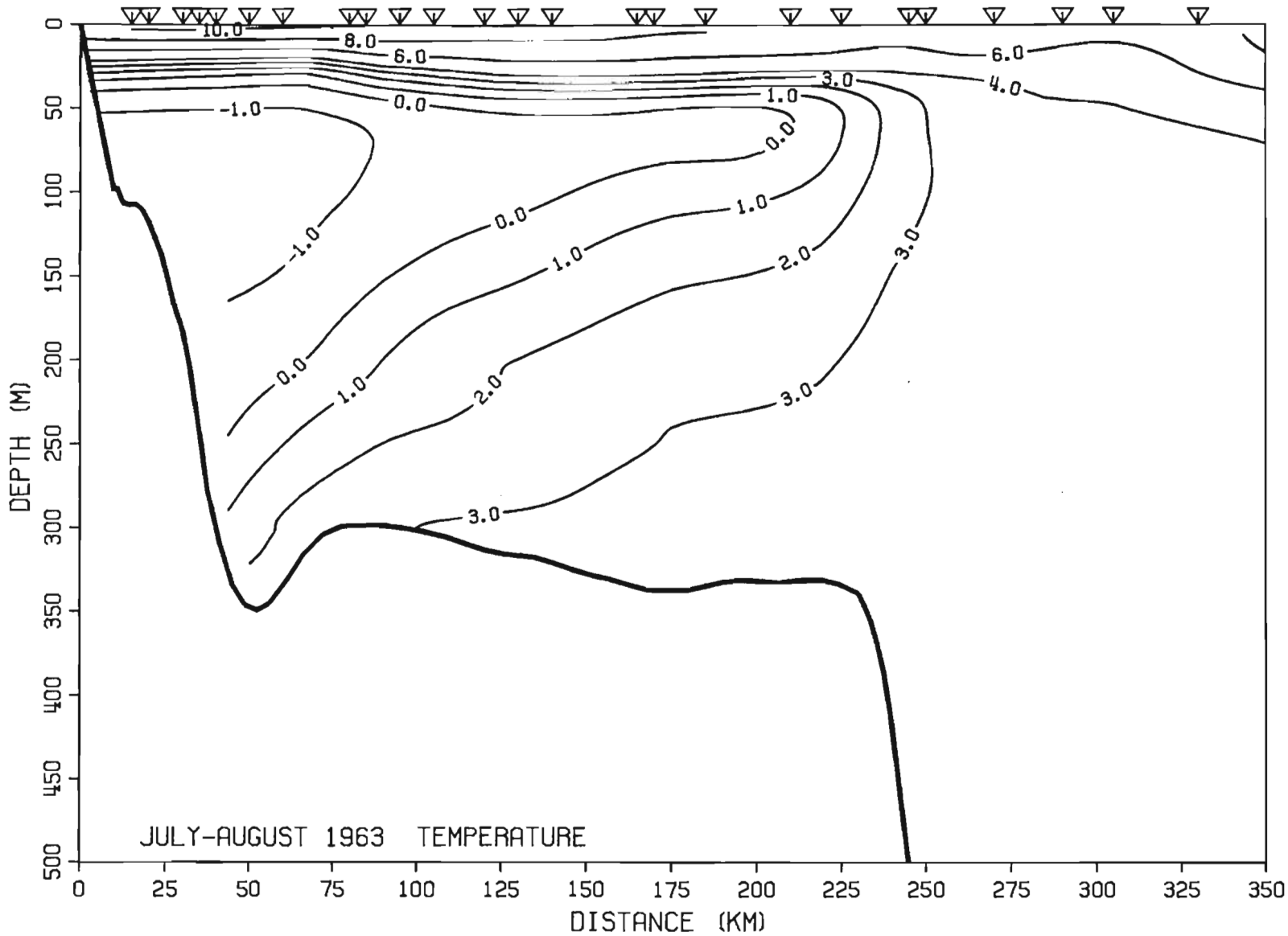
JULY-AUGUST 1963 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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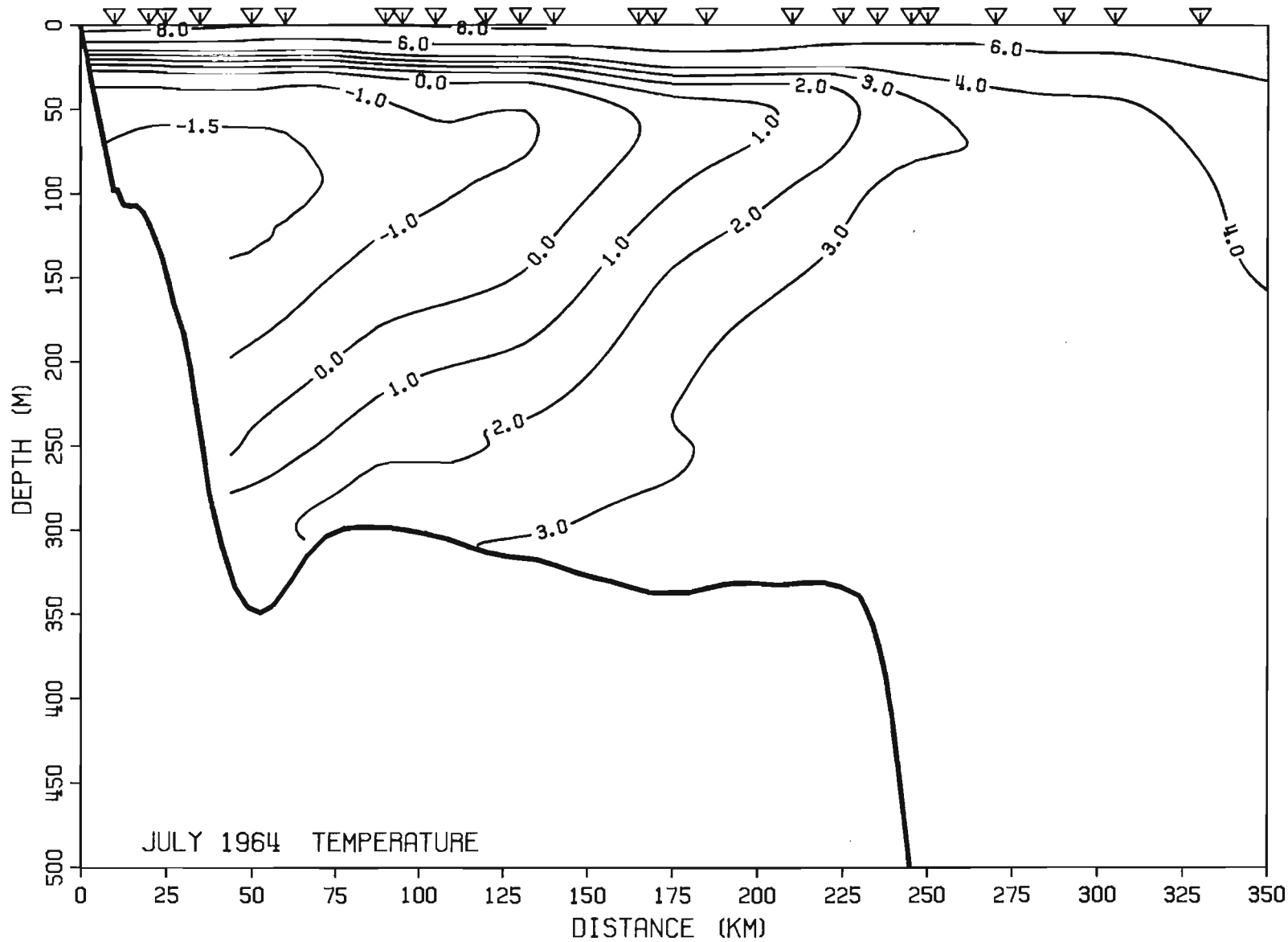
JULY 1964 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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125
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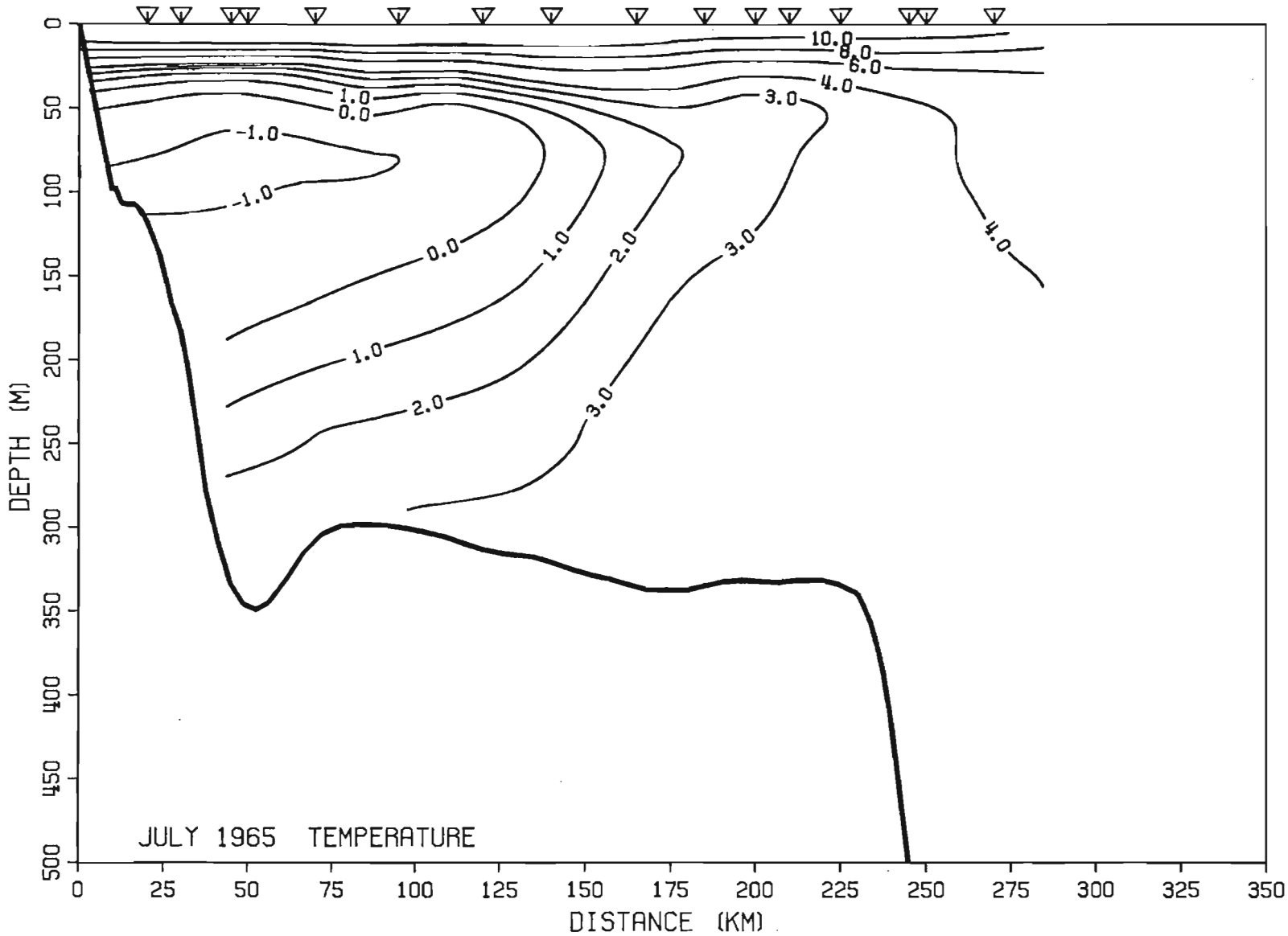
-1.0
-1.5


JULY 1965 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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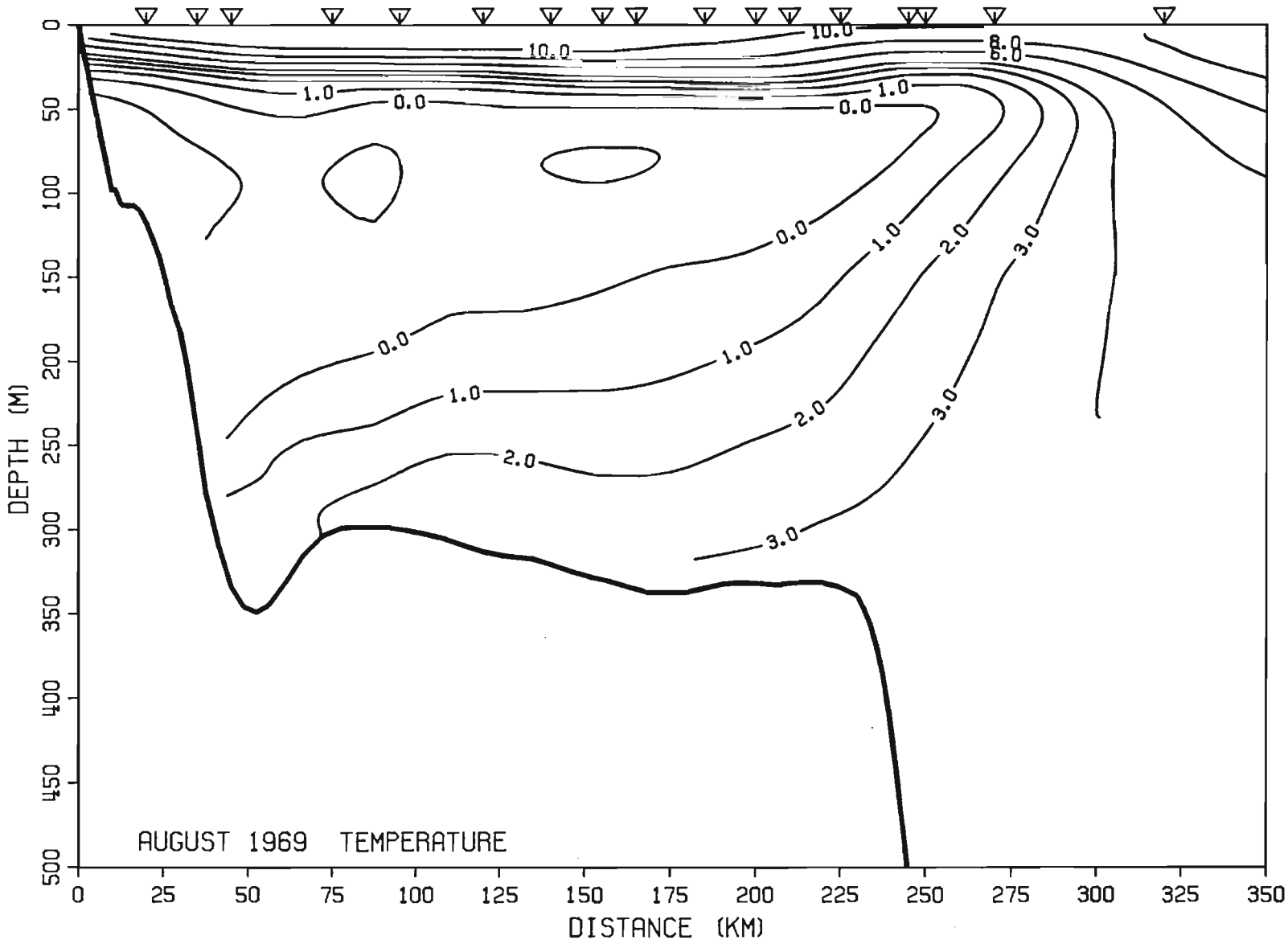
AUGUST 1969 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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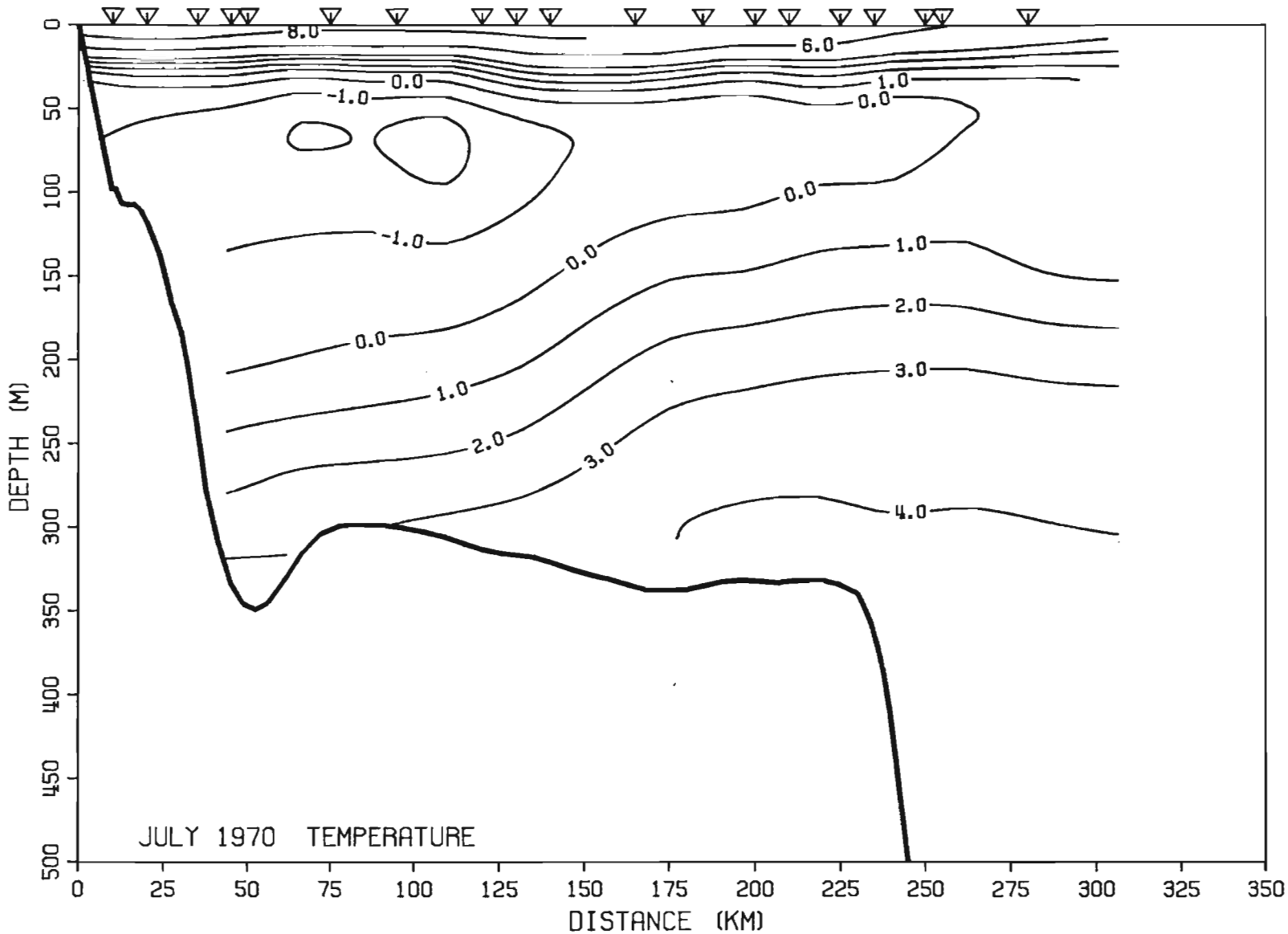
3.0


JULY 1970 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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200
250
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350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
8.0
6.0
0.0
1.0
-1.0
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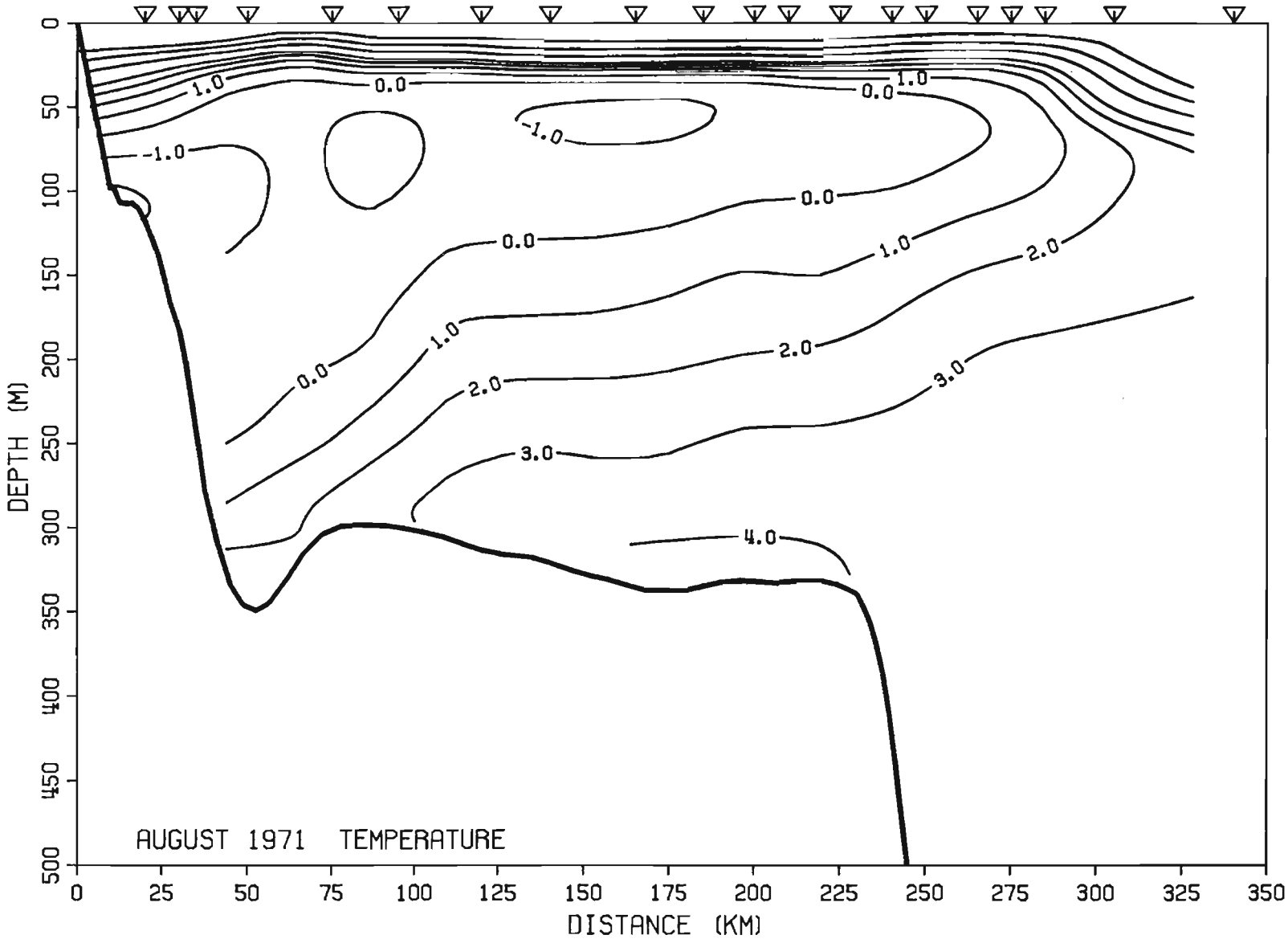
4.0


AUGUST 1971 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
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300
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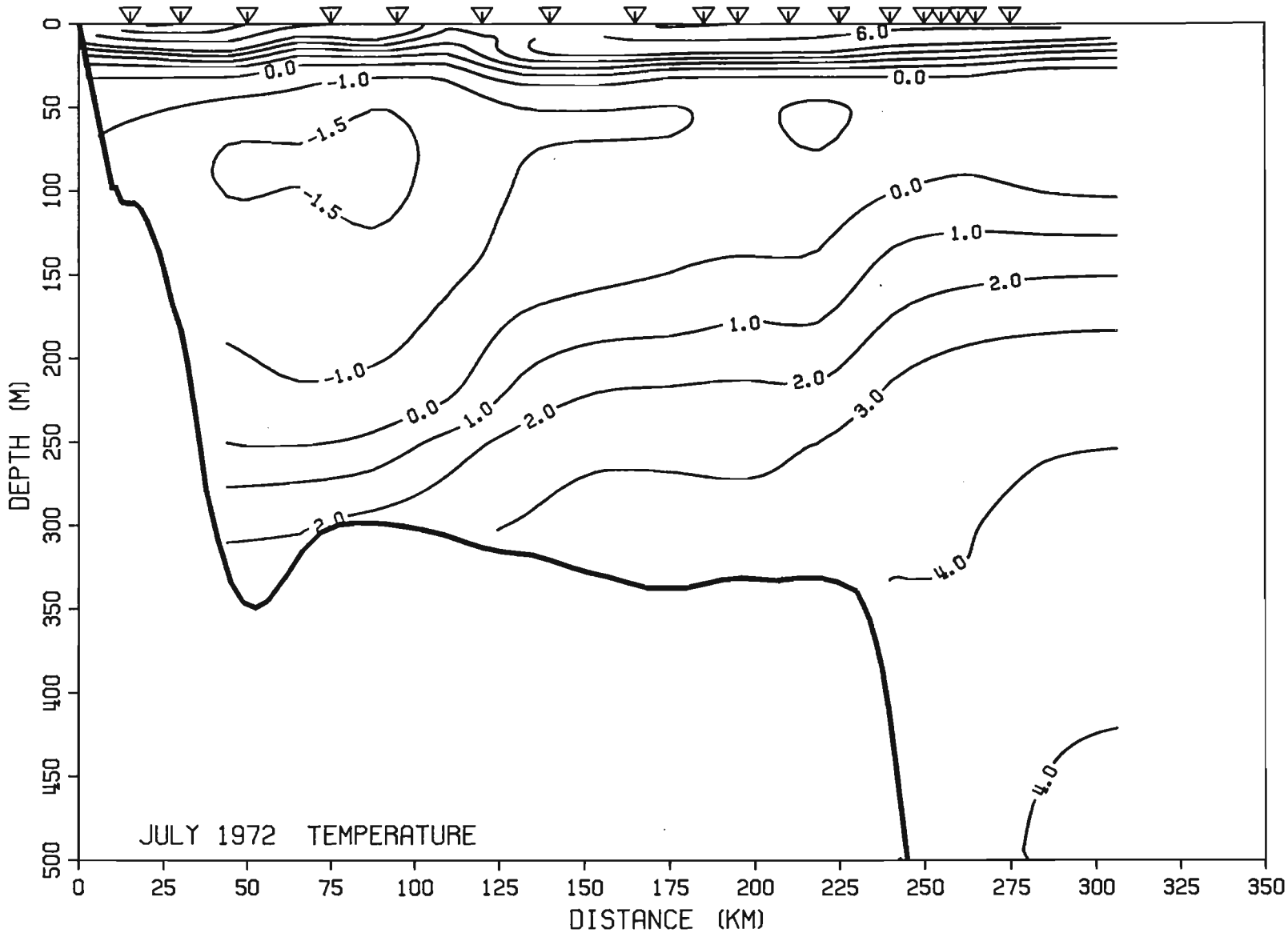
JULY 1972 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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200
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400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
6.0
0.0
-1.0
-1.5
-1.5
0.0
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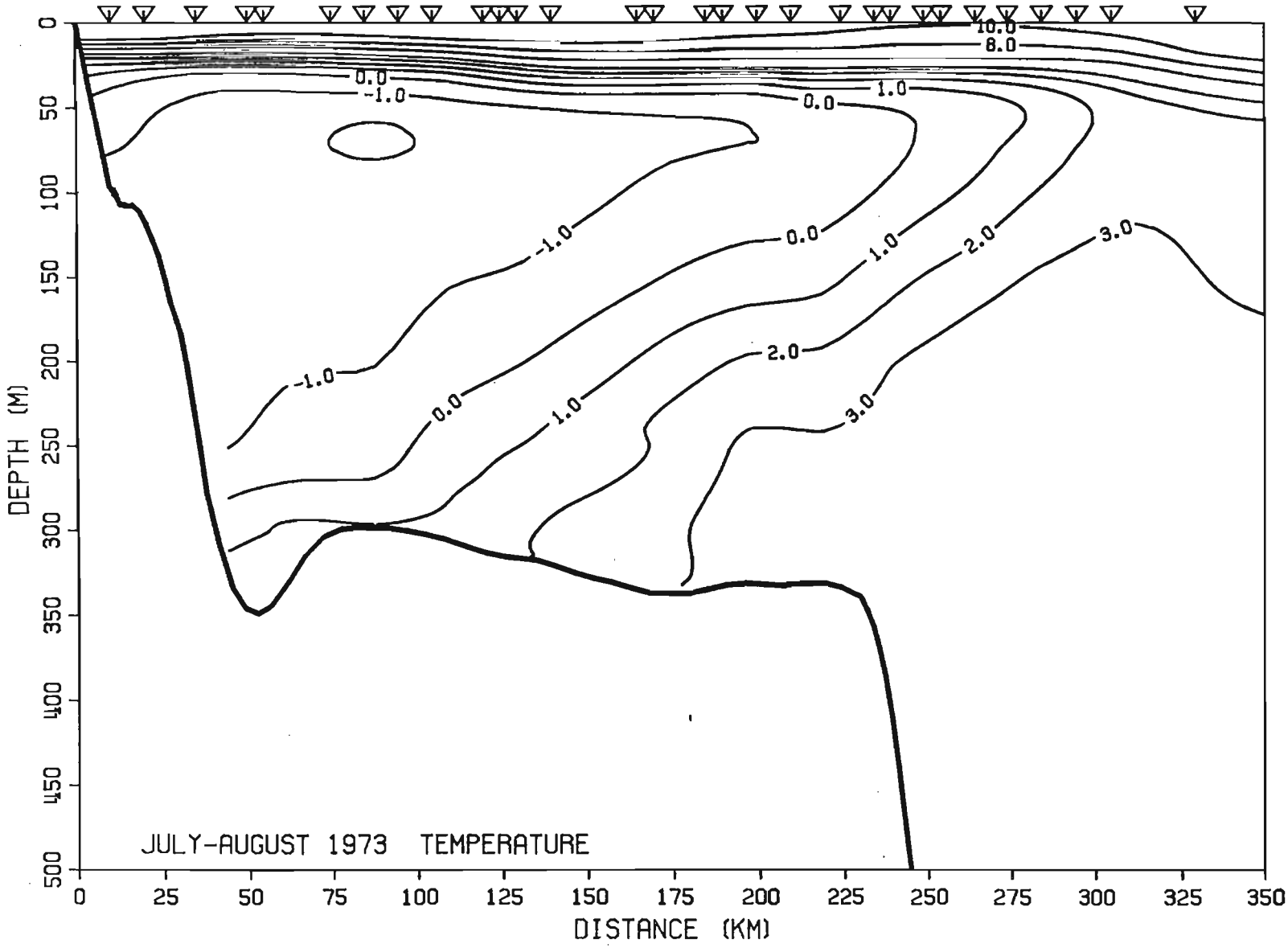
JULY-AUGUST 1973 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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150
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300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
10.0
8.0
0.0
-1.0
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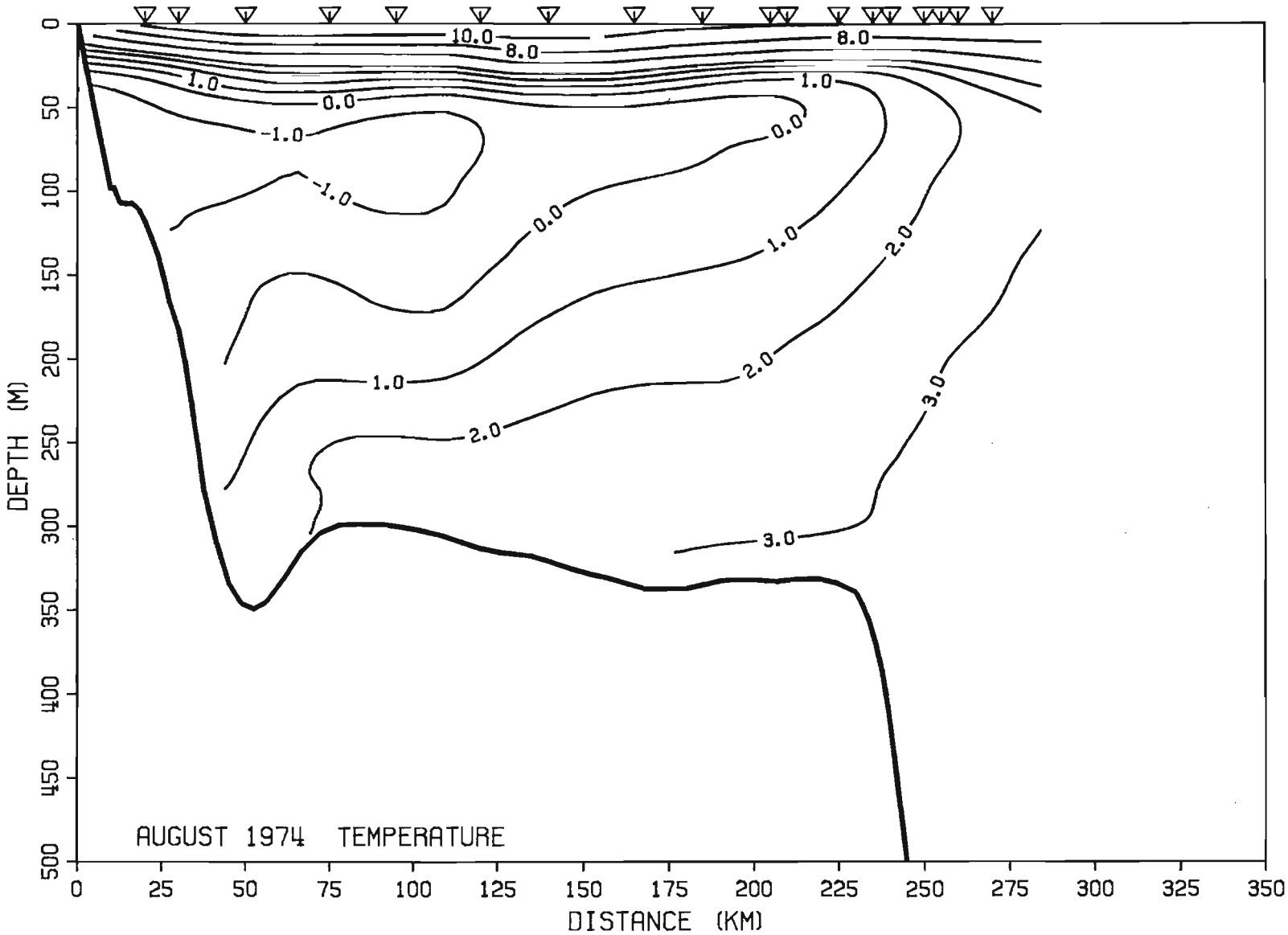
AUGUST 1974 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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200
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350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
10.0
8.0
8.0
1.0
0.0
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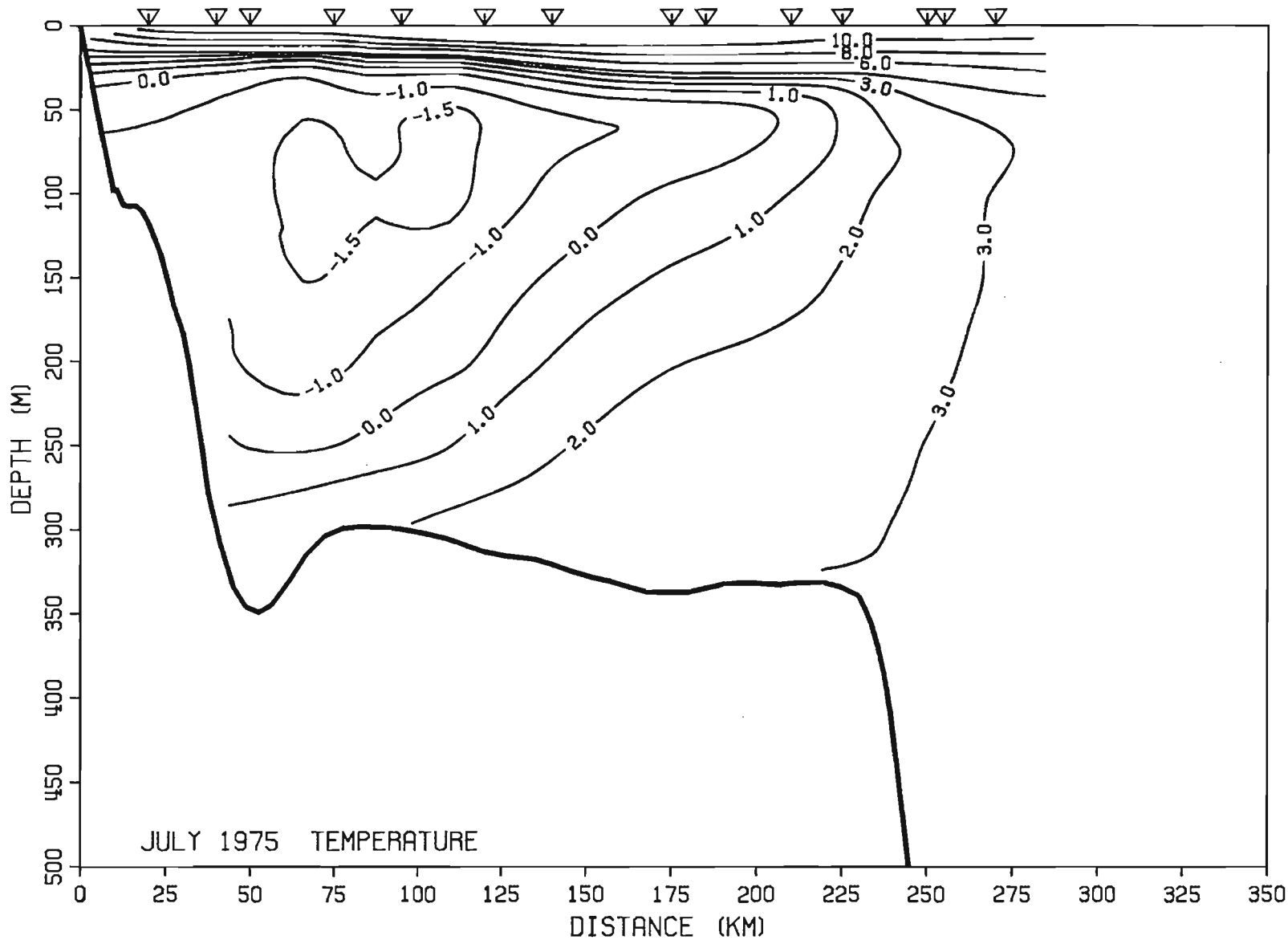
JULY 1975 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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100
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200
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400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
10.0
8.0
6.0
3.0
1.0
0.0
-1.0
-1.5
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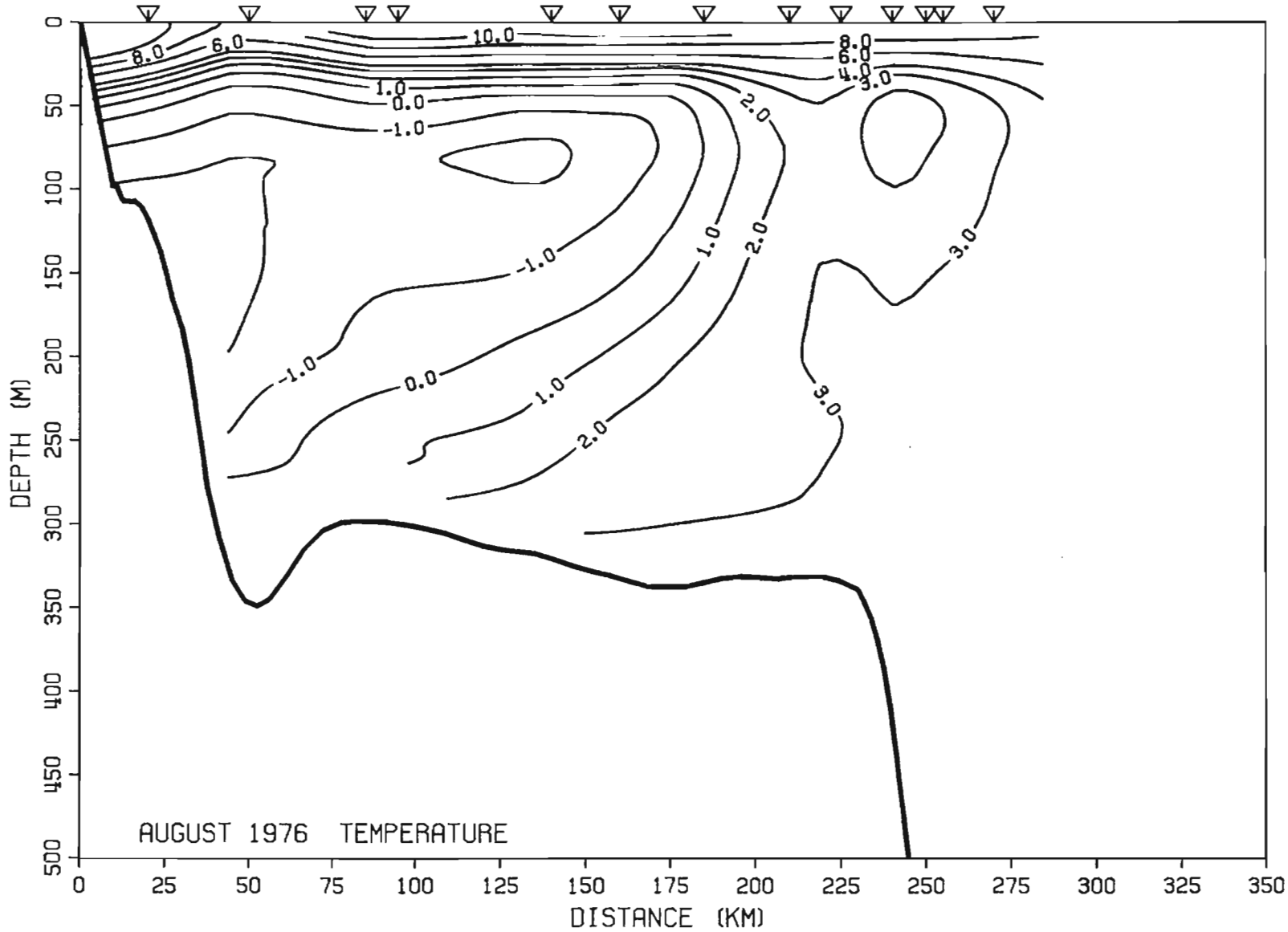
2.0
3.0


AUGUST 1976 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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100
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200
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400
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500
0
25
50
75
100
125
150
175
200
225
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6.0
4.0
3.0
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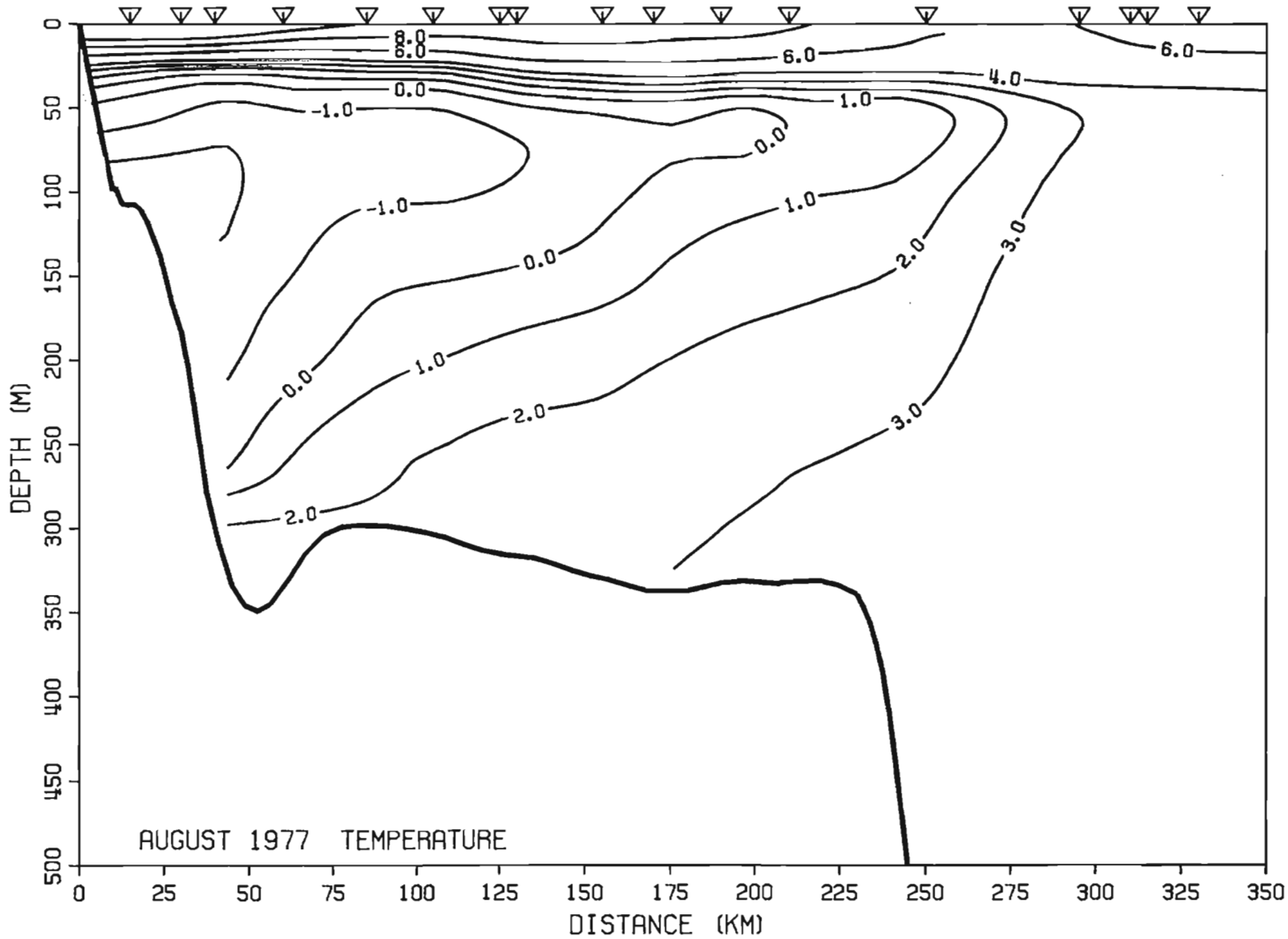
0.0
-1.0


AUGUST 1977 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
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250
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300
325
350
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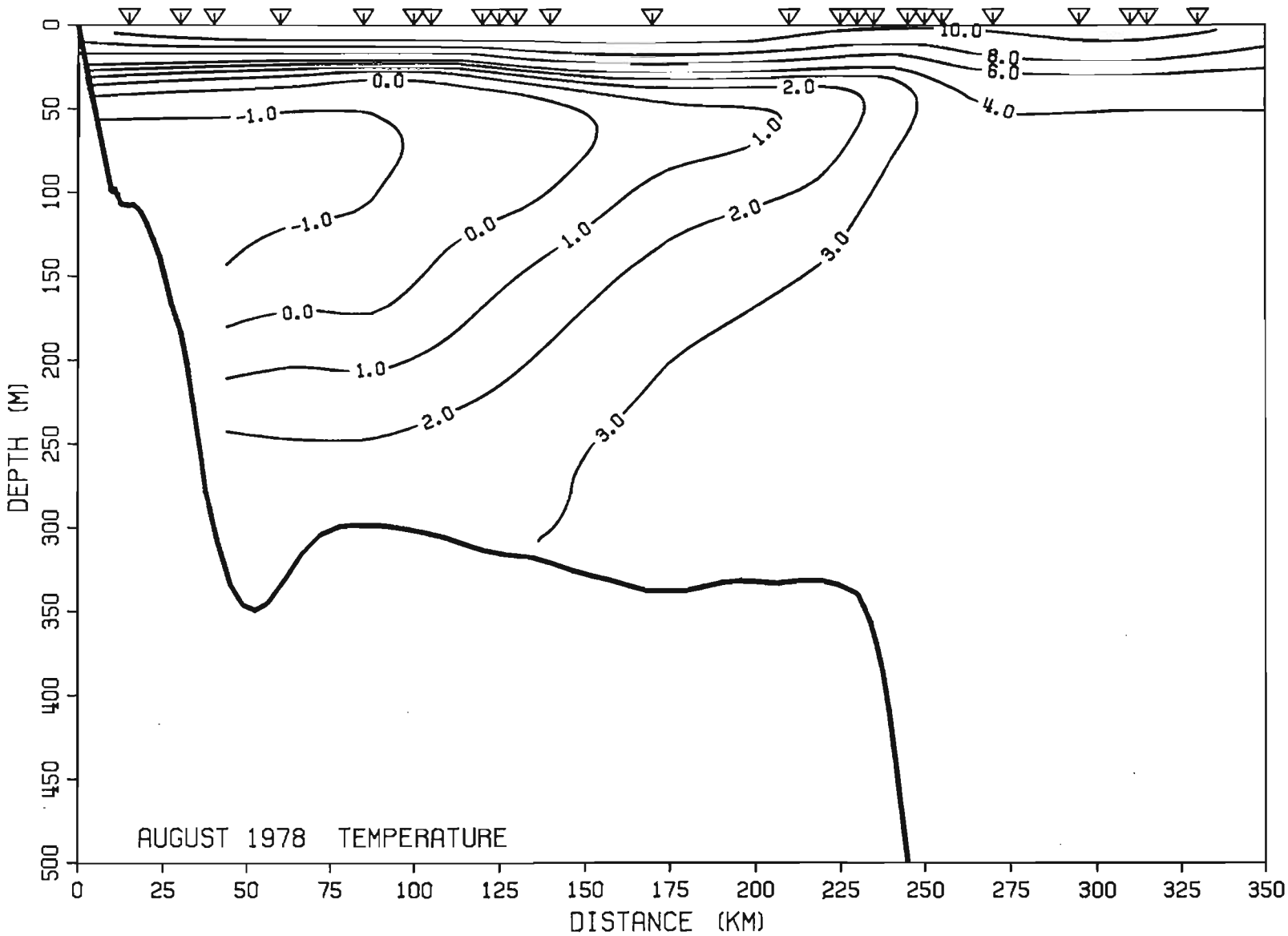
6.0
4.0
0.0
-1.0
1.0
2.0
3.0


AUGUST 1978 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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100
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200
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400
450
500
0
25
50
75
100
125
150
175
200
225
250
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300
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10.0
8.0
6.0
4.0
2.0
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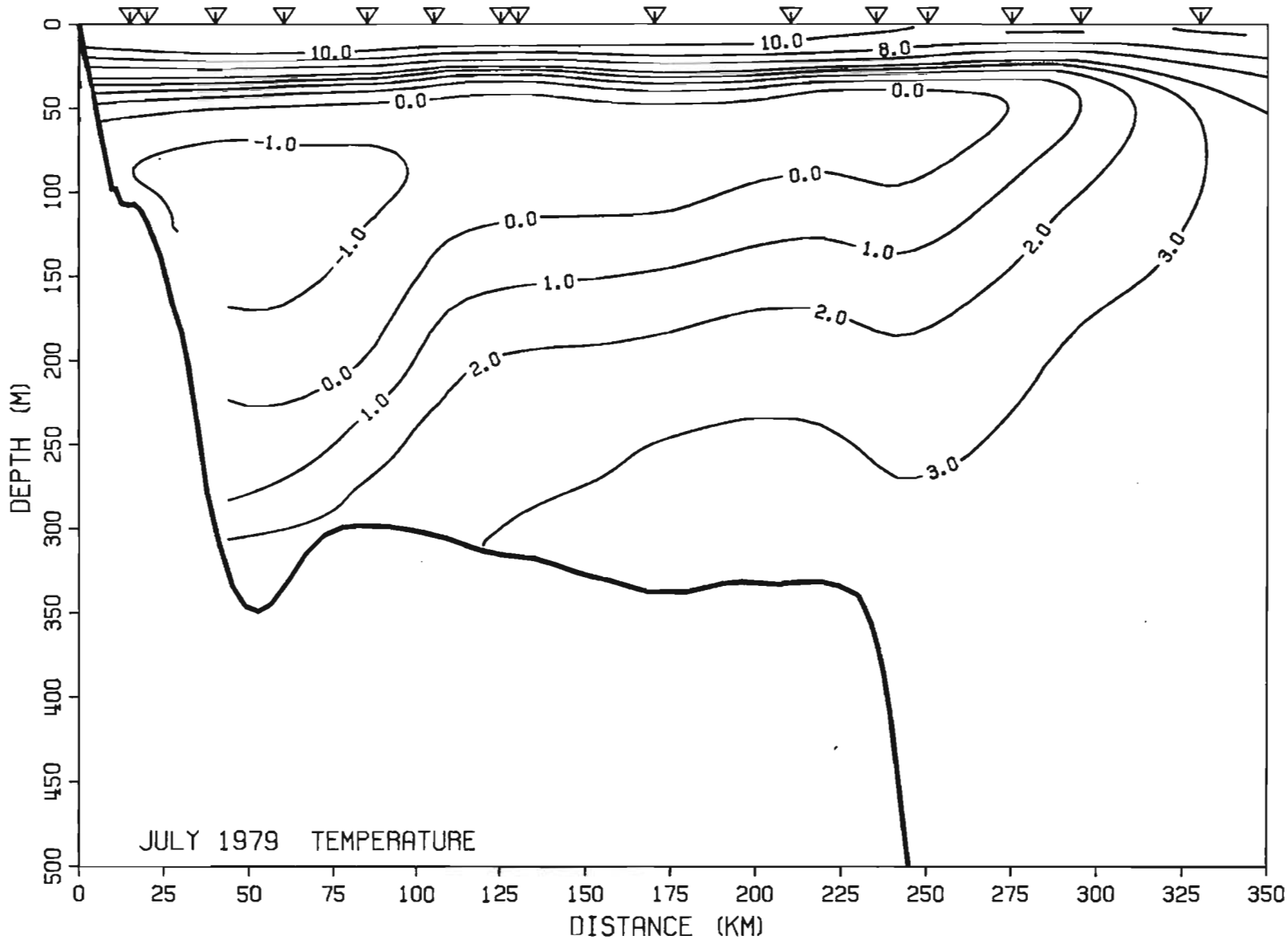
2.0
3.0


JULY 1979 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
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100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
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275
300
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-1.0
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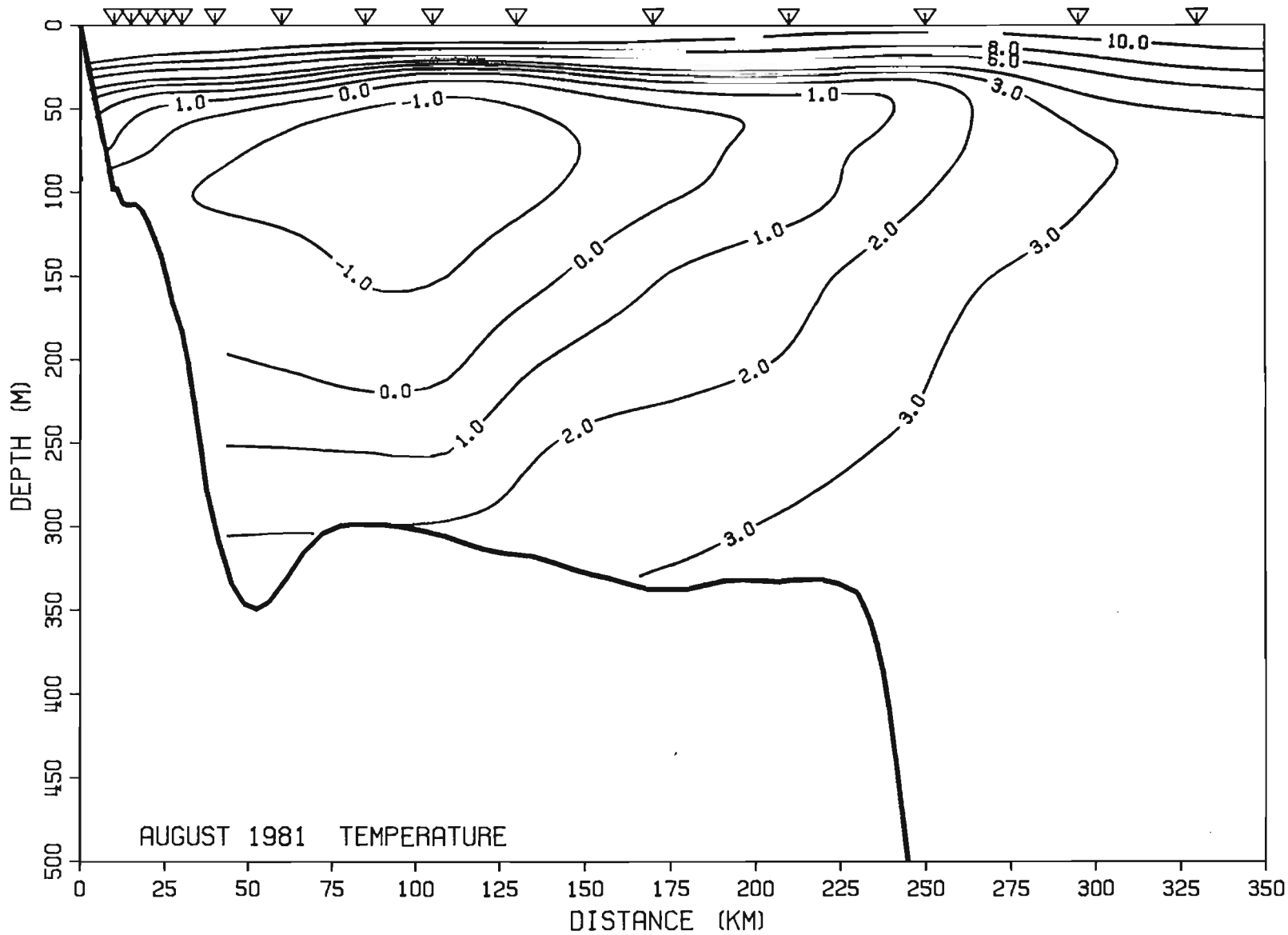
2.0
3.0


AUGUST 1981 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
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100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
10.0
8.0
6.0
3.0
1.0
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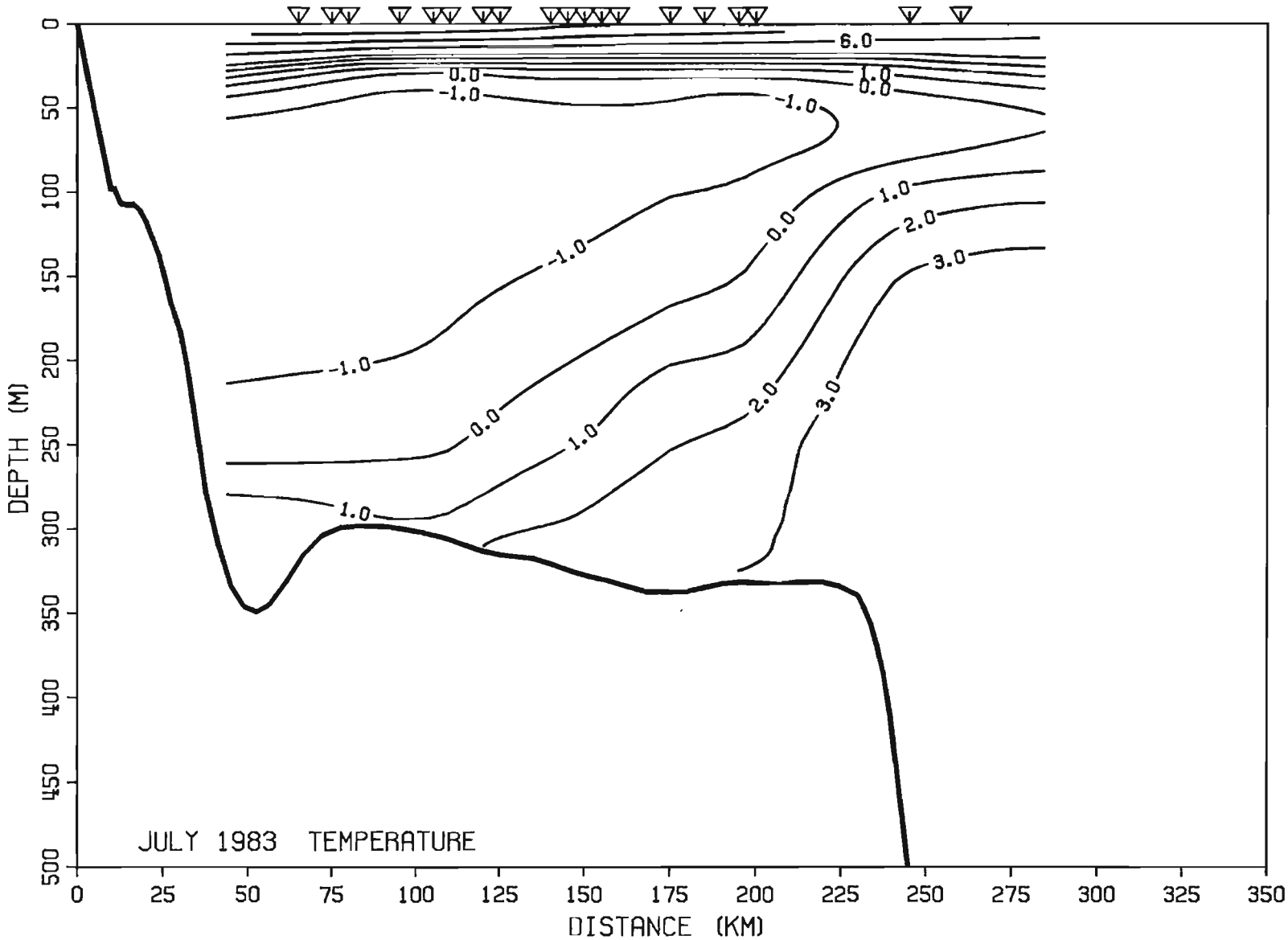
-1.0
2.0


JULY 1983 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
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100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
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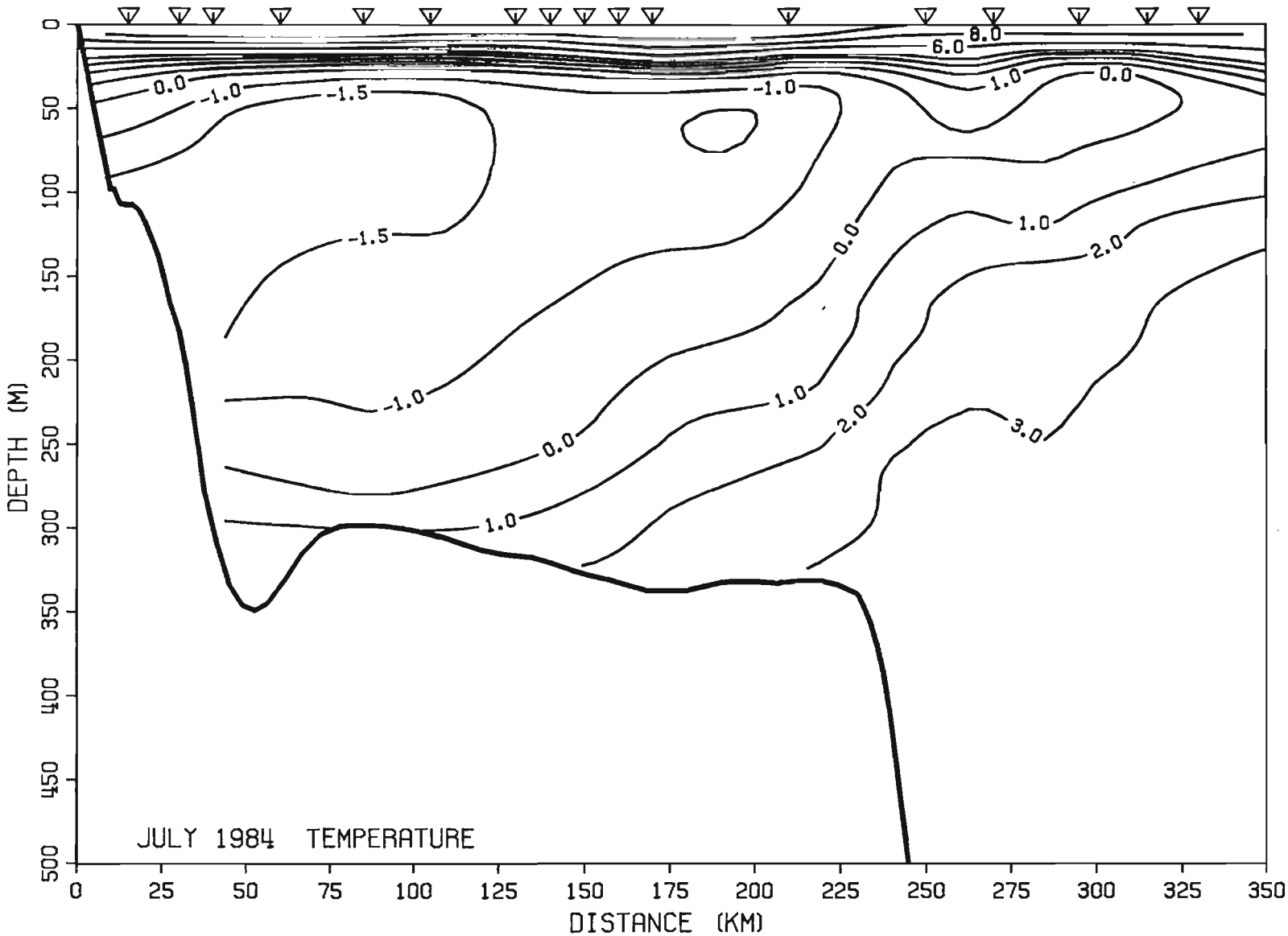
-1.0
1.0
2.0
3.0


JULY 1984 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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150
200
250
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350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
8.0
6.0
0.0
-1.0
-1.5
-1.0
1.0
0.0
-1.5
0.0
1.0
2.0
-1.0
1.0
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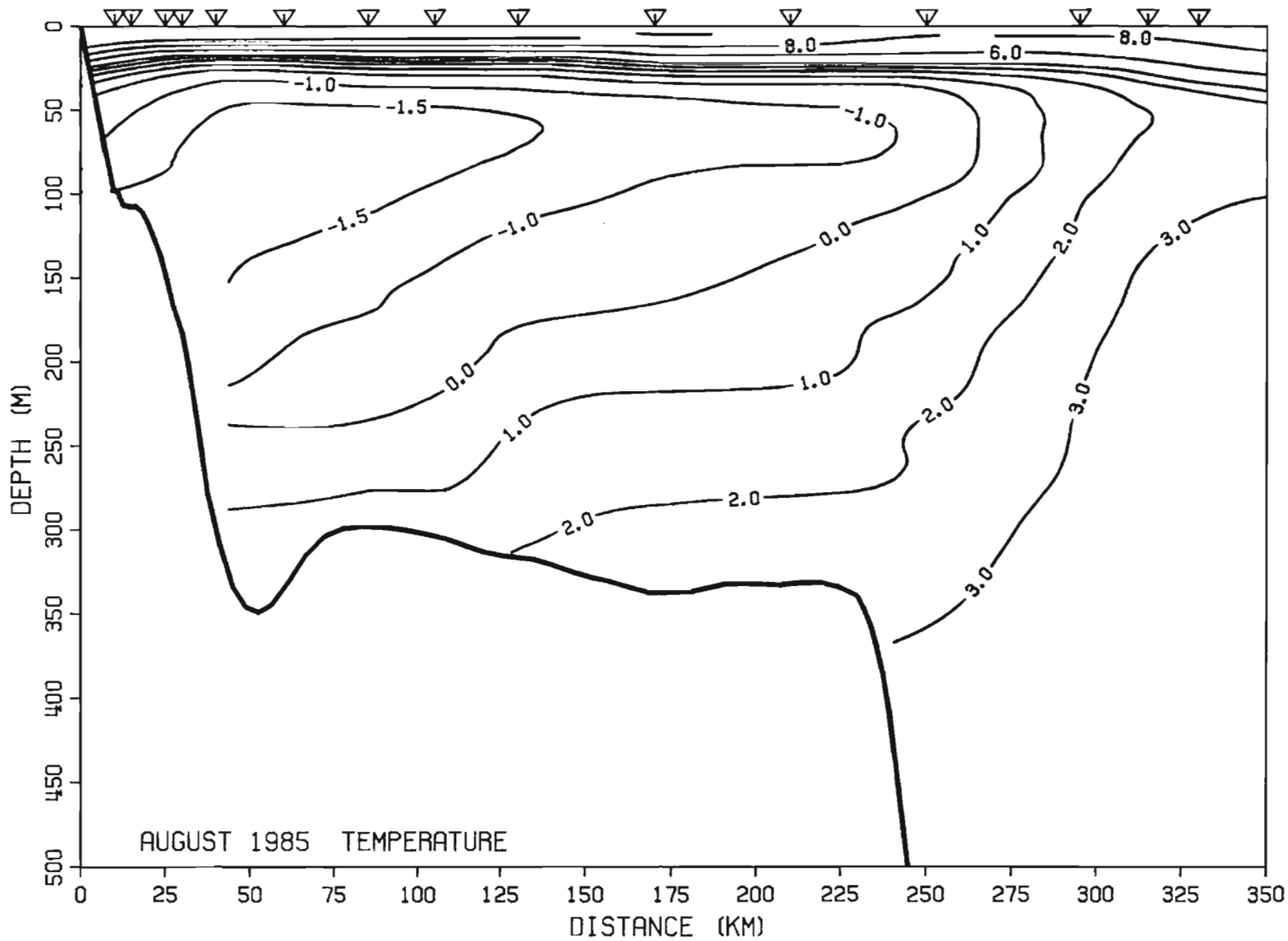
0.0
3.0
1.0


AUGUST 1985 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
8.0
6.0
8.0
-1.0
-1.5
-1.0
-1.5
-1.0
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3.0
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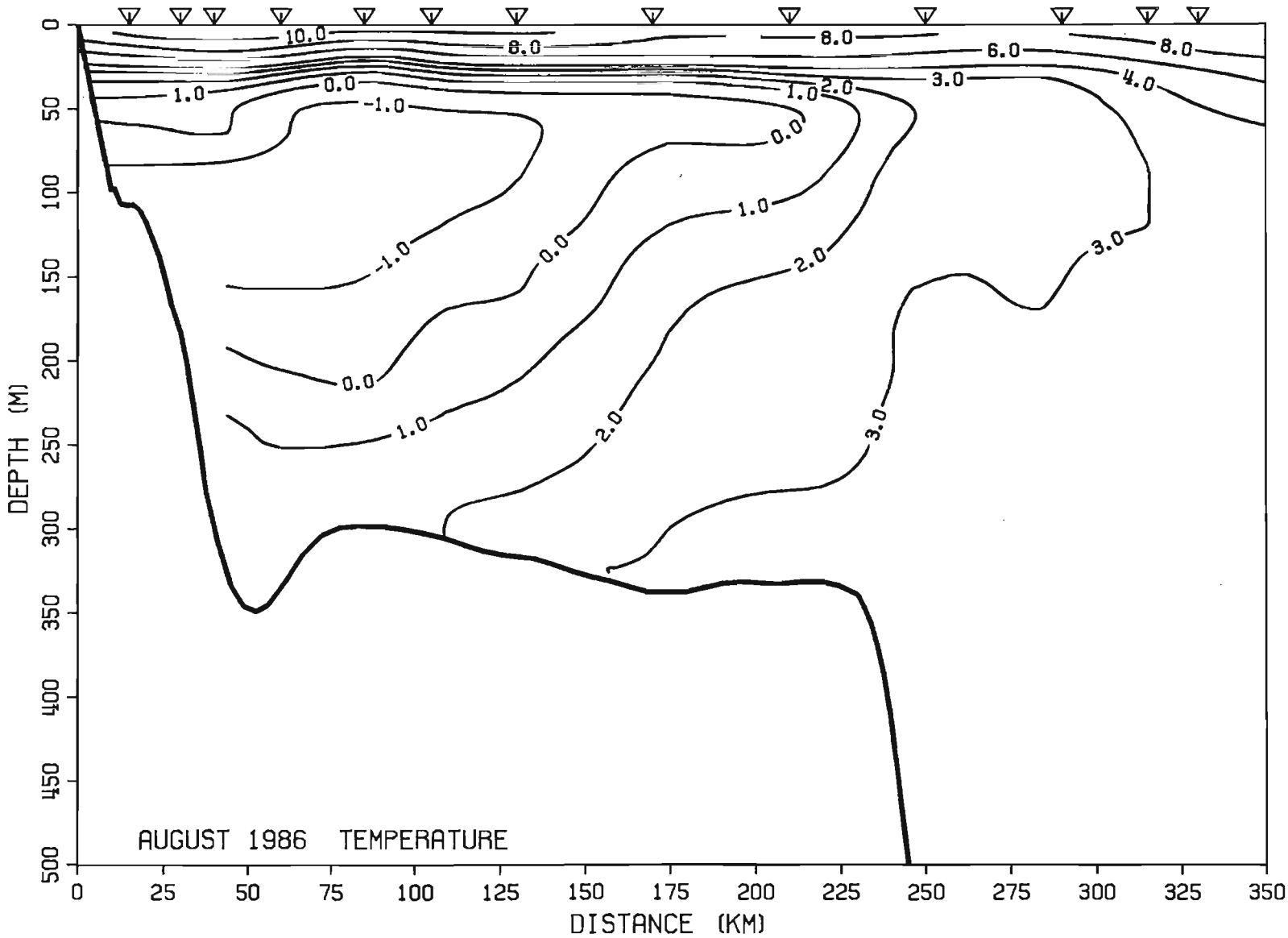
2.0
3.0


AUGUST 1986 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
10.0
8.0
8.0
6.0
8.0
1.0
0.0
-1.0
1.0
2.0
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3.0
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2.0
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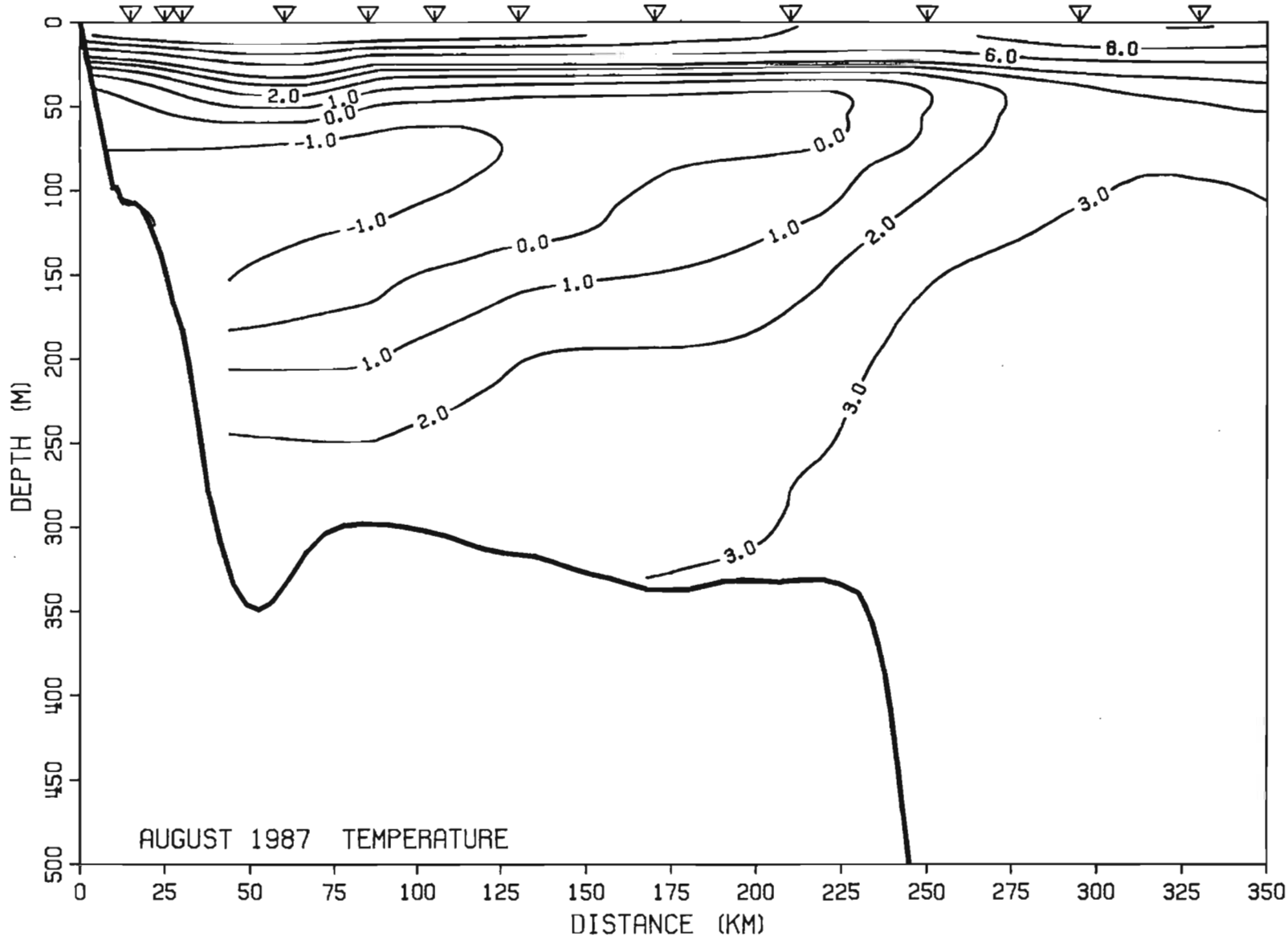
AUGUST 1987 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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200
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300
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400
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500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
8.0
6.0
2.0
1.0
0.0
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-1.0
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1.0
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2.0
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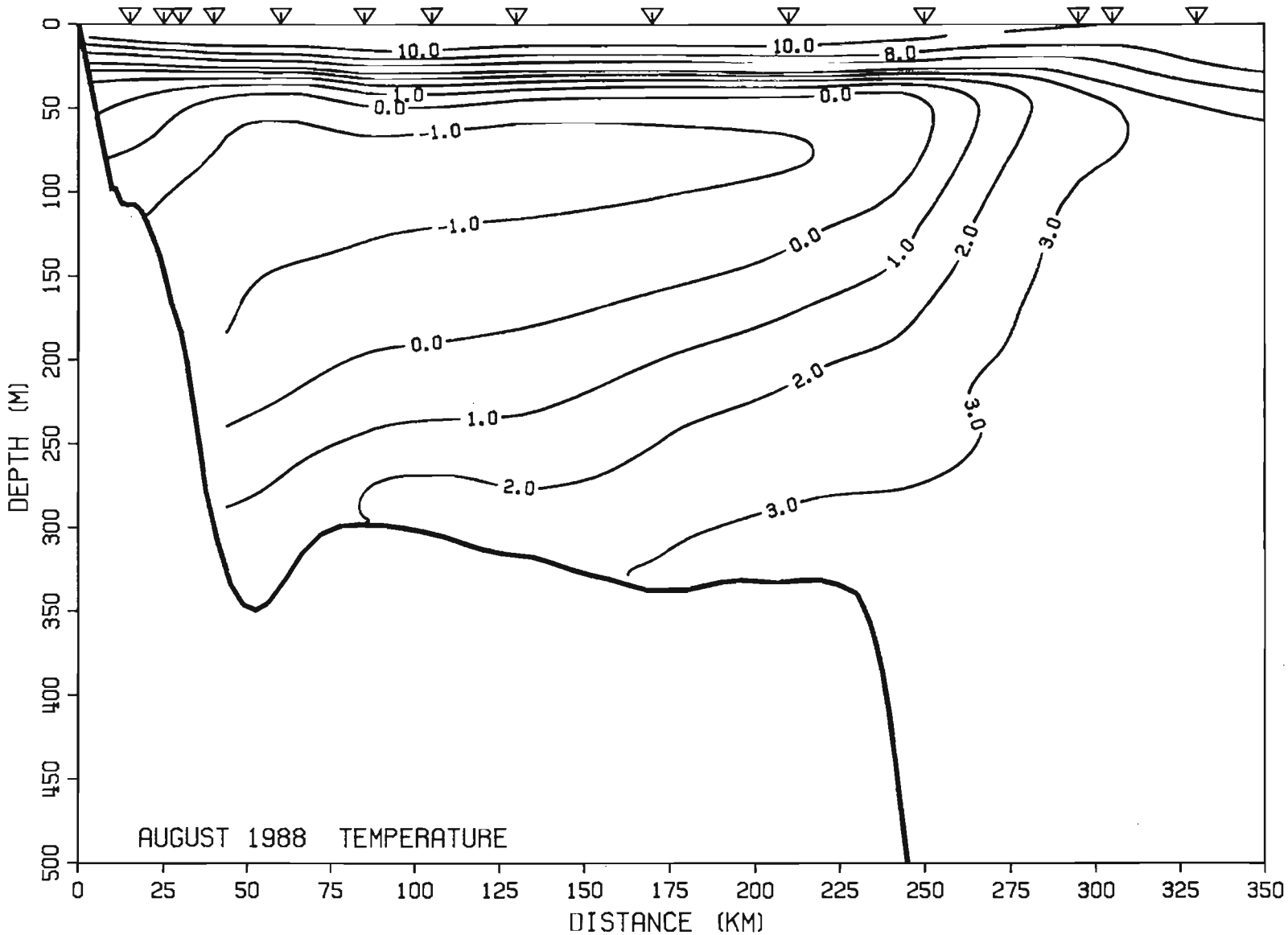
AUGUST 1988 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
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275
300
325
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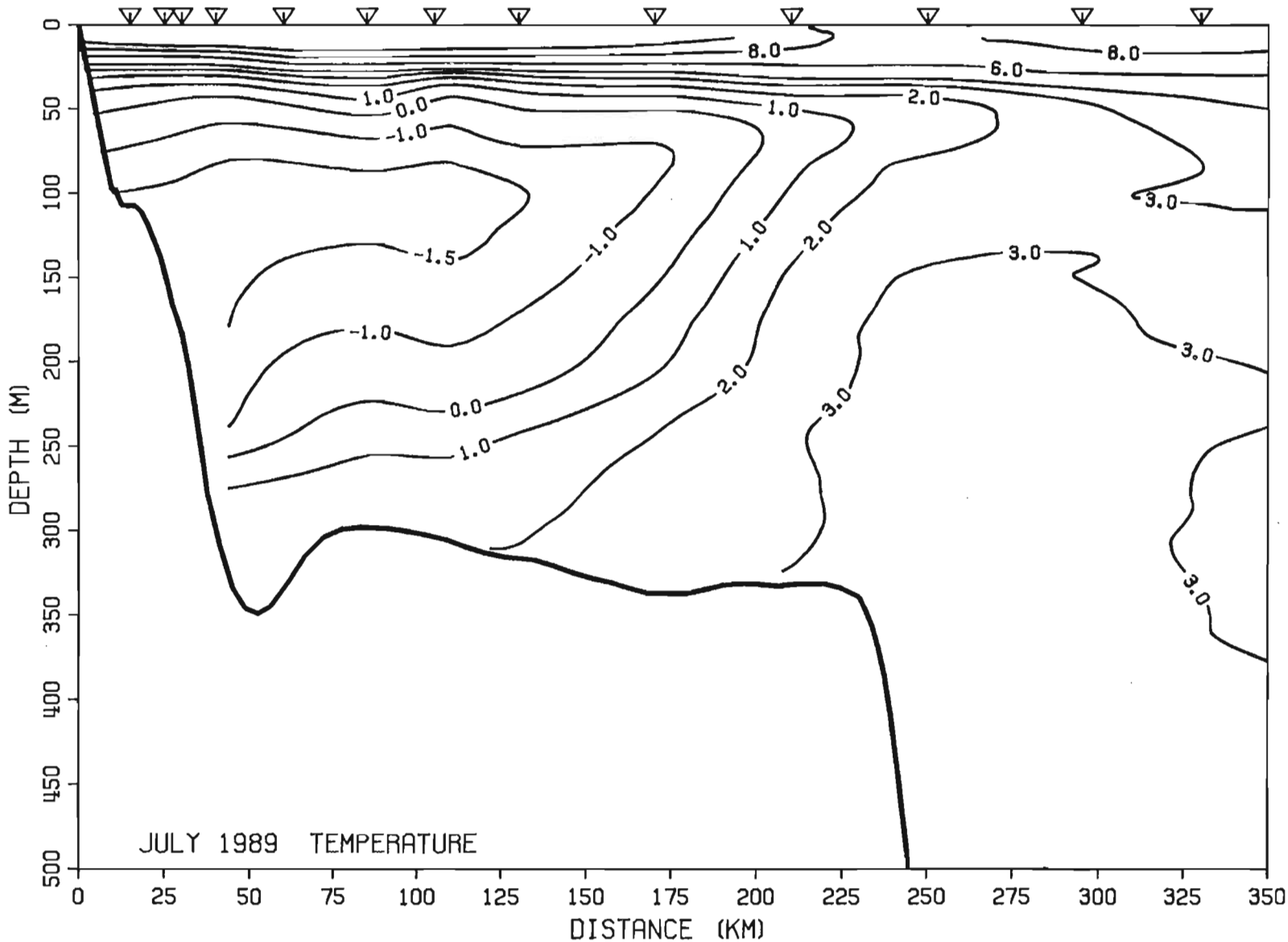
1.0
0.0
-1.0
2.0
3.0


JULY 1989 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
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325
350
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1.0
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-1.0
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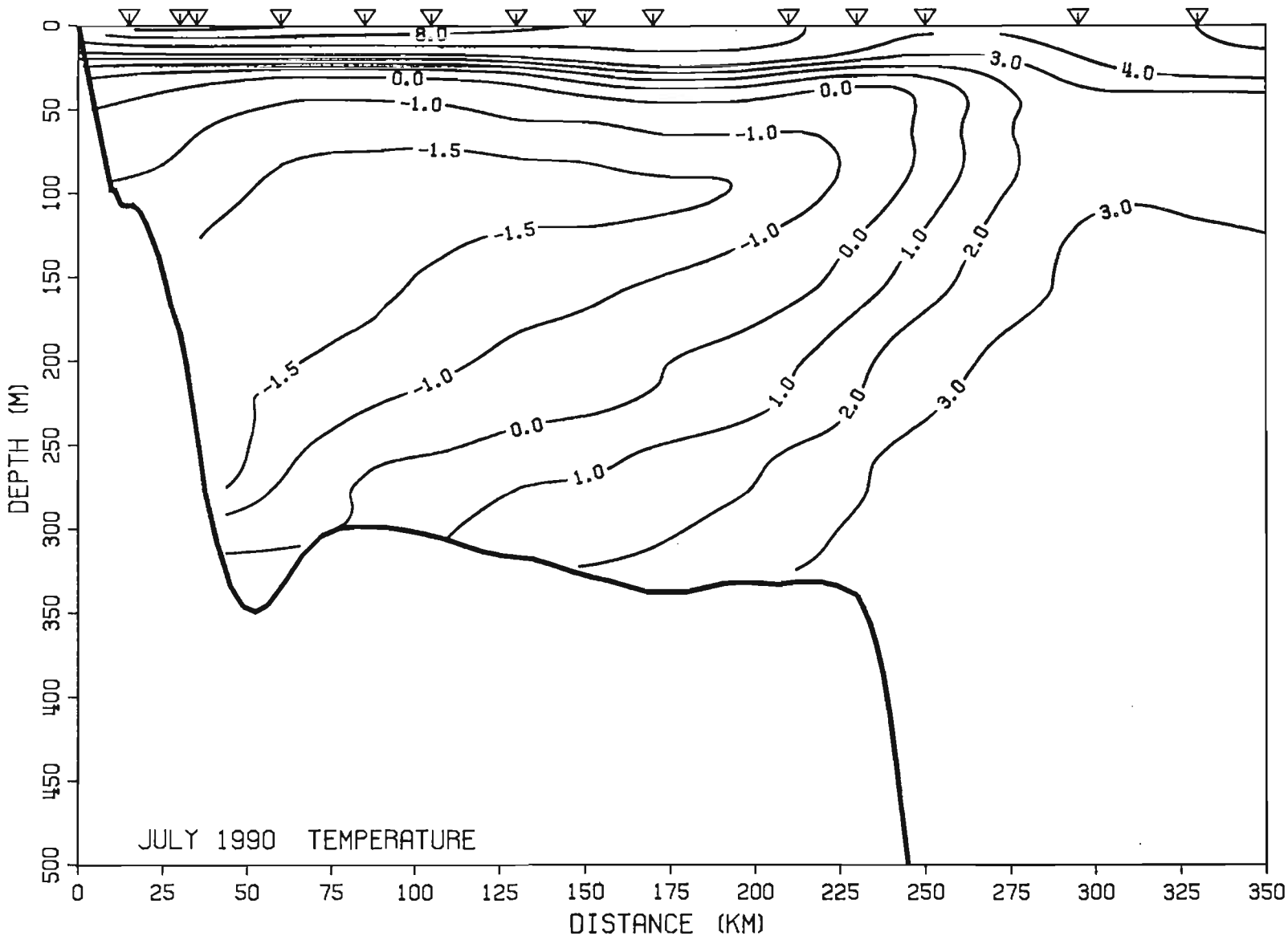
3.0


JULY 1990 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
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100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
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325
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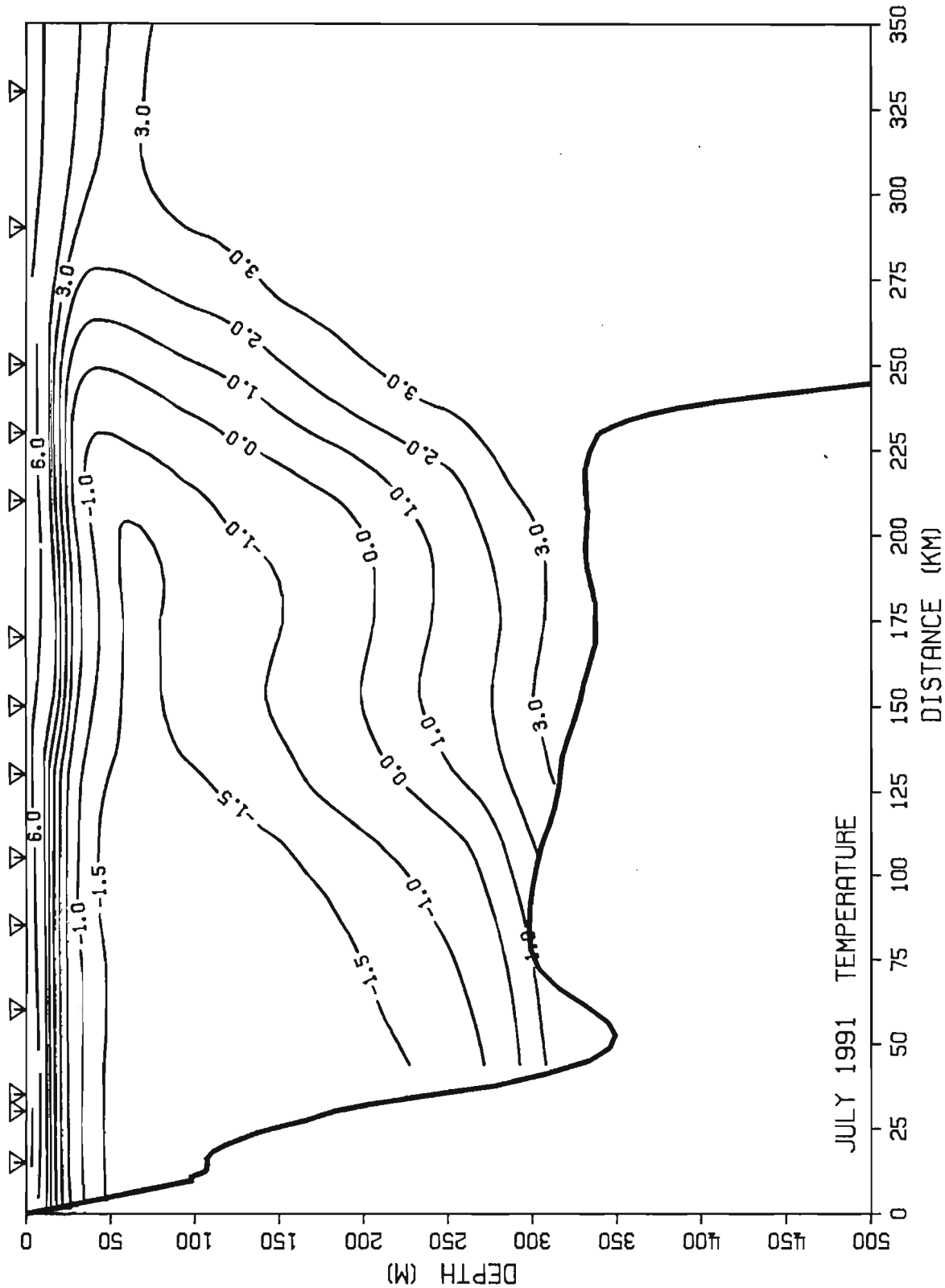
3.0
4.0
0.0
-1.0
-1.5
1.0
2.0


JULY 1991 TEMPERATURE
DISTANCE (KM)
DEPTH (M)
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75
100
125
150
175
200
225
250
275
300
325
350
0
50
100
150
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250
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350
400
450
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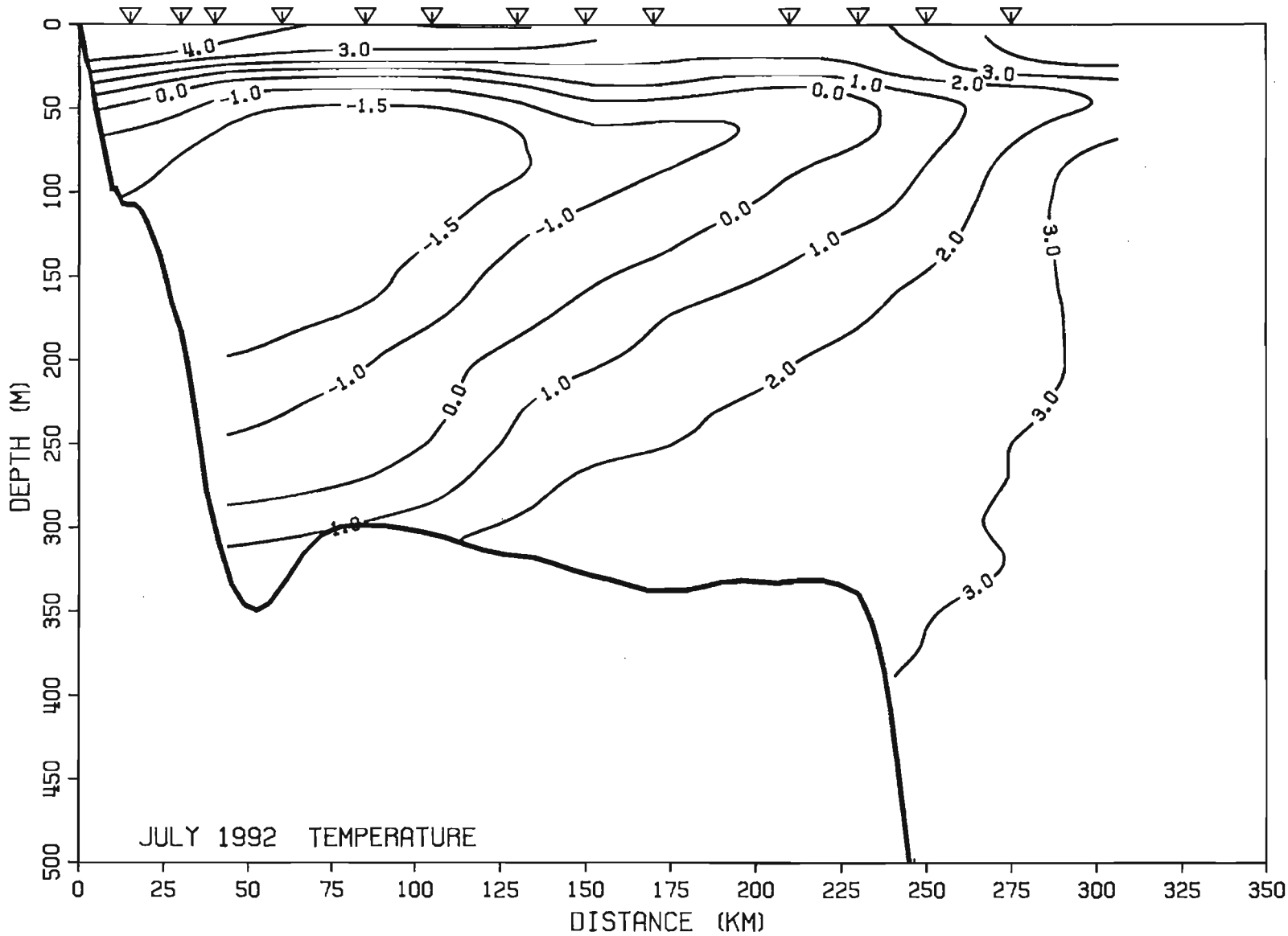
3.0
2.0
1.0
0.0
-1.0
-1.5
6.0


JULY 1992 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
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250
275
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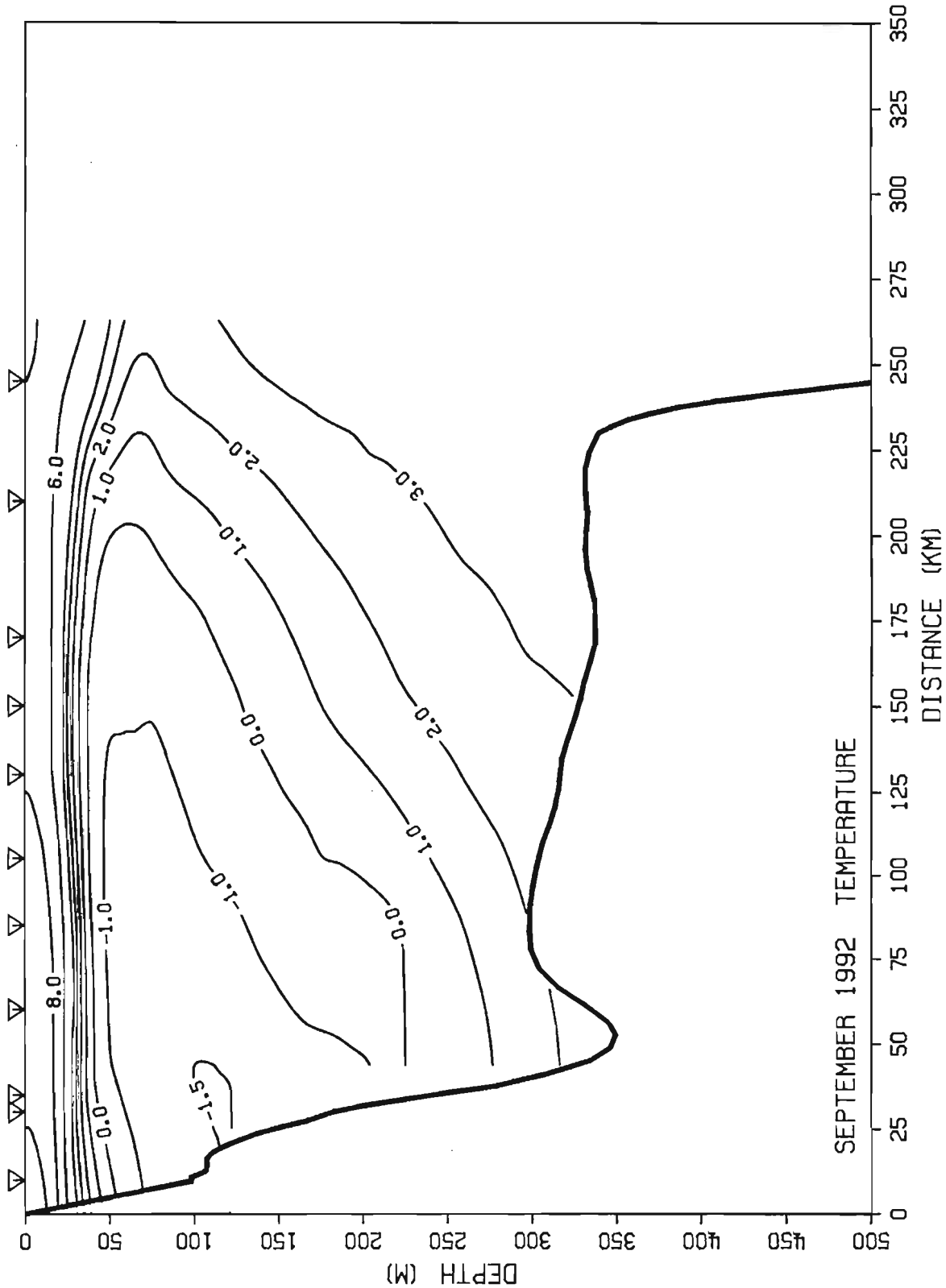
325
350
4.0
3.0
0.0
-1.0
-1.5
1.0
2.0
3.0


SEPTEMBER 1992 TEMPERATURE
DISTANCE (KM)
DEPTH (M)
0
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50
75
100
125
150
175
200
225
250
275
300
325
350
0
50
100
150
200
250
300
350
400
450
500
8.0
6.0
2.0
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-1.5
-1.0
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2.0
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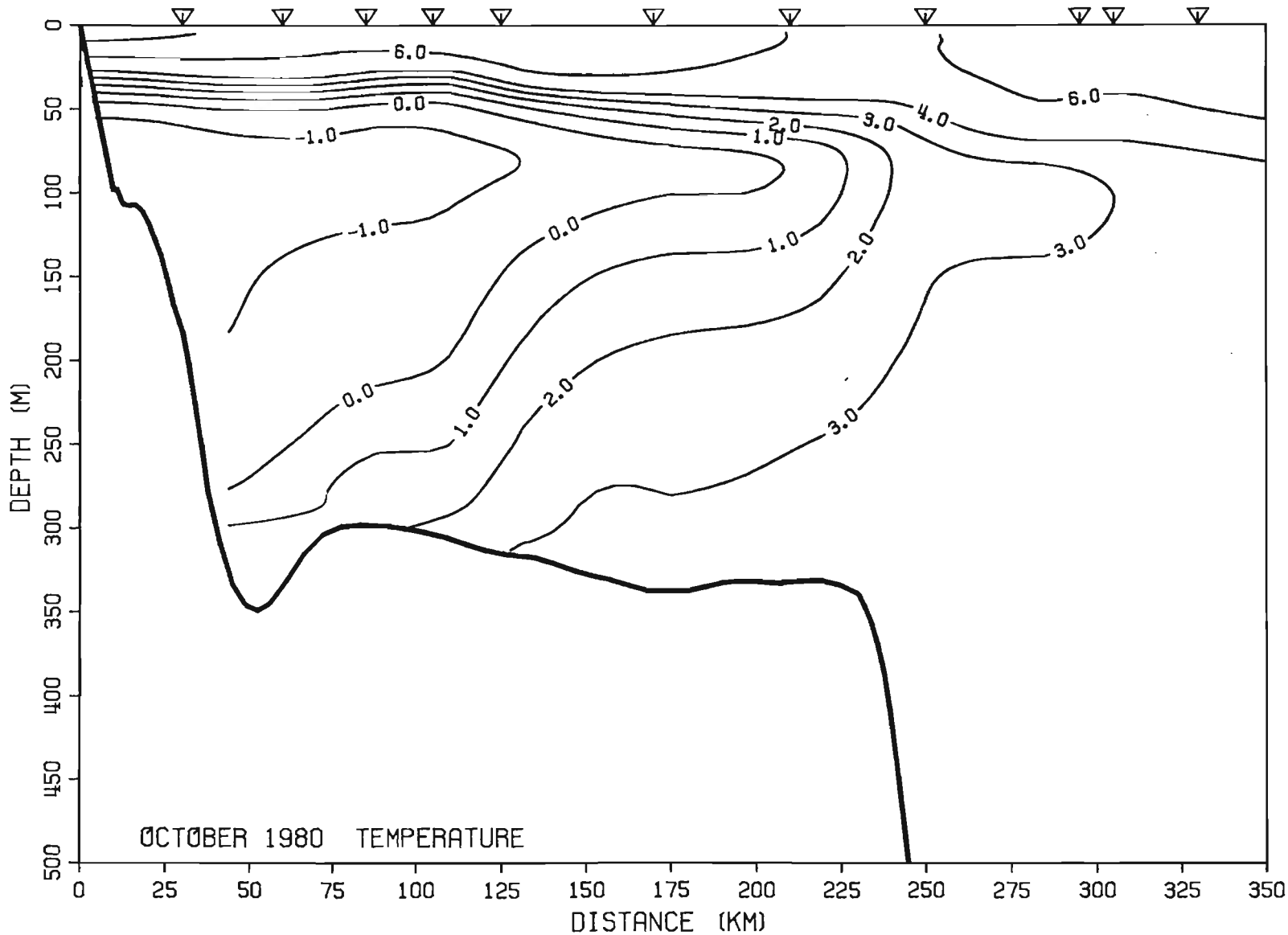
0.0


OCTOBER 1980 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
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100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
6.0
0.0
-1.0
-1.0
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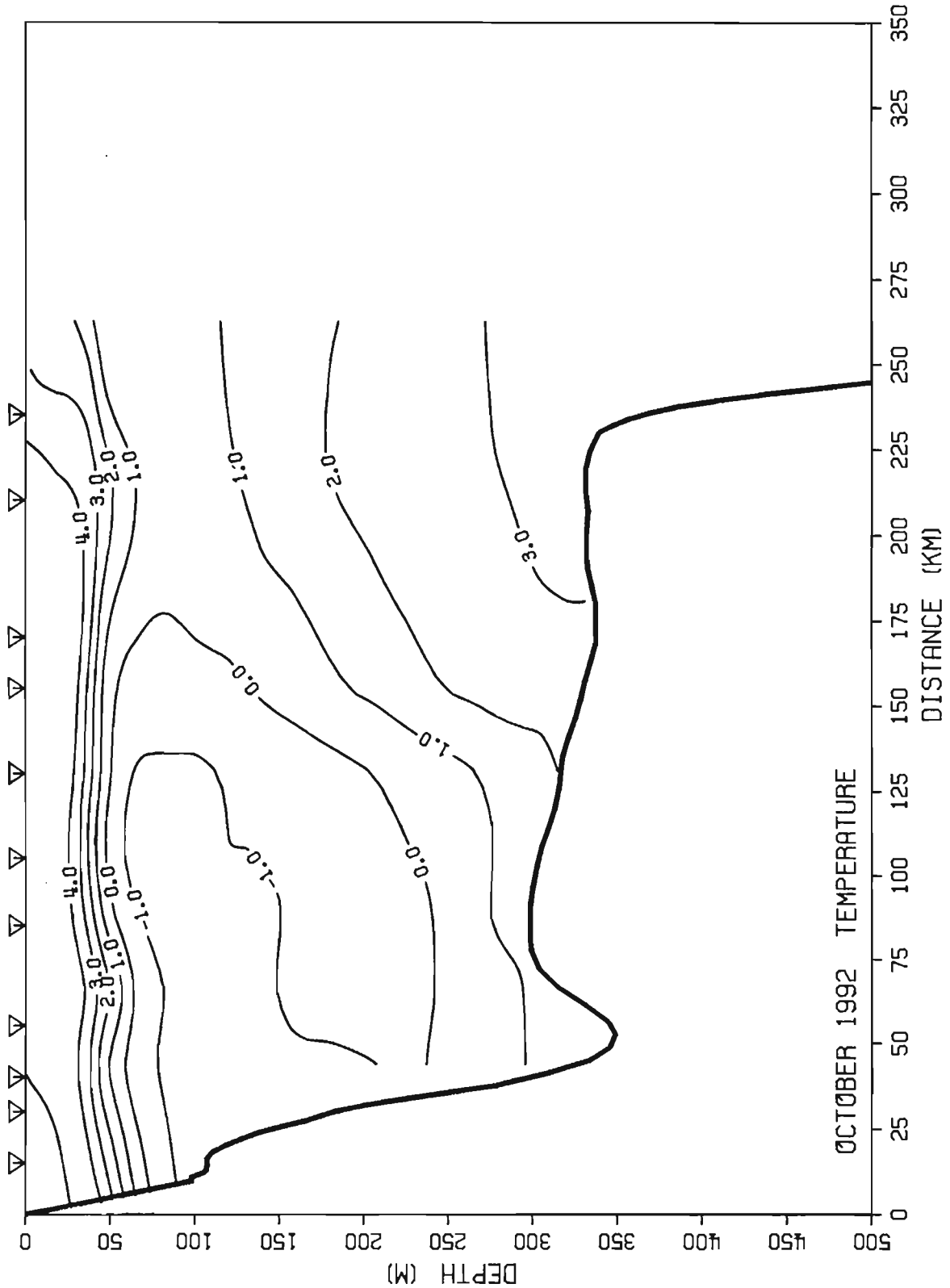
0.0
1.0
1.0
2.0
2.0
3.0
3.0
4.0
6.0


OCTOBER 1992 TEMPERATURE
DISTANCE (KM)
DEPTH (M)
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
0
50
100
150
200
250
300
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400
450
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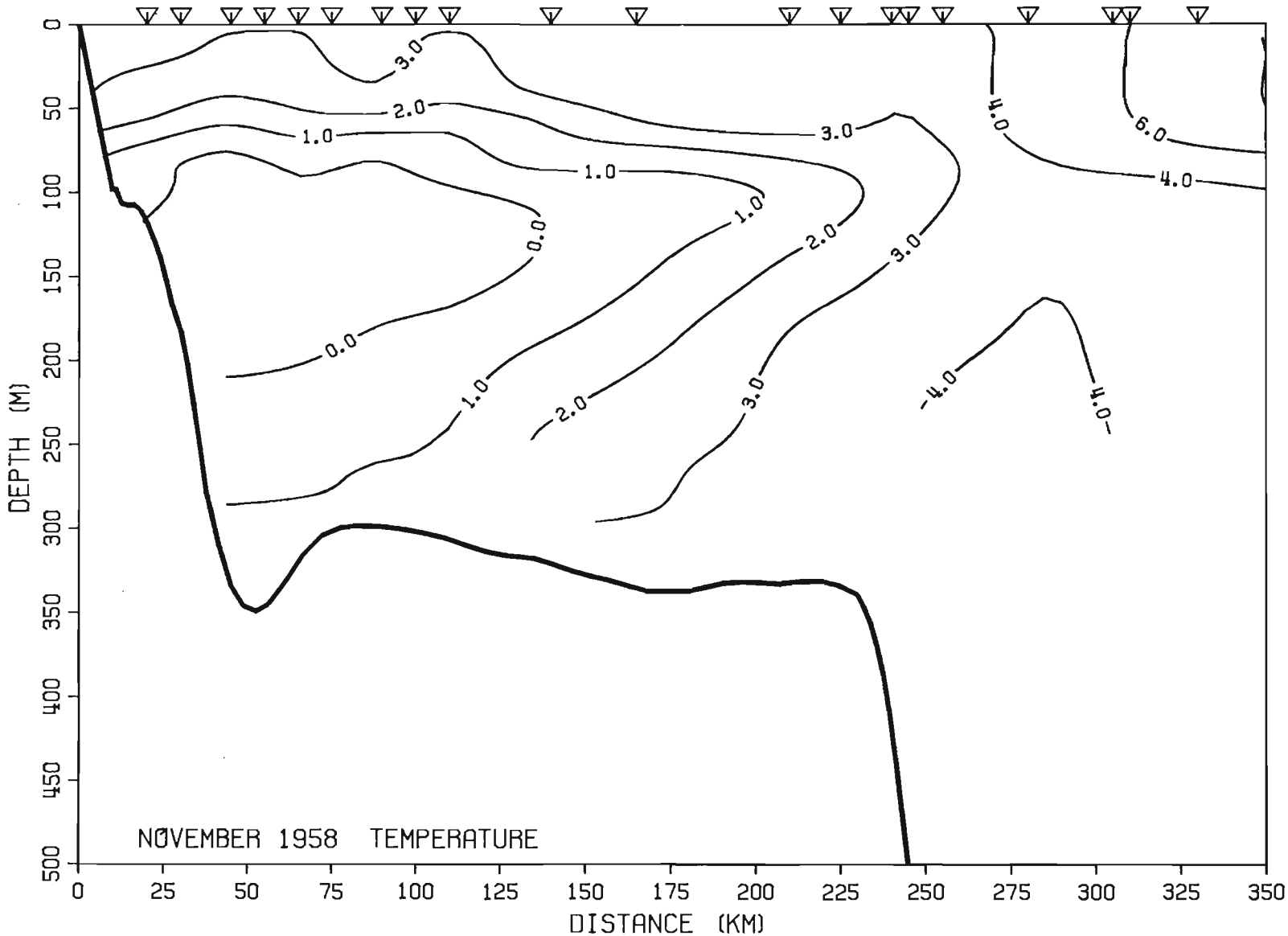
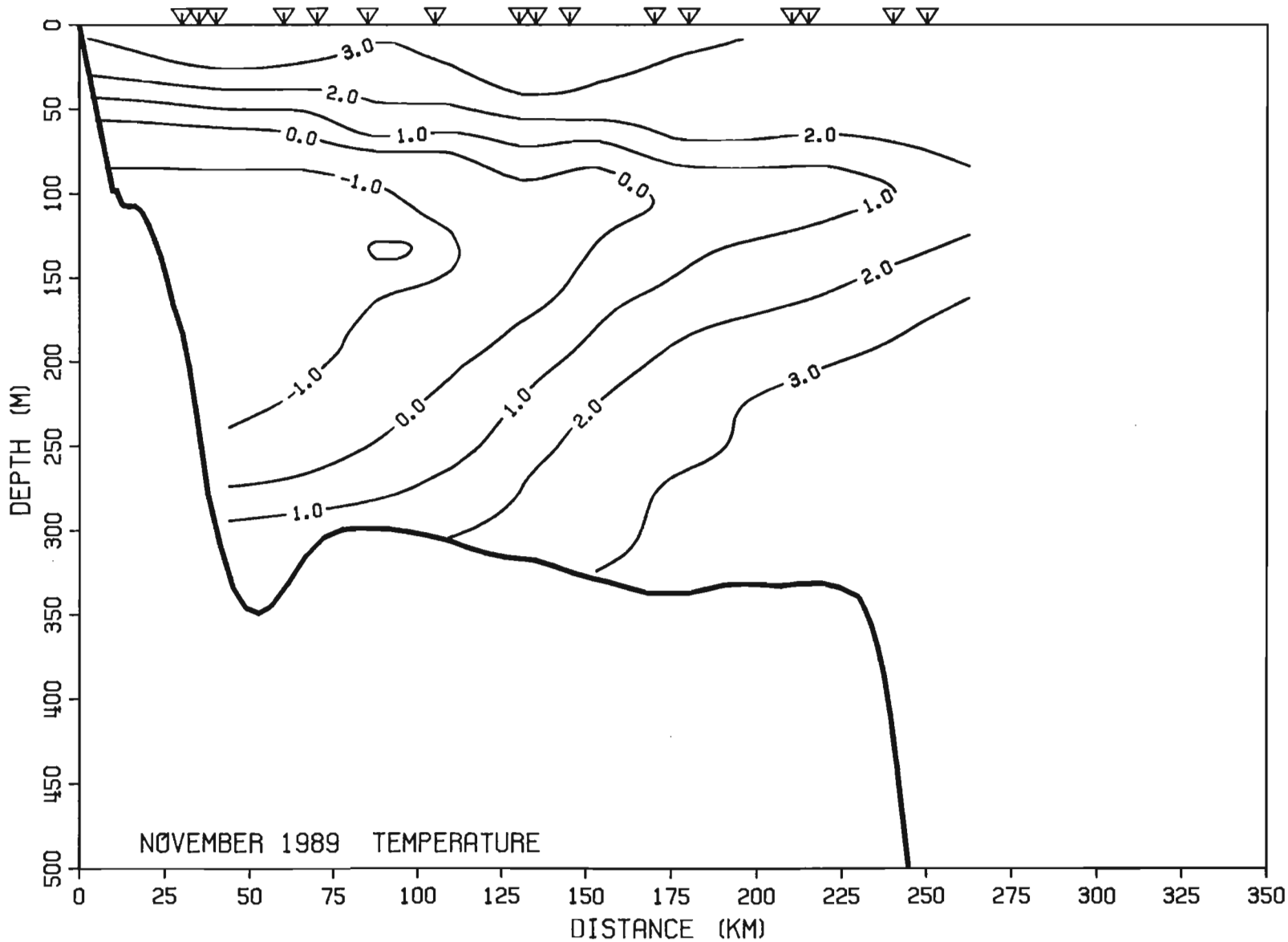
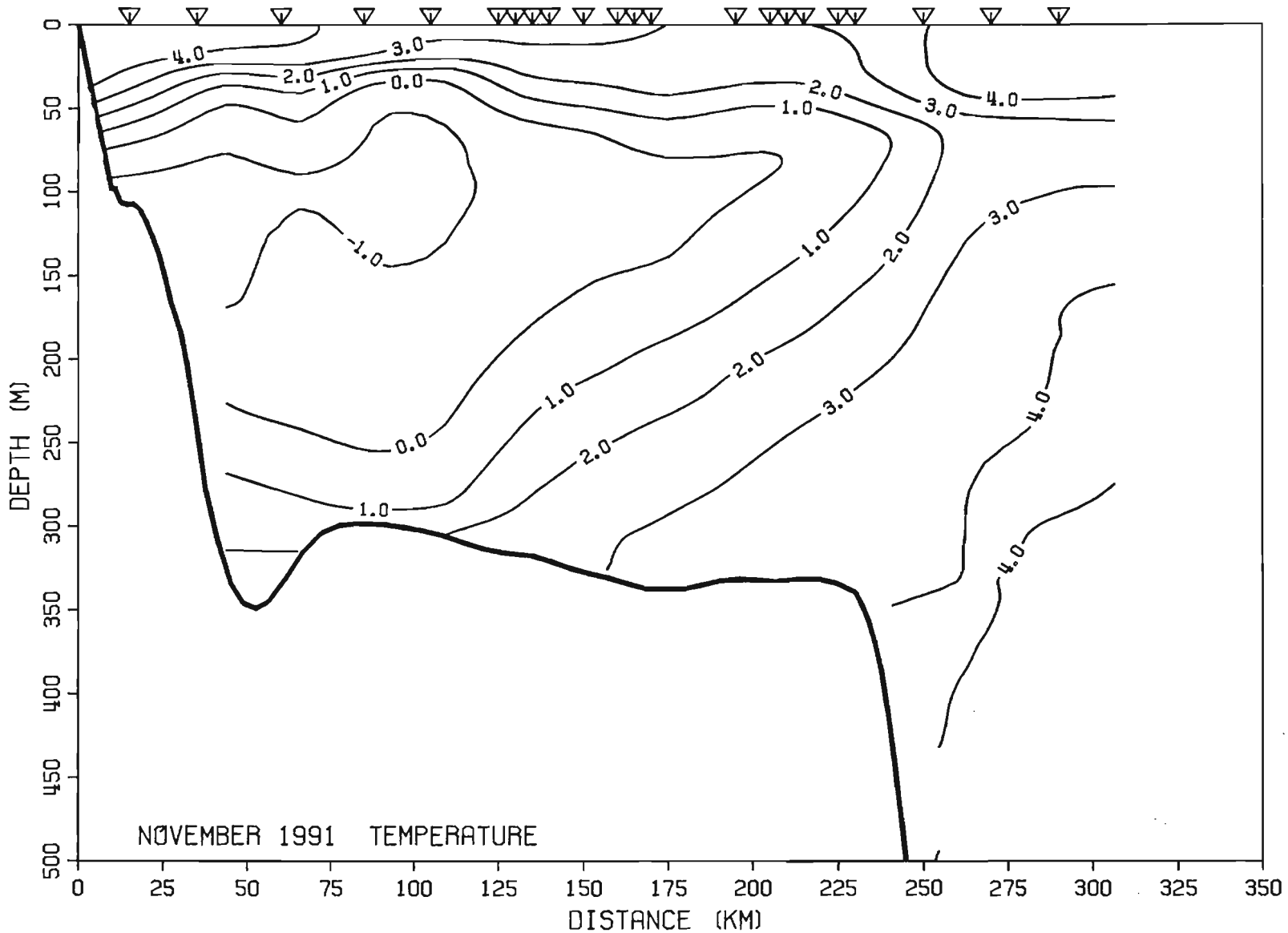
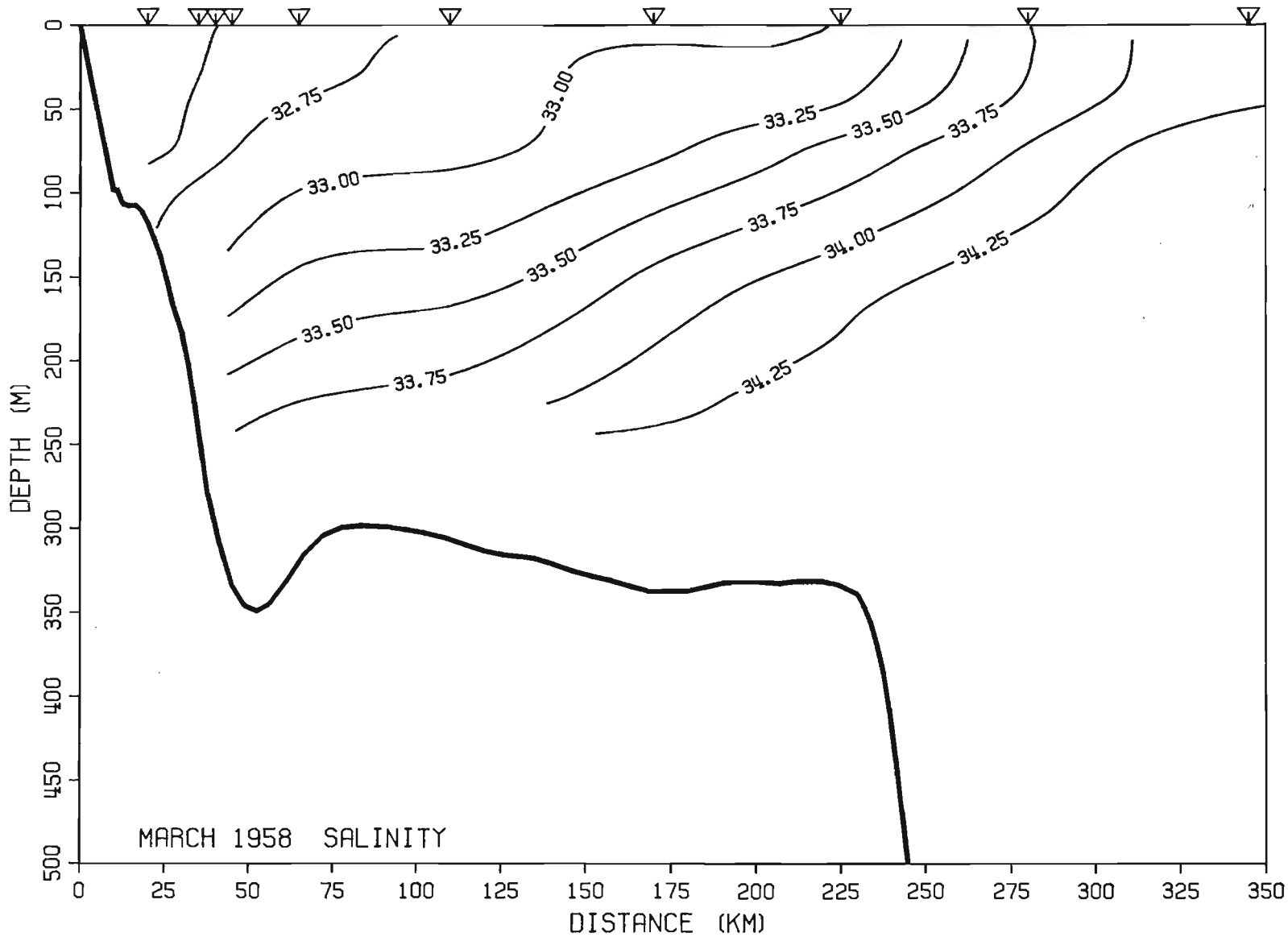
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0


NOVEMBER 1958 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
3.0
2.0
1.0
0.0
-4.0
4.0
6.0


NOVEMBER 1989 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
3.0
2.0
1.0
0.0
-1.0


NOVEMBER 1991 TEMPERATURE
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
4.0
3.0
2.0
1.0
0.0
-1.0

APPENDIX F. Cape Bonavista Salinity.


MARCH 1958 SALINITY
DEPTH (M)
DISTANCE (KM)
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100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
32.75
33.00
33.25
33.50
33.75
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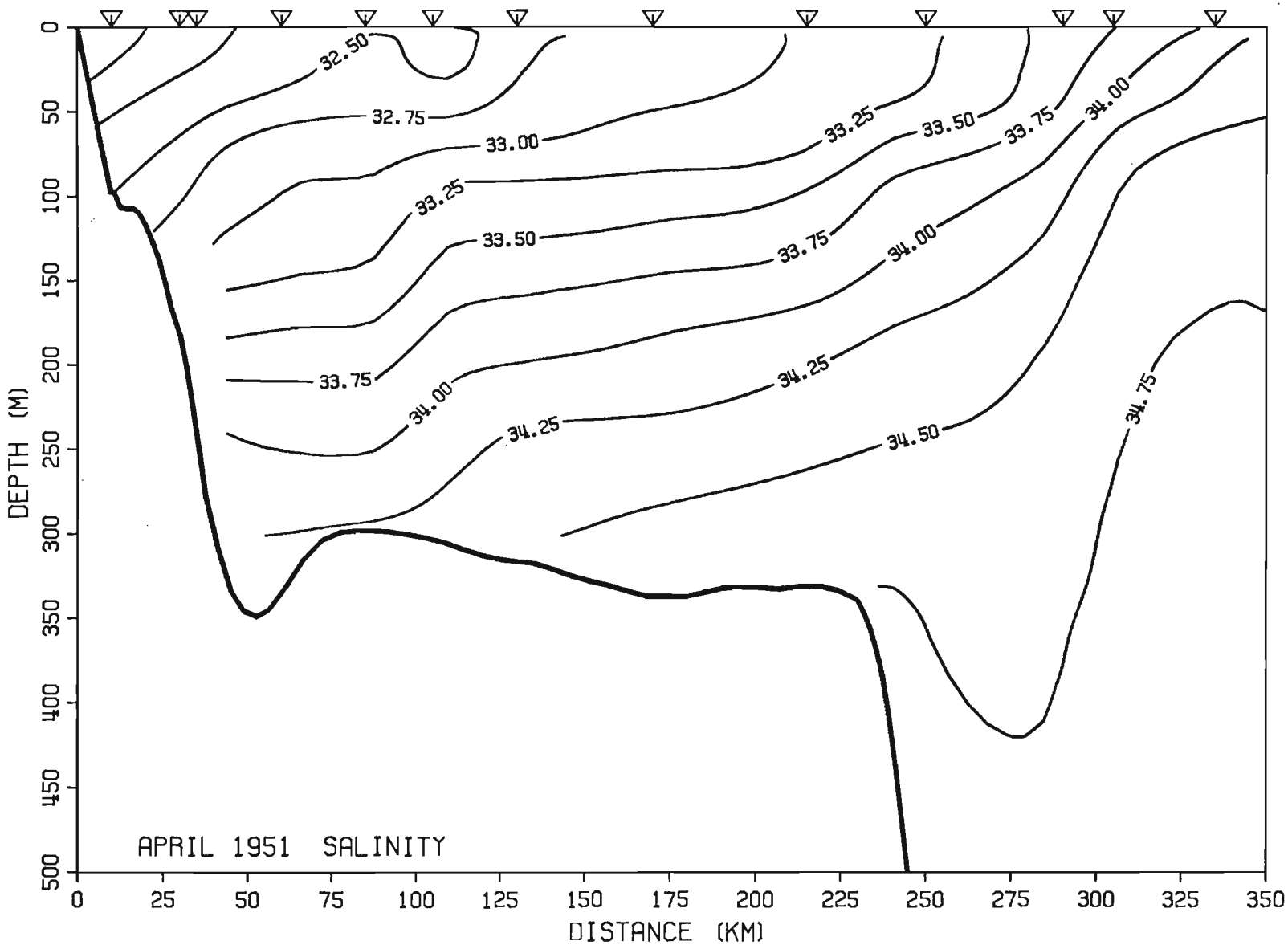
34.25


APRIL 1951 SALINITY
DEPTH (M)
DISTANCE (KM)
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25
50
75
100
125
150
175
200
225
250
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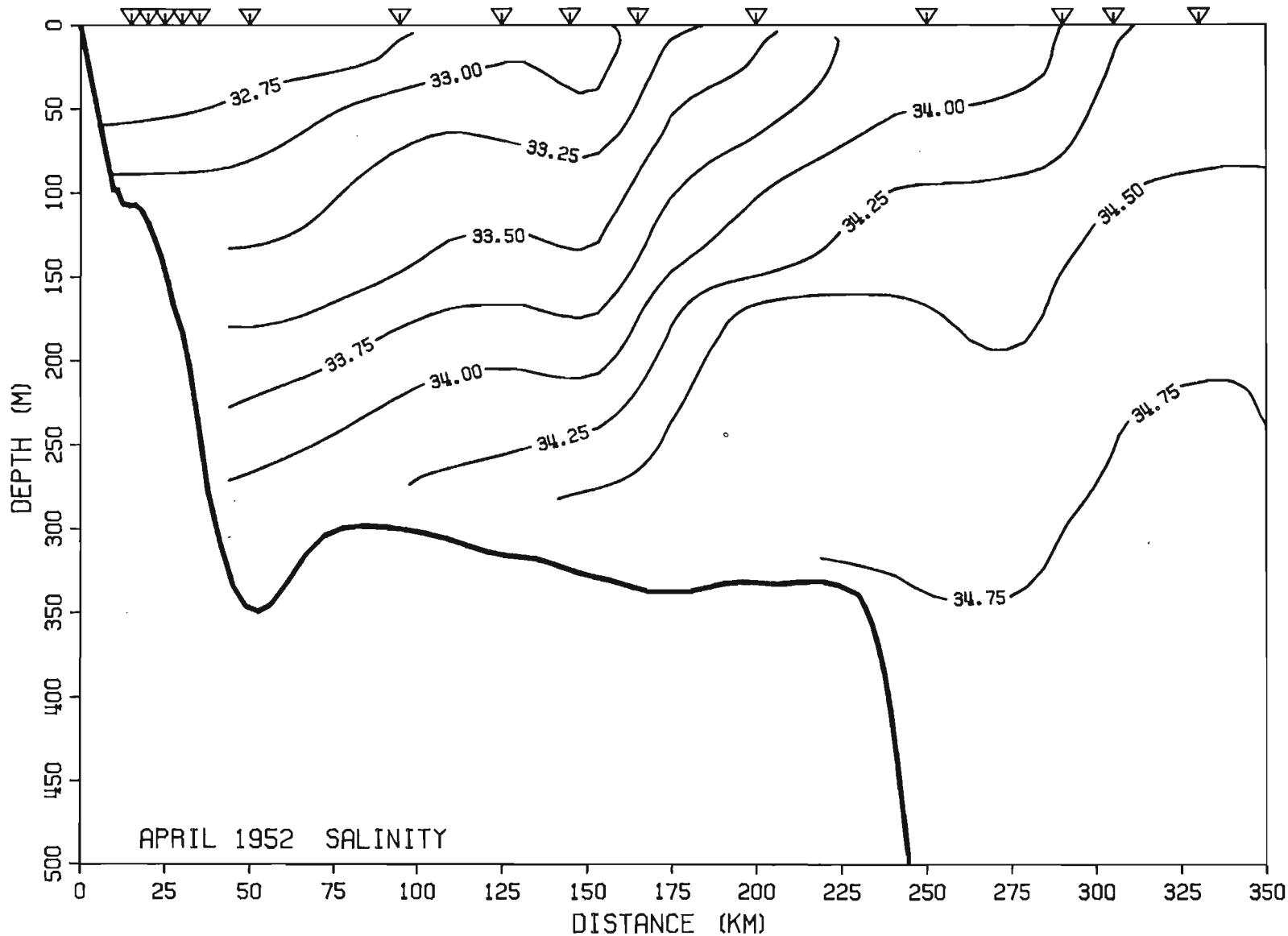
APRIL 1952 SALINITY
DEPTH (M)
DISTANCE (KM)
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100
125
150
175
200
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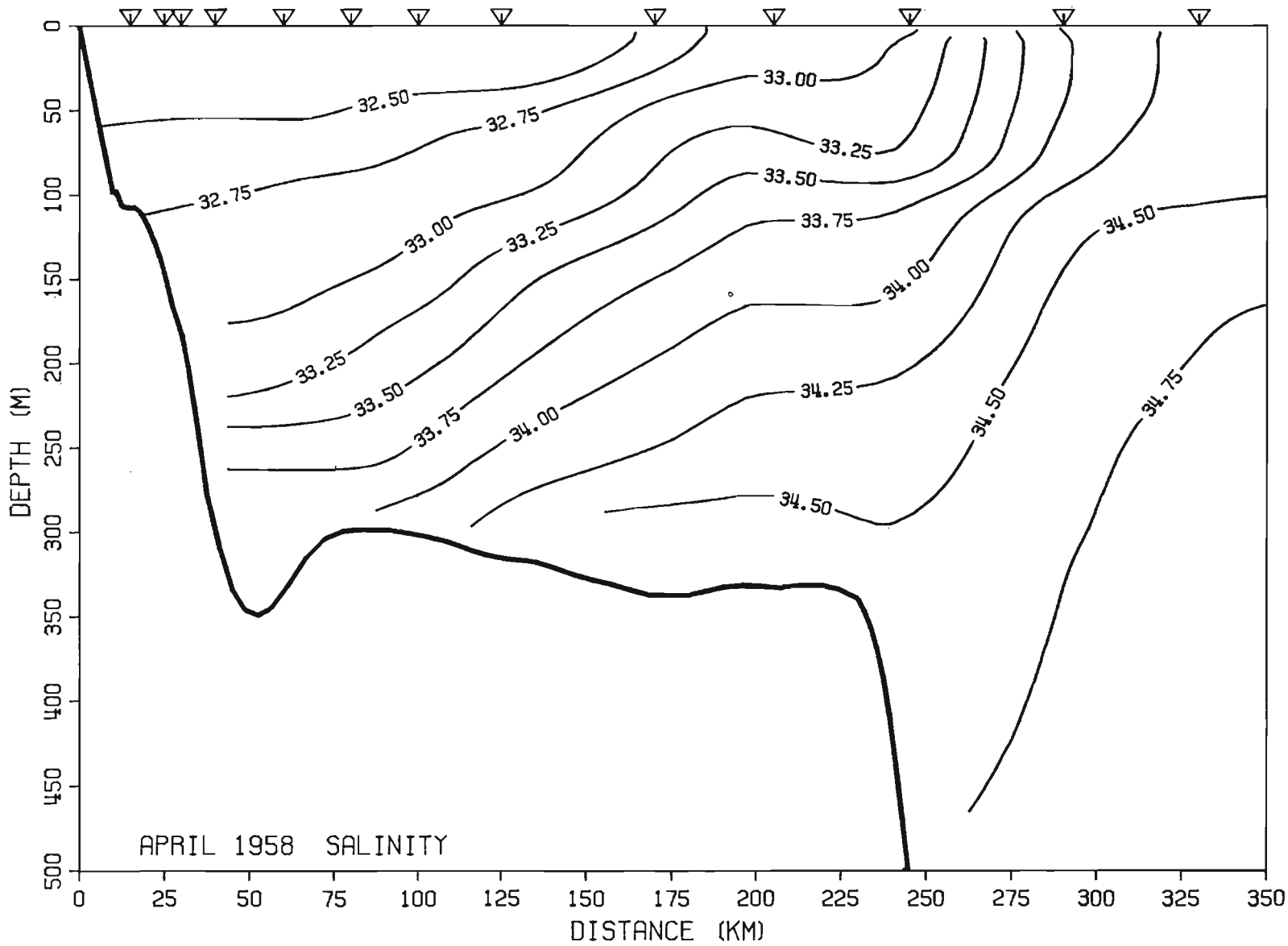
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DEPTH (M)
DISTANCE (KM)
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150
175
200
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250
275
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325
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32.50
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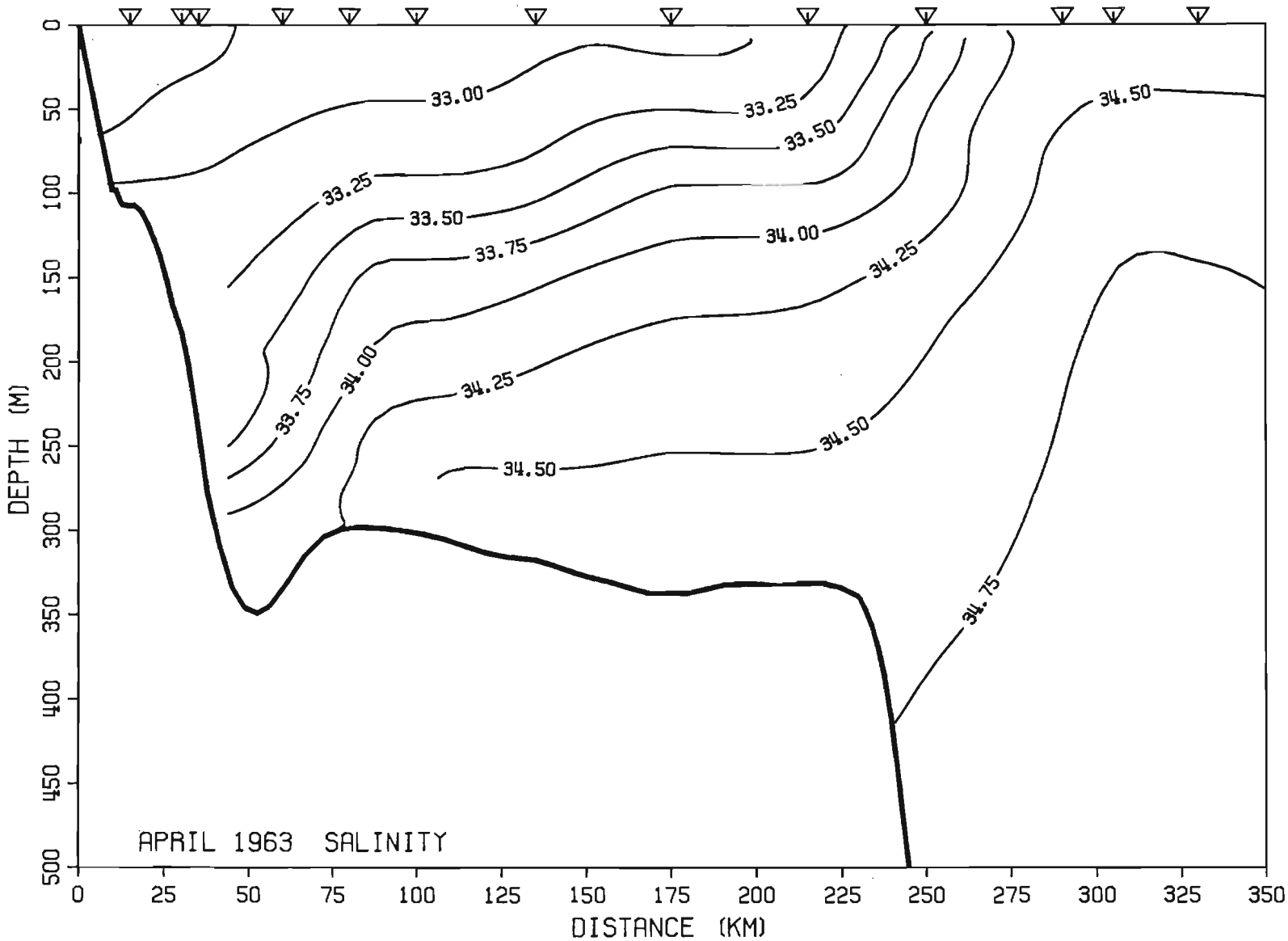
APRIL 1963 SALINITY
DEPTH (M)
DISTANCE (KM)
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100
125
150
175
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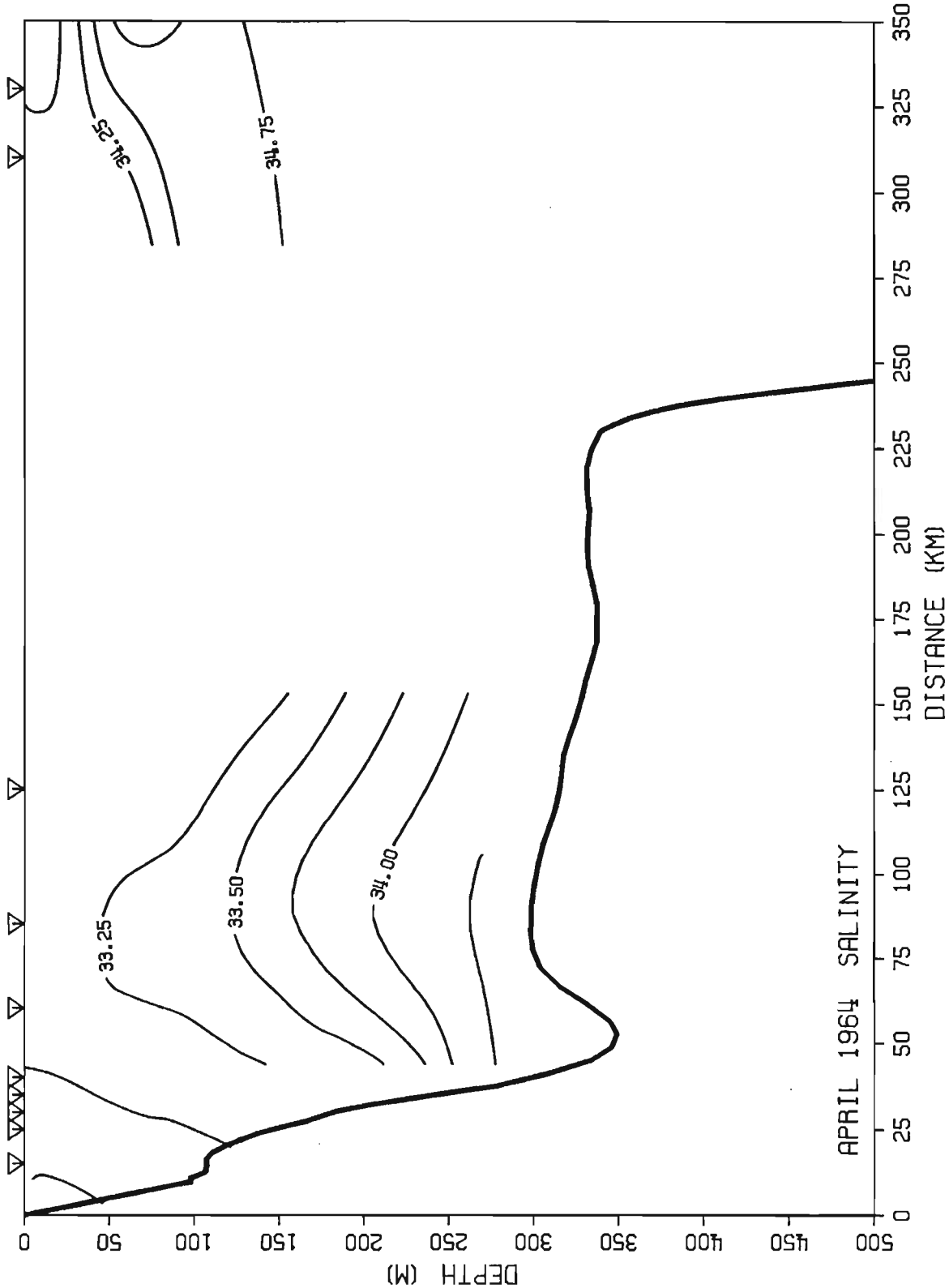
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DISTANCE (KM)
DEPTH (M)
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75
100
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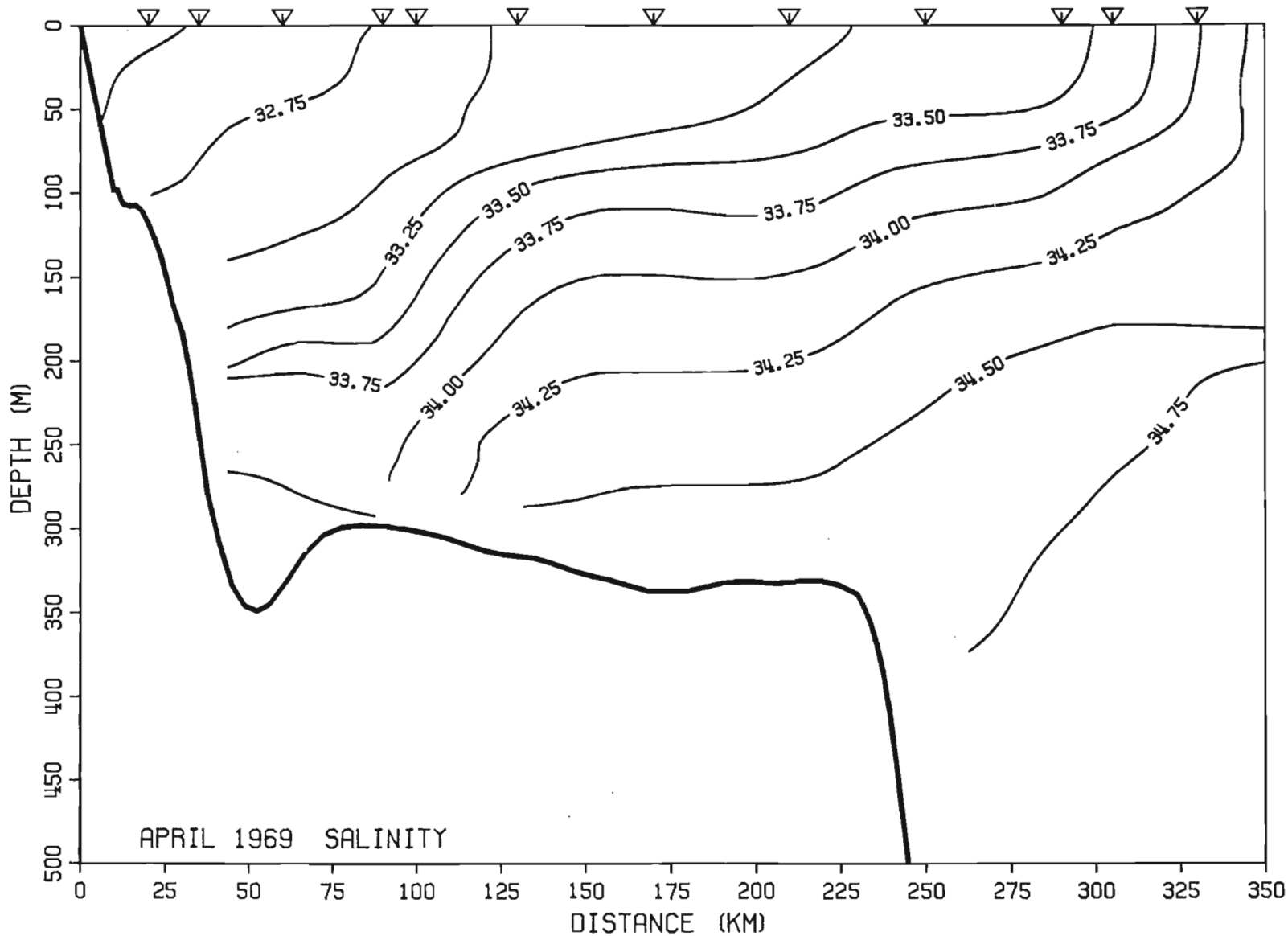
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DEPTH (M)
DISTANCE (KM)
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400
450
500
0
25
50
75
100
125
150
175
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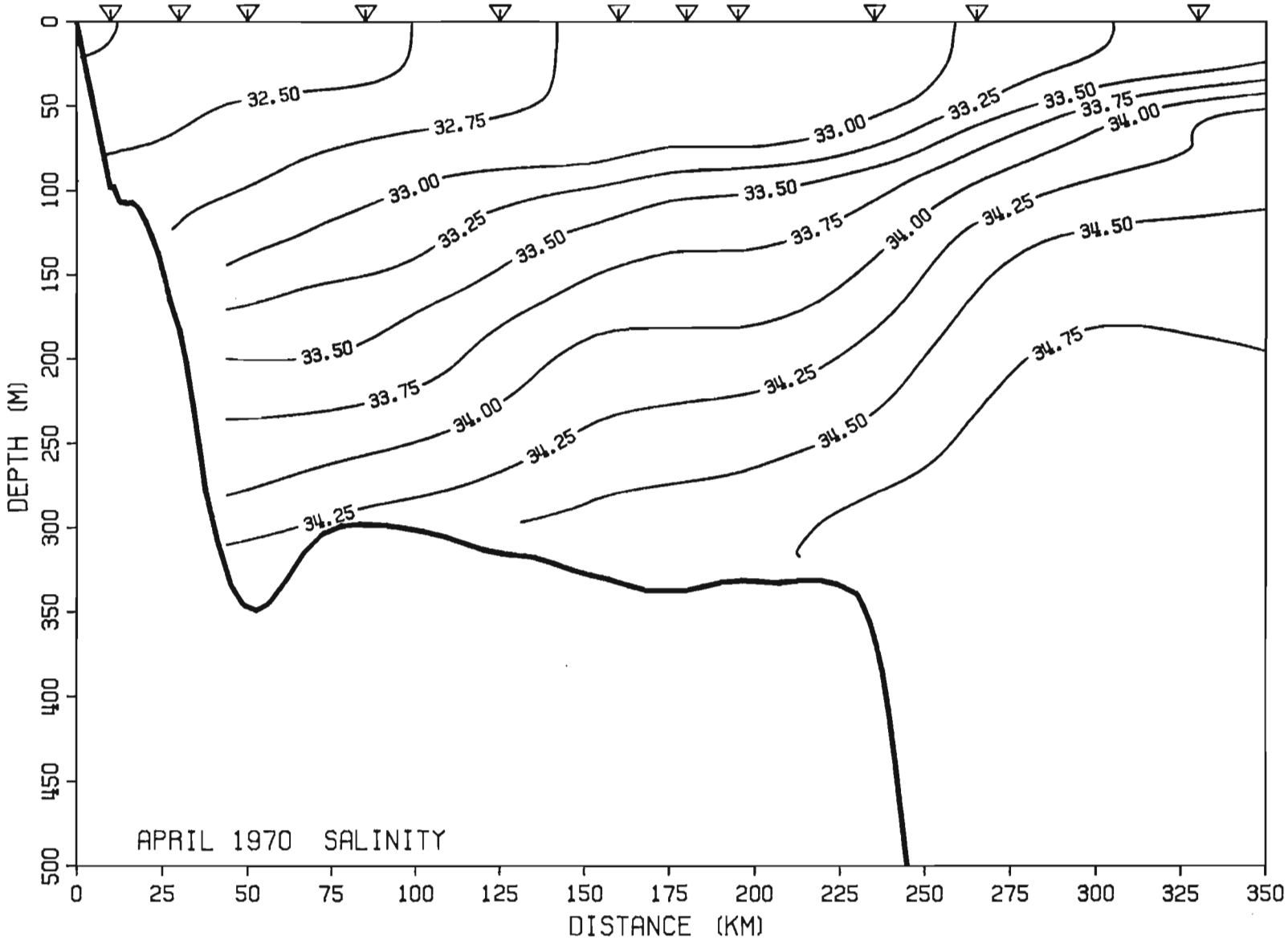
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DISTANCE (KM)
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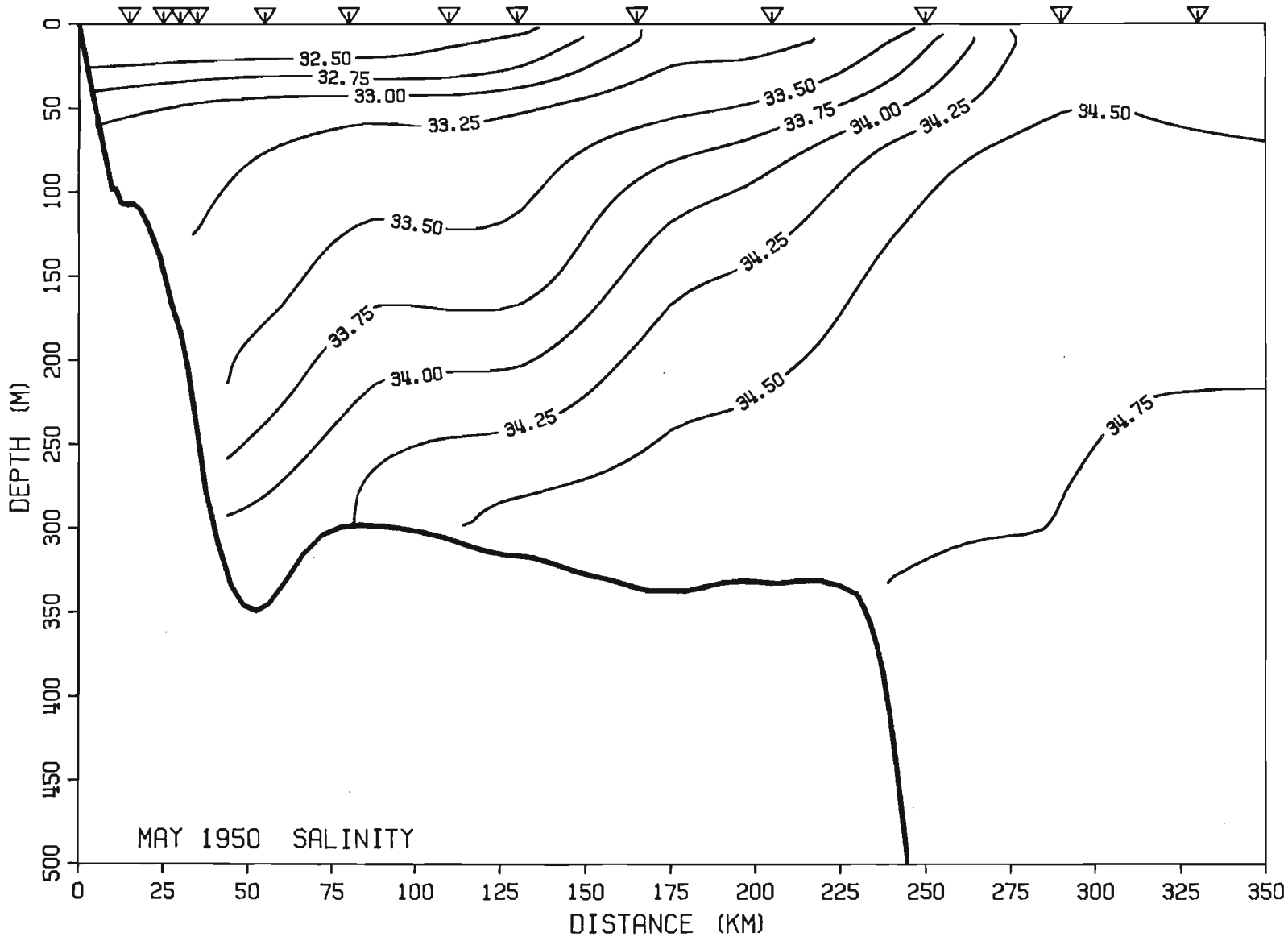
MAY 1950 SALINITY
DEPTH (M)
DISTANCE (KM)
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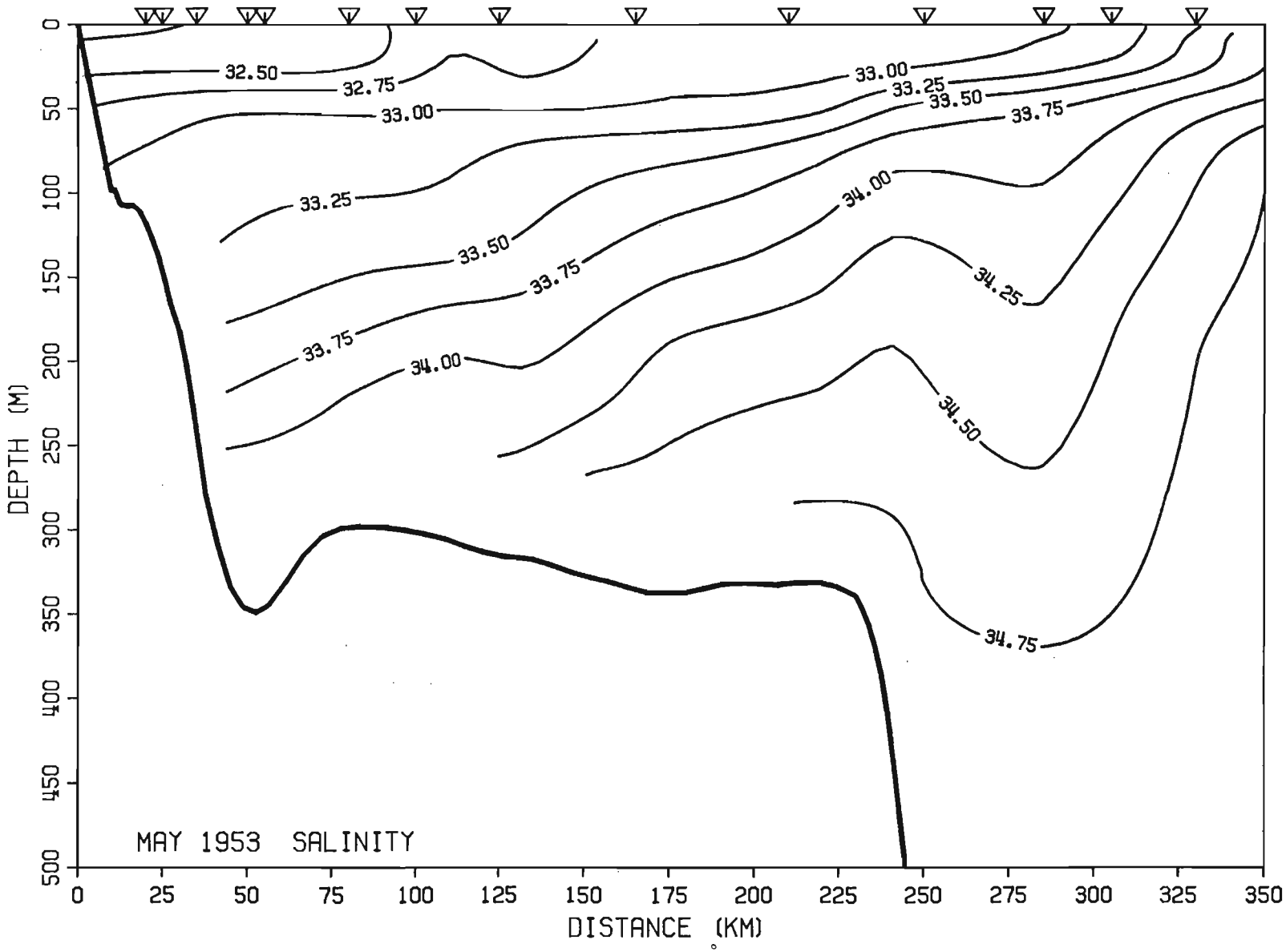
MAY 1953 SALINITY
DEPTH (M)
DISTANCE (KM)
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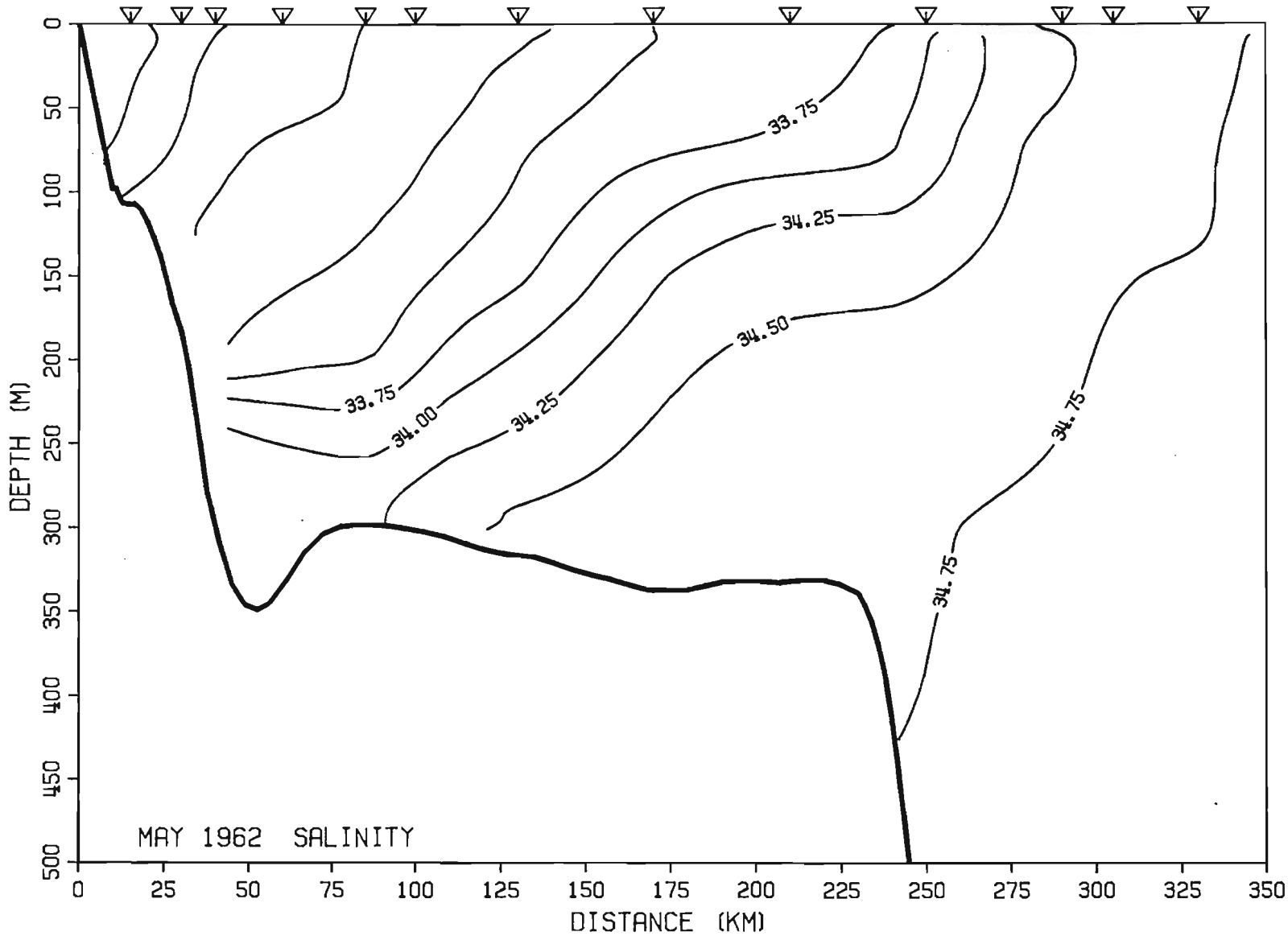
MAY 1962 SALINITY
DEPTH (M)
DISTANCE (KM)
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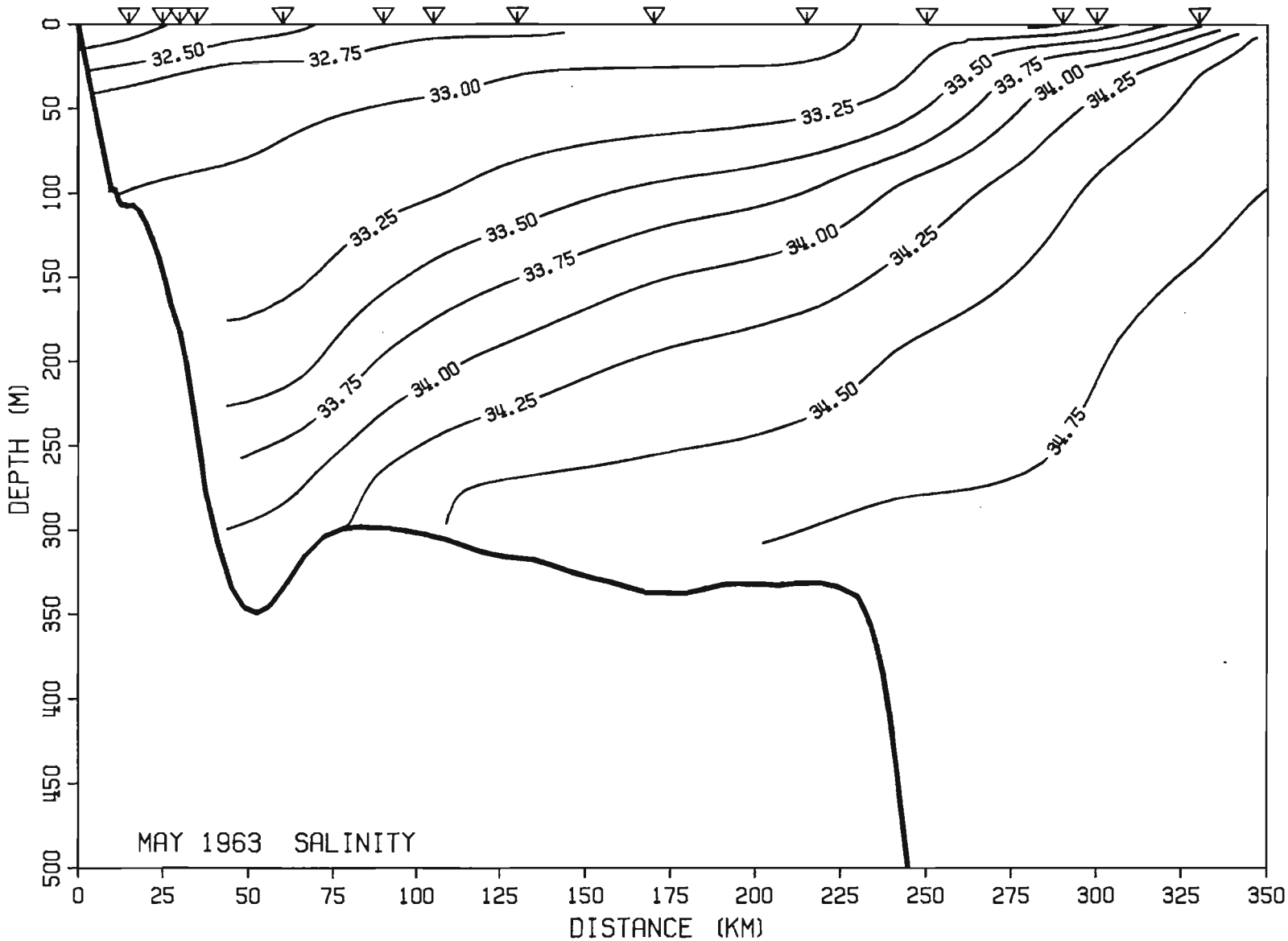
MAY 1963 SALINITY
DEPTH (M)
DISTANCE (KM)
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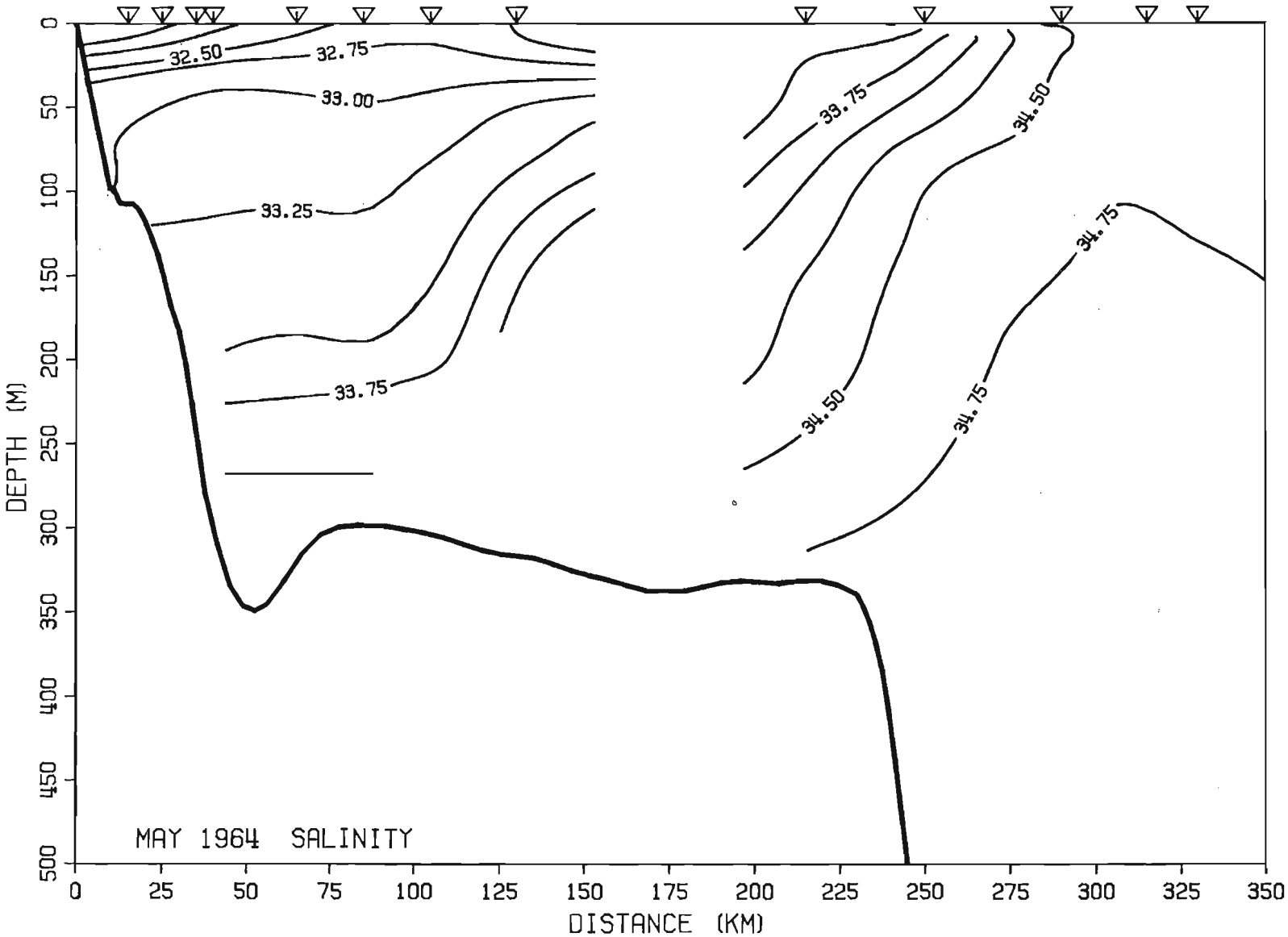
MAY 1964 SALINITY
DEPTH (M)
DISTANCE (KM)
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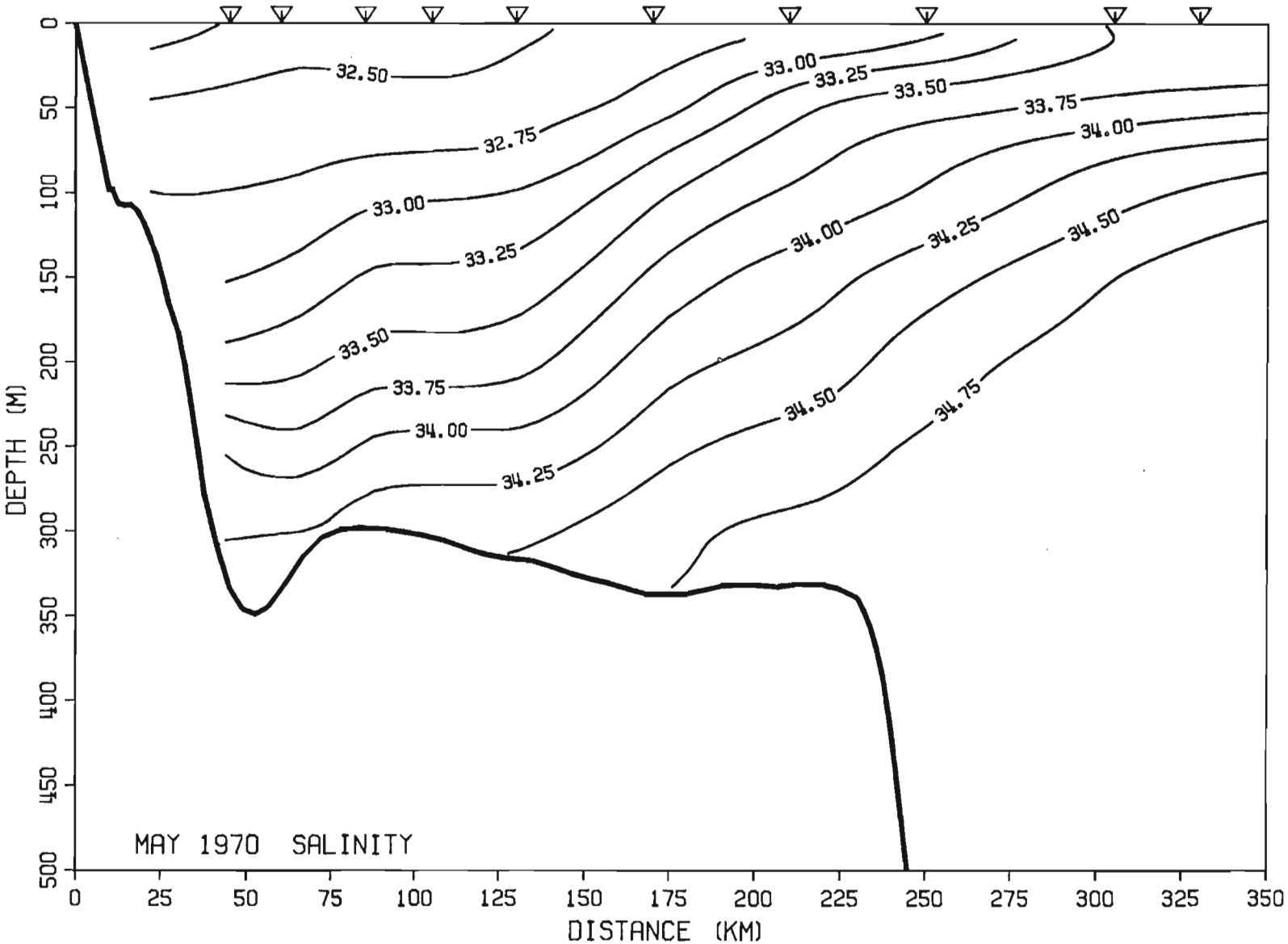
MAY 1970 SALINITY
DEPTH (M)
DISTANCE (KM)
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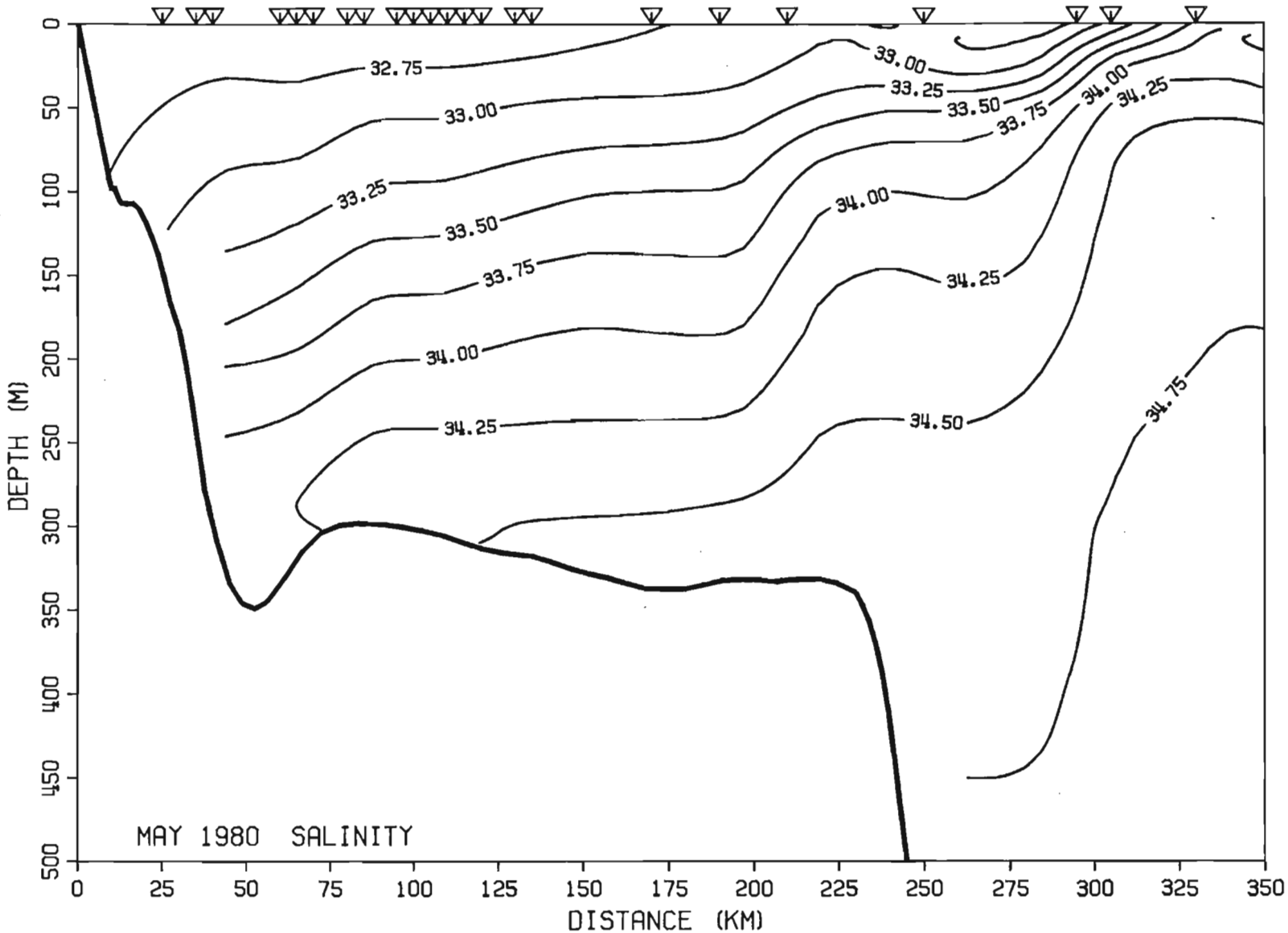
MAY 1980 SALINITY
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DISTANCE (KM)
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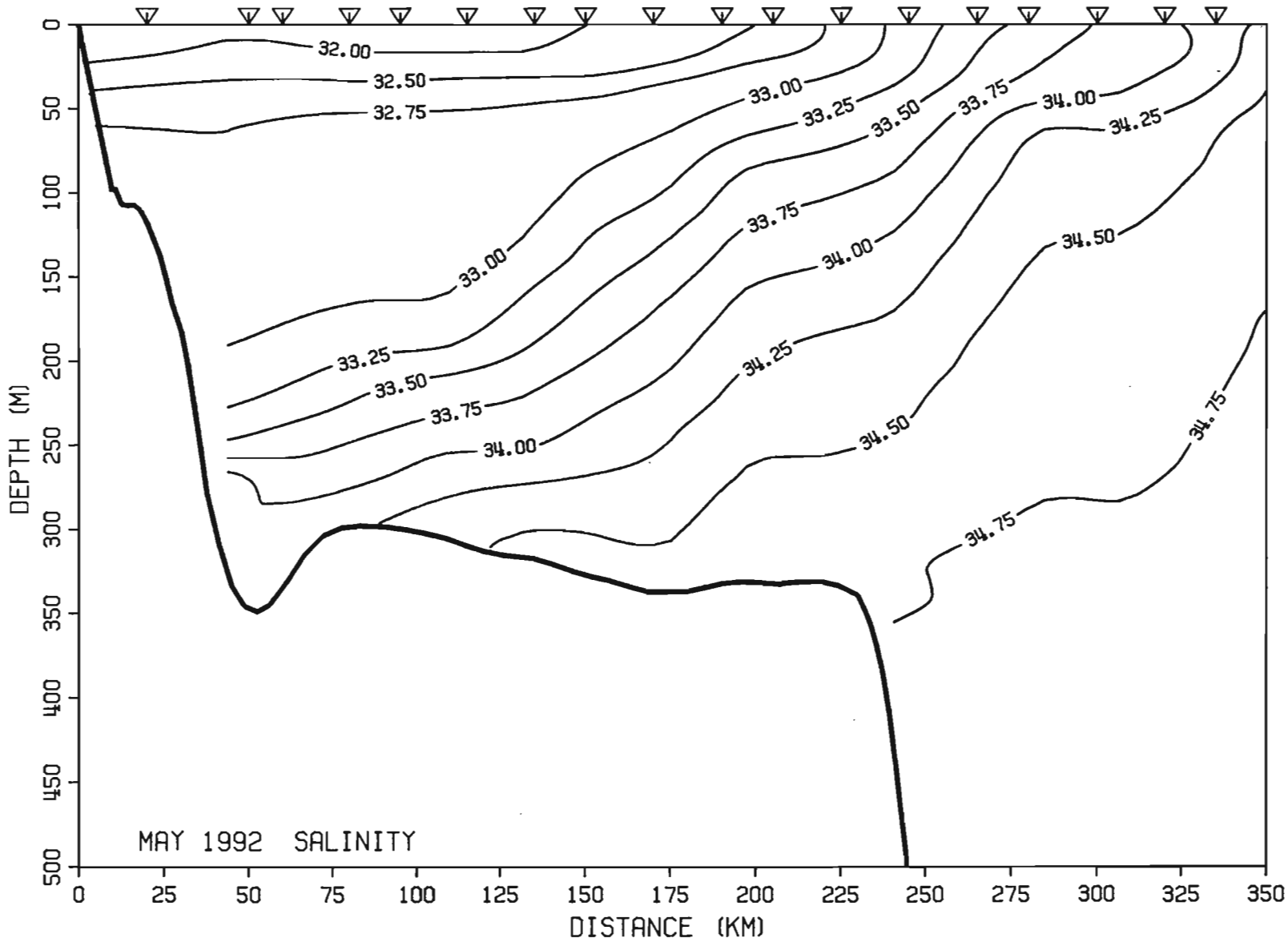
MAY 1992 SALINITY
DEPTH (M)
DISTANCE (KM)
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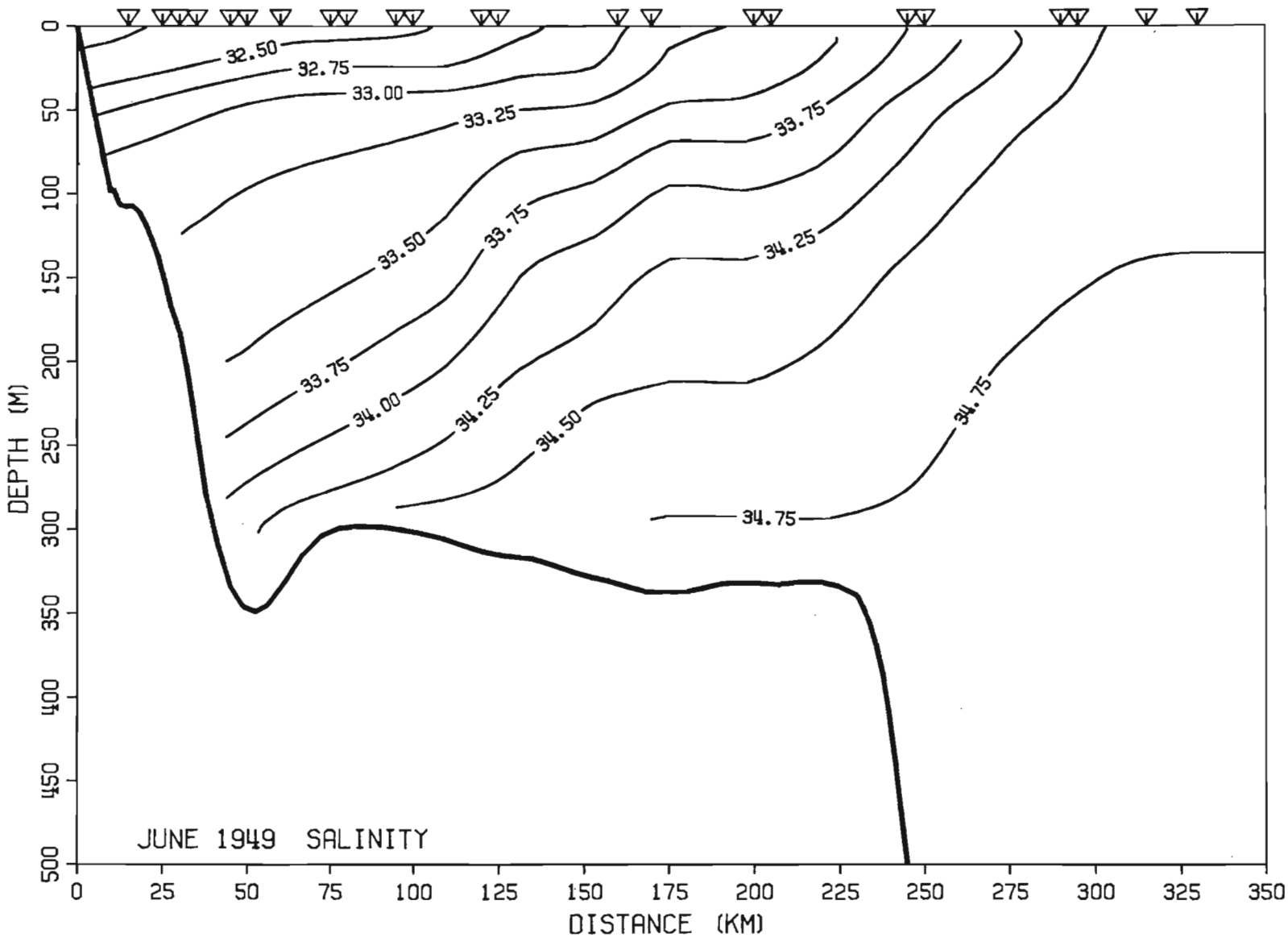
JUNE 1949 SALINITY
DEPTH (M)
DISTANCE (KM)
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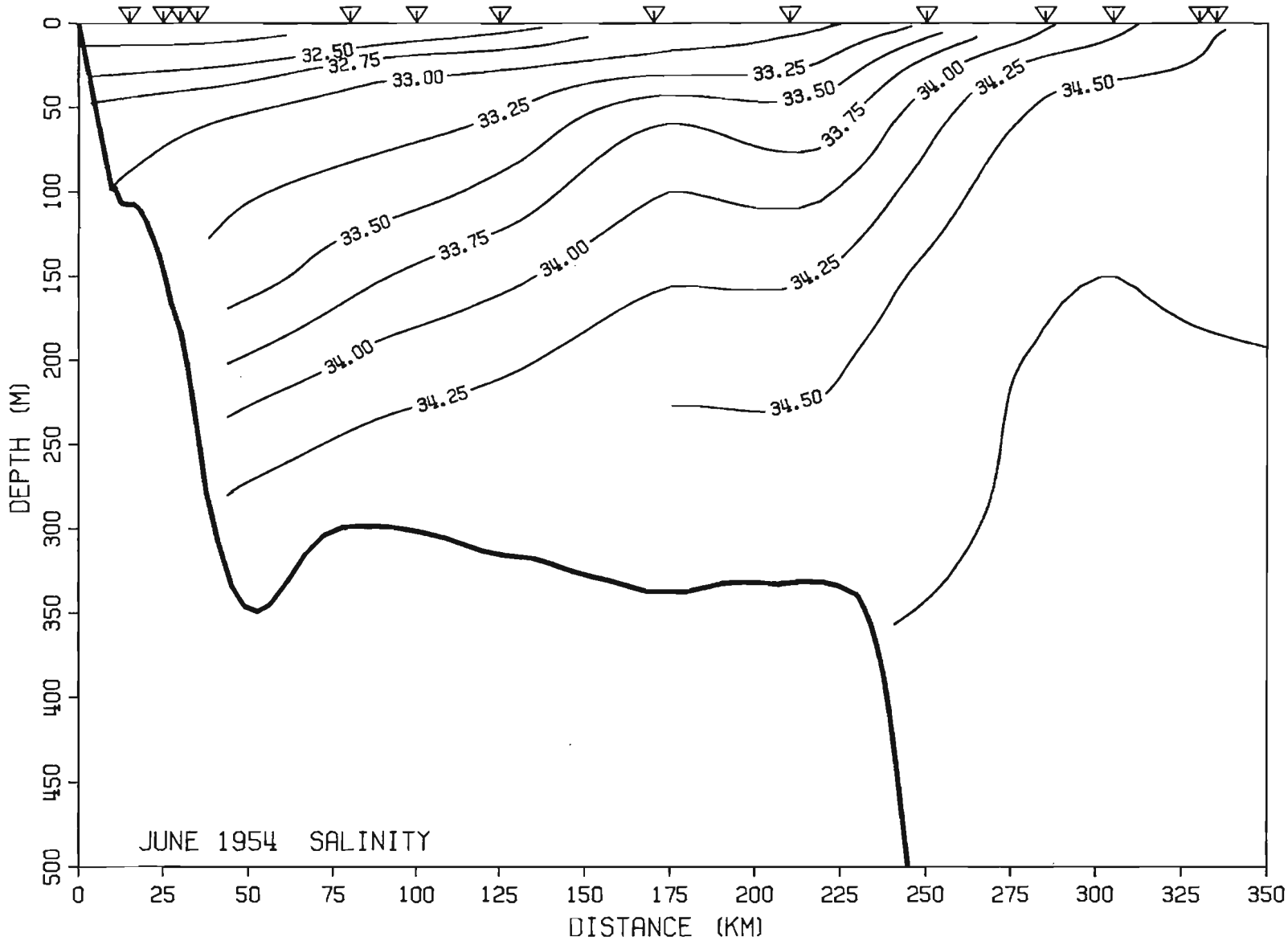
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DISTANCE (KM)
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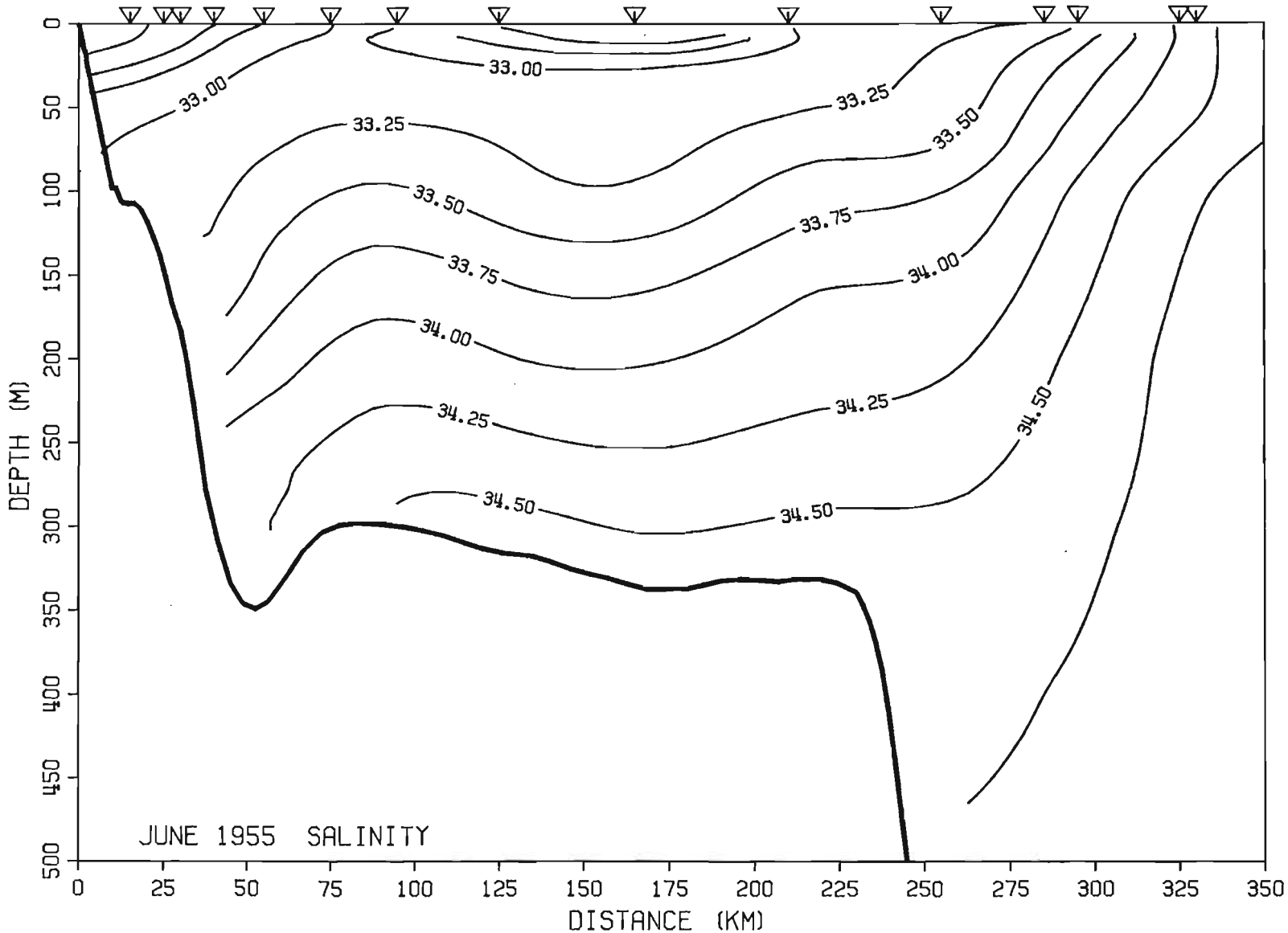
JUNE 1955 SALINITY
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DISTANCE (KM)
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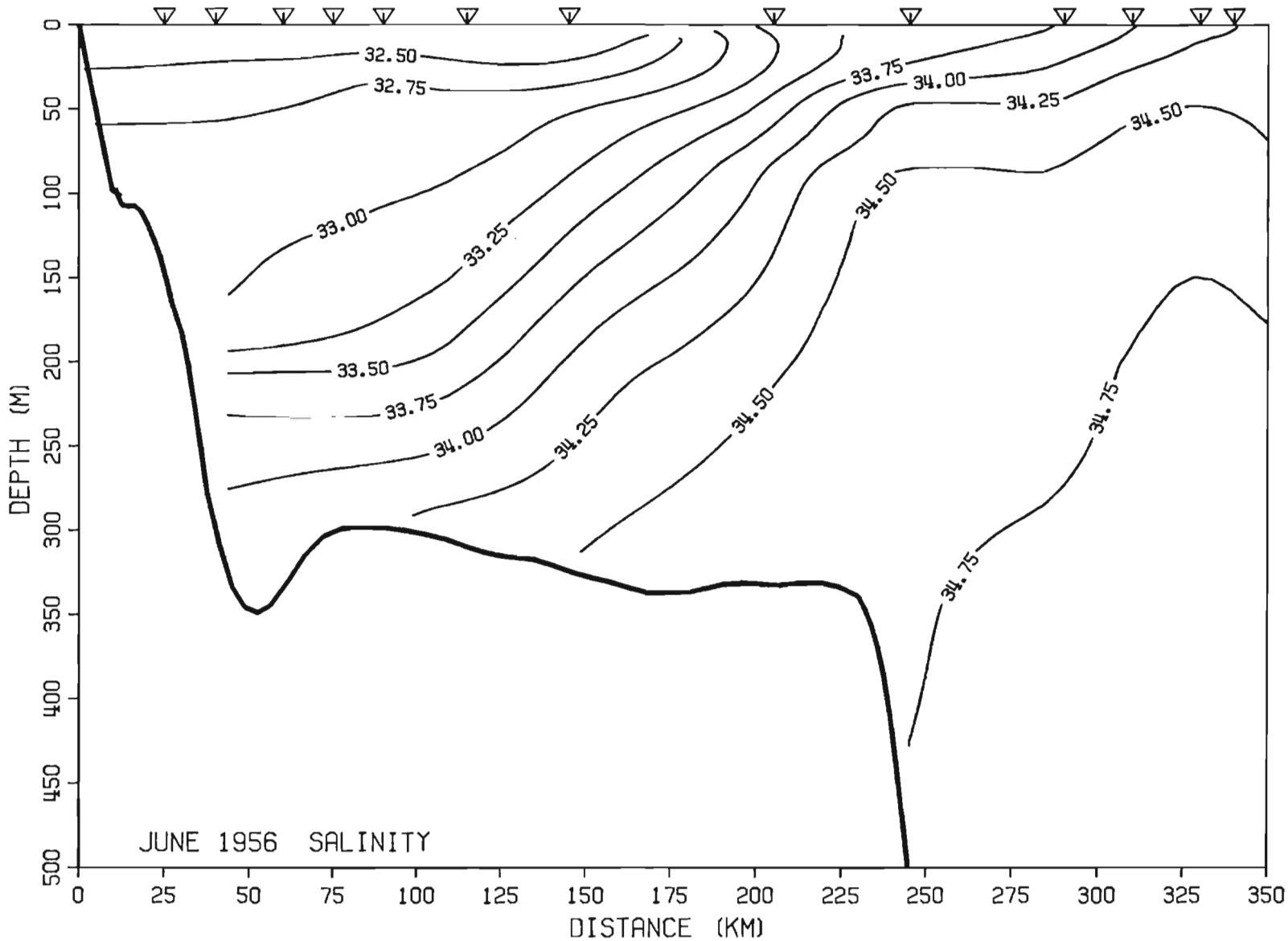
JUNE 1956 SALINITY
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DISTANCE (KM)
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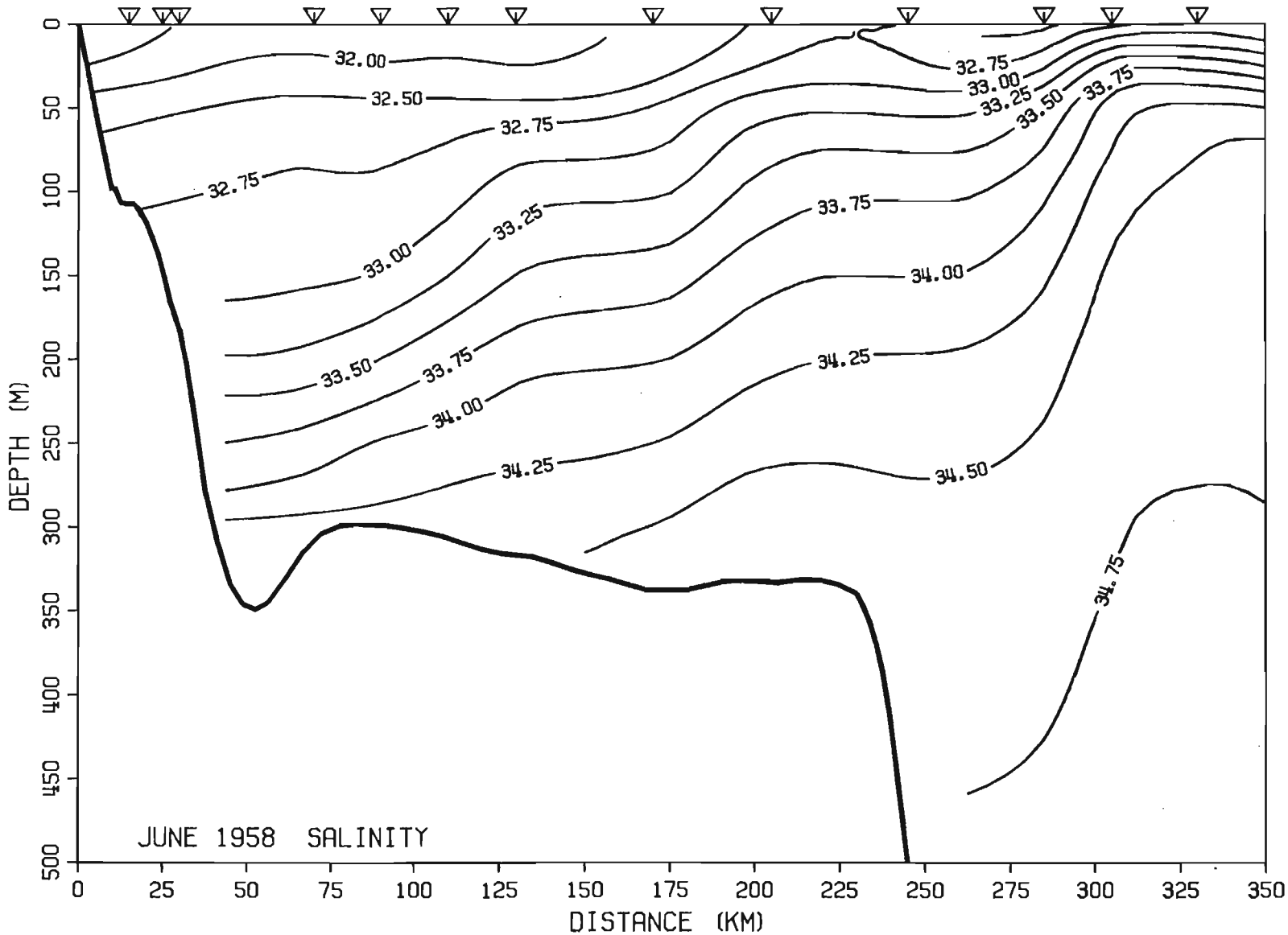
JUNE 1958 SALINITY
DEPTH (M)
DISTANCE (KM)
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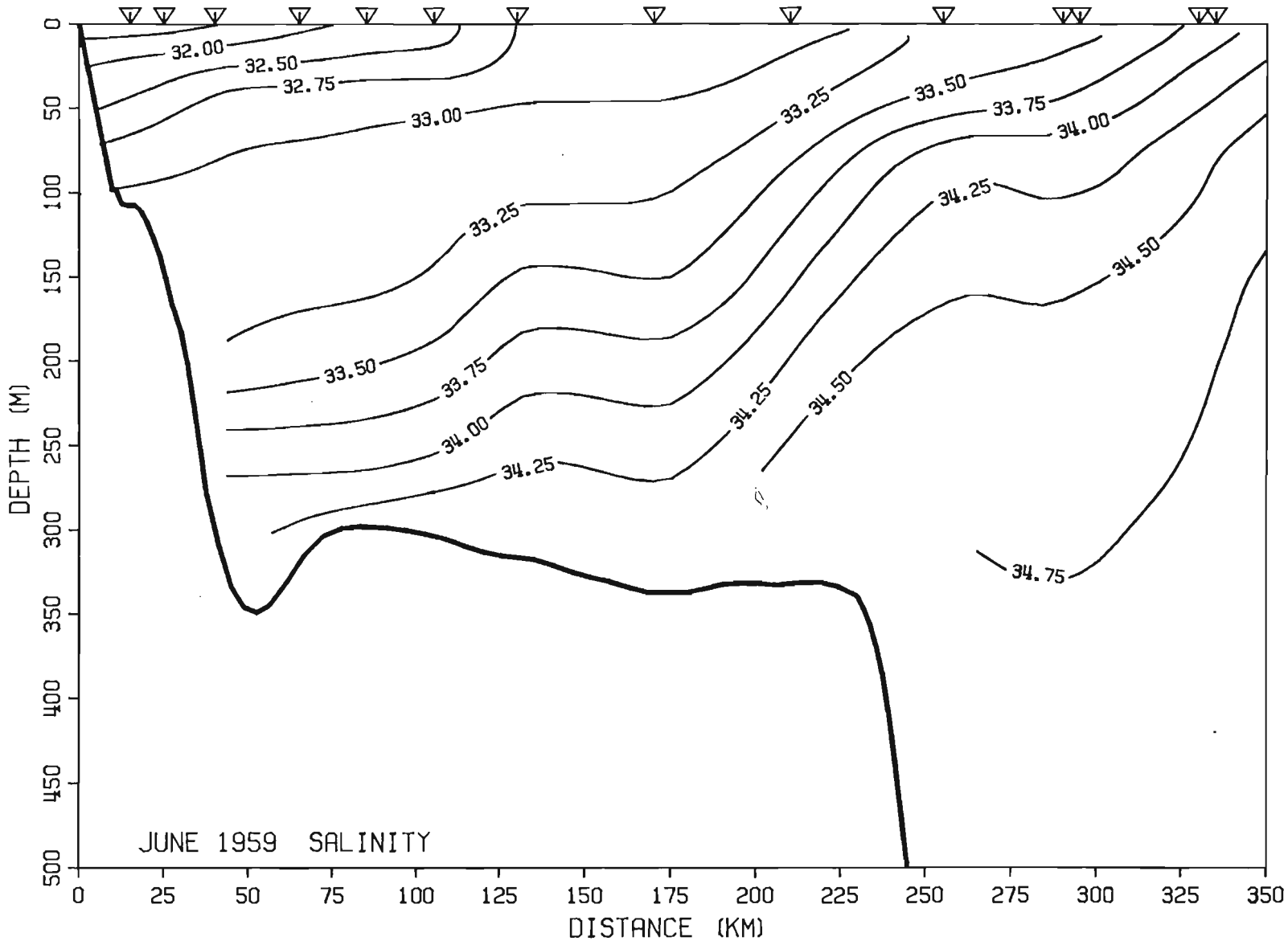
JUNE 1959 SALINITY
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DISTANCE (KM)
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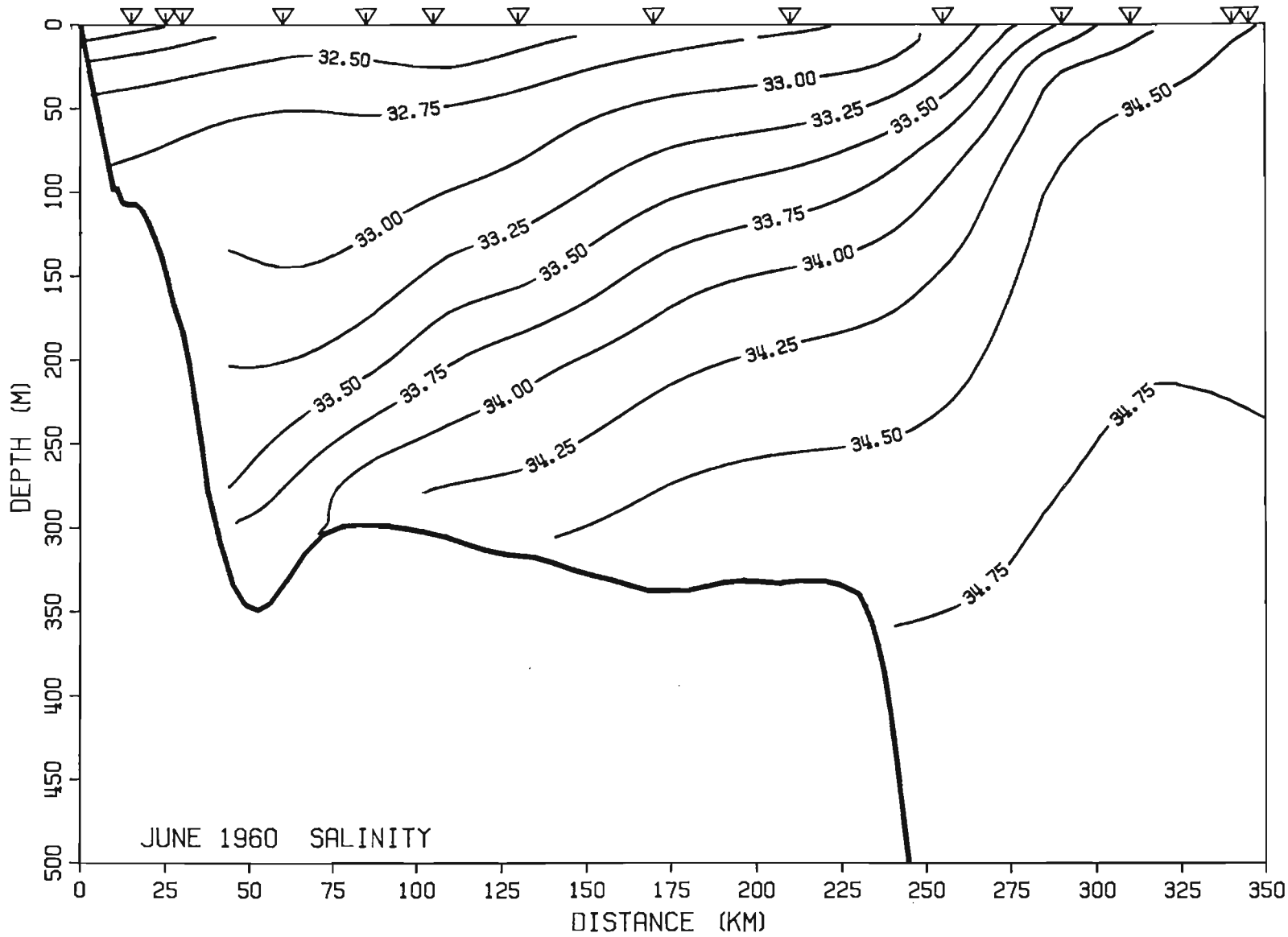
JUNE 1960 SALINITY
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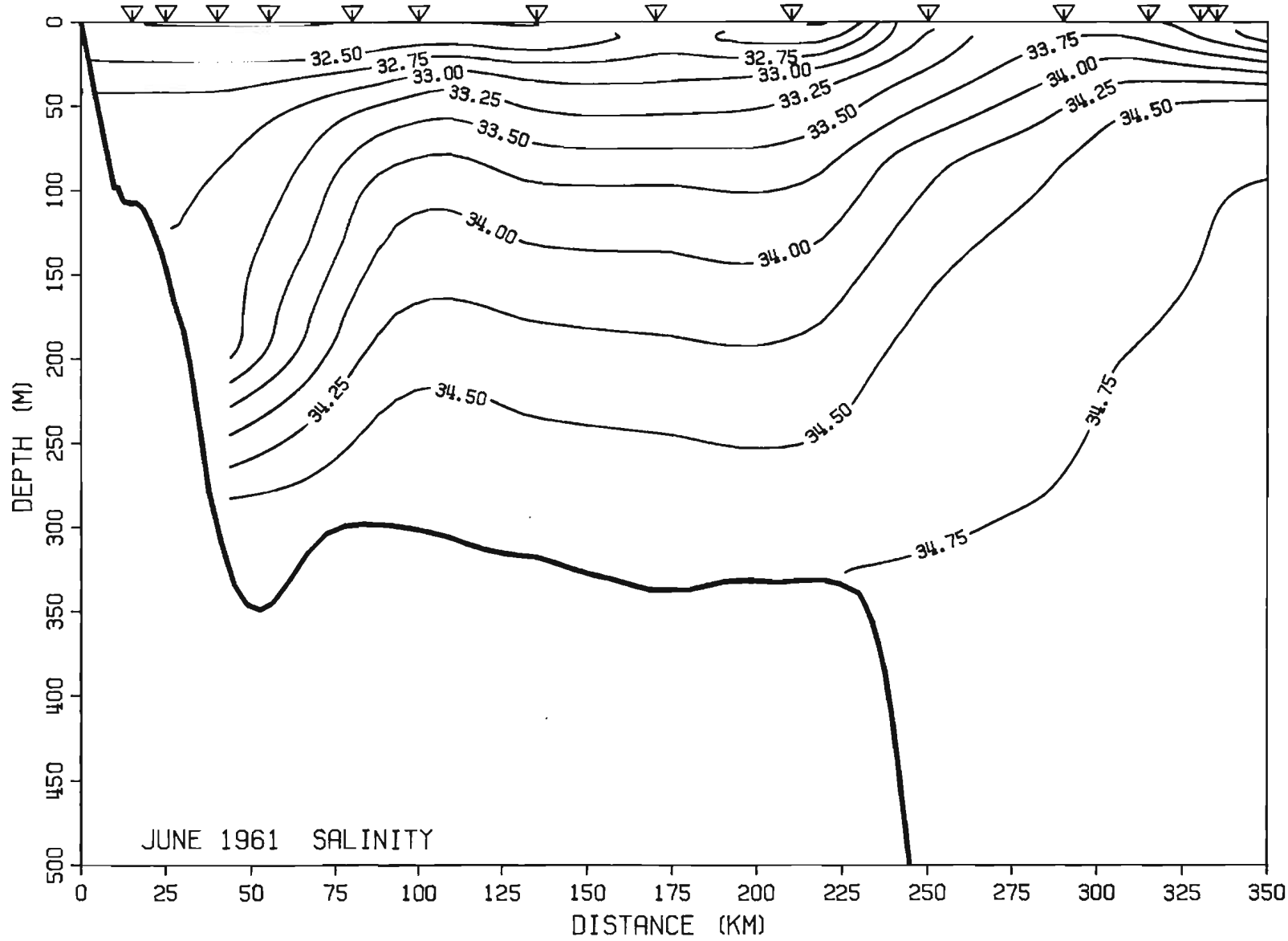
JUNE 1961 SALINITY
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DISTANCE (KM)
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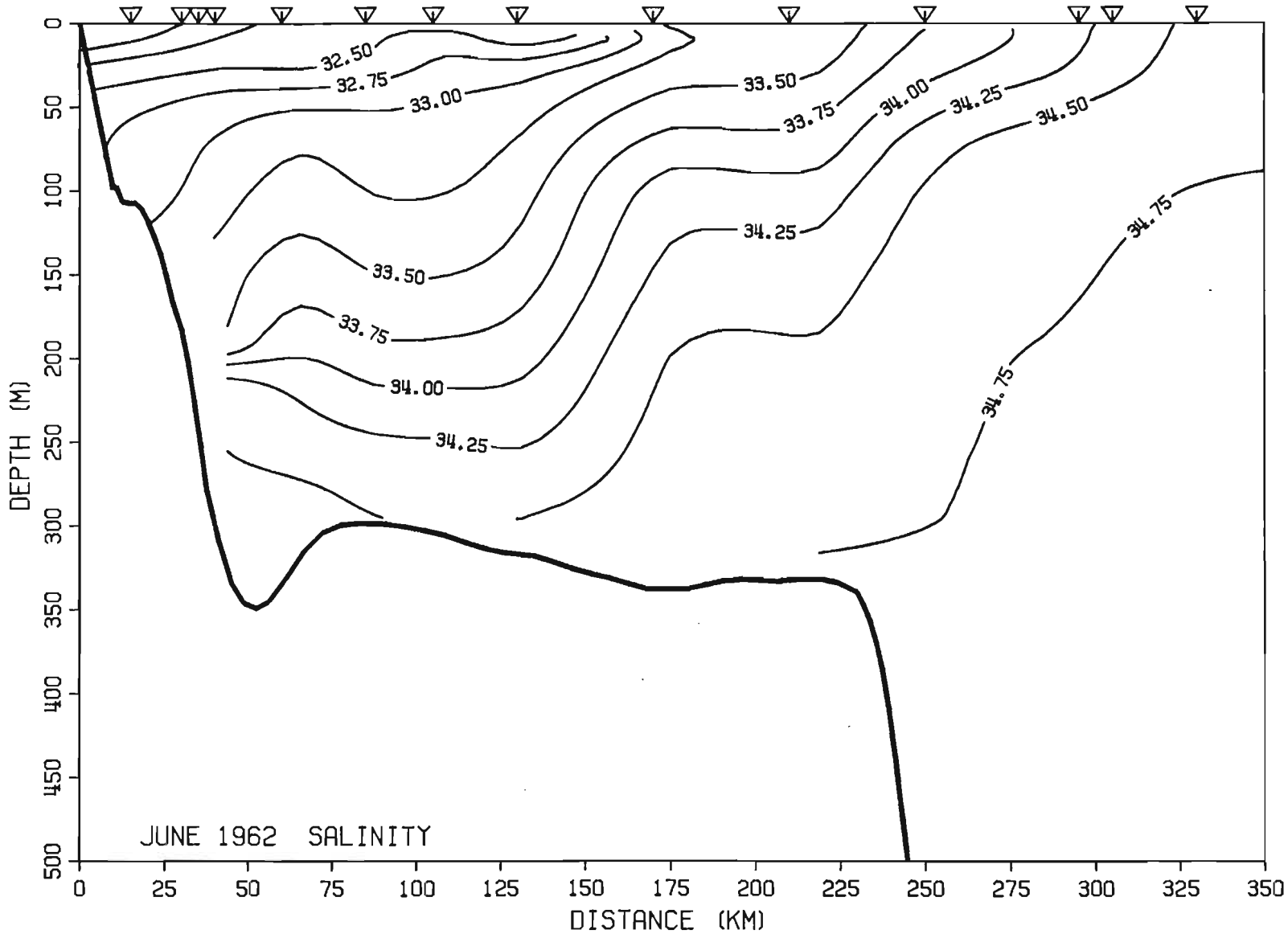
JUNE 1962 SALINITY
DEPTH (M)
DISTANCE (KM)
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0
25
50
75
100
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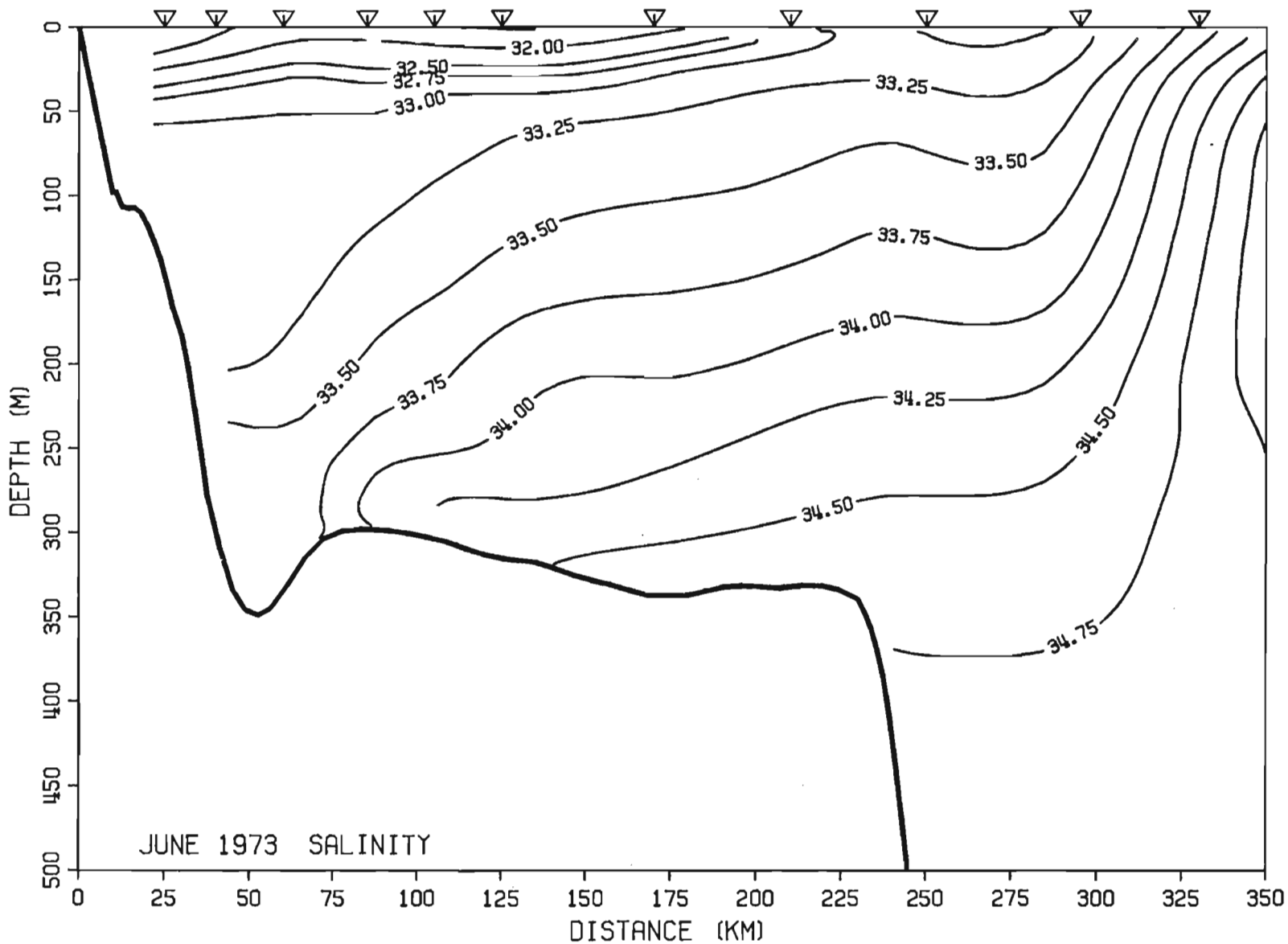
JUNE 1973 SALINITY
DEPTH (M)
DISTANCE (KM)
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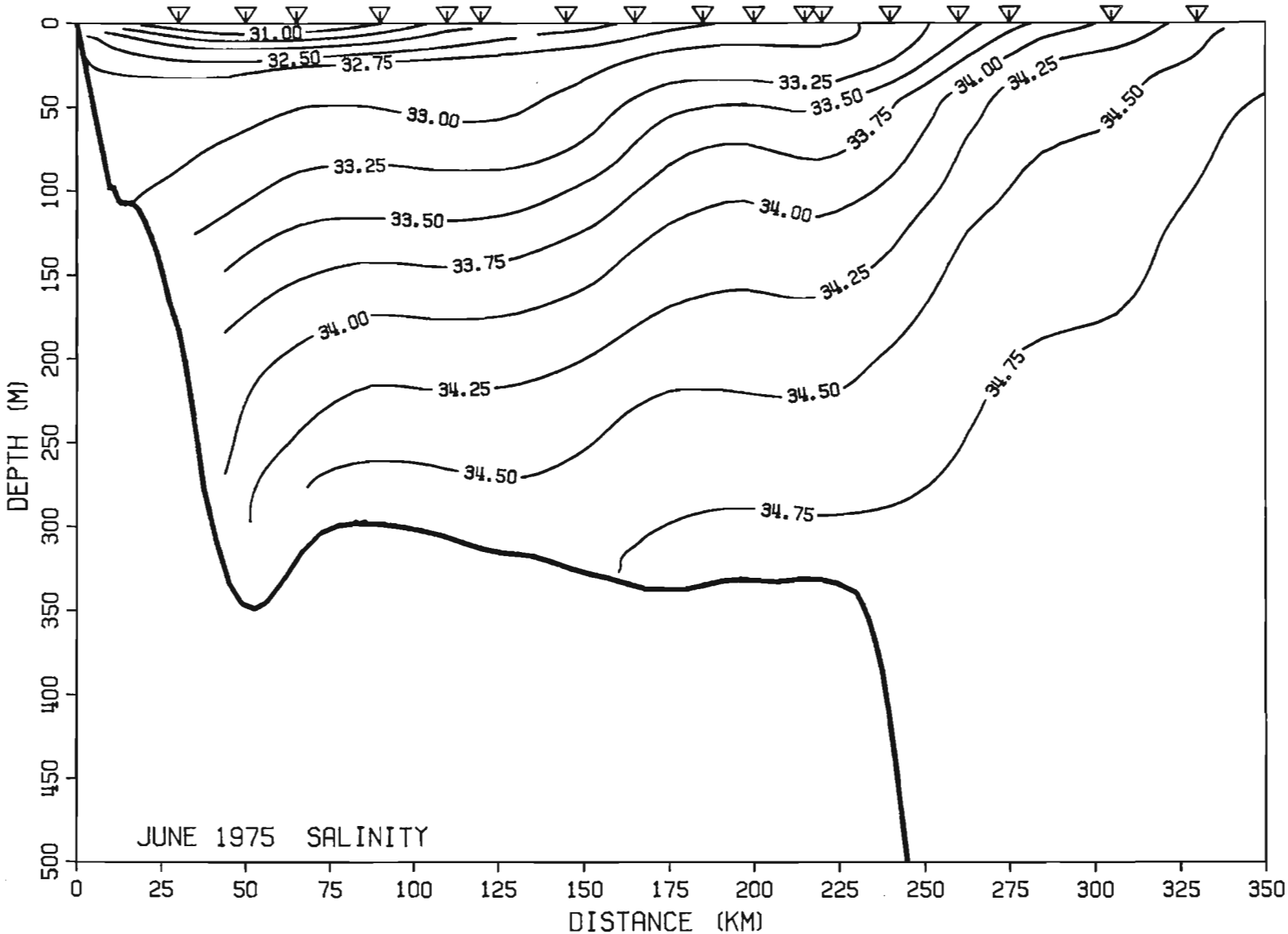
JUNE 1975 SALINITY
DEPTH (M)
DISTANCE (KM)
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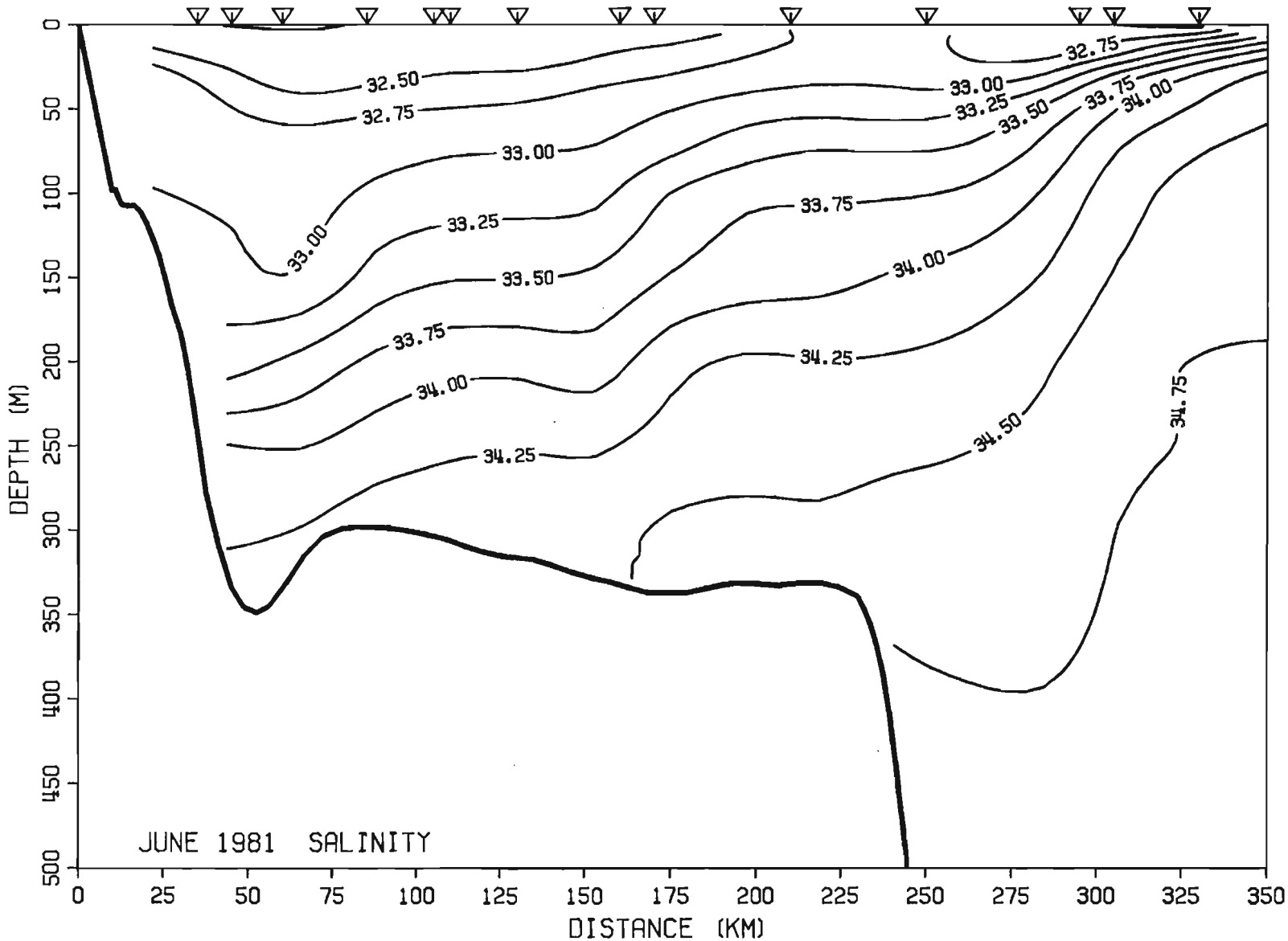
JUNE 1981 SALINITY
DEPTH (M)
DISTANCE (KM)
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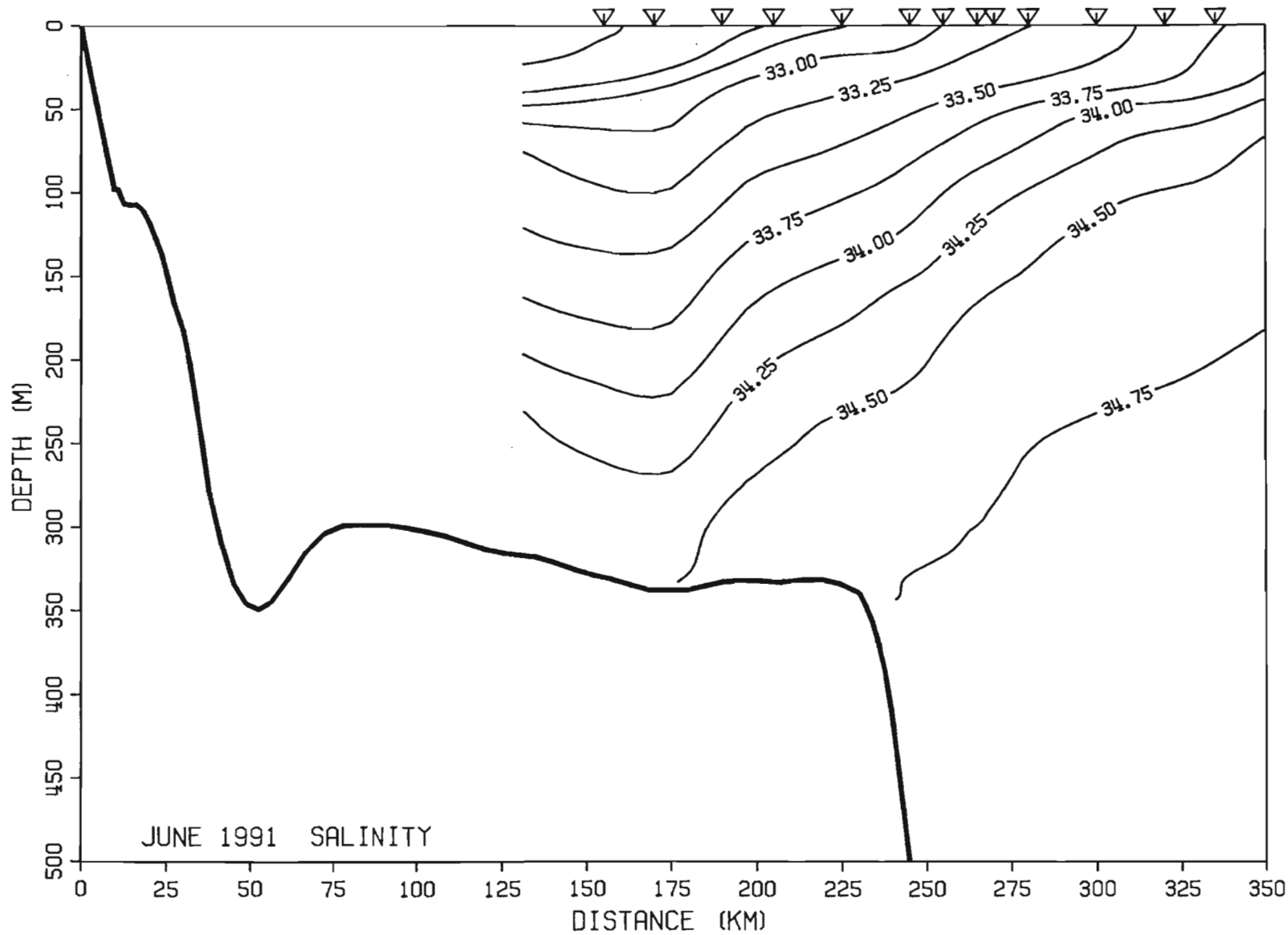
JUNE 1991 SALINITY
DEPTH (M)
DISTANCE (KM)
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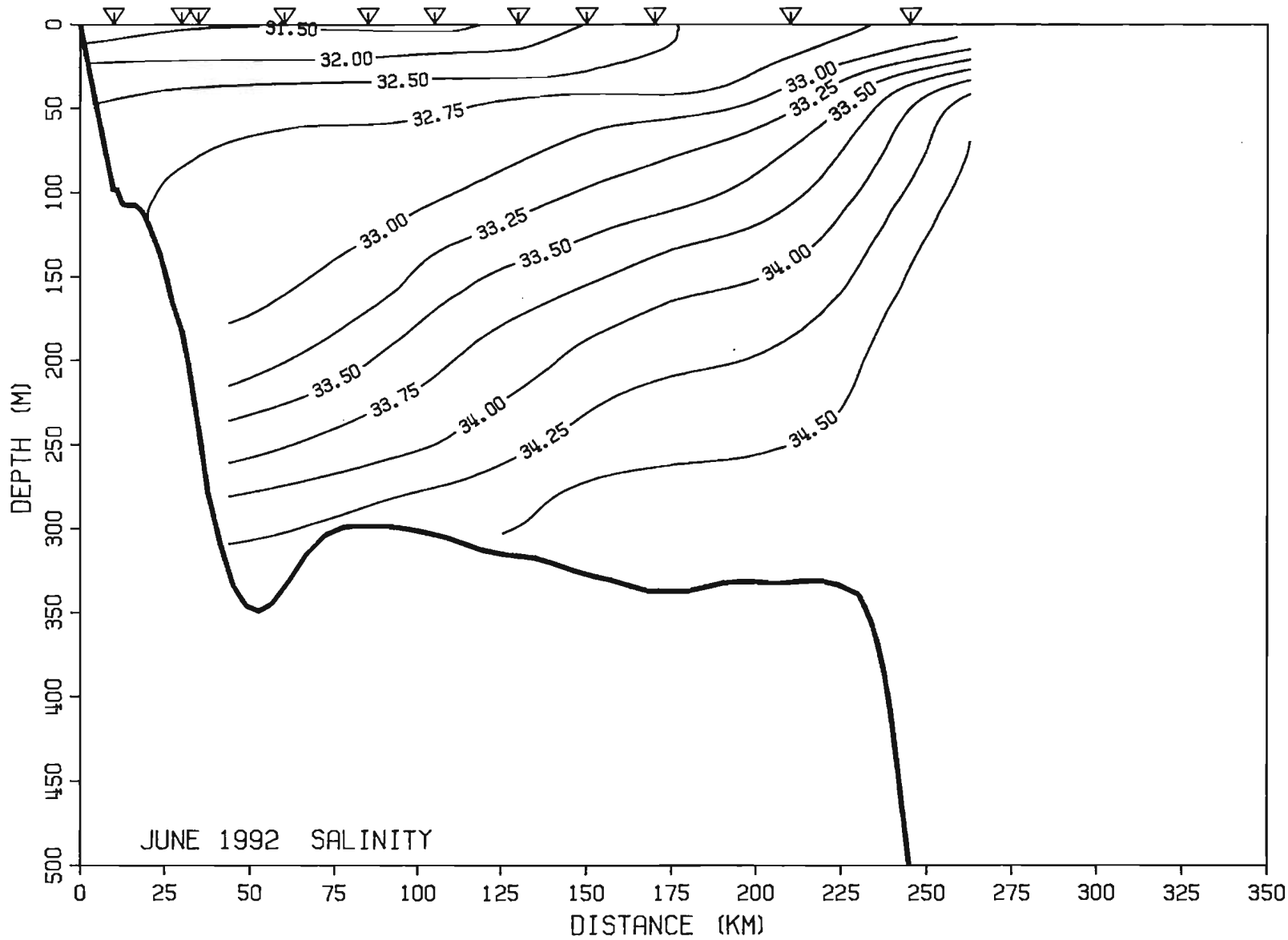
JUNE 1992 SALINITY
DEPTH (M)
DISTANCE (KM)
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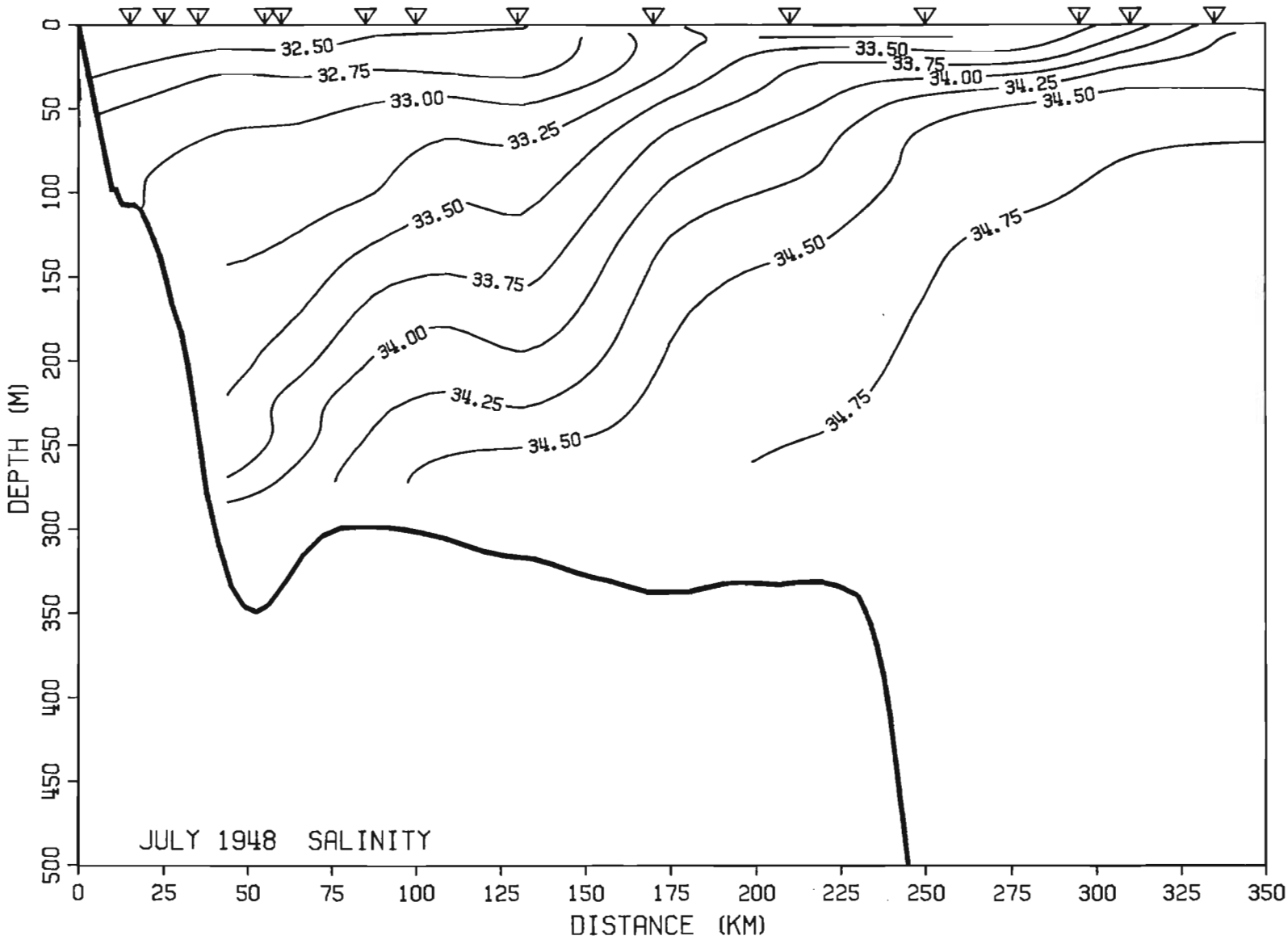
JULY 1948 SALINITY
DEPTH (M)
DISTANCE (KM)
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100
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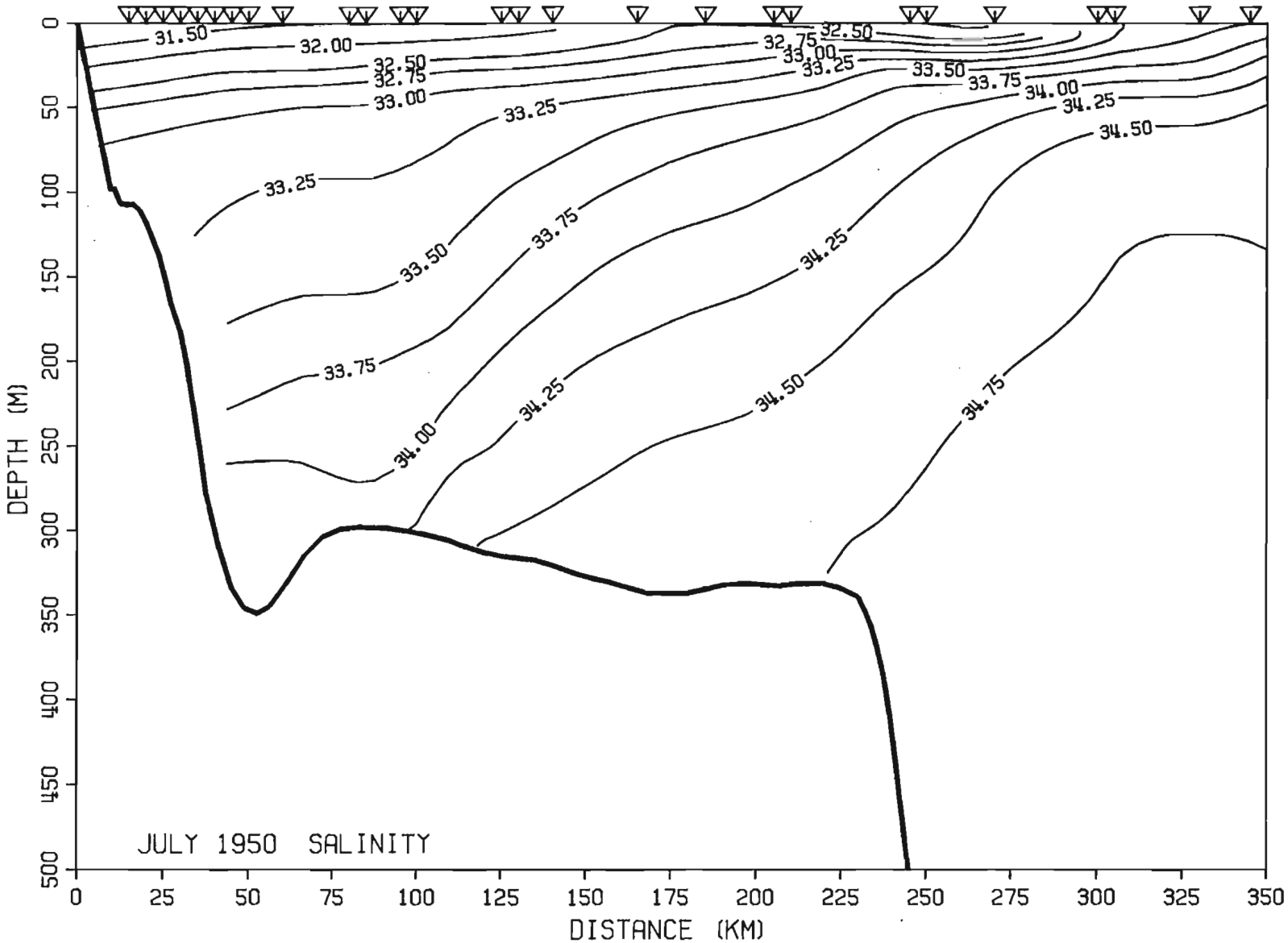
JULY 1950 SALINITY
DEPTH (M)
DISTANCE (KM)
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0
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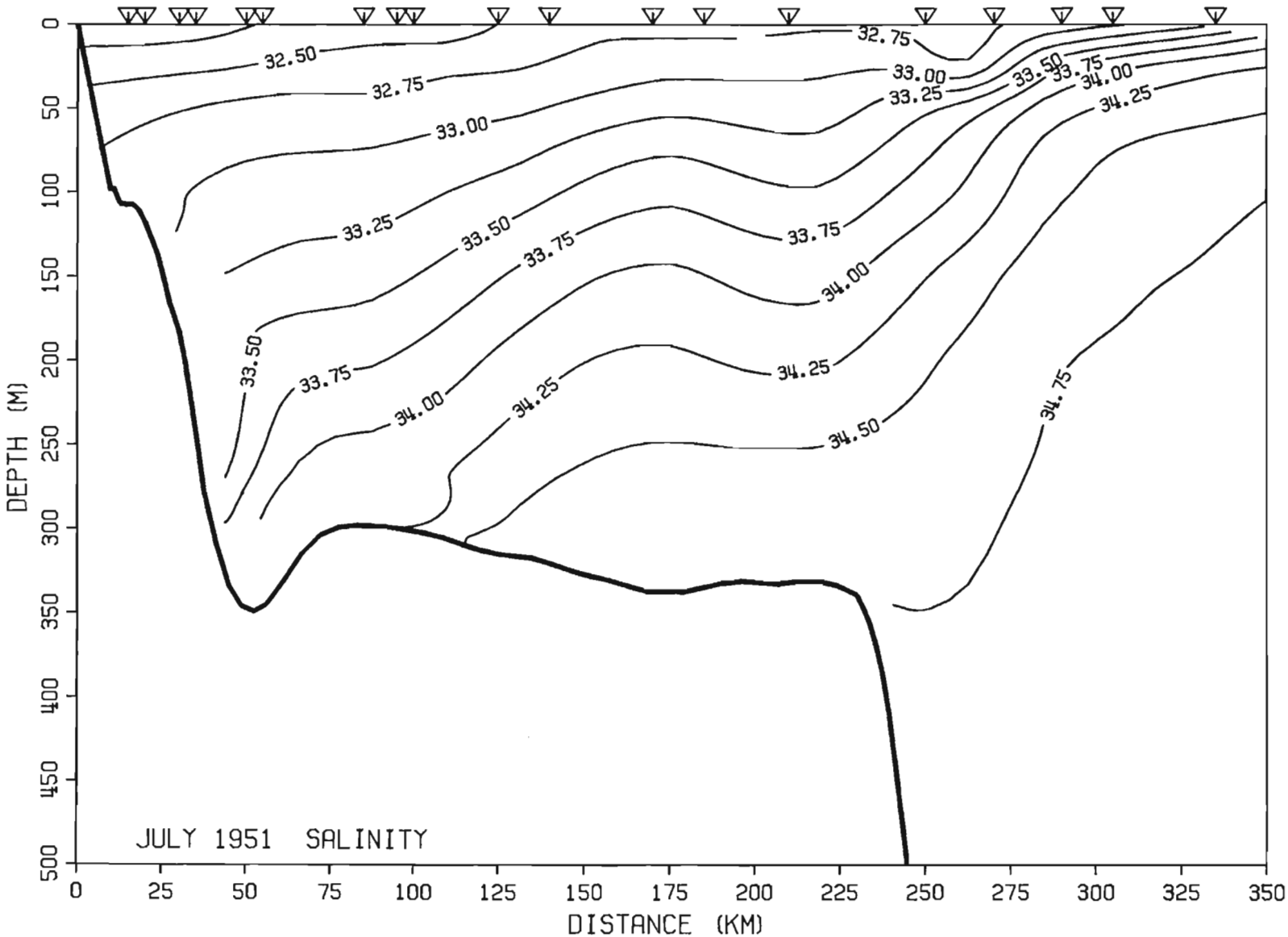
JULY 1951 SALINITY
DEPTH (M)
DISTANCE (KM)
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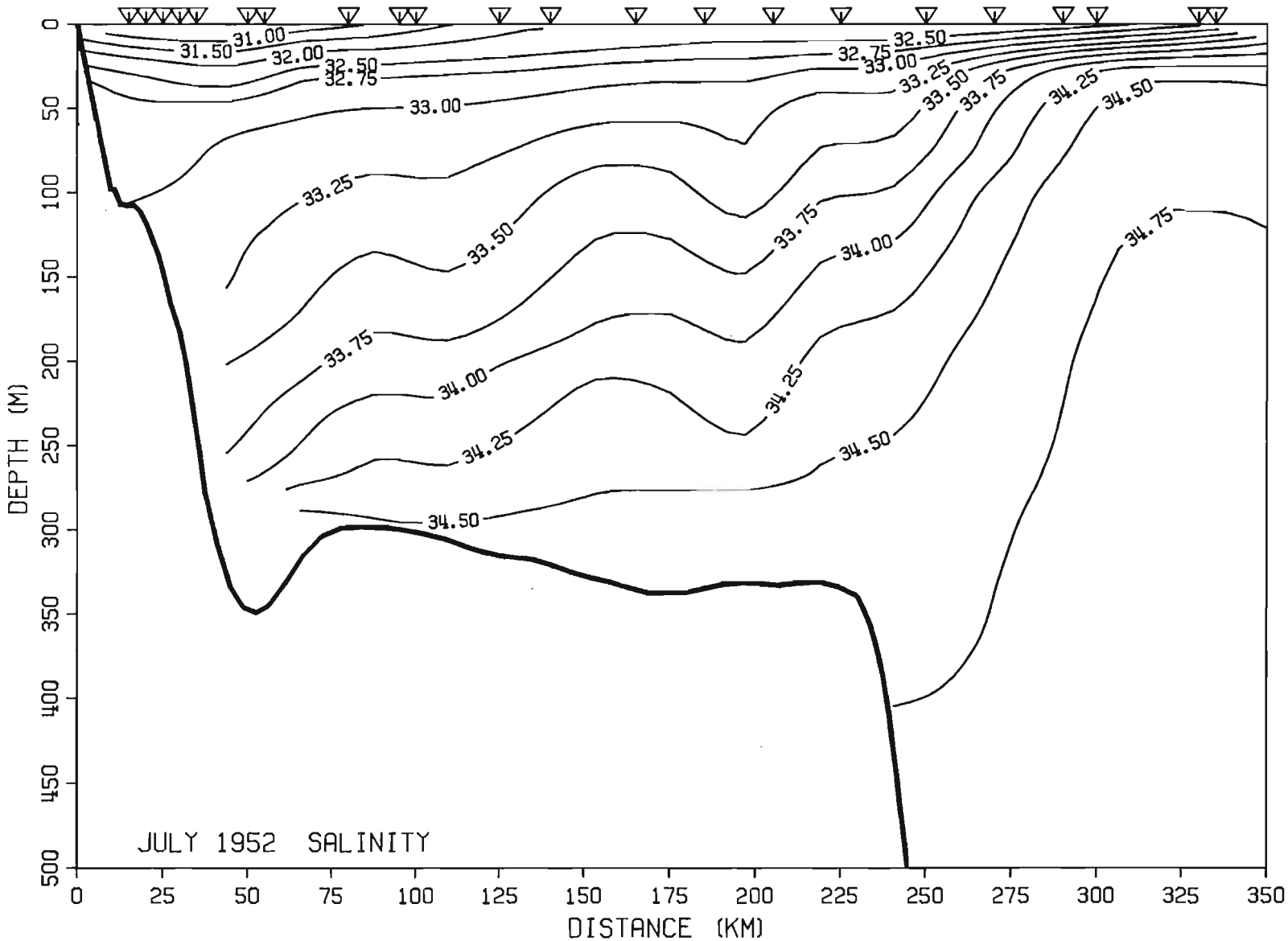
JULY 1952 SALINITY
DEPTH (M)
DISTANCE (KM)
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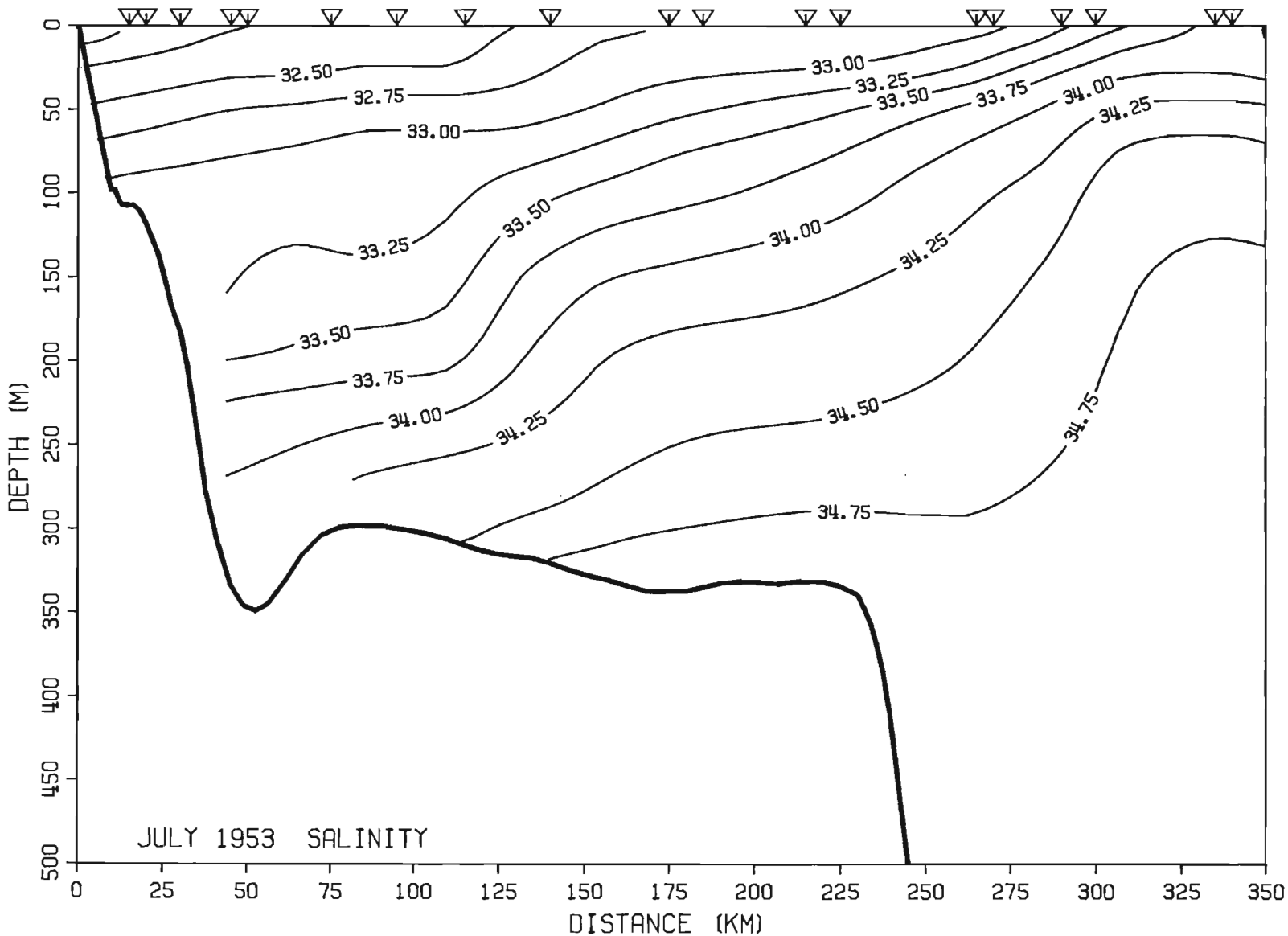
JULY 1953 SALINITY
DEPTH (M)
DISTANCE (KM)
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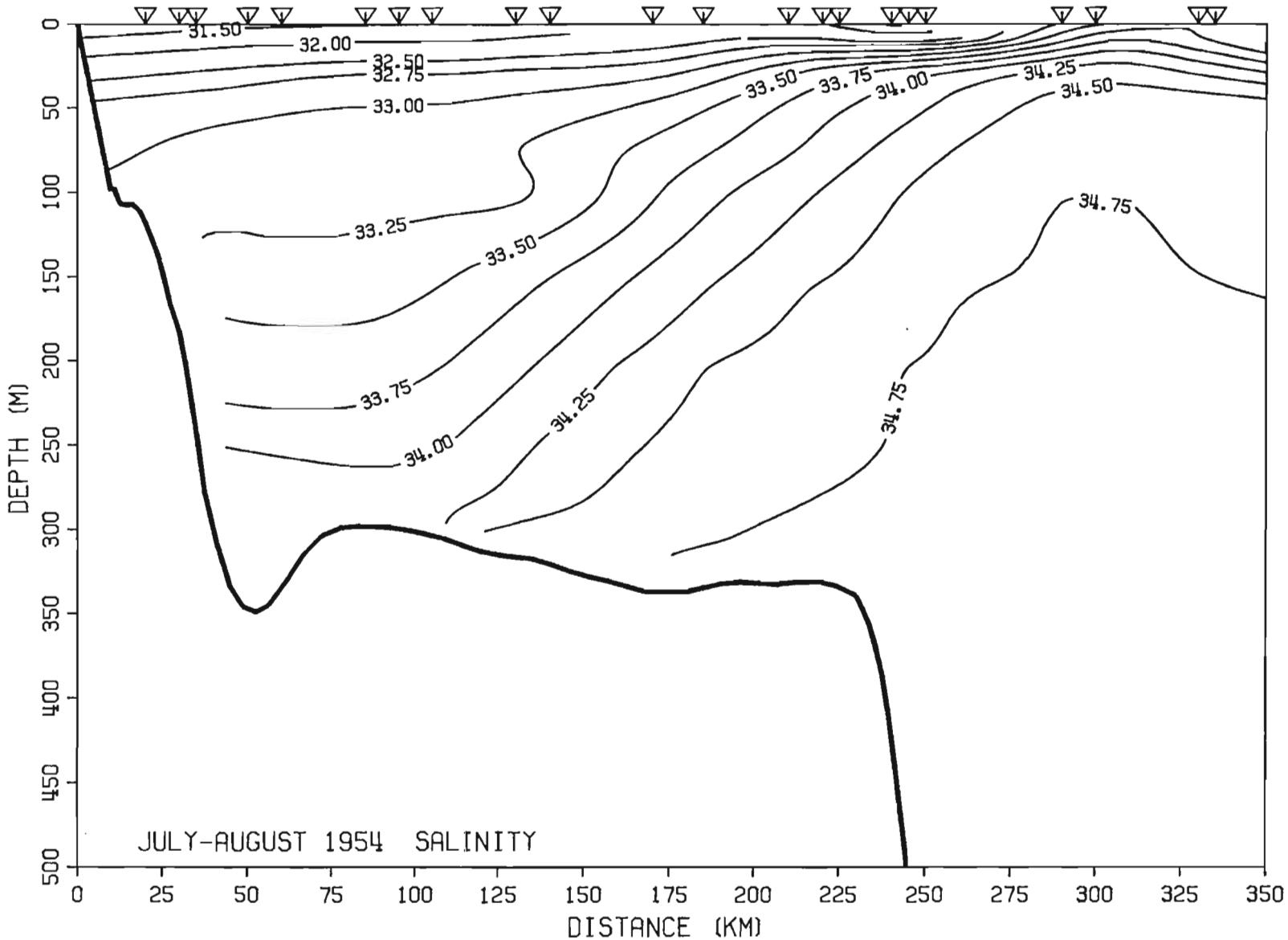
JULY-AUGUST 1954 SALINITY
DEPTH (M)
DISTANCE (KM)
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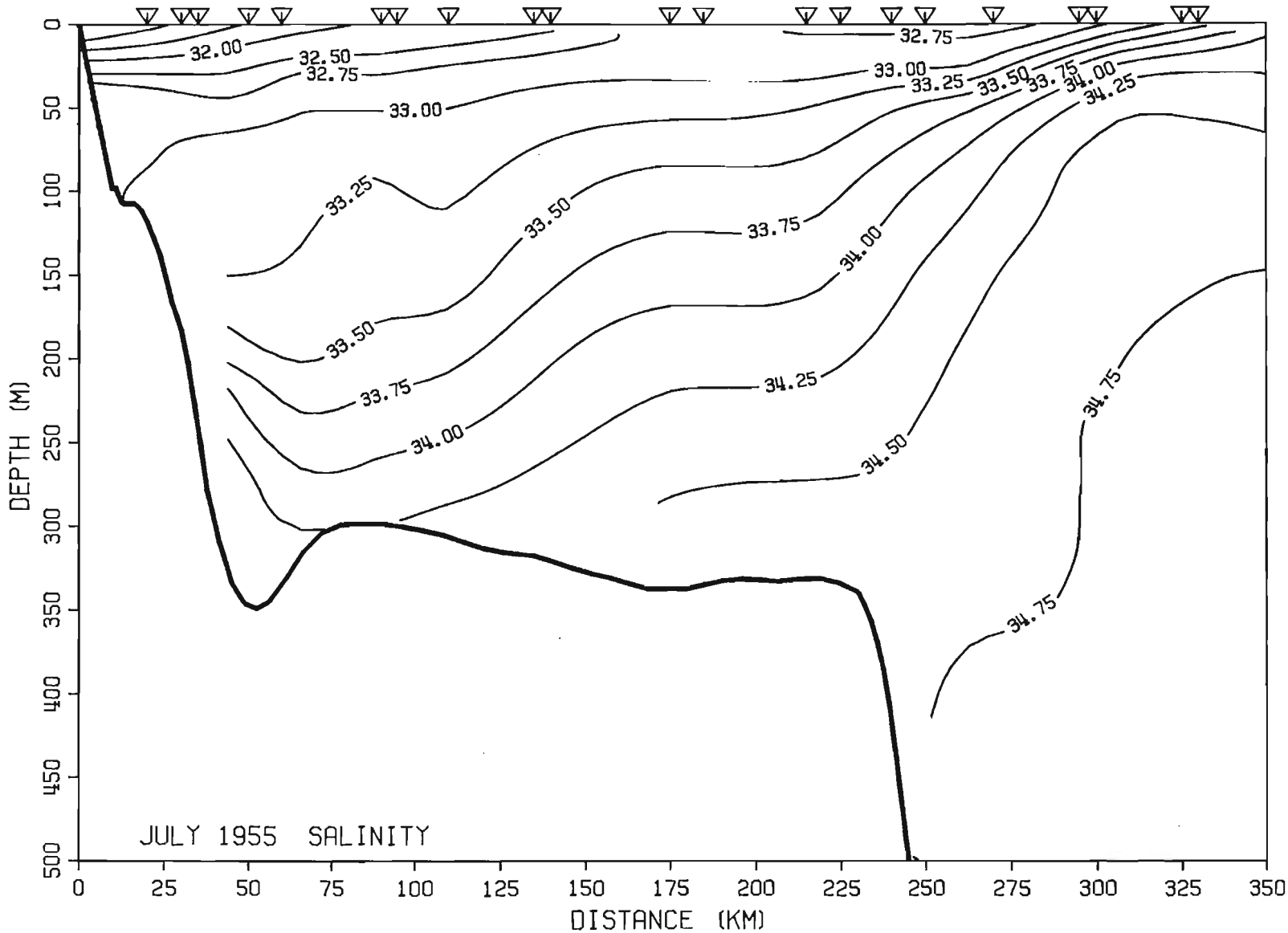
JULY 1955 SALINITY
DEPTH (M)
DISTANCE (KM)
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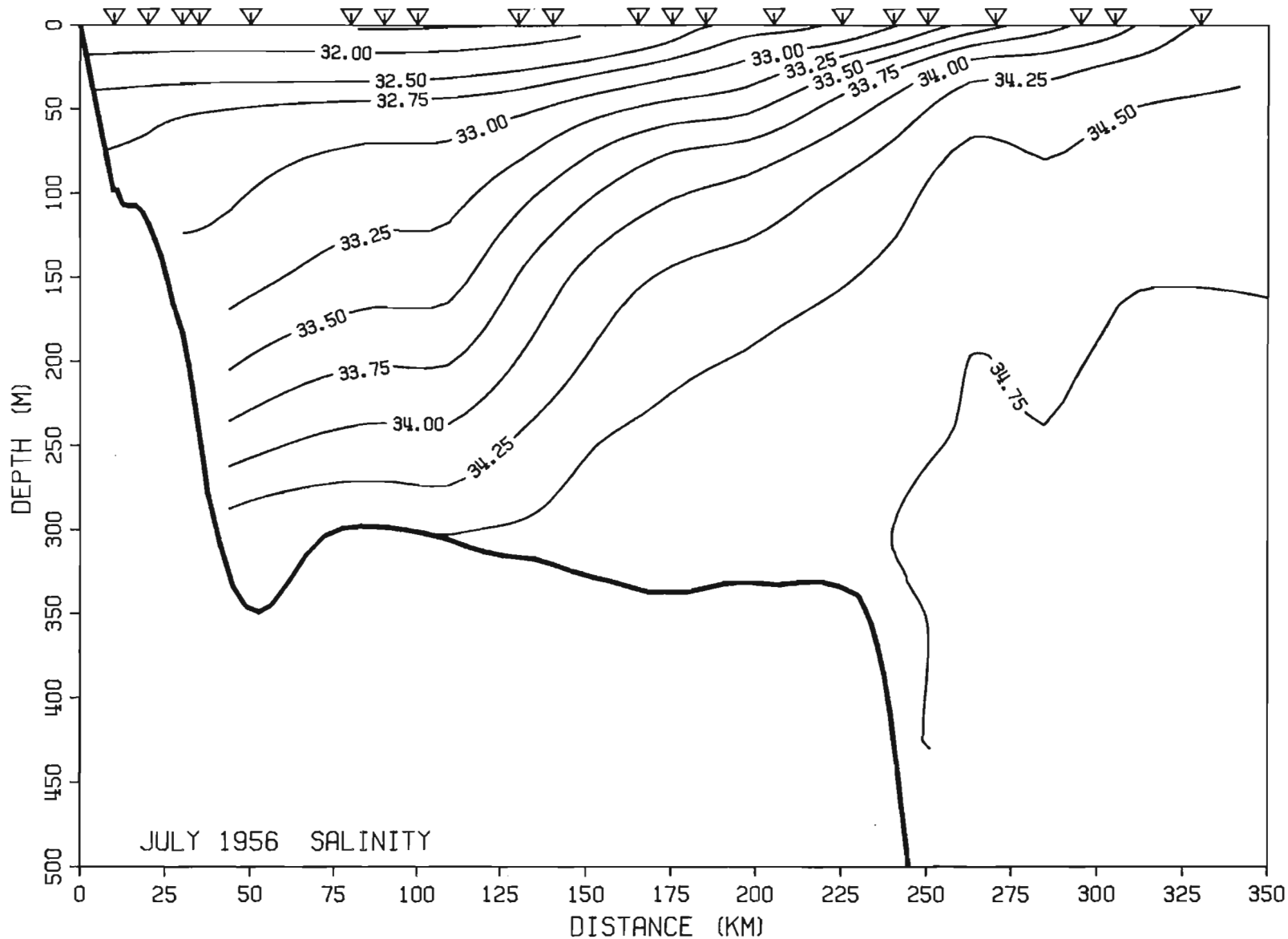
JULY 1956 SALINITY
DEPTH (M)
DISTANCE (KM)
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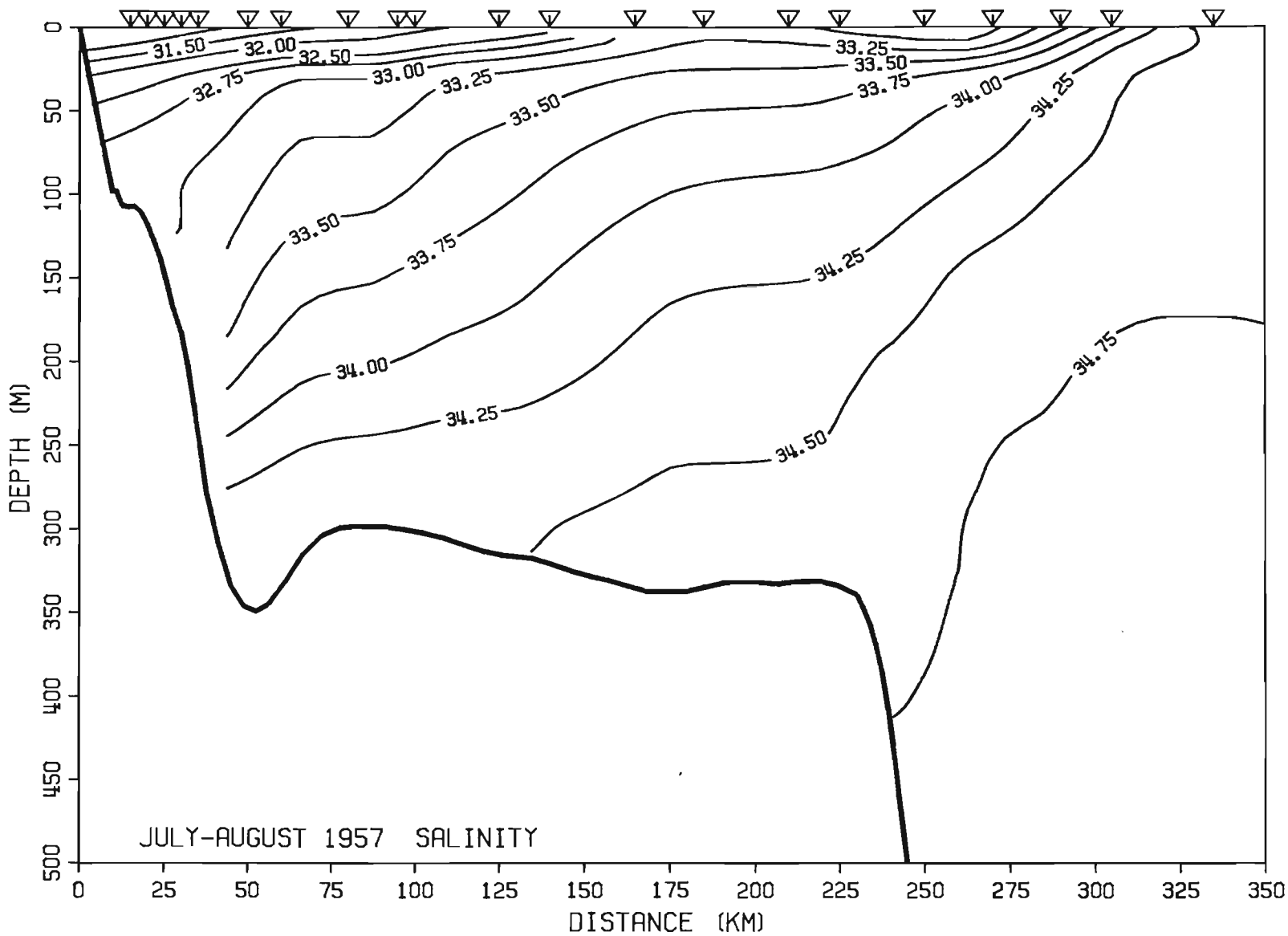
JULY-AUGUST 1957 SALINITY
DEPTH (M)
DISTANCE (KM)
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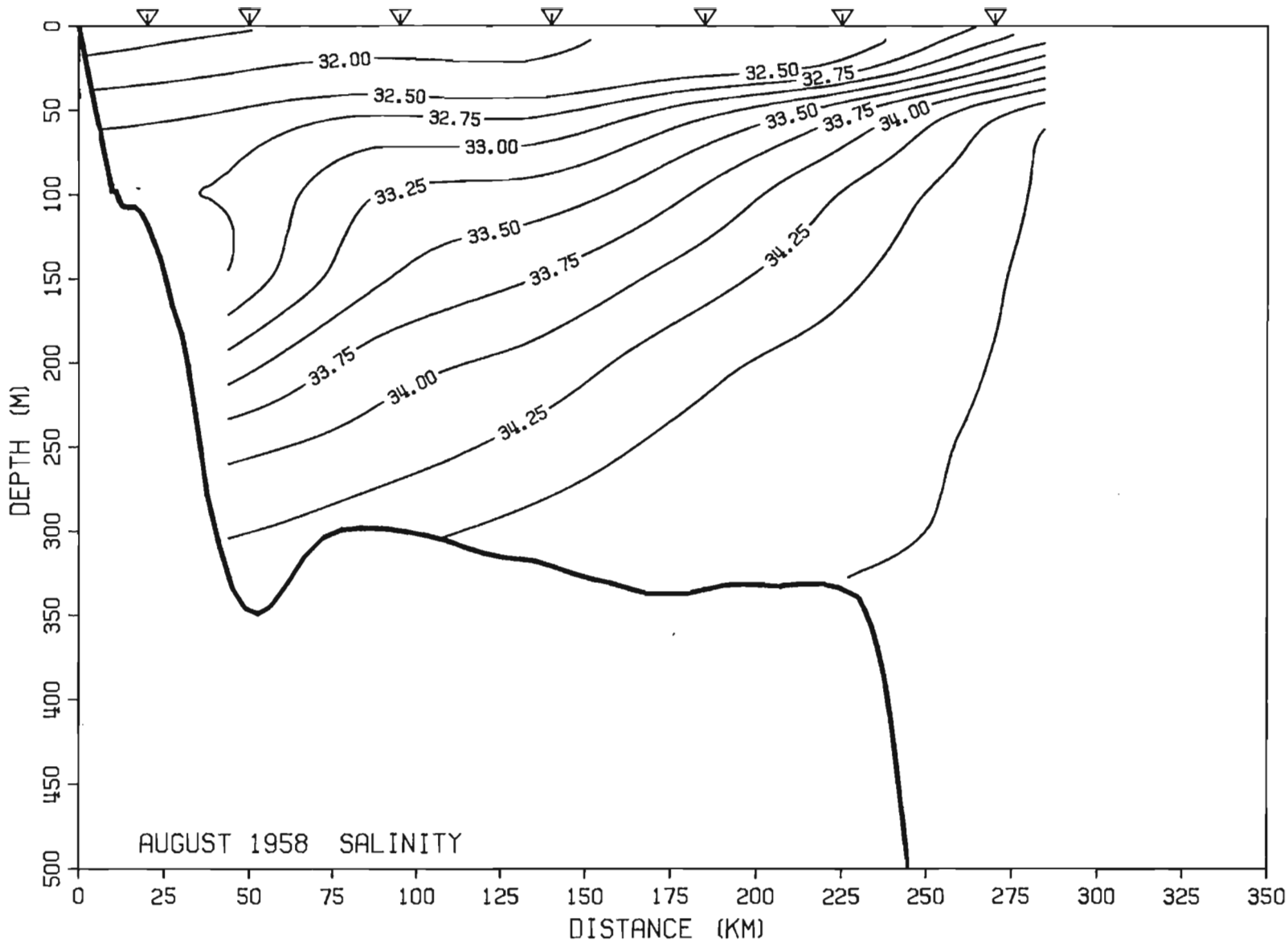
AUGUST 1958 SALINITY
DEPTH (M)
DISTANCE (KM)
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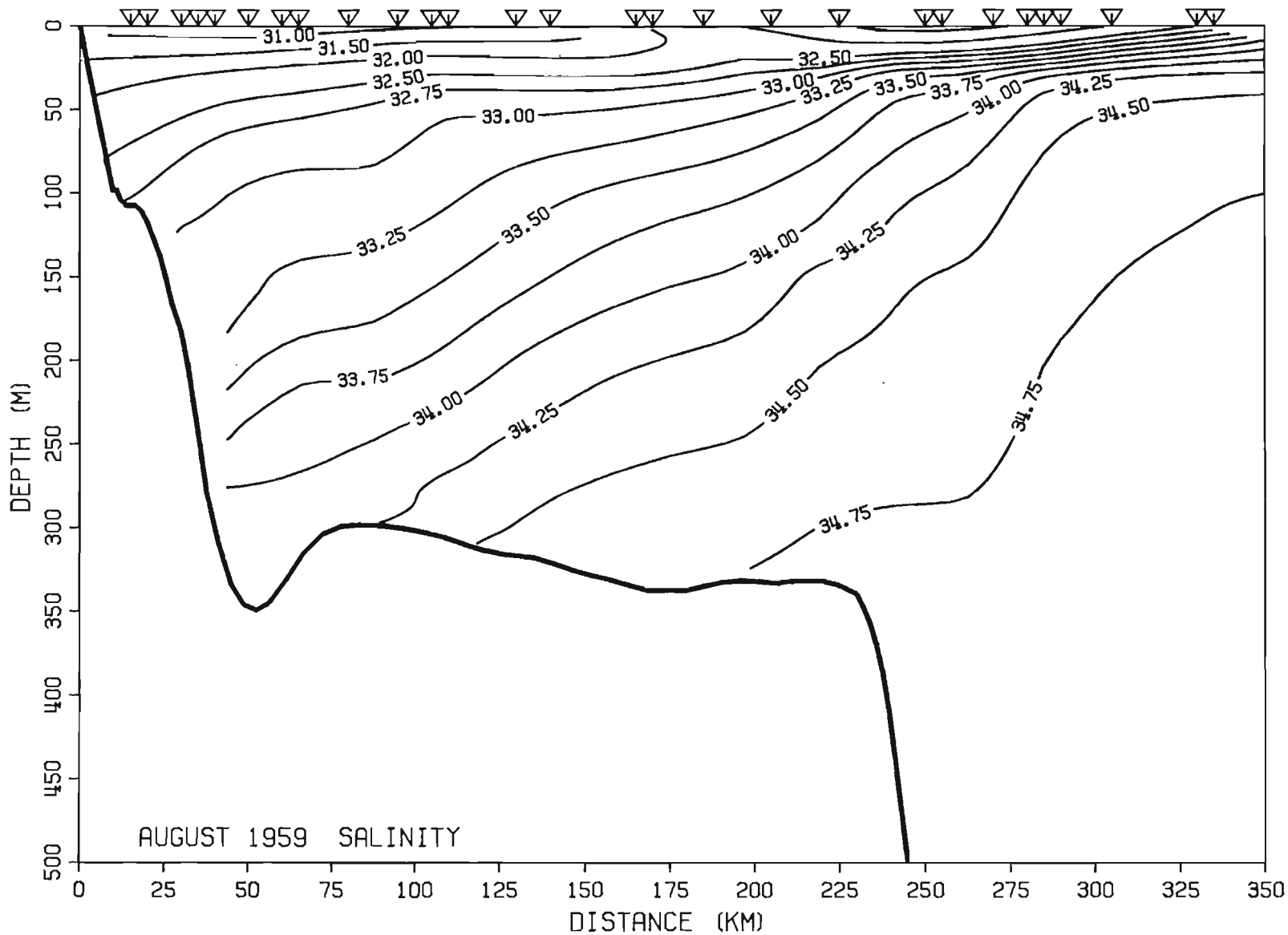
AUGUST 1959 SALINITY
DEPTH (M)
DISTANCE (KM)
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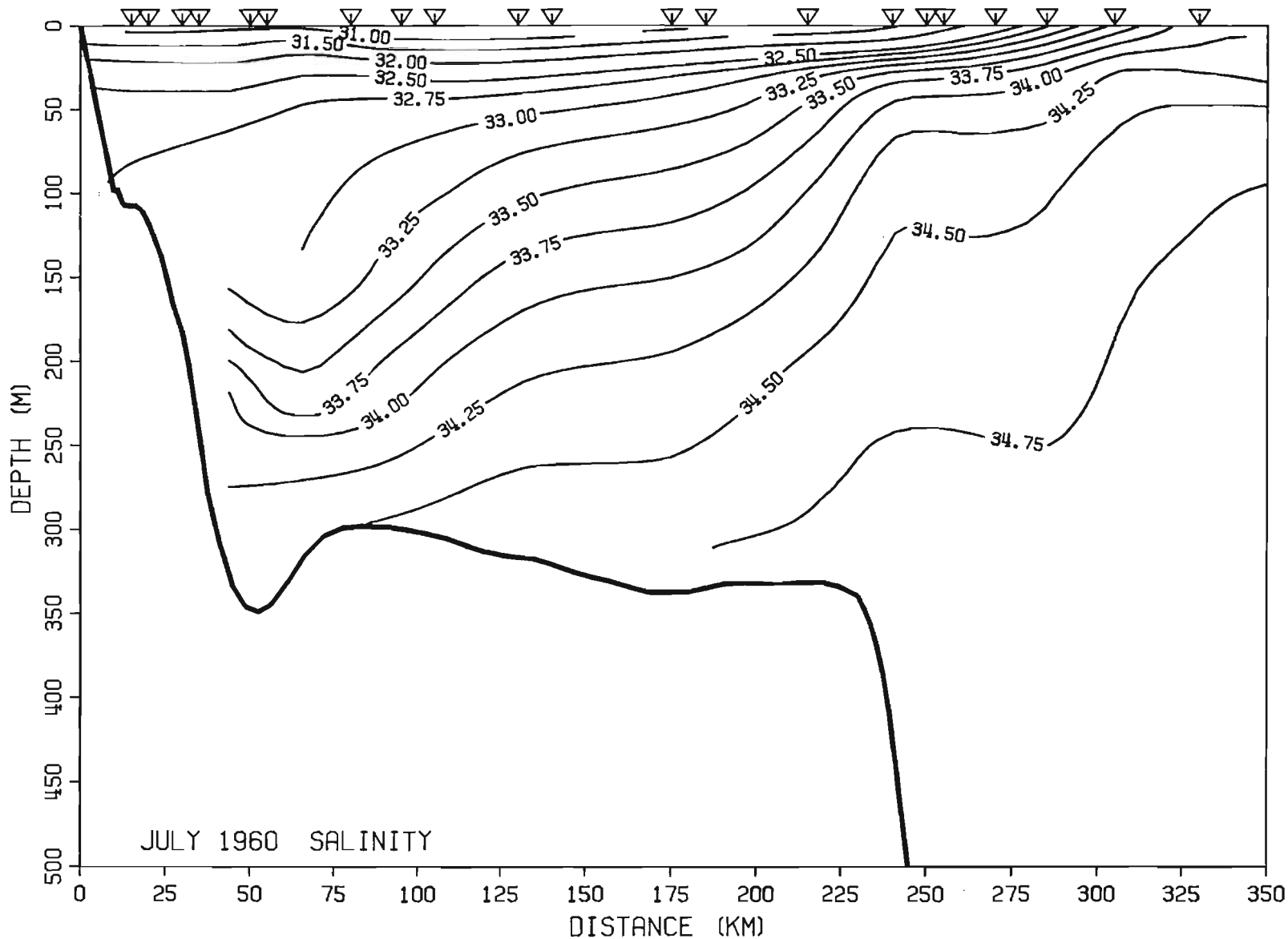
JULY 1960 SALINITY
DEPTH (M)
DISTANCE (KM)
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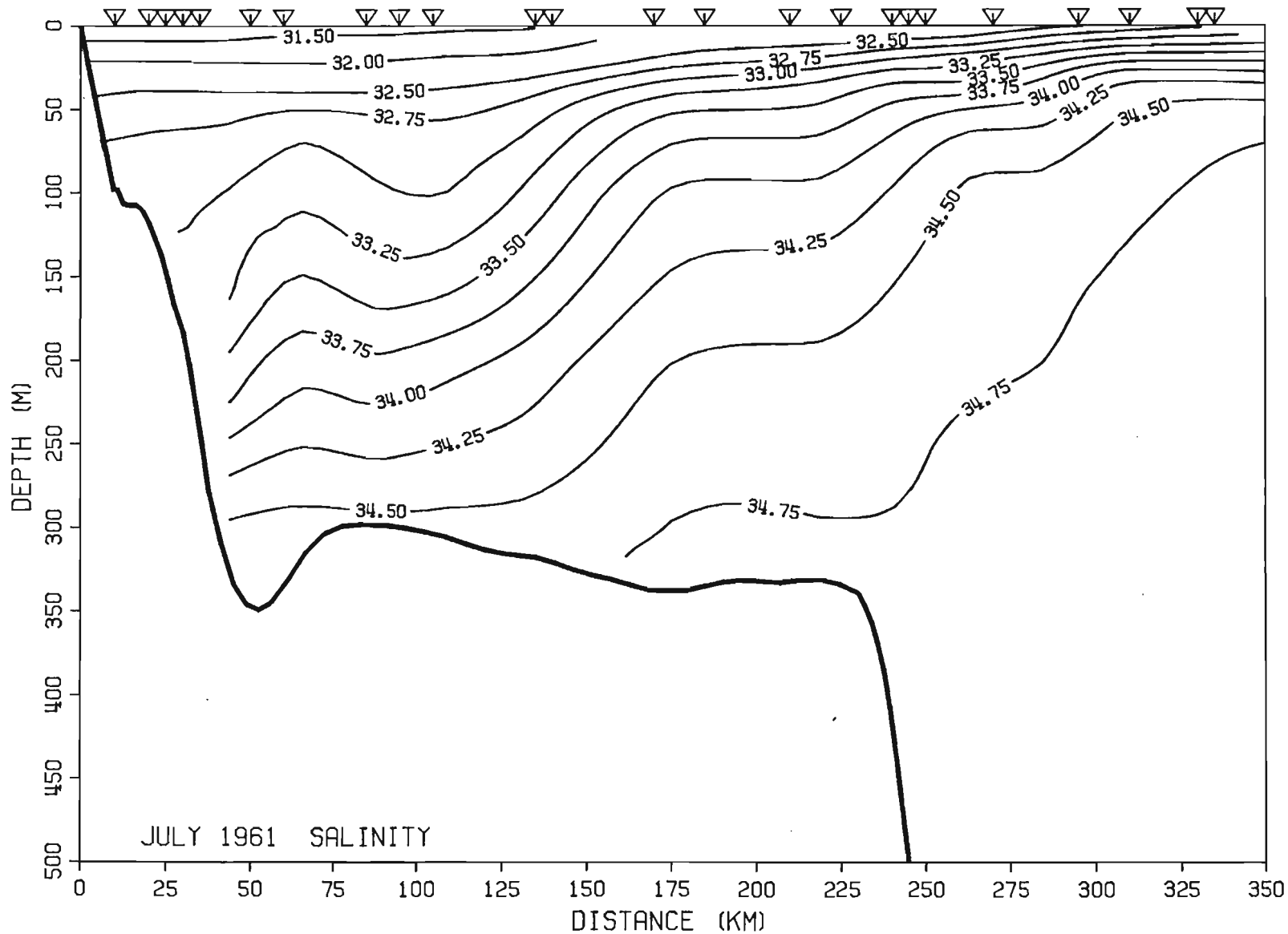
JULY 1961 SALINITY
DEPTH (M)
DISTANCE (KM)
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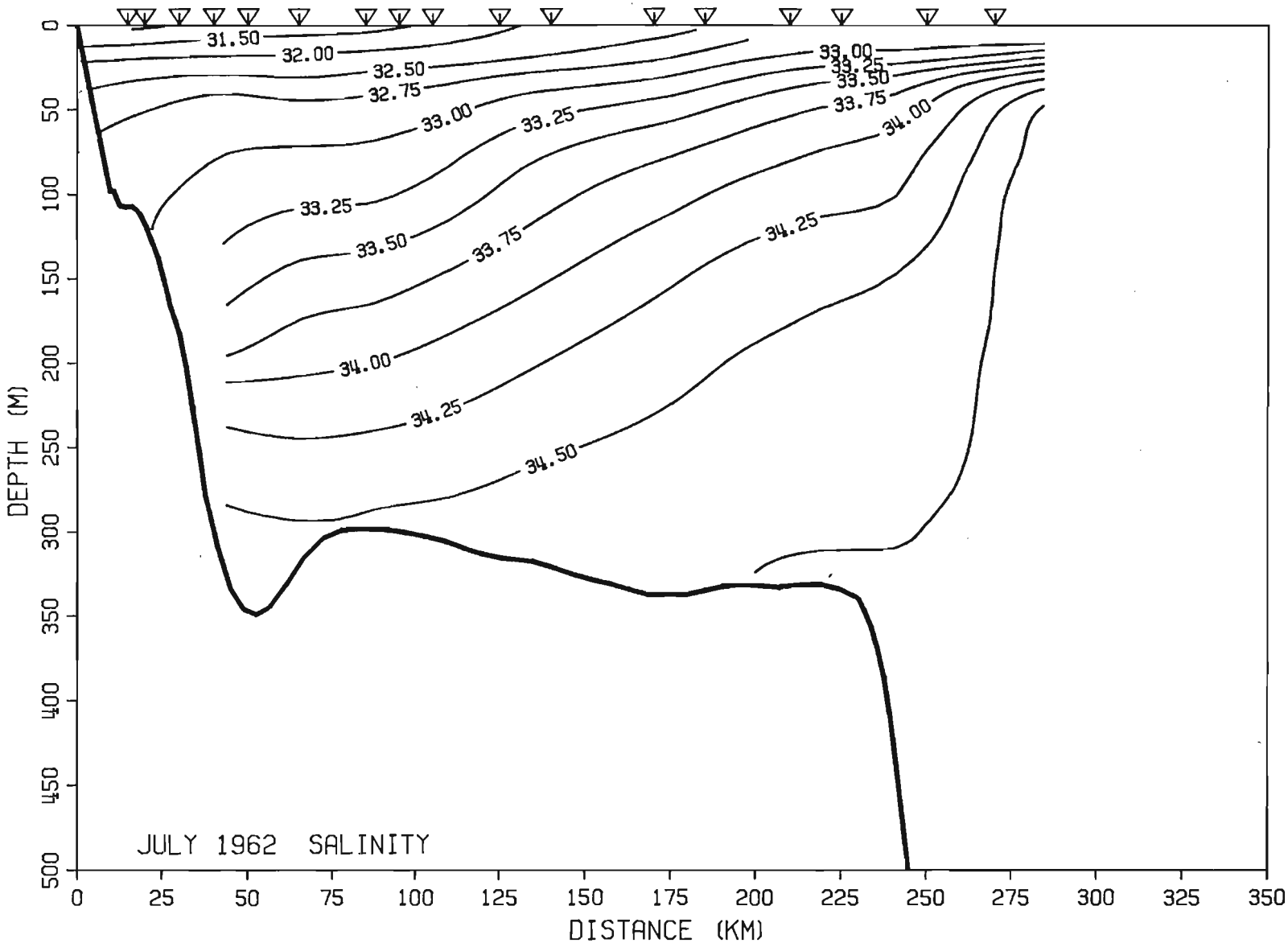
JULY 1962 SALINITY
DEPTH (M)
DISTANCE (KM)
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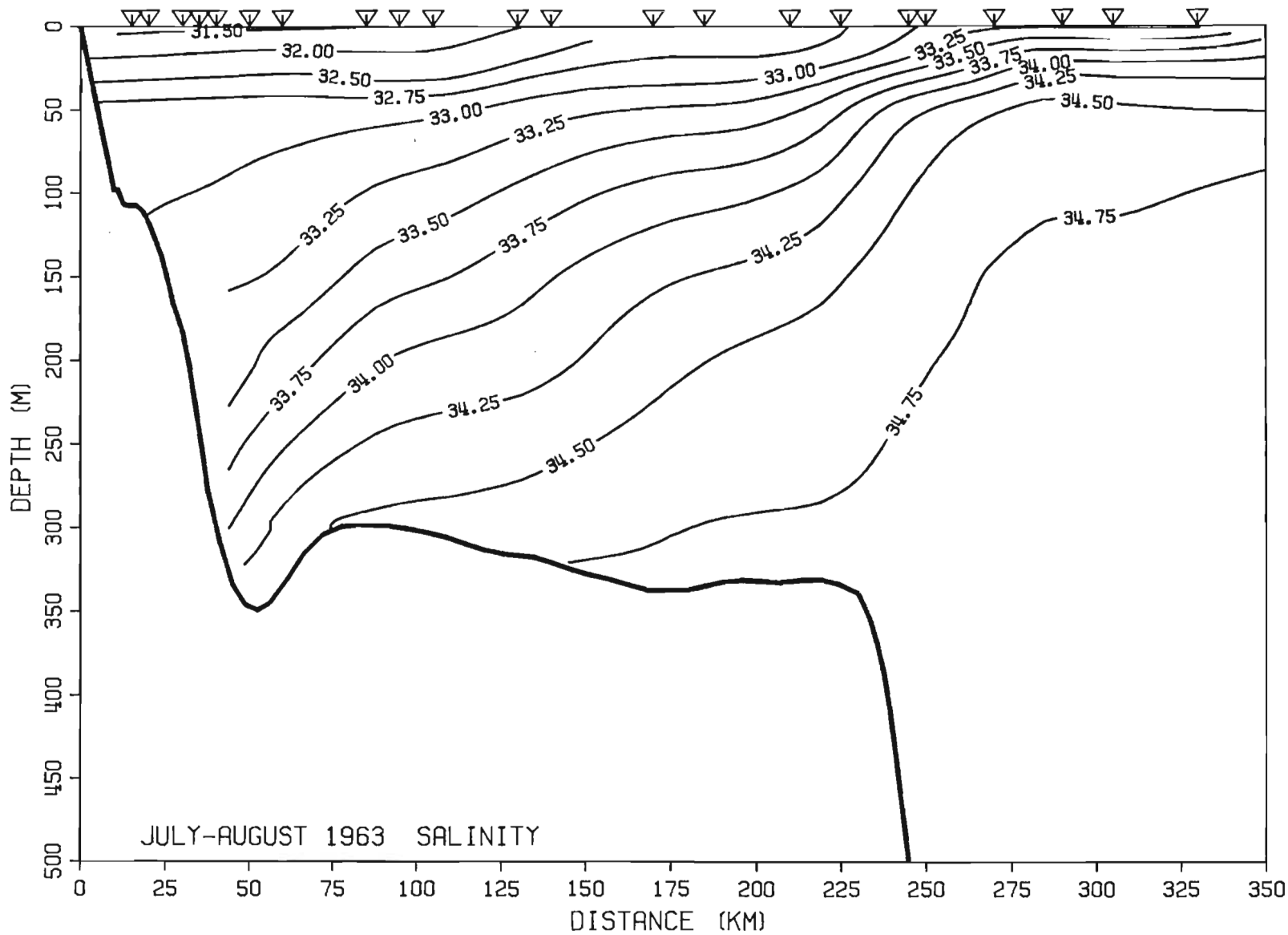
JULY-AUGUST 1963 SALINITY
DEPTH (M)
DISTANCE (KM)
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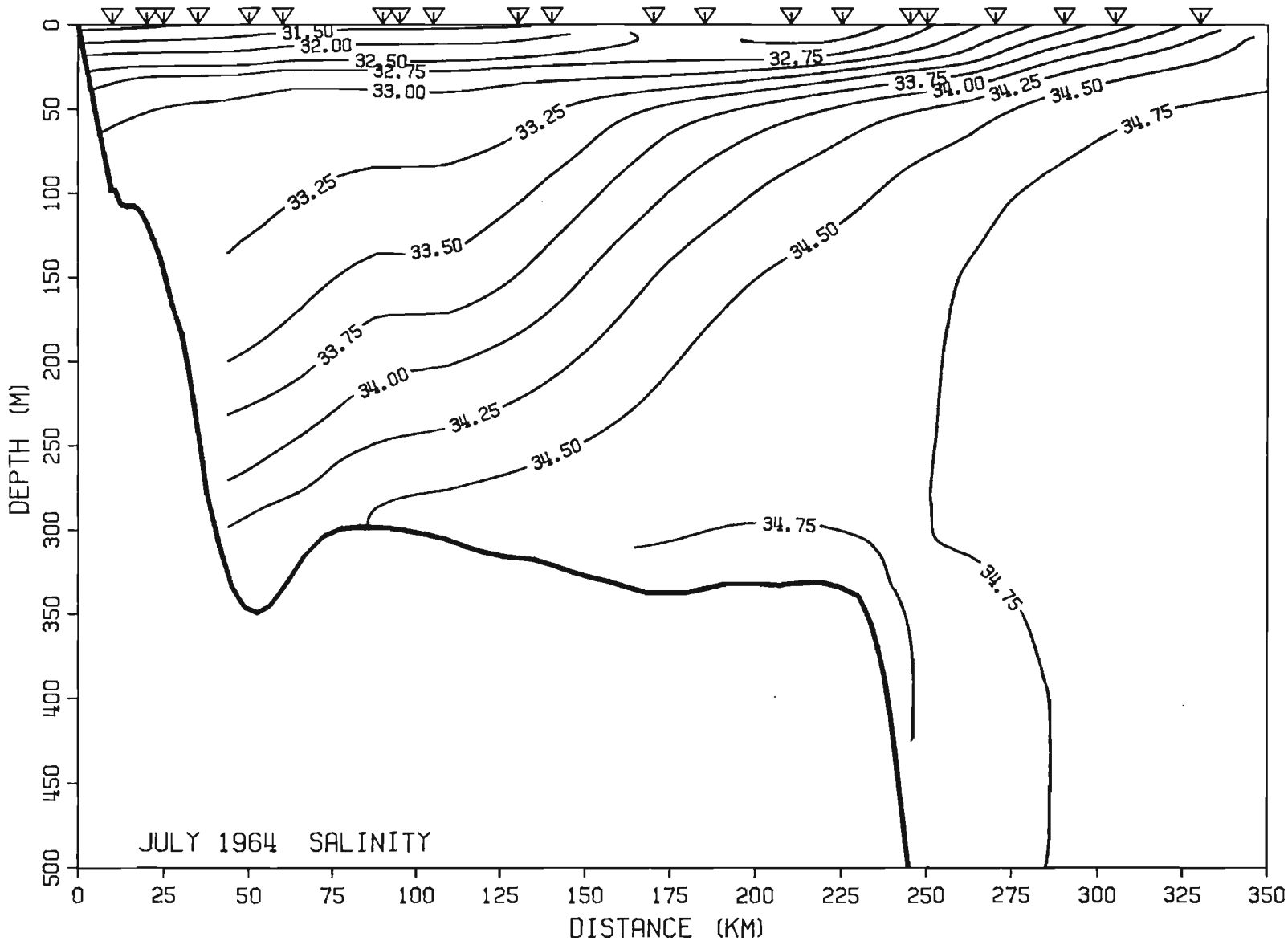
JULY 1964 SALINITY
DEPTH (M)
DISTANCE (KM)
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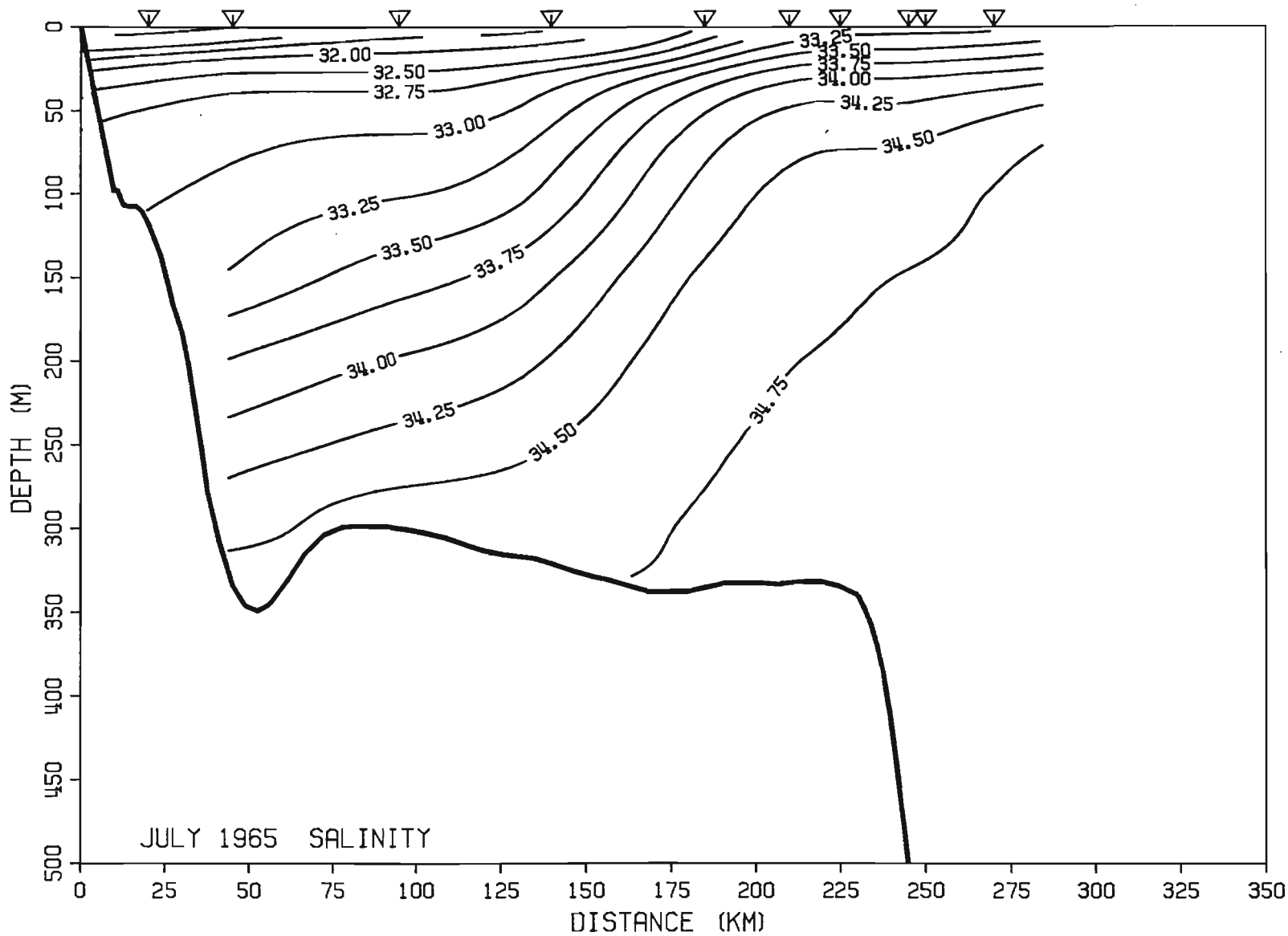
JULY 1965 SALINITY
DEPTH (M)
DISTANCE (KM)
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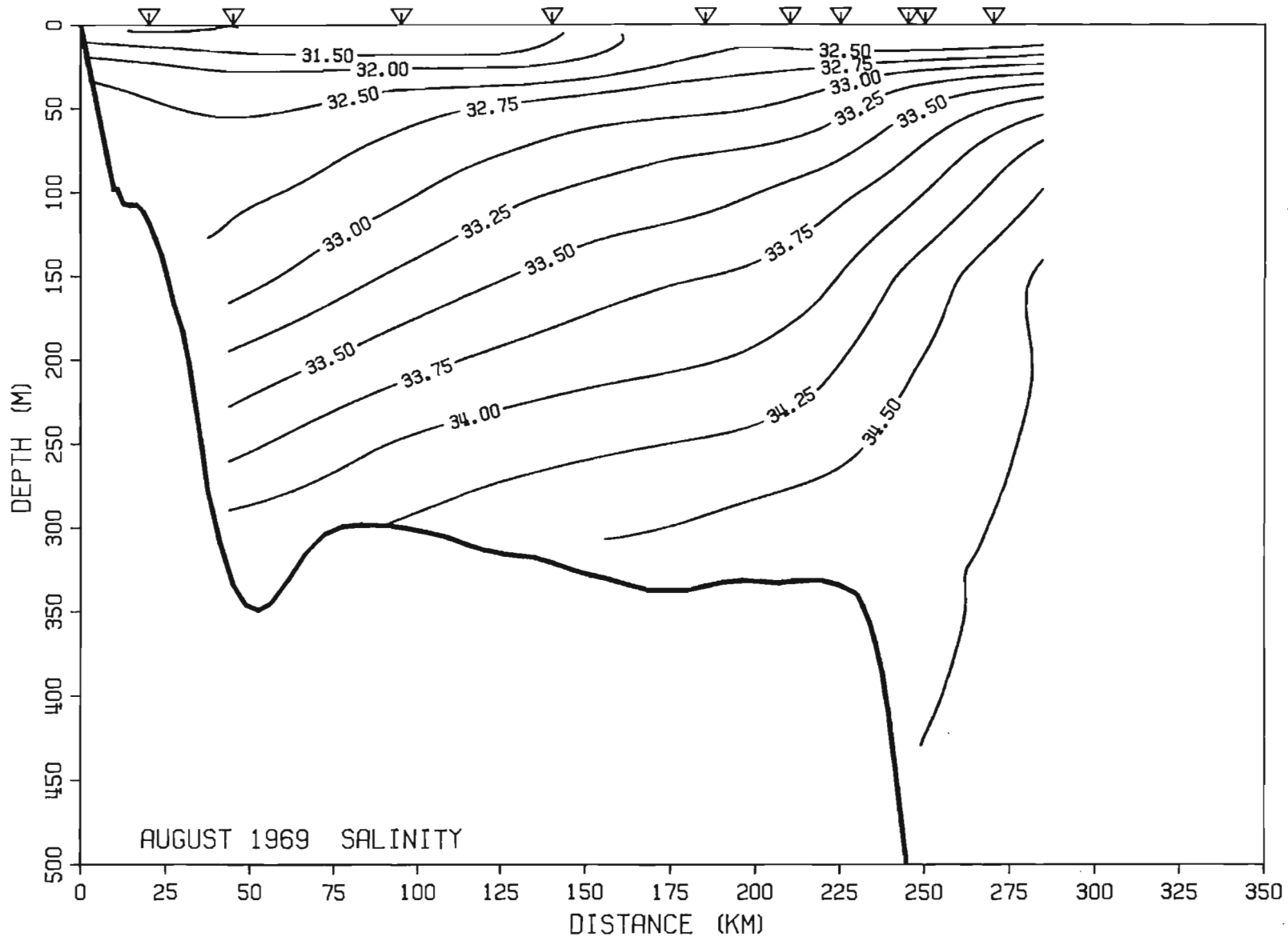
AUGUST 1969 SALINITY
DEPTH (M)
DISTANCE (KM)
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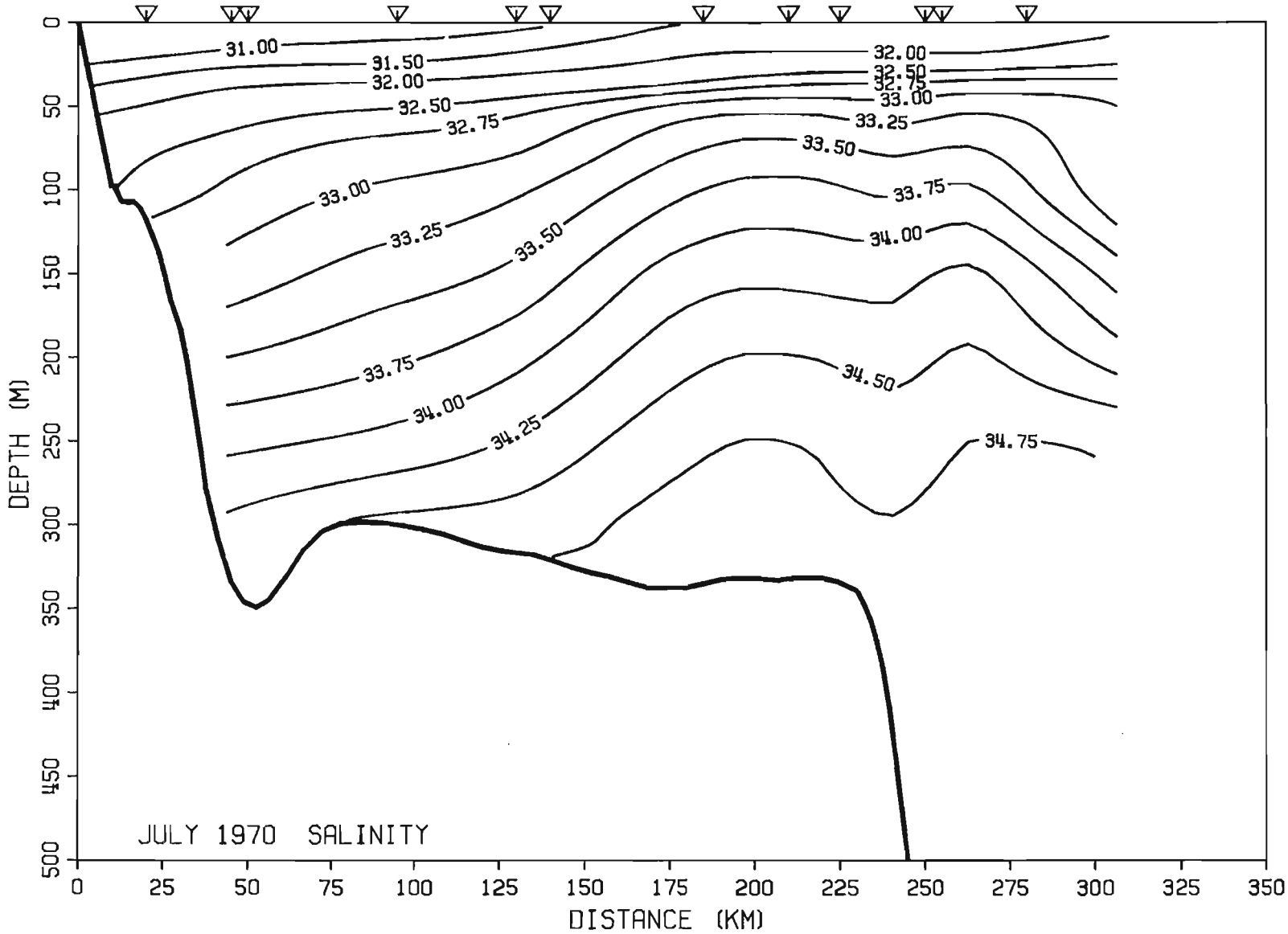
JULY 1970 SALINITY
DEPTH (M)
DISTANCE (KM)
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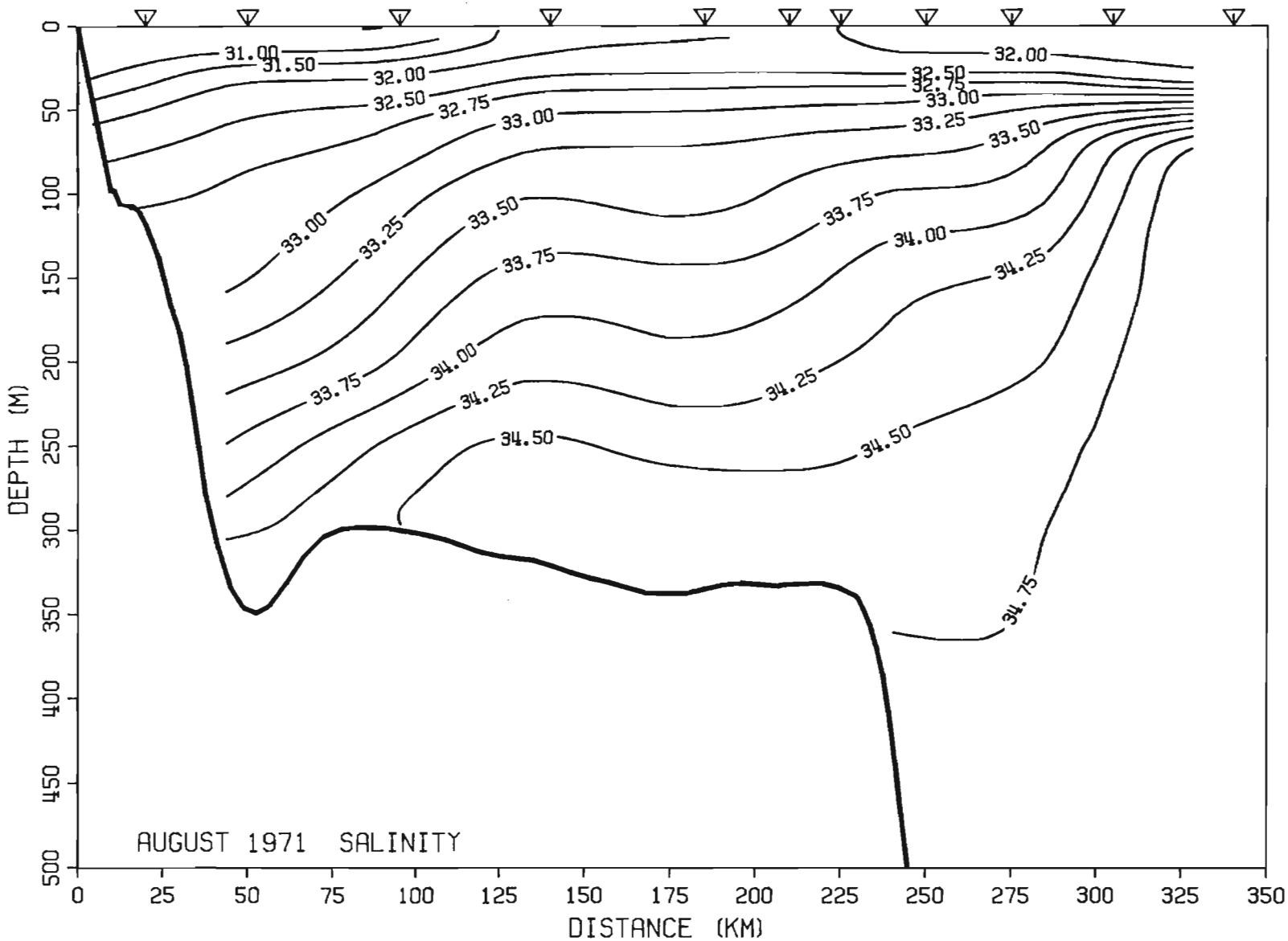
AUGUST 1971 SALINITY
DEPTH (M)
DISTANCE (KM)
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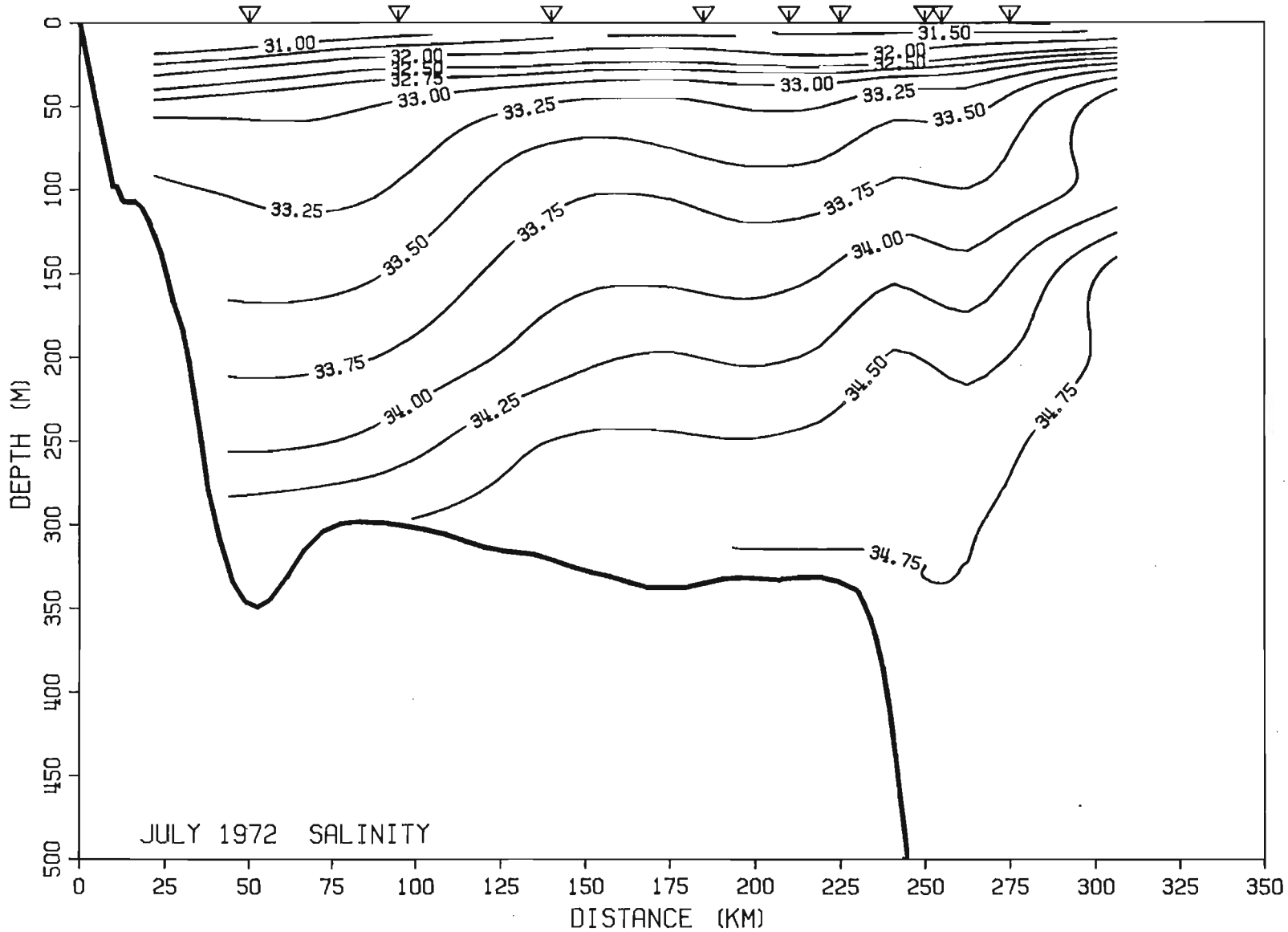
JULY 1972 SALINITY
DEPTH (M)
DISTANCE (KM)
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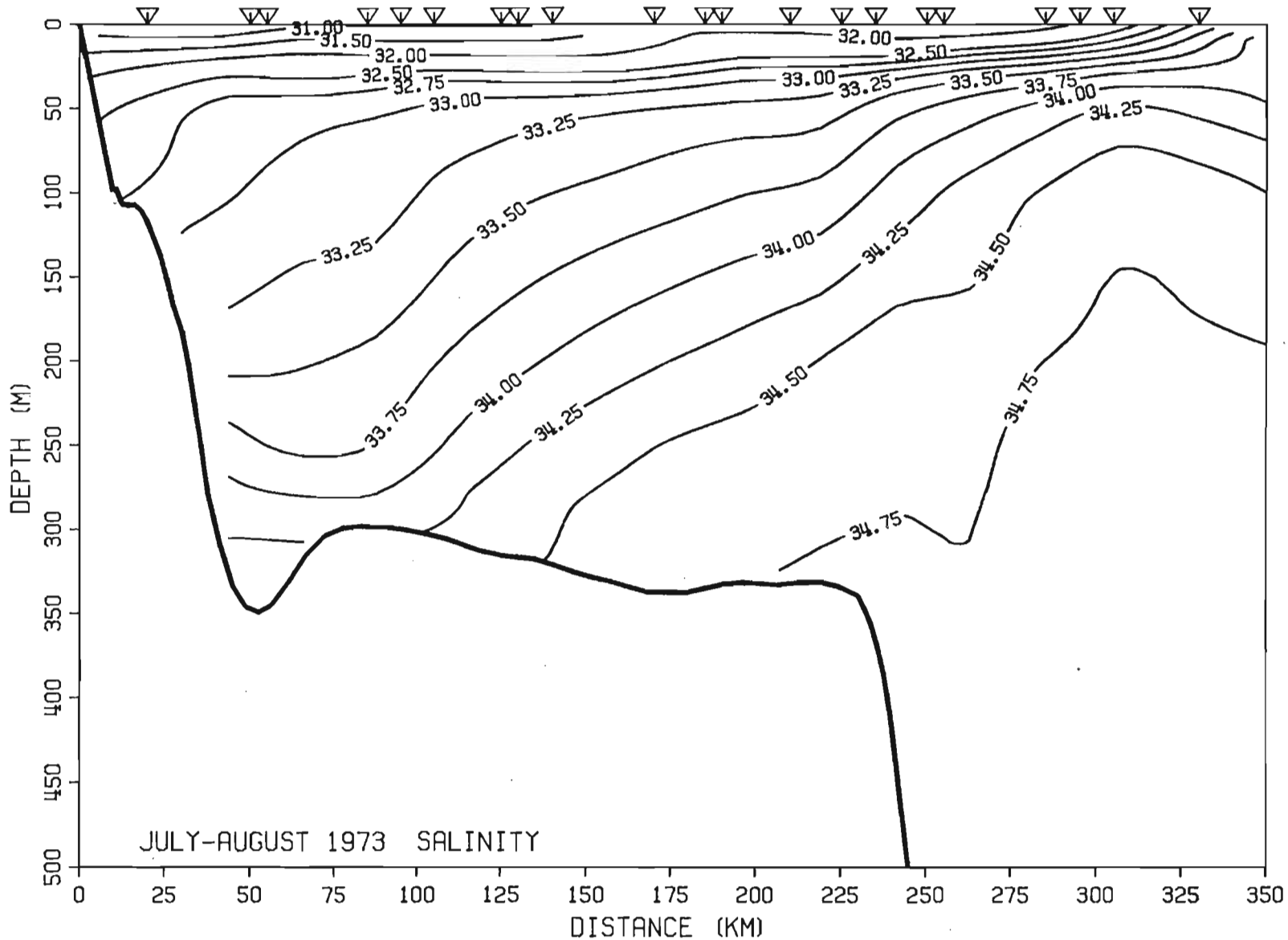
JULY-AUGUST 1973 SALINITY
DEPTH (M)
DISTANCE (KM)
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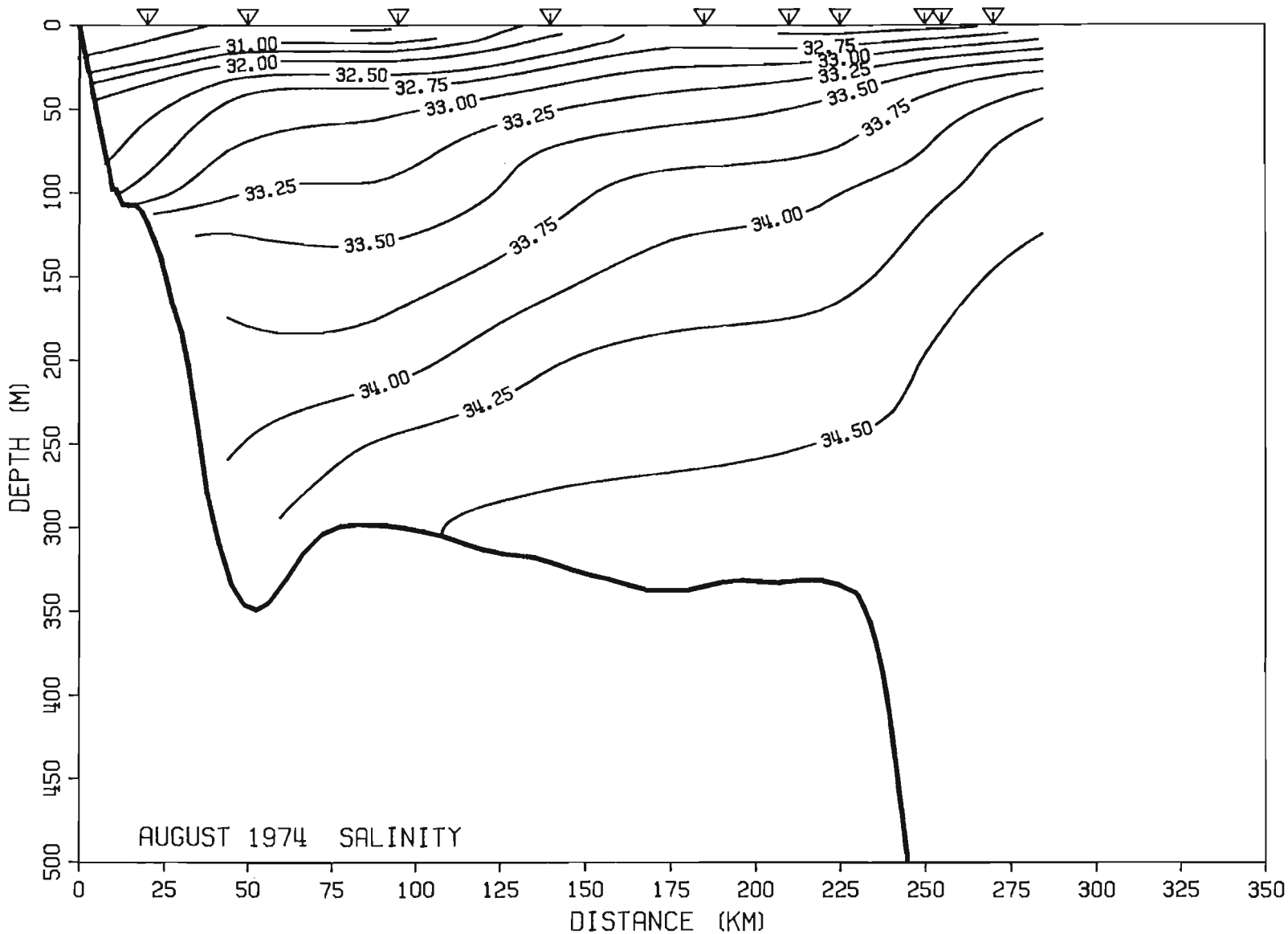
AUGUST 1974 SALINITY
DEPTH (M)
DISTANCE (KM)
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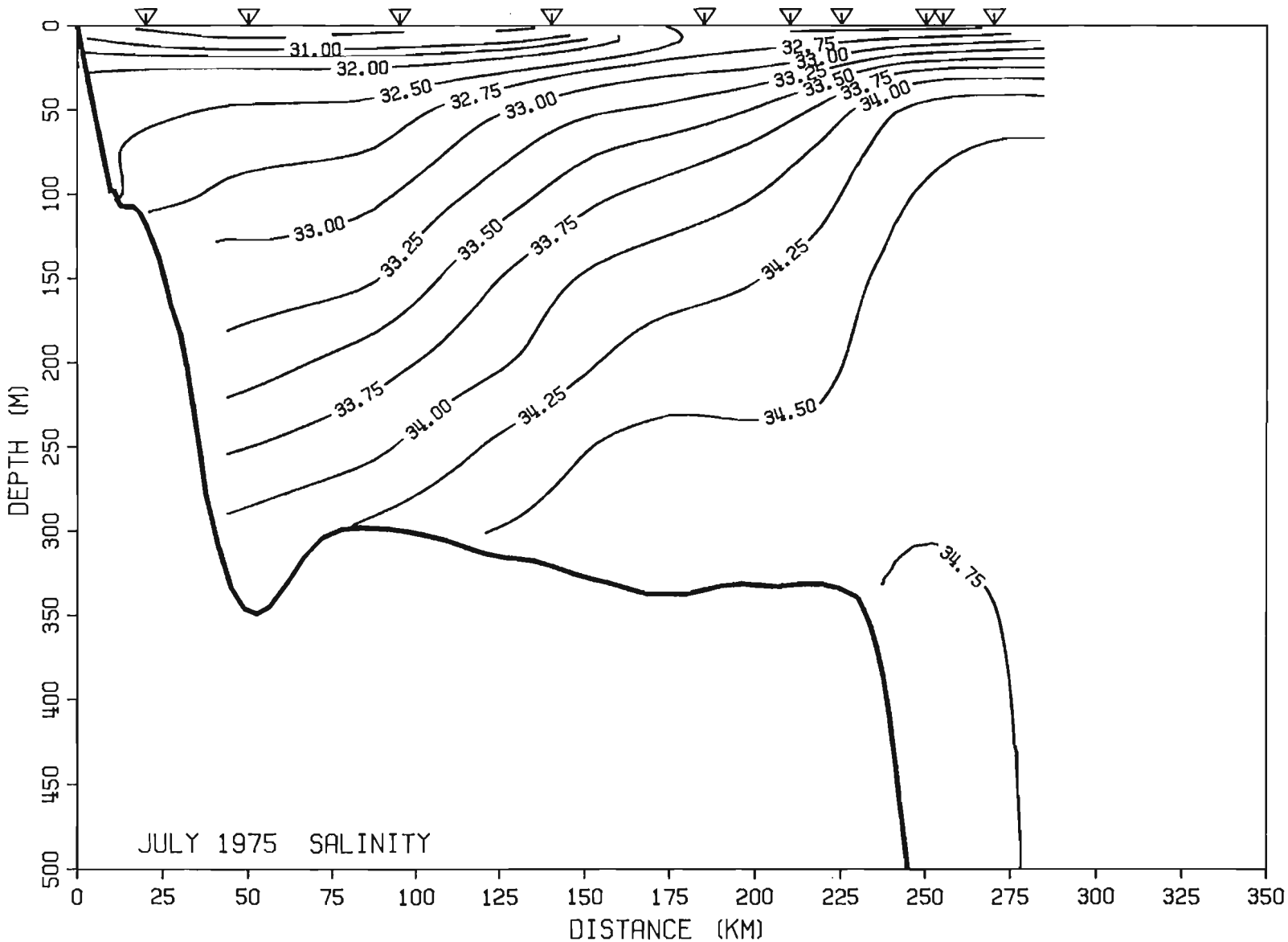
JULY 1975 SALINITY
DEPTH (M)
DISTANCE (KM)
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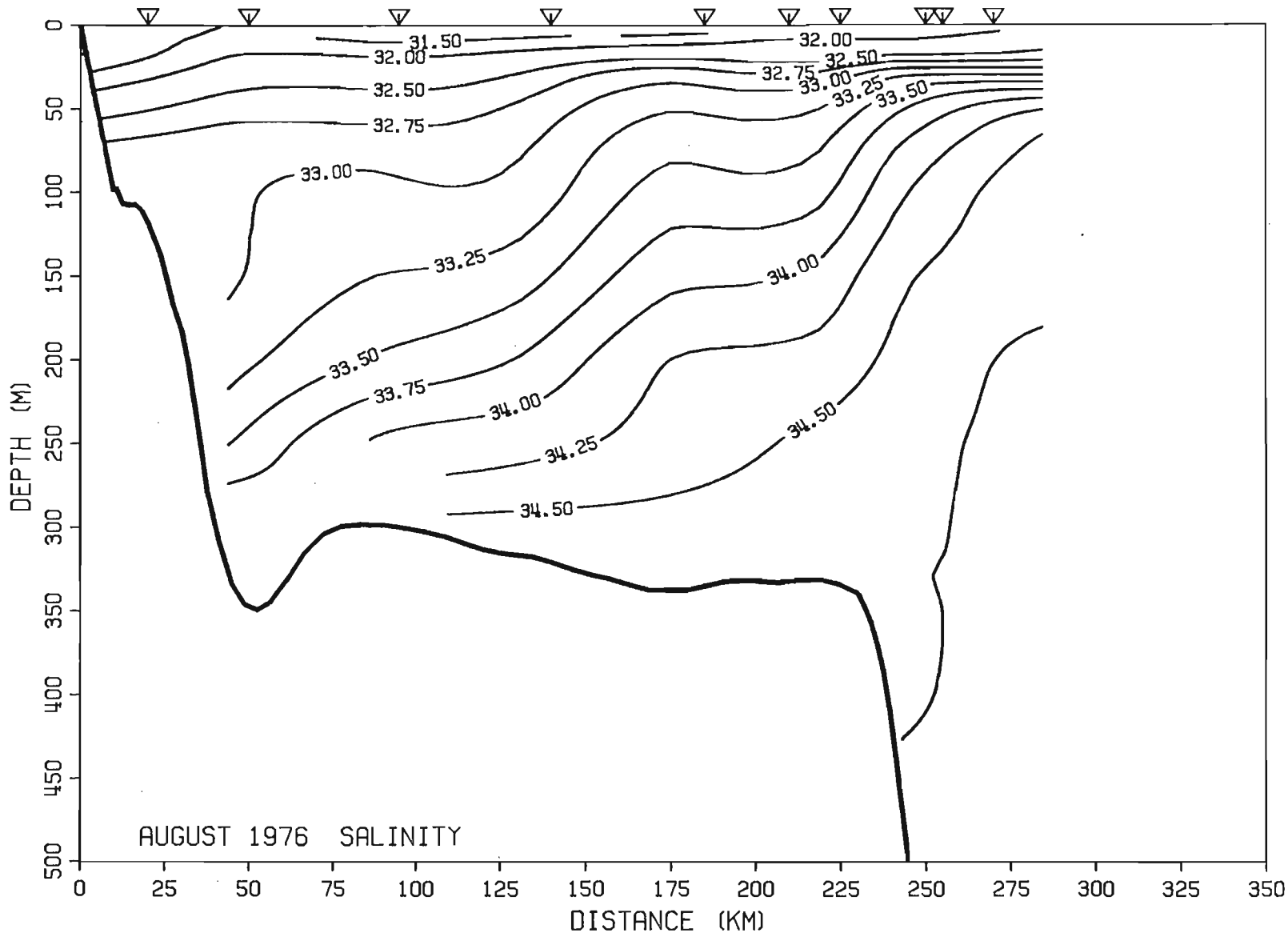
AUGUST 1976 SALINITY
DEPTH (M)
DISTANCE (KM)
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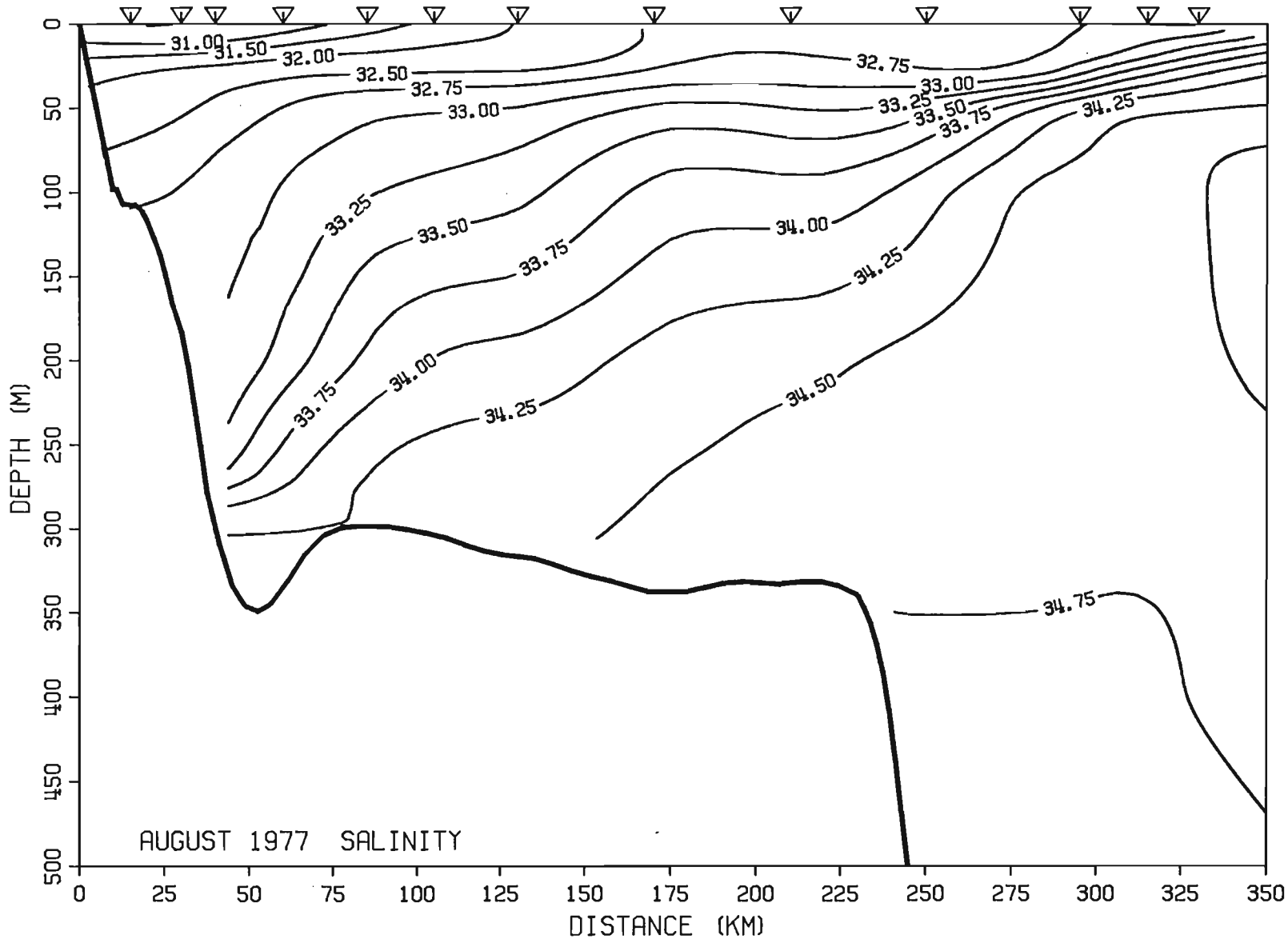
AUGUST 1977 SALINITY
DEPTH (M)
DISTANCE (KM)
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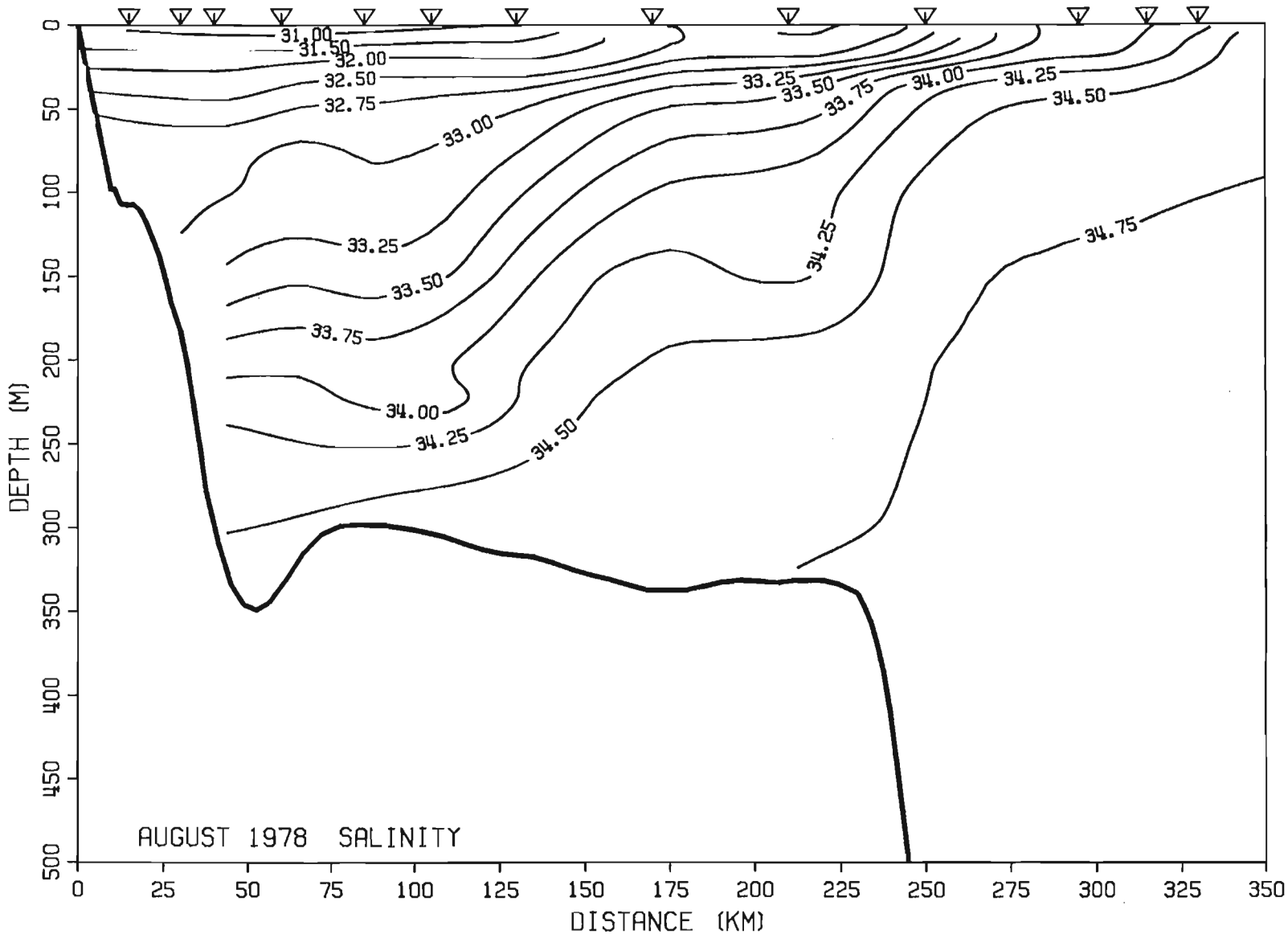
AUGUST 1978 SALINITY
DEPTH (M)
DISTANCE (KM)
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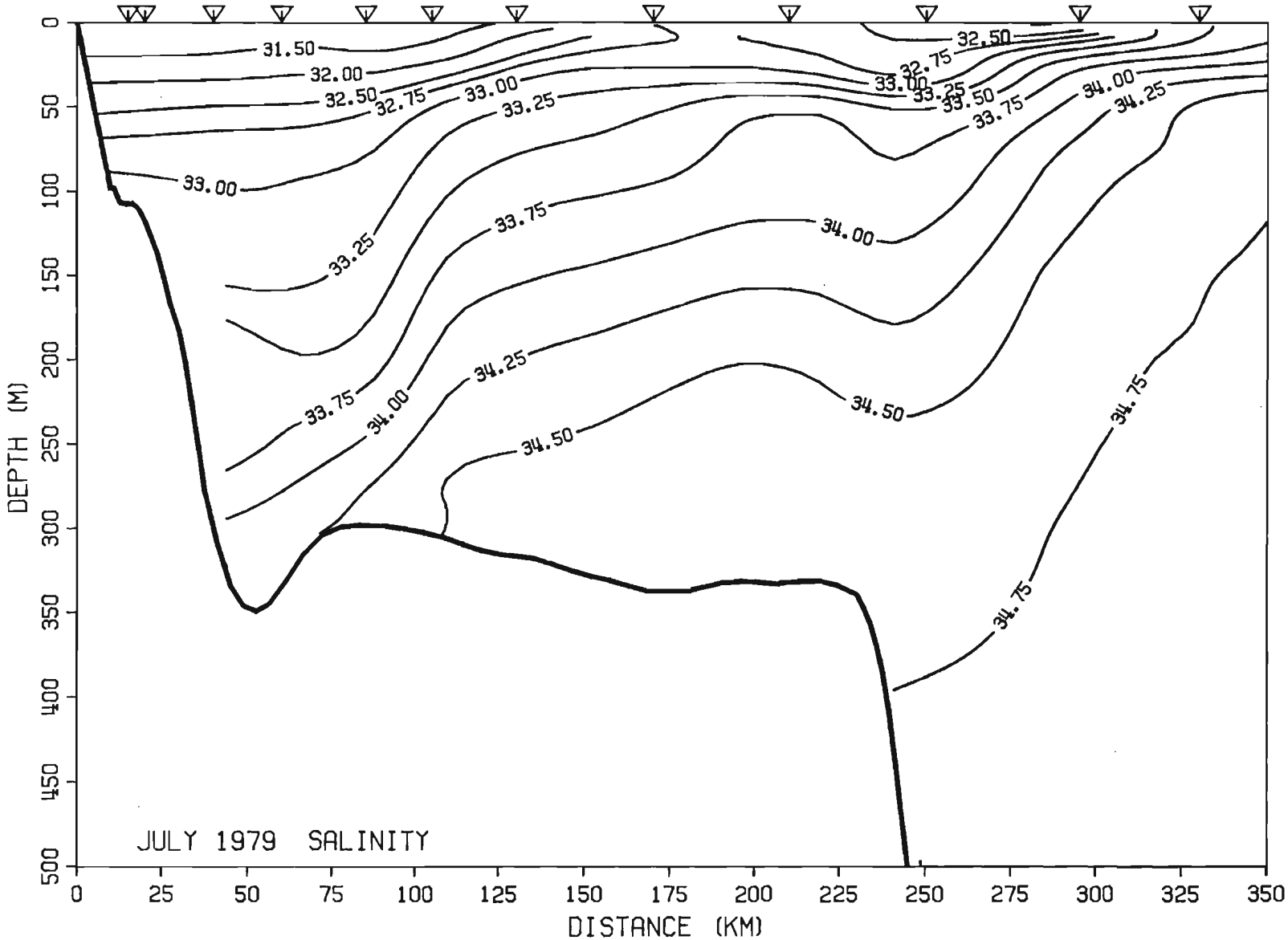
JULY 1979 SALINITY
DEPTH (M)
DISTANCE (KM)
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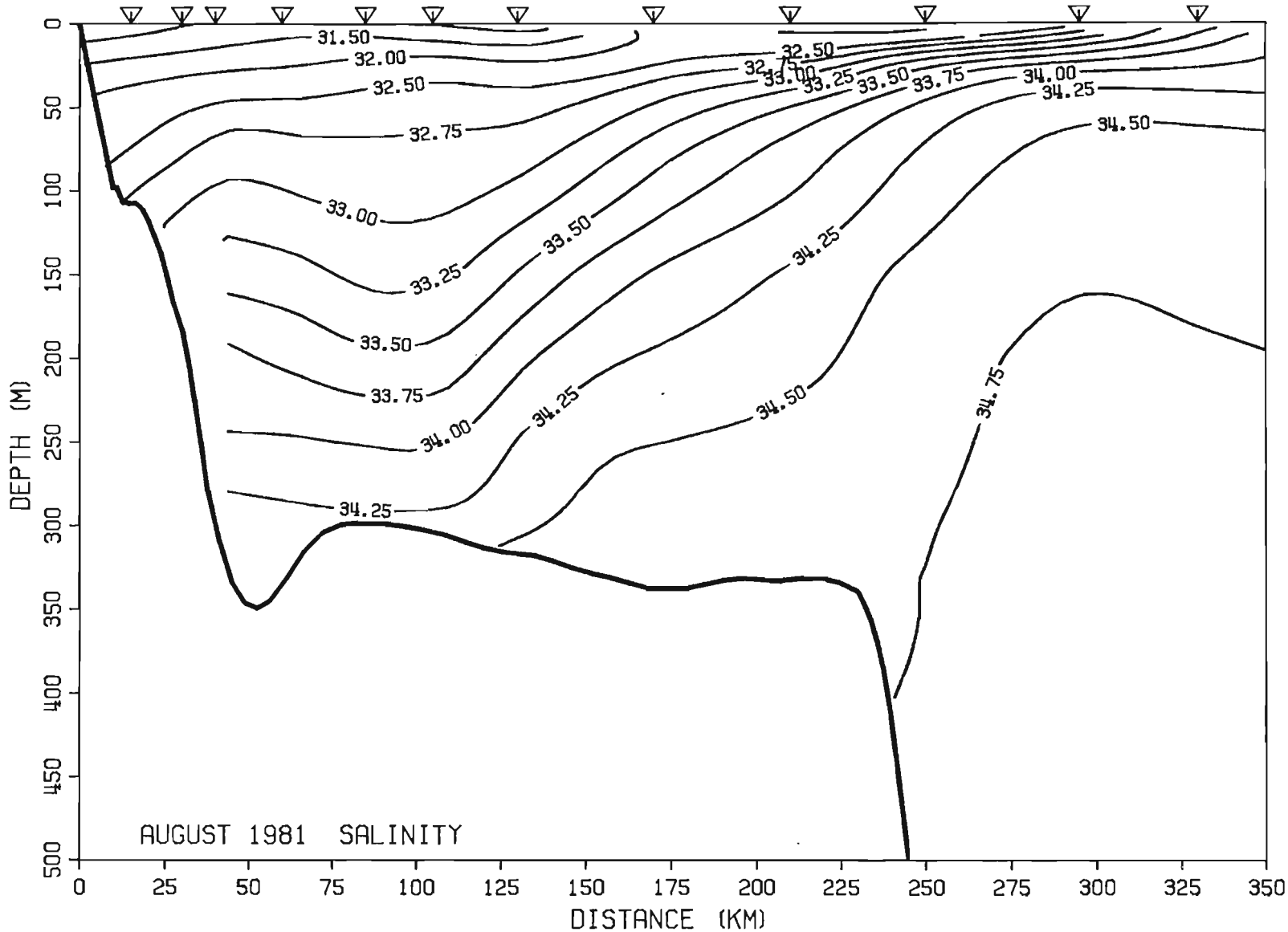
AUGUST 1981 SALINITY
DEPTH (M)
DISTANCE (KM)
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200
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300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
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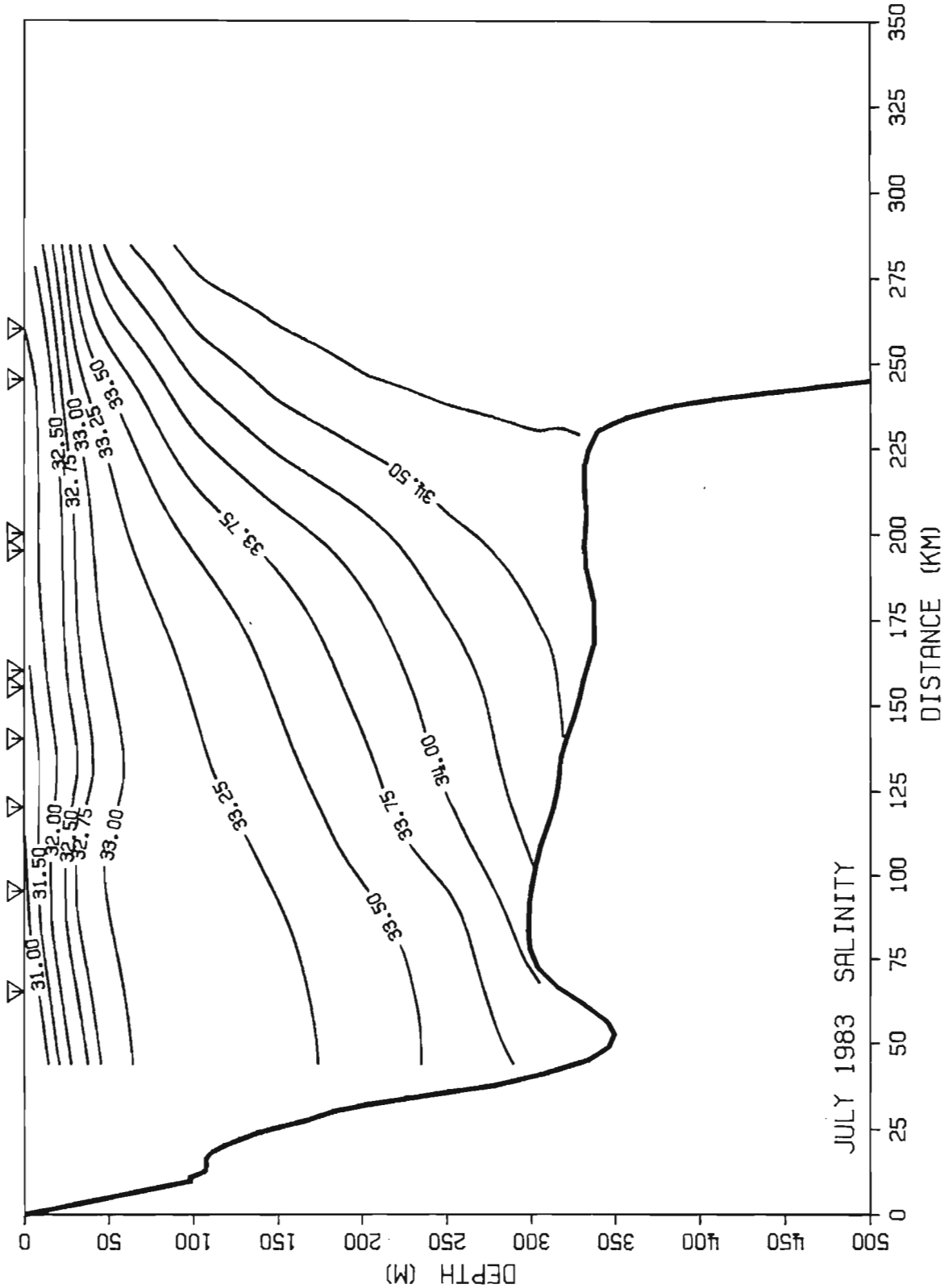
34.75


JULY 1983 SALINITY
DISTANCE (KM)
DEPTH (M)
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25
50
75
100
125
150
175
200
225
250
275
300
325
350
0
50
100
150
200
250
300
350
400
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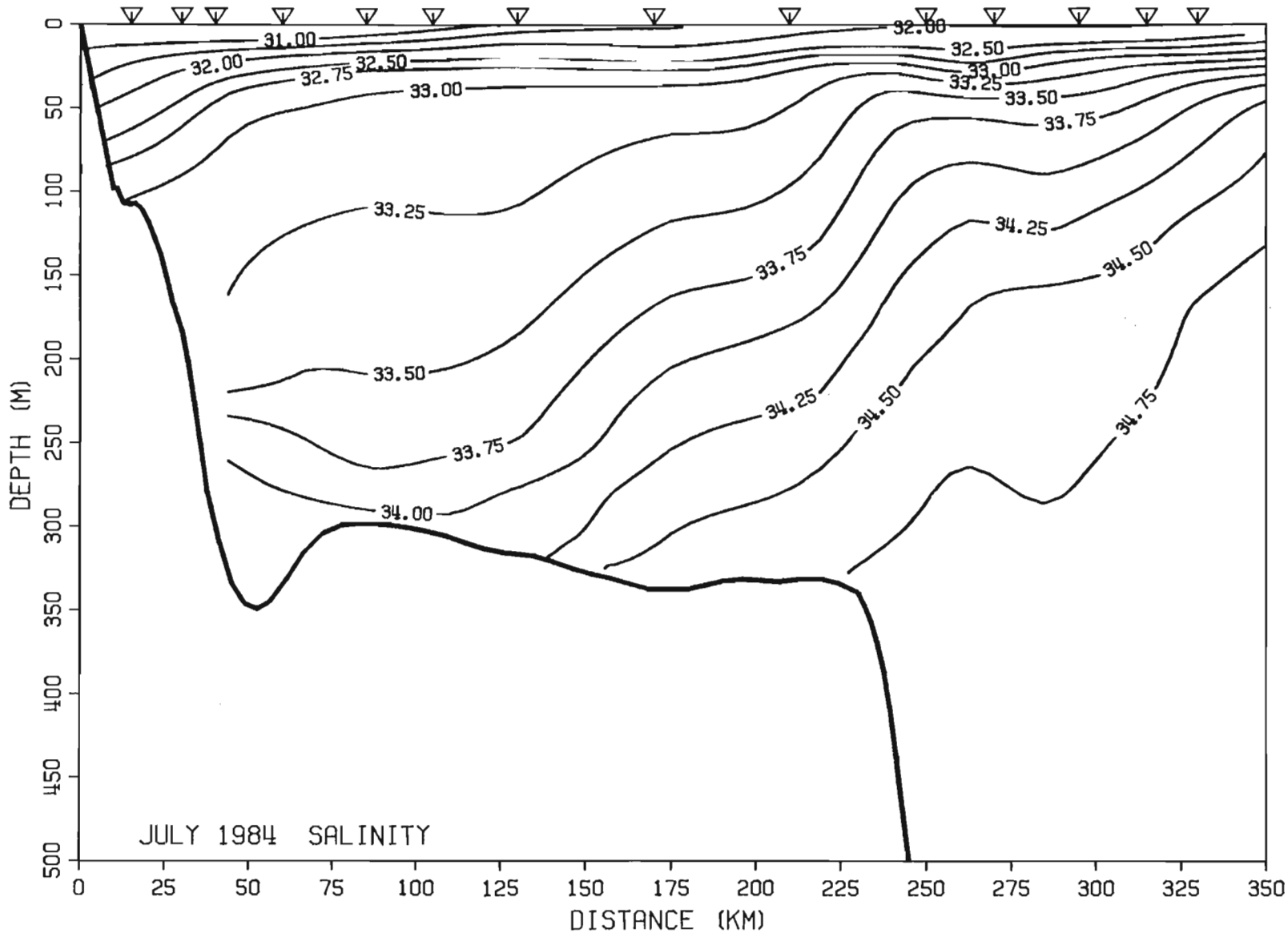
34.50


JULY 1984 SALINITY
DEPTH (M)
DISTANCE (KM)
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350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
31.00
32.00
32.75
32.50
33.00
32.00
32.50
33.00
33.25
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33.50
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34.25
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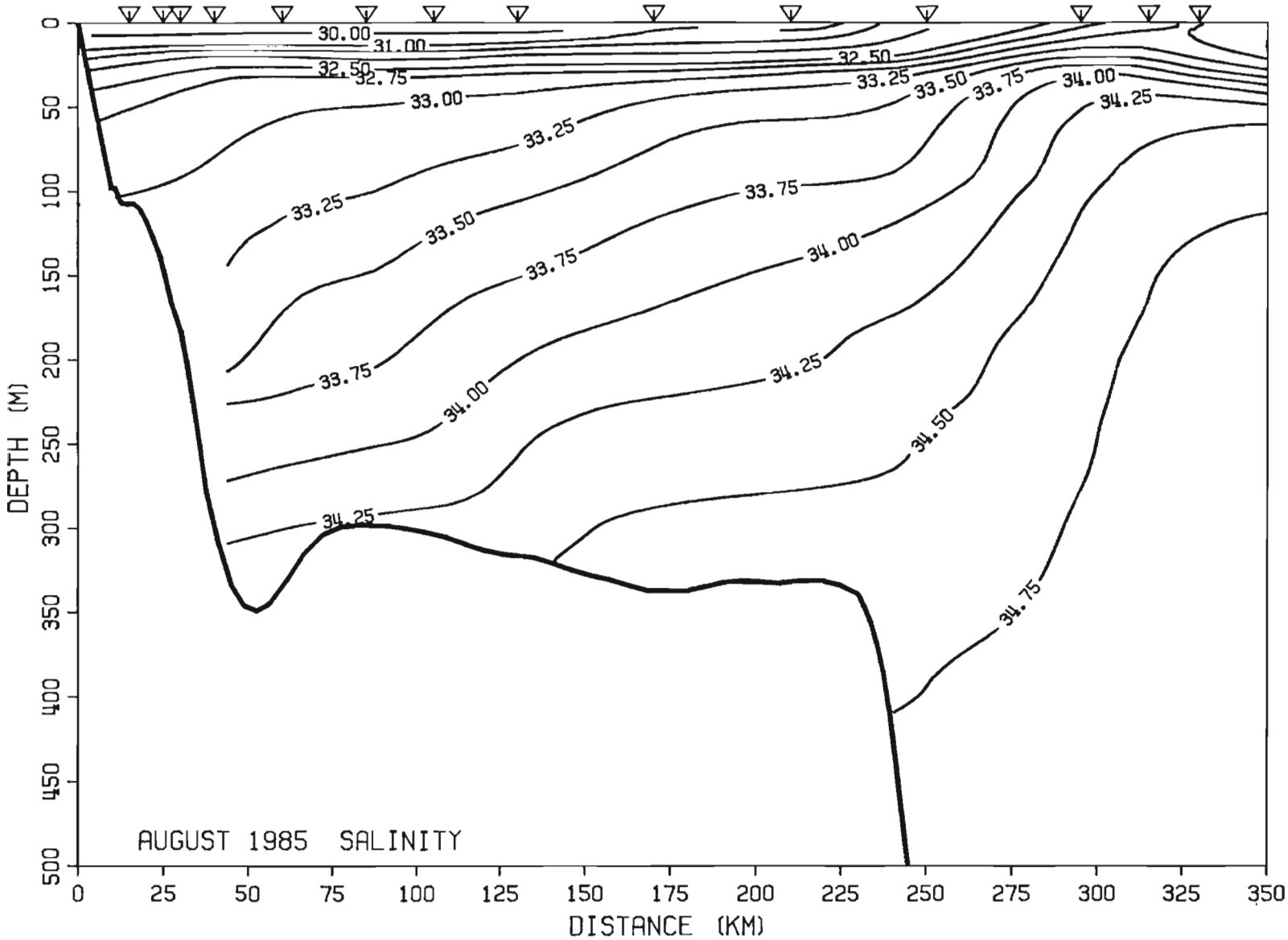
34.75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DEPTH (M)
DISTANCE (KM)
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200
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400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
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32.75
33.00
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33.50
33.75
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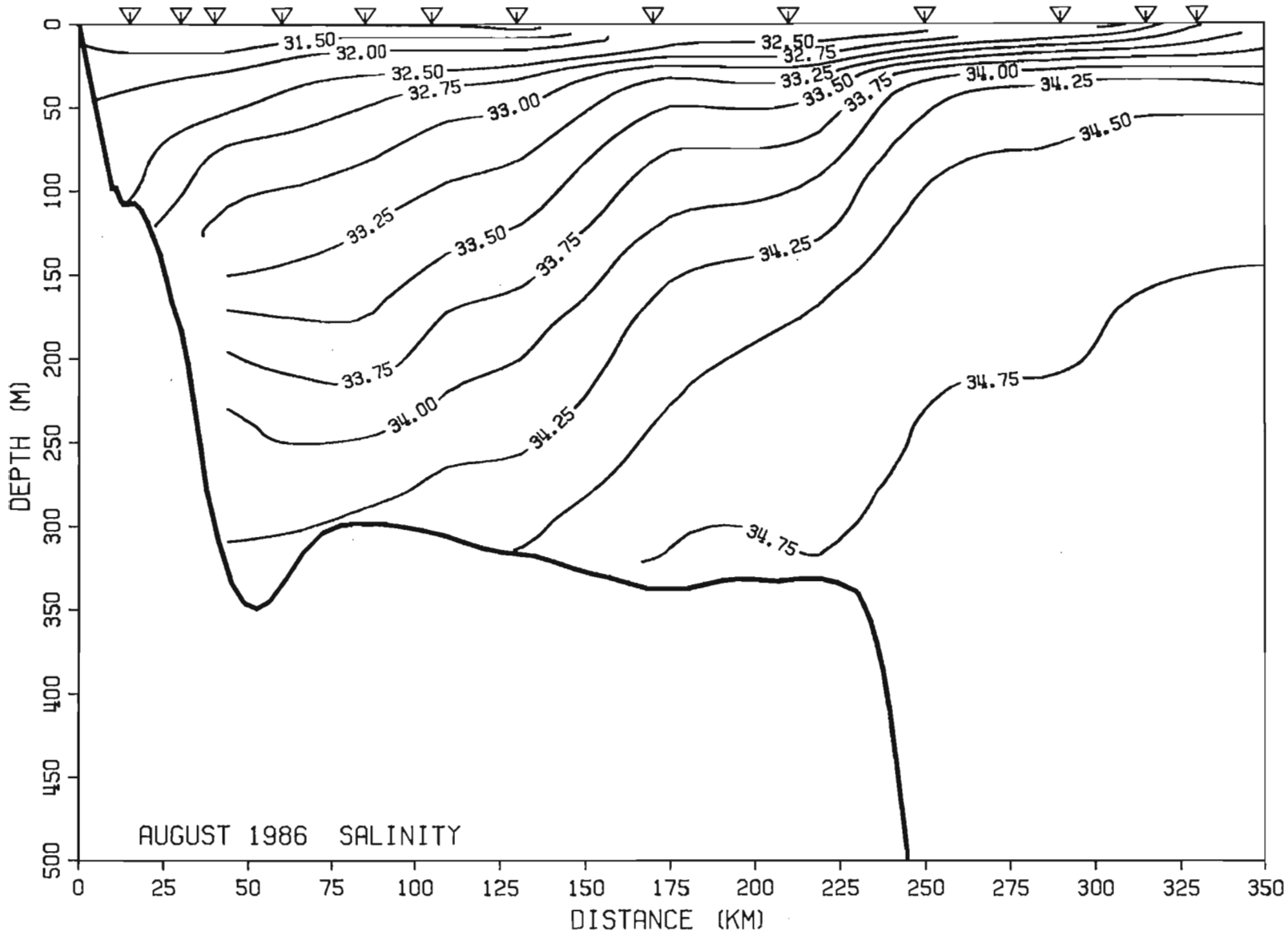
34.75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DEPTH (M)
DISTANCE (KM)
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200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
31.50
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32.75
33.00
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33.75
34.00
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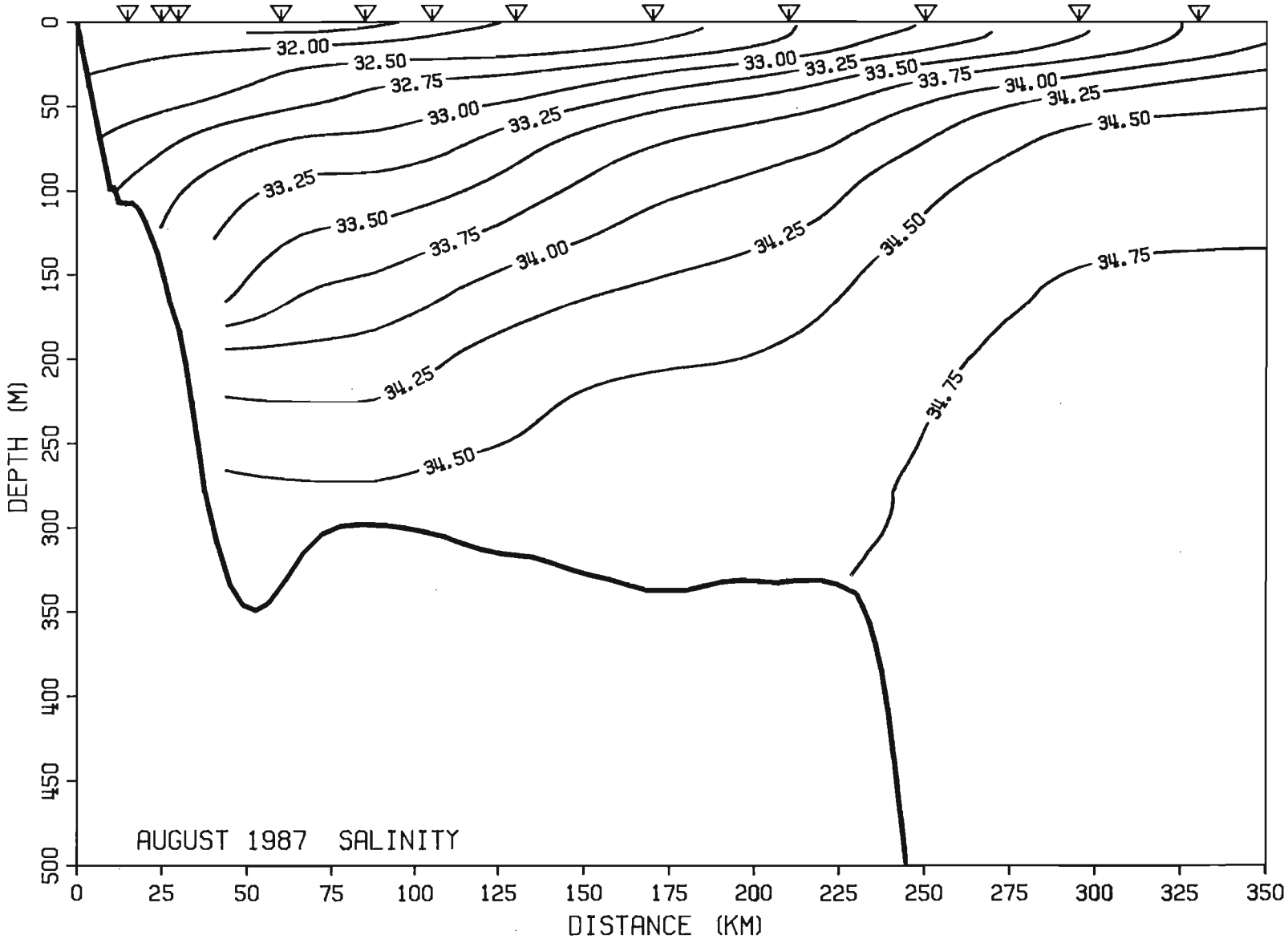
34.75


AUGUST 1987 SALINITY
DEPTH (M)
DISTANCE (KM)
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200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
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33.75
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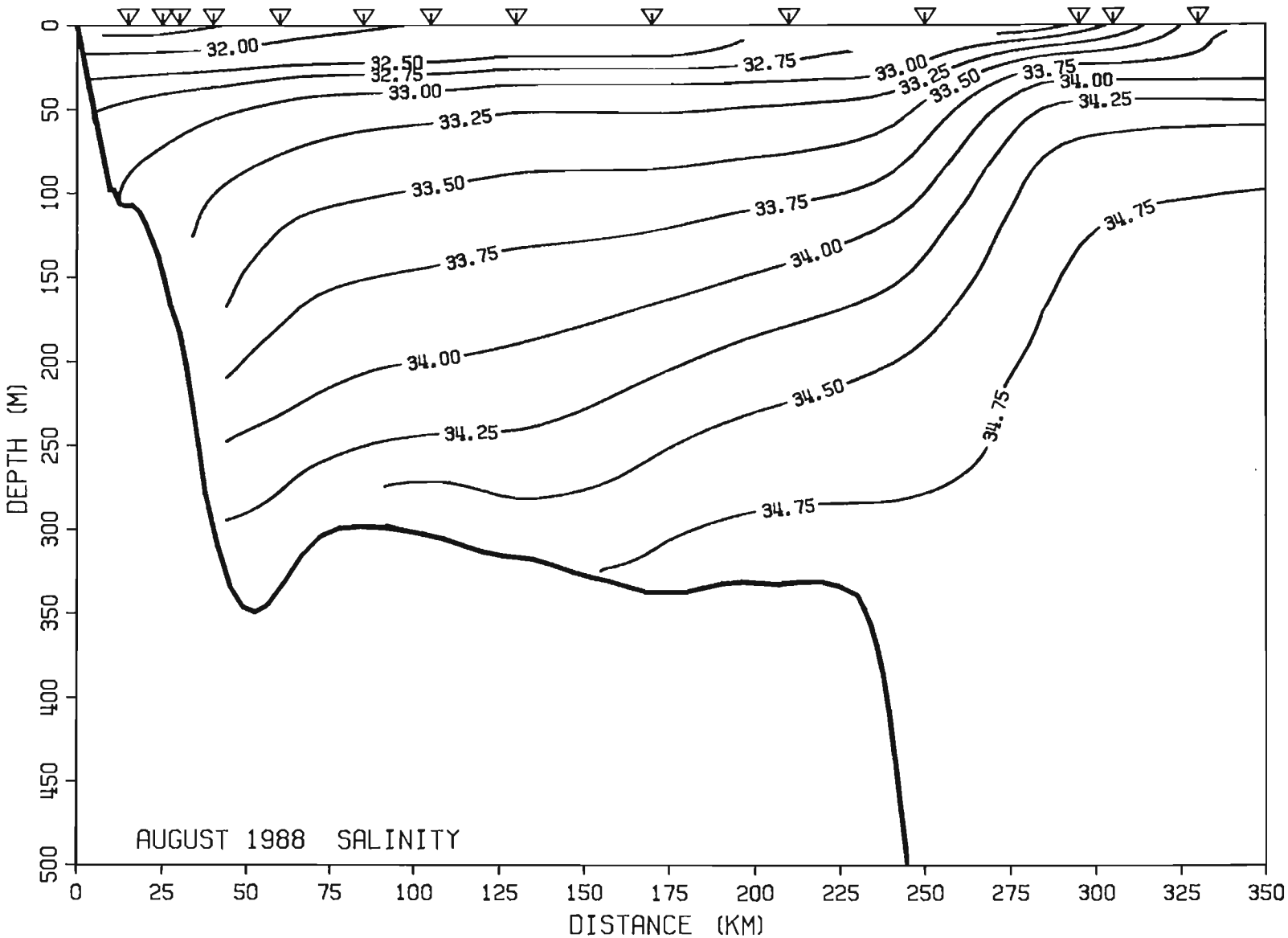
34.75


AUGUST 1988 SALINITY
DEPTH (M)
DISTANCE (KM)
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200
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350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
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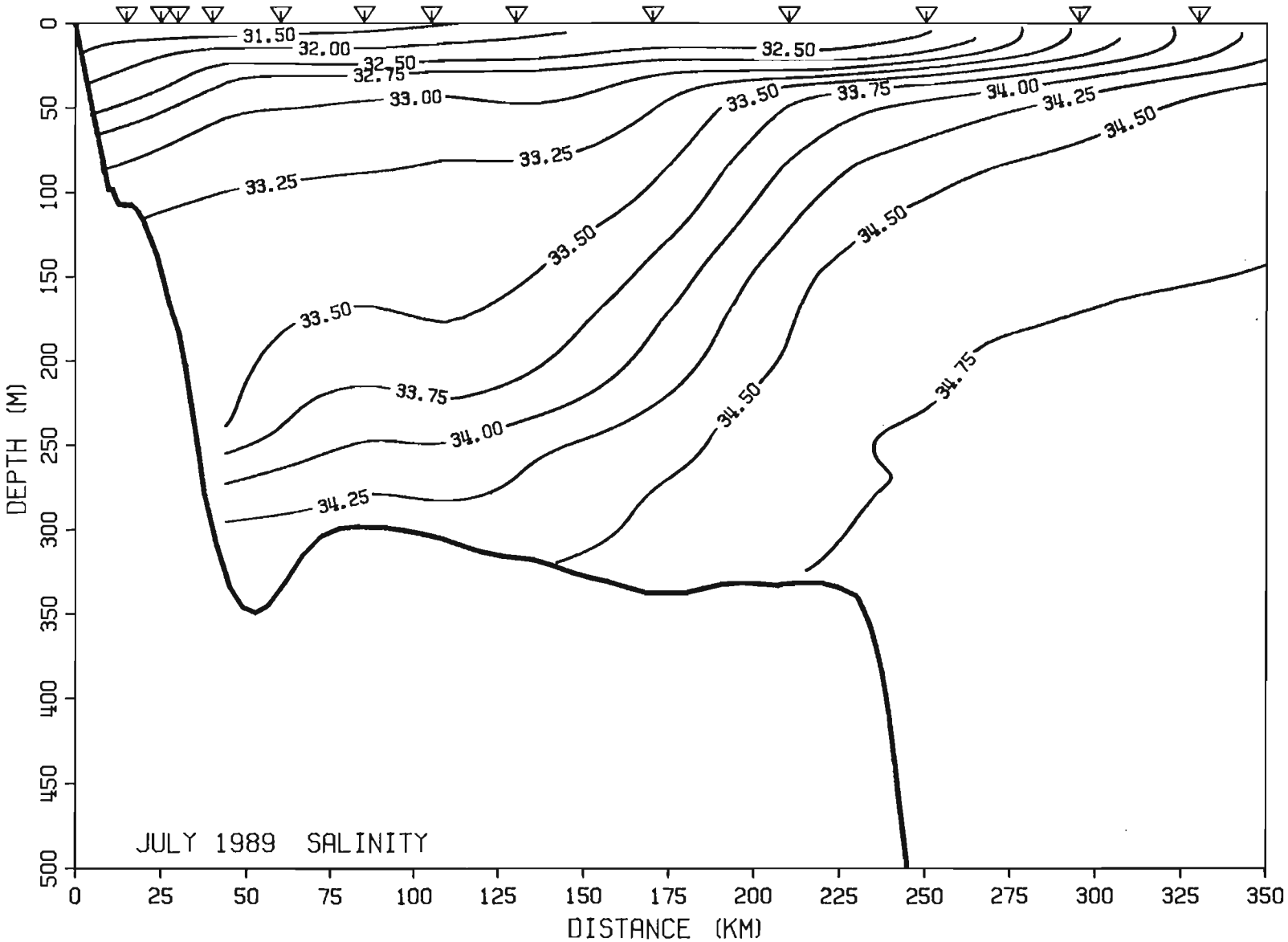
JULY 1989 SALINITY
DEPTH (M)
DISTANCE (KM)
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200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
31.50
32.00
32.50
32.75
33.00
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33.50
33.75
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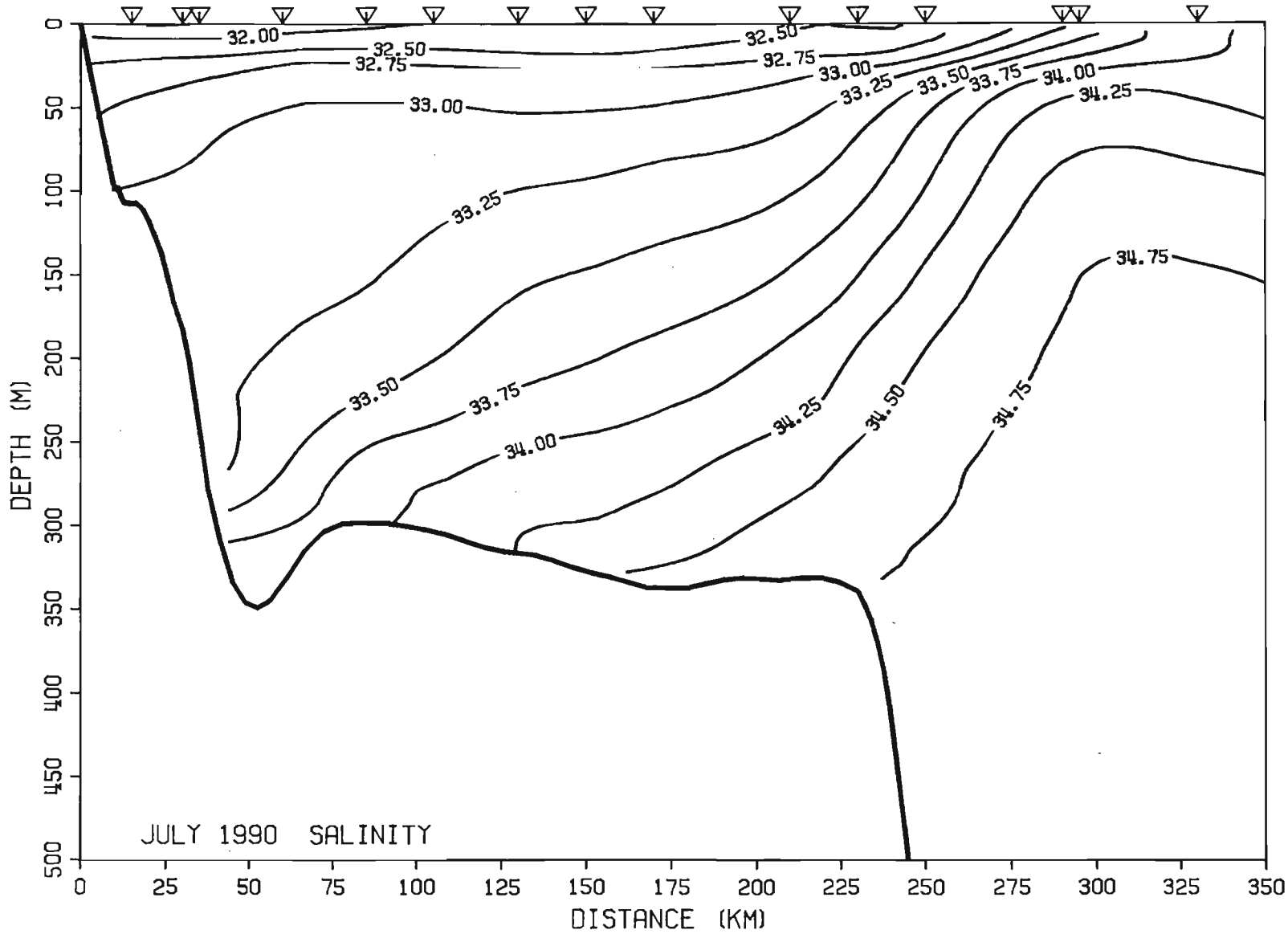
34.50
34.75


JULY 1990 SALINITY
DEPTH (M)
DISTANCE (KM)
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100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
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32.75
33.00
33.25
33.50
33.75
34.00
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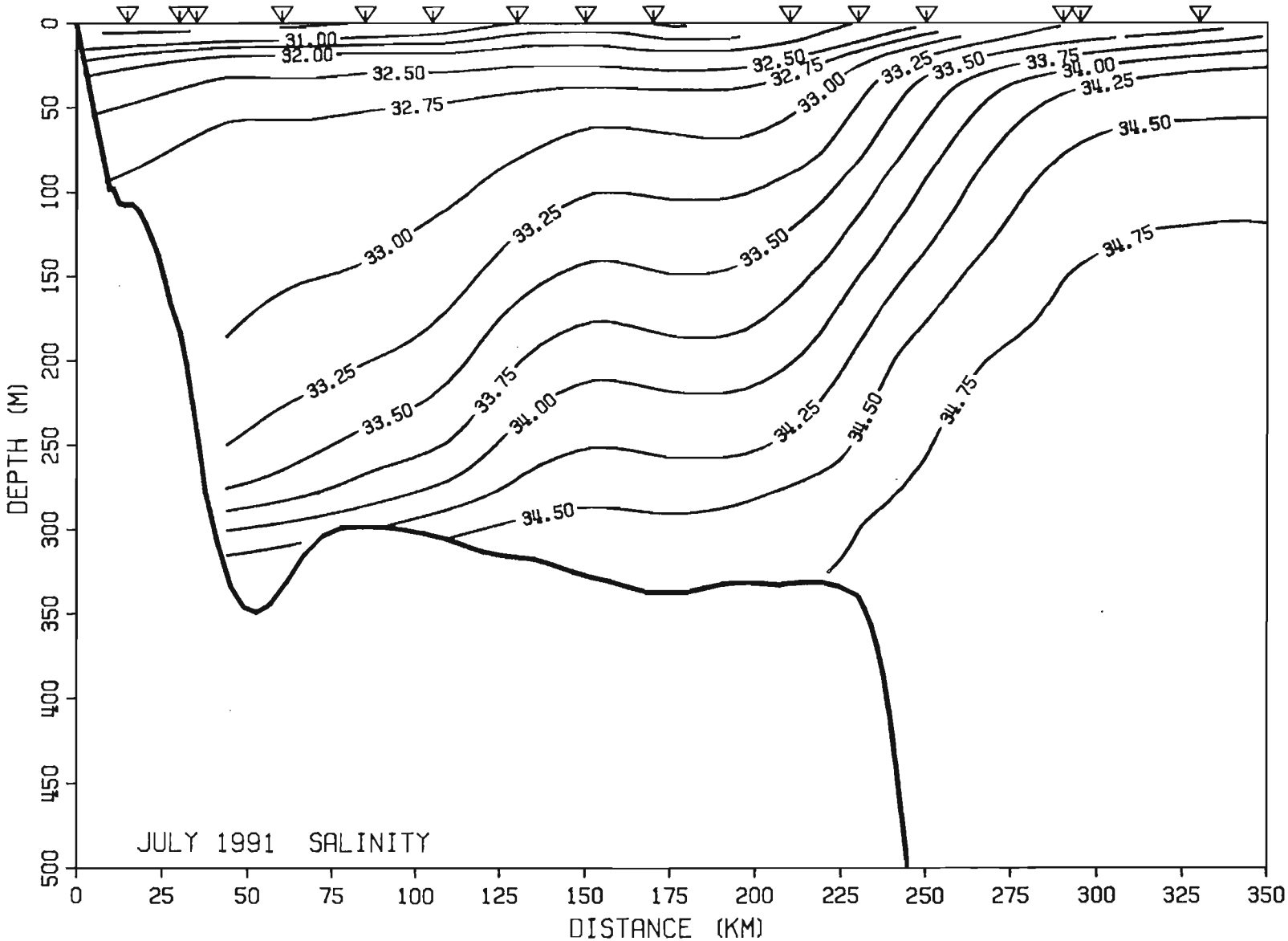
34.50
34.75


JULY 1991 SALINITY
DEPTH (M)
DISTANCE (KM)
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400
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500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
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33.50
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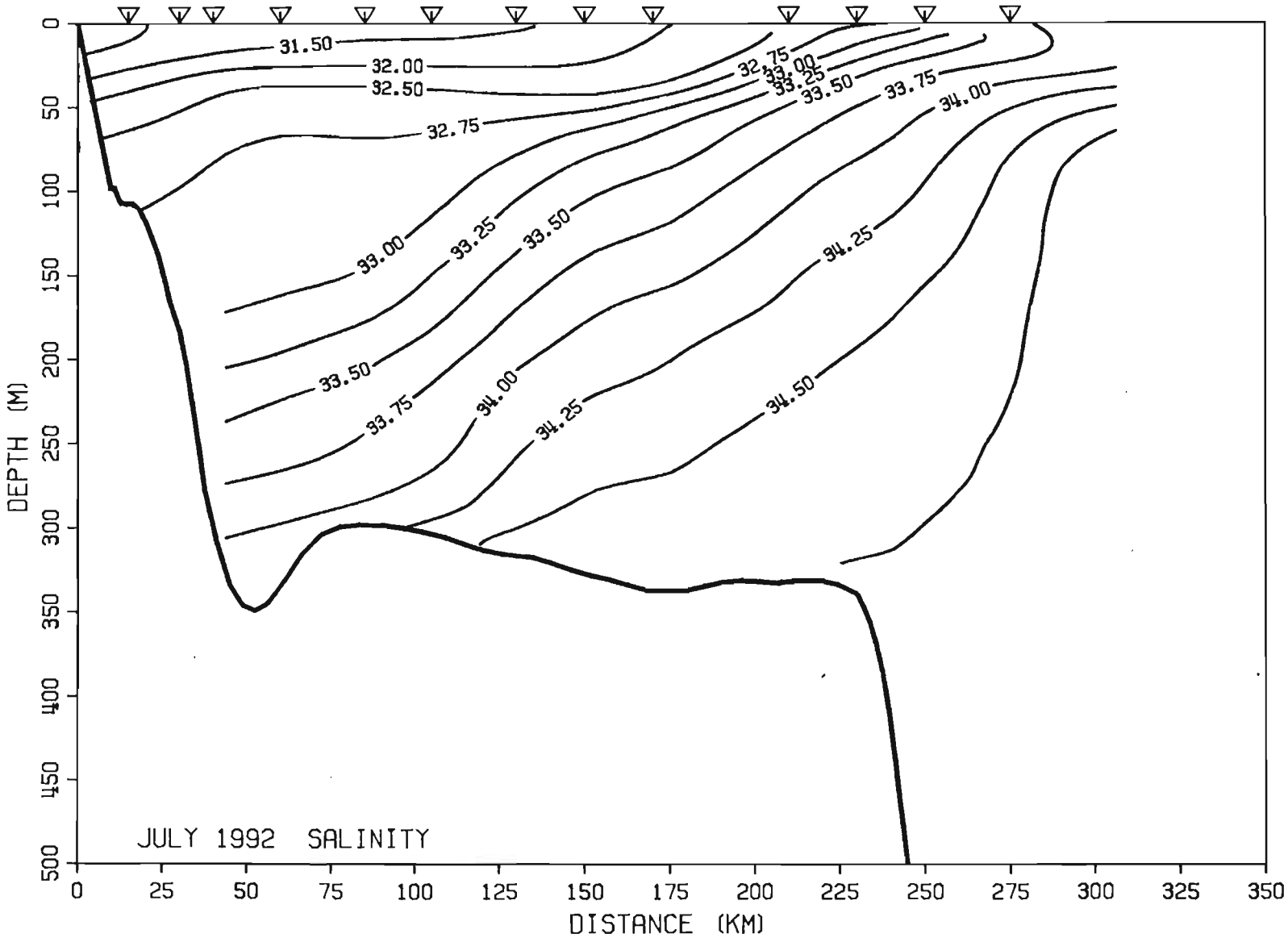
34.50
34.75


JULY 1992 SALINITY
DEPTH (M)
DISTANCE (KM)
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100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
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32.50
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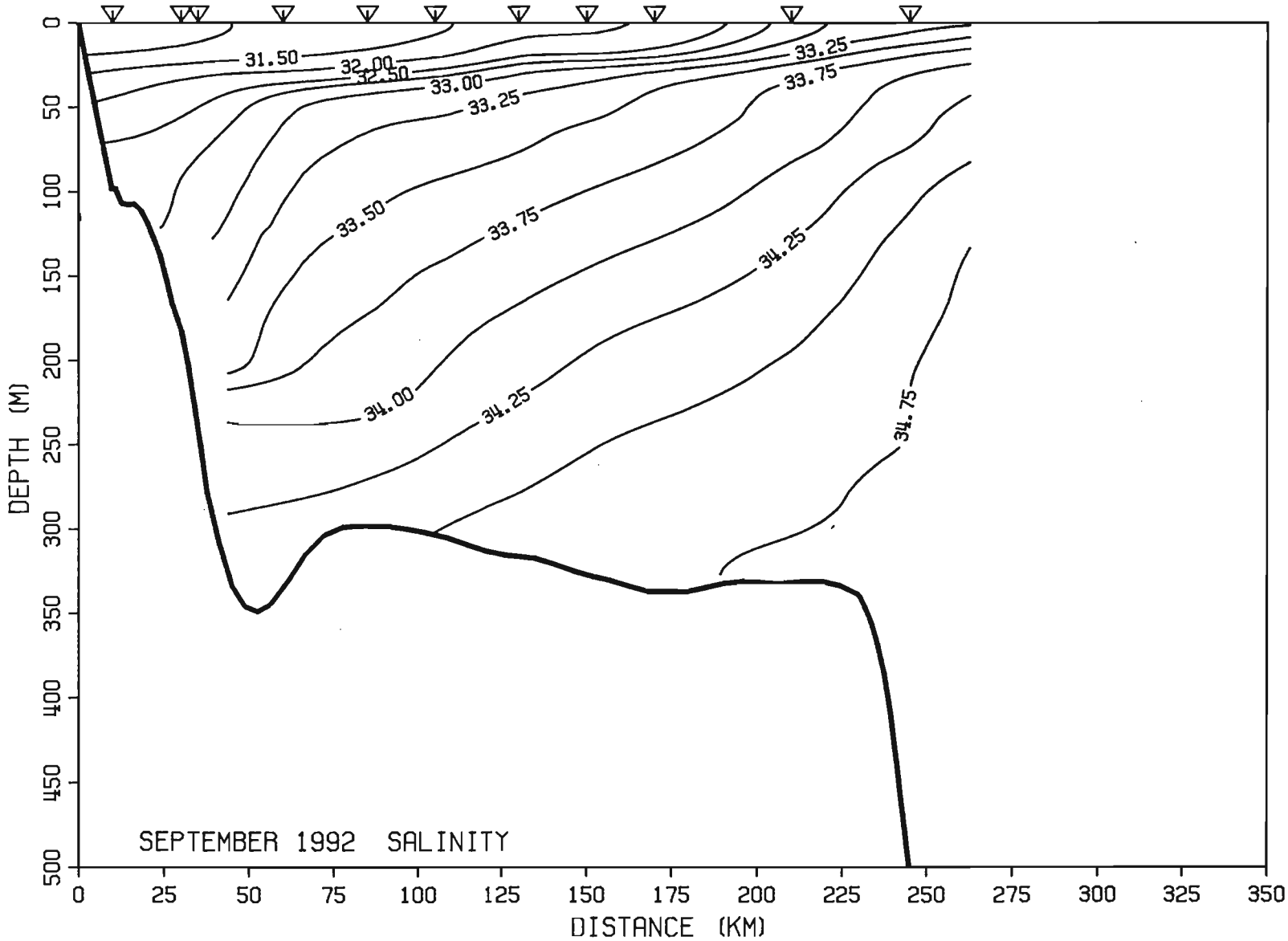
33.00
33.25
33.50
33.75
34.00
34.25
34.50


SEPTEMBER 1992 SALINITY
DEPTH (M)
DISTANCE (KM)
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200
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300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
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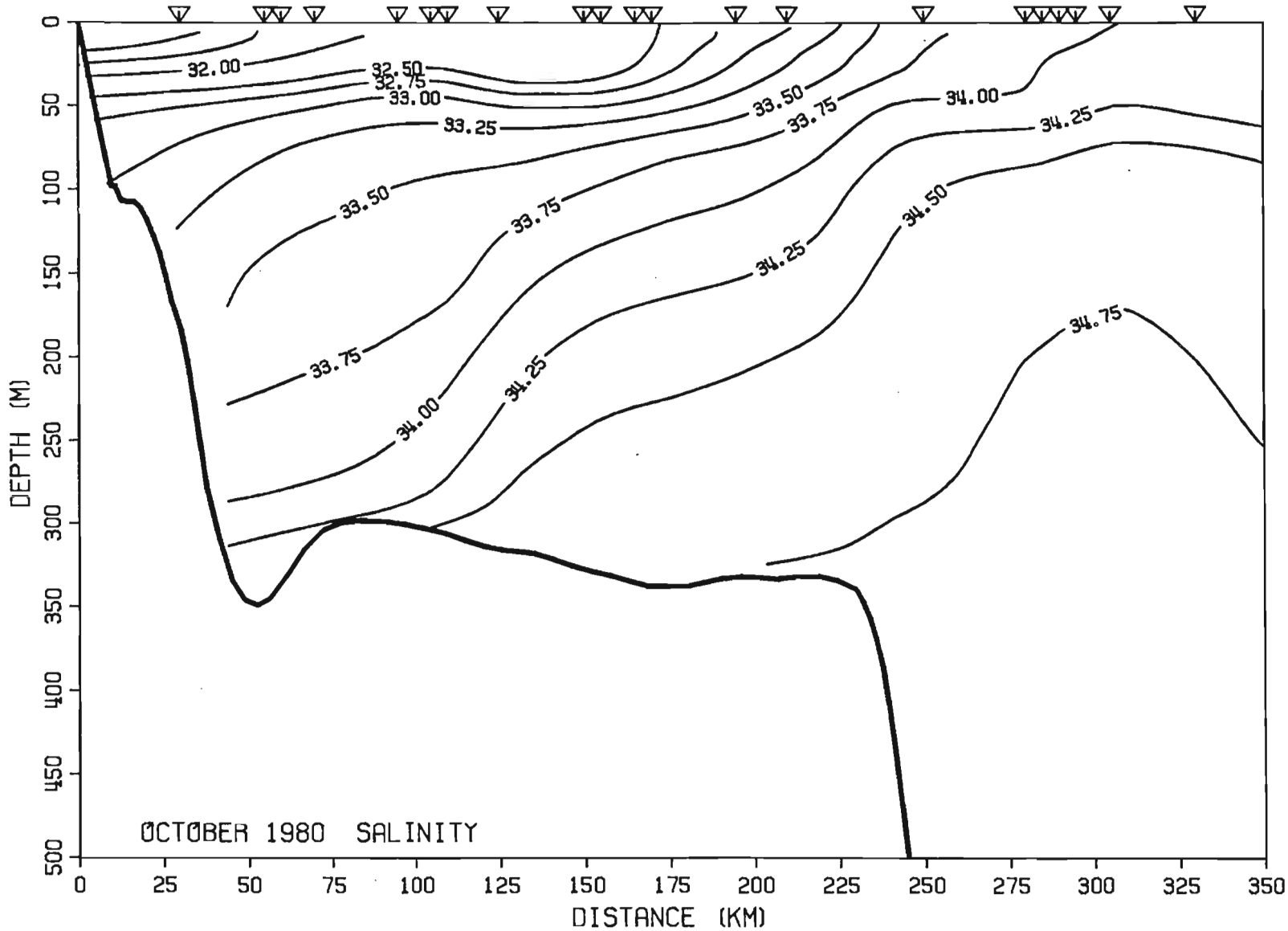
32.00
32.50
33.00
33.25
33.50
33.75
34.00
34.25
34.75


OCTOBER 1980 SALINITY
DEPTH (M)
DISTANCE (KM)
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100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
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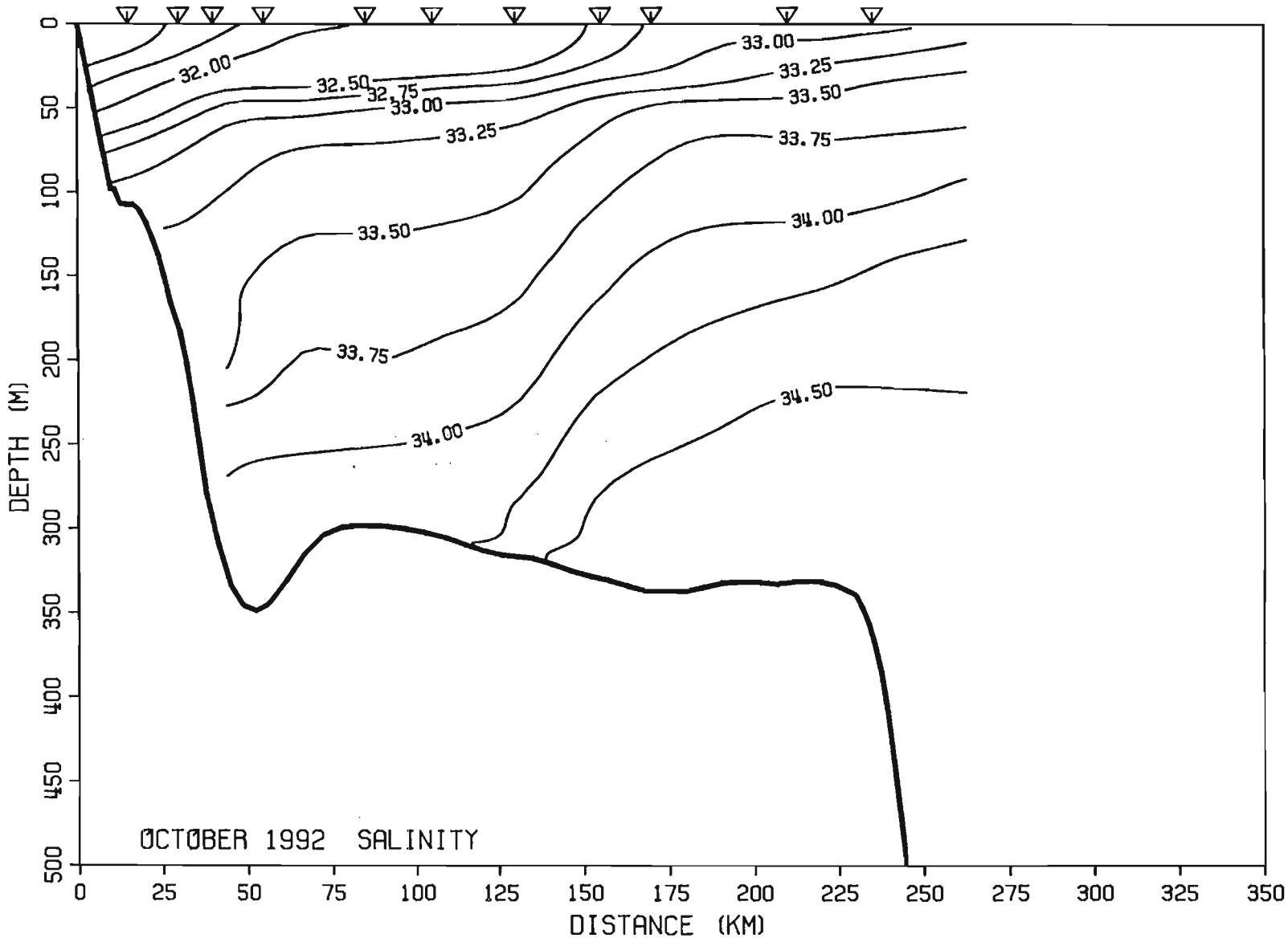
32.50
32.75
33.00
33.25
33.50
33.75
34.00
34.25
34.50
34.75


OCTOBER 1992 SALINITY
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
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350
32.00
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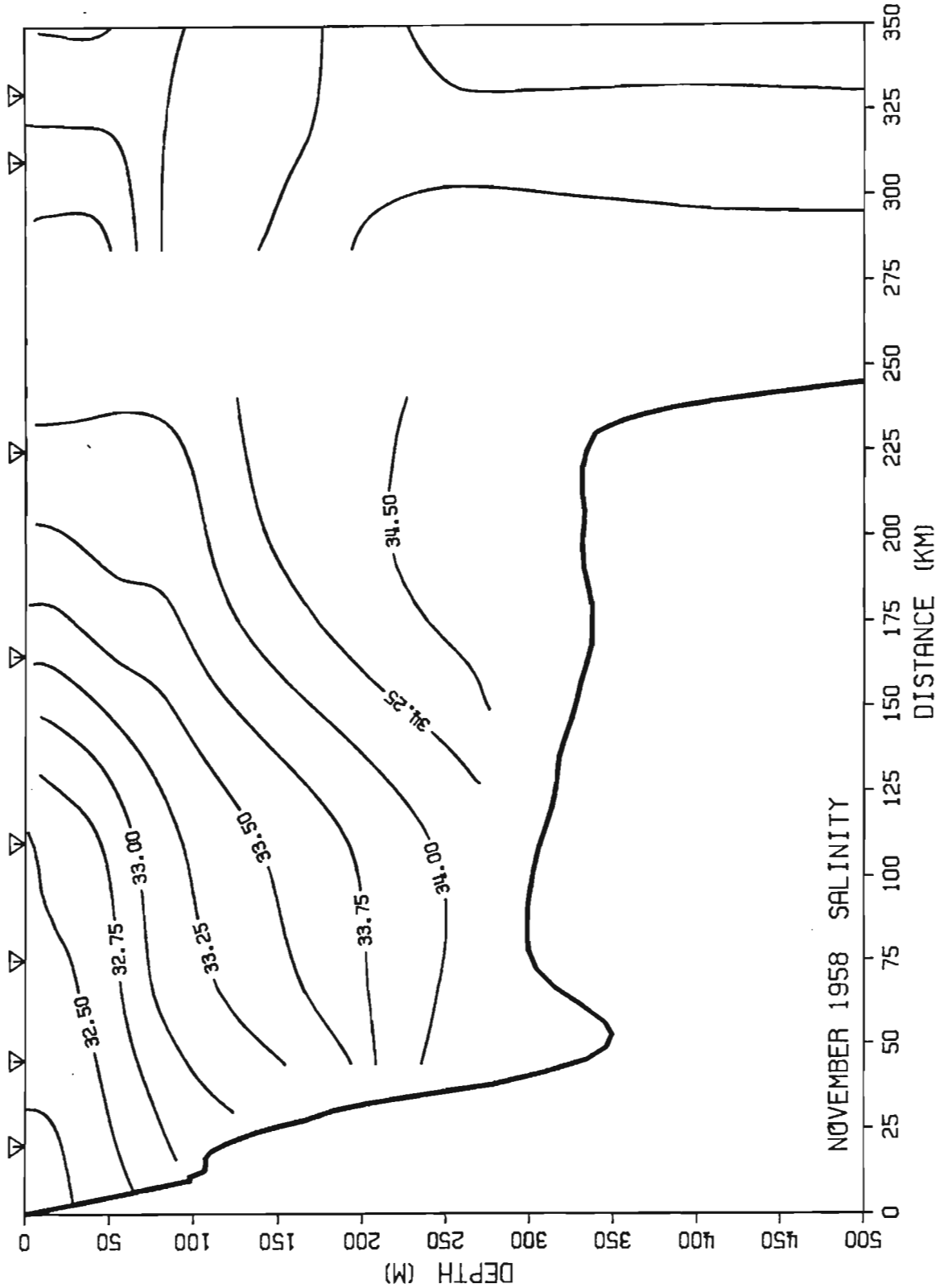
32.75
33.00
33.25
33.50
33.75
34.00
34.50


NOVEMBER 1958 SALINITY
DISTANCE (KM)
DEPTH (M)
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
0
50
100
150
200
250
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500
32.50
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33.00
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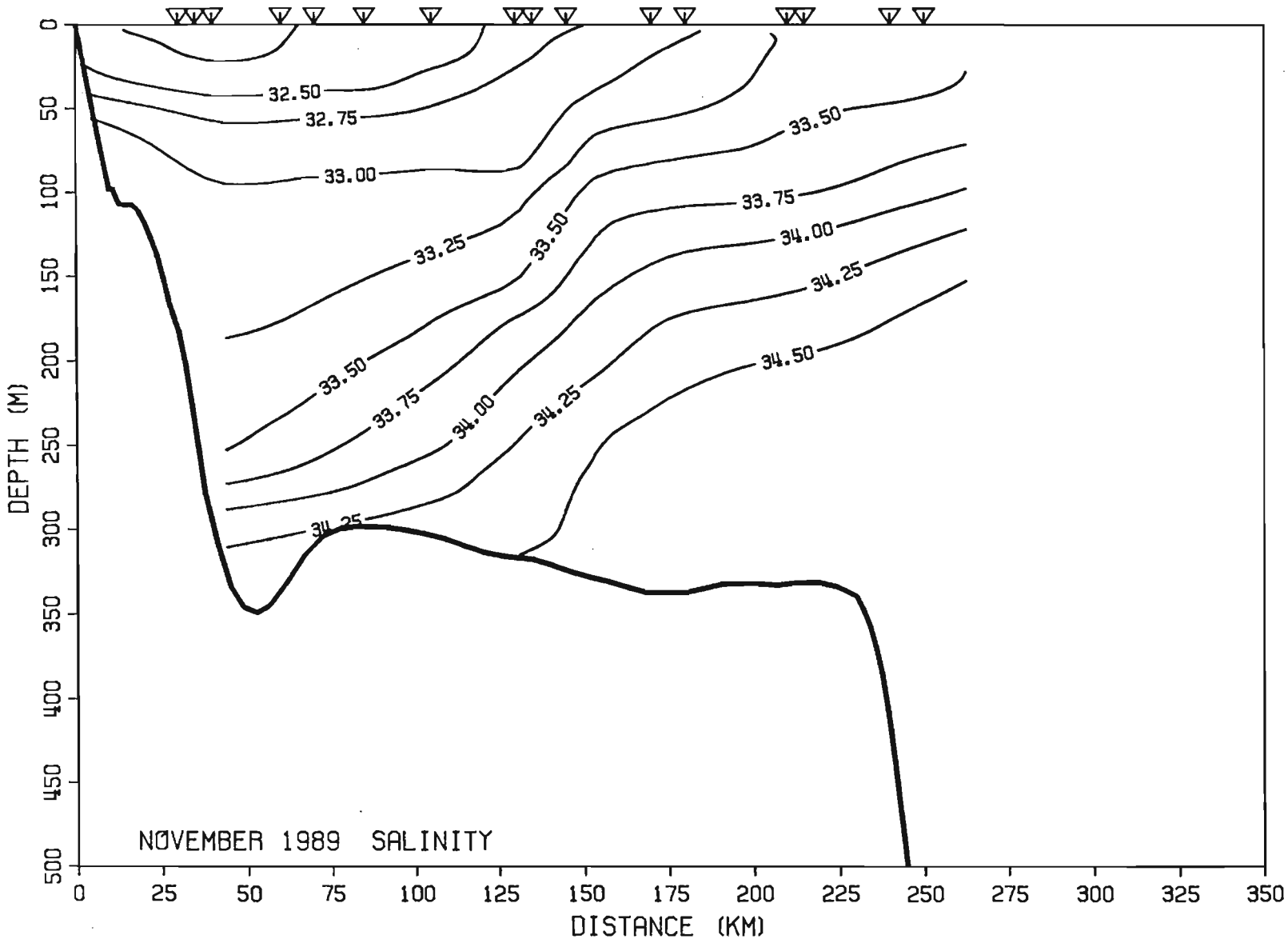
33.50
33.75
34.00
34.25
34.50


NOVEMBER 1989 SALINITY
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
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275
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33.00
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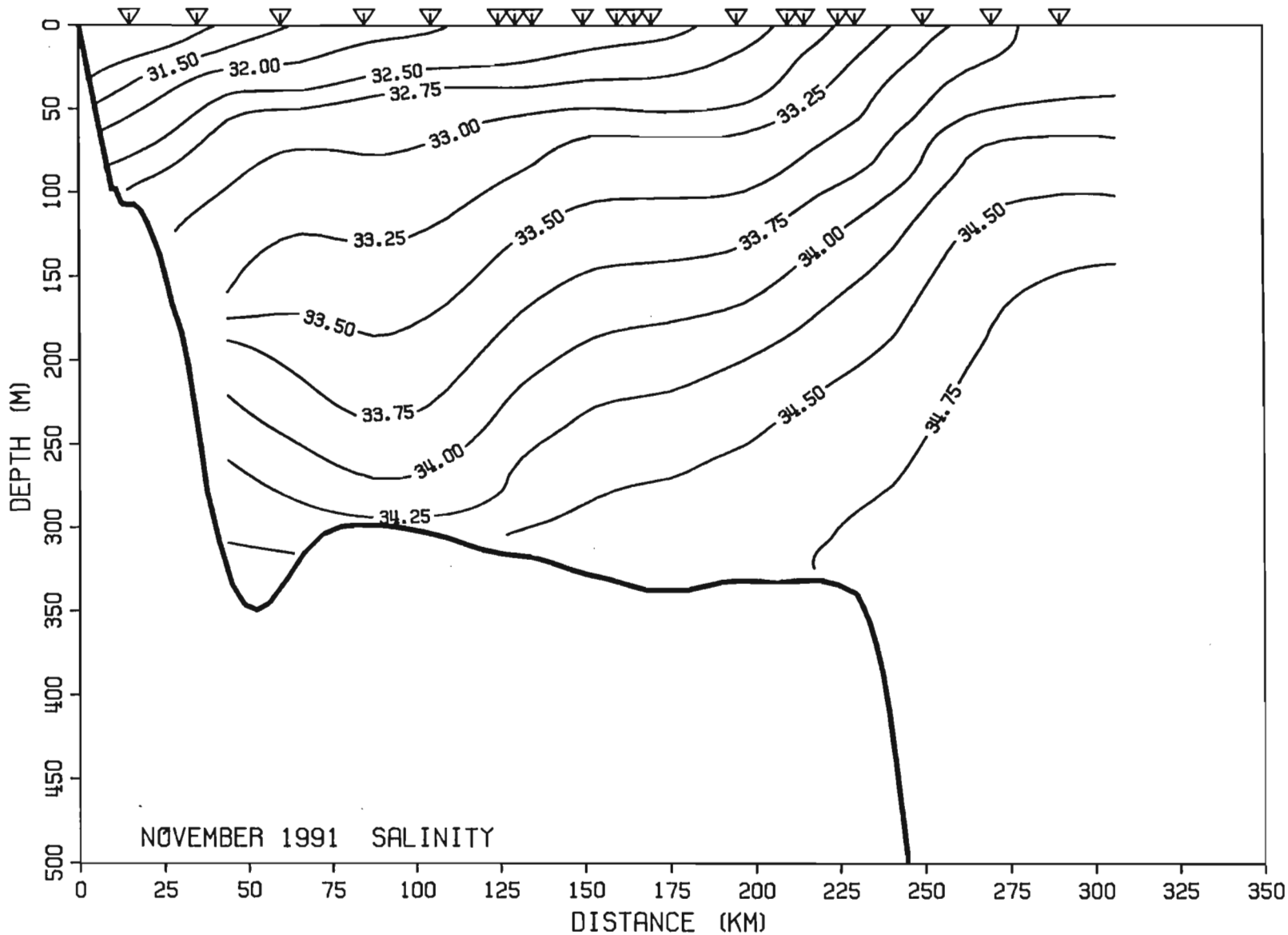
33.50
33.75
34.00
34.25
34.50


NOVEMBER 1991 SALINITY
DEPTH (M)
DISTANCE (KM)
31.50
32.00
32.50
32.75
33.00
33.25
33.50
33.75
34.00
34.25
34.50
34.75
0
50
100
150
200
250
300
350
400
450
500
0
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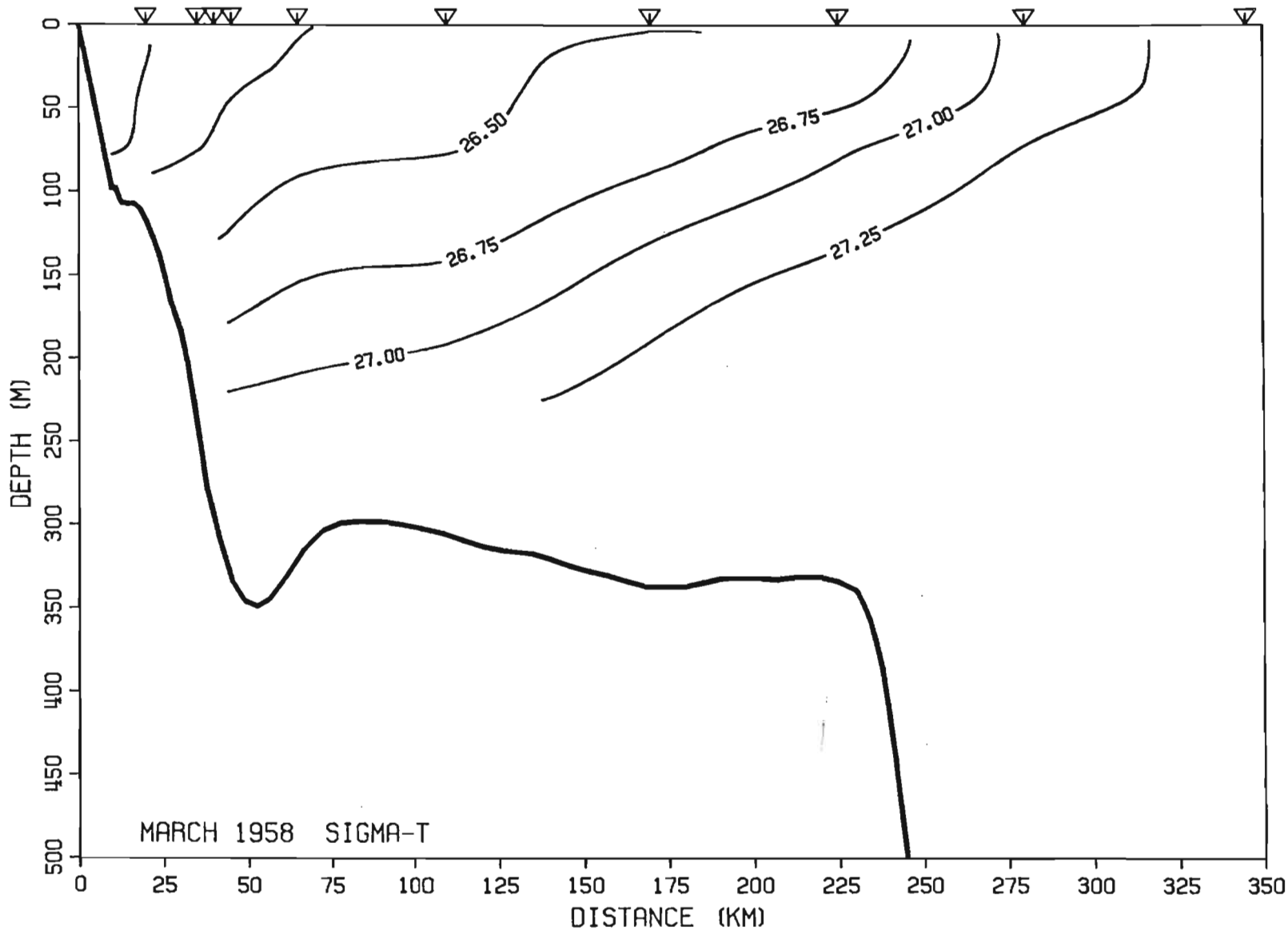
50
75
100
125
150
175
200
225
250
275
300
325
350

APPENDIX G. Cape Bonavista Density.


MARCH 1958 SIGMA-T
DEPTH (M)
DISTANCE (KM)
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26.75
27.00
26.75
27.00
27.25
0
50
100
150
200
250
300
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500
0
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50
75
100
125
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175
200
225
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275
300
325
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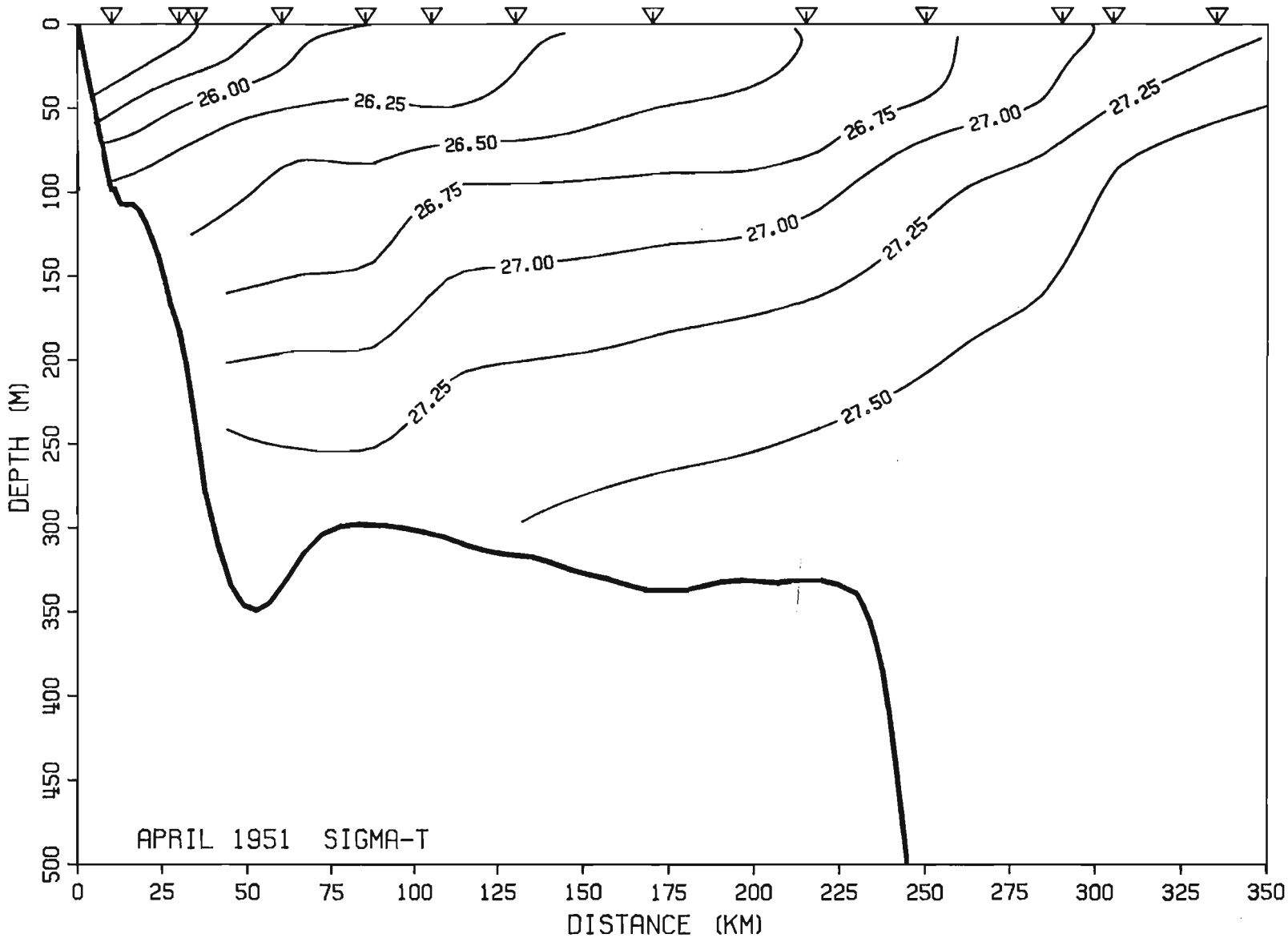
APRIL 1951 SIGMA-T
DEPTH (M)
DISTANCE (KM)
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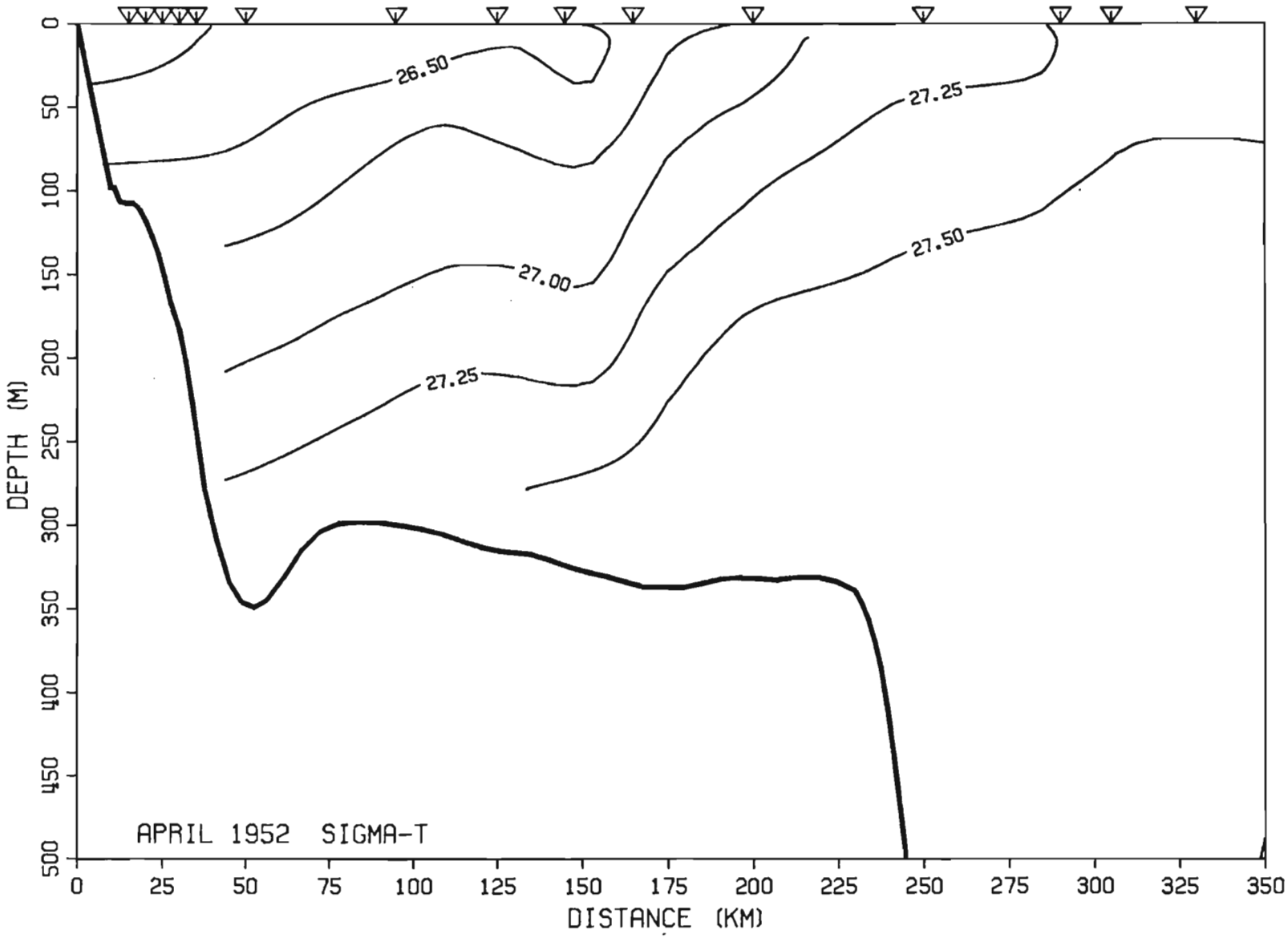
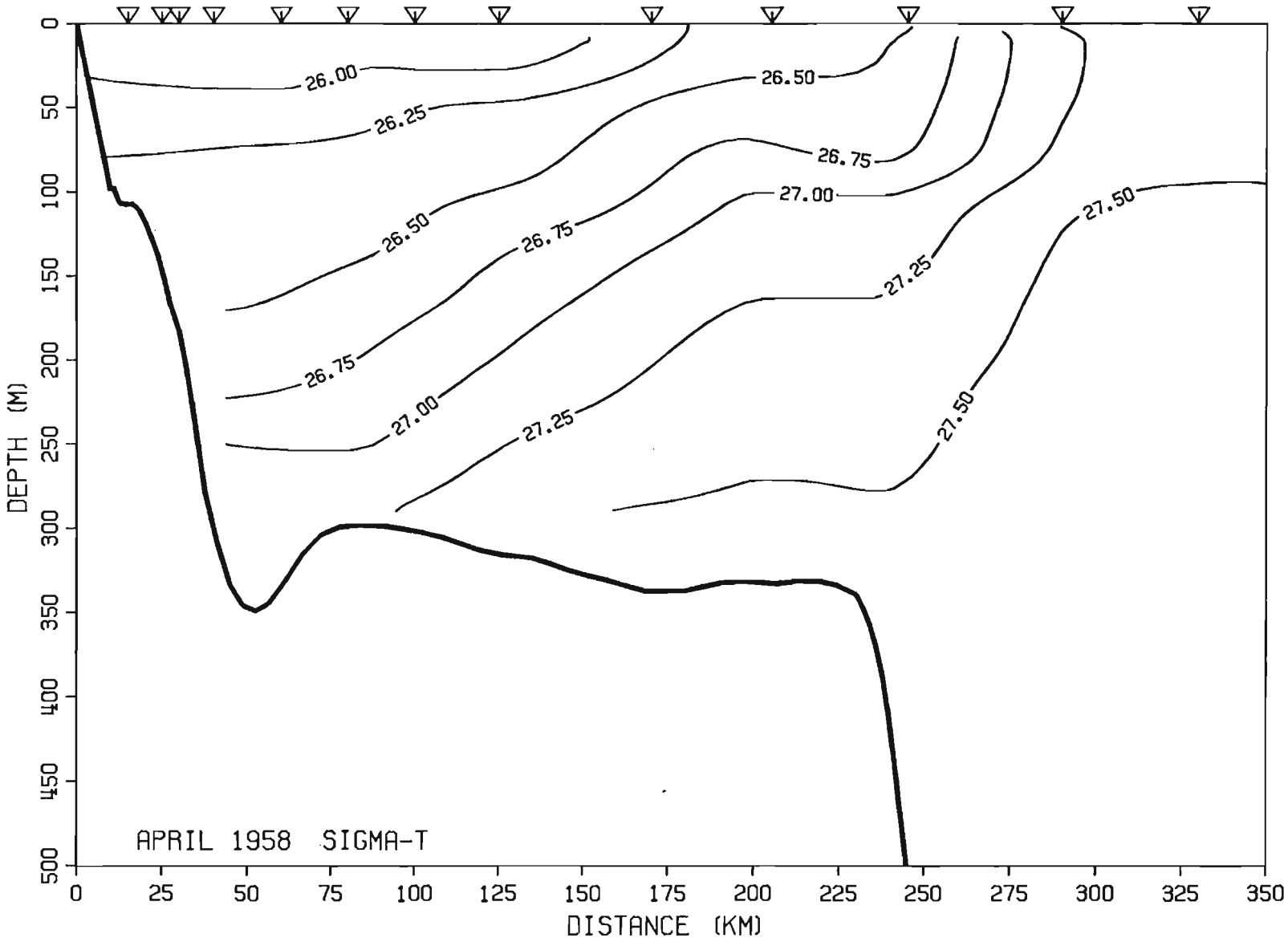
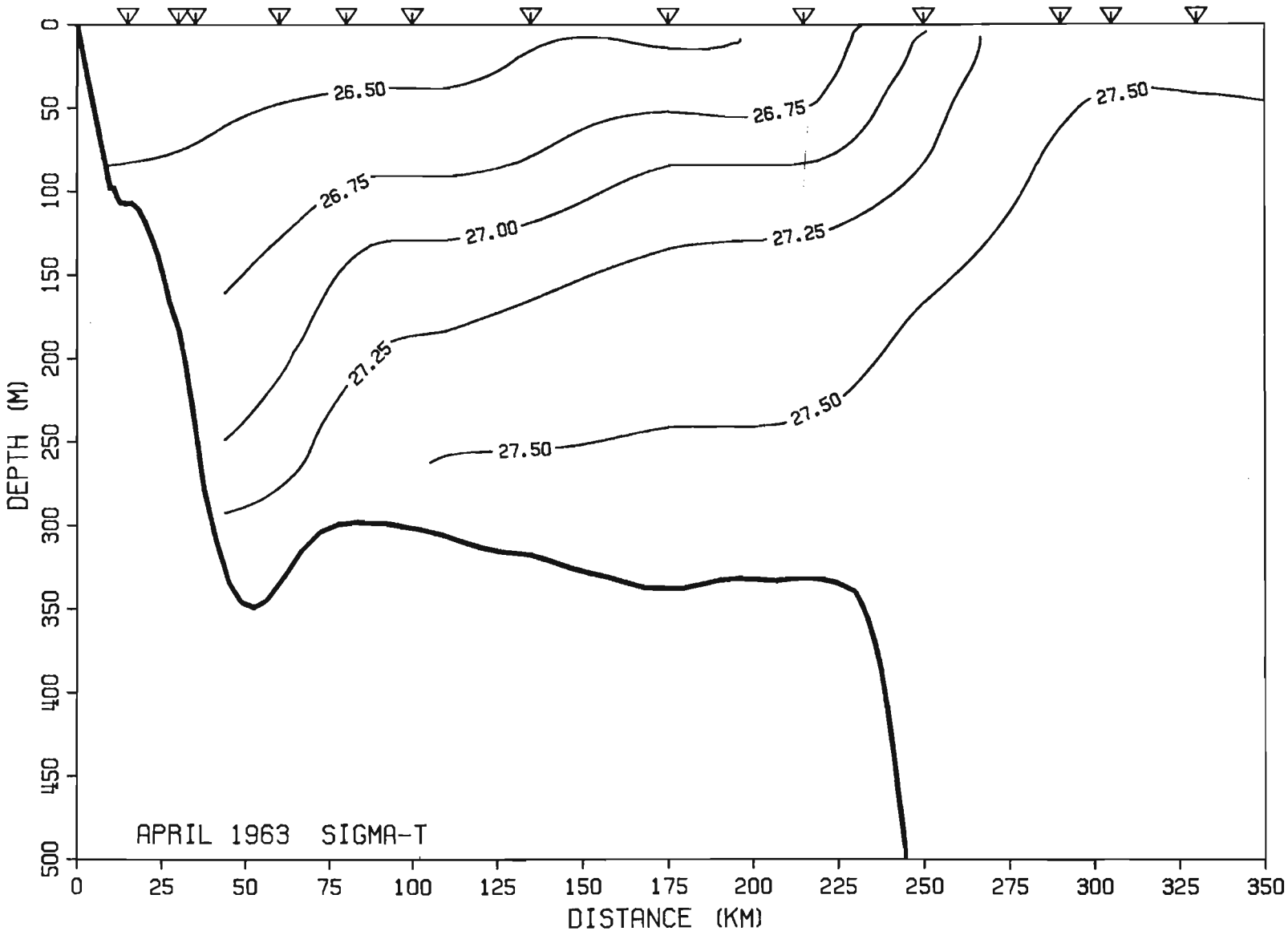
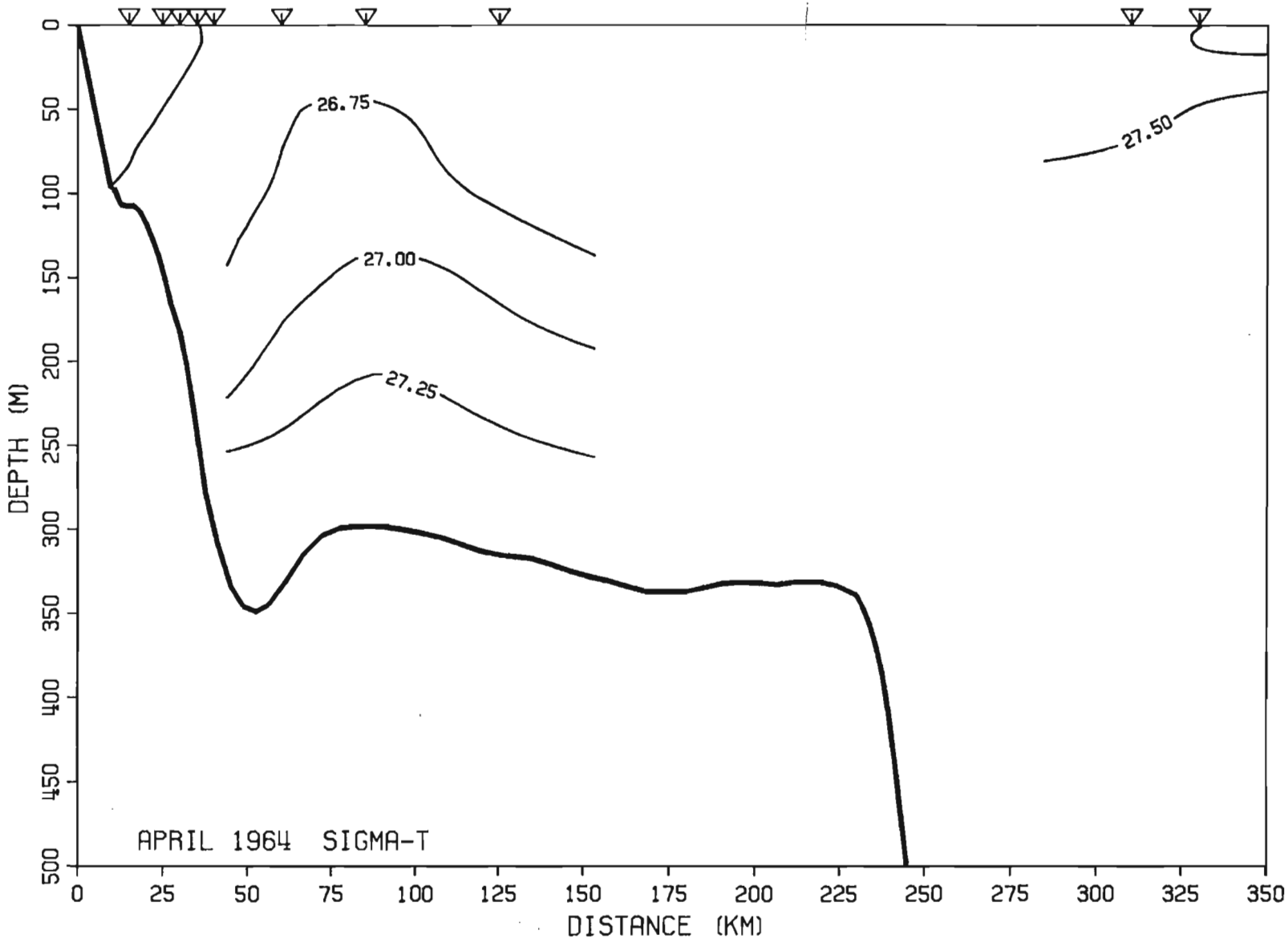
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
26.00
26.25
26.50
26.75
27.00
27.25
27.50


26.50
27.00
27.25
27.25
27.50
APRIL 1952 SIGMA-T
DEPTH (M)
0
50
100
150
200
250
300
350
400
450
500
DISTANCE (KM)
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350


26.00
26.25
26.50
26.75
27.00
27.25
27.50
26.50
26.75
27.00
27.25
27.50
26.75
APRIL 1958 SIGMA-T
DEPTH (M)
0
50
100
150
200
250
300
350
400
450
500
DISTANCE (KM)
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350


26.50
26.75
26.75
27.00
27.25
27.25
27.50
27.50
27.50
APRIL 1963 SIGMA-T
DEPTH (M)
0
50
100
150
200
250
300
350
400
450
500
DISTANCE (KM)
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350


26.75
27.00
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APRIL 1964 SIGMA-T
DEPTH (M)
0
50
100
150
200
250
300
350
400
450
500
DISTANCE (KM)
0
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50
75
100
125
150
175
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225
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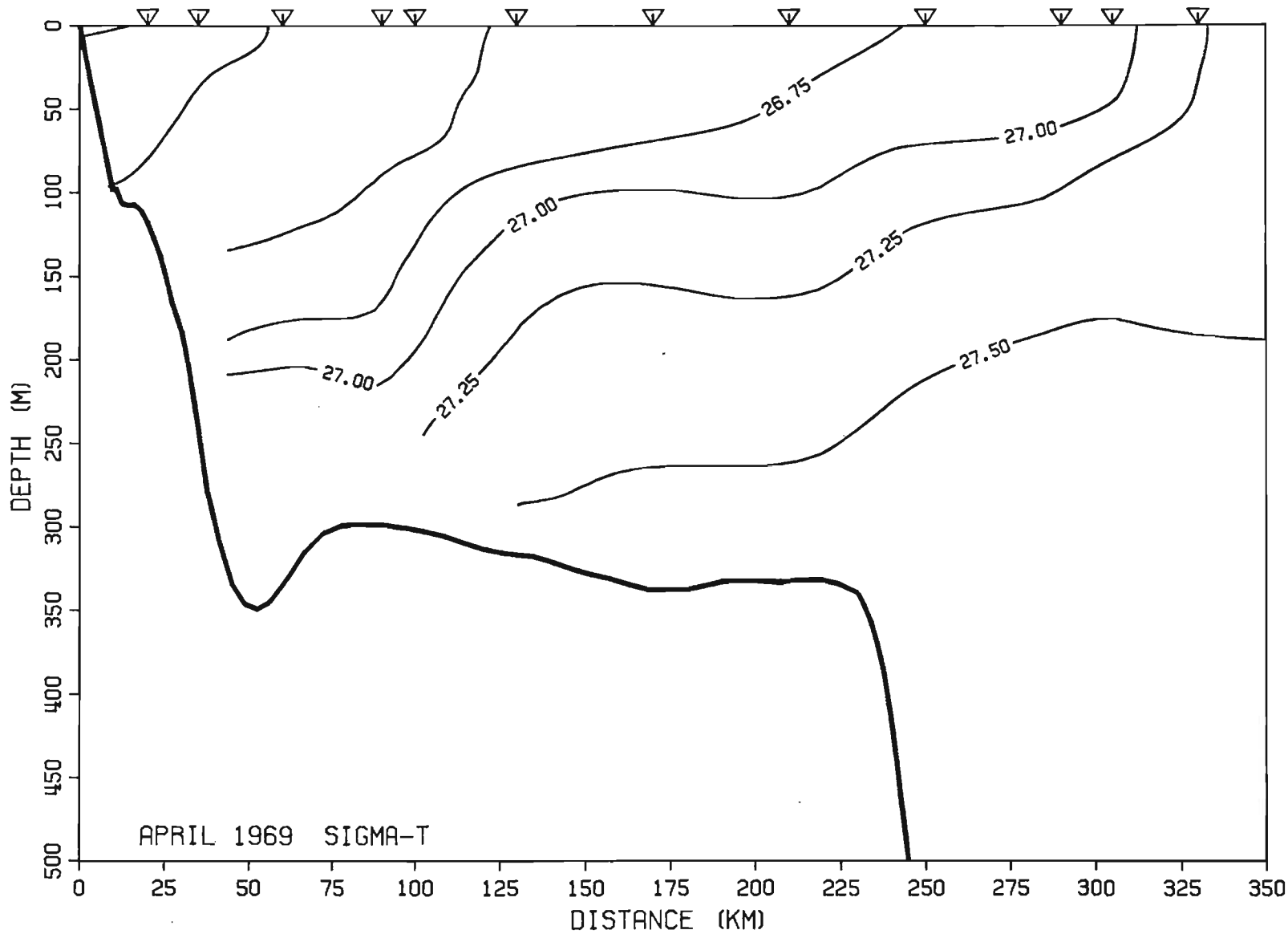
325
350


APRIL 1969 SIGMA-T
DEPTH (M)
DISTANCE (KM)
0
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100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
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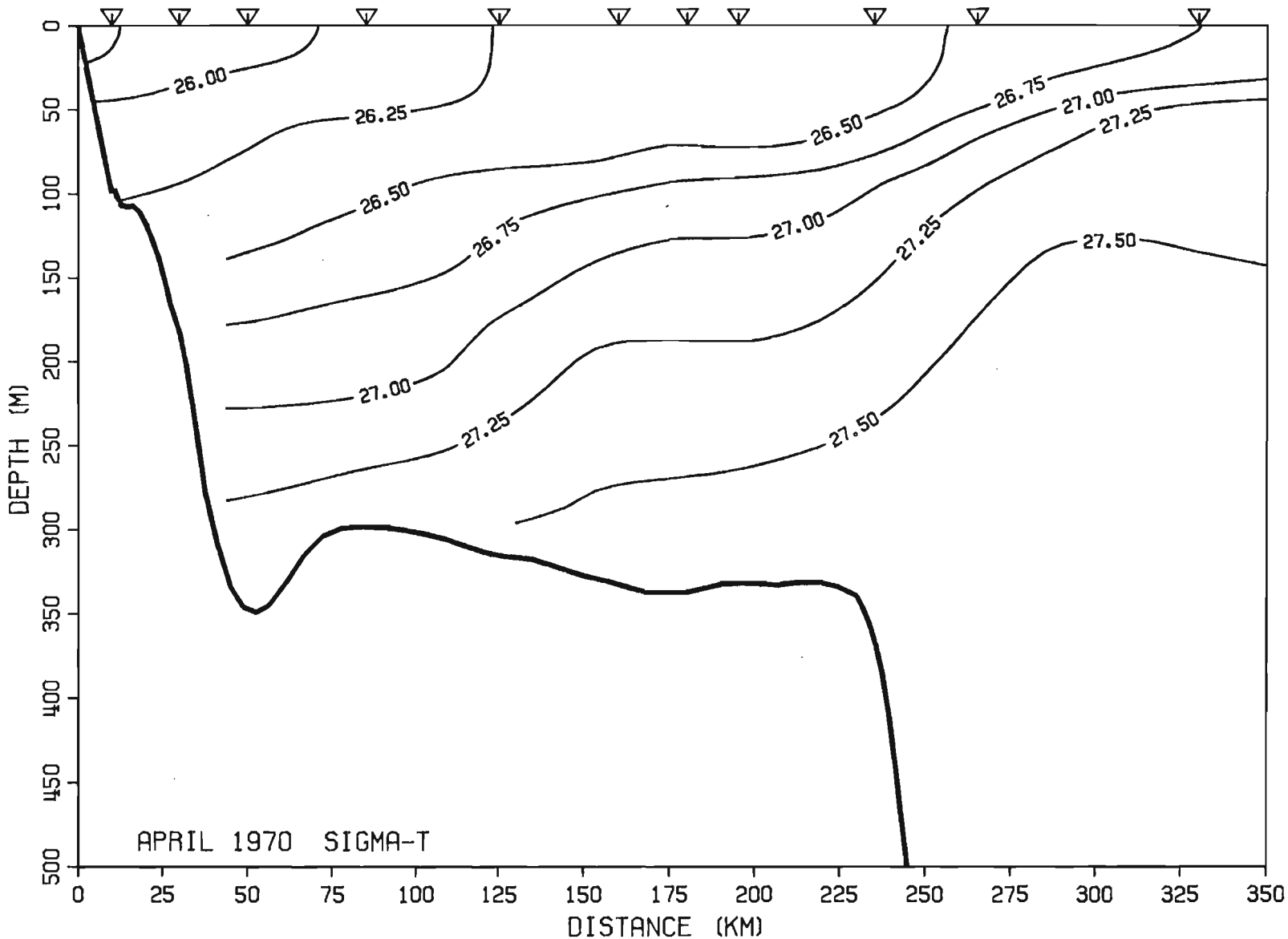
27.00
27.00
27.25
27.25
27.50


26.00
26.25
26.50
26.75
27.00
27.25
27.50
APRIL 1970 SIGMA-T
DEPTH (M)
0
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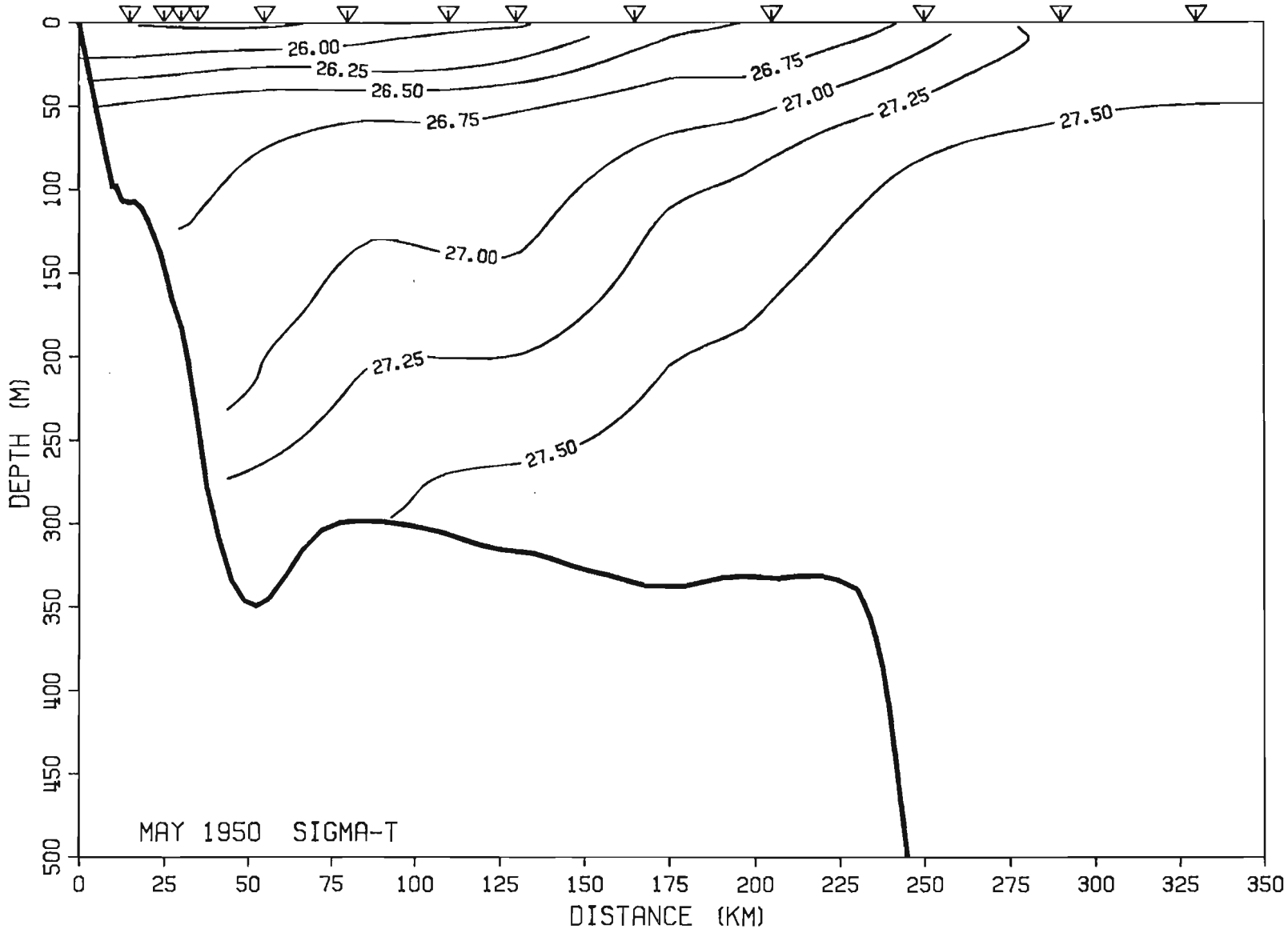
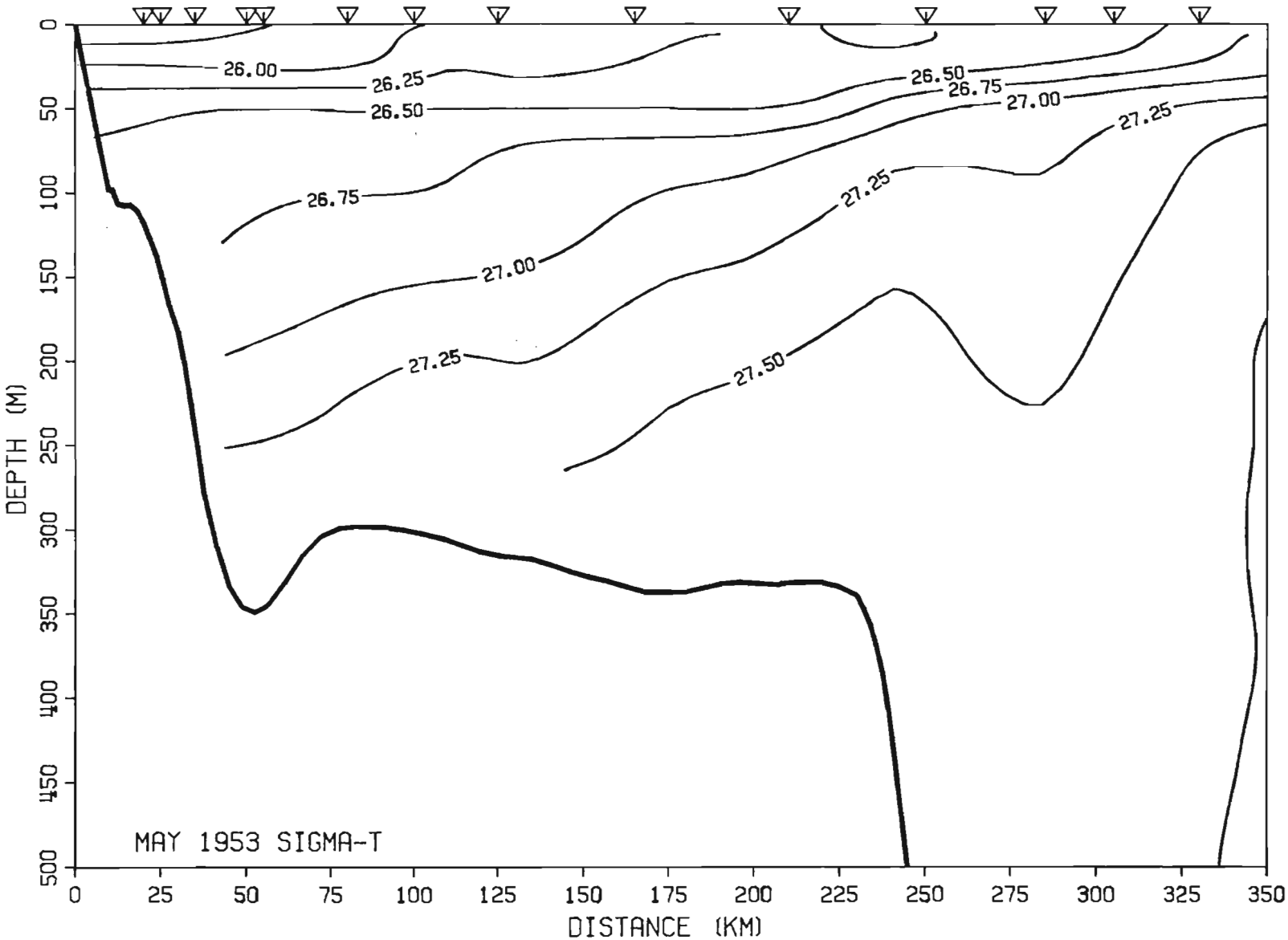
100
150
200
250
300
350
400
450
500
DISTANCE (KM)
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350


26.00
26.25
26.50
26.75
26.75
27.00
27.00
27.25
27.25
27.50
27.50
MAY 1950 SIGMA-T
DEPTH (M)
0
50
100
150
200
250
300
350
400
450
500
DISTANCE (KM)
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350


MAY 1953 SIGMA-T
DEPTH (M)
DISTANCE (KM)
0
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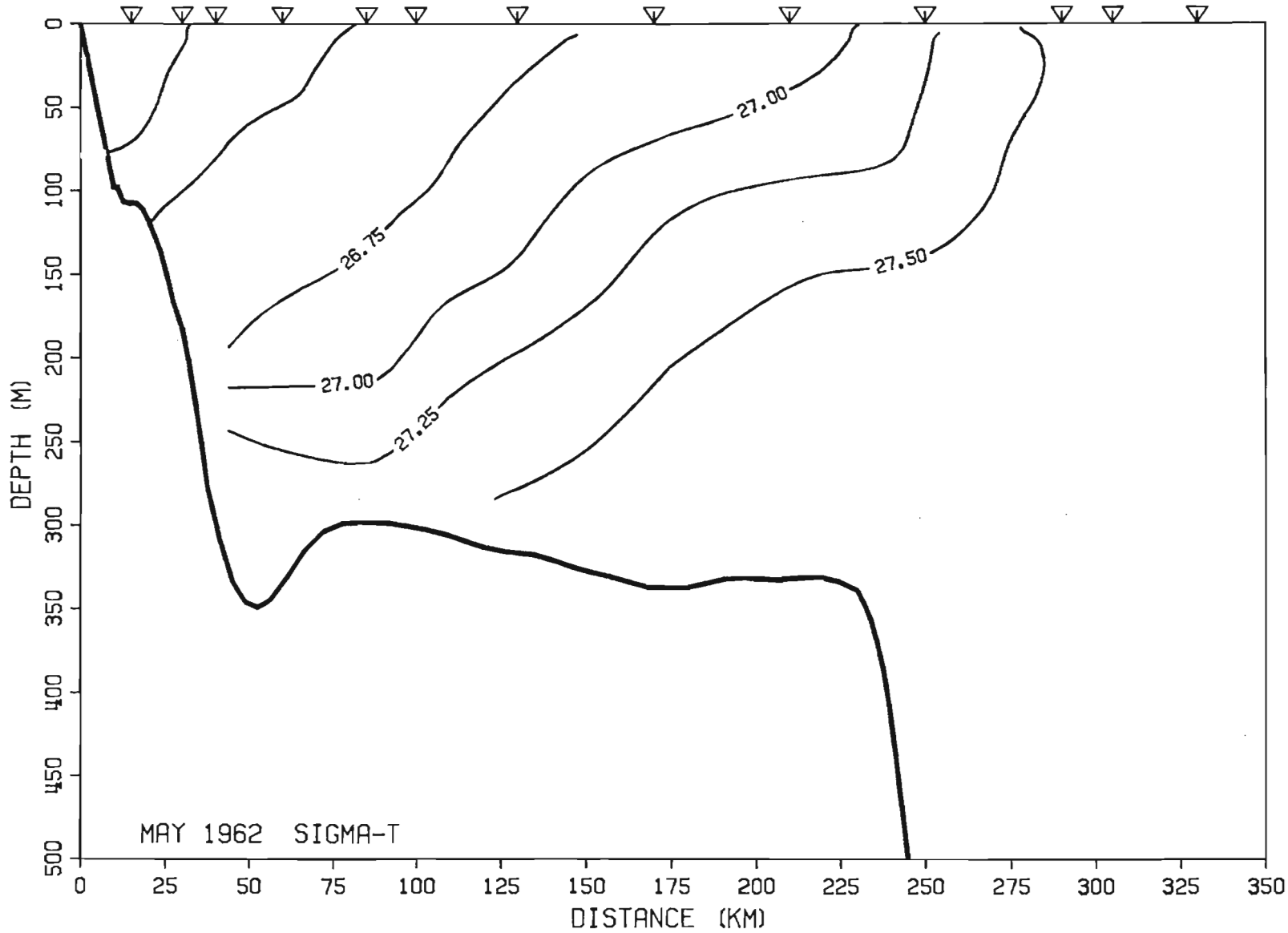
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
26.00
26.25
26.50
26.75
27.00
27.25
27.50


MAY 1962 SIGMA-T
DEPTH (M)
DISTANCE (KM)
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100
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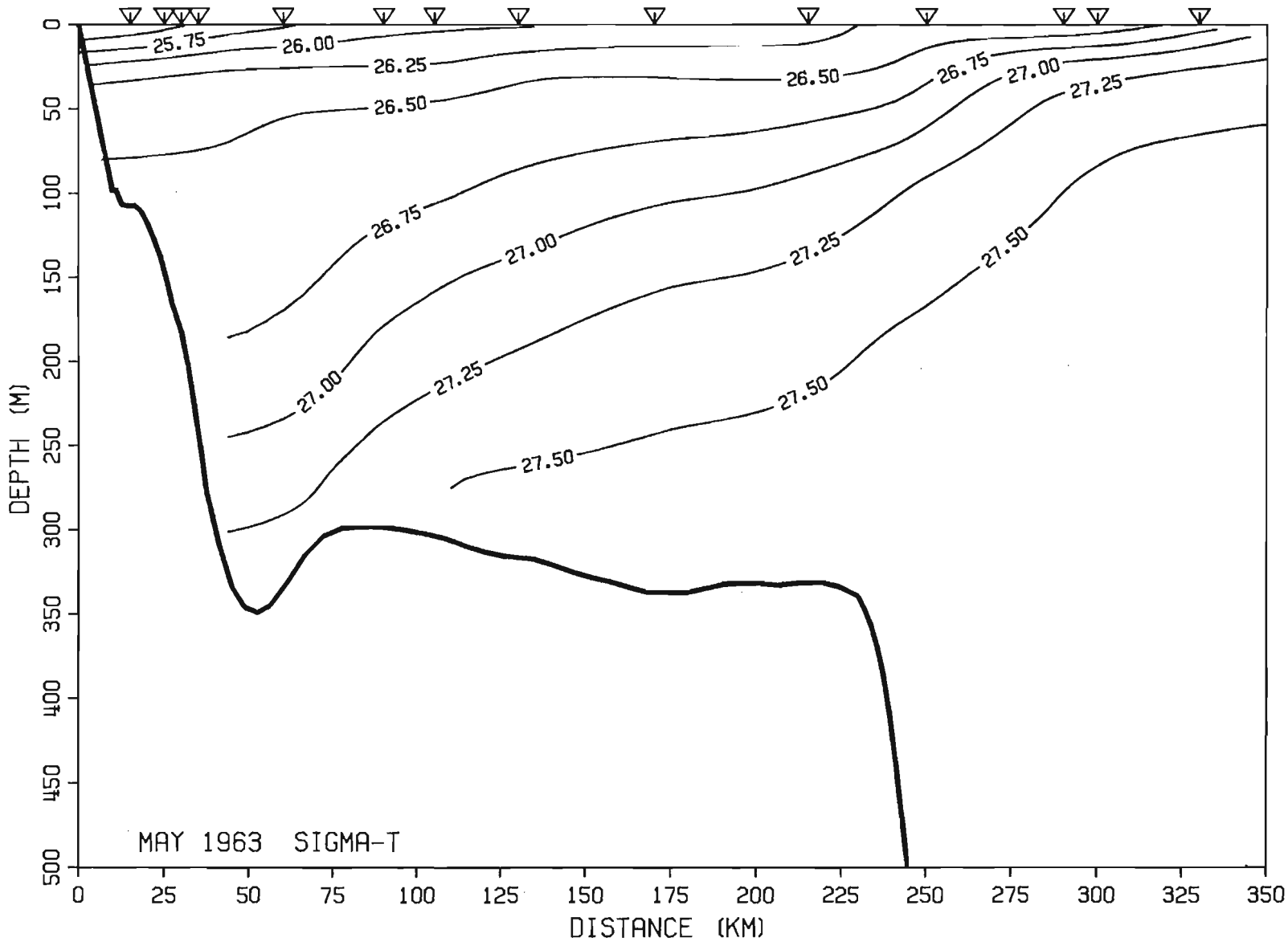
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
26.75
27.00
27.25
27.00
27.50


MAY 1963 SIGMA-T
DEPTH (M)
DISTANCE (KM)
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100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
25.75
26.00
26.25
26.50
26.50
26.75
27.00
27.25
26.75
27.00
27.25
27.50
27.00
27.25
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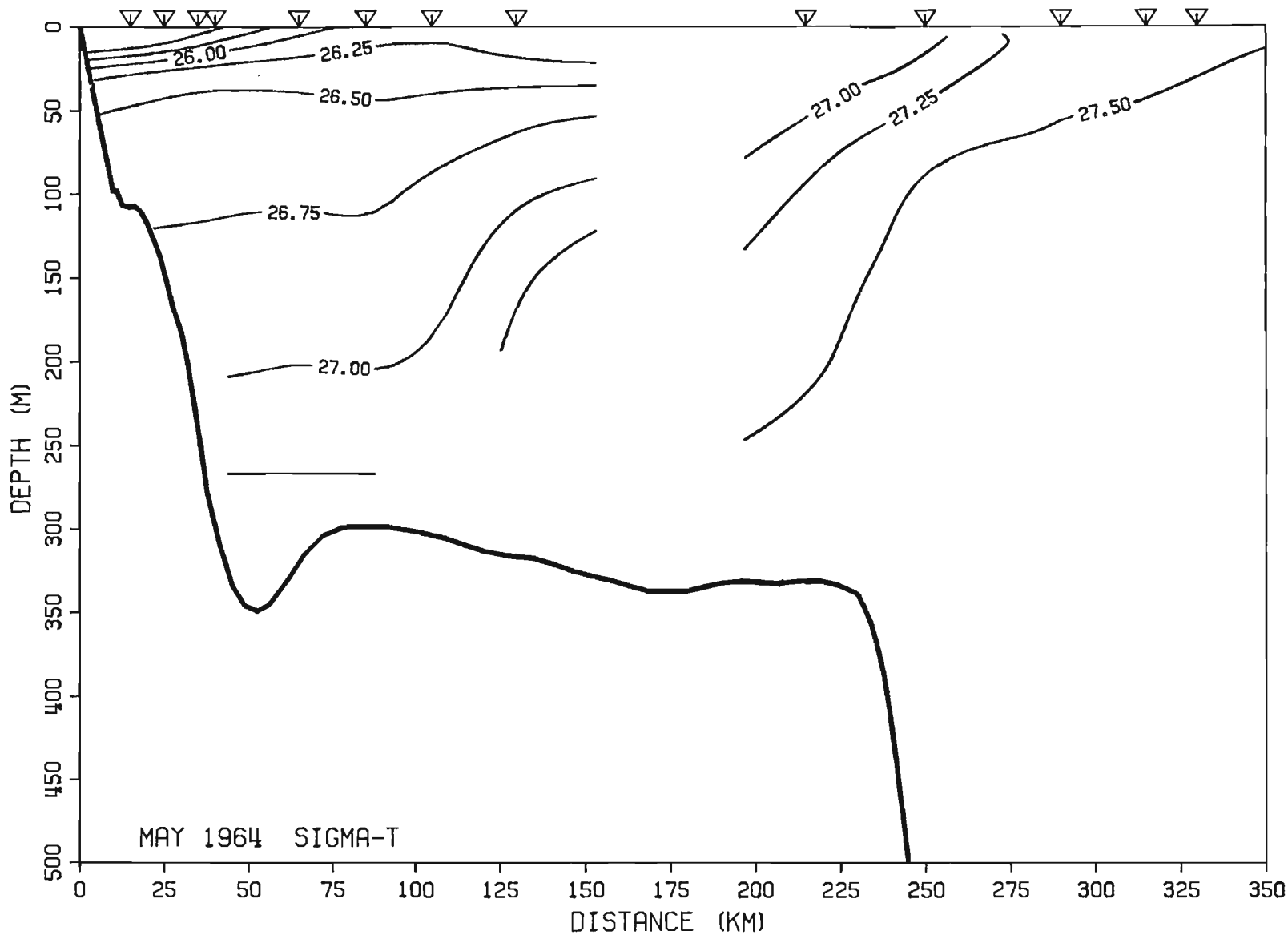
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DEPTH (M)
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DISTANCE (KM)
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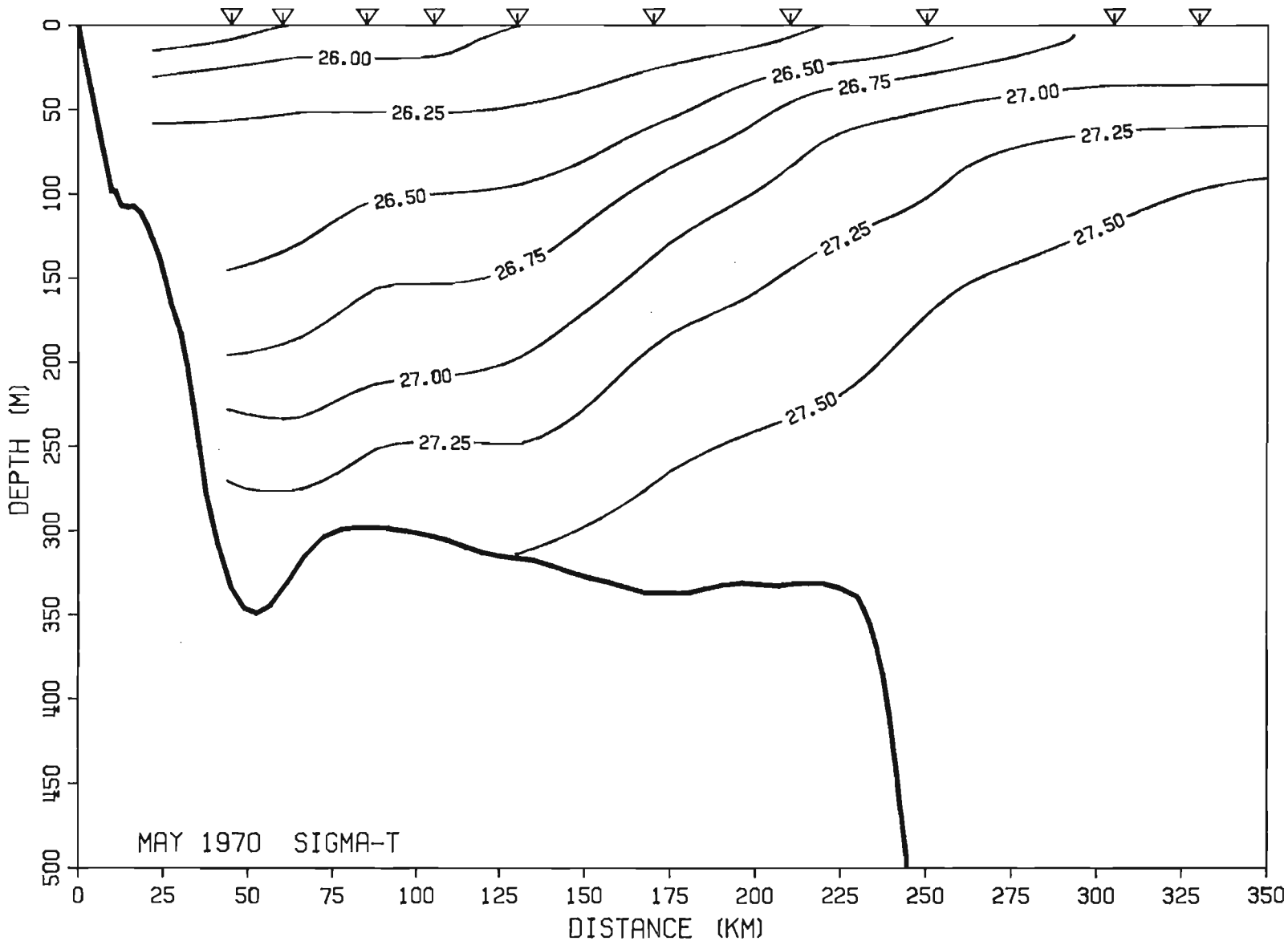
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DEPTH (M)
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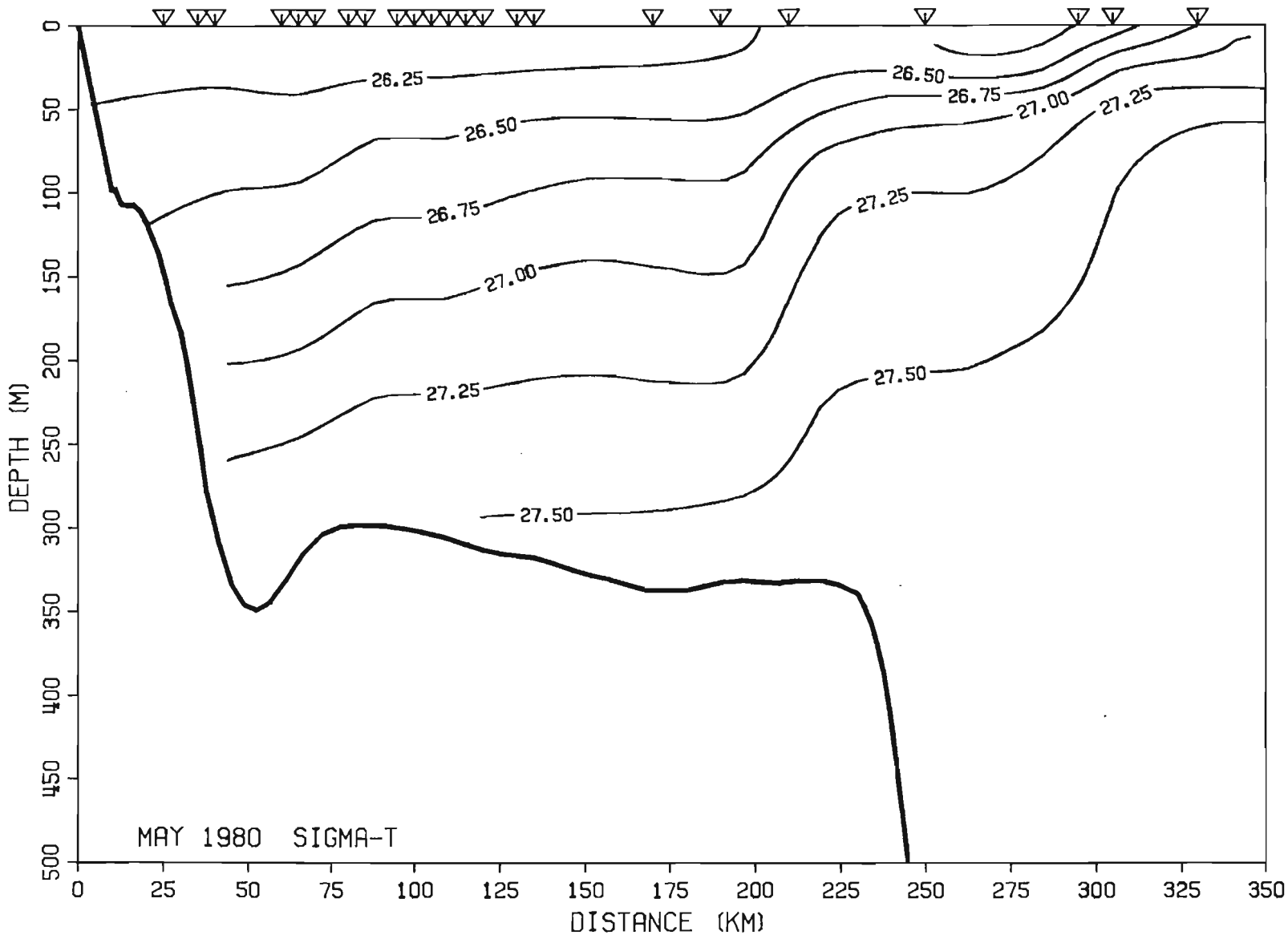
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DEPTH (M)
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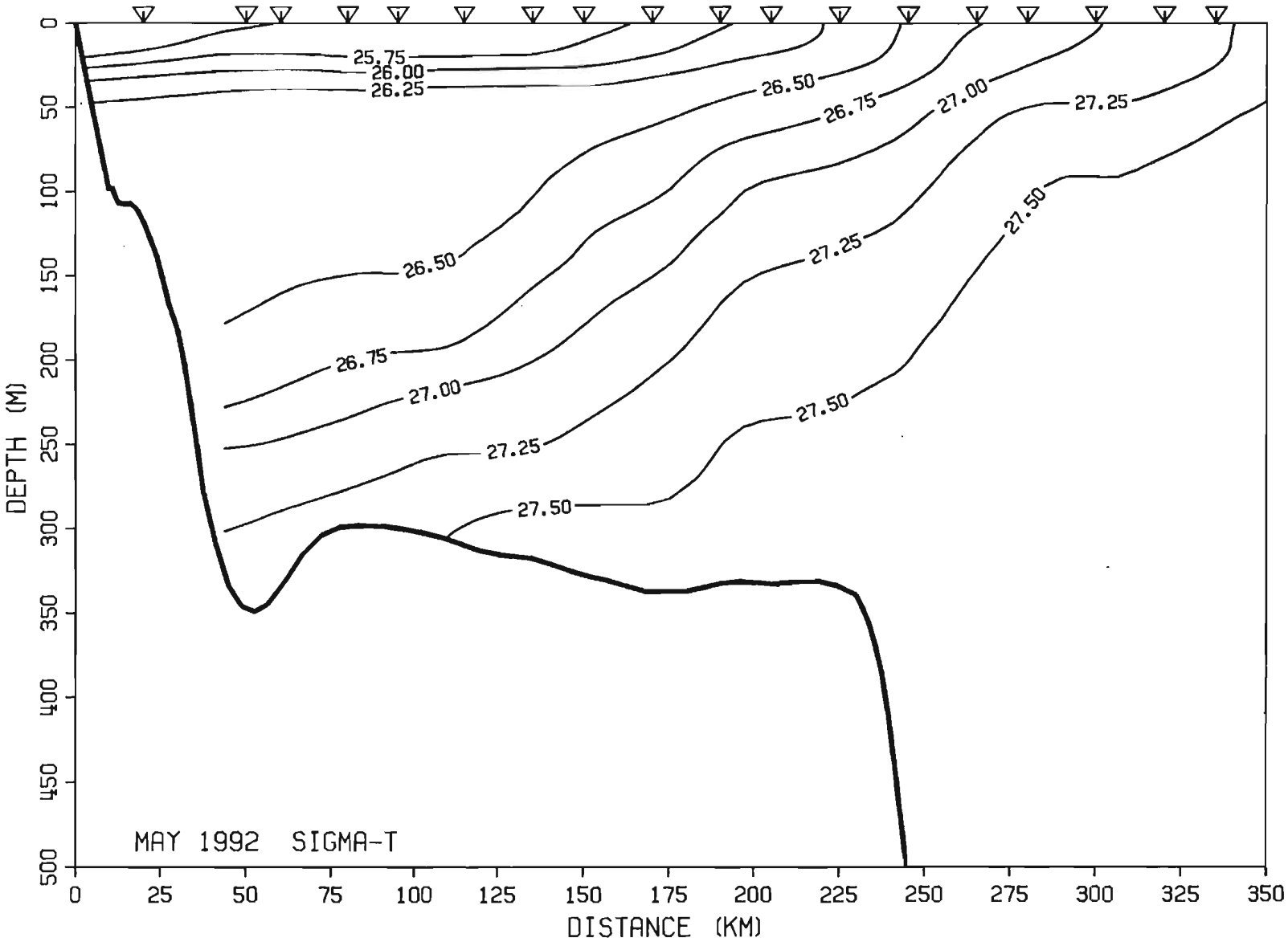
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DISTANCE (KM)
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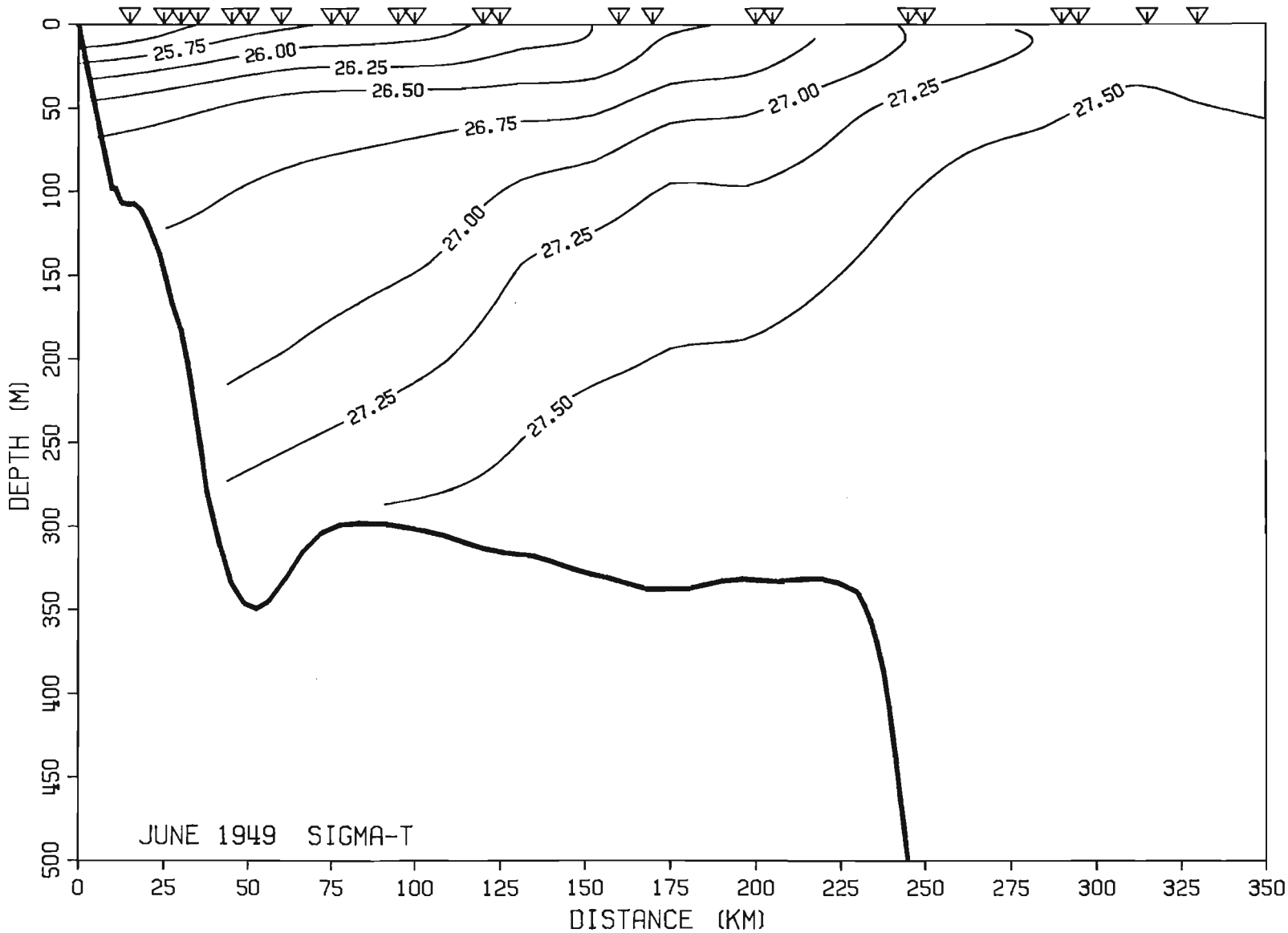
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JUNE 1949 SIGMA-T
DEPTH (M)
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DISTANCE (KM)
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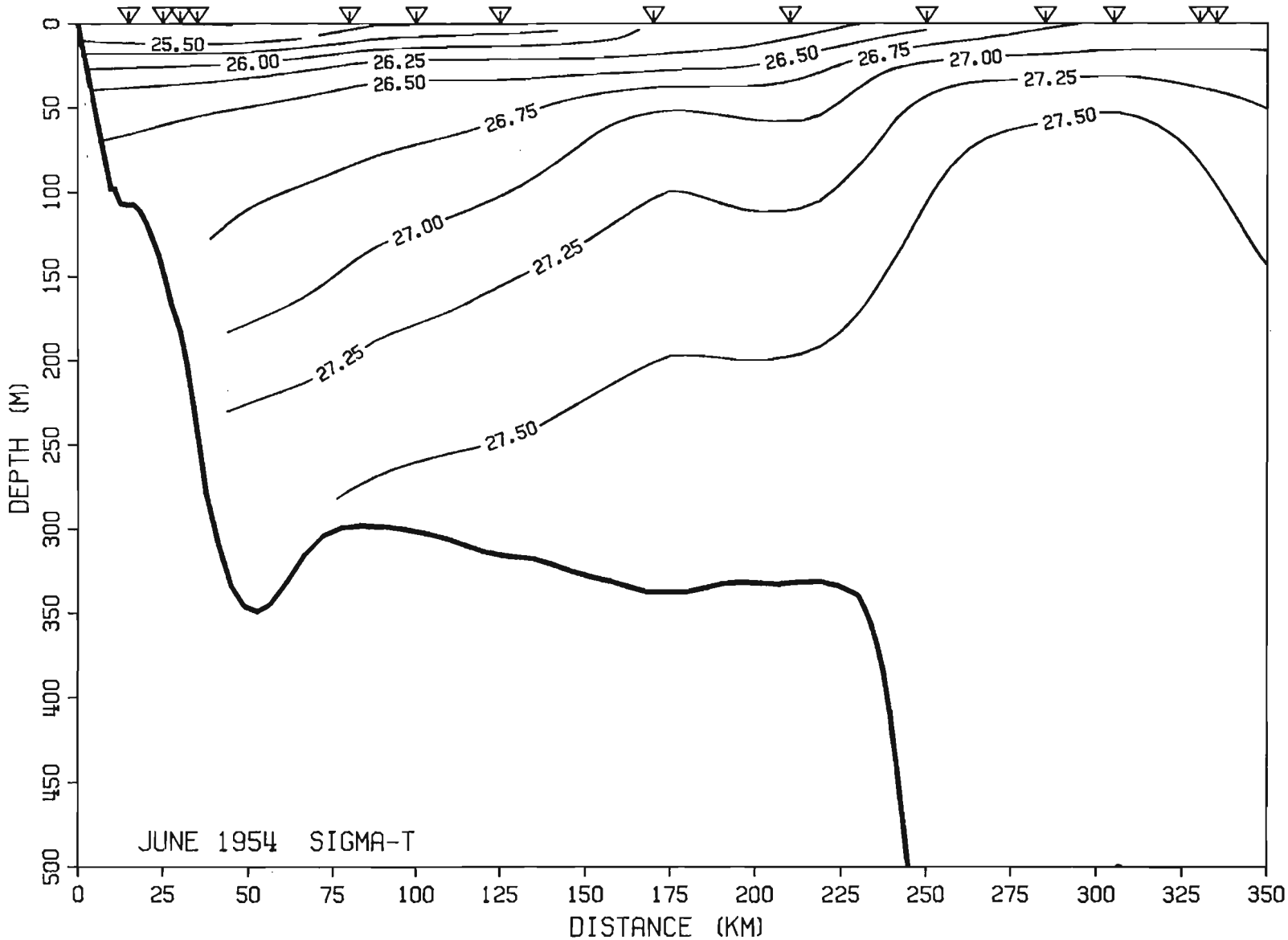
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JUNE 1954 SIGMA-T
DEPTH (M)
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DISTANCE (KM)
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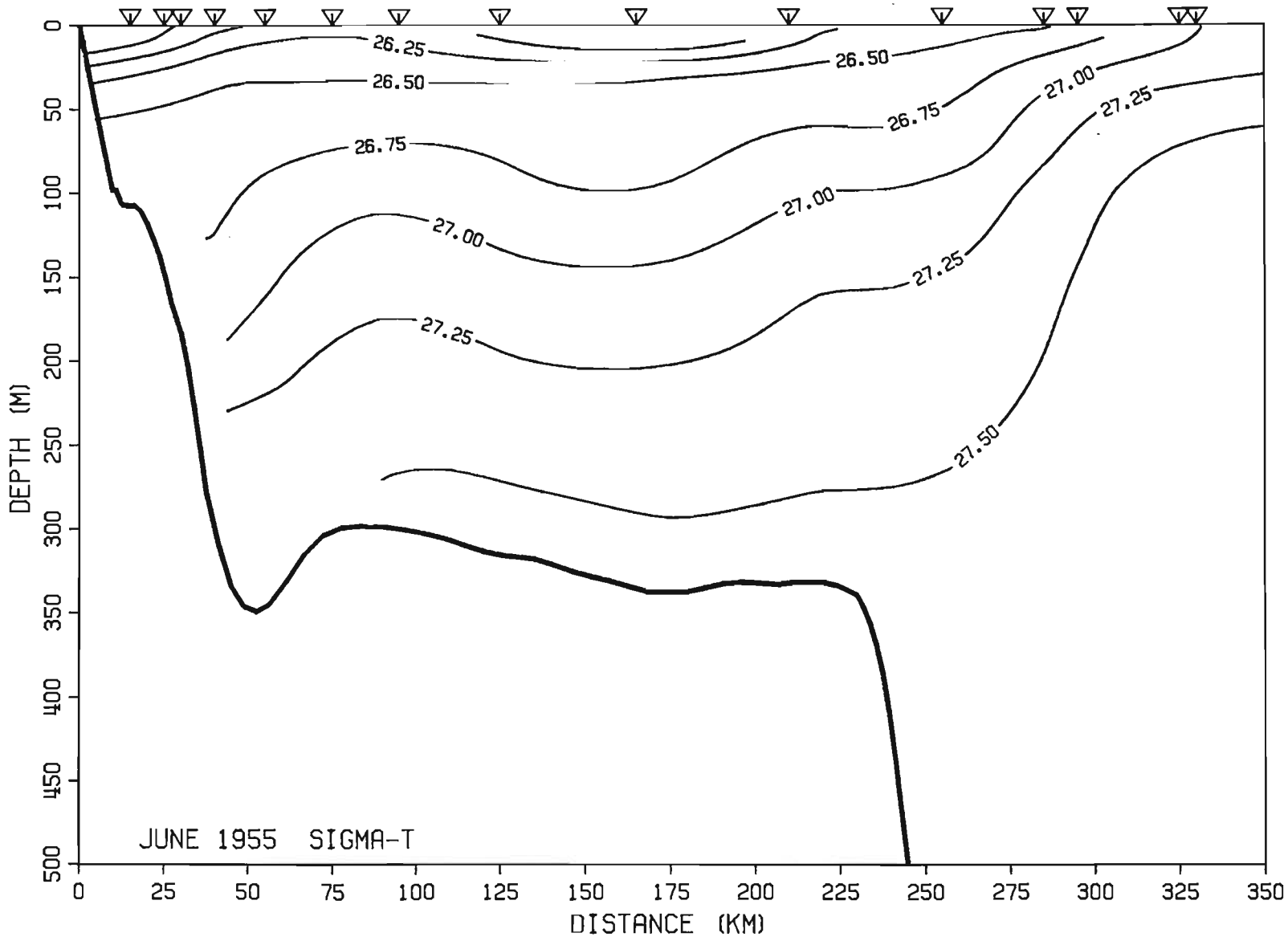
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JUNE 1955 SIGMA-T
DEPTH (M)
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100
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DISTANCE (KM)
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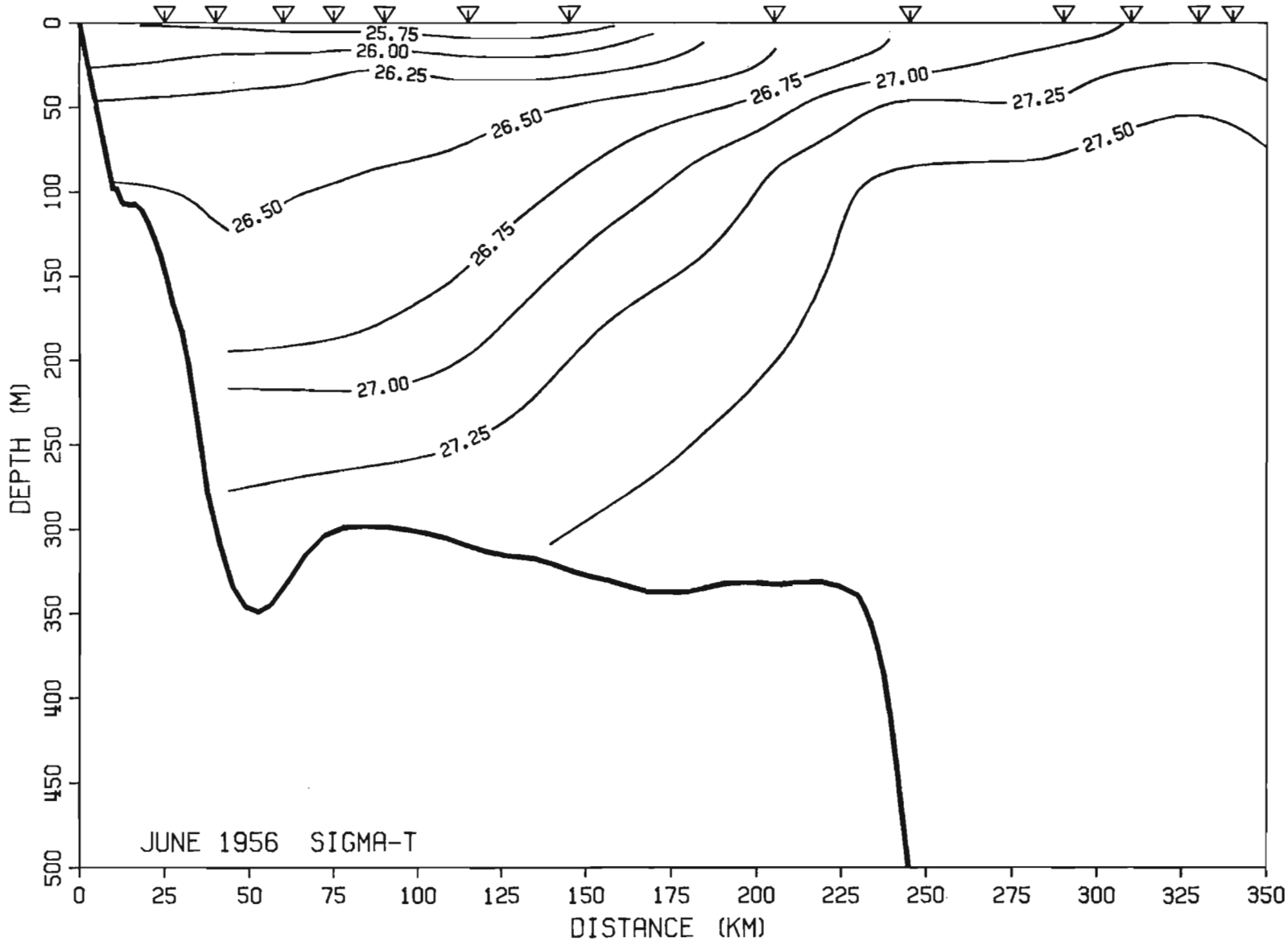
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DEPTH (M)
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DISTANCE (KM)
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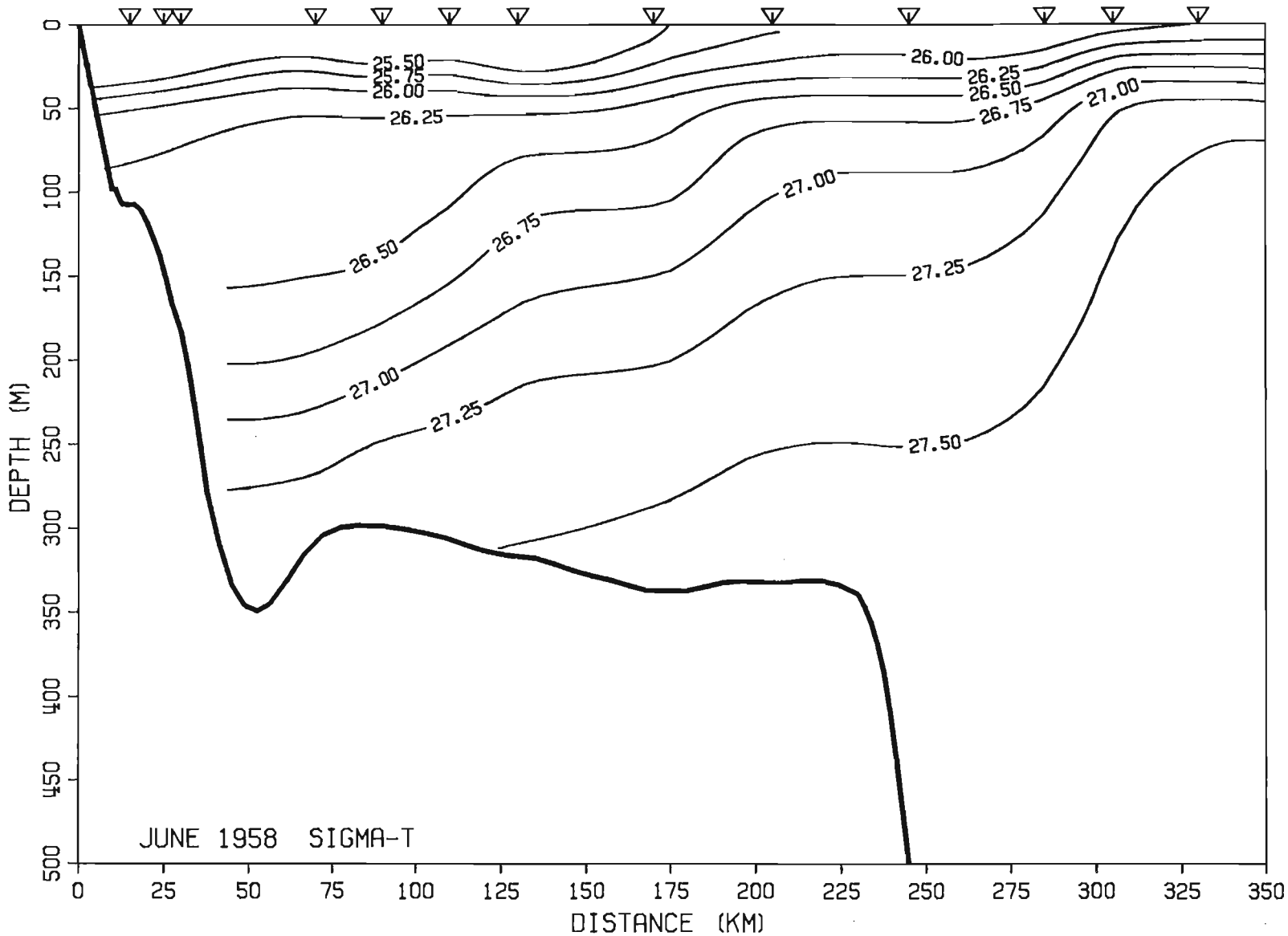
JUNE 1958 SIGMA-T
DEPTH (M)
DISTANCE (KM)
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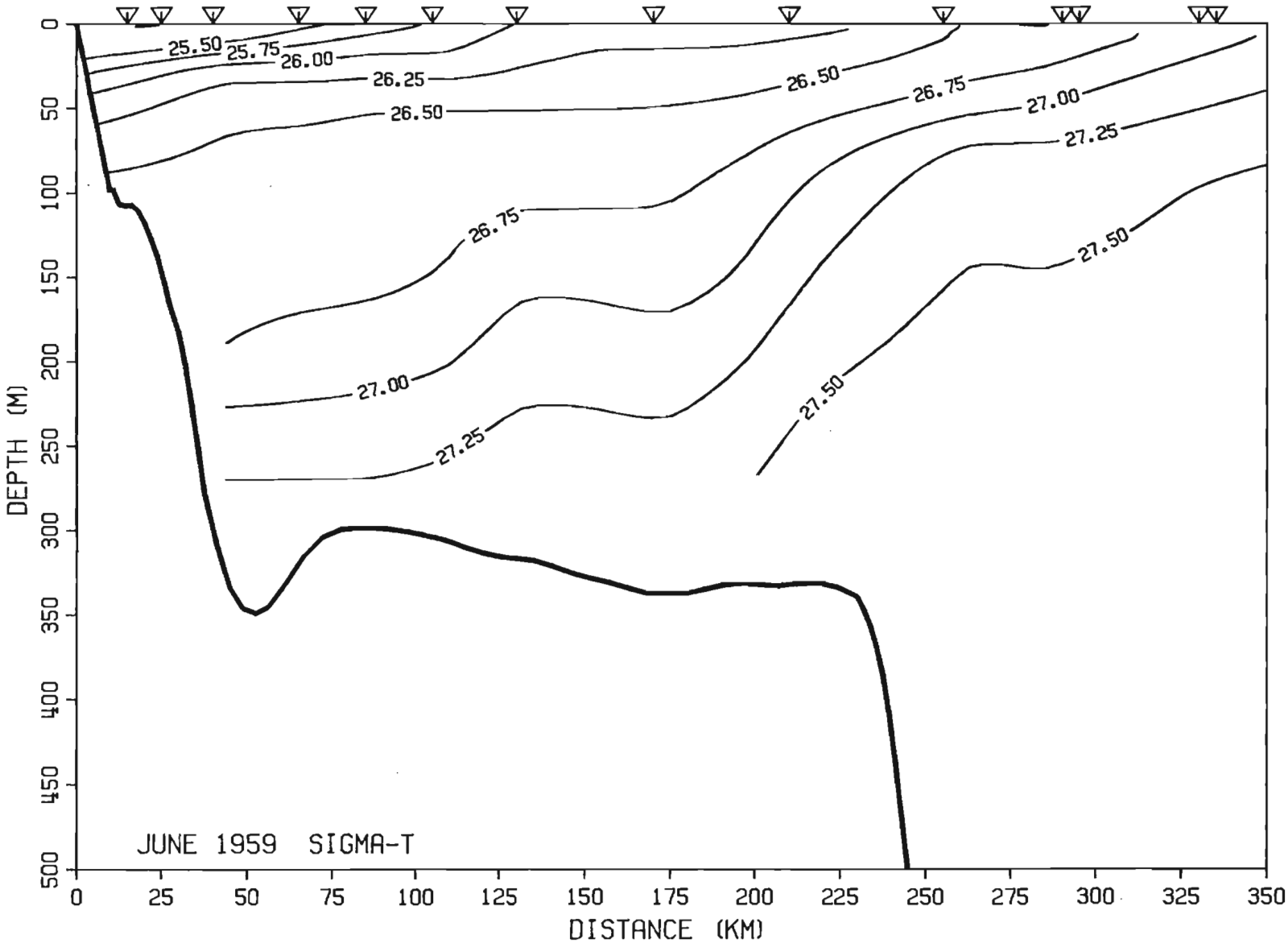
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JUNE 1959 SIGMA-T
DEPTH (M)
0
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100
150
200
250
300
350
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DISTANCE (KM)
0
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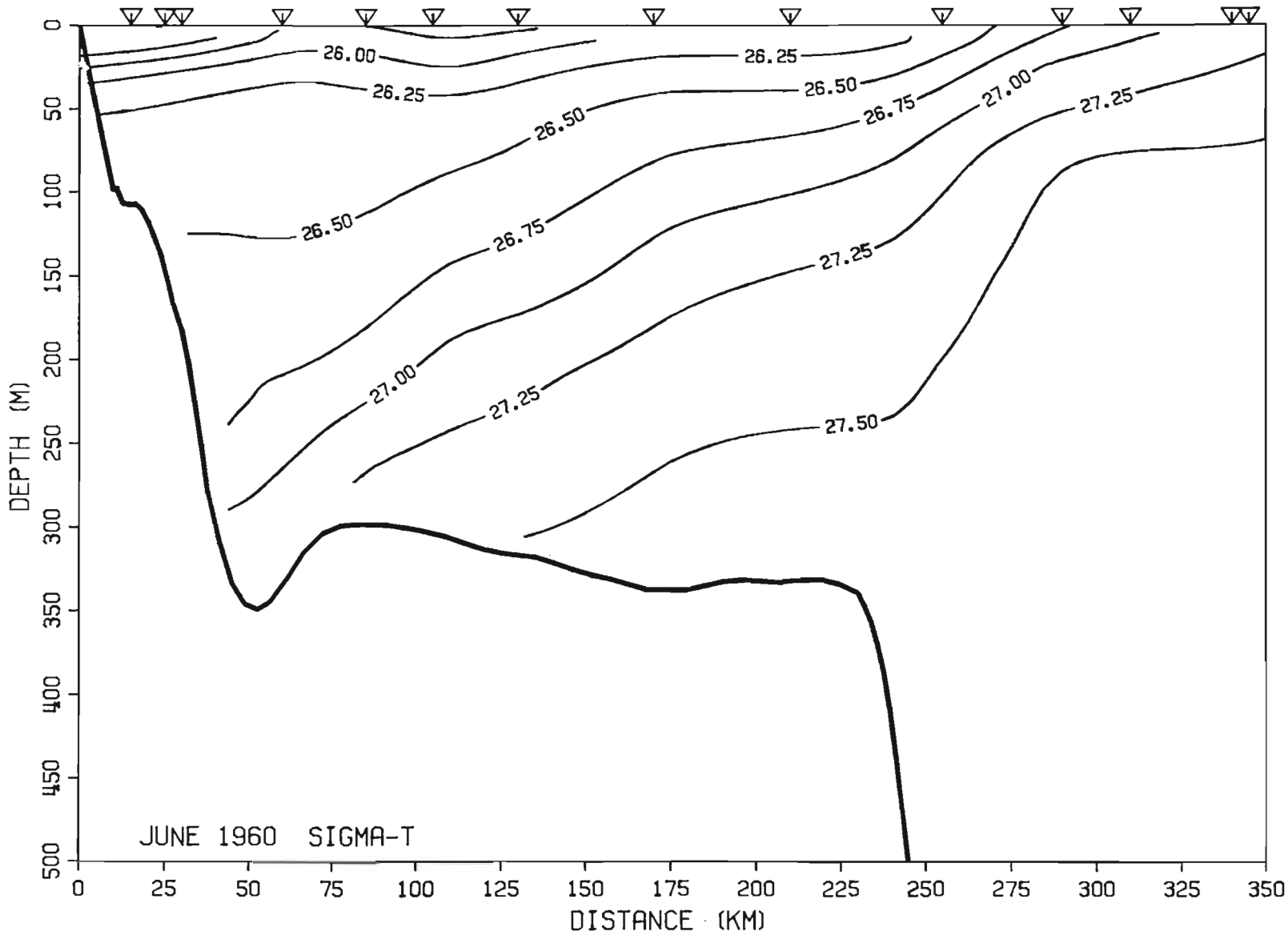
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0
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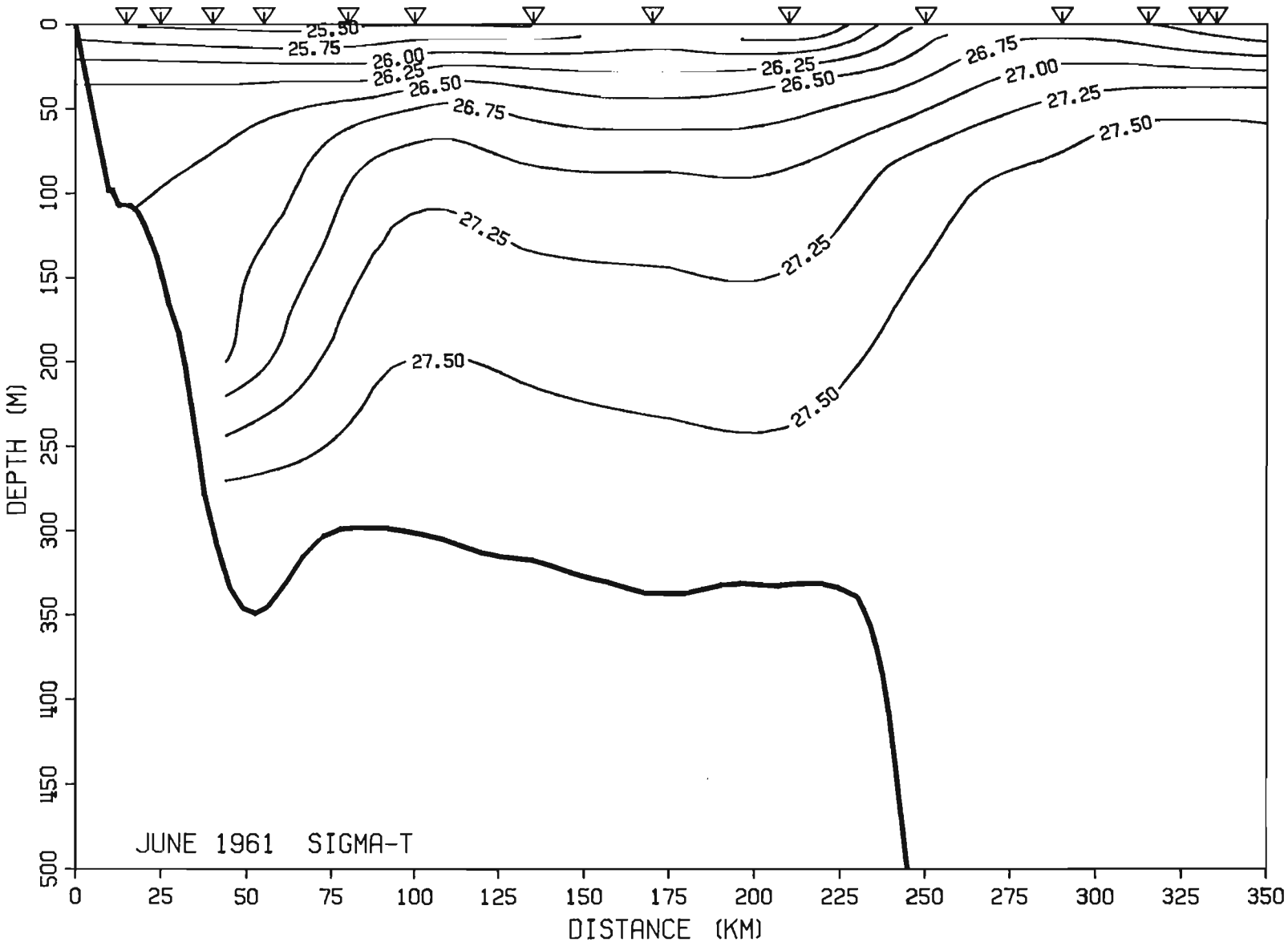
JUNE 1961 SIGMA-T
DEPTH (M)
DISTANCE (KM)
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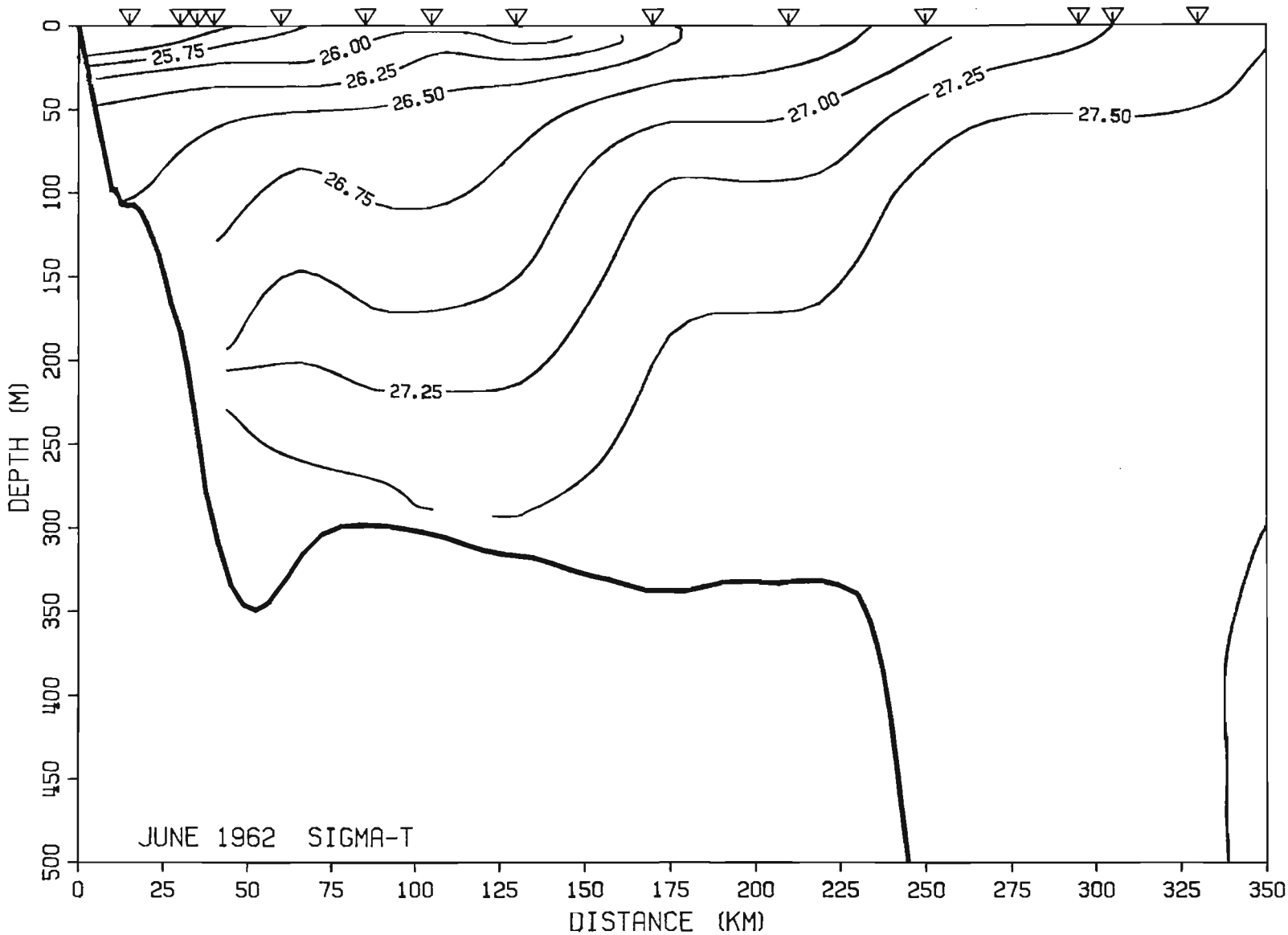
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DEPTH (M)
DISTANCE (KM)
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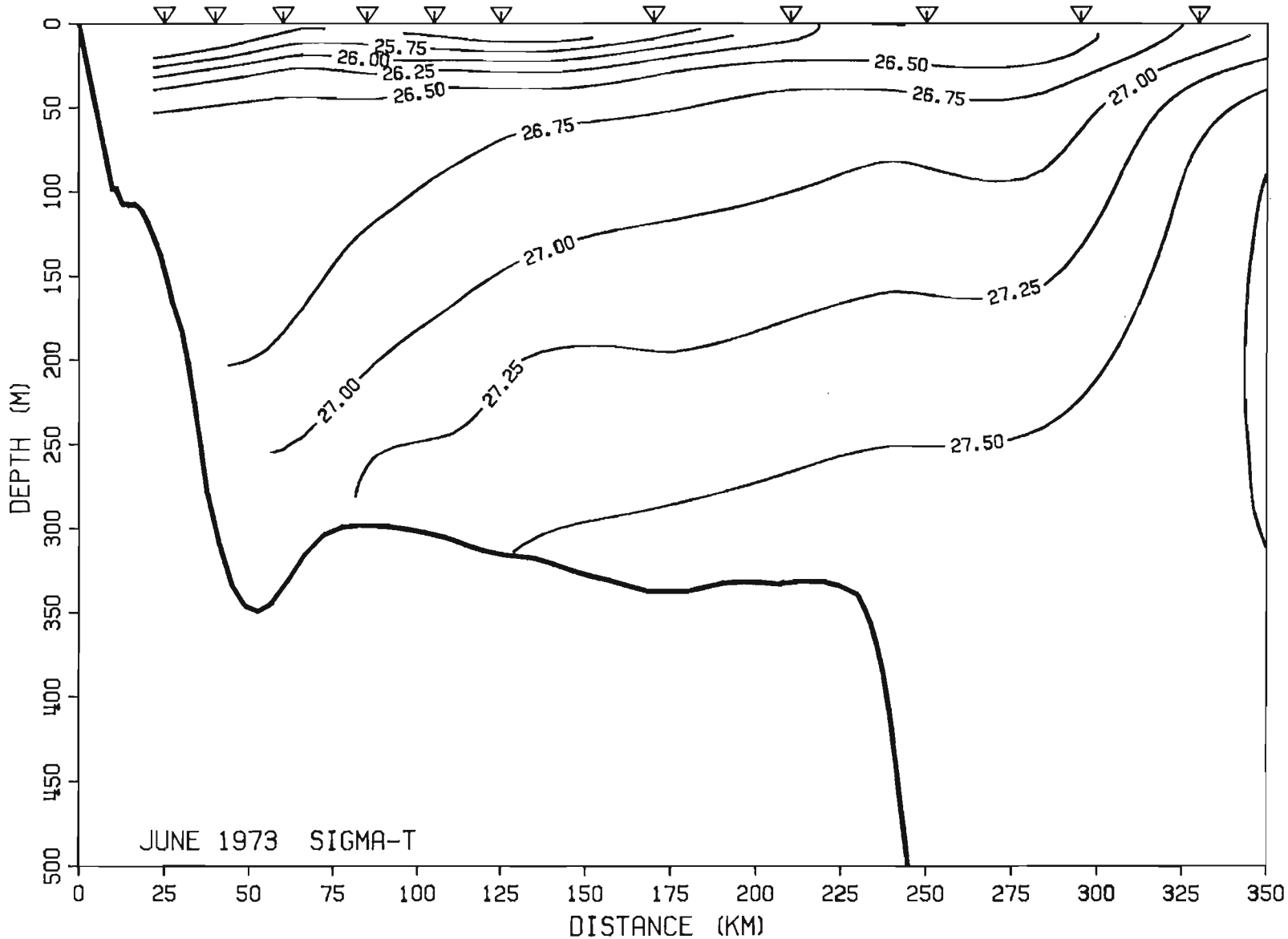
JUNE 1973 SIGMA-T
DEPTH (M)
DISTANCE (KM)
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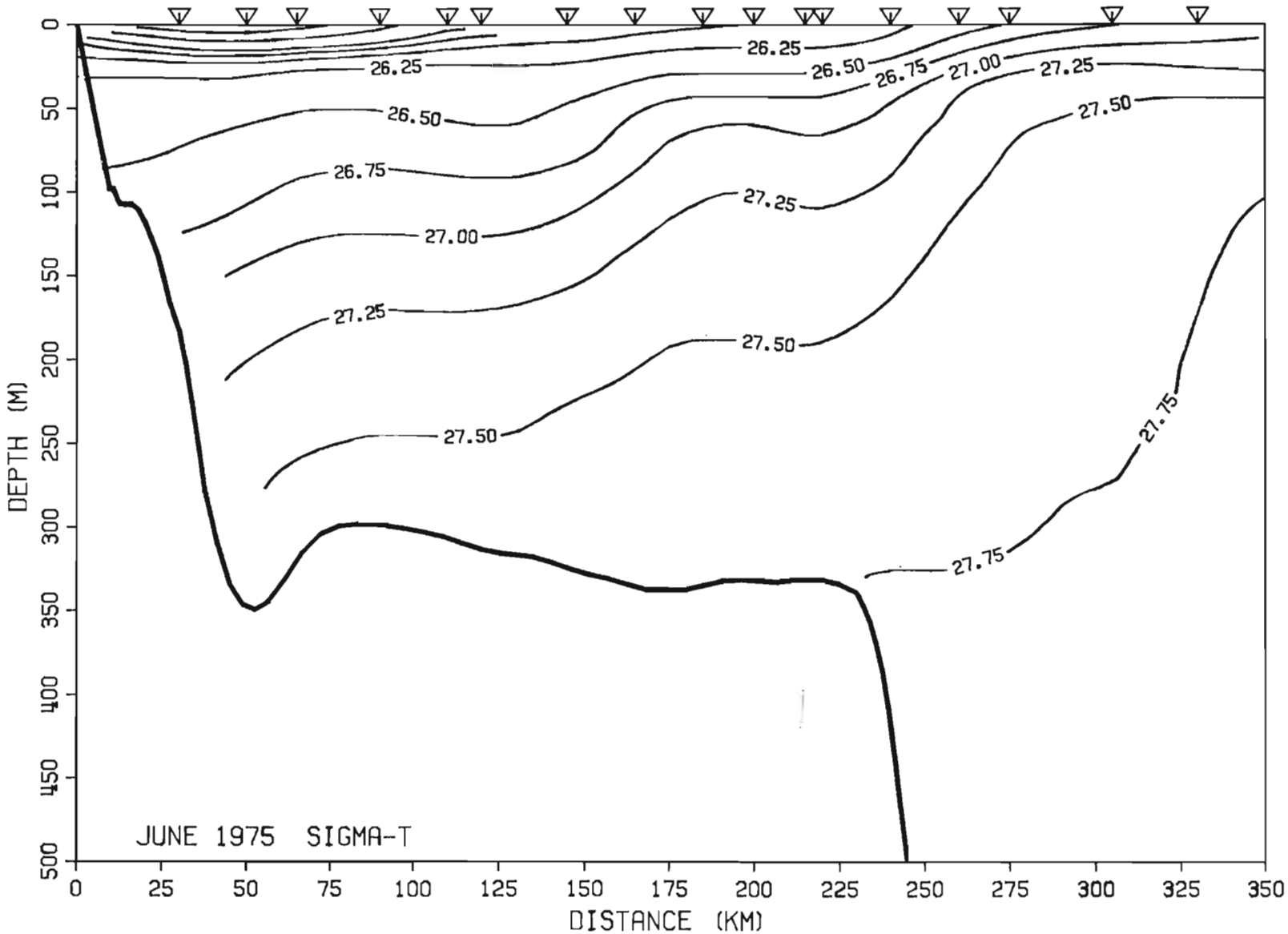
JUNE 1975 SIGMA-T
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DISTANCE (KM)
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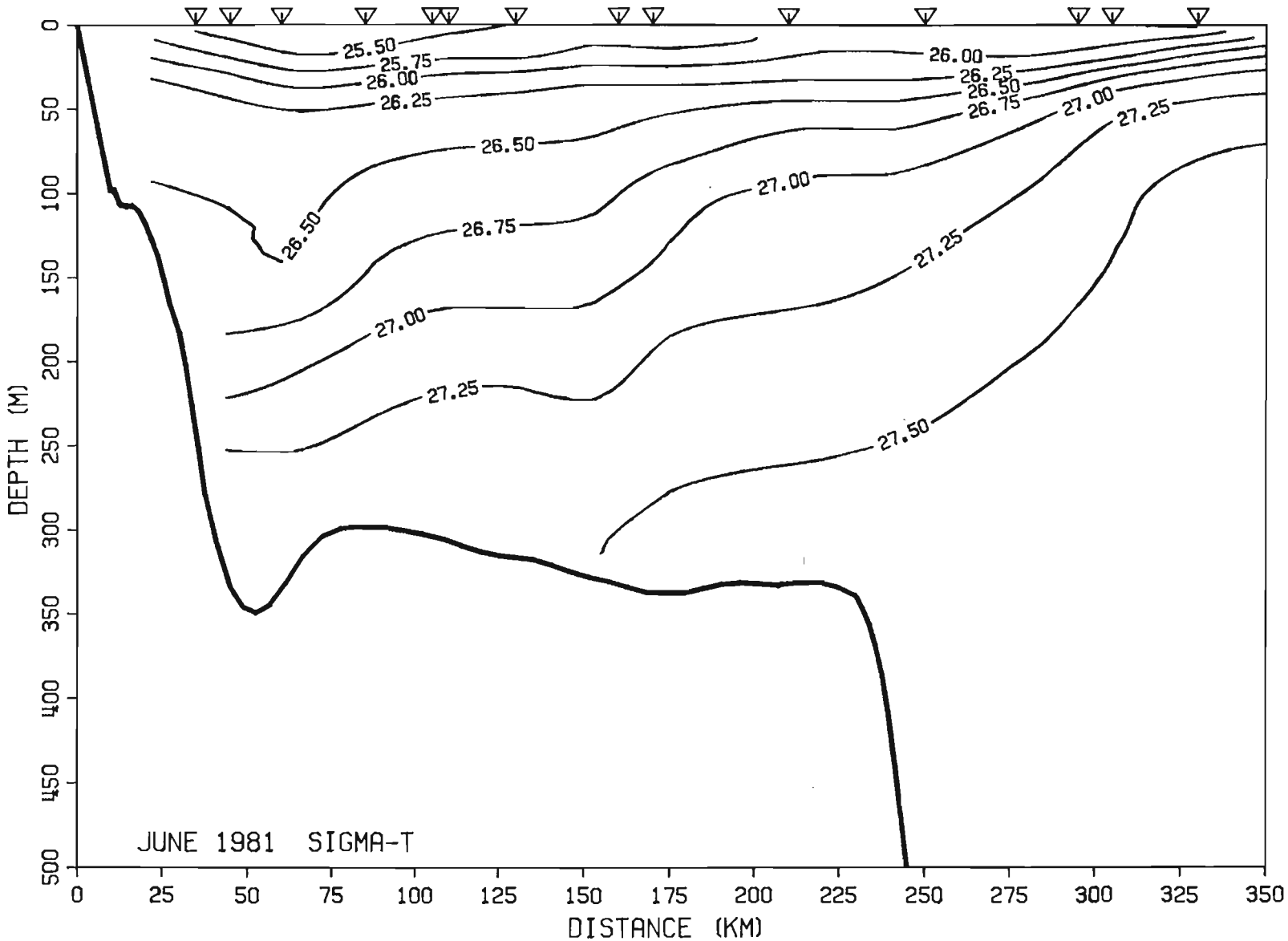
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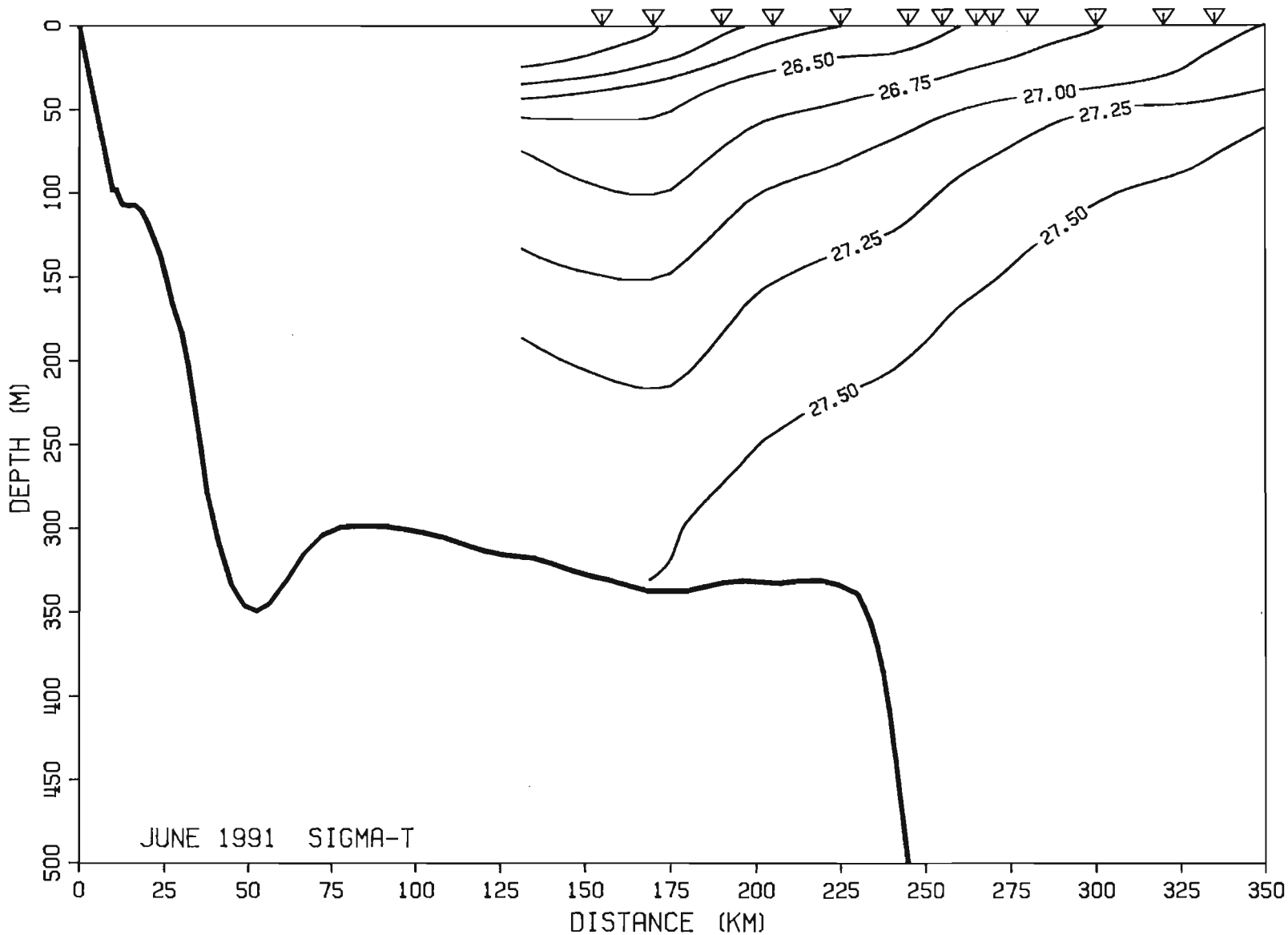
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JUNE 1991 SIGMA-T
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DISTANCE (KM)
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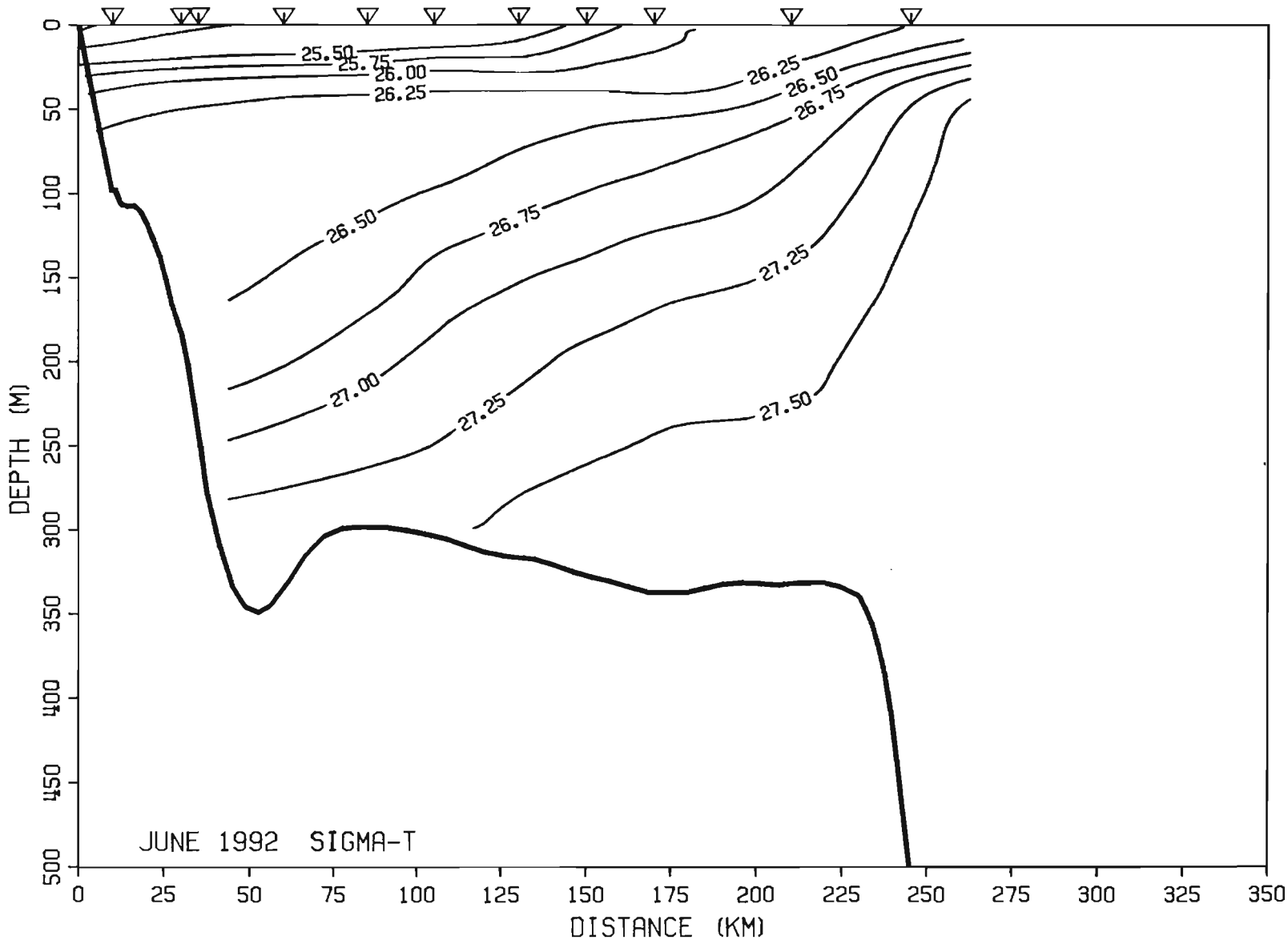
JUNE 1992 SIGMA-T
DEPTH (M)
DISTANCE (KM)
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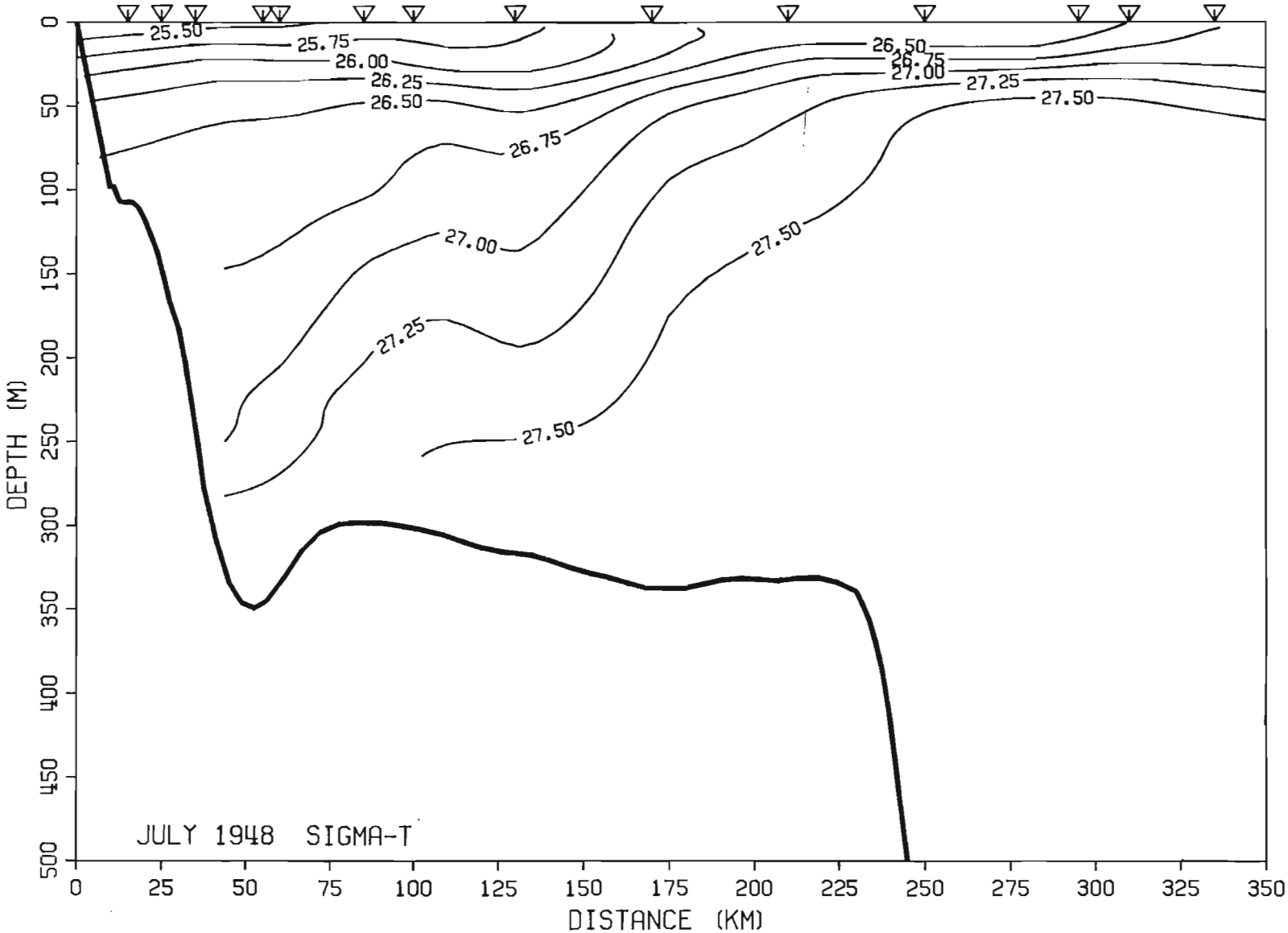
JULY 1948 SIGMA-T
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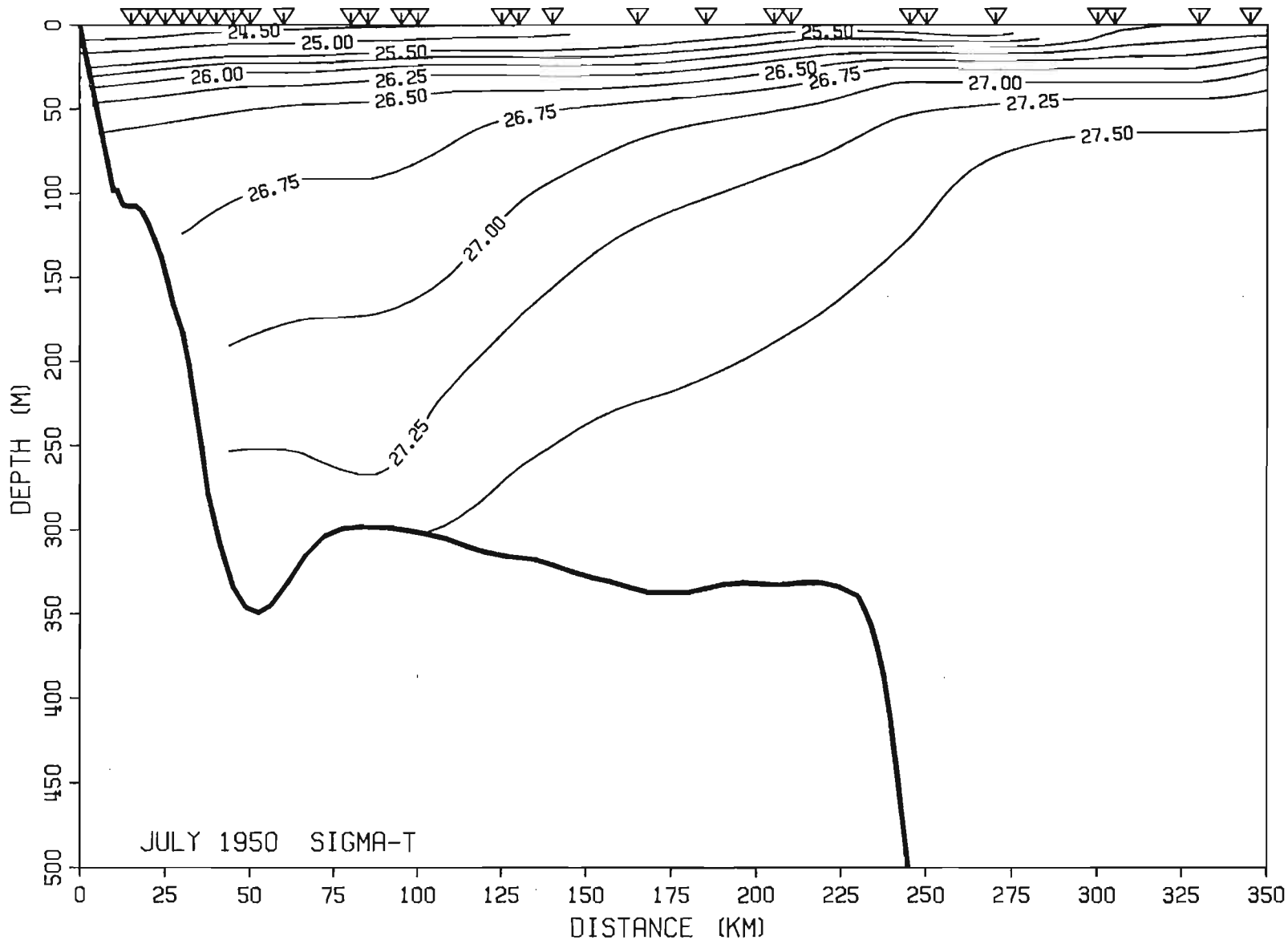
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JULY 1950 SIGMA-T
DEPTH (M)
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DISTANCE (KM)
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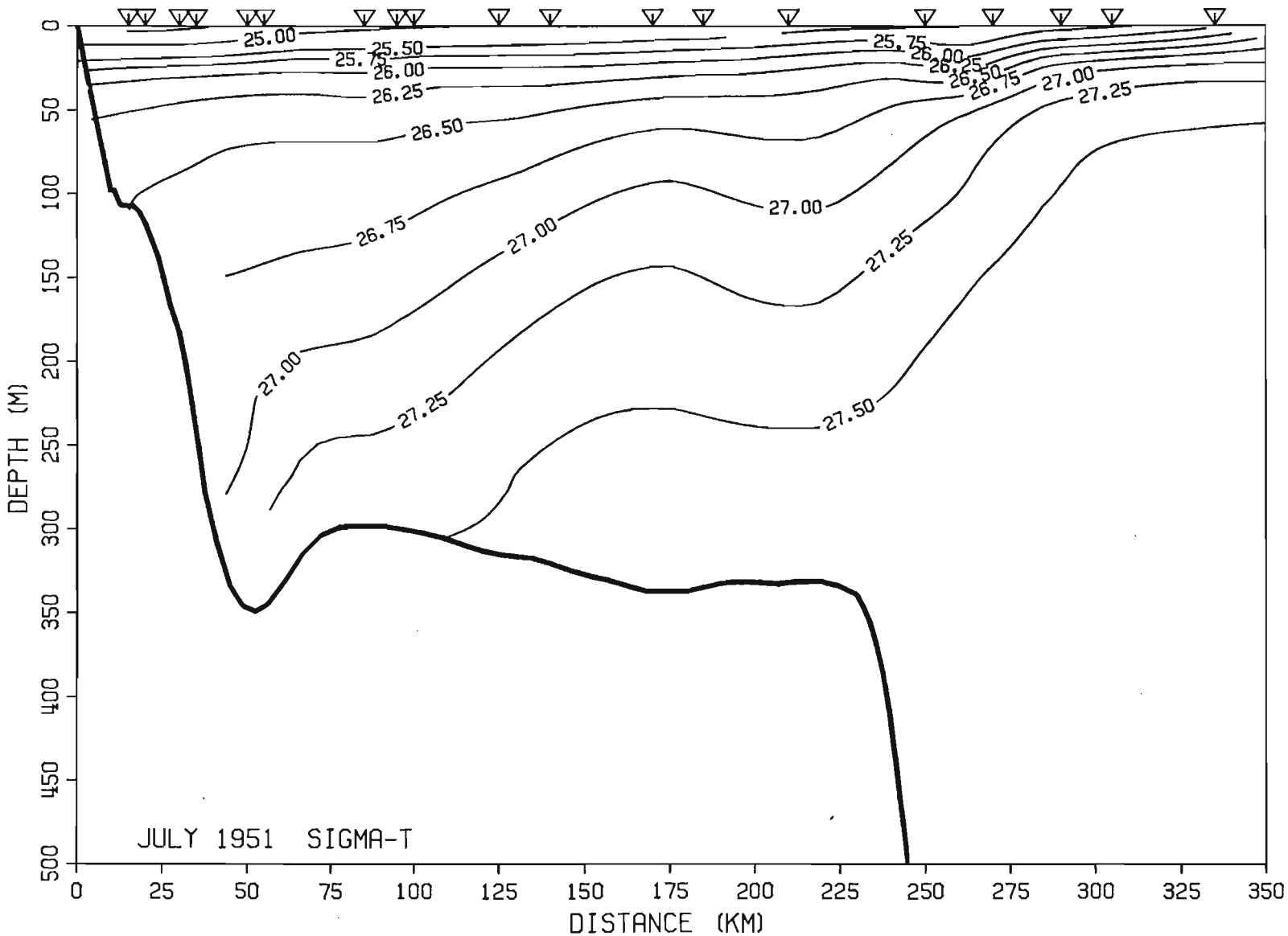
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DISTANCE (KM)
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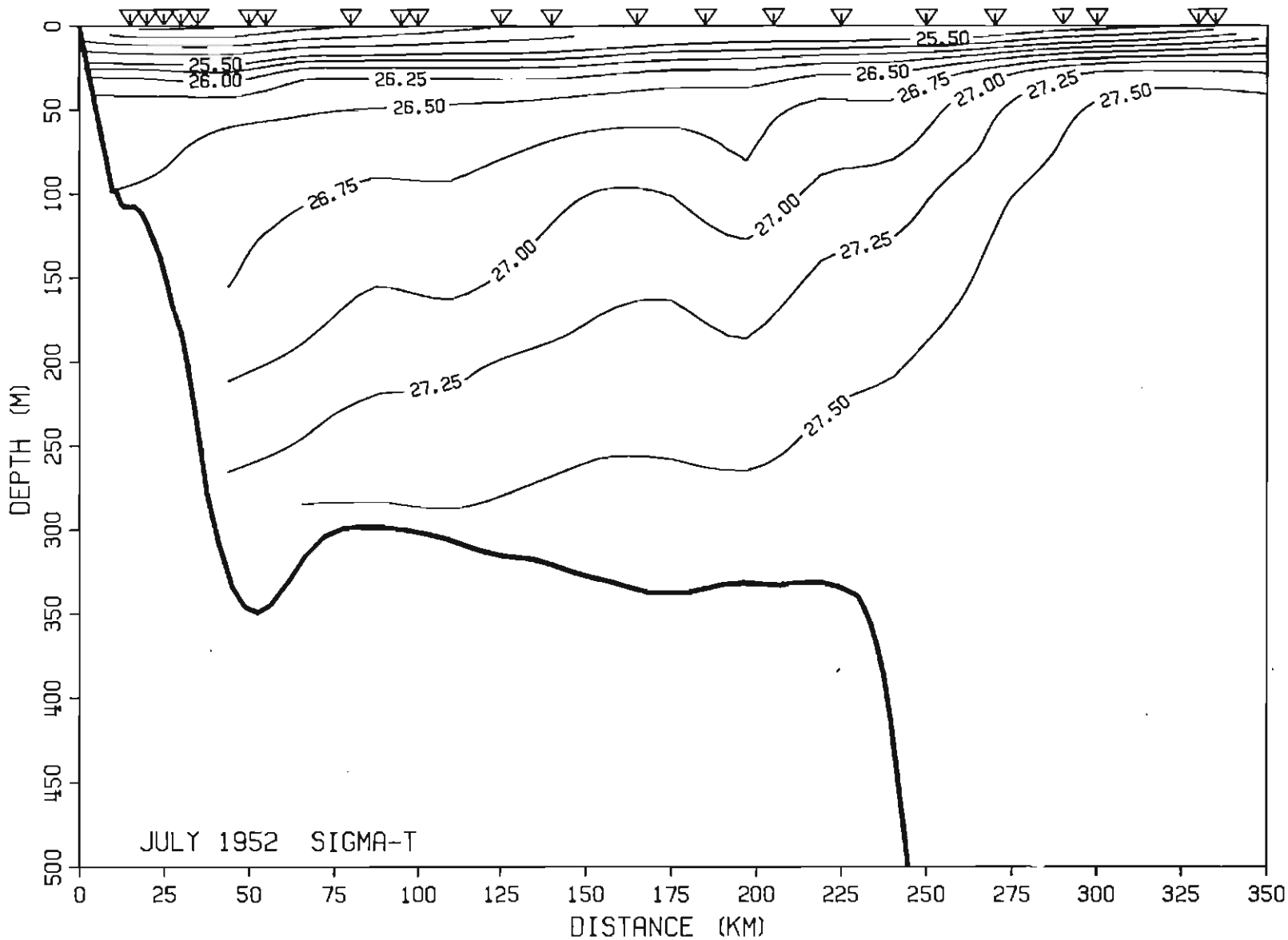
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DEPTH (M)
DISTANCE (KM)
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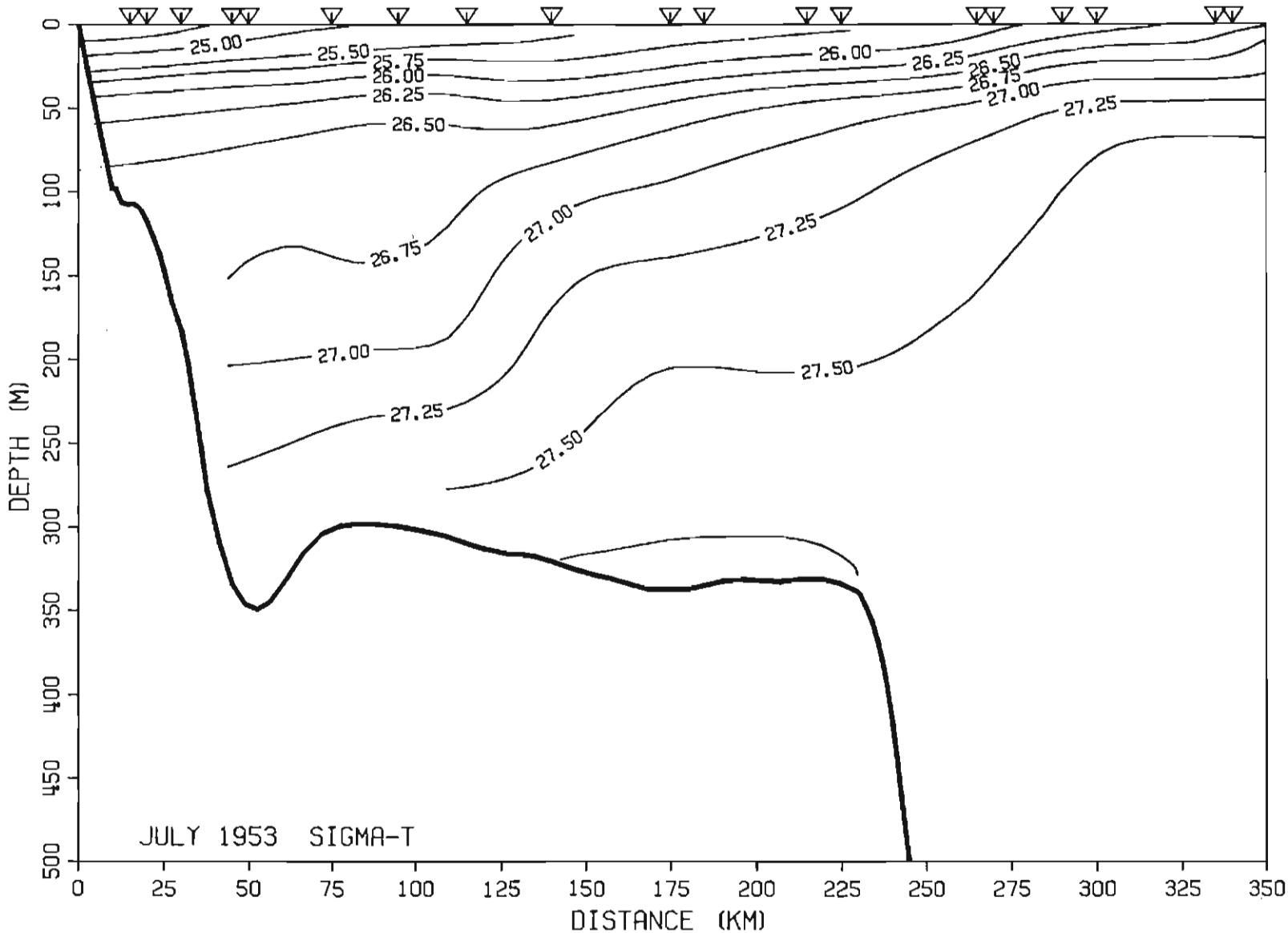
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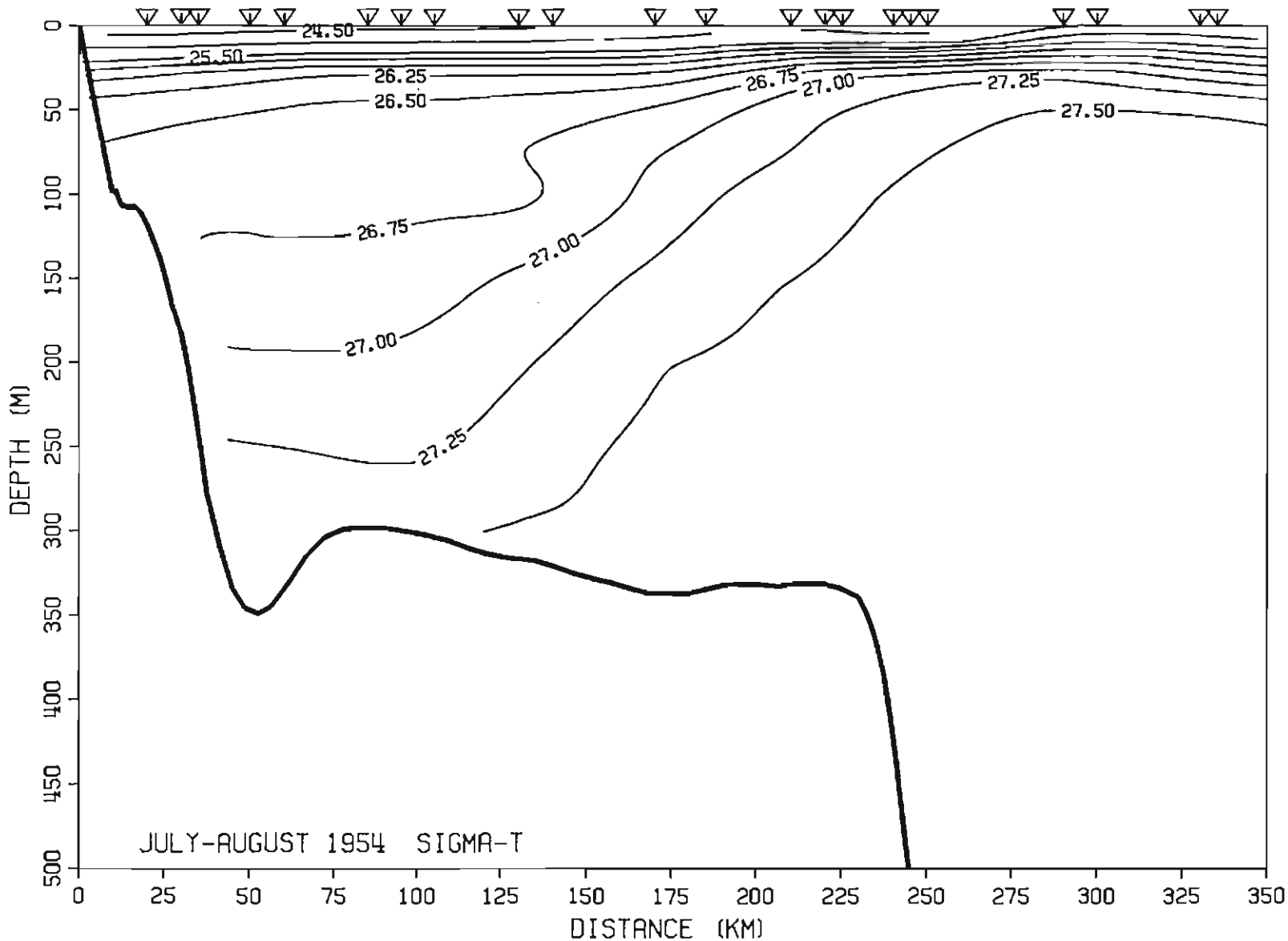
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JULY-AUGUST 1954 SIGMA-T
DEPTH (M)
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DISTANCE (KM)
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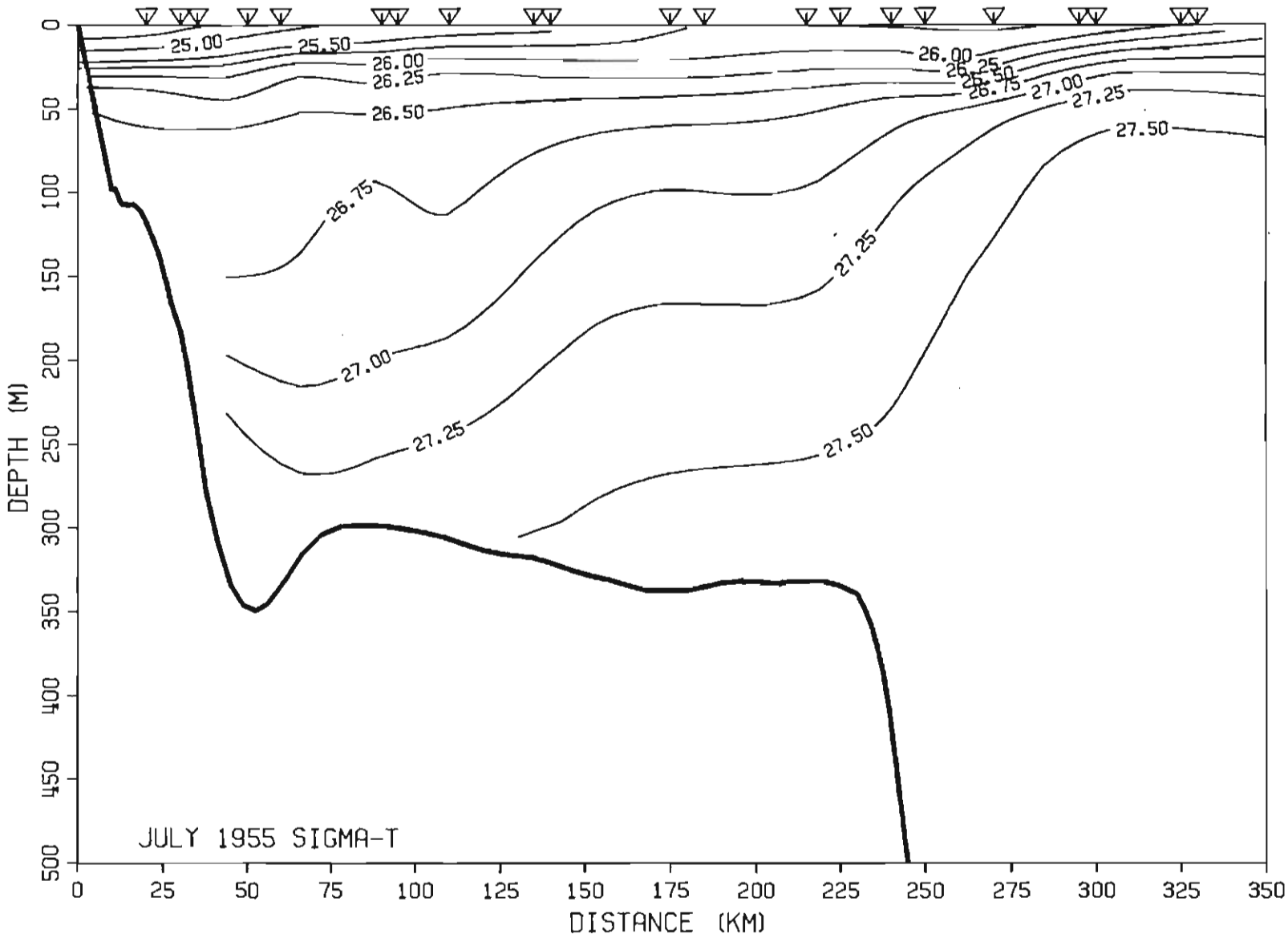
JULY 1955 SIGMA-T
DEPTH (M)
DISTANCE (KM)
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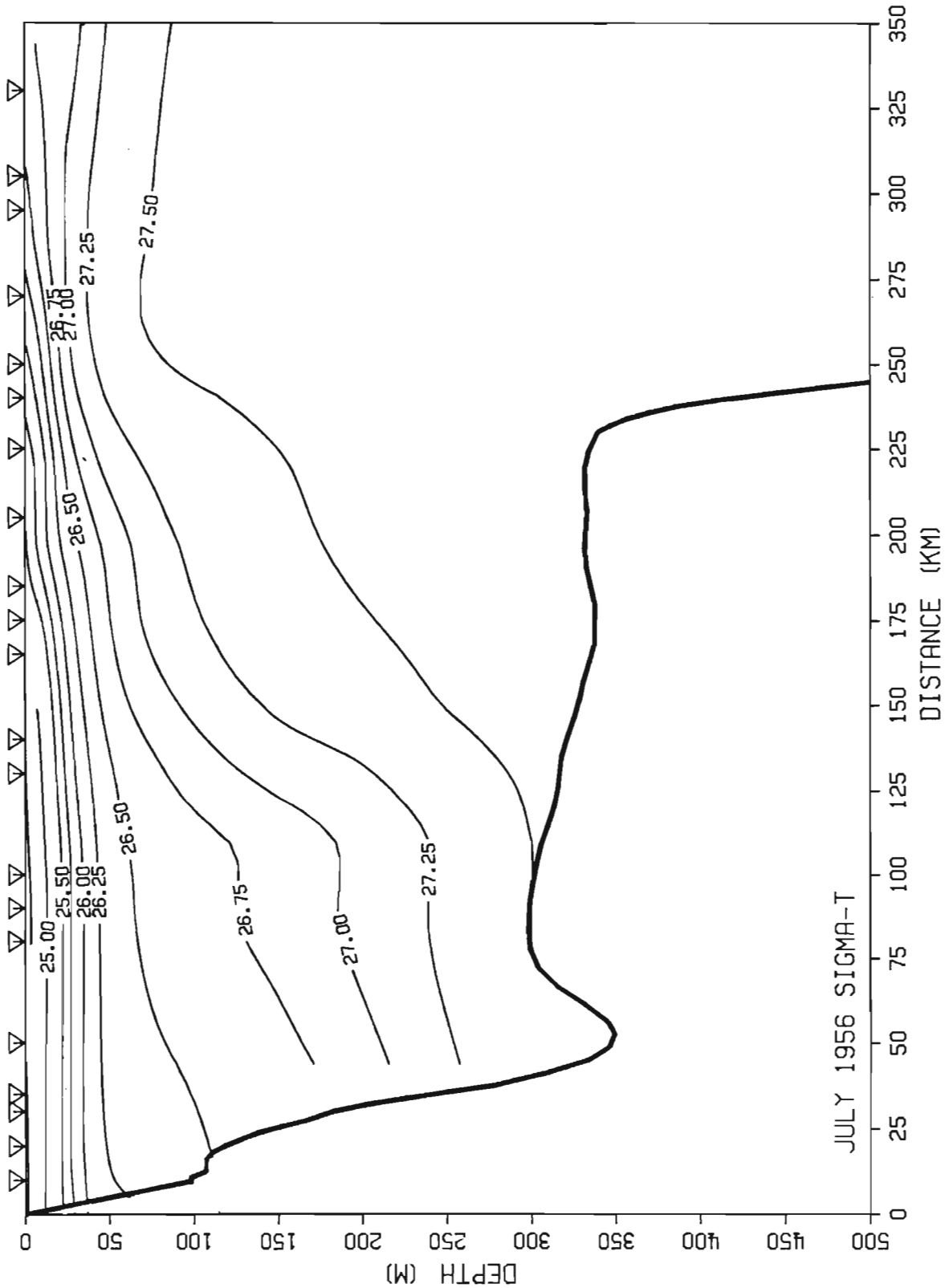
JULY 1956 SIGMA-T
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DEPTH (M)
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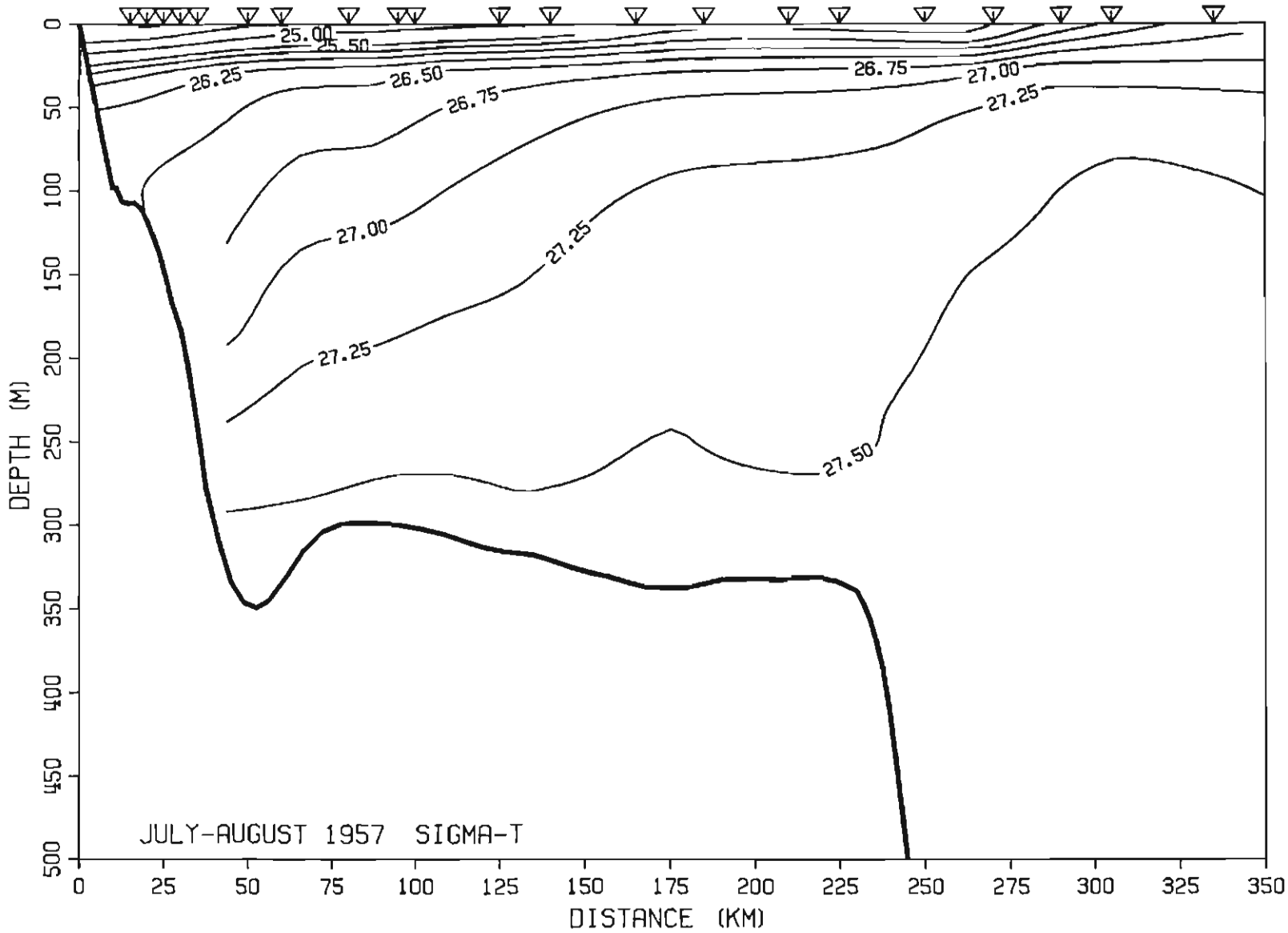
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JULY-AUGUST 1957 SIGMA-T
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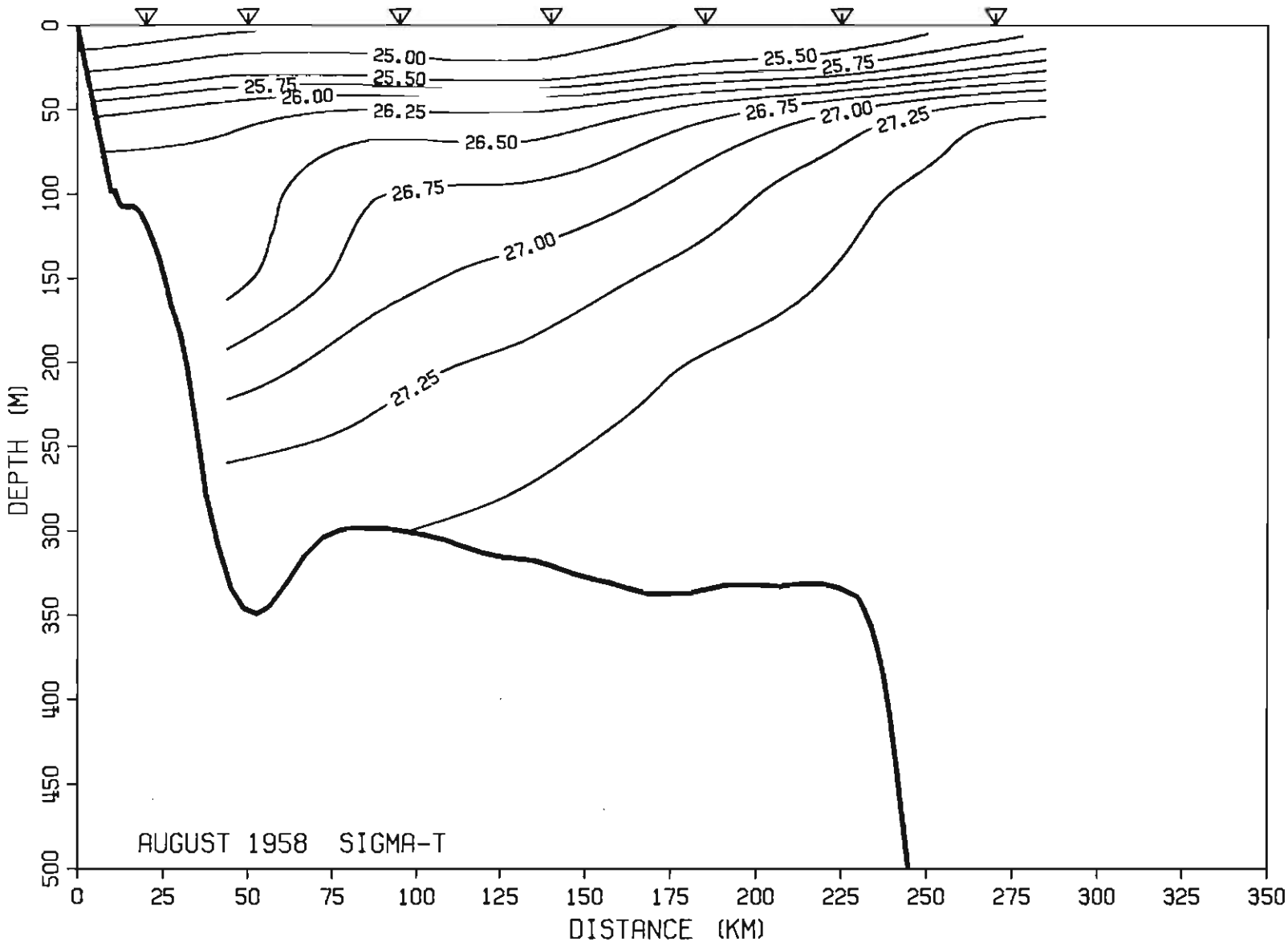
AUGUST 1958 SIGMA-T
DEPTH (M)
DISTANCE (KM)
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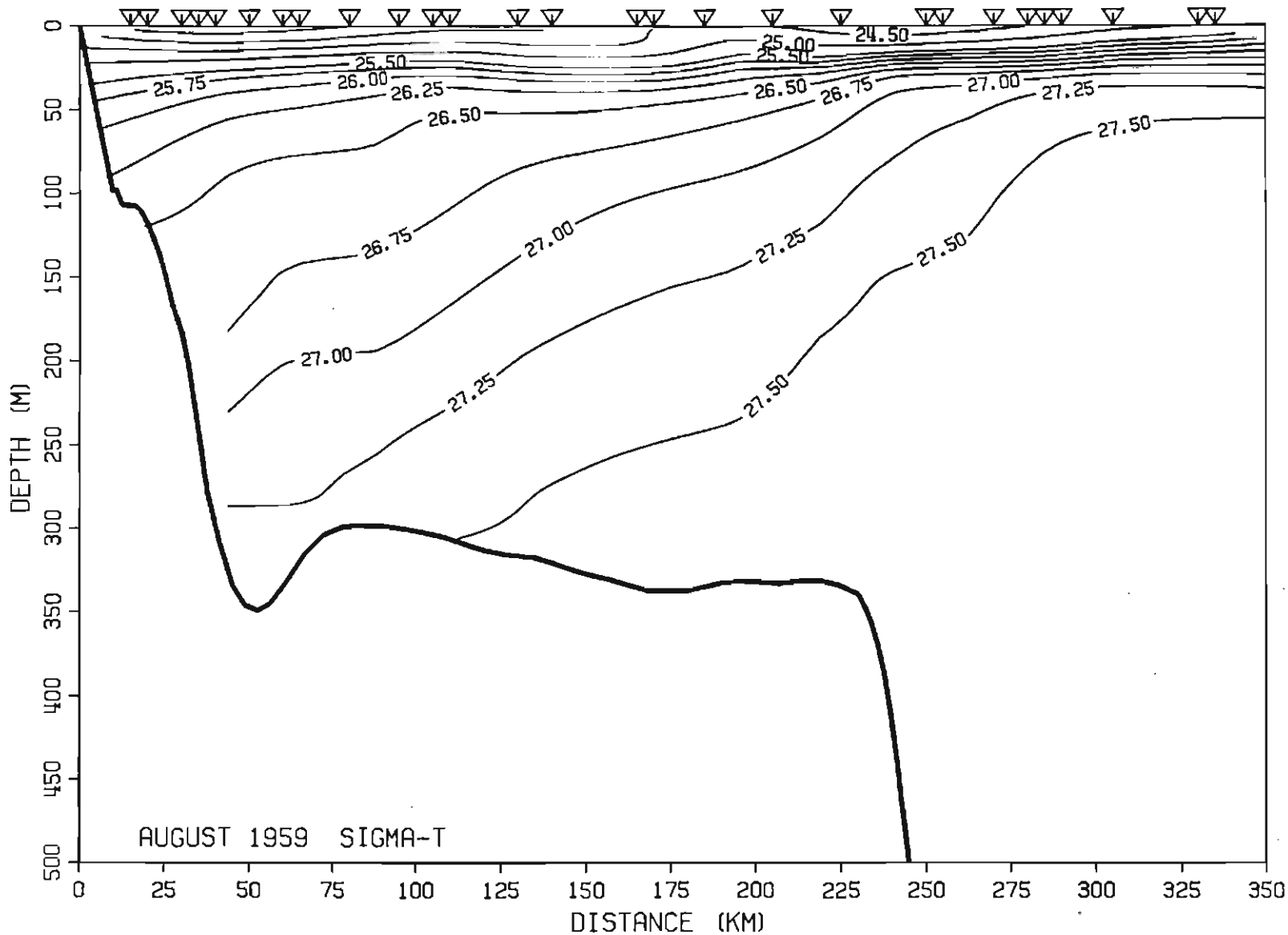
AUGUST 1959 SIGMA-T
DEPTH (M)
DISTANCE (KM)
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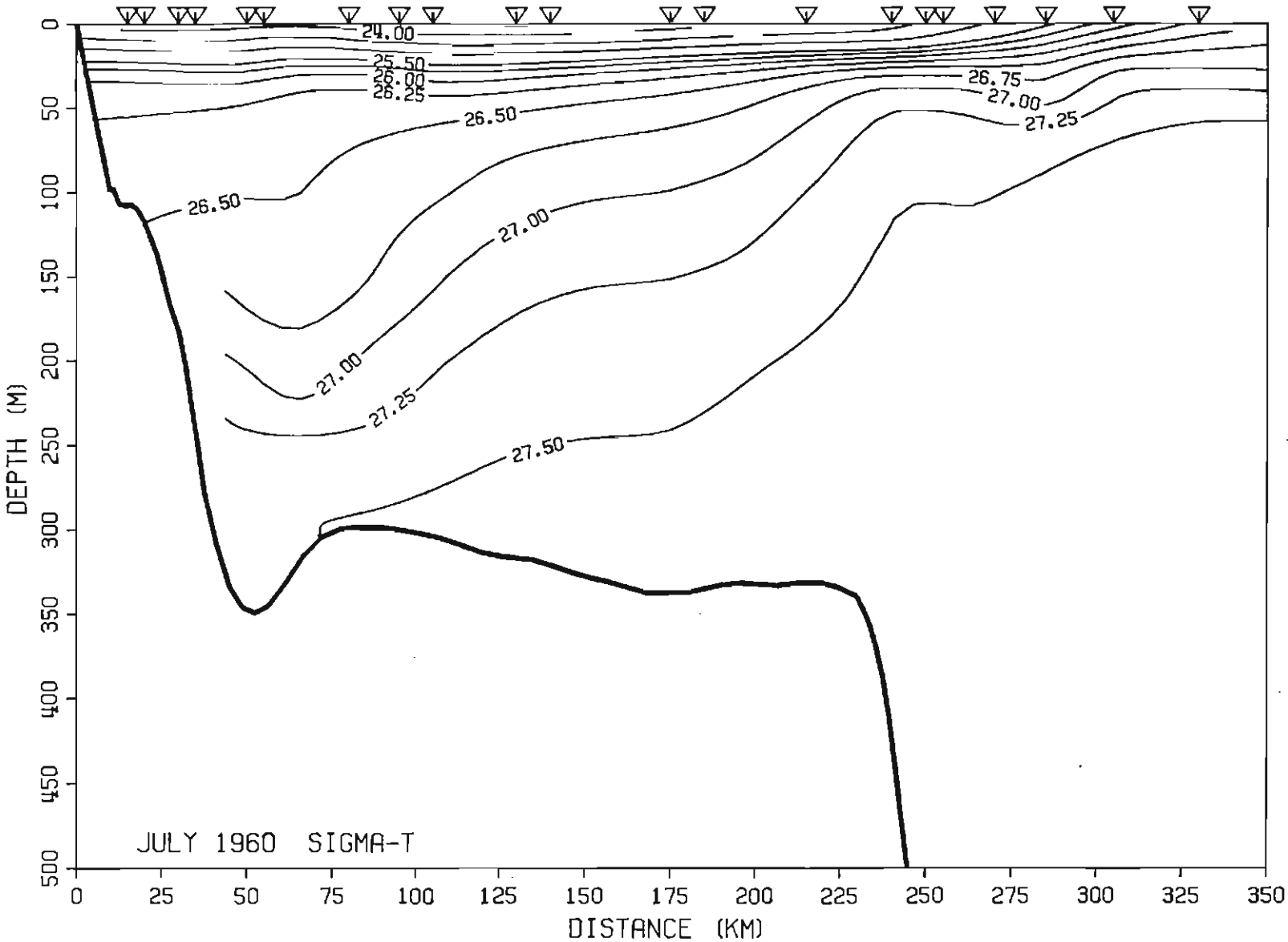
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DEPTH (M)
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DISTANCE (KM)
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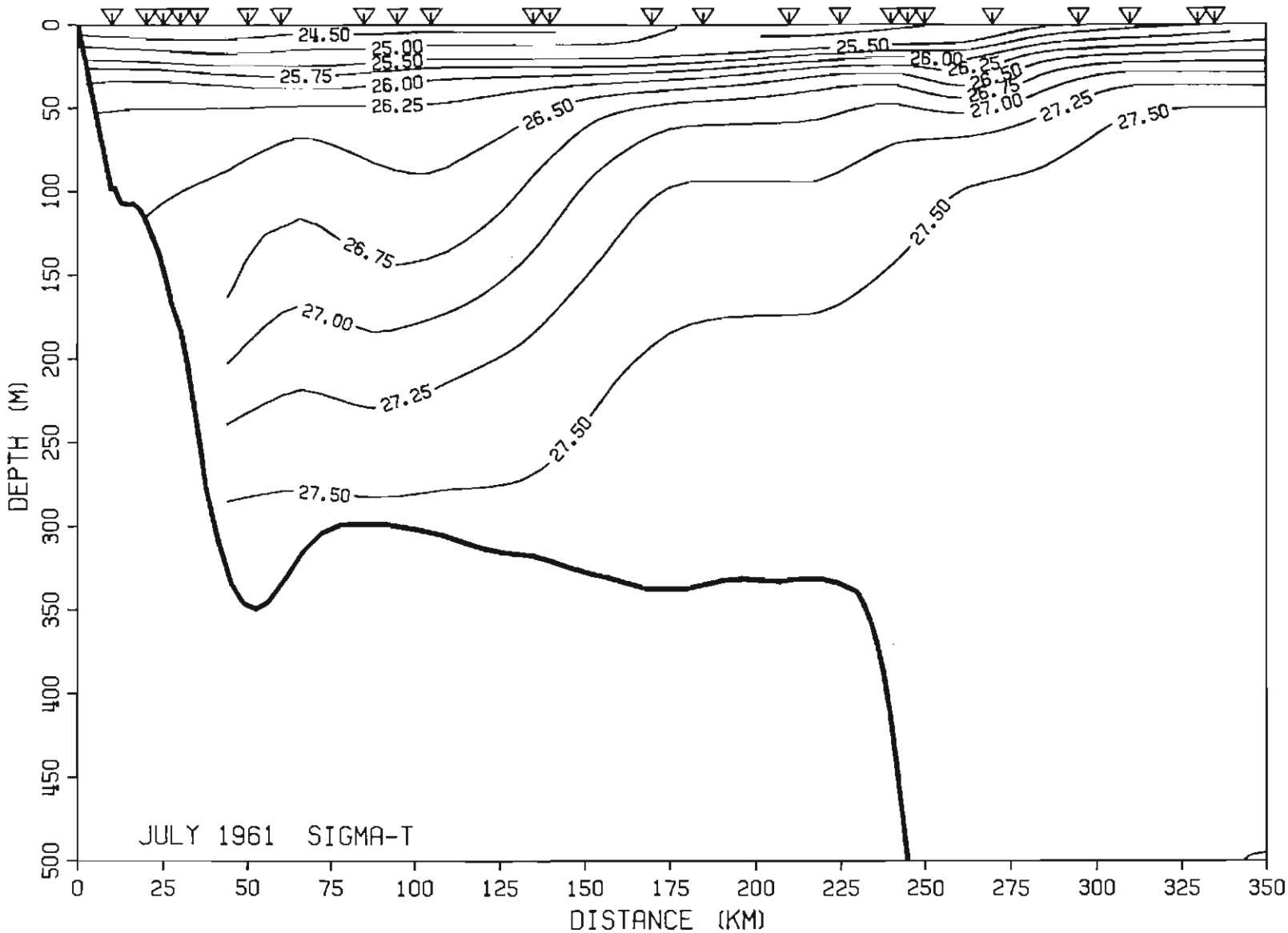
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DEPTH (M)
DISTANCE (KM)
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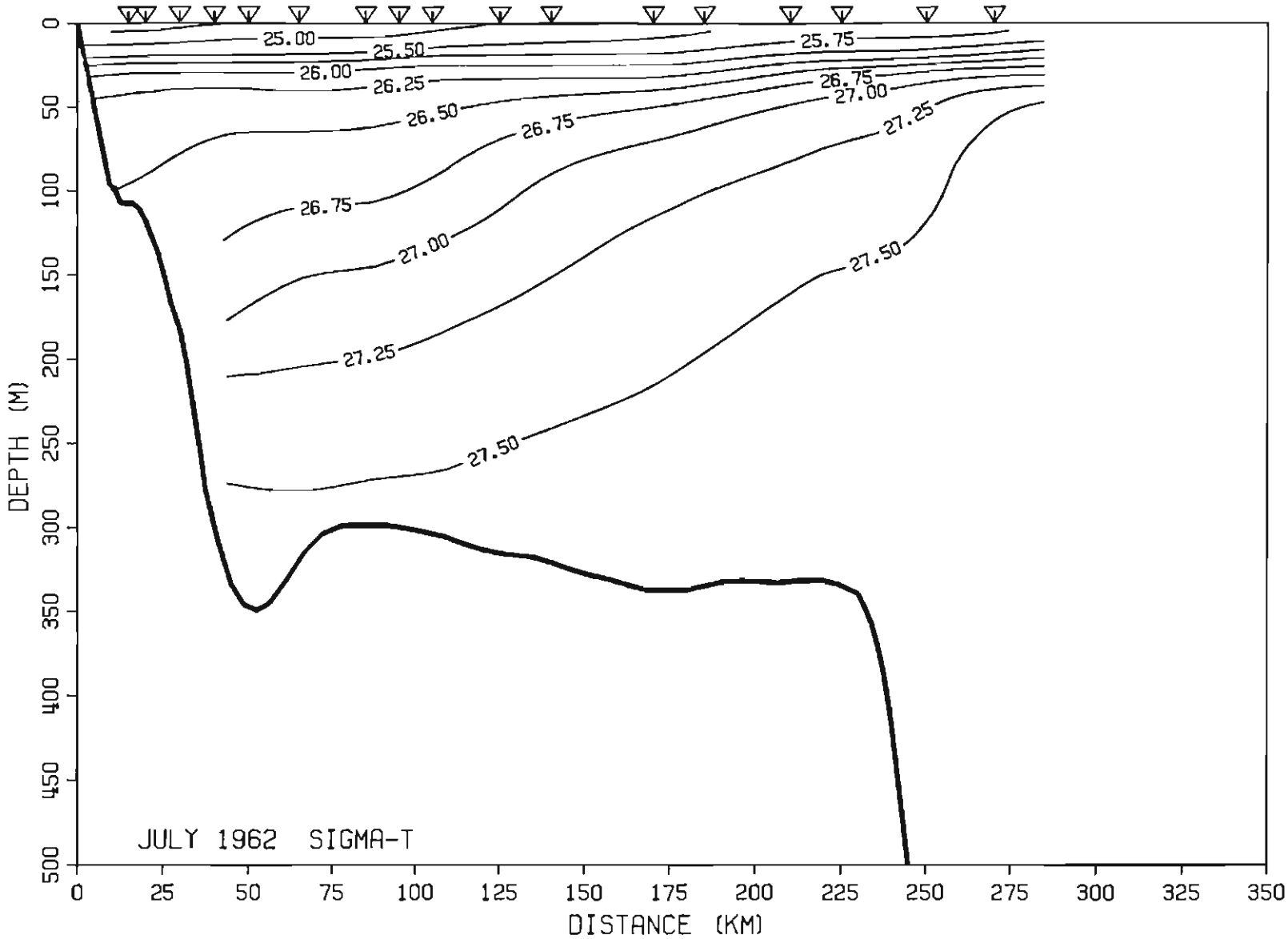
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DEPTH (M)
DISTANCE (KM)
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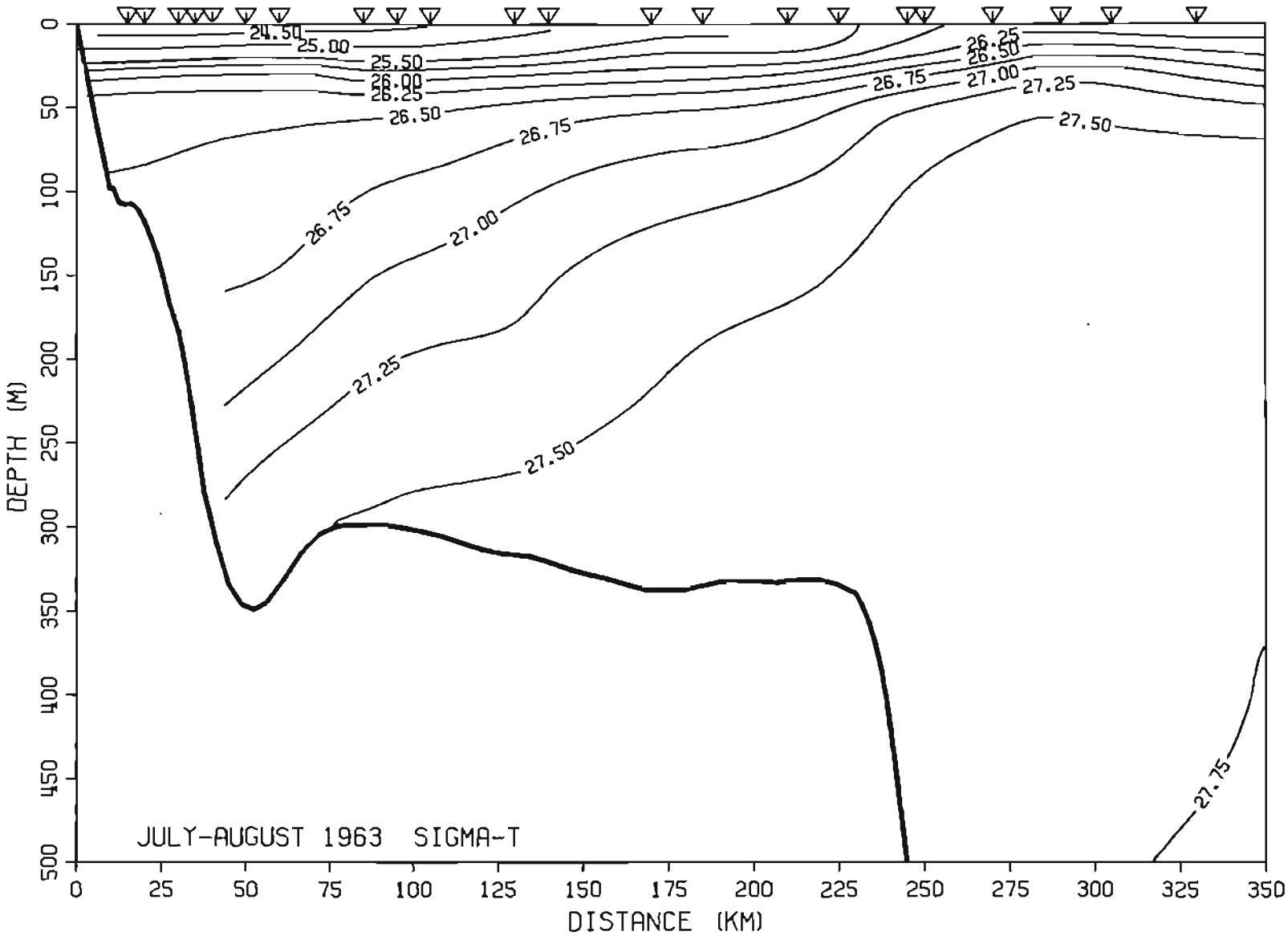
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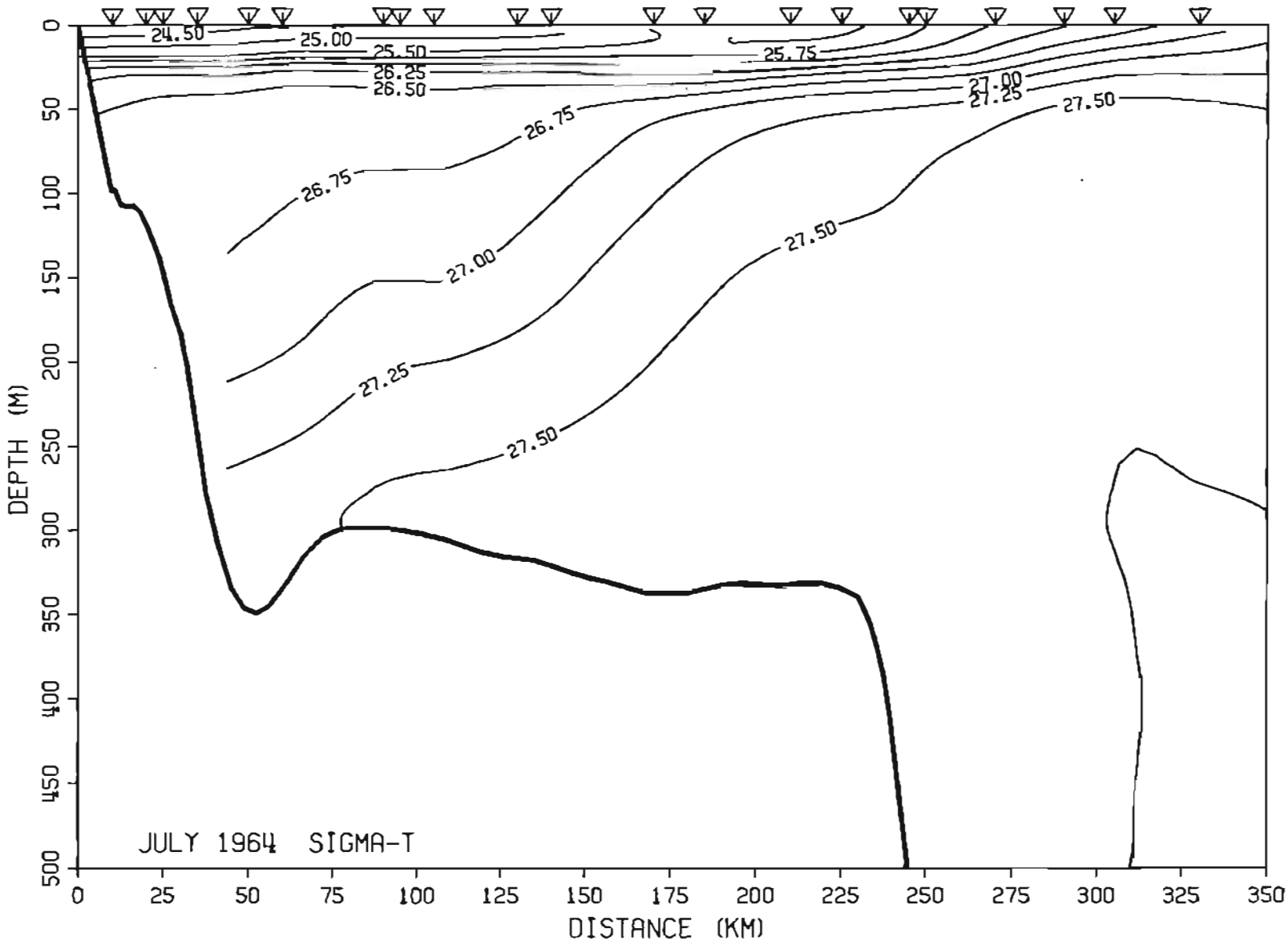
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DEPTH (M)
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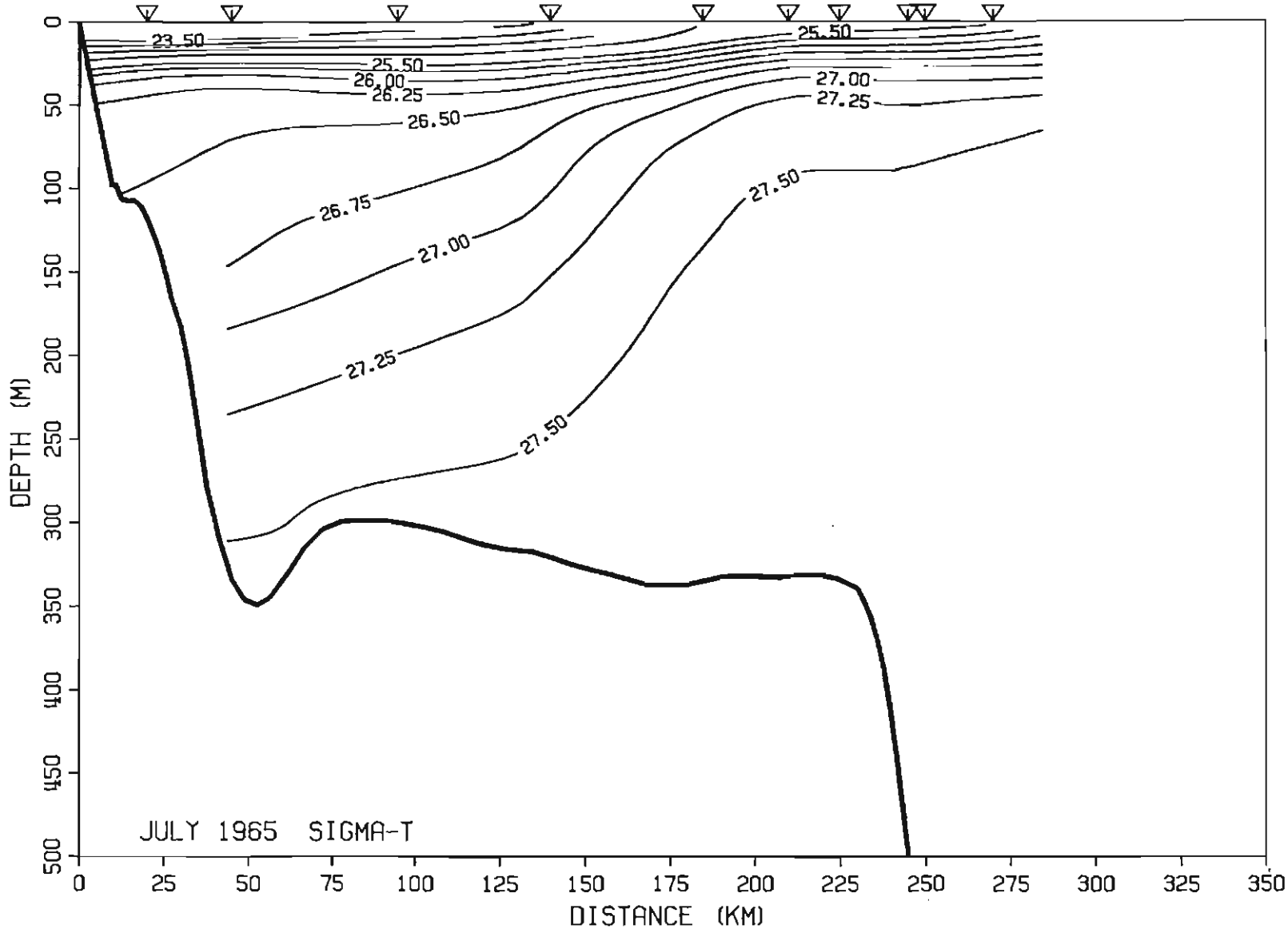
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DEPTH (M)
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DISTANCE (KM)
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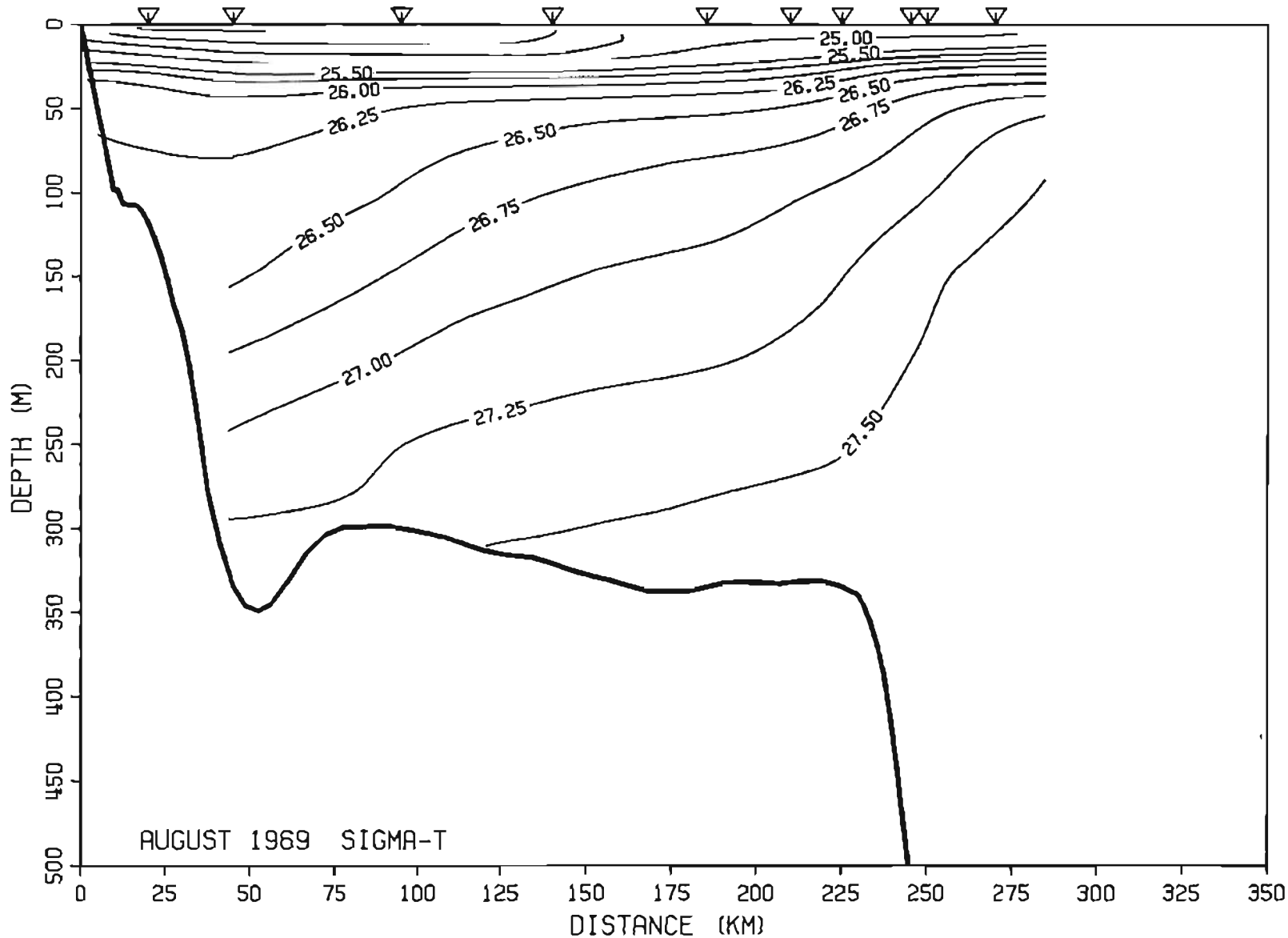
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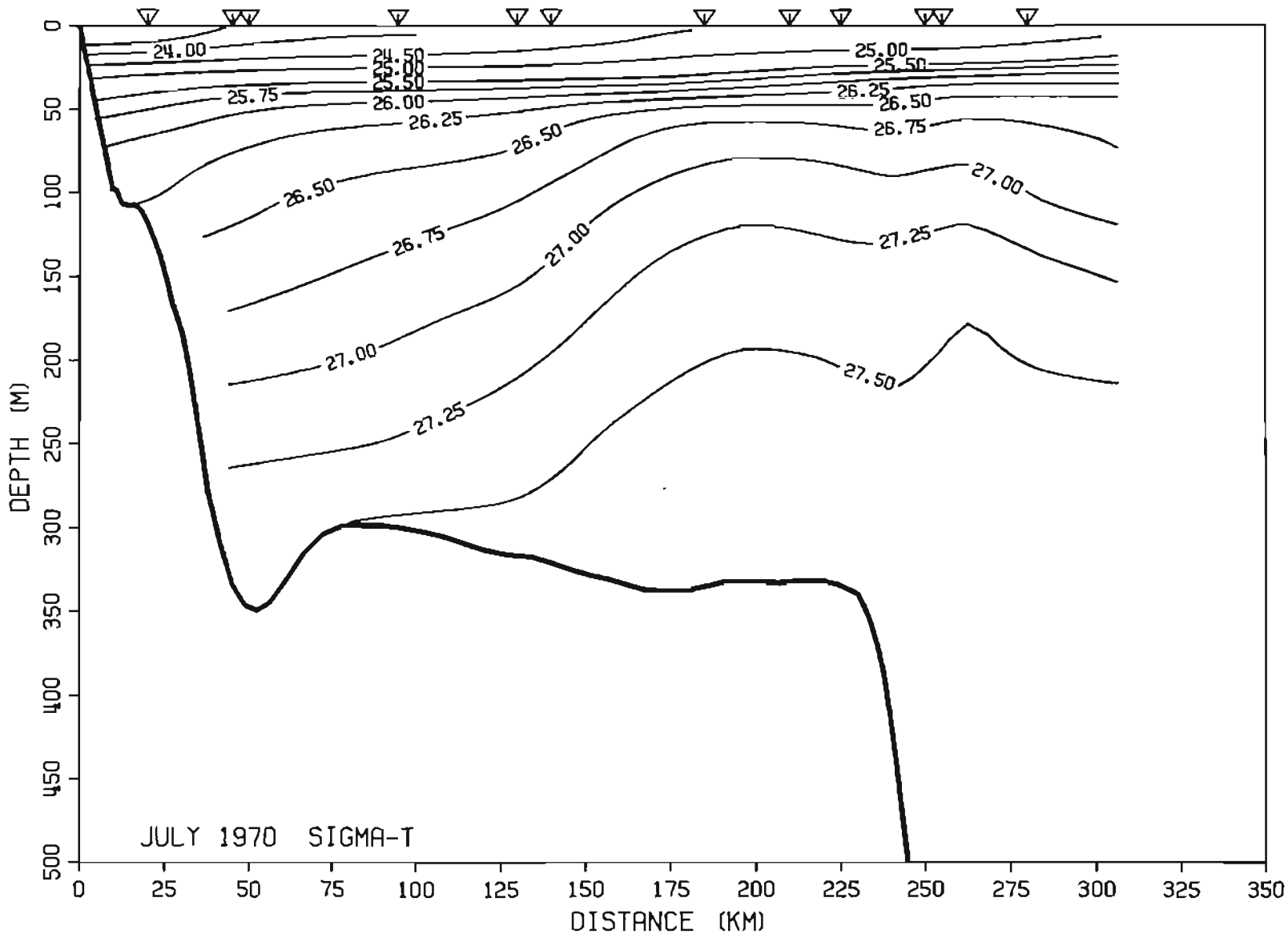
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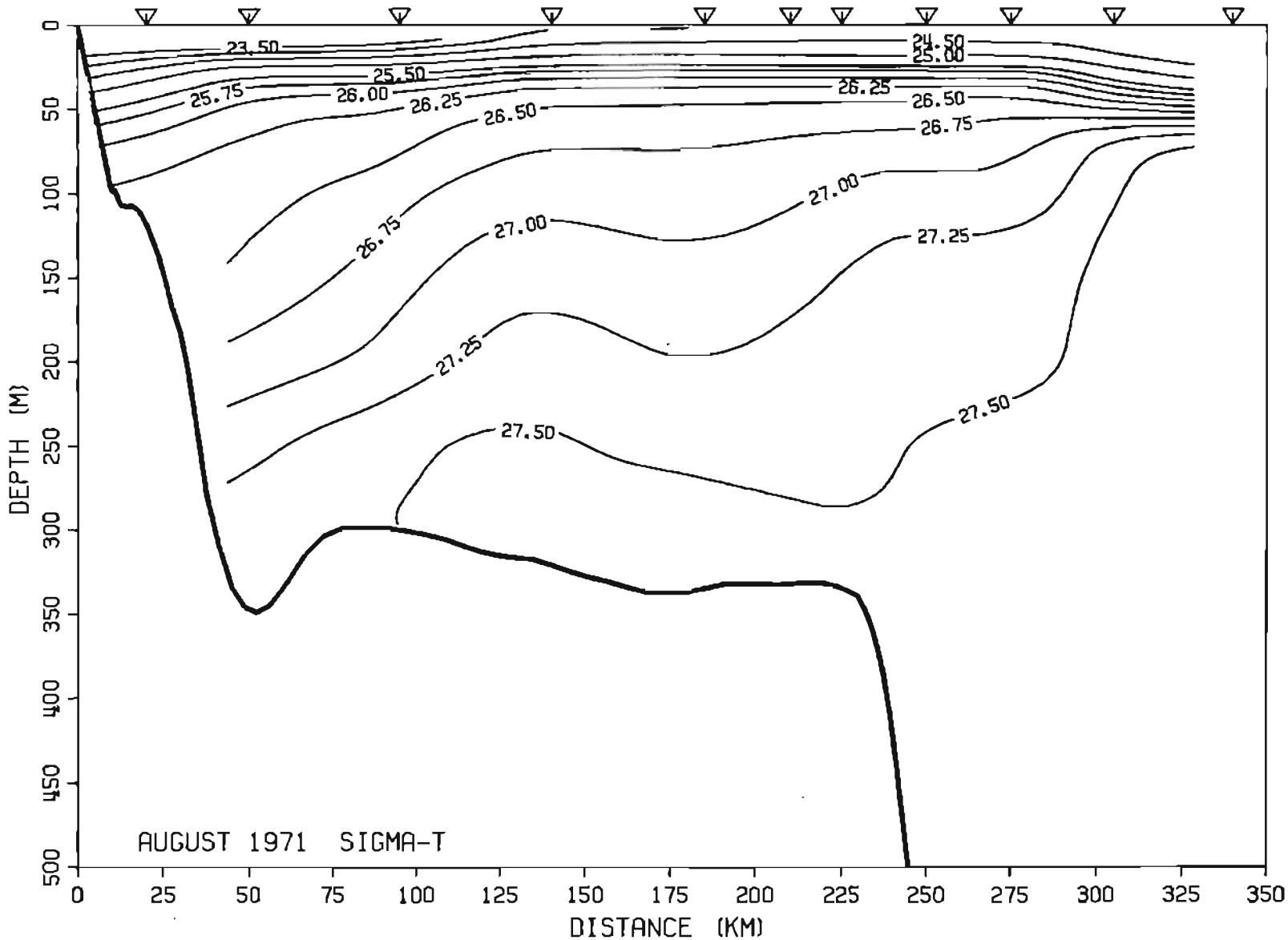
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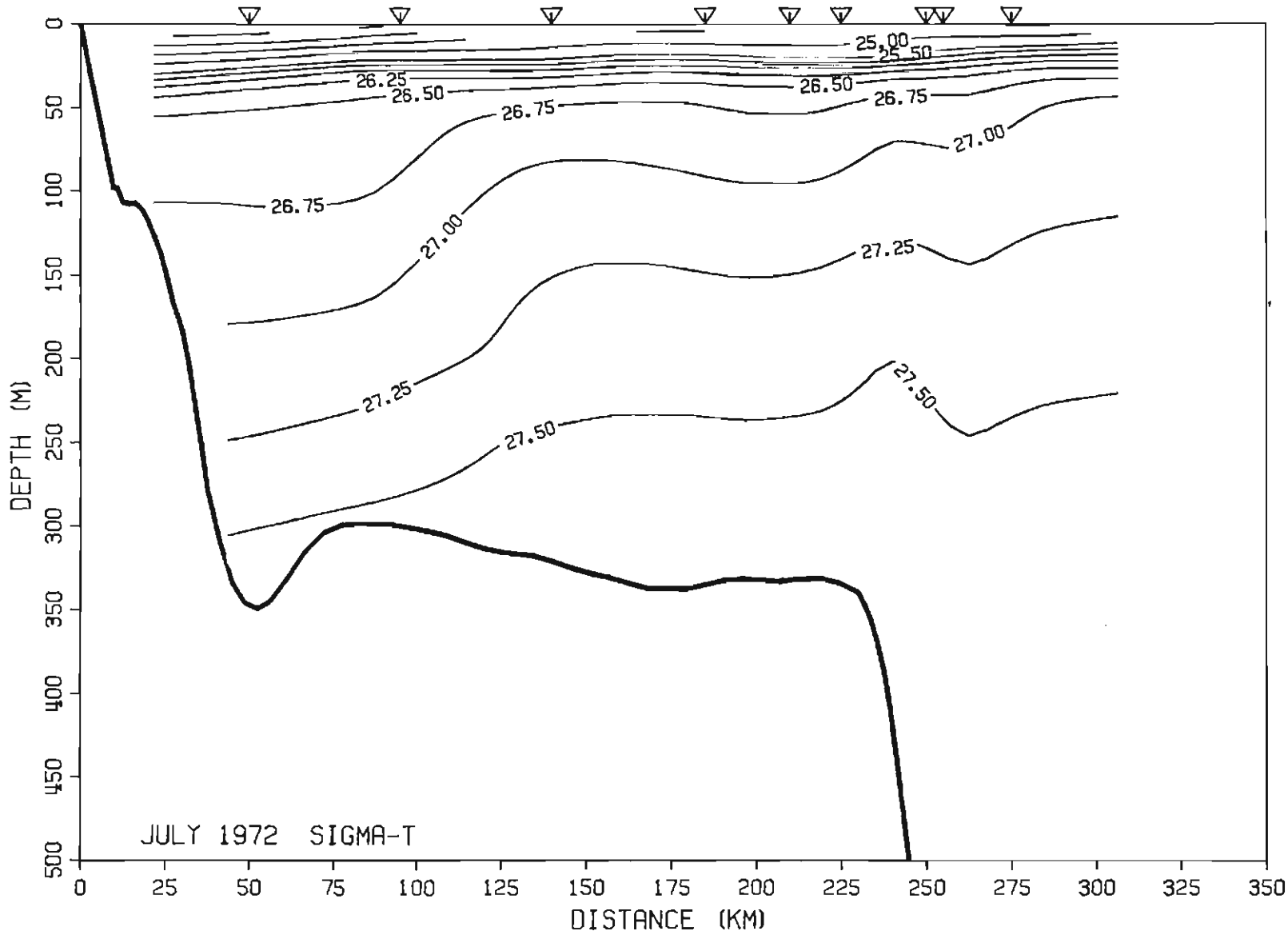
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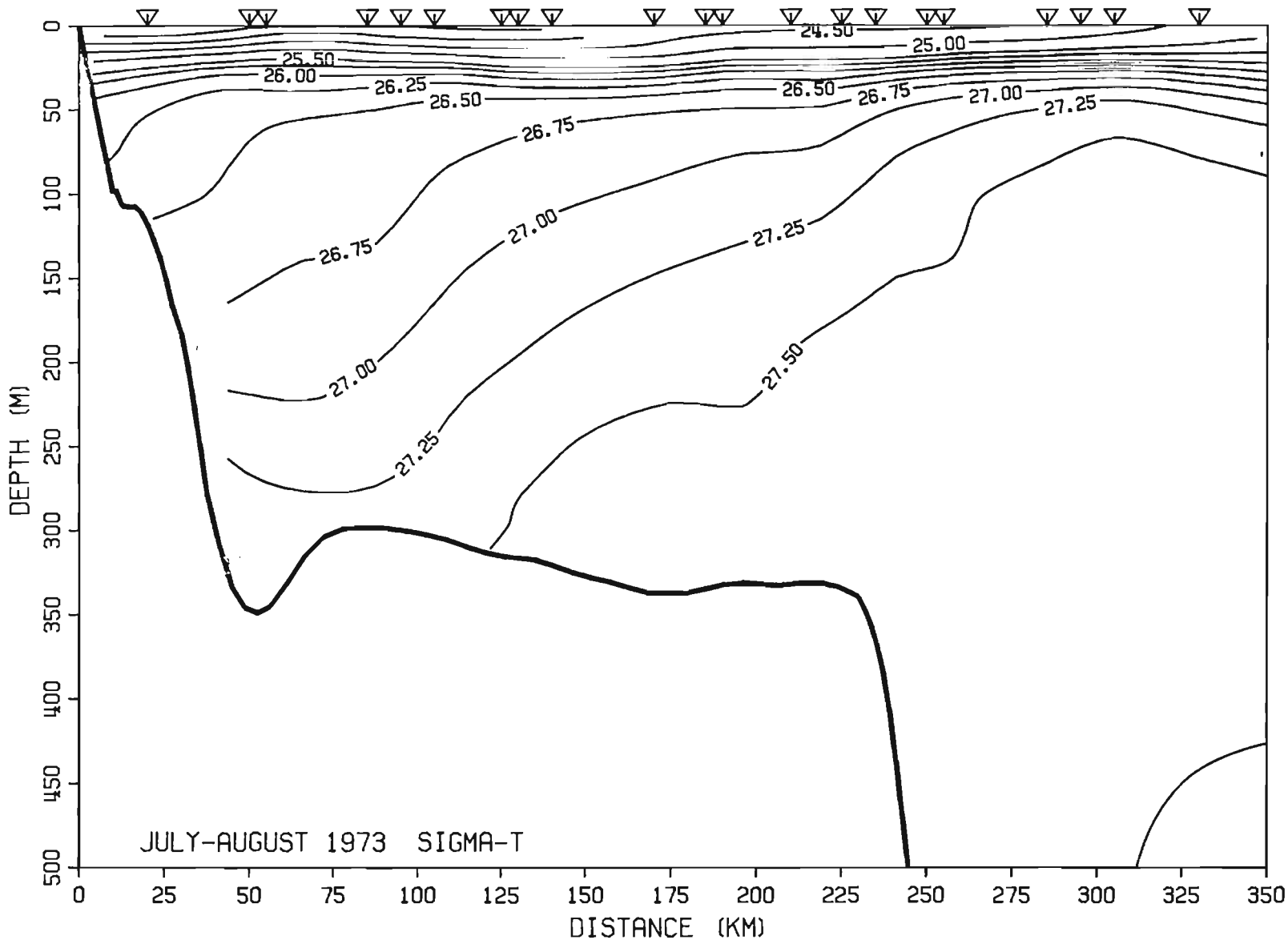
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DEPTH (M)
DISTANCE (KM)
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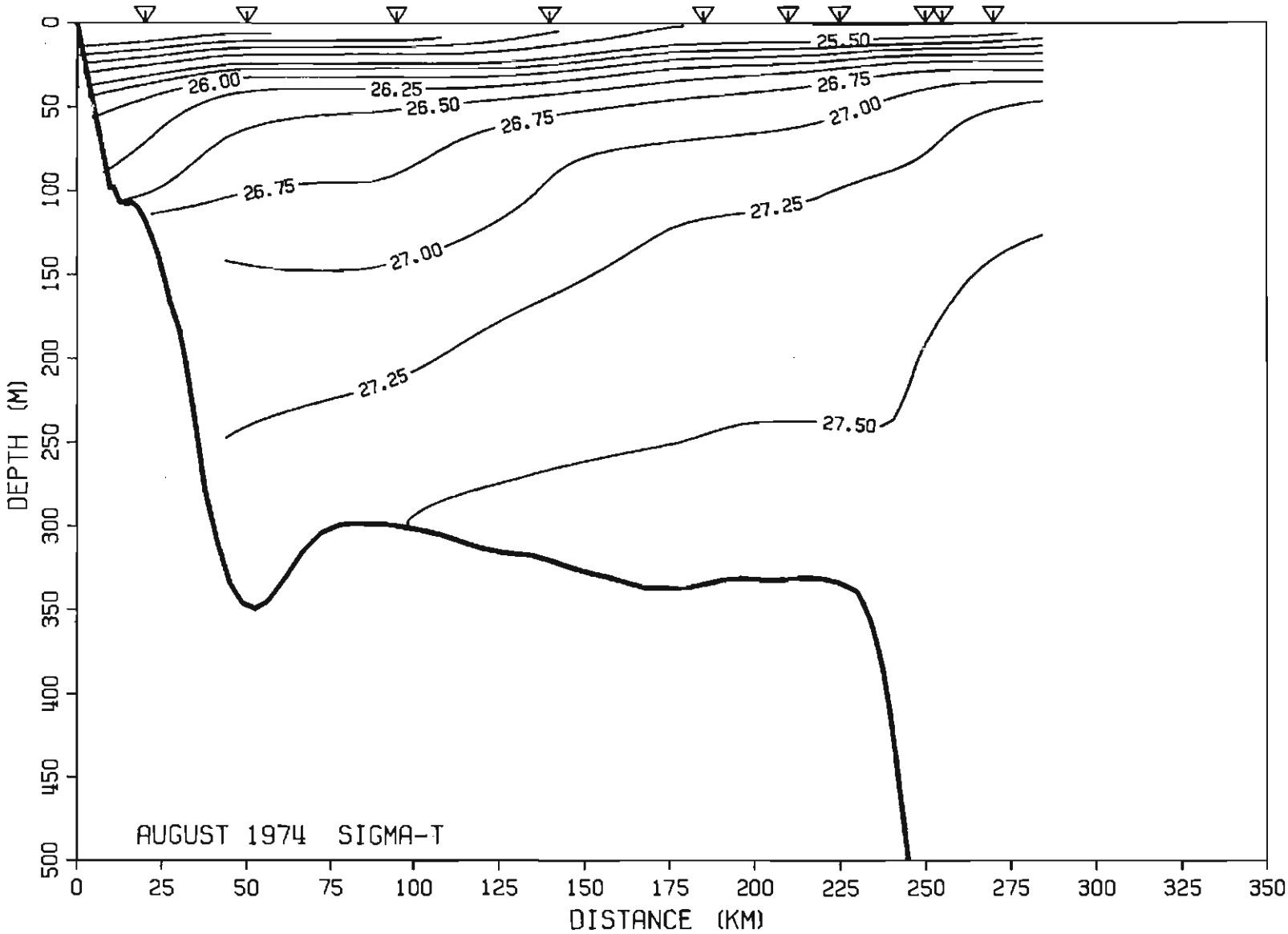
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DEPTH (M)
DISTANCE (KM)
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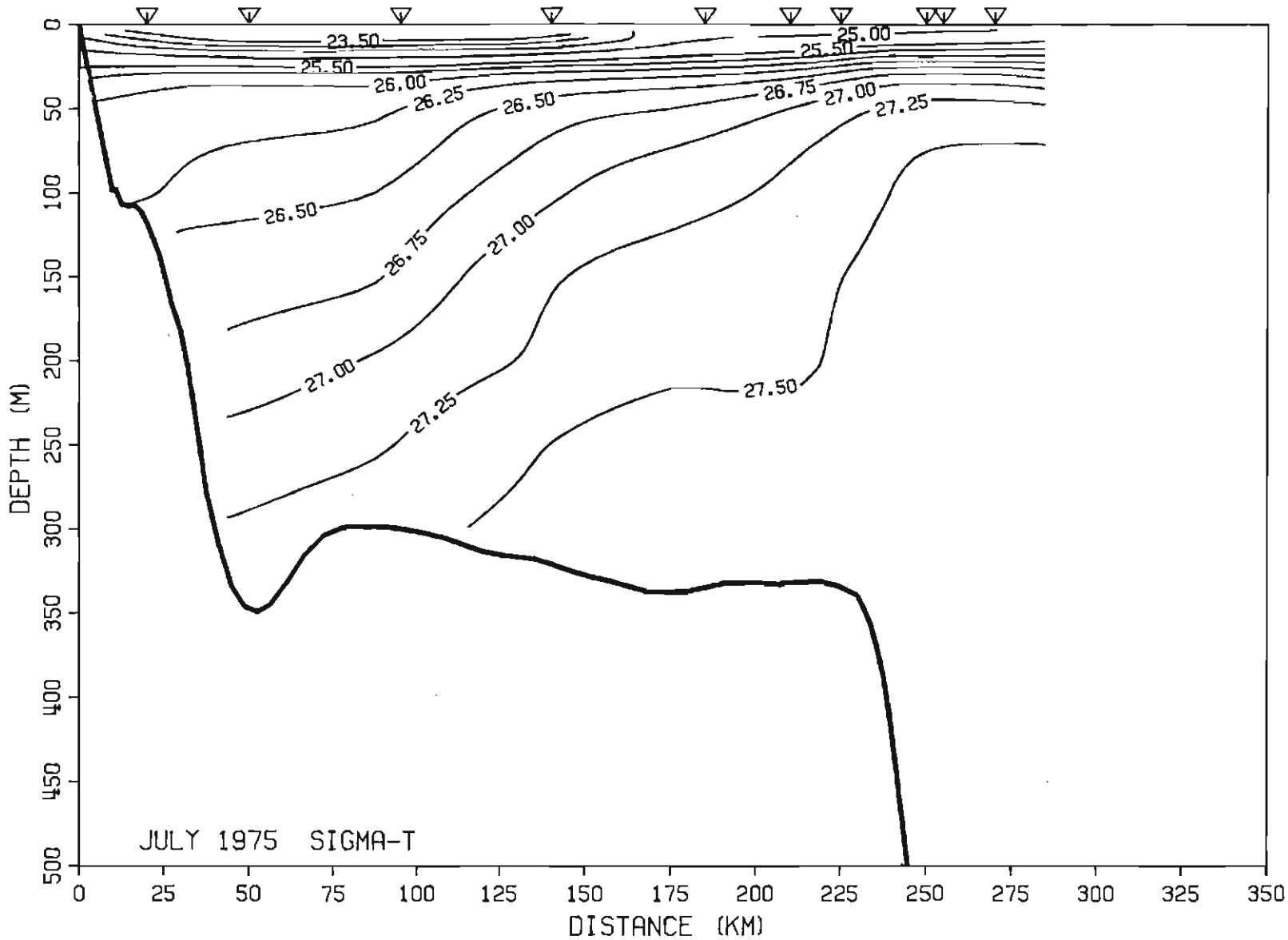
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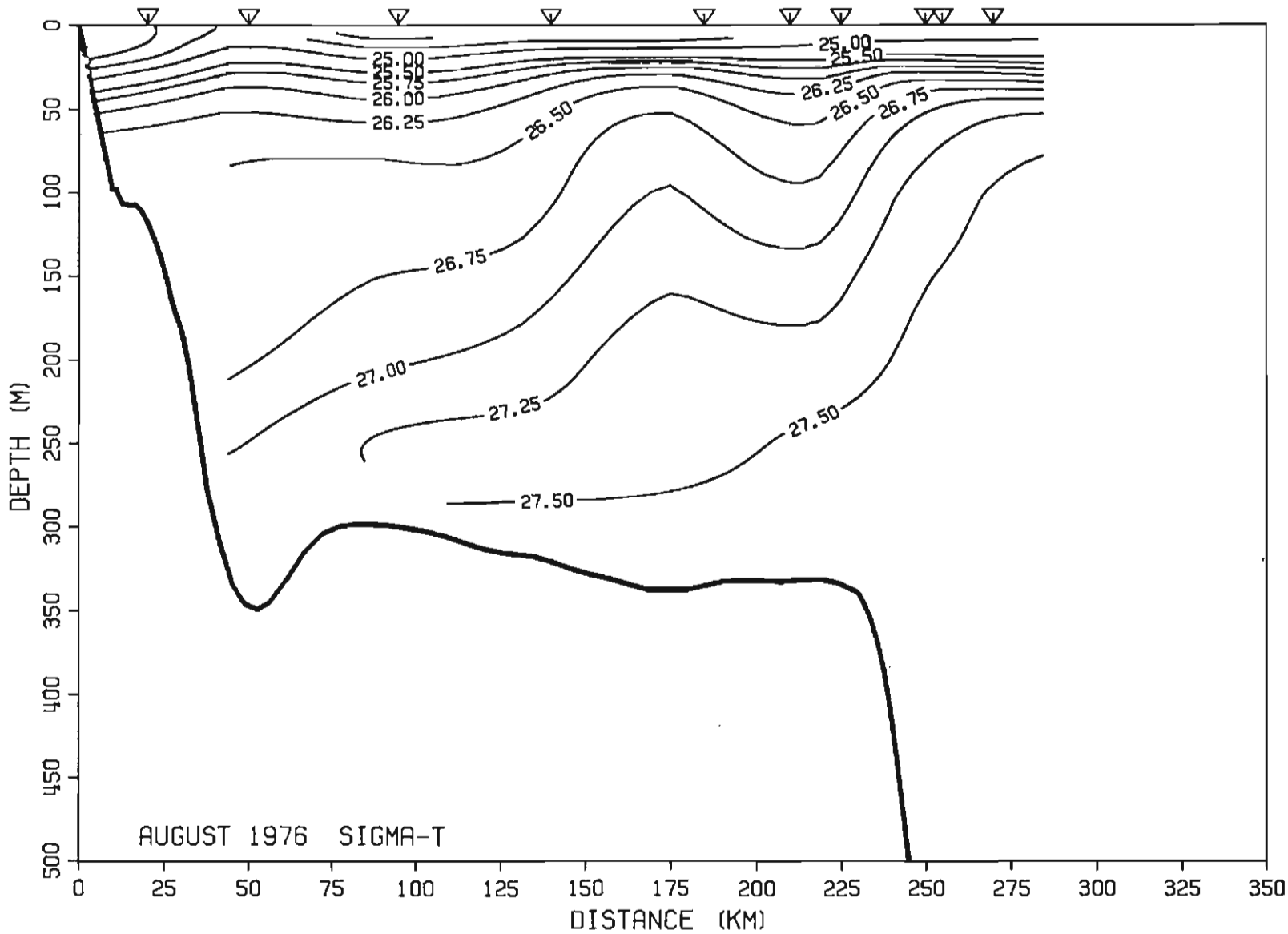
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DISTANCE (KM)
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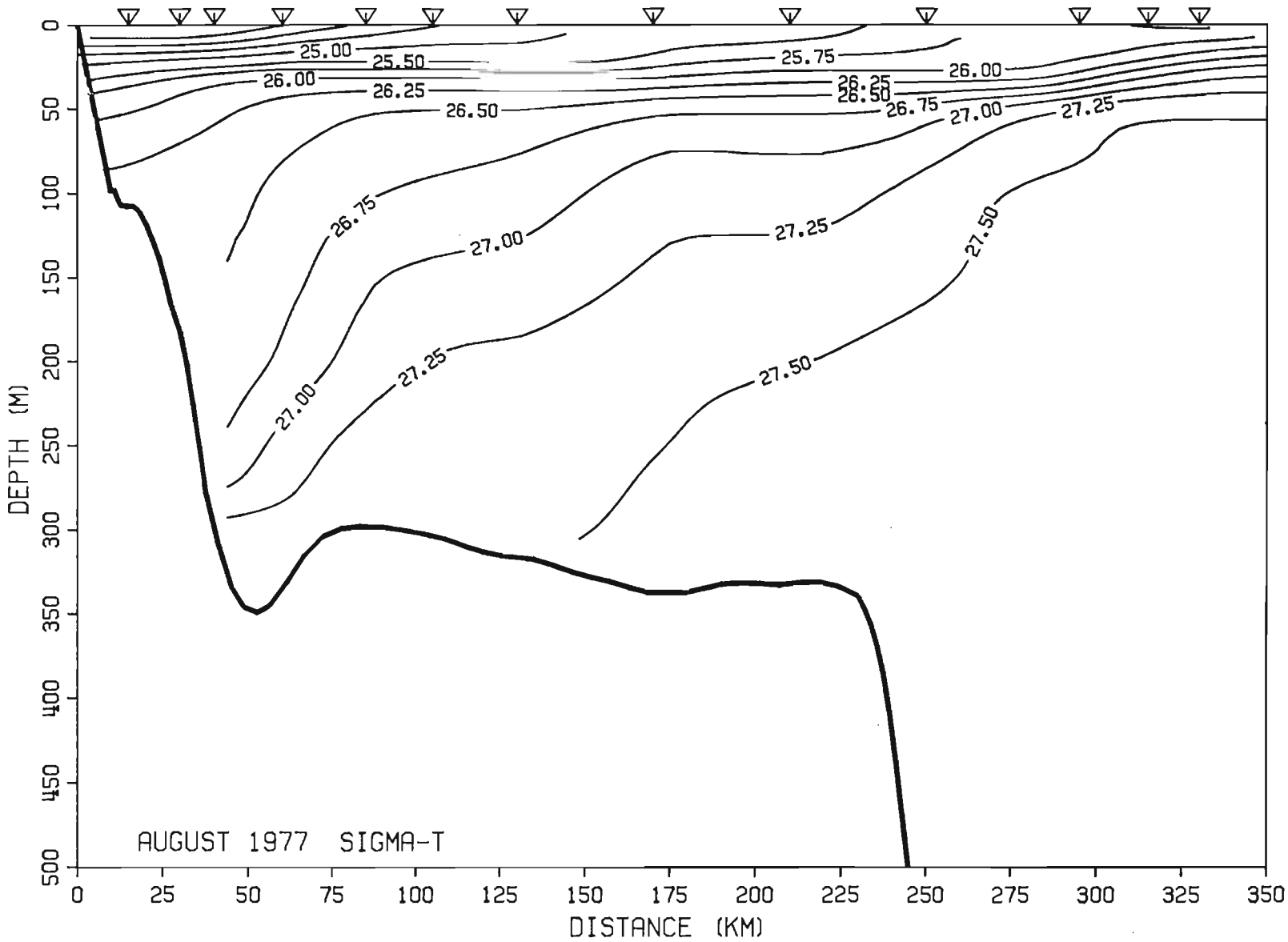
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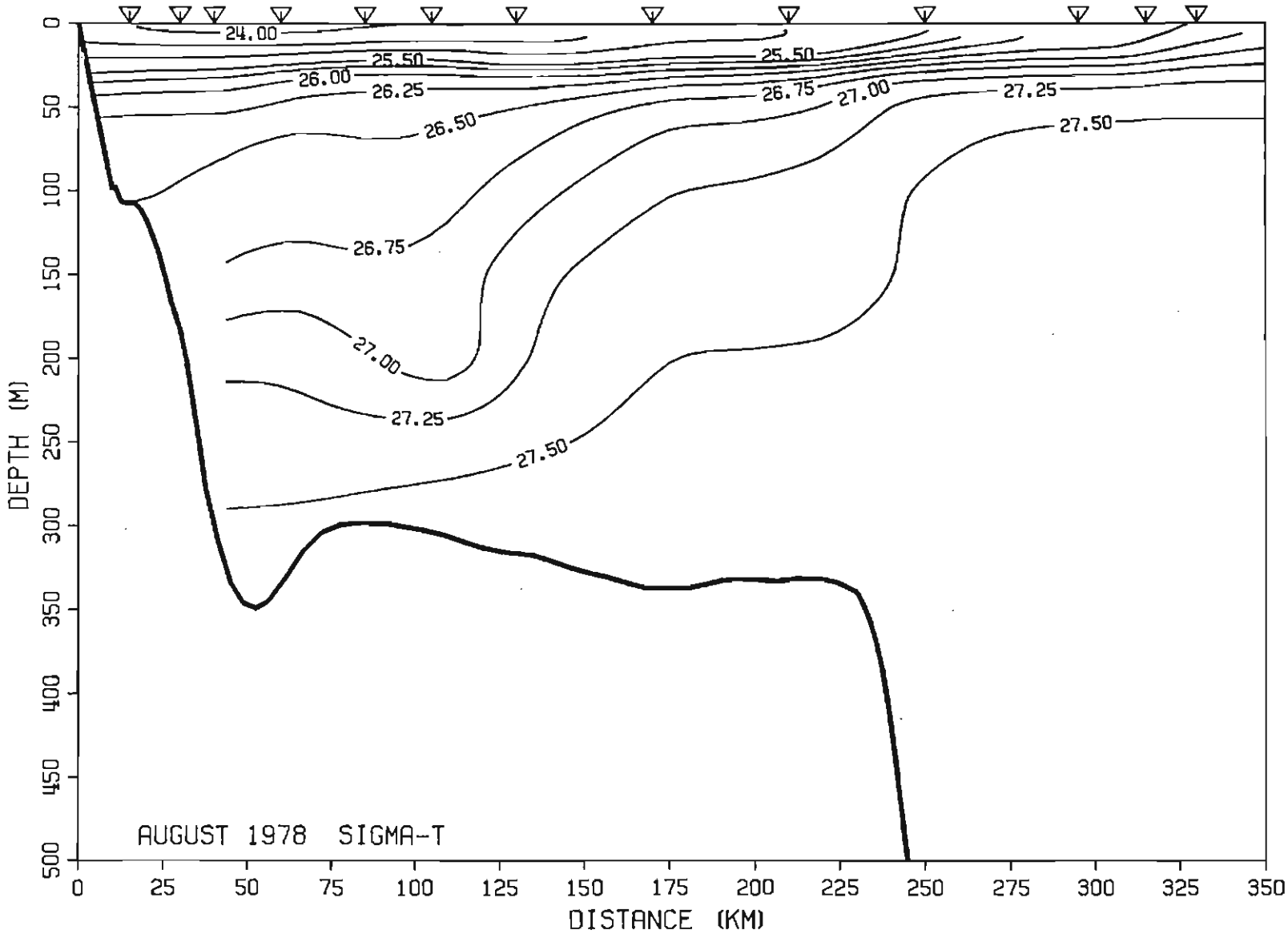
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AUGUST 1978 SIGMA-T
DEPTH (M)
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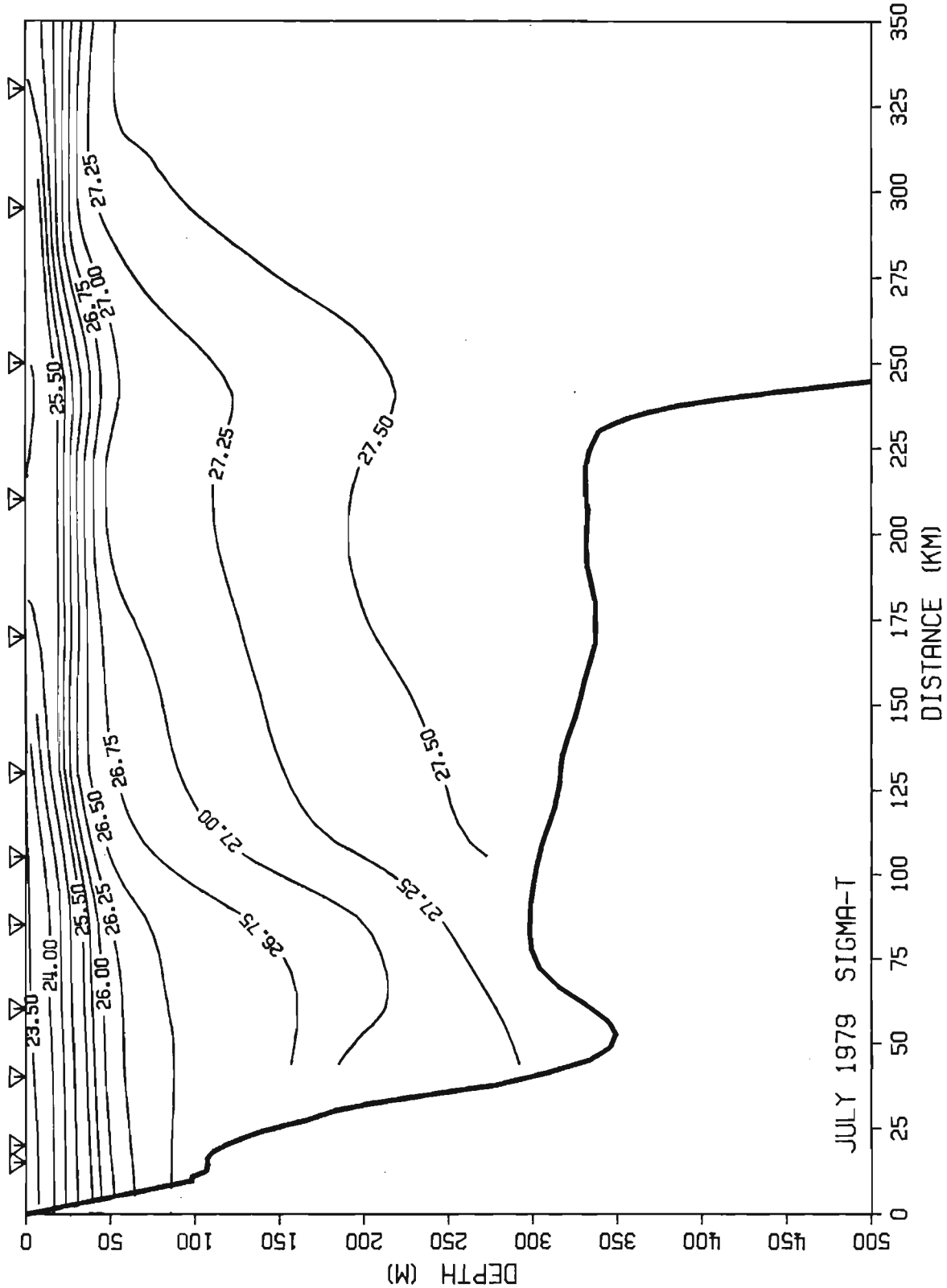
JULY 1979 SIGMA-T
DISTANCE (KM)
DEPTH (M)
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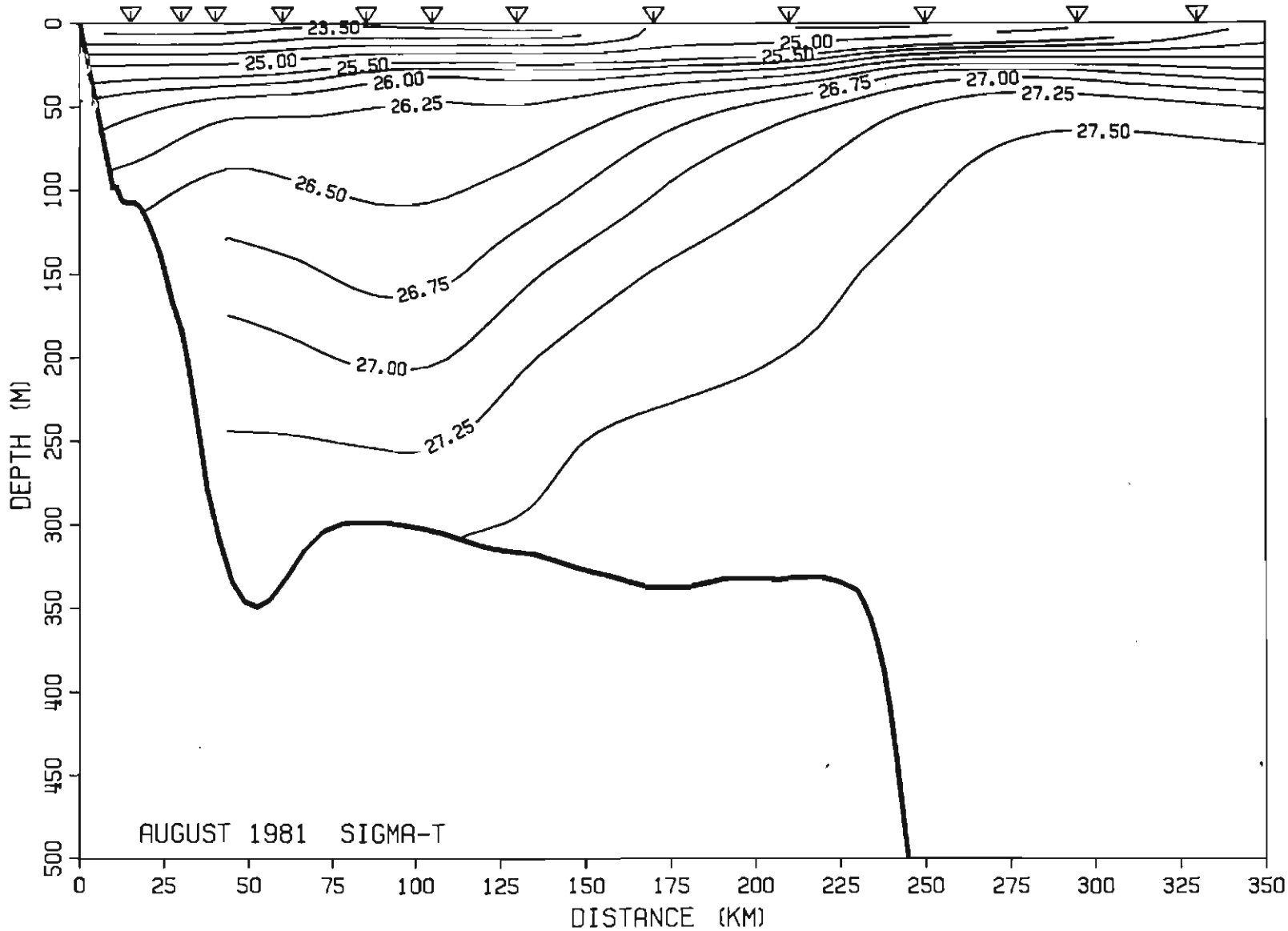
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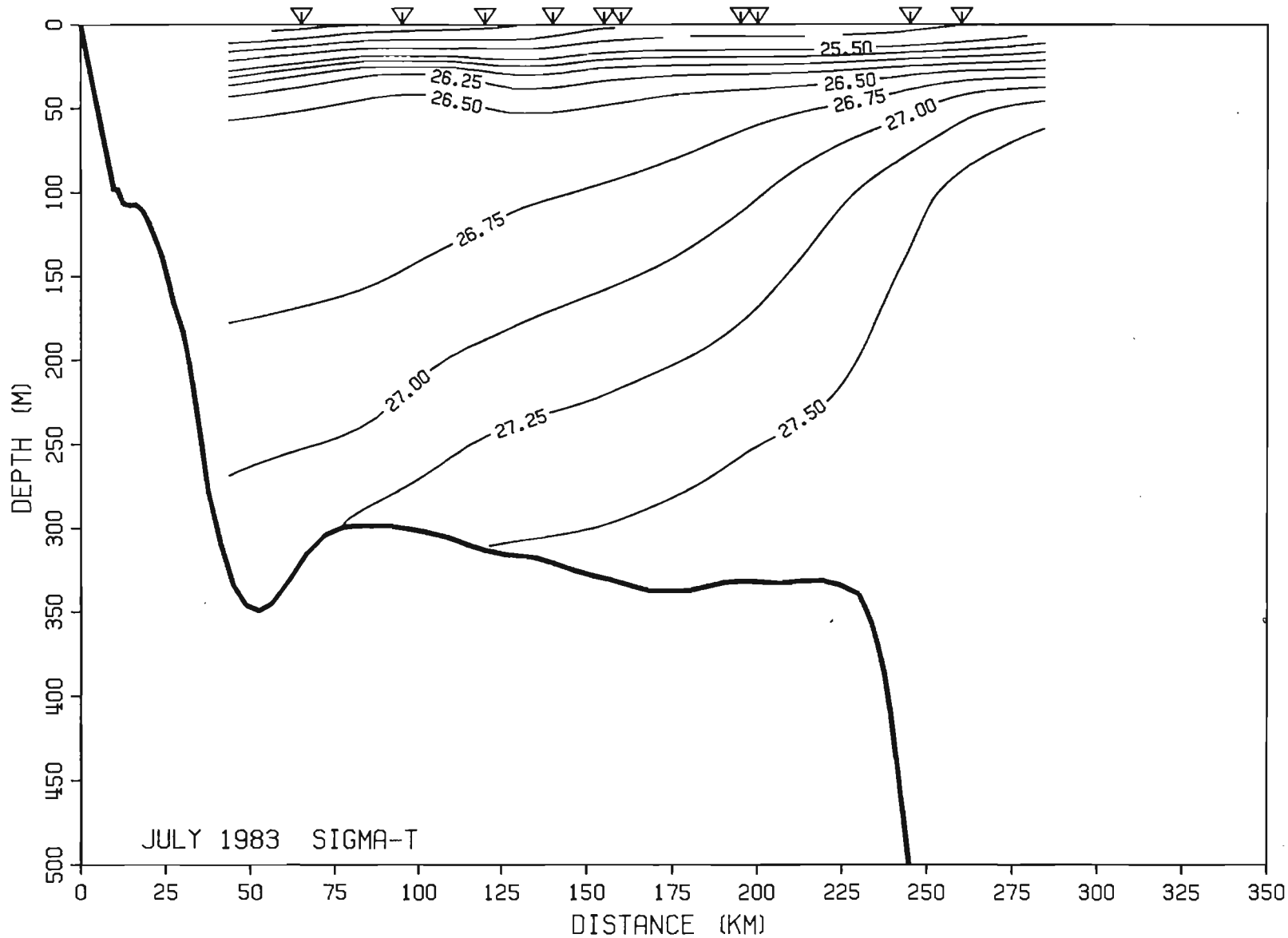
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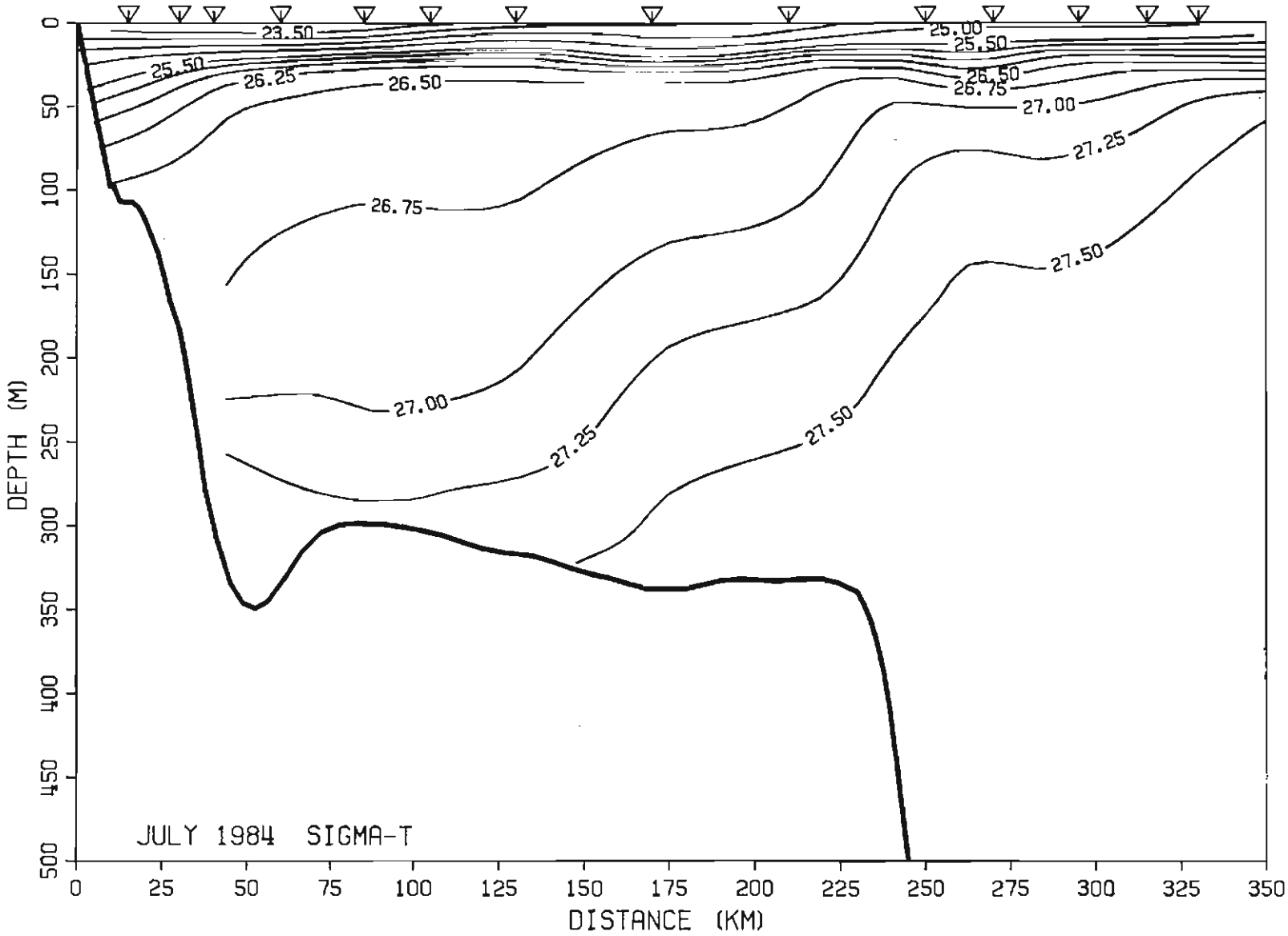
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JULY 1984 SIGMA-T
DEPTH (M)
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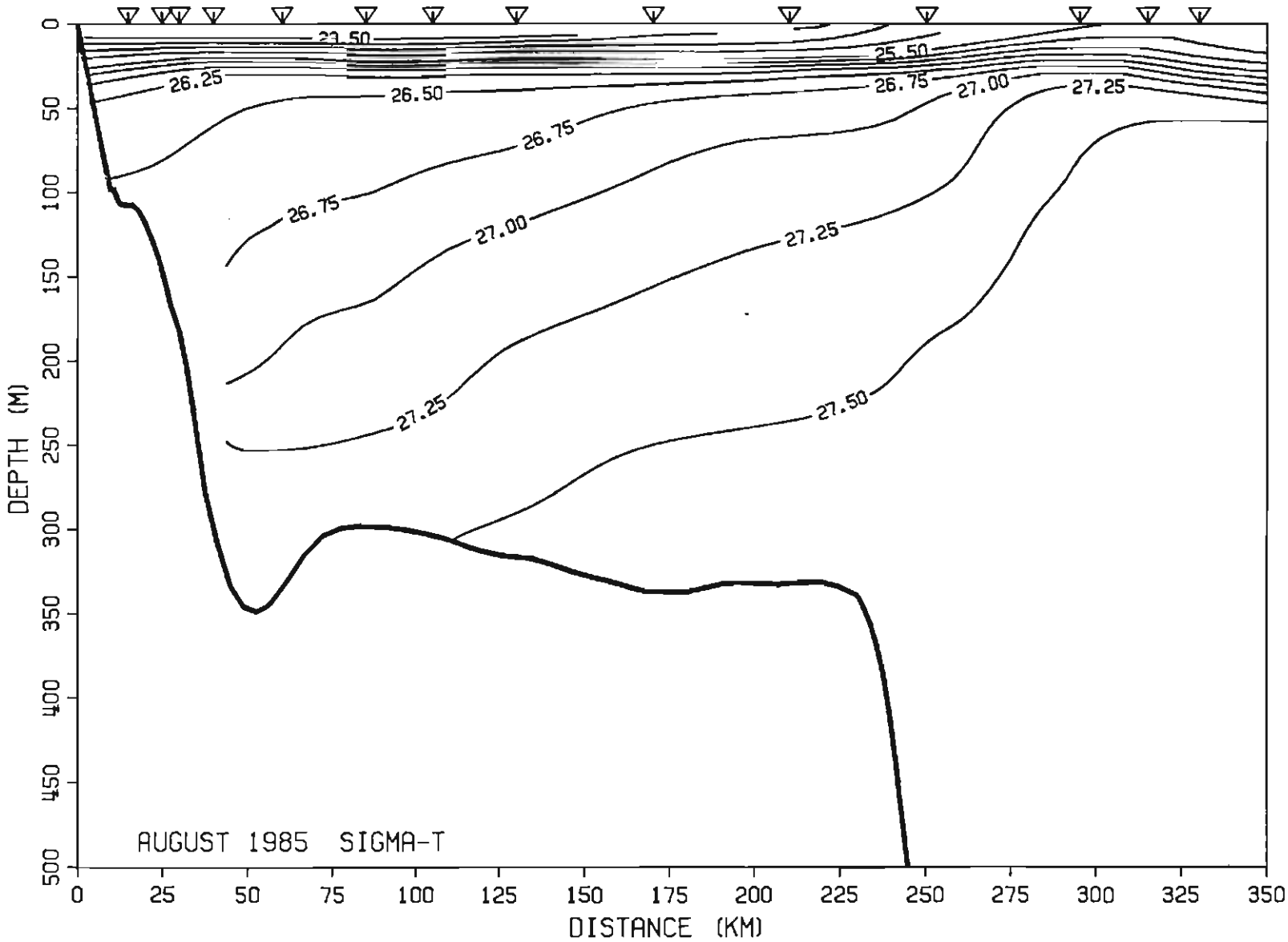
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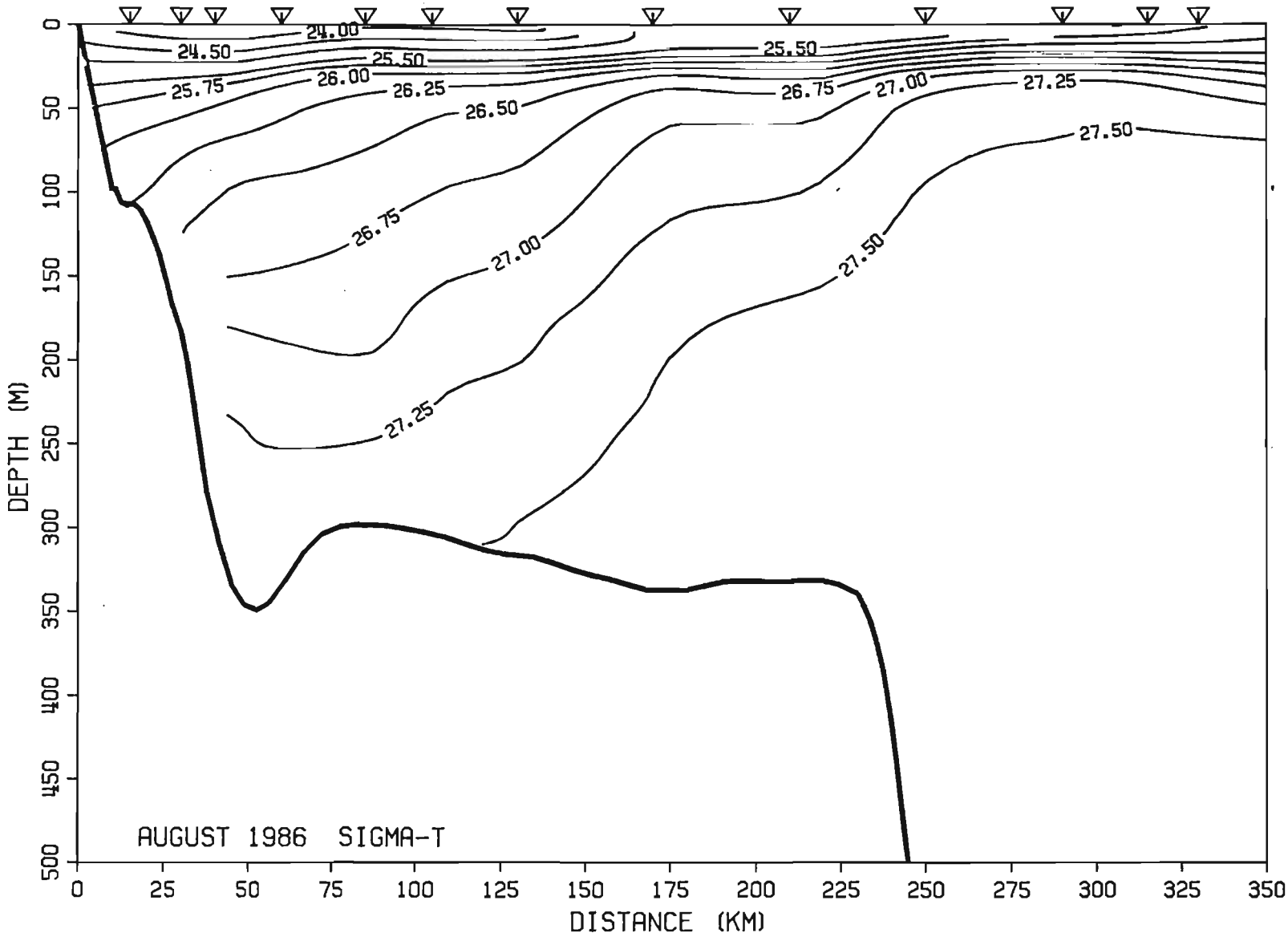
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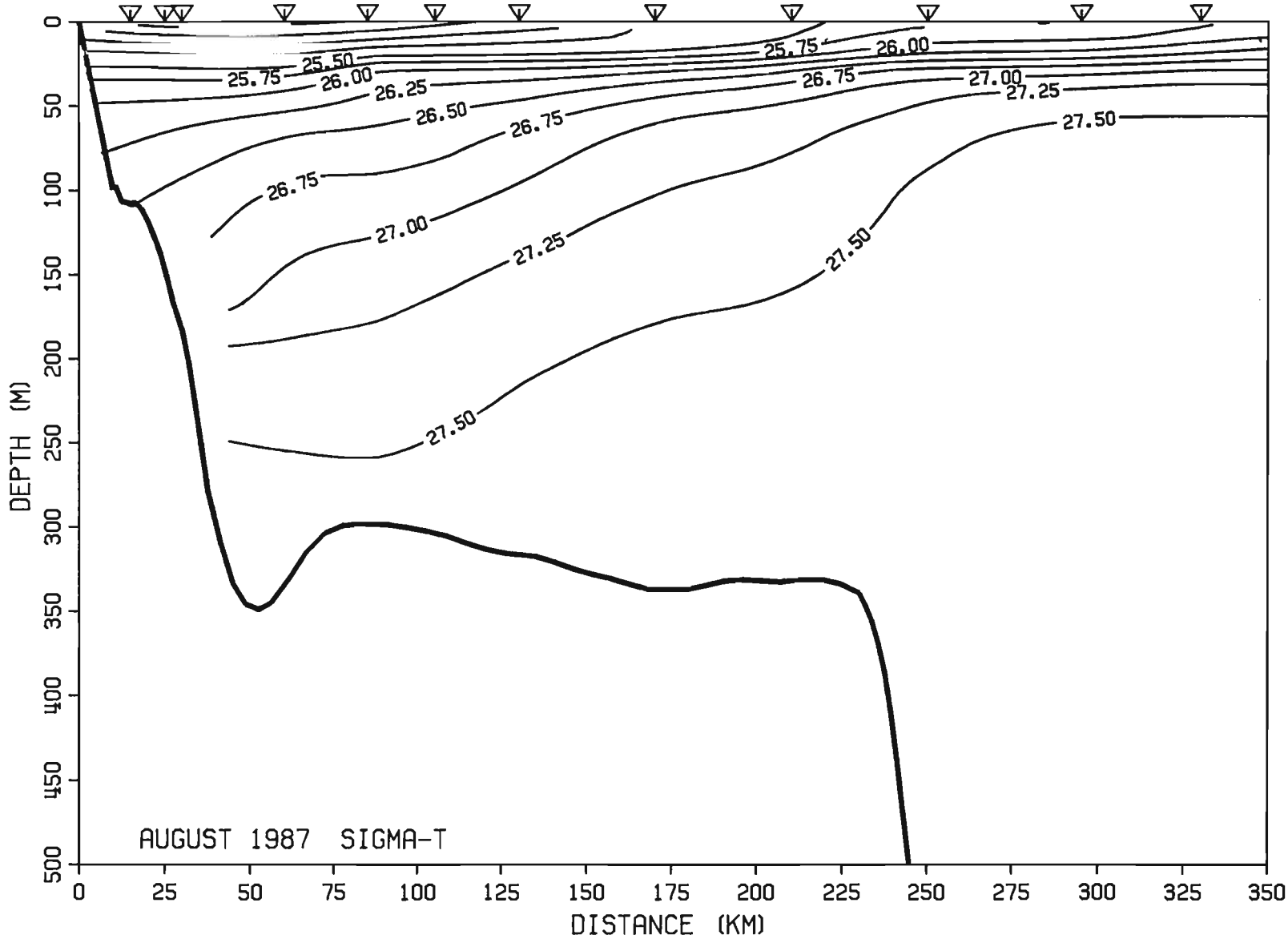
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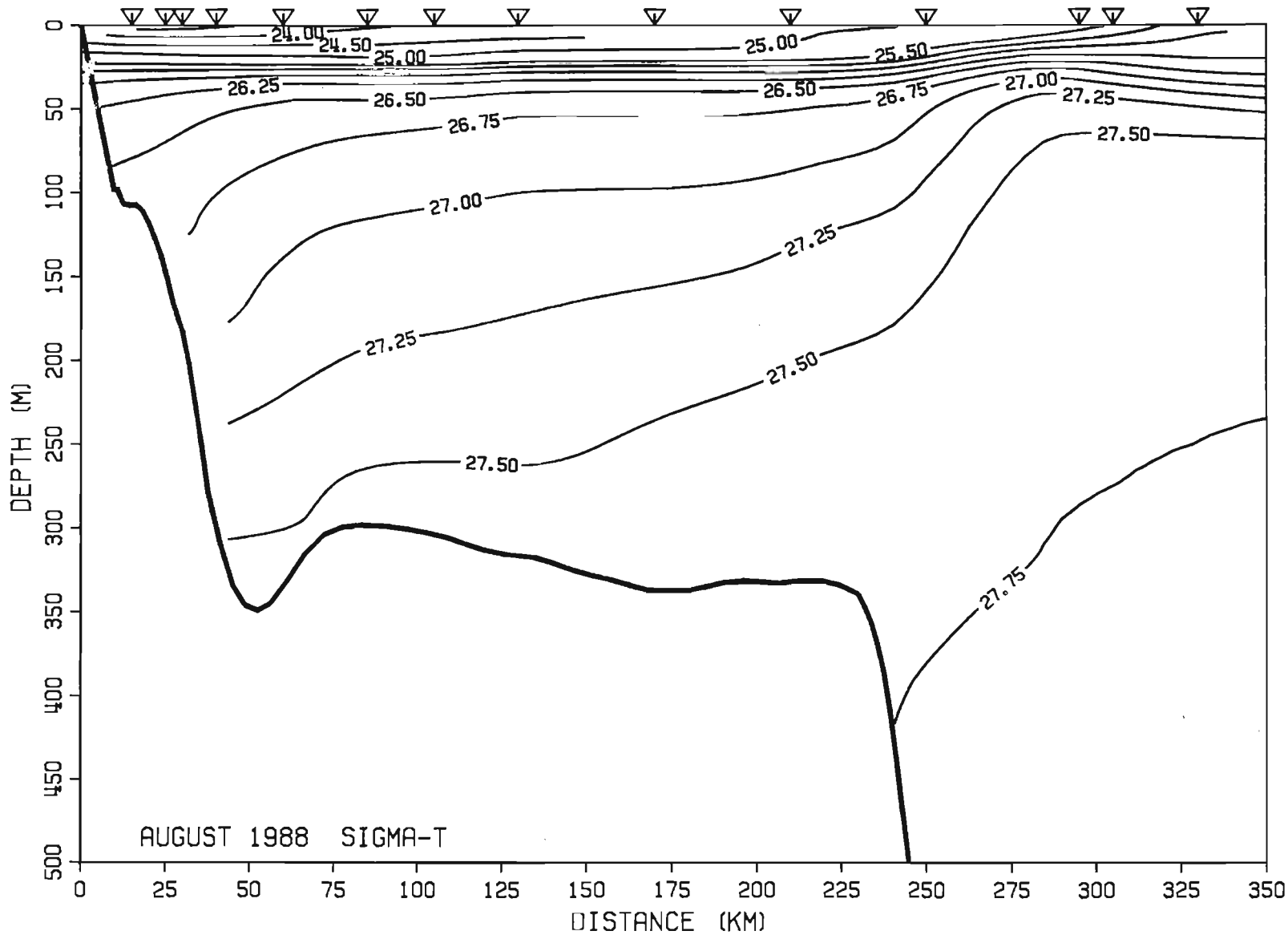
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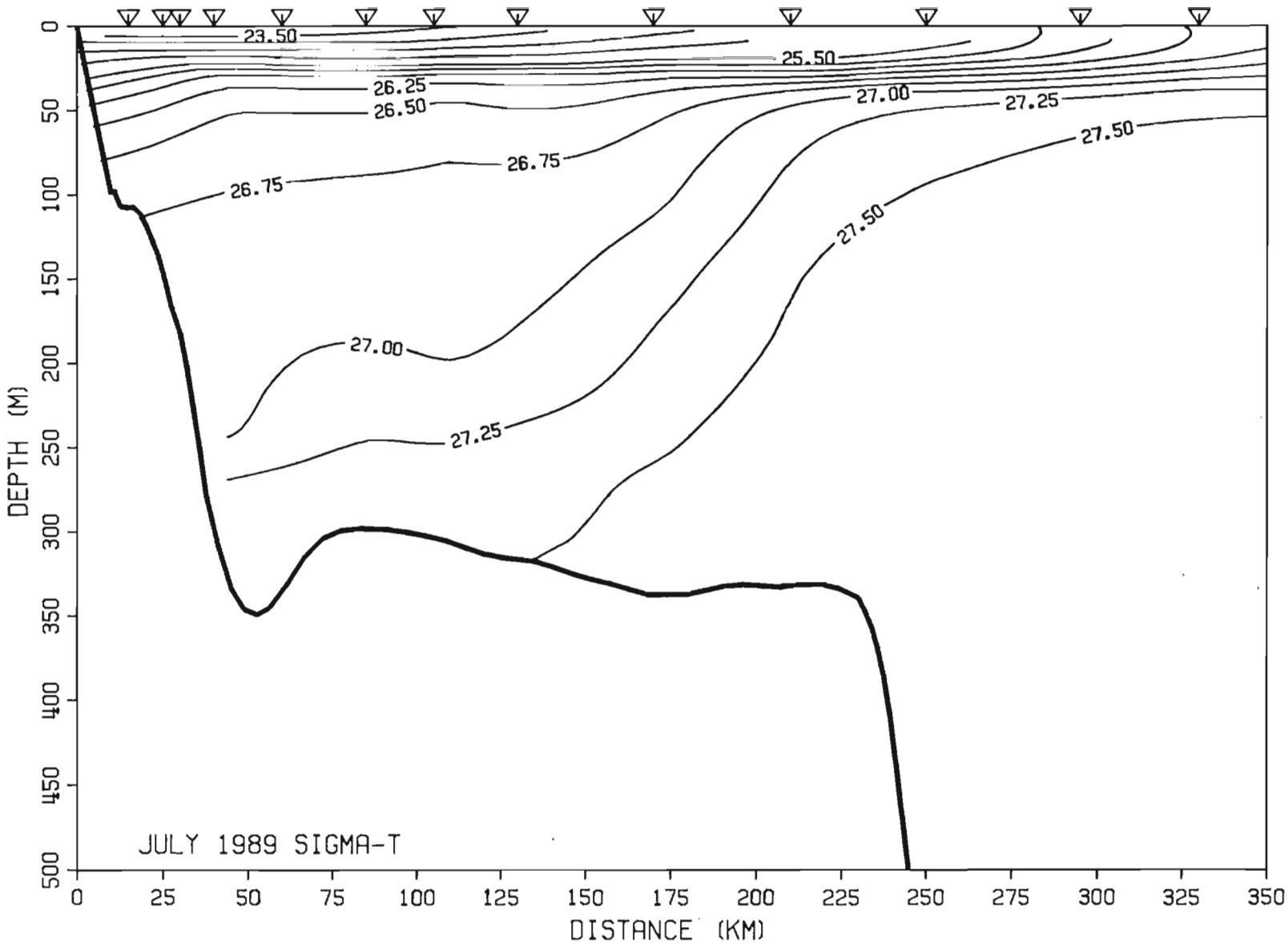
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JULY 1989 SIGMA-T
DEPTH (M)
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DISTANCE (KM)
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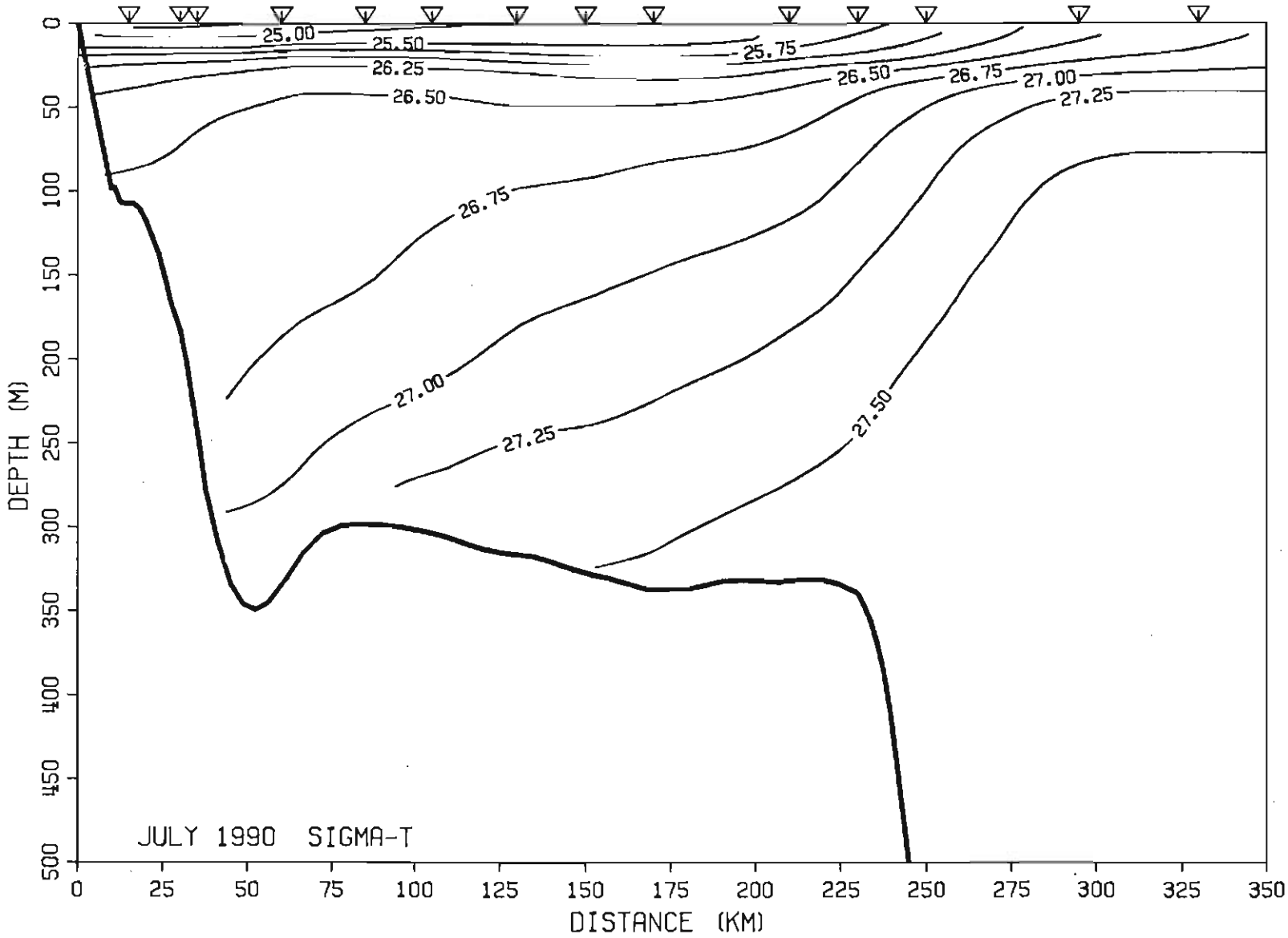
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JULY 1990 SIGMA-T
DEPTH (M)
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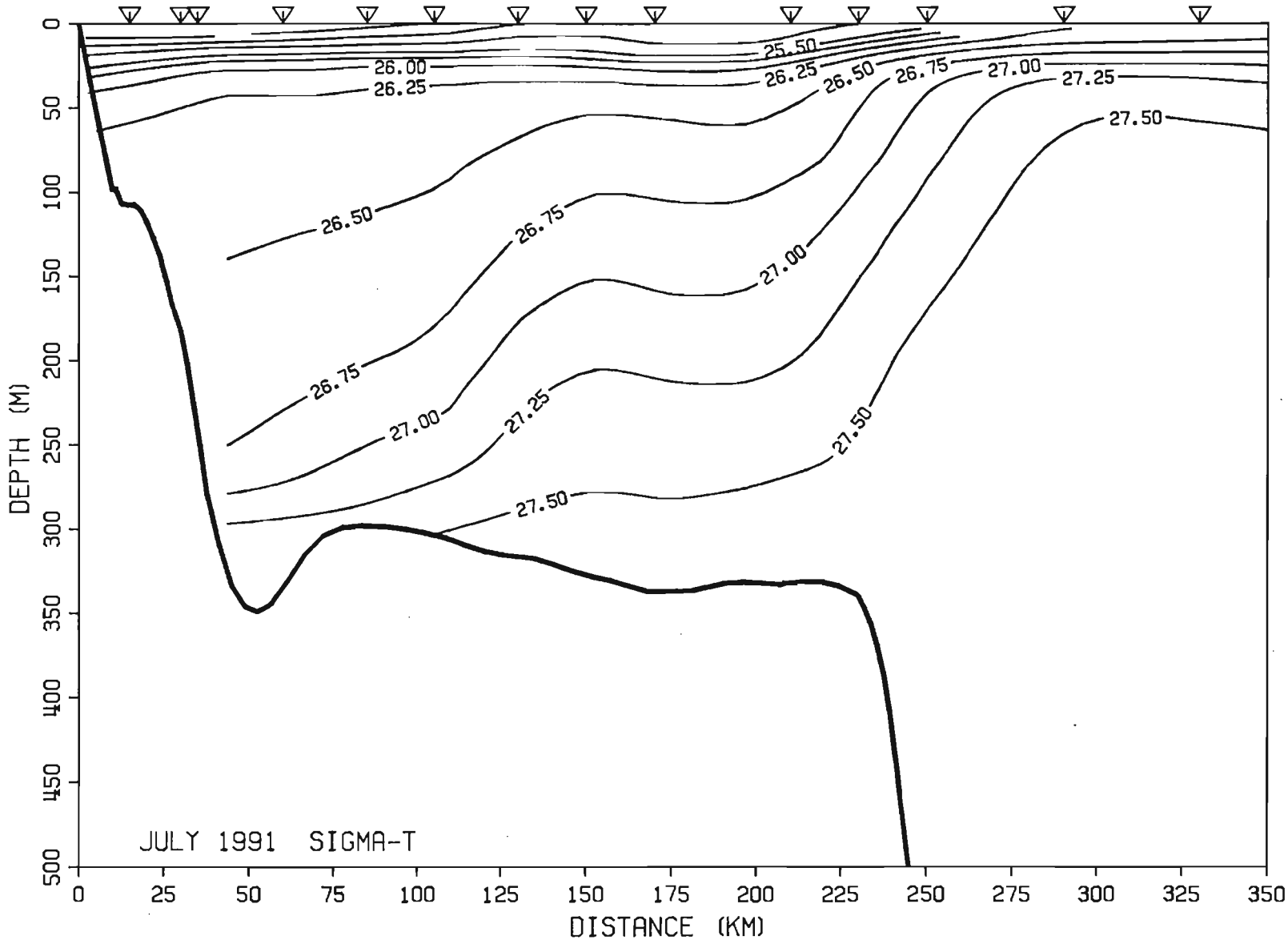
JULY 1991 SIGMA-T
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DISTANCE (KM)
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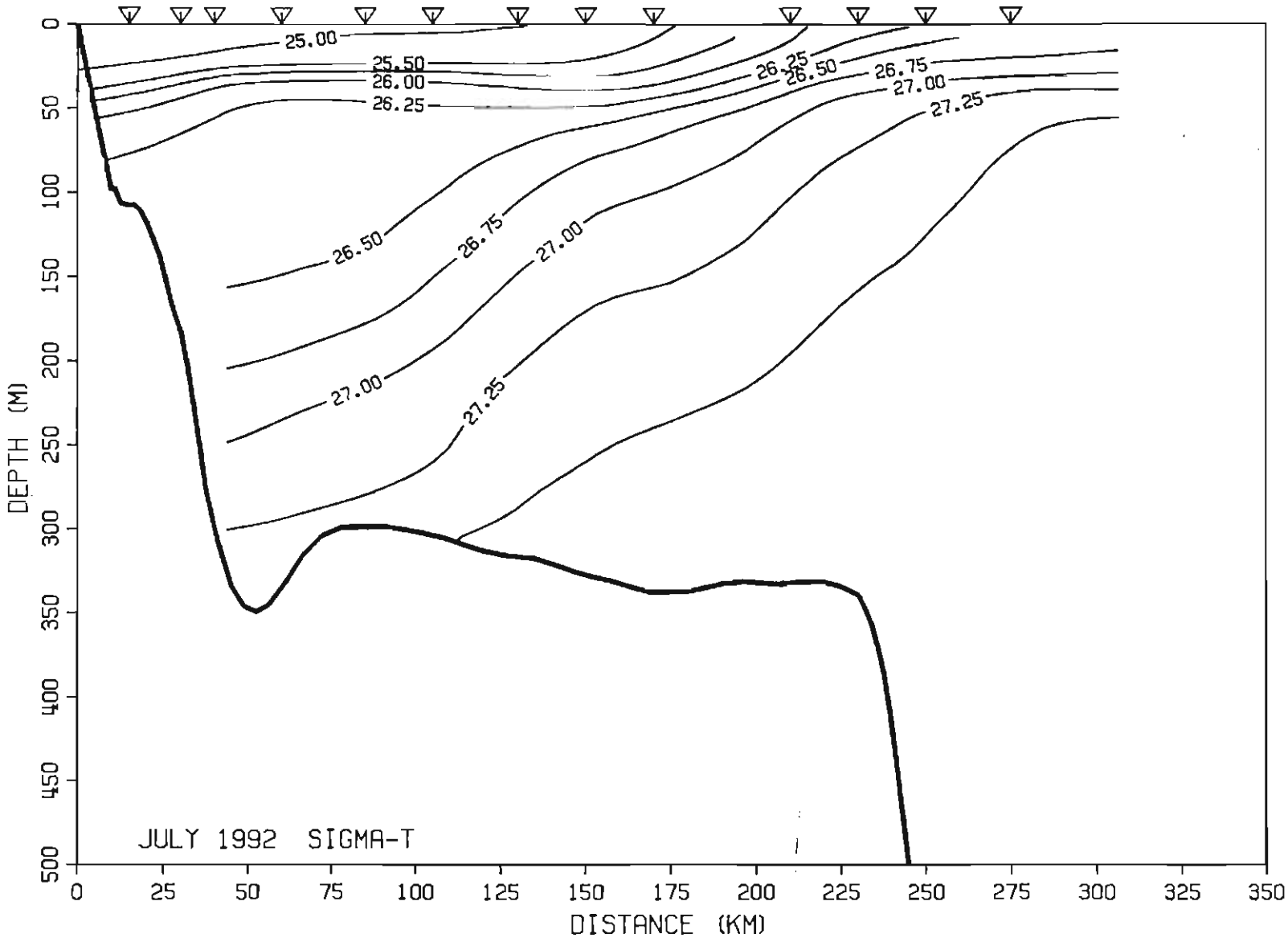
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DEPTH (M)
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DISTANCE (KM)
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325
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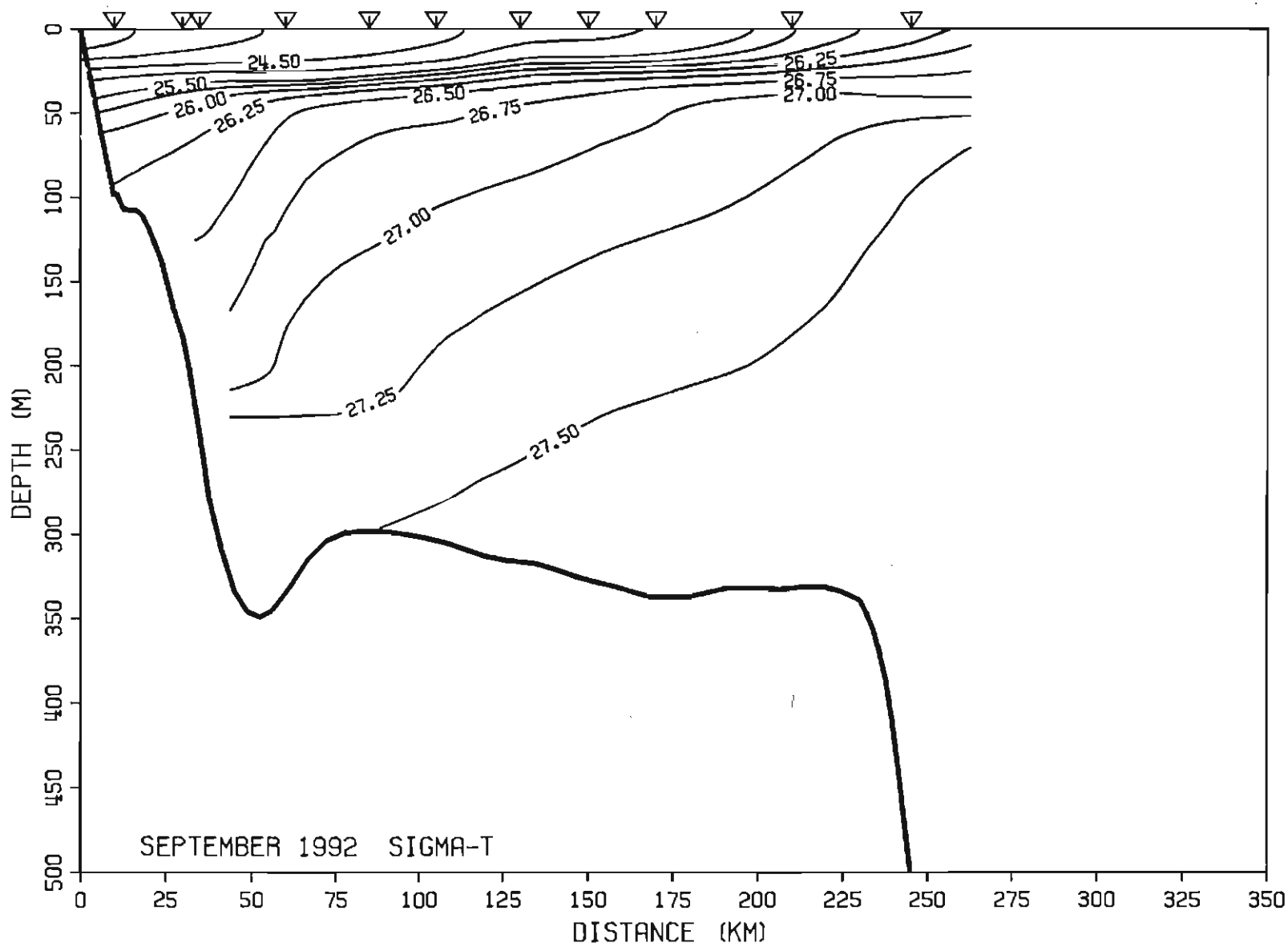
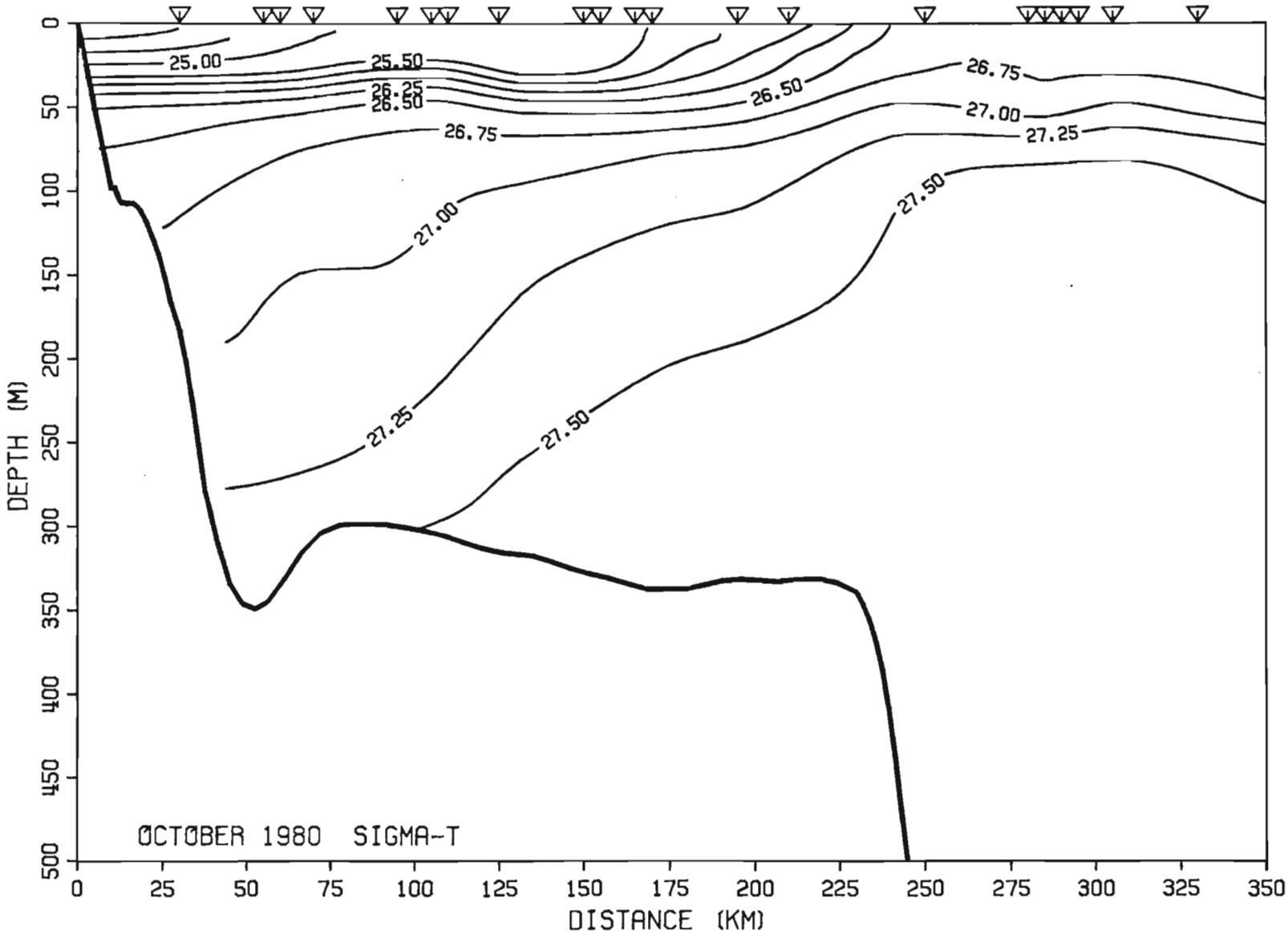
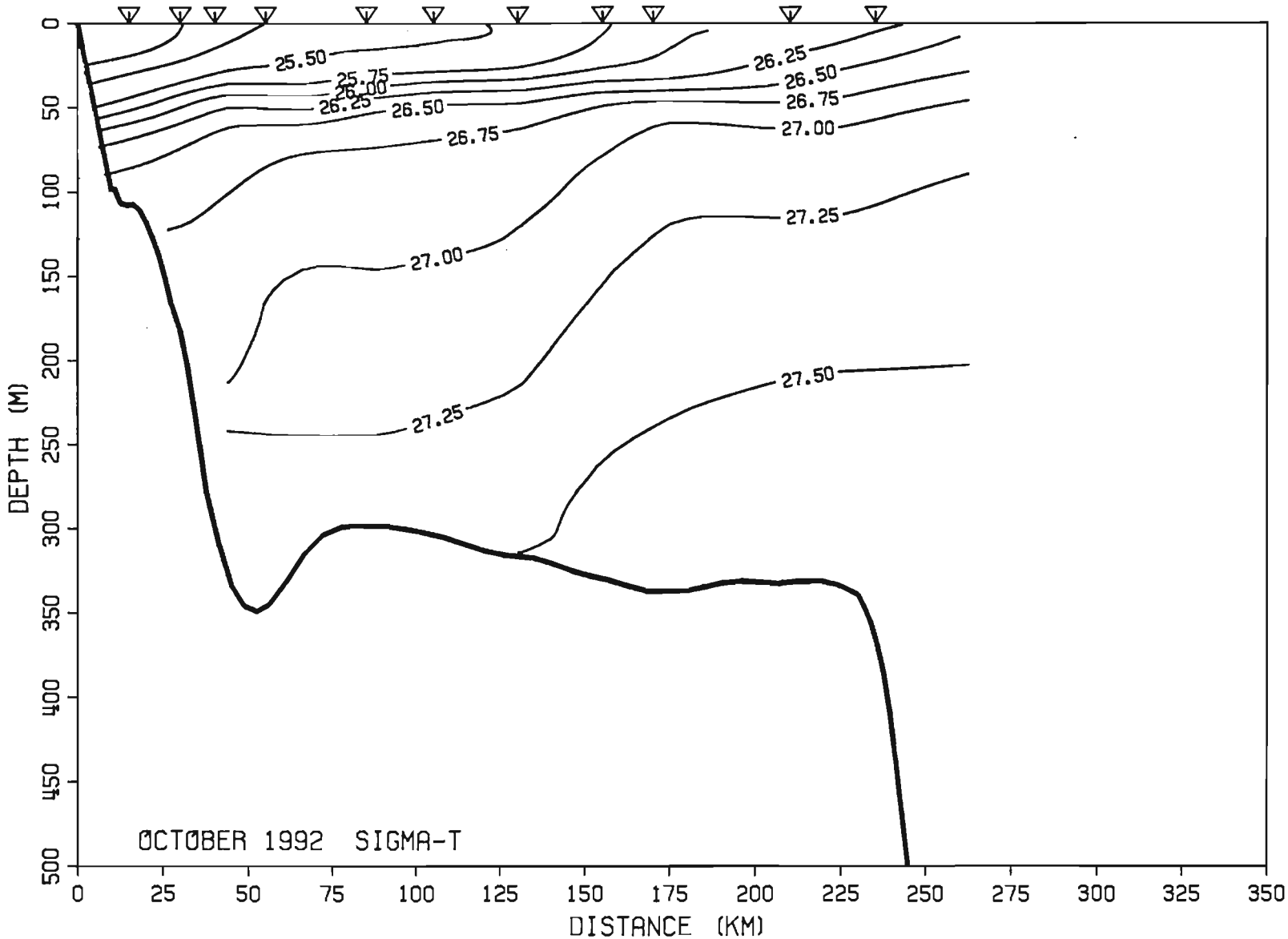
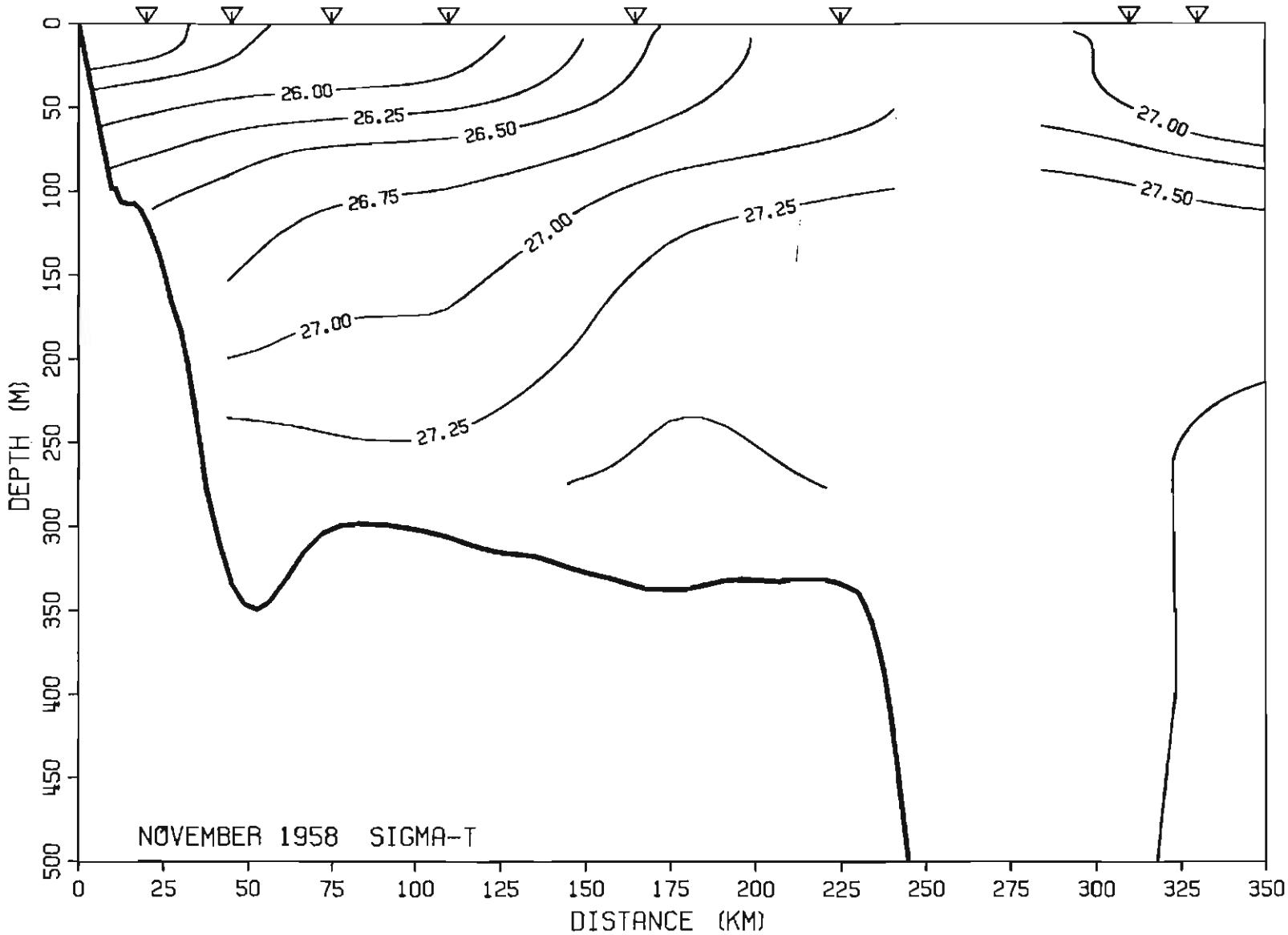
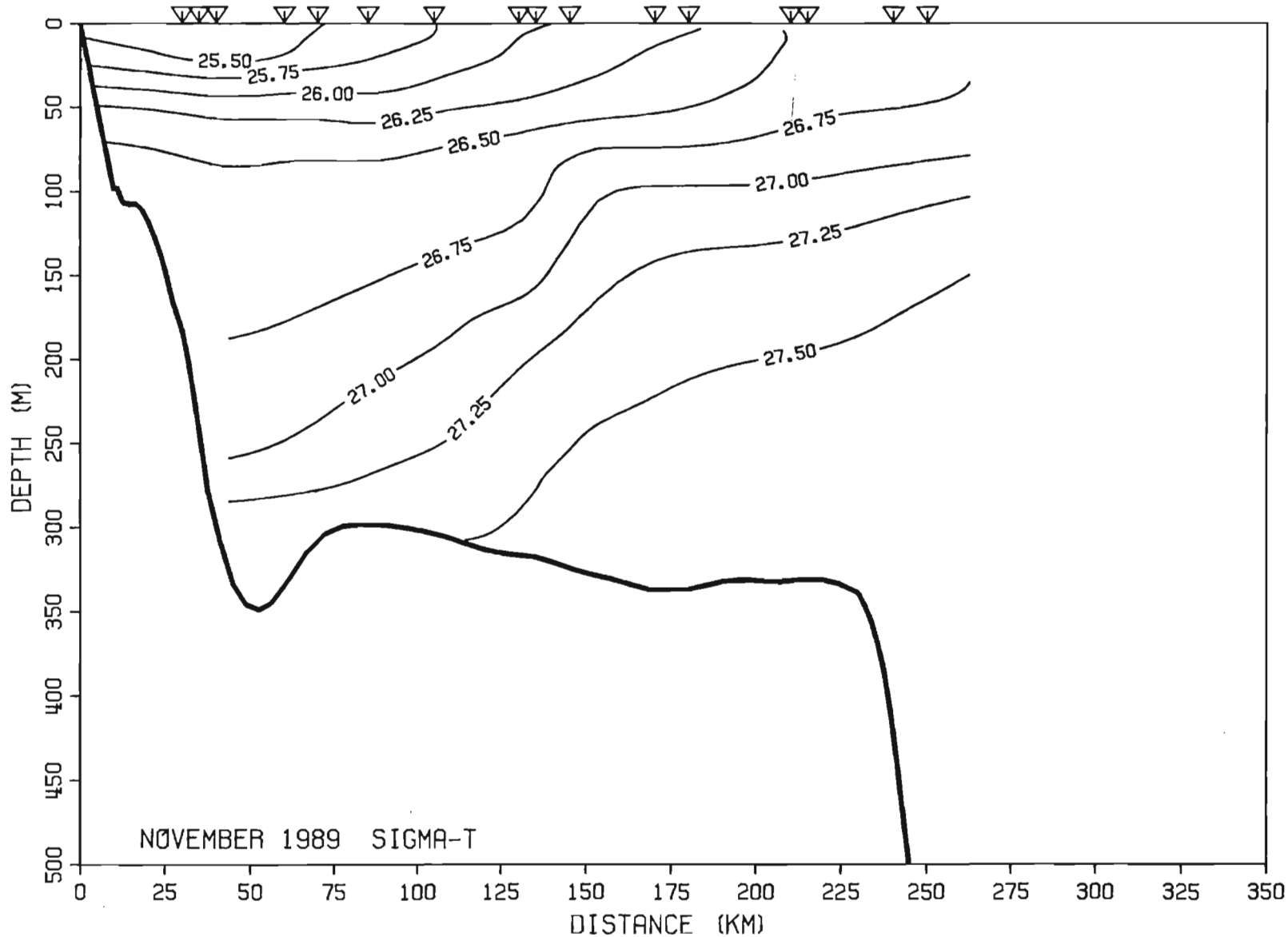

SEPTEMBER 1992 SIGMA-T
DEPTH (M)
DISTANCE (KM)
24.50
25.50
26.00
26.25
26.50
26.75
27.00
27.25
27.50
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350


OCTOBER 1980 SIGMA-T
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
25.00
25.50
26.25
26.50
26.75
27.00
27.25
27.50


OCTOBER 1992 SIGMA-T
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
25.50
25.75
26.00
26.25
26.50
26.75
27.00
27.25
27.50


26.00
26.25
26.50
26.75
27.00
27.25
27.00
27.50
27.00
27.25
NOVEMBER 1958 SIGMA-T
DEPTH (M)
0
50
100
150
200
250
300
350
400
450
500
DISTANCE (KM)
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350


NOVEMBER 1989 SIGMA-T
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
25.50
25.75
26.00
26.25
26.50
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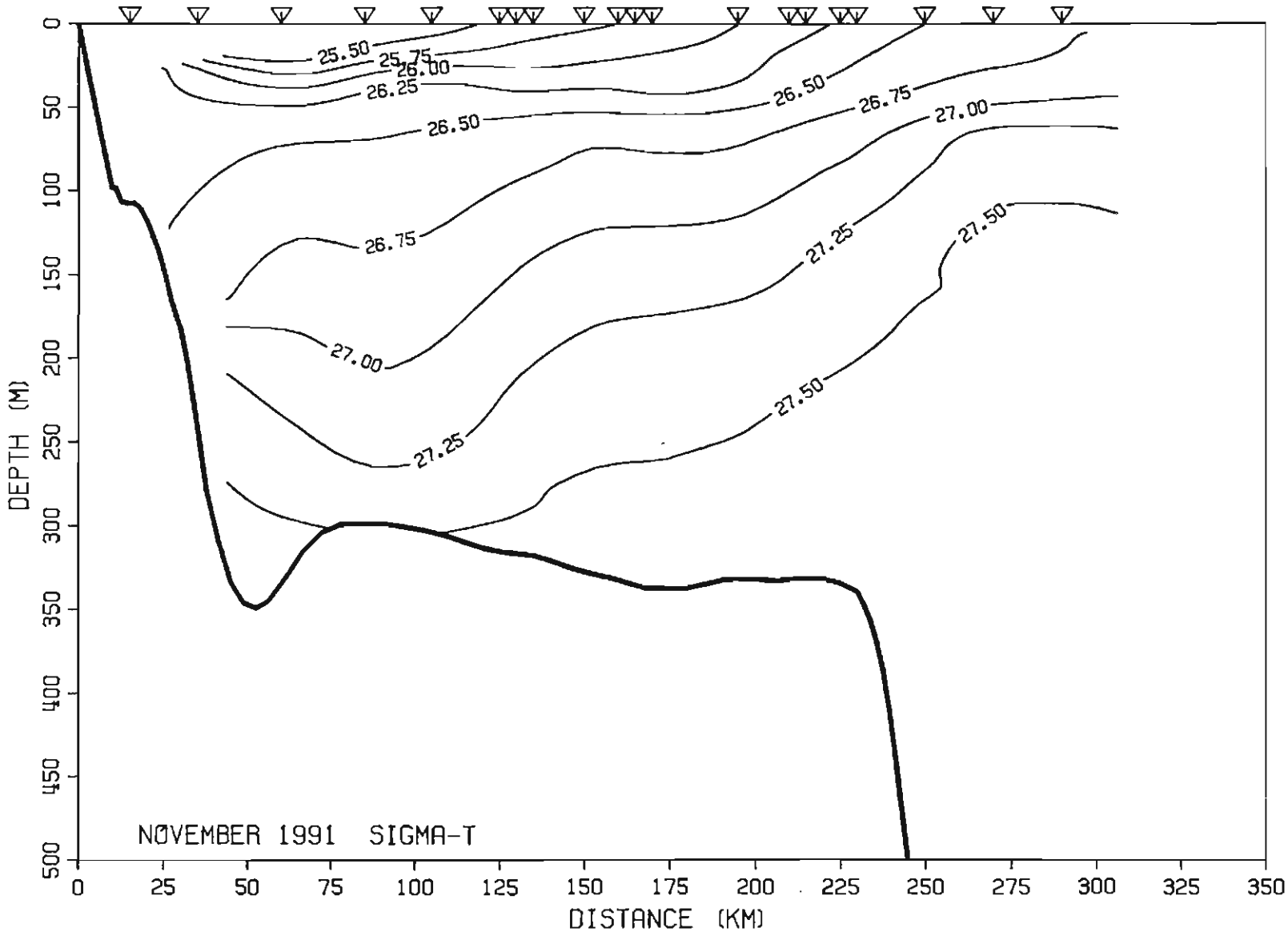
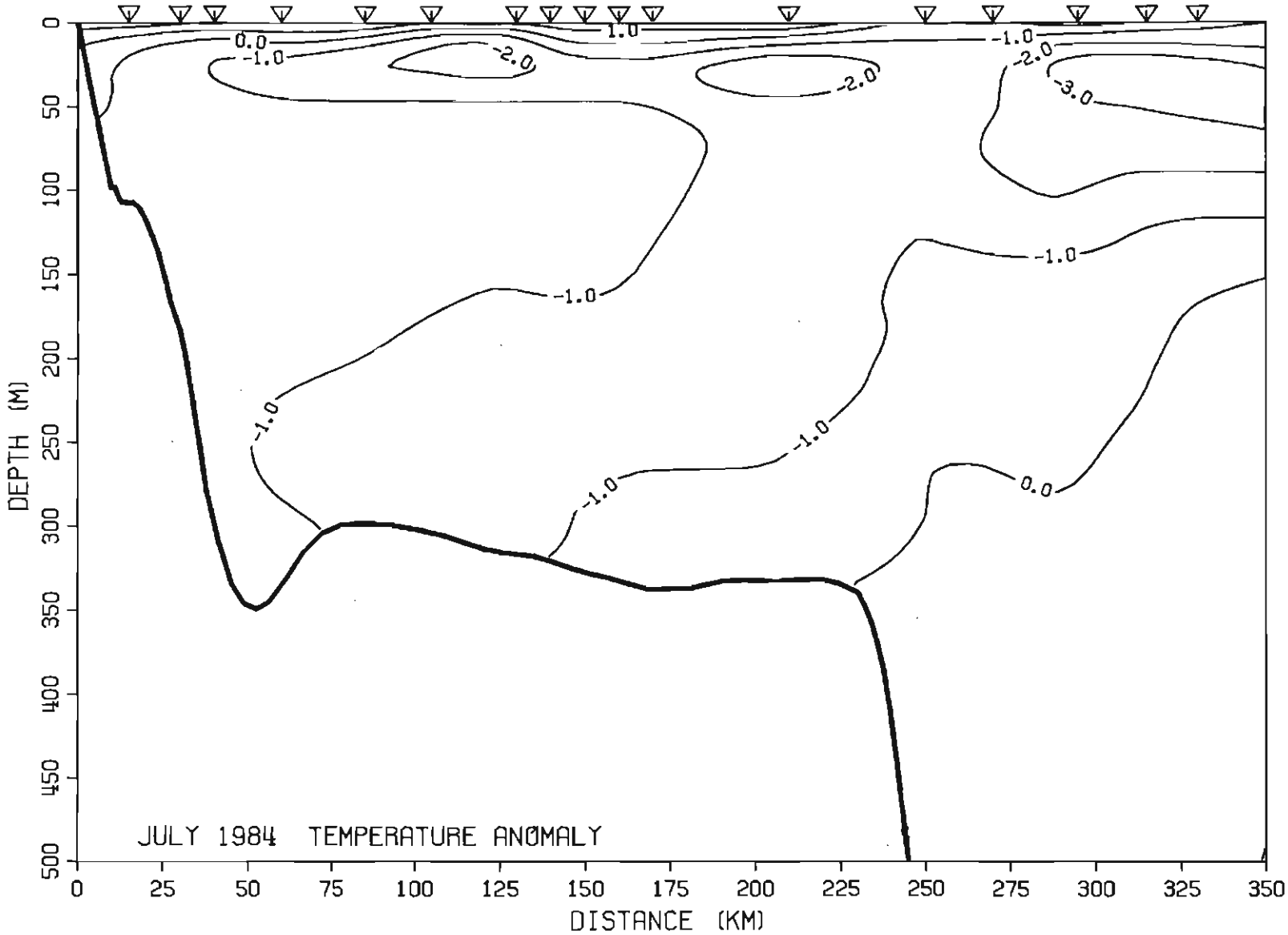
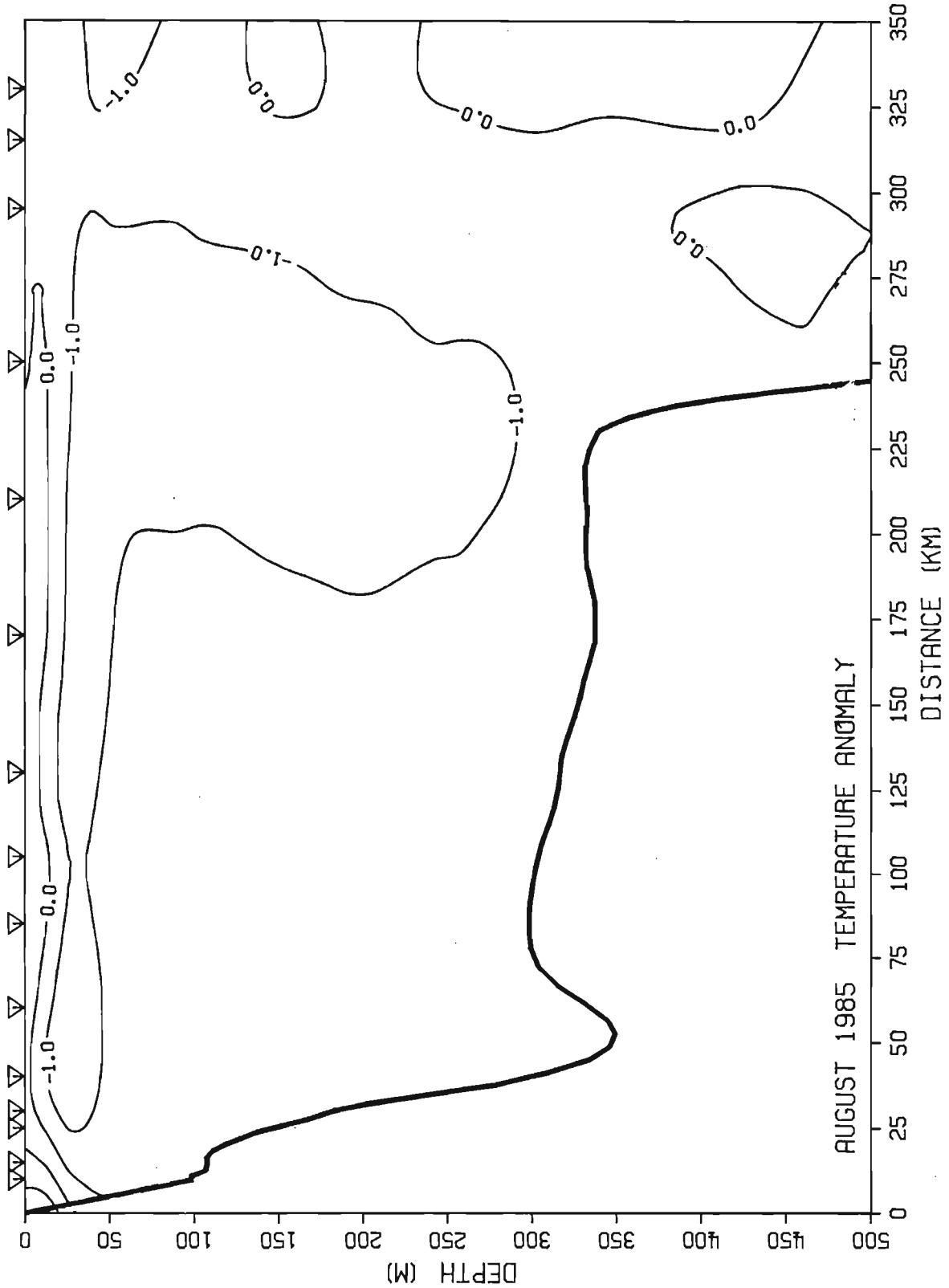
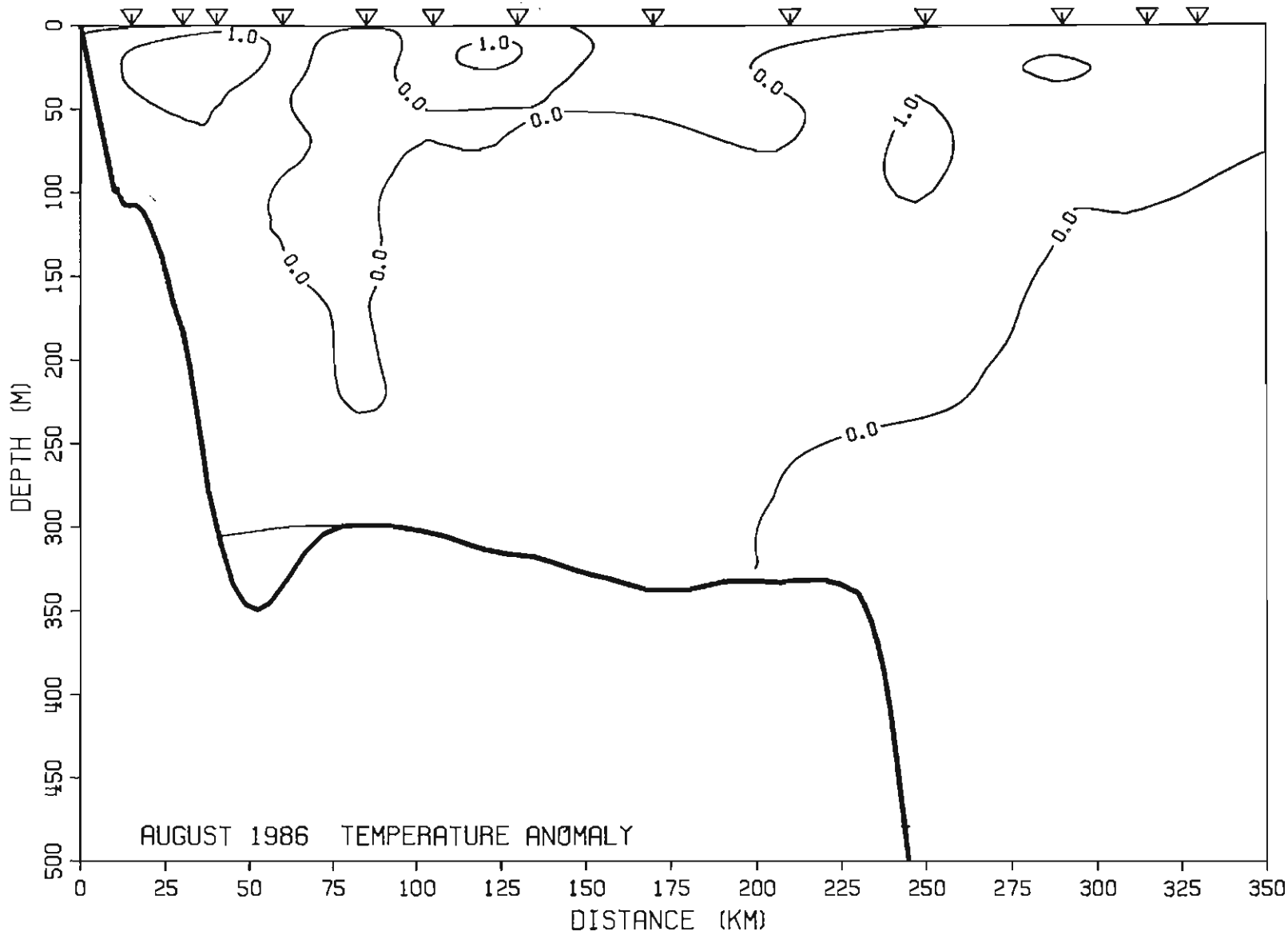
27.00
27.25
27.50
26.75
27.00
27.25

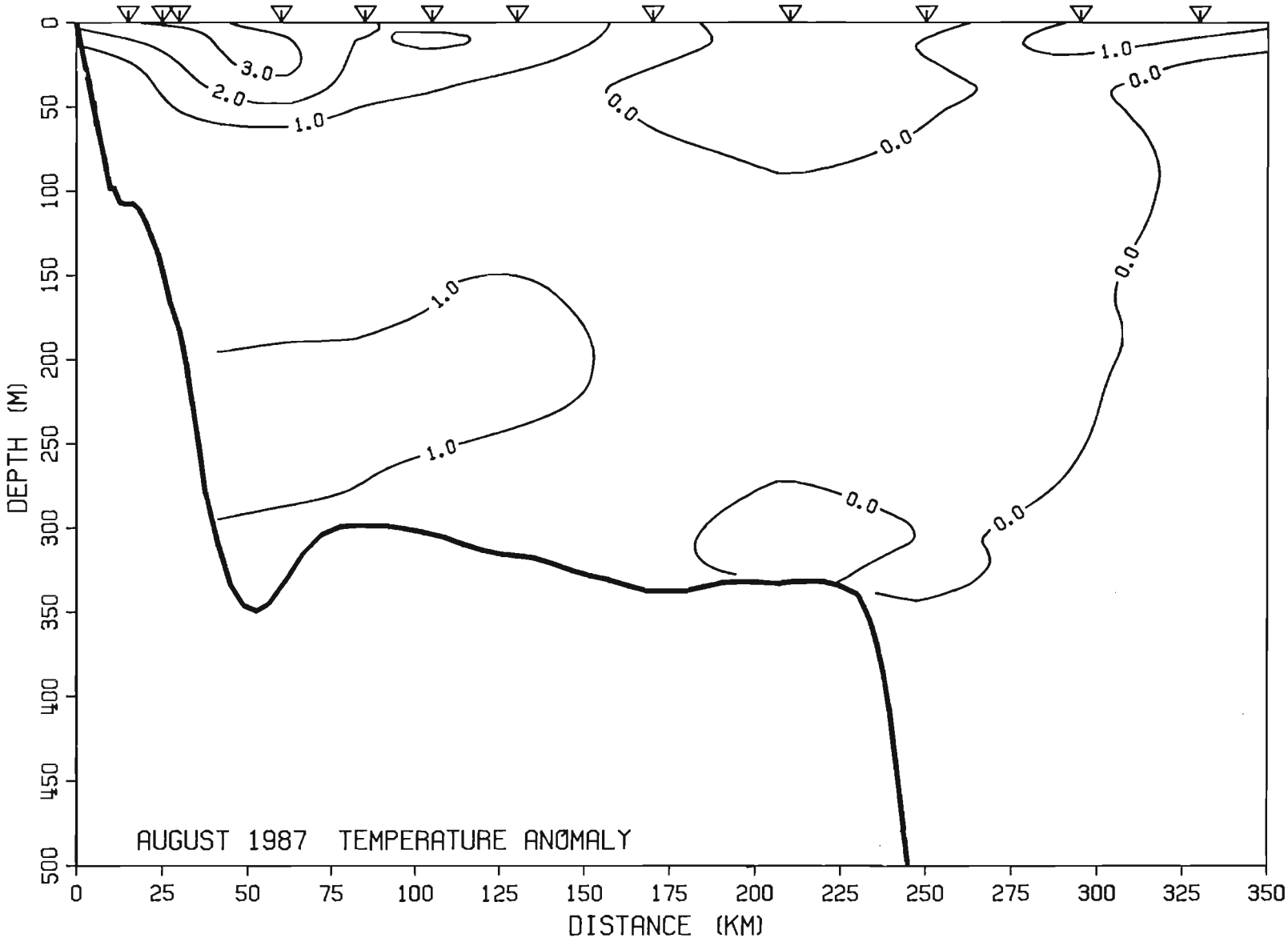

NOVEMBER 1991 SIGMA-T
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
25.50
25.75
26.00
26.25
26.50
26.75
27.00
27.25
27.50

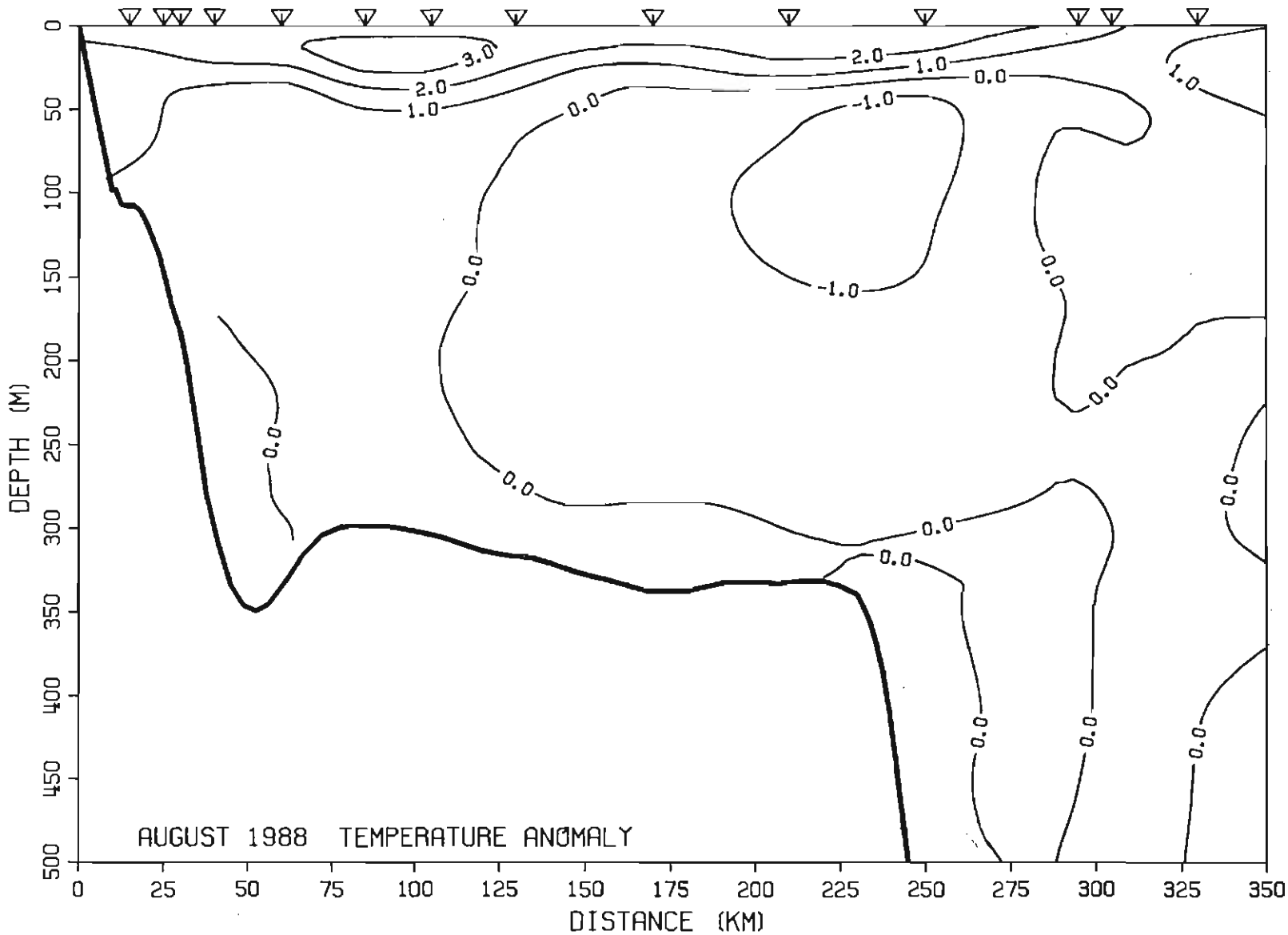
APPENDIX H. The 1984 to 1992 summer temperature anomalies.

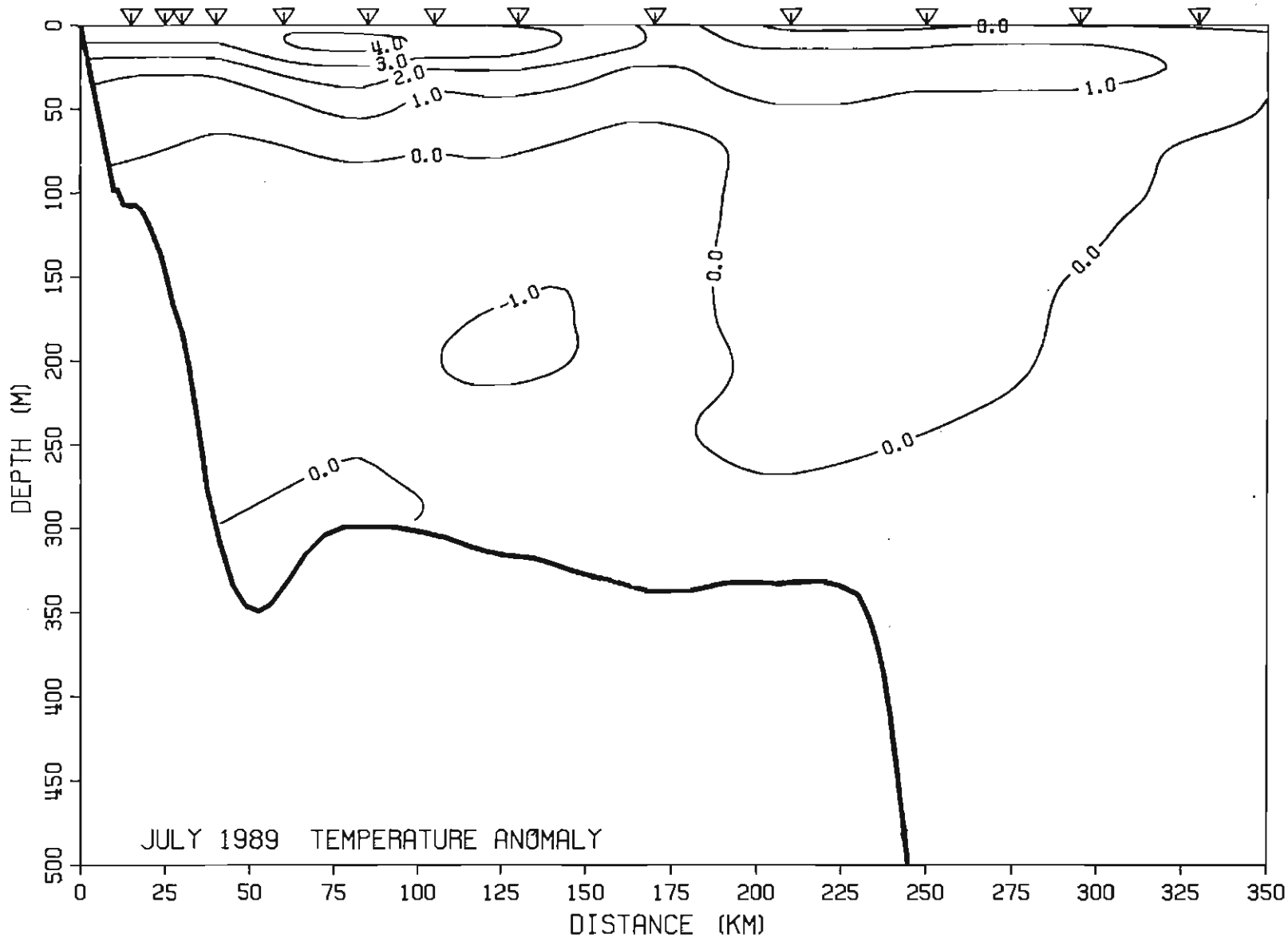

JULY 1984 TEMPERATURE ANOMALY
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
1.0
0.0
-1.0
-2.0
-3.0

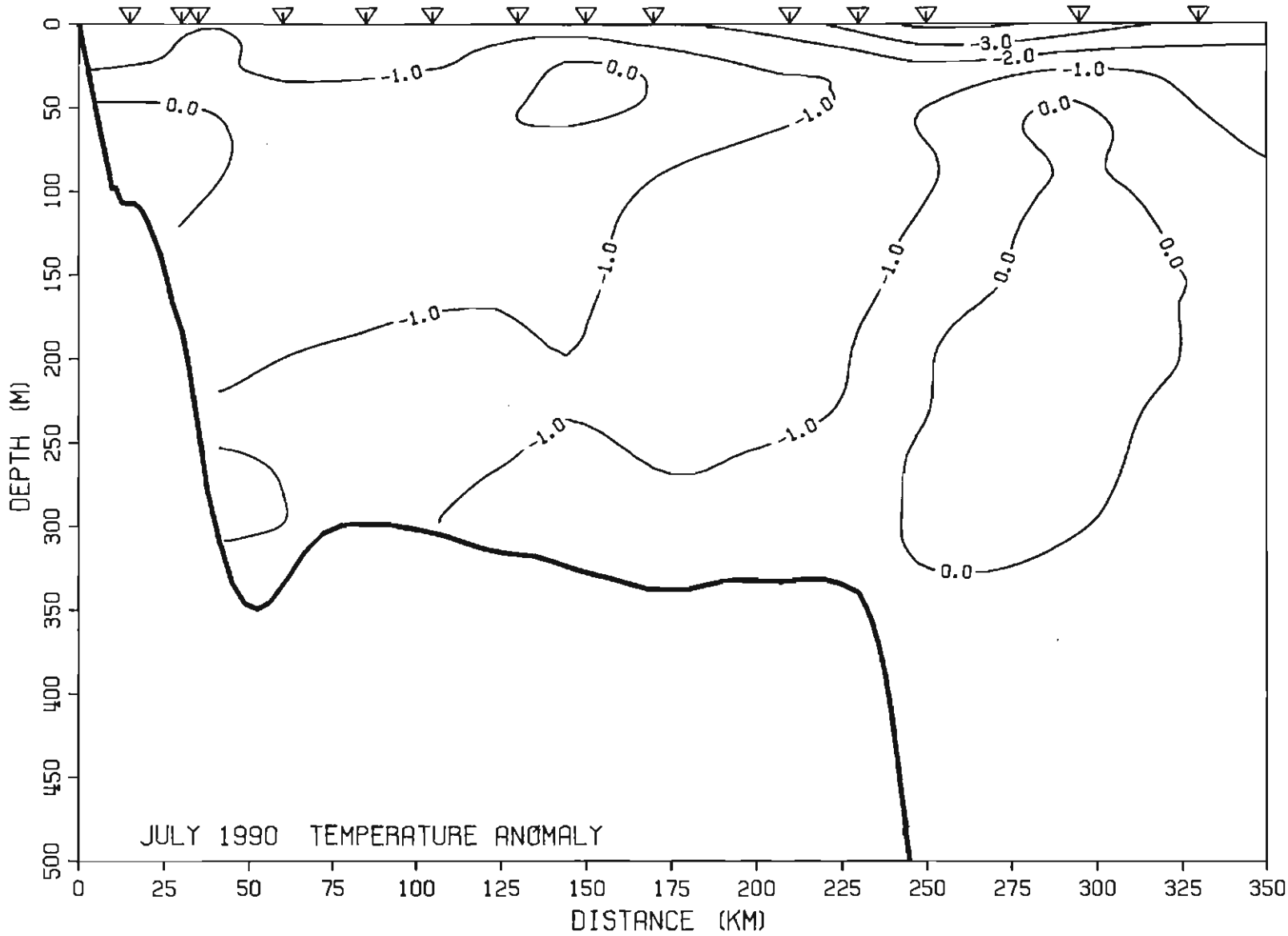

AUGUST 1985 TEMPERATURE ANOMALY
DISTANCE (KM)
DEPTH (M)
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
0
50
100
150
200
250
300
350
400
450
500
-1.0
0.0
-1.0
0.0
-1.0
0.0
-1.0
0.0
-1.0
0.0
0.0

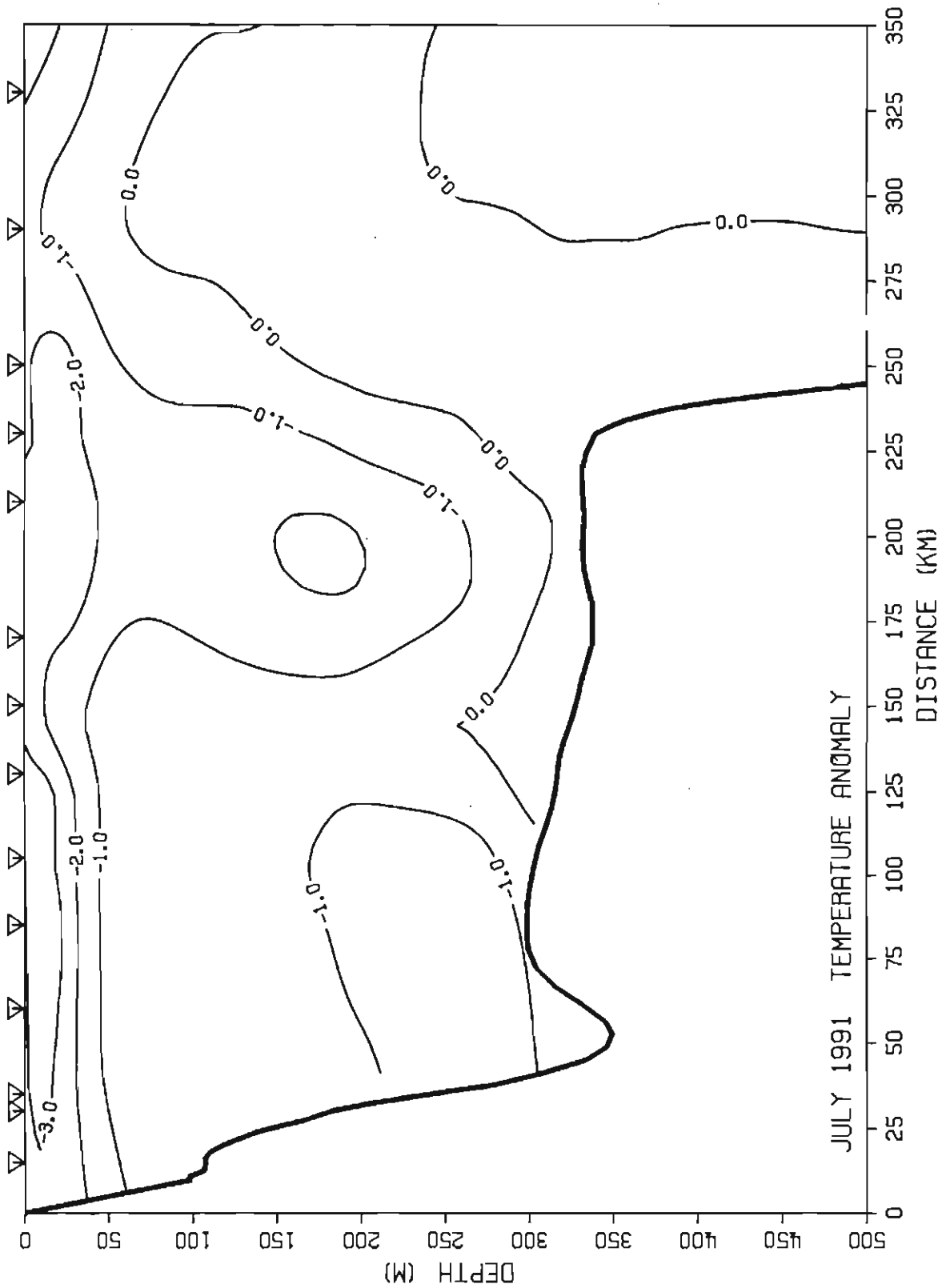

AUGUST 1986 TEMPERATURE ANOMALY
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
1.0
1.0
0.0
0.0
0.0
1.0
0.0
0.0
0.0
0.0

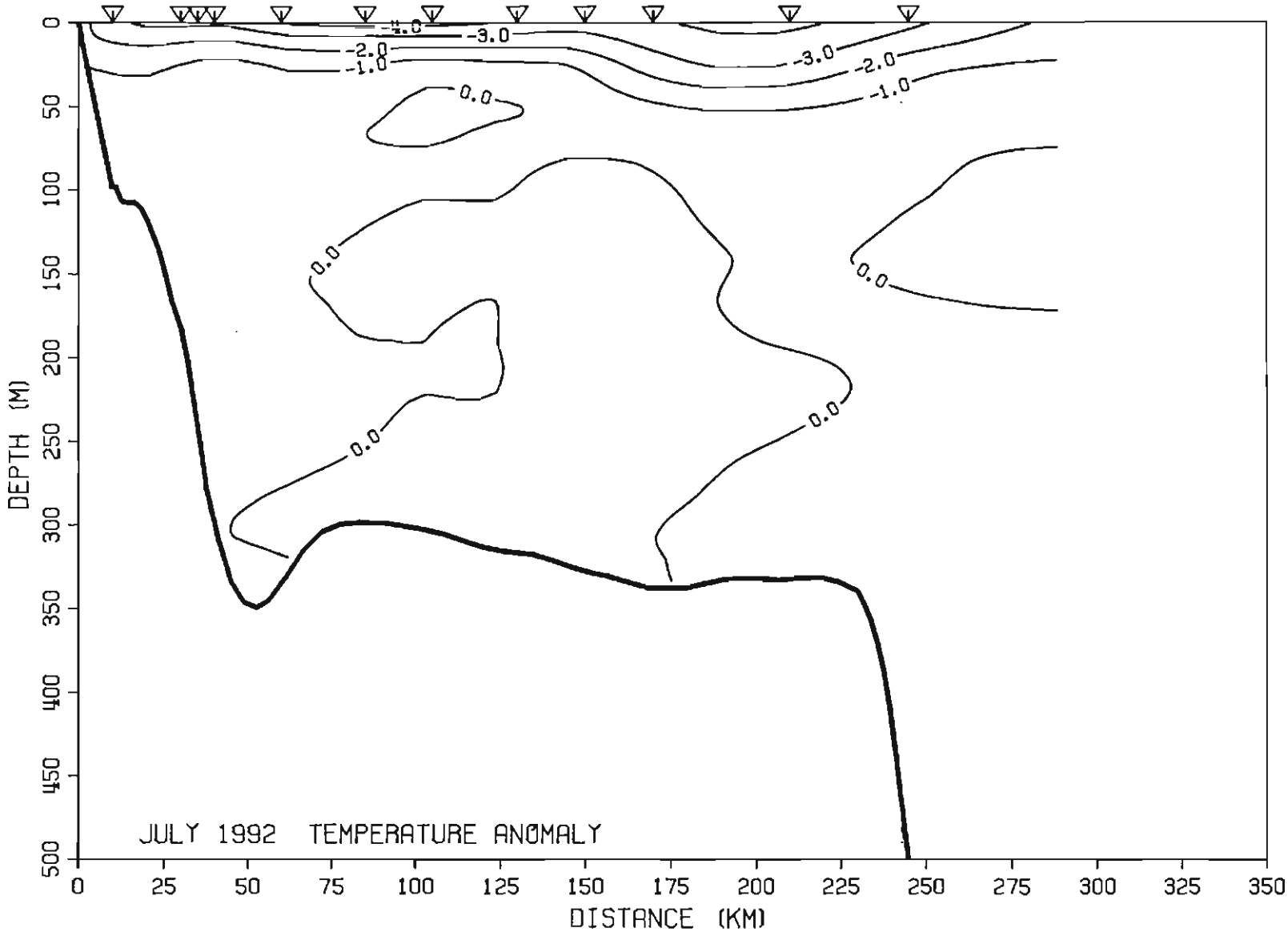

AUGUST 1987 TEMPERATURE ANOMALY
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
3.0
2.0
1.0
0.0
1.0
0.0
1.0
0.0
1.0
0.0
0.0
0.0


AUGUST 1988 TEMPERATURE ANOMALY
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
3.0
2.0
1.0
0.0
-1.0

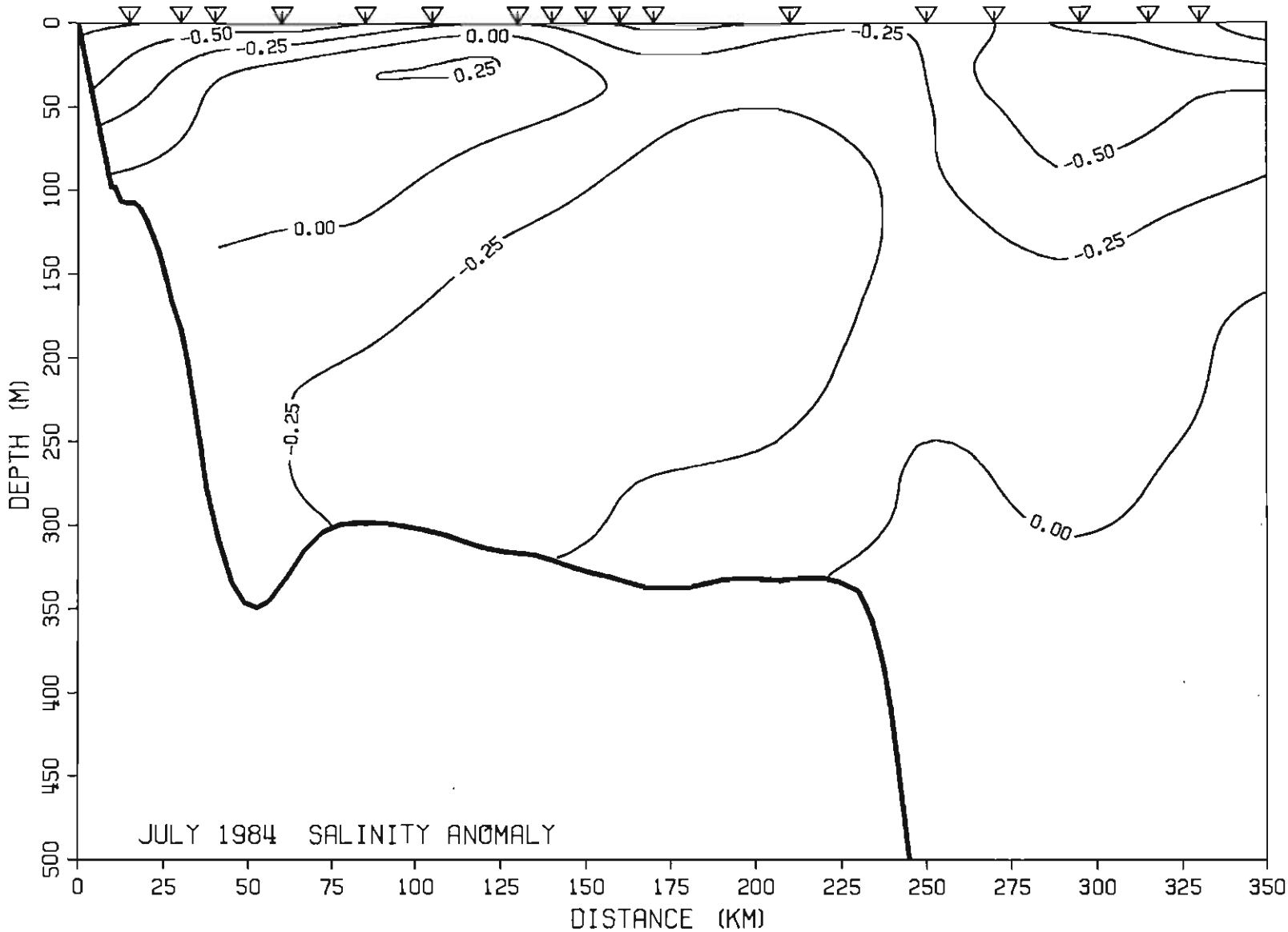

JULY 1989 TEMPERATURE ANOMALY
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
4.0
3.0
2.0
1.0
0.0
-1.0

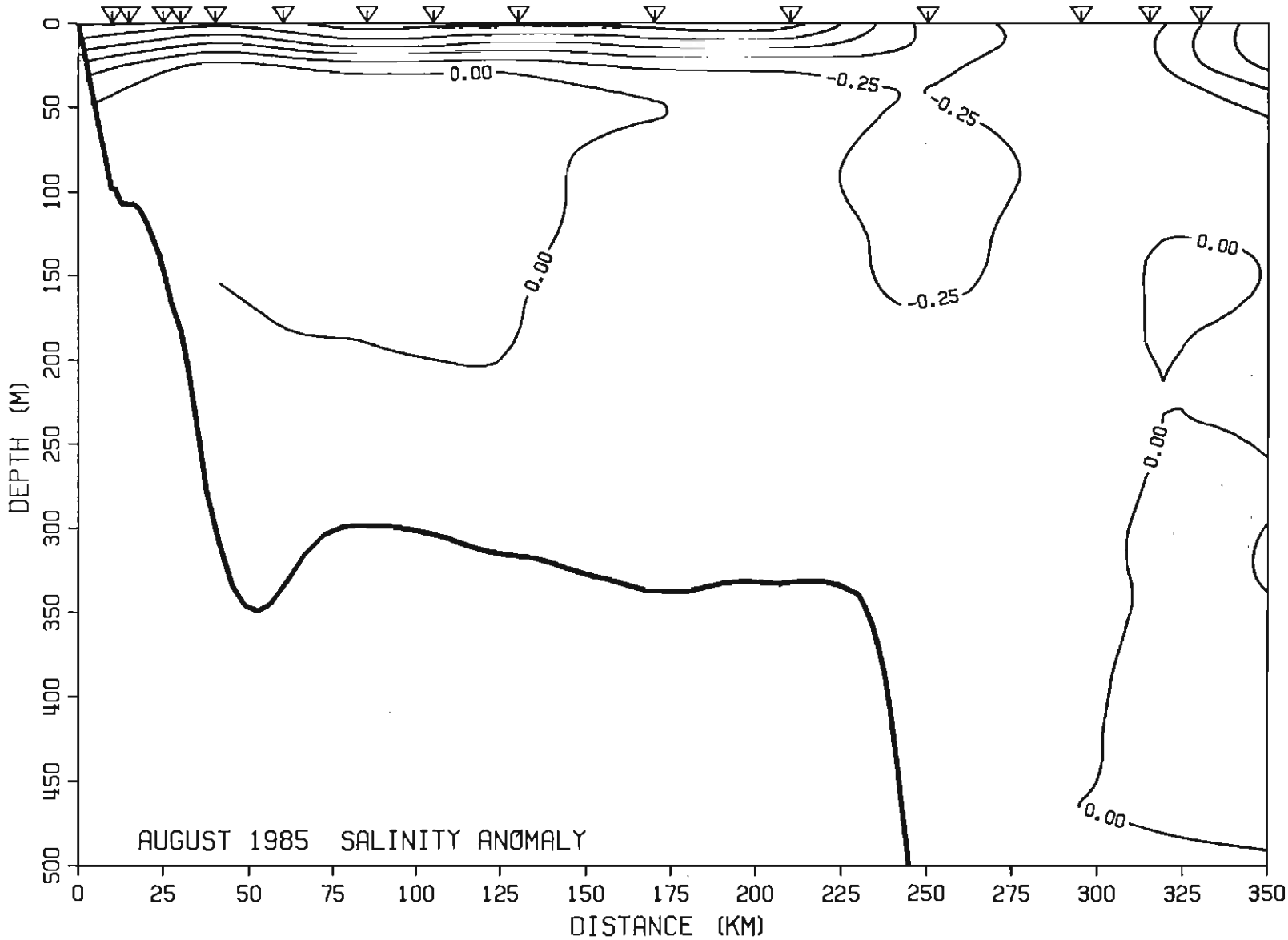

JULY 1990 TEMPERATURE ANOMALY
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
-3.0
-2.0
-1.0
0.0

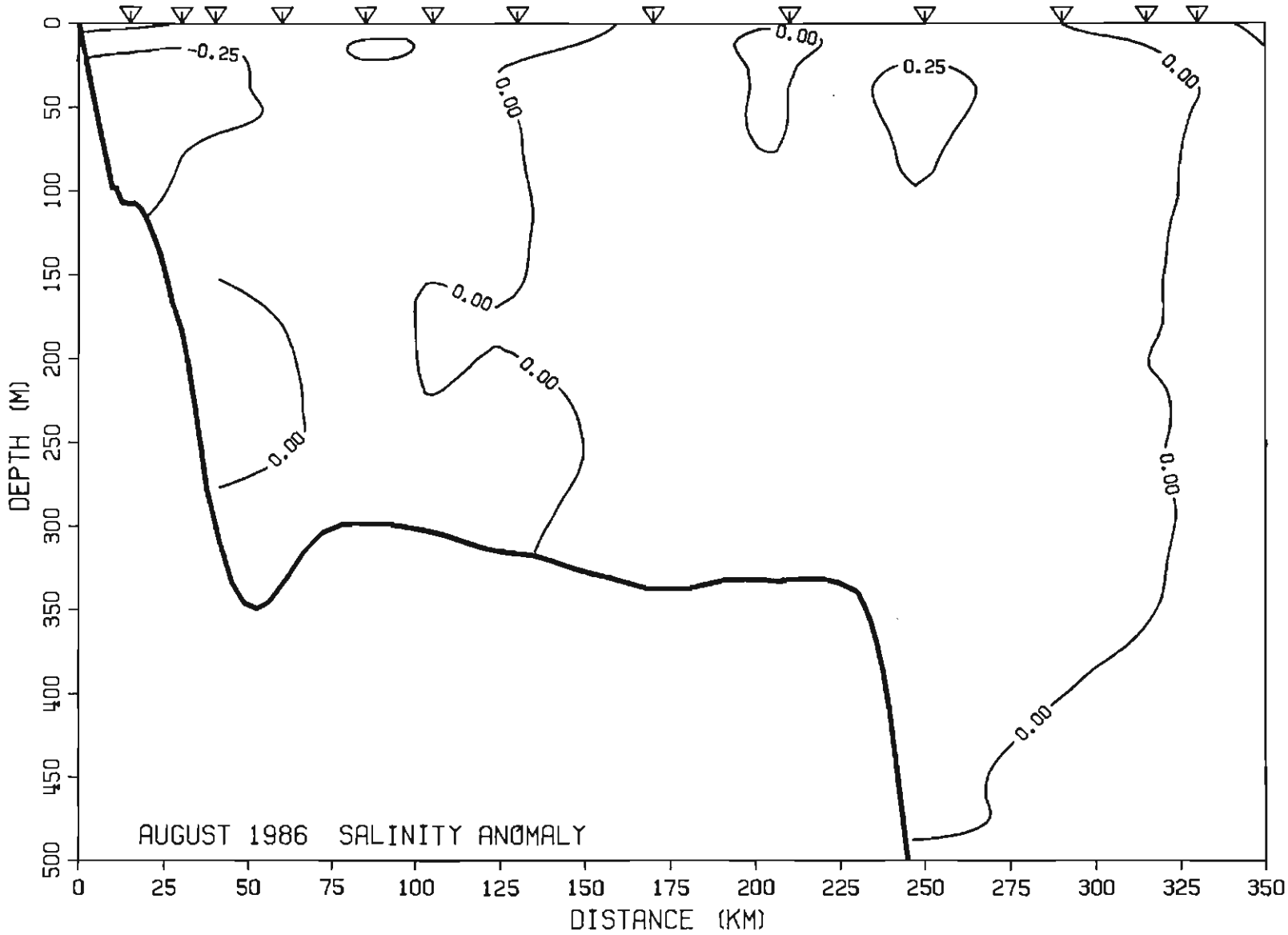

JULY 1991 TEMPERATURE ANOMALY
DISTANCE (KM)
DEPTH (M)
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
0
50
100
150
200
250
300
350
400
450
500
-3.0
-2.0
-1.0
0.0
1.0

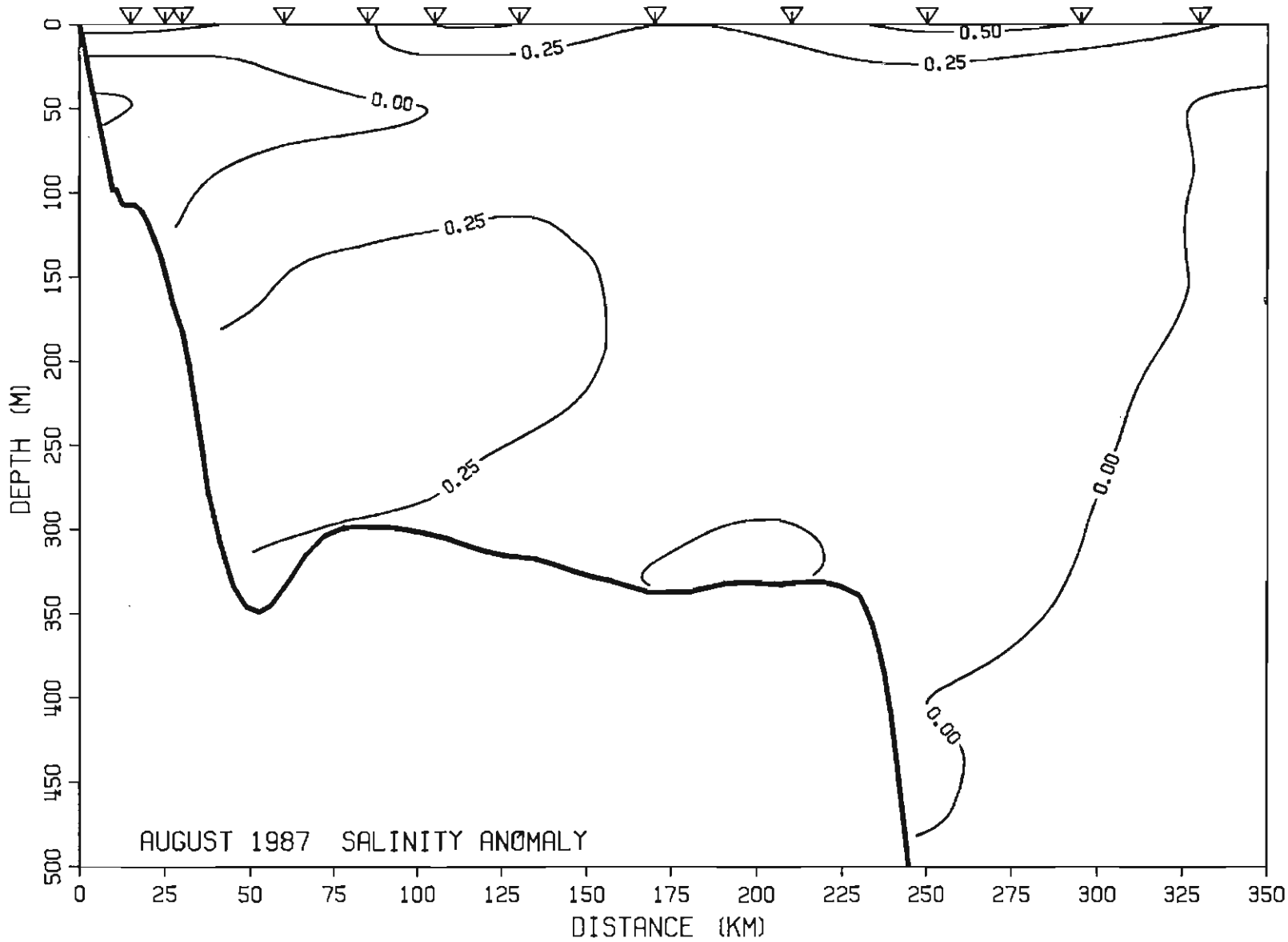

JULY 1992 TEMPERATURE ANOMALY
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
-4.0
-3.0
-2.0
-1.0
0.0

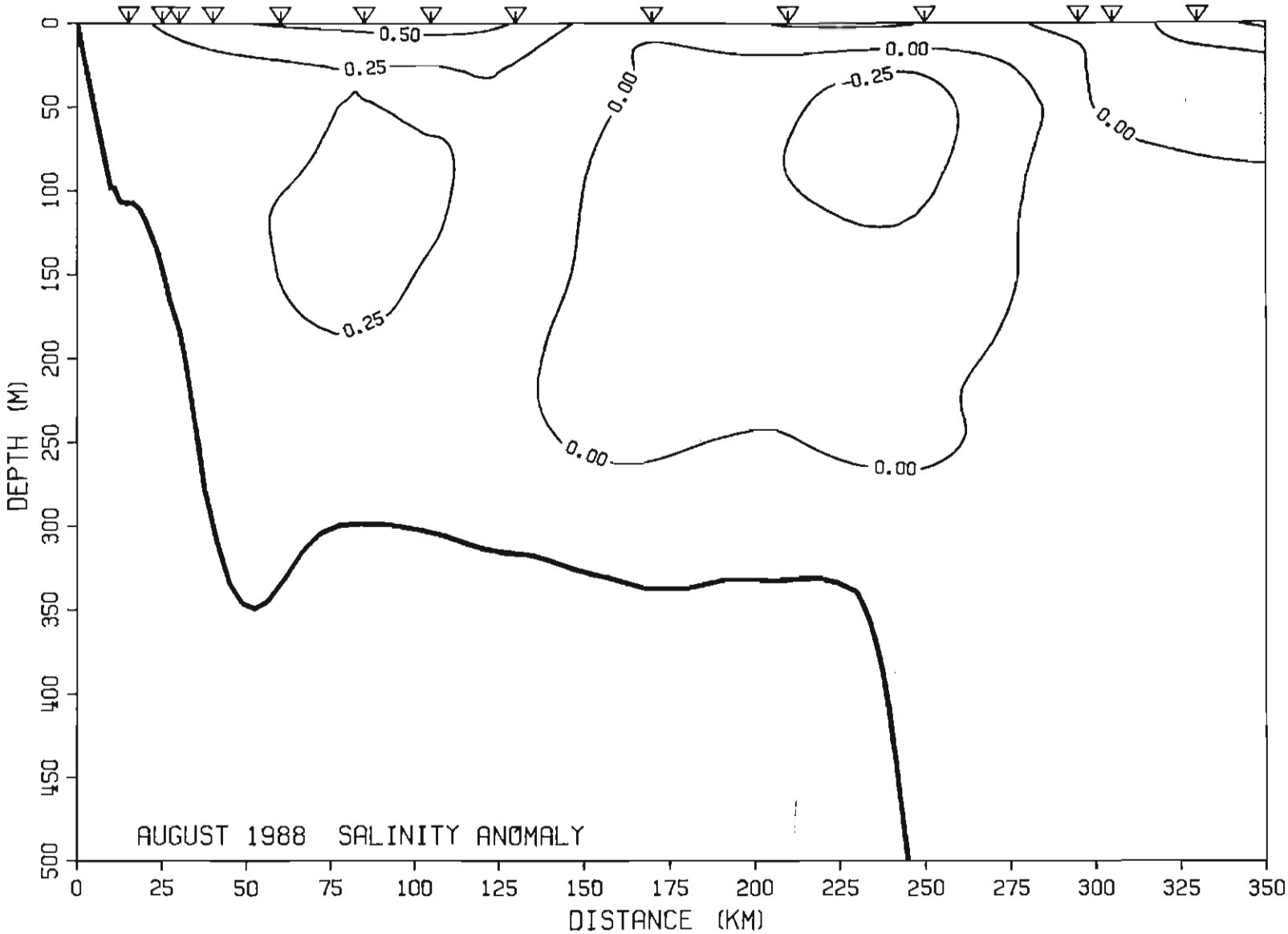
APPENDIX I. The 1984 to 1992 summer salinity anomalies.

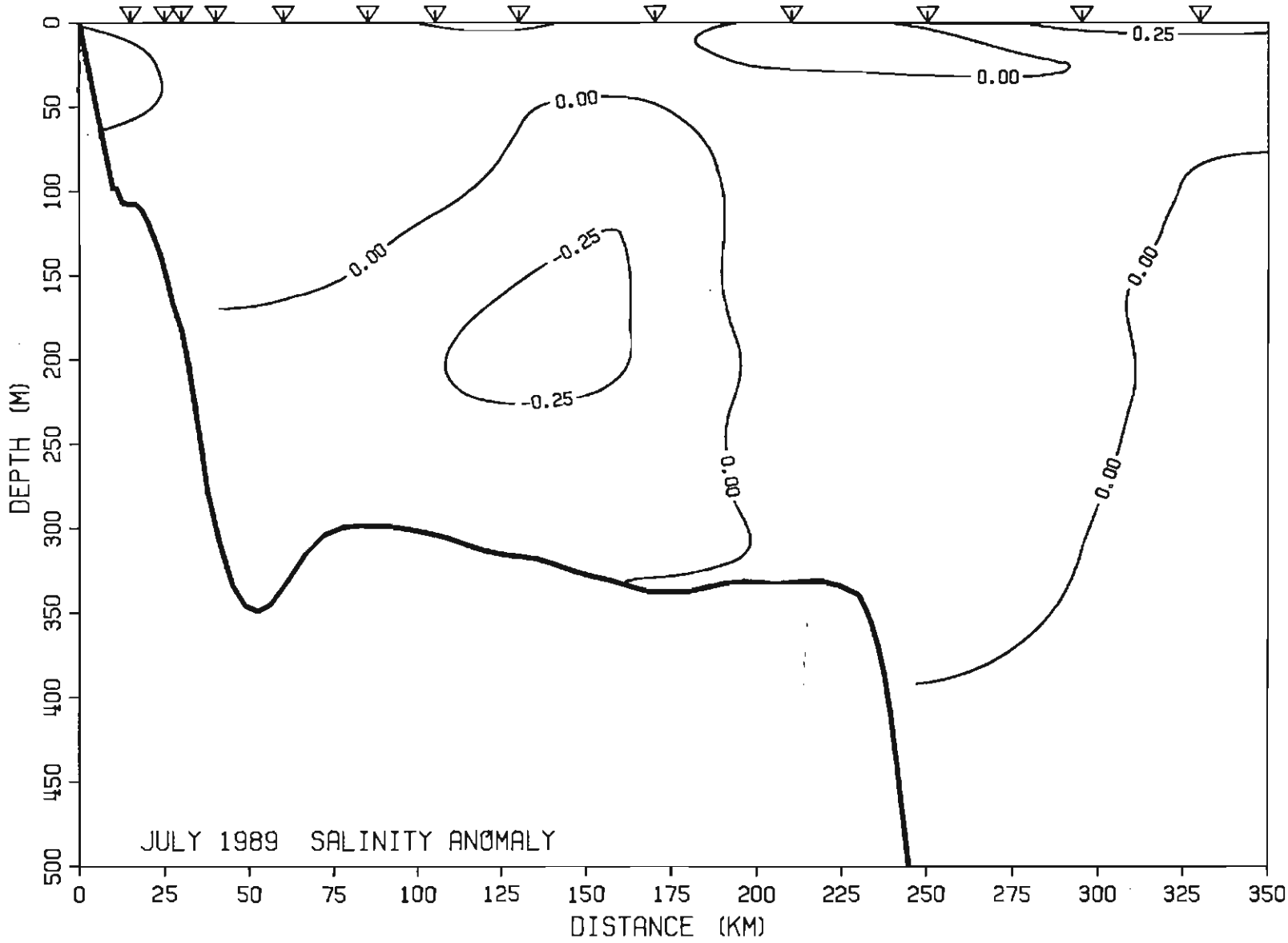

JULY 1984 SALINITY ANOMALY
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
-0.50
-0.25
0.00
0.25
-0.25
-0.50
0.00
-0.25
-0.25
-0.25
0.00

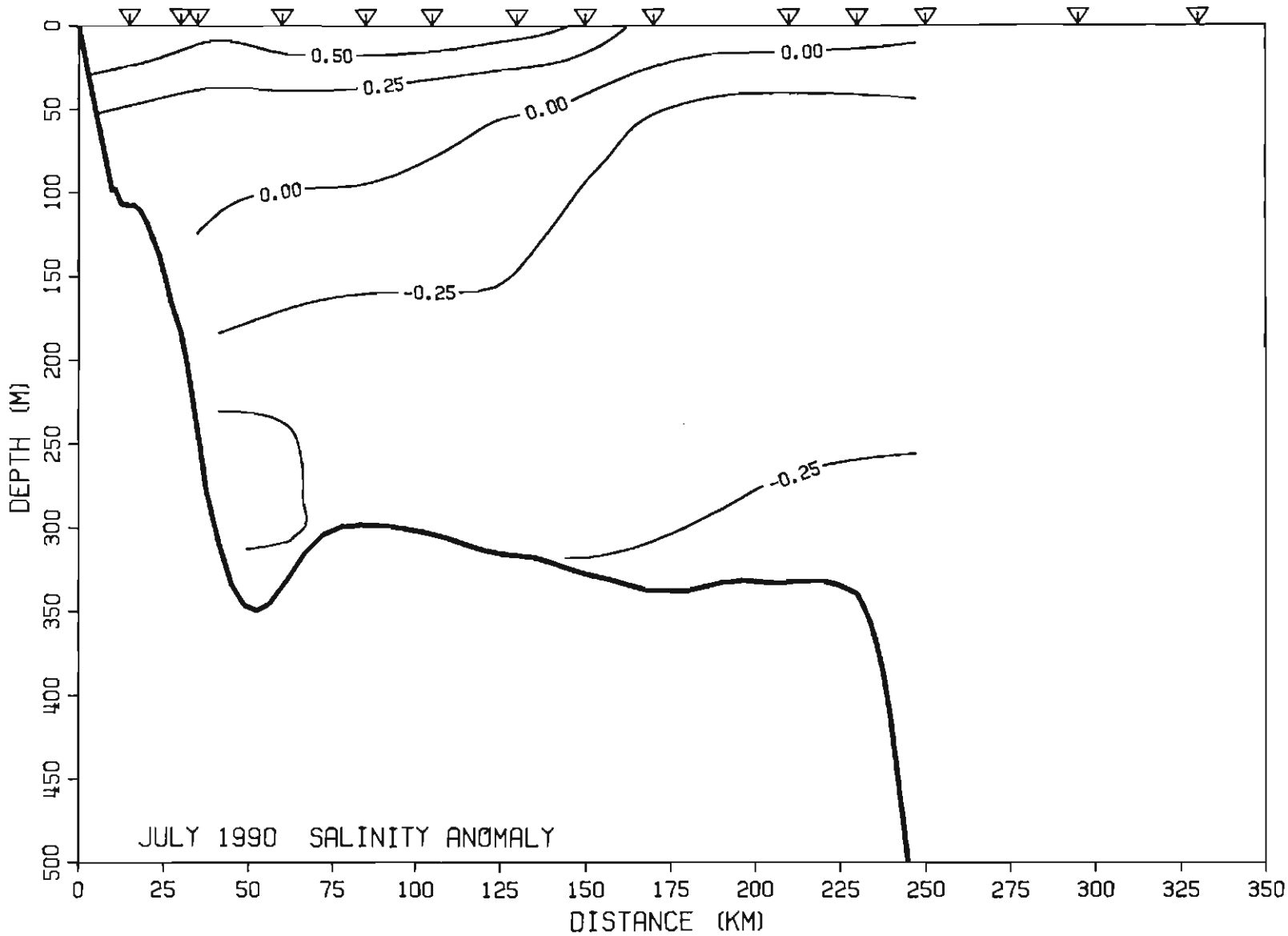

AUGUST 1985 SALINITY ANOMALY
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
0.00
-0.25
-0.25
-0.25
0.00
0.00
0.00
0.00

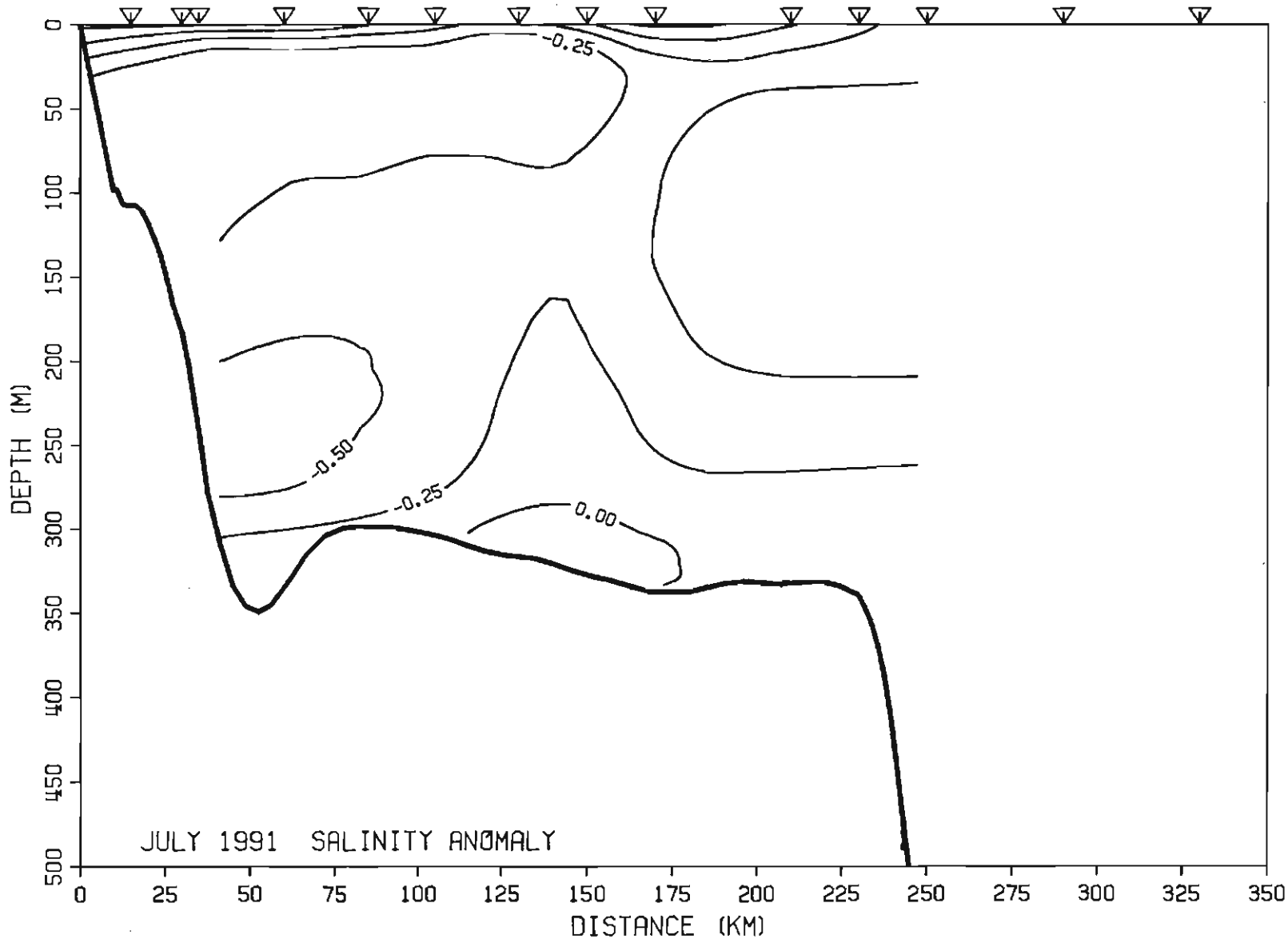

AUGUST 1986 SALINITY ANOMALY
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
-0.25
0.00
0.25

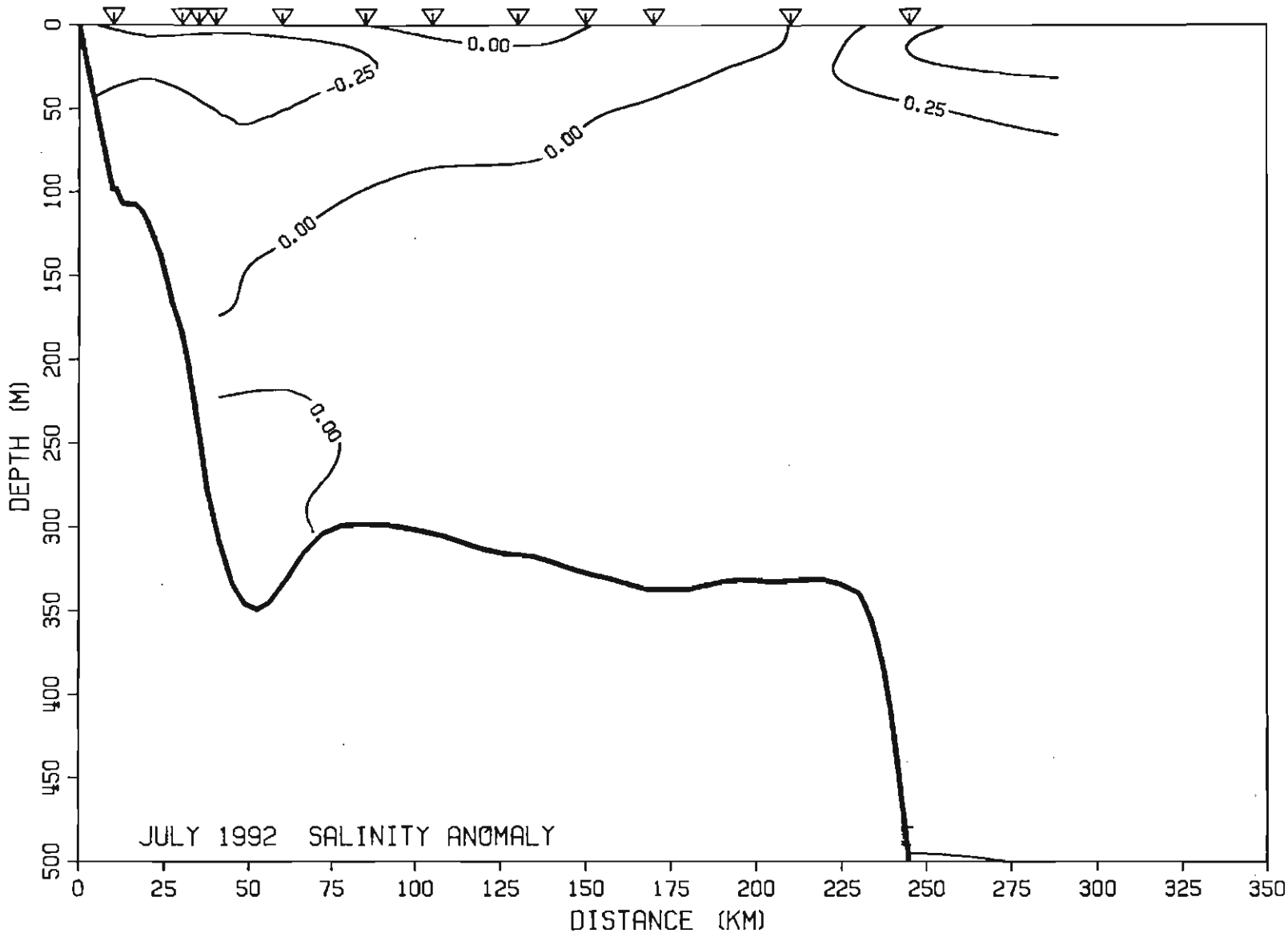

AUGUST 1987 SALINITY ANOMALY
DEPTH (M)
DISTANCE (KM)
0.50
0.25
0.00


AUGUST 1988 SALINITY ANOMALY
DEPTH (M)
DISTANCE (KM)
0.50
0.25
0.25
0.00
0.00
-0.25
0.00
0.00
0.00
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350


JULY 1989 SALINITY ANOMALY
DEPTH (M)
DISTANCE (KM)
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
0.25
0.00
0.00
0.00
-0.25
-0.25
0.00
0.00
0.00


JULY 1990 SALINITY ANOMALY
DEPTH (M)
DISTANCE (KM)
0.50
0.25
0.00
0.00
0.00
-0.25
-0.25
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350


JULY 1991 SALINITY ANOMALY
DEPTH (M)
DISTANCE (KM)
-0.25
-0.50
-0.25
0.00
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350


JULY 1992 SALINITY ANOMALY
DEPTH (M)
DISTANCE (KM)
0.00
-0.25
0.25
0.00
0.00
0.00
0
50
100
150
200
250
300
350
400
450
500
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350