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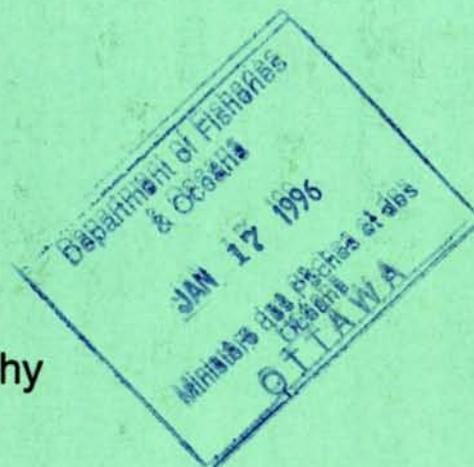
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Oceanographic conditions off the Scotian Shelf during mesopelagic resource inventory cruises, 1984-89

R.G. Halliday, D.E. Themelis
C.E. Dale, and G.D. Harrison

Marine Fish Division
Science Branch
Maritimes Region
Bedford Institute of Oceanography
P.O. Box 1006, Dartmouth
Nova Scotia
B2Y 4A2



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Marine Fish Division
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P.O. Box 1006, Dartmouth
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ABSTRACT

Halliday, R.G., D.E. Themelis, C.E. Dale, and G.D. Harrison. 1995. Oceanographic conditions off the Scotian Shelf during mesopelagic resource inventory cruises, 1984-89. *Can. Manuscr. Rep. Fish. Aquat. Sci.* 2327: 303p.

Water temperature and salinity data, collected during 11 mesopelagic resource inventory cruises conducted in 1984-89 in the continental slope region between 55 and 65°W, are presented. These data are analyzed to define water mass boundary positions in the upper 450 m during the period of each cruise. Charts of surface boundary positions based on satellite infrared imagery are used as aids in interpreting cruise data. Small numbers of XBT casts to 1830 m and CTD casts to 1000 m provide data for deeper waters. The variation of temperature and salinity over time at a fixed location (41°00' N 61°30' W) is also described based on three occupations for periods of 1.5 to 3.5 days.

RÉSUMÉ

Halliday, R.G., D.E. Themelis, C.E. Dale, and G.D. Harrison. 1995. Oceanographic conditions off the Scotian Shelf during mesopelagic resource inventory cruises, 1984-89. *Can. Manuscr. Rep. Fish. Aquat. Sci.* 2327: 303p.

On présente ici des données sur la salinité et la température de l'eau recueillies durant onze voyages d'évaluation des ressources infrapélagiques réalisés de 1984 à 1989 sur le talus continental, entre 55° et 65° de longitude O. On analyse ces données afin de définir les positions limites de la masse d'eau dans la couche supérieure de 450 m au cours de chacun de ces voyages. Des cartes des positions limites en surface, établies par imagerie satellitaire infra rouge, servent à interpréter les données. Un petit nombre de lancers de bathytermographe largable à 1830 m et de sonde CTD à 1000 m fournit des données sur les eaux plus profondes. On décrit aussi les variations temporelles de salinité et de température en un point fixe (41° 00' de latitude N. et 61° 30' de longitude O.), fondées sur trois périodes d'observation allant de 1, 5 à 3, 5 jours.

INTRODUCTION

In 1984, the Marine Fish Division (MFD) of the Biological Sciences Branch (BSB) at the Bedford Institute of Oceanography (BIO) initiated an investigation of the fauna of the continental slope and adjacent oceanic areas. The first cruise, aboard the research vessel *Lady Hammond* (H127) in 1984, was mounted jointly with the Invertebrate and Marine Plants Division (IMPD) of BSB and with the Atlantic Reference Centre (ARC), St. Andrews, N.B. This cruise conducted bottom trawling on the slope and also sampled the mesopelagic fauna south of the shelf edge off Nova Scotia. Arrangements were made in the winter of 1986 a) for a joint cruise with IMPD on the research vessel *Alfred Needler* (N057) to expand a juvenile squid survey at the Gulf Stream edge south of Nova Scotia, to include a wider faunal spectrum and to sample a greater area; and b) to acquire the fish component from samples taken during an immediately subsequent cruise by the research vessel *Gadus Atlantica* (G121) on a juvenile squid survey conducted further to the east by the Science Branch, Newfoundland. In the autumns of 1986 and 1987 MFD, in cooperation with the Department of Biology, Dalhousie University, conducted broadscale surveys (N067, N089) of the mesopelagic fish fauna in the Slope Water area between the Gulf Stream and the shelf edge and from the western Scotian Shelf (about 65°W) to the Tail of the Grand Bank (50°W). These exploratory surveys were used to develop sampling methodologies for a series of standard surveys to follow.

The standard survey series was conducted in 1988-89 and consisted of six cruises (N096, N110, N112, N119, N122 and N126). Collectively, these cruises provided sampling every second month of the year in an area between the shelf edge and 41°N south of the Scotian Shelf between 59°W and 63°W. They were conducted cooperatively between MFD and the Departments of Biology at Acadia and Dalhousie universities and with assistance from the ARC.

A primary objective of all of these cruises was to investigate the distribution of mesopelagic organisms in relation to oceanographic factors. Thus, observations of temperature and salinity in surface waters, and in subsurface waters to at least 450 m and sometimes deeper, were an integral part of the cruise plans. This Report presents a summary of the oceanographic data collected on these 11 cruises and provides a description of oceanographic conditions in the area sampled during each cruise. Interpretations of the cruise data are aided by reference to the oceanographic analyses for the Gulf Stream-Slope Water area provided by the United States National Oceanic and Atmospheric Administration (NOAA), which are based on sea surface infrared imagery using satellites supplemented by sea surface temperature observations from ships of opportunity. The results presented in the Report are for use in analyses of faunal distributions.

The Slope Water region is the area between the edge of the continental shelf to the north and the Gulf Stream to the south and extends from Cape Hatteras in the west to the Tail of the Grand Bank in the east. This area has also been referred to as the Slope Sea (Csanady and Hamilton 1988), a term which allows a useful distinction to be made between this geographic area and the water masses which occupy it. The main water mass in the upper 500 m or so of the Slope Sea is Slope Water, as defined by McLellan (1957), which occupies all but its extreme northeastern part. Slope Water is a warm, high salinity, water mass, similar in characteristics to

North Atlantic Central Water (Sargasso Sea water - NACW) from which it is predominantly derived. Labrador Water enters the Slope Sea from the northeast in the Labrador Current (LCW) and is modified by mixture with Slope Water to form what McLellan (1957) labelled Coastal Water, and it is this water mass which generally occupies the northeastern Slope Sea. Gatiien (1976) equated the term Coastal Water to a narrow surface layer adjacent to the continental shelf with the characteristics of shelf water and labelled deeper layers as Labrador Slope Water, and thus required the relabelling of McLellan's Slope Water as Warm Slope Water. The terms chosen for use in this Report are Shelf Water (SHW) to denote water typical of that overlying the continental shelf and occupying no more than the top 100 m or so of the water column, Labrador Slope Water (LSW) for cold, low salinity, water deeper than 100 m and Warm Slope Water (WSW) to denote waters in the top 500 m over continental slope and oceanic depths which have warm salty characteristics, and lie north of the Gulf Stream (GS). (Temperature versus salinity plots characteristic of these water masses are illustrated in Appendix 2.) Earlier analyses of the zoogeography of mesopelagic fish faunas in the Northwest Atlantic (e.g. Jahn and Backus 1976) used the 9°C isotherm at 200 m to define the boundary between WSW and LSW and the 15°C isotherm at 200 m to define the boundary between WSW and the GS, following Worthington (1964). These same conventions are used, for consistency, in this Report.

The Slope Sea is an oceanographically very dynamic area. North of Cape Hatteras, the Gulf Stream forms meanders that are frequently spun off forming Warm Core Rings (WCRs). These may dissipate in the Slope waters or be recaptured by the Gulf Stream. There is also extensive intermixing of Labrador and Warm Slope waters and, in surface layers, Shelf Water is frequently drawn off the shelf and entrained in Slope waters. Thus, water characteristics can vary greatly over quite short distances (<10 km) or at the same geographic location over short periods of time (days).

MATERIALS AND METHODS

The dates of the 11 cruises, the number of vertical profiles of temperature collected using expendable bathythermographs (XBTs) and of temperature and salinity collected using a conductivity-temperature-depth recorder (CTD), and cross-references to Tables 2-12 containing detailed listings of station data for each cruise, are provided in Table 1. In Tables 2-12, and in all figures, XBT and CTD stations are numbered independently in X and C series, respectively. Associated with each XBT and CTD profile, sea surface temperature and salinity observations were also collected, except that on H127 and G121 temperature only was observed. On CTD casts (other than on H127 and N057), independent observations of temperature and salinity were made at the deepest point of each cast to check instrument accuracy.

Surface water samples were obtained using a bucket and surface temperatures were determined by thermometer. Subsamples of the water were retained for laboratory determination of salinity using a Guildline Autosol Model 8400. A Guildline High Precision Oceanographic CTD was used except on N057 when a Guildline Portable unit was used. On N089 and subsequent cruises the CTD was mounted on a General Oceanics rosette sampler equipped with a reversing water bottle to collect a water sample at known depth. Temperature was determined

from the bottle thermometer and salinity as for the surface samples.

The CTDs were calibrated prior to and between usages. However, as a result of a conductivity cell malfunction no usable salinity data were obtained on H127. Also, the portable unit used on H057 provided salinity readings which were consistently high compared to surface salinity observations, the only independent salinity data collected on that cruise. An overall correction of -0.75 was applied to those data. Although large, this correction should be reliable as the CTD and Autosal surface salinities at each station were highly correlated ($R^2=0.995$, $n=13$). For the seven subsequent cruises on which CTD data were collected, comparisons with subsurface salinity samples indicated close agreement. Deviations of CTD readings from bottle salinities lay between +0.05 and -0.06 in over 90% of cases (reflecting a slight negative bias in CTD readings) and outliers were scattered among cruises. Thus, no corrections were applied to these data. The data from CTD casts were edited and despiked using both standard computer edit programs and visual inspection. The data for up-casts were used for analysis except on a few occasions when malfunctions made down-cast data more complete or reliable.

Cruise data are presented in three forms: geographical plots of surface temperature and salinity from surface bucket sampling, vertical sections of temperature and salinity from just below the surface to 450 m (Appendix 1), and plots of temperature against salinity at each CTD station (Appendix 2). Temperature sections were constructed for the sampling transects occupied on each cruise and, for the last six cruises (N096-N126), several of these transects were in standard locations. Nonetheless, within the transects, station locations and spacing varied depending on prevailing oceanographic conditions, an effort being made to sample more intensively across fronts. Salinity sections were constructed for transects, or parts of transects, when enough data were available but it was only for the last three cruises (N119-N126) that there were enough data to have complete sets of salinity sections to match those for temperature. Presentation is standardized so that sections are viewed from the south, when the predominant direction of the section was east-west, or the east, when the predominant direction was north-south. As CTD data were averaged into bins using 2 m depth intervals prior to interpolation, the shallowest data illustrated in vertical sections are not necessarily representative of at-surface conditions. As the water masses of interest occupied the top 500 m of the water column, most XBTs used had a depth rating of 460 m and most CTD casts were limited to a maximum depth of 500 m. Although a few deeper XBT and CTD casts were made (to 1830 m and 1000 m respectively - Tables 2-12) these were too few to incorporate depths greater than about 450 m into sections. The T-S plots for each CTD cast in Appendix 2 aid in diagnosing the nature of the water sampled. The first figure in Appendix 2 is from McLellan (1957, figure 4) and provides the standard T-S relationships defined by McLellan for his Slope and Coastal waters, in comparison with NACW and LCW. The second figure is from Petrie and Drinkwater (1993, figure 7) and provides their derivation, from Gatién (1976), of envelopes representing T-S characteristics of WSW and LSW (for depths ≥ 100 m) and average T-S curves for NACW and LCW from Morgan (1969). The remaining figures, representing present data, can be compared to these generalized relationships and classified as to water mass at the location of data collection.

The NOAA satellite charts of water mass positions are produced every two or three days and reflect conditions on the day of issue and in the immediately preceding three day period. If reliable data are not available for that period, e.g. due to cloud cover, frontal positions in the previous period are repeated or, if also unavailable, the frontal positions are estimated. Fronts are defined on the basis of greatest surface temperature gradients from satellite imagery supplemented by sea surface temperature data from ships of opportunity, and water mass labels are assigned, by NOAA analysts. Infrared imagery gradients are representative of a very shallow surface layer but these data can be compared directly to surface bucket data.

RESULTS

Results are presented in three parts. The first provides a cruise by cruise analysis of oceanographic conditions in the upper 450 m of the water column. The second describes time series of observations at a fixed location, 41°00 'N 61°30 'W, where vertical distribution studies were conducted on three cruises. The third presents data collected at depths greater than 500 m.

Oceanographic conditions during each cruise

The 11 cruises fall into two groups, the first five being exploratory and the last six being fairly standard with regard to area of coverage and methodology. The accounts for each cruise, which are ordered chronologically, describe the vertical section data, then the surface temperature and salinity data. Satellite chart data are then compared to the latter. Conclusions about the distribution of water masses in the cruise area are then drawn which reconcile differences among data sources to the extent possible. The intermediate results of the analyses, in the form of vertical sections and T-S plots, are available in Appendices 1 and 2, ordered by cruise chronologically and numerically within cruises. As these are thus readily locatable, references to them in the text are not accompanied by references to particular figure numbers. Sea surface temperature and salinity data are provided in the appropriate figures accompanying the account of each cruise and histograms of the frequency of observations by 1°C and 0.5, respectively, are provided in Fig. 1. The latter were used as a guide in separating the observations into spatially coherent groups which could be taken as representing different water masses.

Up to five figures are used to illustrate the data and results of each cruise. The first provides a map of station locations by station number. The second illustrates the transects defined for analysis, annotated by transect number and the station numbers of transect endpoints. The boundaries between water masses at 200 m, determined on the basis of the vertical sections and T-S plots in Appendices 1 and 2, are superimposed on this second figure. The third and fourth figures show surface temperature and salinity data with interpreted water mass boundaries superimposed. The fifth figure illustrates satellite information on frontal locations during the cruise period. Interpretations of fronts in cruise data are illustrated using solid lines in the proximity of transects and dashed lines for interpolations between distantly spaced transects to indicate greater uncertainty. However, the decision to use solid or dashed lines is obviously subjective. Figures illustrating satellite data use solid lines to indicate boundaries observed in the three day period preceding the chart date, and dashed lines to indicate older data.

Cruise H127, 24 October - 5 November 1984: The first exploratory cruise extended from the western Scotian Shelf to St. Pierre Bank in the east and into the southern Laurentian Channel (Fig. 2). Stations did not extend far offshore from the shelf edge (about 100 km). No salinity data of any sort were collected on this cruise.

Sampling was not conducted along predetermined transects. Stations were selected for analysis which more or less fell along straight lines. This gave eight transects (Fig. 3) for which vertical temperature sections could be derived. On section 1, a front was observed between X9 and X10 and temperatures seaward as high as 23°C in the top 50 m indicate the presence of a WCR. A tongue of cold, probably shelf, water of less than 8°C at about 75 m extended as far offshore as X9 (over bottom depths of about 1700 m - Table 2). However, WSW (water >9°C at 200 m) extended shoreward under this tongue at least as far as X3 (800 m bottom depth). Section 2 (split into 2A and 2B for presentation) was occupied at its west end by the WCR identified in section 1 as far east as X15 and in its remainder by WSW with a temperature of about 12°C at 200 m. However, a number of localized cold spots occurred between 50 and 150 m. A strong, subsurface front occurred on section 3 at X33. A cold band of SHW extended slightly south of X33. Its core temperature of less than 2°C was found at X35. Although a narrow band of WSW (>9°C) extended under the SHW to X34, most of the deeper water appeared to be LSW. Section 4 across the southern slope of Banquereau and the Laurentian Channel mouth was predominantly cold with only slight traces of >9°C water at about 200 m suggesting some stirring. Section 5 up the Laurentian Channel contained cold water <8°C, except at the surface. Section 6, south from the eastern tip of Banquereau, encountered the WSW front at about C43. Again cold water at about 100 m overlay warm water at 200 m over a distance of approximately 75 km. Section 7 crossed this front slightly to the west, but at this location the transition was more abrupt. Section 8 extended along the shelf slope at about the central Scotian Shelf and illustrated that, at this location, WSW extended to the shelf edge. Thus, the major subsurface oceanographic features (superimposed on Fig. 3) were that WSW extended to the shelf slope west of about 60°W but east of that there was a band of LSW, overlain by SHW, next to the shelf. A WCR occupied the southern and western ends of sections 1 and 2, respectively.

Surface temperature data fell into three groups, those between 8 and <13°C, between 14 and <20°C, and 22-23°C (Fig. 1). (Note that a temperature of, say, 8°C refers to all records between 8.0 and 8.9°C, and so on.) All of the 22-23°C records were associated with the WCR identified by subsurface data (Fig. 4). The coldest temperatures, less than 13°C, all occurred in the northeast corresponding to the locations occupied by SHW at the surface. Thus, these temperature changes, from coldest to warmest, were representative of SHW, WSW and a WCR.

Reliable satellite data for the cruise area in the appropriate period are scant. The satellite charts of 26 and 29 October, the most appropriate ones for transects 1 and 2A, provide no reliable data west of 62°W and it is necessary to rely on the chart for 24 October. This shows a WCR at the western end of transect 2A, as in cruise data, but indicates that WSW did not extend to the shelf edge at that longitude and, furthermore, that there was a band of SHW extending well south of the shelf at about 62°W (Fig. 5). The chart of 29 October shows that transect 2B was in part in WSW, SHW and a WCR. That of 31 October, confirmed by that of

2 November, shows all water to the northeast of transect 2B to be in SHW except for the most seaward stations on transects 6 and 7 as in cruise data. The chart for 5 November shows that transect 8 (conducted 2-4 November) was in WSW, as the bulge of WSW between 60 and 62°W first observed in the 31 October chart (Fig. 5) continued to lie against the shelf slope.

The data sets are in quite good agreement overall, particularly east of 60°W. West of this, cruise data indicate that WSW extended to the shelf edge whereas satellite data showed more offshore limits for SHW at the surface.

Cruise N57, 10-20 February 1986: The second exploratory cruise extended south from the central and eastern Scotian Shelf to approximately 39°N. Four sampling transects were completed, the first parallel to the shelf edge over bottom depths of 1400-3000 m and the remaining three in a north-south direction further offshore (Fig. 6).

Four vertical oceanographic sections were constructed from XBT and a small number of CTD casts (Table 3, Fig. 7). On the first section, a subsurface tongue of WSW extended from the western end (C1) to station X10 in the east (except at X4), but cold SHW occupied the surface layer along the entire section. On section 2A at 57°30'W, WSW overlain by cold low salinity water (<6°C, <33.5), apparently SHW, occupied the northern part, but the GS boundary lay between X17 and X18 at 41°20'N on 14 February. This boundary was crossed in the reverse direction 12 hours later on 15 February (section 2B). The boundary was marked by temperatures >15°C and salinities exceeding 36.0 at 200 m to its south. To its north, WSW had a temperature of about 12°C and salinity of 35-35.5 at 200 m. Section 3 at 60°30'W was also occupied by WSW to the north but, in contrast to section 2, surface layers were also warm, particularly south of 40°40'N (station X30). The GS boundary was located just south of X33 at 39°30'N. The short section 4 was entirely within WSW.

The T-S plots for this cruise cannot be considered very reliable considering the large correction to the salinity measurements that was required. Nonetheless, they illustrate clearly that the CTD casts were made in water typical of WSW at depths of 200 m and deeper, except for C6 and C7 which were in GS water and C8 and C9 which were on the GS/WSW boundary and oscillate between these. The surface layers at WSW stations typically had cold, low salinity water, particularly on sections 1 and 2 to the north and east.

Sea surface temperature and salinity data (Fig. 1) allow stations associated with the GS, with temperatures >16°C and salinities >36.0, to be clearly separated out. The remaining data lend themselves to several plausible interpretations but that most consistent with satellite chart data (see below) suggests that SHW and WSW are best represented by water <6°C and <33.5 and 6 to <16°C and 33.5 to <36.0 respectively. On this basis, transect 1 and the northern end of transect 2 were in SHW (Fig. 8, 9). A tongue of WSW engulfed X15 but more southerly stations were again in SHW until a sharp transition occurred from SHW through WSW to GS water between C5/C10 and X17/C9. Transect 3 was at the SHW/WSW boundary at its northern end and in the GS boundary at its southern tip, the remainder being in WSW. A secondary boundary within this WSW can be observed between X30 and X31 with colder, less saline, water in the

north. Vertical section data indicate that this phenomenon is limited to the upper 50-75 m. Transect 4 was entirely in WSW.

Satellite charts for 14 and 19 February, the only ones providing data suitable for comparison, suggest that all of transect 1 (of 12-13 February) was occupied by SHW (Fig. 10). Transect 2 at 57°30' W, conducted 13-14 February, was occupied by WSW south of station X14 at about 43°00' N, with an incursion of SHW from the east at 42°00' N. This incursion is reflected by the colder (3.3-5.6°C) and less saline (32.8-33.4) water at the surface in the middle of transect 2, but subsurface data indicate that this SHW was restricted to about the top 30 m. (The WSW centered on X15 was identified as a WCR but vertical section data indicate that it had largely dissipated.) The north wall of the GS at this longitude was estimated (not observed) to be at about 40°35' N, whereas cruise data showed it to be at 41°15' N on 14 February. The northern end of section 3 (17-18 February), according to satellite charts, was in WSW. The north wall of the GS at this longitude was observed in the 19 February chart at about 39°25' N coincident with the sea surface data. Section 4 (18-19 February) was located entirely in WSW in satellite, as in cruise data.

There was reasonable agreement, then, between satellite and sea surface and subsurface data with regard to the position of the GS when allowance is made for the fact that the satellite position on transect 2 was an estimate only based on much earlier data. The satellite data boundary between SHW and WSW, when compared to sea surface data, can be seen to separate waters with a temperature and salinity above and below about 6°C and 33.5. Subsurface data indicate that transect 2, north of the GS, was entirely in WSW, with 200 m temperatures about 12°C and salinities 35.0-35.5. Transect 1 also showed a substantial presence of WSW in subsurface tongues centered on about 150 m. There was, therefore, poor correspondence between surface and subsurface fronts between SHW/LSW and WSW.

Cruise G121, 21 February - 9 March 1986: This cruise, directed towards sampling juvenile squid, conducted a transect south from St. Pierre Bank to the Gulf Stream and subsequently occupied short transects across the Slope Water-Gulf Stream boundary (Table 4). The transects shown (Fig. 11) are those on which fishing stations were also conducted. The northern part of section 1 was occupied by LSW overlain by water of 4°C or less to 100 m, except at station X10 at which a filament of warm water occurred. The northern boundary of WSW occurred between X15 and X16 at 42°45' N at 200 m, but the surface layer boundary was found at X18 (42°20' N). The GS was located at X38 (39°00' N). The southern ends of the remaining sections approximate the GS boundary.

The satellite chart of 21 February (24 February chart - no data) provides observational data for the position of the SHW/WSW front on transect 1 (22-23 February) at about 41°20' N, well south of the subsurface boundary and also of the near-surface boundary based on cruise data. The interpreted feature in satellite data appears to correspond (at about X25) with a secondary boundary generated by a lens of cold surface water between X20 and X25. The GS was observed in satellite data only in the charts for 21 February and 5 March which bracket the cruise observational dates and in both cases its location approximated that observed in cruise data

(Fig. 11). Thus, cruise and satellite data can be considered to be in agreement regarding GS location but not regarding the SHW/WSW front.

Cruise N067, 25 August - 5 September 1986: This exploratory cruise conducted transects in a sawtoothed pattern between the shelf edge and about 42°N except for a southeastern excursion south to 40°N and as far as 54°W (Fig. 12). Hydrographic stations (Table 5) can be arranged to form 13 transects (Fig. 13).

Vertical sections 1-3 extended to the shelf edge at the central part of the Scotian Shelf. These indicate that WSW extended onto the slope in this area although a tongue of colder SHW centered on 50 m overlay it to station X7 on section 1, X11 on section 2, and X19 on section 3. On sections 4 and 5 WSW was apparently located further offshore, the boundary being at X29 at the northern end of section 4 and between X32 and X33 on section 5 (Fig. 13), although WSW occurred still in the 100-200 m layer at the most northern stations on these sections and could have extended closer to the slope. A WCR occupied the southern parts of sections 3 and 4 from X20 to X25. Shelf water was again encountered on section 6 at its northern extremity (X45), but the remainder of section 6 was in WSW. On section 7 SHW extended far offshore to X51. Although 9°C water extended at 200 m more or less to the northern end of this section, the primary front of WSW was also at X51. Section 8 was in typical WSW, as was section 9 except for a cold feature at X74 to X76. Section 10 was also WSW, with a colder spot at X83. In contrast, section 11 was composed primarily of cold water with a layer between 50 and 100 m with a core temperature of less than 0°C. On section 12 the cold layer overlay a tongue of WSW which extended to the entrance of the Laurentian Channel. Section 13 across this channel showed WSW on the west side while the east side was occupied by colder water. The evidence indicates that the waters near 0°C were of Labrador current origin.

Sea surface temperature and salinity data (Fig. 14, 15) tended to fall into three groups; the first of these had temperatures of 14 to <17°C and salinities of 31.3 to <33.0 and overlay cold tongues of SHW in the northern sections 7 and 11-13 and the northern ends of 3-6. The other two groups were characterized by temperatures and salinities of 17 to <20°C and 33.0 to <34.5, and of 20 to <23°C and 34.5-35.8. The warmest, most saline water overlay typical WSW (13°C at 200 m) or, in the case of sections 3-4 and 5-6 possibly lay over the remnants of WCRs, whereas the intermediate water overlay cooler features of WSW.

Two satellite charts, those of 29 August and 3 September, almost bracket the observation dates during the cruise (28 August-4 September) and give reliable coverage of the cruise area. That of 29 August is used for comparisons west of about 57°W (the first part of the cruise) and that of 3 September for the latter part of the cruise east of 57°W (Fig. 16). The boundary between WSW and SHW, according to satellite charts, undulated through transects 1-6 but moved away from the shelf edge east of 59°W, crossing transect 7 at its offshore extremity. The boundary then looped south close to, and possibly crossing transect 8, before extending to the northeast to about station X86 at the intersection of transects 10 and 11. This boundary corresponded quite closely to that defined by sea surface data of water <17°C and <33. Satellite data show the GS just to the southeast of transect 9, and thus outside the surveyed area.

However, five WCRs were located along the survey track. One was at the southern end of transects 3 and 4, corresponding to surface temperature and salinity of about 20°C and 35-35.5, and was clearly observed in subsurface data to a depth of at least 450 m. Another WCR was located midway along transect 6 while a third lay just to the south of this transect. It appears that both influenced surface conditions with temperatures of 20-21°C and salinities >35 occurring. Neither of these rings had important influences in deeper waters, but were recognizable by the 15°C isotherm deepening to greater than 100 m at X36 and X40. The third WCR mentioned was a large one which also extended over the southern ends of transects 8 and 9. Again surface waters were >20°C and >35 but the effects were restricted to surface layers. A fourth WCR was identified by satellite at the eastern end of transect 9 and that, and a fifth WCR, occupied all of transect 10. The fourth ring is identifiable in surface data but there was no evidence of the fifth in cruise data. Thus, the division in WSW noted in sea surface observations was the result of WCRs, which accounted for the warmest, most saline water. Agreement between surface data and satellite data was quite good although one WCR was not located in surface data. In subsurface data, only one ring had marked effects.

In summary, the oceanographic situation during this cruise was complex but the different data sets are in broad agreement, particularly for surface layers. In vertical sections only one of the five possible WCRs is clearly detectable. The 200 m WSW boundary corresponded to surface data fairly well but tended to lie slightly further north. Its position between sections 8, 9 and 10 can only be speculated upon (Fig. 13) based on surface data.

Cruise N089, 21 September - 1 October 1987: The last of the exploratory cruises, N089, looped from the central Scotian Shelf to south of St. Pierre Bank, traversed the western slope of Grand Bank to its southern tip, then extended south, before returning directly to the starting point on the central Scotian Shelf (Table 6, Fig. 17). The data were arranged into six transects (Fig. 18).

Vertical section 1, southeast from the central Scotian Shelf, featured a cold layer centered on 80 m and cool water below this. The T-S plots for stations C1-C3 on this section show C1 to be occupied by WSW at about 100-200 m but the water otherwise, at this station and at C2 and C3, had the characteristics of LSW. On section 2 these cold waters extended to X6 at about 80 m but a tongue of WSW extended west at 100-200 m as far as X4. Stations east of X6 were in WSW and, at X7, there was evidence of a WCR which affected temperatures to about 200 m. The T-S plot for C4 was typical of WSW. Colder water recurred, centred on about 50 m, on section 3A as far south as X14 but was underlain by WSW as far north as X17 on section 3B. The salinity section for transect 3B showed water >35.0 as far north as C7, supporting this latter conclusion. The T-S plots for C5-C8 show, for C5-C7, WSW occupying depths below about 70 m but with irregularities showing some mixing. Station C8 was predominantly LSW below that depth. Section 4 had a complex temperature structure suggesting mixing but was nonetheless predominantly occupied by cool water. The only T-S plot available for this transect (C9) indicated occurrence of Labrador Current water at about 50 m then a layer of LSW separating that from WSW at 150-200 m, and at deeper depths alternating bands of Labrador Current and LSW. Section 5, which extended due south from the Tail of Grand Bank, was also occupied in its northern part by the Labrador Current with temperatures <4°C and salinities <34.5. The T-S

plot for C11 showed this station to be in pure Labrador Current. At C10 a pocket of LSW occurred at 100-150 m, whereas C12 was in LSW. From C12 south to X33 the water can be classified as LSW, the boundary with WSW being at about X34. Section 6A crossed into the GS at about X39 and remained within water with GS characteristics to X46 where the section reentered WSW. The T-S plot for C14 is typical of GS water. Section 6B extended through typical WSW (13°C and 35.5 at 200 m) from X47 to X54. Station X54 was close to X6 on section 2 where the WSW boundary was also found. A tongue of warmer water also occurred nearer the coast at X56 indicating a complex interleaving. The locations of fronts at 200 m are illustrated in Fig. 18.

Sea surface temperatures were mainly between 16 and 18°C with a mode at 17°C (Fig. 1). A second mode occurred at 22 - 23°C and a few observations were as low as 10°C . Surface salinity data had a mode at 32.5 - 32.9 and a tail of observations extending to 36.5 . The lowest temperatures $<13^{\circ}\text{C}$ were associated with the Labrador Current which can be distinguished rounding the Southern Grand Bank also by a localized area of low salinity (32.3 - 32.6) (Fig. 19, 20). The highest temperature water (22 - 23°C) was associated with high salinities (>36) on transect 6A and represented GS water. The remaining water fell into two categories, warm, saline WSW (18 - 20°C , 33.5 - 35.9) and colder, lower salinity SHW/LSW (13 - 17.9°C , 31.5 - 33.4). A batch of particularly warm, saline water (19.5 - 22.7°C , 35.2 - 35.9) occurred in WSW near the intersection of transects 2 and 6B ($42^{\circ}30'$ N, 58°W) suggesting the presence of a WCR, but vertical sections indicated this was essentially a surface water phenomenon.

The satellite charts of 25 September and 30 September provide the greatest amount of relevant observed data but that of 28 September is drawn upon for the most eastern part of the area (Fig. 21). The boundaries in these charts correspond quite closely to those identified in sea surface data. The WSW boundary came close to the shelf edge at 57°W and also at 53°W . The particularly warm water centered on $42^{\circ}30'$ N, 58°W was recognized by satellite, although not attributed to a WCR. The WSW/SHW boundary at the western end of transect 6B in the 30 September chart was located between X56 and X57 but surface data indicate that this was a secondary boundary and that the primary boundary remained substantially further offshore.

There was a good correspondence between surface and vertical section data for various features. The WSW boundary at about 59°W , for which there are two measurements six days apart, was one of these features, as were the Labrador Current and GS observations, although the western edge of the GS was offset by a couple of stations. The primary disagreement was that the subsurface WSW boundary occurred on transect 3, about 44°N , and not on transect 2 as in surface data. This implies that WSW extended, in subsurface layers, over a greater area to the northeast than it did at the surface. However, the interpretation in Fig. 18 must be viewed as fairly speculative as there were large areas without observations.

Cruise N096, 15 - 26 February 1988: Cruise N096 was the first standard cruise which sampled in a block between the shelf edge off Nova Scotia and about $40^{\circ}30'$ N and between longitudes $59^{\circ}00'$ W and $64^{\circ}00'$ W (Table 7, Fig. 22). The stations occupied can be arranged into six transects (Fig. 23). Temperature structure of the top 450 m of the water column can be described

in vertical sections for all six transects, but salinity sections are available for three short subsections only (Fig. 23).

Section 1 at 59°W had SHW extending in the surface layers south to station X3 but WSW underlay this water as far north as C4. Stations C2 and C3 were in LSW. The southern parts of this section were occupied by WSW of approximately 12°C and 35.5 at 200 m. Section 2, which ran in a northwesterly direction from the southern end of section 1, also contained WSW as far northwest as X15. Station C14, at the northwestern end of the section was occupied by water typical of SHW/LSW. Section 3 had cold SHW water (<7°C) as far south as C18 underlain by a bulge of WSW at 200 m almost, but not quite, to C16. Although the transect was occupied by WSW to the south, a lens of cold SHW occurred in the top 75 m between stations X21 and C20. Another diagonal section to the northwest (section 4) was in WSW except for a narrow band of LSW about 35 km wide between X29 and X31, about 110 km south of the shelf edge. Nonetheless, the surface layer, to 50 m or deeper, along the entire section (except at X30) was <7°C. Thus, the lens of cold water on section 3 (between X21 and C20) was likely an eastward extension of this cold surface layer. Section 5 consisted of WSW, again overlain by cold water. Section 6 was too short to interpret.

Sea surface temperatures and salinities each fell into two distinct ranges; temperatures between 1 and 9°C and 10 to <15°C, salinities ranged from 31.5 to <34.5 and 34.5 to 36.1 (Fig. 1). The warmer, more saline water was found in the southeast and can be characterized as WSW whereas SHW occurred to the north and west (Fig. 24, 25).

Three satellite charts are relevant in the context of this cruise, those of 19, 22 and 24 February. However, that of 19 February, relevant only to transect 1, showed the WSW/SHW boundary at about 41°20'N, well south of the boundary in sea surface data. This was rectified in the 22 February chart, when a body of "cool" WSW was identified north of the 19 February boundary (Fig. 26). This body of water had a northern boundary on transect 1 close to that in sea surface data. Correspondence between data sets is exact on transect 2. Two reliable estimates are available from satellite data (those of 22 and 24 February) for transect 3 (conducted 22-23 February). The front was moving west quite rapidly at that time and agreement between satellite and surface data is good. All remaining stations were in SHW according to both data sets.

There was a substantial offset between the surface and subsurface fronts. Subsurface WSW fronts were substantially closer to the shelf edge than surface water fronts on transects 1-4 and there was an intrusion of WSW underlying all of transect 5.

Cruise N110, 17 - 28 October 1988: The second standard cruise sampled along the five transects occupied on the first cruise (N096) except that transect 3 was relocated to 61°30'W (from 61°20'W). This revised location was retained for subsequent cruises. For this cruise only, three additional transects were occupied, transect 6 being a partial duplication of transect 3, transect 7 being a diagonal northeast-southwest transect between 61°30'W and 64°W, and transect 8 was a south to north transect at 64°W (Table 8, Fig. 27, 28).

The vertical section on transect 1 at 59°W contained typical WSW solely, as far north as about station C3. Stations C1 and C2 contained predominantly LSW with WSW interleaved at intermediate depths and had a surface layer of low salinity (<33.5) SHW. Transect 2 had particularly warm water at its southeastern extremity (as had transect 1) and a tongue of saline water of about 36 extended at 100 m as far northwest as somewhere between C8 and C9. A block of cold, low salinity LSW occurred, centered on Station C10. A greater influence of WSW was noticeable further to the northwest but both temperature and salinity remained lower than at station C9, and those to the southeast. Section 3 was occupied by LSW to the north of X19, and WSW to the south of it, at 200 m. Surface layers were more complex with warm water overlying the cold water between X18 and X19 in the north, and with very warm water in the top 100 m from X20 south. Section 4 had this same very warm water in the southeast, station C14 being at the edge of the GS (see below), and the WSW/LSW boundary occurred in the northwest between X25 and X26. Salinity data for the southeastern half of this section showed a tongue of very saline water >36 at 100 m extending as far northwest as C17. Section 5 was entirely in SHW/LSW. Section 6 overlapped at its southern three stations (C23-C25) with the northern three of section 3 (X16-X18) three days later, and at this time was found to contain WSW, as did stations C19 and C20 to the west of this section, but the surface layer was low salinity SHW. The first stations on section 7 indicate that the WSW on section 6 may have been a pocket of warm water only as it did not extend southwest beyond C25. Nonetheless, the main WSW front occurred between C26 and C27 and the rest of the section was WSW except for a cold water lens, with characteristics intermediate between LSW and WSW, between C29 and C31, the effects of which extended mainly to 100 m, but with some effects also in deeper waters. This cold water on section 7 was likely the eastern extension of a cold layer which section 8 illustrates extended from the shelf edge as far south as X38 on that section in a continuous band centred on about 75 m. Salinity data on section 8 are in agreement with temperature data except that low salinity water actually extended to C32 at the southern terminus of the transect. The northern extent of WSW at 200 m was C35 although a small disjunct body of water >9 °C and salinity >35 occurred along the shelf edge. The T-S plots illustrate that, by C34, there was very little WSW present and, by C36, none. At C37-C41, a small amount of WSW occurred at 150-200 m.

In summary, section data indicate a complex situation which can perhaps best be interpreted by identifying primary and secondary fronts (Fig. 28). The primary front, south of which the water column was entirely occupied by typical WSW, extended from C3 on section 1 to C9 on section 2, X19 on section 3, C26/C27 on section 7, and X25/X26 on Section 4. The complex situation on section 8 and the southwestern end of section 7 does not allow ready definition of the main front. It appears to be at X38, although some low salinity SHW occurred at the surface south of this station. North of this primary front, however, an intermediate layer of WSW, cooler than that found further offshore, and partially segregated from it, lay adjacent to the shelf slope. This water occupied the north of section 2, but not of section 3, on 21 October although on 23 October it extended as far south as C25, and thus its boundary appears to have moved extensively to the southwest in the intervening two days. Although there was none of this intermediate WSW layer on section 5 at 63°00'W on 23 October, it occupied the northern part of section 8 at 64°00'W on 26 October. Also on section 8, at its southern end, WSW extended at

intermediate depths, quite far north of the primary front, taken to be at X38.

Sea surface temperature and salinity data fell into two groups (Fig. 1, 29, 30), cold low salinity water of 11 to $<18^{\circ}\text{C}$ and 31 to <34.5 and warm high salinity water of $18\text{-}23.9^{\circ}\text{C}$ and $34.5\text{-}36.3$, representing SHW and WSW, respectively. The WSW lay to the southeast, with the boundary on transect 1 being between X1 and X2, i.e. south of the subsurface front. On transect 2, the boundary, between X14 and C9, was only slightly south of the subsurface boundary. The same was true on transect 3 where the surface boundary was between X20 and X21. The subsurface boundary on transect 4 was not sharp and, consistent with this, in surface waters SHW and WSW interleaved north of C17. The northern transition on transect 7 from SHW to WSW at C27 was only slightly south of the sharp subsurface boundary. All stations west of C28/C29 on section 7 and all on section 8 were classified as being in SHW. The subsurface data at the southern ends of these sections are difficult to interpret but it appears that the primary subsurface boundary was rather further north and that WSW was overlain by a surface layer of SHW.

The satellite chart for 19 October, is the most appropriate for comparison with transects 1-4 conducted on 19-22 October. (The chart for 21 October provided little new observational data in their vicinity.) This 19 October chart indicates that much of transect 1 was occupied by a WCR (Fig. 31). The northern boundary of this WCR with SHW occurred at $43^{\circ}00'\text{N}$, close to C3 and corresponding exactly with the subsurface boundary but north of the sea surface boundary between X1 and X2 at $42^{\circ}30'\text{N}$. A southern transition from WCR to WSW at about $41^{\circ}20'\text{N}$, suggested by satellite charts, was not reflected in cruise data. The boundary on transect 2 in cruise data at about C9 ($42^{\circ}00'\text{N } 60^{\circ}21'\text{W}$) was reflected precisely in satellite data as a suggested WCR to WSW transition. Transect 3, conducted on 21 October, had its northern end in WSW according to satellite data with a boundary with SHW to the south at $42^{\circ}10'\text{N}$ (X18) and a re-entry into WSW at $41^{\circ}20'\text{N}$ (X21). The northern warm water feature was not identified in cruise data. The primary boundary on transect 3, according to cruise data, occurred at about X20 ($41^{\circ}30'\text{N}$), which corresponded quite well with the more southern boundary in satellite data. The southern tip of transect 3 in the satellite data was on the northern edge of the Gulf Stream and this boundary was intimated in cruise data at C14. (The front position from the 21 October chart is shown, as in this case that chart provided the most up to date data.) The satellite charts for both 19 and 24 October illustrate that transect 4, conducted 21-22 October, ran along the SHW/WSW boundary in its northwestern half, and this could explain the weak subsurface boundary and the interleaving in surface layers. Section 5 lay in SHW according to all information. According to the 24 October chart WSW still extended to the shelf edge north of transect 6, which was a repeat, in its southern part, or transect 3 about 2-3 days later on 23-24 October. Transect 6 was occupied by rather warmer water than transect 3 in subsurface layers but there was little difference in surface temperatures in the zone where transect 3 and 6 overlapped. Satellite data for transects 7 and 8, conducted between 24 and 26 October, suggest rapid changes in boundaries during that period. The chart for 24 October indicated that the southern halves of these transects were in WSW, but that for 26 October showed SHW extending south and encompassing all of the area that these transects traversed. The latter condition is approximately by cruise data for surface waters except that the central part of transect 7 was occupied by WSW.

There was a good correspondence overall between satellite and cruise data when allowance is made for the fairly poor satellite coverage and the apparently rapid movement of boundaries. The primary discrepancy is that satellite data showed WSW extending to the shelf edge at 61-62°W whereas this is not the interpretation given to cruise data. The situation was not clear cut, however, and subsurface data suggest strong mixing.

Cruise N112, 29 November - 9 December 1988: The third standard cruise occupied the five established transects except that transect 4, interlinking transects 3 and 5 ran roughly between their midpoints in an east-west direction rather than diagonally as in previous cruises (Table 9, Fig. 32, 33).

The vertical section on transect 1 started in the north in LSW with a sharp, subsurface boundary just south of station C6 (43°N) at 200 m, although SHW extended further south at the surface to about X4 (42°20' N). Warmer water was encountered south of X8 (41°40' N) possibly indicating the remnants of a WCR. A salinity section at the north of the transect between C3 and C6 showed this to have been occupied by water <35 except for a warm saline patch (>9°C, >35.0) centred at about 175 m at C5. Section 2 started at X14 in the boundary of the GS (or a WCR). (The location of X14 was identical to that of X11.) A front between WSW and LSW occurred between X22 and X23, although to the northwest of it there were interleaving layers of warm and cold water. On section 3, the WSW front was encountered between X32 and X33 (42°20' N), and the north wall of the GS at X37 (41°35' N). Section 4 was in WSW but west of station X41 a cold layer occurred between about 100 and 150 m. Section 5 consisted of WSW except between X46 and X48 in the south where there was a cold core of water, mainly between 70 and 150 m but also affecting the deeper layers. This cold core appears to have run from west to east and was the same body of water observed on the western half of section 4. Thus, LSW appears to have occupied the northern parts of sections 1-3 and the southern part of section 5. Remaining stations were in WSW except the most southern one of section 3, which was in the GS (Fig. 33). Stations at the southern ends of sections 1 and 2 appear to have been close to either the GS or a WCR.

Sea surface data fell into three ranges for both temperature and salinity (Fig. 1), cold fresh water closest to the shelf edge (6 to <12°C, 31.0 to <33.5), warmer more saline water further offshore (12 to <15°C, 33.5 to <35.0), and very warm, high salinity water (15-21.8°C, 35.0-36.2) at the south of transects 1, 2 and 3 (Fig. 34, 35). These ranges appear to correspond to SHW, WSW and GS/WCR waters, respectively.

The satellite chart of 2 December, relevant to transect 1 (30 November-2 December), indicates a boundary between SHW and WSW/WCR at about 42°10' N (Fig. 36) between X6 and X7. Transect 2, conducted on 3-4 December, crossed the WCR/WSW boundary at X17 according to the 2 December chart. (There were no new observations of location of that front incorporated in the 5 December chart.) The 5 December chart shows transect 2 crossing the WSW/SHW boundary at X20/X21. Transect 3, conducted 5-6 December, crossed from SHW to WSW at X34/X35 and from WSW to GS at X36/X37, based on the 7 December chart. Transect 4 was conducted 6-7 December and the 7 December chart shows the SHW/WSW boundary at

X39/X40 at its eastern end. According to the 9 December chart, this boundary was substantially further west at X42/X43 and a comparison of SHW/WSW front locations from the charts of 5, 7 and 9 December suggest rapid movement to the west over this period.

There is a broad correspondence between sea surface and satellite chart data. Both identify a warm, saline, feature at the south of transects 1 and 2 and a SHW/WSW boundary not far from it to the north and west. The boundaries of WSW and GS on transect 3 also correspond well, as does the boundary at the eastern end of transect 4. Interpretations diverge for the western part of transect 4 and the south of transect 5. Subsurface data indicate that there was a cold feature at that location and conditions could be classified as transitional. Subsurface data also identify clearly the GS at the south of transect 3 and the WCR at the south of transects 1 and 2. The primary LSW/WSW front in subsurface waters was, however, much further north than indicated by surface data.

Cruise N119, 11 - 21 April 1989: This standard cruise was abbreviated, only transects 1-3 being completed (Table 10, Fig. 37, 38).

The vertical section on transect 1 contained WSW except for a surface occurrence of SHW at its northern extremity (at stations C1-C2). A WCR influenced the top 200 m between stations C4/5 and C8, with temperatures $>15^{\circ}\text{C}$ and salinities >36.0 between about $42^{\circ}30' \text{N}$ and $41^{\circ}40' \text{N}$. On section 2, WSW occurred southeast of X2 (about $42^{\circ}\text{N } 60^{\circ}\text{W}$). Salinity in the northwest of this section was <35 and T-S plots indicate that that part of the section was occupied by LSW. On section 3 a sharp boundary occurred between C15 and X3 in subsurface waters, although cooler water extended at the surface as far south as X4. Thus, the LSW/WSW front was close to the shelf edge on transect 1, looped south on transect 2, returning fairly closely to the shelf edge again on transect 3 (Fig. 38).

Sea surface data fell into two main categories, cold, low salinity water (1 to $<5^{\circ}\text{C}$, 32 to <33.5) and warm, high salinity water (13 to $<19^{\circ}\text{C}$, 35-36.6) (Fig. 1, 39, 40). A small number of stations were of intermediate characteristics (8 to $<12^{\circ}\text{C}$, 33.5 to <35). On transect 1 the cold, low salinity water occurred at stations C1 and C2 at its northern end, the remainder of the transect being occupied by the warm, high salinity water. The possible WCR was identifiable between C5 and C8/C9 as water $>16^{\circ}$ and >36.0 . On transect 2 the transition between water types occurred between X1 and X2. It was on transect 3 that the intermediate water occurred between the cold water which occupied C13-C15 and the warm water which occurred at the southern end of the transect south of X5.

Satellite charts for the cruise period were all similar for the study area and comparisons are therefore based on that for 14 April (Fig. 41), as there were no direct observations contributing to subsequent charts. Satellite data showed WSW occupying all but the most northern station of transect 1 and that several stations at about 42°N were located on the western edge of a WCR. This corresponded well with both surface and subsurface cruise data. The WSW boundary on transect 2 was just south of X2, again as in cruise data. On transect 3 the WSW boundary was at its southern end between X5 and X6, which corresponded with sea surface data but not with

the 200 m boundary which lay at the northern end between C15 and X3. The more northern 200 m boundary corresponded, instead, with the boundary in the surface layer between cold fresh and intermediate water identified in surface data. The southern surface boundary (at X5/X6) can be observed as a minor front in subsurface data influencing only the upper 100 m. Thus, the intermediate surface water on transect 3 was cool WSW, and that $<5^{\circ}\text{C}$ and <33.5 was SHW.

Cruise N122, 5 - 15 June 1989: The fifth standard cruise, N122, occupied all five of the established transects (Table 11, Fig. 42, 43).

On transect 1 the LSW/WSW boundary was located between stations C4 and C5 where a rapid transition occurred from cold water with salinity <35.0 to WSW and, between C5 and C6, from WSW into a WCR which extended to the southern end of the transect. Salinity data confirm that WSW formed only a narrow strip between cold water and WCR with T-S relationship of GS character. The T-S plots show stations C1-C4 were in LSW. Section 2 to C11/C12 was also within this WCR, the remainder of the section being in WSW, although there was a thin layer of cooler, low salinity, water overlying this. Section 3 also was entirely in WSW. A cold temperature feature occurred at station C21, and temperatures to the south of this were much warmer in the top 100 m than they were to the north of it. Most of section 4 was also in WSW although a quite sharp transition to LSW occurred between X5 and X6. Surface waters over the WSW cooled north of X3 on this section. Section 5 indicated that the northwest end of section 4 was part of a mixing area which extend northward to the shelf edge. The temperature and salinity at 200 m remained about 9°C and 35 throughout section 5. Water mass distributions, based on the locations of these fronts, are illustrated in Fig. 43.

At the sea surface, the primary separations in frequency distributions of temperature and salinity were at 18°C and 35.0, cool, lower salinity water lying to the north and warm, higher salinity water occurring in the south (Fig. 1, 44, 45). However, reference to the subsurface data indicates that this was a secondary feature. The strong spatial coherence of the groups was something of an artifact resulting from a transect spacing which allows the remnants of a WCR feature at the south of transects 3 and 4 to be directly linked up with the strong WCR at the south of transects 1 and 2. An interpretation of surface data which is more consistent with subsurface data is one which first separates out the WCR at the south of transects 1 and 2 with temperatures and salinities of 22°C and greater and 36.0 and greater. A second boundary separating waters $<15^{\circ}\text{C}$ and <33.5 from those of greater temperature and salinity provides a SHW/WSW boundary corresponding almost exactly with the primary front in subsurface waters.

The satellite chart for 9 June, the most relevant with regard to transect 1 conducted 7-8 June, shows a boundary between SHW and a WCR at $42^{\circ}30'$ N, which was between C4 and C5 (Fig. 46). This corresponds not with the WCR boundary in cruise data, between C5 and C6 some 10-15 n mi further south, but with the subsurface boundary between LSW and WSW. Transect 2 (8-9 June), according to satellite data (9 June), recrossed the WCR/SHW boundary between C12 and C13. Transect 3 (9-10 June) crossed from SHW in the north to WSW at $41^{\circ}15'$ N to $41^{\circ}40'$ N depending on whether the satellite chart used is that of 9 or 12 June. Satellite data (14 June) show section 4 (14 June) traversing a WSW/SHW boundary between X3 and X4. All of

transect 5 was in SHW according to satellite data. Thus, satellite data also identify boundaries coinciding with the major discontinuity in surface data, and are at odds with subsurface data.

In summary, within cruise data, the subsurface water mass boundary between LSW and WSW corresponded most closely with the surface boundary separating off the coolest, least saline water ($<15^{\circ}\text{C}$, <33.5). Both surface and subsurface data also identified clearly the WCR at the south of transects 1 and 2. Satellite data correspond most closely, although by no means exactly, with the boundary most obvious in cruise surface data at 18°C and 35. However, in subsurface data it can be seen that this boundary was a feature of limited significance, restricted in its effects to the top 50 m or so. Thus, satellite data do not, overall, give a very accurate or clear perception of water mass distributions in this case.

Cruise N126, 9 - 18 August 1989: The last standard cruise, N126, also occupied the five established transects (Table 12, Fig. 47, 48).

On transect 1 vertical temperature and salinity sections illustrate that the main boundary of WSW in the north was at C4 although there was also a patch of WSW at C2. On section 2 the WSW boundary occurred at about C18. At station C10, which was the southern station on both these transects, there was evidence of warmer, more saline water indicating proximity to a WCR or the GS. Section 3 illustrated a clear LSW/WSW boundary at C21. Section 4 started in the southeast in WSW but a sharp transition to LSW occurred between X2 and C34. There was evidence at C37, and on the short section 5, that the water was rather warmer than on the northern part of section 4 but nonetheless LSW greatly predominated at these stations (Appendix 2). Water mass boundaries at 200 m, as interpreted above, are illustrated in Fig. 48.

Sea surface temperature data (Fig. 49) are difficult to interpret but salinity data (Fig. 50) fall into two quite separate categories divided at 33.5 (but 33.0 could be used equally well) which defines a front more or less identical to that exhibited by subsurface waters. However, the only clear, spatially coherent, separation among surface temperature data is that at 20°C which separates northeastern stations.

Satellite chart data for 11 August, which corresponds most closely to the time transect 1 was conducted (10-12 August) illustrate that the northern end of transect 1 was in a mixed area of warm and cooler SHW and that the boundary with WSW occurred at about $42^{\circ}50' \text{N}$ (Fig. 51), i.e. about C4 which was where cruise data showed it to be in subsurface waters and approximately the location of the 33.5 surface salinity boundary. The southern tip of transect 1 lay just north of the GS, again consistent with cruise data. Transect 2, according to the satellite chart for 14 August (transect conducted 12-13 August), crossed the WSW/SHW boundary between C18 and C19, and transect 3 (13-14 August) recrossed this boundary from north to south between C21 and C22. These boundary positions were again consistent with cruise data. Transects 4 and 5 were conducted between 16 and 18 August. However, the satellite charts for 16 and 18 August show the boundary between SHW and WSW to be unchanged from that on 14 August at about X2, as indicated by cruise data. All stations to the northwest of X2 were in SHW, according to satellite data. Thus, all data sets were in quite good overall agreement.

Temporal sampling at 41°00 'N 61°30 'W

The location 41°00 'N 61°30 'W was chosen as the primary site for faunal vertical distribution studies using an opening and closing Tucker trawl. This site was occupied on three occasions in 1989, 18-20 April (N119), 10-14 June (N122) and 14-16 August (N126). Temperature and salinity profiles were obtained approximately every 12 hours during these occupations.

Variation in oceanographic conditions within the sampling periods was noticeable in April and June but not in August. In April (Fig. 52), water temperature in the top 50 m increased by close to 2C° over the approximately two day period and the volume of water with salinity >35.5 also increased in the top 200 m, but there was little change in deeper waters. In June (Fig. 53), a layer of relatively low salinity (<34.5) and cool temperature (<11°C), centered at about 50 m, occurred during the early to mid part of the occupation, but in the latter part salinity was above 35.0 throughout the water column. Temperatures in the water column deeper than 150 m gradually decreased during the period by about -0.5C° in total at any particular depth. In August (Fig. 54), virtually no changes occurred during the two and a half day occupation.

Variation among sampling periods was also not large except for the development of a strong thermocline by June at 20-50 m which had intensified by August. At greater depths, temperatures varied between 12 and 14°C at 100 m, being rather warmer in August, and at 200 m it was 11-12°C in all seasons. At depths greater than 200 m, temperatures in June and August were almost identical. In April, however, temperatures were as much as a degree lower at each depth than they were later in the year. In all seasons bands of water with salinity >35.5 occurred in the top 200 m and, in general, water characteristics were typical of WSW.

Observations deeper than 500 m

In total, temperature data were collected from depths greater than 500 m on 75 occasions, and on 43 of these salinity data were also collected (Table 13). However, the number of observations decreased rapidly with depth. At 1000 m, the deepest operating depth for the CTD used, the number of observations of temperature and salinity were 41 and 14 respectively. At 1800 m, the deepest sampling depth for XBTs, 22 temperature observations were made.

These data are too scant to support detailed examination of temperature and salinity in deep waters in relation to time and place of collection. However, they were summarized based on categorization of the overlying water mass, as assigned in the above analysis, to see if the distinctions observed in upper layers were also reflected in these deeper waters. The deep stations were categorized by whether the subsurface layers in the upper 500 m were occupied by WSW or LSW, or by GS waters. (The WSW includes data from WCRs, as these could not be rigorously separated.) Temperature at LSW stations was, on average, slightly more than 1.5C° colder at 500 m than at WSW stations (Table 14). At 600 m this difference was slightly greater than 1.0C° and at greater depths a differential of rather more than 0.5C° was maintained. A persistent differential was observed in salinity also of about 0.1 at 500-600 m and about 0.03 in

700-1000 m (Table 14). Gulf Stream water, for which temperature data only were available, was distinctly warmer than WSW down to about 1300 m but much the same thereafter. However, data were available for only three GS stations (only two from >800 m), and these were peripheral to the GS and are not likely to be an adequate representation of the GS in deeper waters.

Two stations stood out among those assigned to LSW as being particularly cold (N089: X23 and X29), with temperatures less than 4.0°C occurring above 1000 m (from 500 m at X23 and from 800 m at X29) as well as at all deeper depths. (No salinity observations were made in subsurface waters at those locations.) These stations were located southwest and south of Grand Bank. However, no clear geographical distinctions were noted among other data.

DISCUSSION

Although a definition of WSW as water with temperature and salinity between 9 and 15°C and 35.0 and 36.0 at 200 m provided a satisfactory distinction from other water masses in most cases, its definition in surface waters was less clear. The method used here to distinguish water masses on a cruise by cruise basis by looking for separations between modes in histograms of surface temperature and salinity observations, aided by the broader view provided by satellite imagery to interpolate between transects, resulted in different definitions of boundary values of temperature and salinity for different cruises. This would, of course, be expected for temperature values, which are subject to seasonal variation as a result of solar warming, but not for salinity. Salinity values defining the SHW/WSW boundary varied between 33.0 and 34.5. These inconsistencies are, however, more apparent than real; had 33.5 been used in all cases there would be only small changes in the defined boundaries. Surface salinities of <33.5 are characteristic of Labrador Current and continental shelf waters. For separation of surface WSW and GS proper, 36.0 proved satisfactory, but WCRs represented transition conditions. On occasion, satellite data were necessary to allow a decision to be made whether high salinity water belonged to a WCR or the GS. However, in many cases patches of warmer, more saline, water within WSW, although likely the remains of WCRs, were included within the definition of WSW (in deeper as well as surface water, although these remnants were often more obvious at the surface). Surface temperatures, during standard cruises, were clearly different between SHW and WSW during winter. In February, SHW was <9°C whereas WSW was 10-15°C, and in April, SHW was <5°C while WSW was 8-18°C. However, during warmer months, the distinction between SHW and WSW with regard to temperature was much less obvious and for August none could be determined, even when surface salinity and satellite imagery were available as aids.

The primary oceanographic feature described in this analysis is the position of the front between WSW and SHW/LSW. The positions of this front at 200 m are summarized for exploratory cruises in Fig. 55 and standard cruises in Fig. 56. During exploratory cruises in 1984-87, the front lay close to the Scotian Shelf slope west of 59°W, and extended to the east at about the same latitudes but further from the slope. Standard cruises in 1988-89, restricted to the area between 59 and 64°W, showed the front to be, generally, further from the shelf slope than during the 1984-87 cruises. Nonetheless, although the primary front may at times have been quite far south of the shelf edge, the water closer to the shelf at intermediate depths was seldom

entirely LSW. It appeared often that the area adjacent to the shelf edge was a mixing zone with some of the water at intermediate depths having characteristics classifiable as WSW. This was particularly so during N110, but mixed WSW/LSW was identified on transects 4 and 5 of three other cruises (N096, N122, N126) and on transect 2 of N112. Among standard cruises, the primary front appeared more stable in position near 59°W than further to the west, and west of 62°W the frontal position was particularly variable and tended to be further away from the shelf slope. There is no obvious pattern in the variation of frontal position with season or cruise chronology. The WSW fronts in surface waters usually differed in position from those at 200 m. During exploratory cruises, the surface fronts (based on salinity data, although temperature data gave very similar results) tended to be displaced to the south of the subsurface fronts (Fig. 57). This was the case in standard cruises also (Fig. 58), with the greatest southward displacement of the surface front occurring in winter cruises and little or none being observed in summer.

There were other notable features observed in standard cruises. Transect 1 at 59°W , in five of six cases, had particularly warm and saline water occupying its southern part. In four cases a WCR was located there and in two the southern tip was classified as being in GS water. The exception was the February cruise (N096). In contrast, the western transects (west of $61^{\circ}30'\text{W}$) had cold water at various, including southern, locations in four of the five cases. (In the sixth case, N119, the cruise track did not extend to the west beyond $61^{\circ}30'\text{W}$.) It was typical that oceanographic conditions on western transects, south of the central Scotian Shelf, were complex, confused, and the most difficult to interpret.

Cruise data interpretation was greatly aided by the use of NOAA satellite charts. Precise agreement between the two data sources could not be expected as satellite data are integrated over several days whereas the ship crossed a particular front over a period of hours. Furthermore, satellite data are patchy as a result of cloud cover and there was a proportion of cases when there were no reliable satellite data during the days when a particular transect was occupied. Both satellite and cruise data provide evidence that the location of oceanographic features in this region can move substantially over periods of a few days. The greatest value of the satellite data was to provide a broad picture of the distribution of oceanographic features and its evolution over time and thus a context in which cruise data could be interpreted with greater confidence. For most of the 11 cruises it was possible to interpret cruise sea surface data in a manner consistent with satellite data interpretations. There were four exceptions where cruise data illustrated fairly convincingly that the primary front between particular oceanographic features was not where satellite data interpretations had placed it (G121, N096, N119, N122). In these cases, the features identified using satellite data as primary fronts were recognizable in cruise data as of secondary significance. However, the vast majority of interpretations of frontal positions are consistent between data sets and thus satellite data appear to provide a usually reliable indicator of Slope Sea water mass distributions, at least for surface water. However, again it must be noted that subsurface boundaries can be offset substantially from those observed at the surface.

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REFERENCES

- Csanady, G.T. and P. Hamilton. 1988. Circulation of slopewater. *Continental Shelf Research* 8: 565-624.
- Gatien, M.G. 1976. A study in the Slope Water region south of Halifax. *J. Fish. Res. Board Can.* 33: 2213-2217.
- Jahn, A.E. and R.H. Backus. 1976. On the mesopelagic fish faunas of Slope Water, Gulf Stream, and northern Sargasso Sea. *Deep-Sea Research* 23: 223-234.
- McLellan, H.J. 1957. On the distinctness and origin of the Slope Water off the Scotian Shelf and its easterly flow south of the Grand Banks. *J. Fish. Res. Board Can.* 14: 213-239.
- Morgan, C.W. 1969. Oceanography on the Grand Banks Region of Newfoundland in 1967. *Oceanogr. Rep.* 19, CG 373-19, U.S. Coast Guard, Washington, D.C.
- Petrie, B. and K. Drinkwater. 1993. Temperature and salinity variability on the Scotian Shelf and in the Gulf of Maine 1945-1990. *J. Geophys. Res.* 98: 20079-20089.
- Worthington, L.V. 1964. Anomalous conditions in the Slope Water in 1959. *J. Fish. Res. Board Can.* 21: 327-333.

Table 1. Mesopelagic resource inventory cruises: cruise designations, dates and number of oceanographic profiles conducted. (CTD: conductivity-temperature-depth recorder, XBT: expendable bathythermograph.)

Cruise	Dates	No. of Profiles		Table No. for Stn. data list
		CTD	XBT	
H127	24 Oct. - 5 Nov., 1984	17 ¹	61	2
N057	10-20 Feb., 1986	14	37	3
G121	21 Feb. - 9 Mar., 1986	-	175	4
N067	25 Aug. - 5 Sept., 1986	-	102	5
N089	22 Sept. - 1 Oct., 1987	18	58	6
N096	15-26 Feb., 1988	20	40	7
N110	17-27 Oct., 1988	42	40	8
N112	29 Nov. - 9 Dec., 1988	6	52	9
N119	11-21 Apr., 1989	20	6	10
N122	5-15 June, 1989	32	6	11
N126	9-18 Aug., 1989	39	2	12

¹Temperature data only - conductivity sensor malfunction.

Table 2. Hydrographic station data for cruise H127. (Bottom depths in parentheses are estimates from hydrographic charts for cast position. Conductivity sensor malfunctioned on all CTD casts. CTD numbers 1-9, 12, 15-38 not used.)

Hydro. Stn.No.	Ship time	Date	Position		Fishing Stn.No.	Bottom Depth (m)	Remarks
	(UT-3 hrs.) Hr. Min.	D/M/Y	°N	°W			
X01	11:16	25/10/84	42 39	64 19	1	319	
X02	12:47	25/10/84	42 40	64 13	2	478	
X03	01:19	26/10/84	42 39	64 09	4	802	
X04	03:02	26/10/84	42 37	64 13	5	910	
X05	08:56	26/10/84	42 37	64 07	6	882	
X06	13:37	26/10/84	42 33	64 11	7	1100	
X07	16:15	26/10/84	42 32	64 03	8	1150	
X08	18:54	26/10/84	42 32	64 03	9	1170	
C10	22:48	26/10/84	42 37	64 06	10	(1000)	Max. CTD depth = 450 m
X09	01:08	27/10/84	42 23	63 54		(1700)	
X10	02:03	27/10/84	42 17	63 49		(1900)	
X11	02:21	27/10/84	42 15	63 46		(2000)	
C11	(04:16)	27/10/84	42 11	63 42	11	(2000)	Max. CTD depth = 450 m
X12	05:35	27/10/84	42 12	63 37		(2000)	
X13	07:58	27/10/84	42 11	63 23	12	(2200)	
X14	09:01	27/10/84	42 12	63 20		(2200)	
X15	09:45	27/10/84	42 14	63 10		(2200)	
X16	10:30	27/10/84	42 17	63 02		(2200)	
X17	11:06	27/10/84	42 18	62 54		(2200)	
X18	12:01	27/10/84	42 23	62 44		(2200)	
X19	13:15	27/10/84	42 28	62 30		(2000)	
X20	16:07	27/10/84	42 38	62 01		(1600)	
X21	18:01	27/10/84	42 41	61 39		(1800)	
C13	20:44	27/10/84	42 42	61 20	13	(2200)	Max. CTD depth = 400 m
X22	21:11	27/10/84	42 42	61 17		(2200)	
X23	23:10	27/10/84	42 46	60 55		(2700)	
X24	00:07	28/10/84	42 50	60 42		(2200)	
X25	00:41	28/10/84	42 52	60 35		(2200)	
C14	02:46	28/10/84	42 55	60 27	14	(2200)	Max. CTD depth = 46 m
X26	03:00	28/10/84	42 54	60 24	14	(2200)	
X27	03:31	28/10/84	42 56	60 16		(2200)	
X28	04:06	28/10/84	42 58	60 08		(2200)	Malfunction
X29	04:22	28/10/84	42 59	60 04		(2200)	Malfunction
X30	04:25	28/10/84	42 59	60 03		(2200)	
X31	05:43	28/10/84	43 01	59 58	15	(2200)	
X32	07:05	28/10/84	43 10	59 40		(2200)	
X33	08:29	28/10/84	43 22	59 28		(2200)	
X34	10:00	28/10/84	43 34	59 14		(1400)	
X35	11:30	28/10/84	43 47	58 59		(900)	

Table 2. Continued.

Hydro. Stn.No.	Ship time (UT-3 hrs.) Hr. Min.	Date D/M/Y	Position		Fishing Stn.No.	Bottom Depth (m)	Remarks
			°N	°W			
X36	14:49	28/10/84	43 58	58 38	16	362	
X37	16:42	28/10/84	43 56	58 43	17	565	
X38	18:51	28/10/84	43 56	58 38	18	553	
X39	21:54	28/10/84	43 59	58 34	19	(550)	
X40	00:12	29/10/84	44 00	58 26	20	805	
X41	04:33	29/10/84	44 01	58 06	21	(1500)	
X42	06:14	29/10/84	44 06	57 40		(1800)	
X43	08:00	29/10/84	44 18	57 19		(1100)	
X44	09:30	29/10/84	44 28	57 00		(800)	
X45	11:06	29/10/84	44 37	56 42		(385)	
X46	13:25	29/10/84	44 51	56 10		404	
X47	16:57	29/10/84	44 51	55 54	23	794	
X48	21:30	29/10/84	44 52	55 59	25	(460)	
X49	23:42	29/10/84	44 49	56 05	26	562	
X50	01:49	30/10/84	44 49	56 04	27	699	
X51	05:41	30/10/84	44 49	55 49	28	763	
X52	07:34	30/10/84	44 47	55 59	29	(1000)	
X53	10:12	30/10/84	44 46	55 53	30	(1100)	
X54	12:50	30/10/84	44 51	55 58	31	889	
X55	15:28	30/10/84	44 46	56 04	32	906	
X56	17:32	30/10/84	44 46	56 11	33	994	
X57	21:20	30/10/84	44 47	56 01	34	(1000)	
X58	23:07	30/10/84	44 47	56 07	35	(900)	
X59	20:34	31/10/84	45 54	58 18		(200)	
X60	22:30	31/10/84	45 53	58 02	36	(400)	
X61	23:15	31/10/84	45 49	57 54		(420)	
C39	07:51	01/11/84	44 51	57 13	39	(420)	Max. CTD depth = 400 m
C40	11:08	01/11/84	44 17	57 15		(1300)	Max. CTD depth = 400 m
C41	12:38	01/11/84	44 02	57 14		(2300)	Max. CTD depth = 400 m
C42	14:21	01/11/84	43 48	57 12		(3000+)	Max. CTD depth = 400 m
C43	15:52	01/11/84	43 36	57 10		(3000+)	Max. CTD depth = 400 m
C44	17:16	01/11/84	43 20	57 12	40	(3000+)	Max. CTD depth = 400 m
C45	21:37	01/11/84	43 29	57 34	41	(3000+)	Max. CTD depth = 400 m
C46	00:52	02/11/84	43 42	57 52	42	(3000+)	Max. CTD depth = 400 m
C47	03:31	02/11/84	43 53	58 08	43	(2200)	Max. CTD depth = 400 m
C48	22:17	02/11/84	43 14	60 24	45	(1800)	Max. CTD depth = 350 m
C49	01:58	03/11/84	43 12	60 34	46	(1600)	Max. CTD depth = 370 m
C50	13:23	03/11/84	42 53	61 32	48	(1100)	Max. CTD depth = 400 m
C51	01:06	04/11/84	42 59	61 46	55	(290)	Max. CTD depth = 400 m

Table 3. Hydrographic station data for cruise N057. (Bottom depths in parentheses are estimates from hydrographic charts for cast position.)

Hydro. Stn.No.	Ship time	Date	Position		Fishing Stn.No.	Bottom	Remarks
	(UT-4 hrs.) Hr. Min.	D/M/Y	° N	° W		Depth (m)	
X01	22:27	10/02/86	43 54	62 55	1	264	
X02	11:56	11/02/86	42 58	61 45	6	456	
C01	08:10	12/02/86	41 50	61 40	17	(1400)	Max. CTD depth = 460 m
X03	11:03	12/02/86	42 56	61 12		(2100)	
X04	13:17	12/02/86	43 03	60 46		(1800)	
X05	15:35	12/02/86	43 09	60 21		(2000)	
X06	17:24	12/02/86	43 16	59 55		(1800)	
C02	20:55	12/02/86	43 23	59 30	18	(2100)	Malfunction
X07	21:05	12/02/86	43 22	59 30	18	(2100)	
X08	23:30	12/02/86	43 25	59 09	19	(2000)	
X09	01:26	13/02/86	43 30	58 50	20	(2600)	
X10	03:46	13/02/86	43 35	58 32	21	(3000)	
X11	05:59	13/02/86	43 39	58 13	22	(2800)	
X12	08:25	13/02/86	43 46	57 43		(2900)	
X13	10:35	13/02/86	43 40	57 29		(3100)	
X14	12:35	13/02/86	43 19	57 30		(3600)	
X15	14:25	13/02/86	42 59	57 29		(4050)	
X16	16:20	13/02/86	42 40	57 30		(4200)	
C03	18:55	13/02/86	42 18	57 30	23	(4400)	Max. CTD depth = 394 m
C04	03:22	14/02/86	42 01	57 29	24	(4500)	Max. CTD depth = 312 m
C05	06:45	14/02/86	41 43	57 30	25	(4700)	Max. CTD depth = 256 m
X17	08:46	14/02/86	41 25	57 30		(4750)	
X18	09:54	14/02/86	41 15	57 29		(4800)	
X19	10:37	14/02/86	41 08	57 30		(4850)	
X20	11:13	14/02/86	41 02	57 30		(4900)	
X21	11:42	14/02/86	40 58	57 30		(4900)	
C06	13:48	14/02/86	40 59	57 31	26	(4900)	Max. CTD depth = 395 m
C07	18:04	14/02/86	41 04	57 27	27	(4850)	Max. CTD depth = 300 m
X22	20:35	14/02/86	41 14	57 29	28	(4800)	1830 m XBT
X23	22:01	14/02/86	41 14	57 22		(4800)	Malfunction
C08	22:52	14/02/86	41 15	57 29	28	(4800)	Max. CTD depth = 301 m
C09	03:12	15/02/86	41 25	57 29	29	(4750)	Max. CTD depth = 301 m
C10	07:50	15/02/86	41 42	57 30	30	(4700)	Max. CTD depth = 302 m
X24	13:00	17/02/86	41 45	60 29		(4400)	
X25	14:03	17/02/86	41 34	60 30		(4500)	
X26	15:28	17/02/86	41 19	60 30	31	(4600)	
C11	16:57	17/02/86	41 15	60 29	31	(4600)	Max. CTD depth = 299 m
X27	19:22	17/02/86	41 10	60 30	32	(4600)	
C12	20:55	17/02/86	41 07	60 30	32	(4600)	Max. CTD depth = 304 m
X28	23:23	17/02/86	41 00	60 30		(4700)	1830 m XBT
X29	00:32	18/02/86	40 50	60 30		(4800)	
X30	01:37	18/02/86	40 40	60 30		(4800)	1830 m XBT
X31	03:52	18/02/86	40 19	60 30		(5000)	
X32	07:21	18/02/86	39 40	60 30		(5700)	
X33	08:23	18/02/86	39 30	60 29		(5800)	
X34	09:34	18/02/86	39 20	60 30		(5500)	
C13	23:40	18/02/86	40 01	62 01	33	(4800)	Max. CTD depth = 470 m
C14	02:18	19/02/86	40 14	62 00	34	(4700)	Max. CTD depth = 303 m
X35	03:35	19/02/86	40 24	62 00	35	(4700)	
X36	04:55	19/02/86	40 27	62 02	35	(4700)	1830 m XBT
X37	09:21	19/02/86	40 48	62 00		(4600)	

Table 4. Hydrographic station data for cruise G121. (Bottom depths are estimates from hydrographic charts for cast position except for X01. XBT number 133 not used.)

Hydro. Stn.No.	Ship time	Date	Position		Fishing Stn.No.	Bottom Depth (m)
	(UT-4 hrs.) Hr. Min.	D/M/Y	° N	° W		
X01	16:04	21/02/86	47 32	52 36		174
X02	07:16	22/02/86	45 00	55 01		1000
X03	08:21	22/02/86	44 50	55 00		1500
X04	09:35	22/02/86	44 40	55 00		2500
X05	10:50	22/02/86	44 30	55 00		2500
X06	11:40	22/02/86	44 21	55 00		3000
X07	12:27	22/02/86	44 11	55 00		3000
X08	13:14	22/02/86	44 01	55 00		3500
X09	14:03	22/02/86	43 51	55 00		3500
X10	14:52	22/02/86	43 40	55 00		3500
X11	15:40	22/02/86	43 31	55 00		3500
X12	16:28	22/02/86	43 21	55 00		4000
X13	17:18	22/02/86	43 10	55 00		4000
X14	18:09	22/02/86	43 01	55 00		4500
X15	18:58	22/02/86	42 51	55 00		4500
X16	19:54	22/02/86	42 40	55 00		4500
X17	20:40	22/02/86	42 31	55 00		4500
X18	21:32	22/02/86	42 21	55 00		4500
X19	22:27	22/02/86	42 10	55 00		4500
X20	23:17	22/02/86	42 01	55 00		4700
X21	00:11	23/02/86	41 50	55 00		4700
X22	01:07	23/02/86	41 40	55 00		4700
X23	02:07	23/02/86	41 30	55 00		4700
X24	03:40	23/02/86	41 20	55 00		4700
X25	05:10	23/02/86	41 10	55 00		4700
X26	06:22	23/02/86	41 00	55 00		4700
X27	07:40	23/02/86	40 50	55 00		4700
X28	08:52	23/02/86	40 40	55 00		5000
X29	09:55	23/02/86	40 30	55 00		5000
X30	11:00	23/02/86	40 20	55 00		5000
X31	12:00	23/02/86	40 10	55 00		5000
X32	13:08	23/02/86	40 00	55 00		5000
X33	14:14	23/02/86	39 50	55 00		5000
X34	15:21	23/02/86	39 41	55 00		5000
X35	16:25	23/02/86	39 30	55 00		5000
X36	17:27	23/02/86	39 20	55 00		5200
X37	18:37	23/02/86	39 10	55 00		5200
X38	20:01	23/02/86	39 00	55 00		5200
X39	20:45	23/02/86	39 03	55 00		5200
X40	21:14	23/02/86	39 04	55 00	1	5200
X41	23:50	23/02/86	39 12	55 01	2	5200
X42	02:07	24/02/86	39 17	55 00	3	5000
X43	03:46	24/02/86	39 21	55 00		5000
X44	04:32	24/02/86	39 25	55 00	4	5000
X45	06:35	24/02/86	39 30	55 00	5	5000
X46	09:08	24/02/86	39 31	55 16		5000
X47	10:05	24/02/86	39 21	55 16		5200
X48	11:08	24/02/86	39 10	55 16		5200
X49	12:13	24/02/86	39 00	55 16		5200
X50	13:33	24/02/86	38 50	55 16		5200
X51	14:24	24/02/86	38 55	55 16		5200
X52	14:48	24/02/86	38 56	55 16	6	5200
X53	16:59	24/02/86	39 02	55 14	7	5200
X54	19:01	24/02/86	39 08	55 16	8	5200
X55	21:20	24/02/86	39 15	55 16	9	5200
X56	23:00	24/02/86	39 18	55 16	10	5200
X57	01:46	25/02/86	39 00	55 24		5200
X58	02:46	25/02/86	38 50	55 24		5200
X59	03:44	25/02/86	38 40	55 24		5200
X60	04:18	25/02/86	38 45	55 24	11	5200

Table 4. Continued

Hydro. Stn.No.	Ship time	Date	Position		Fishing Stn.No.	Bottom Depth (m)
	(UT-4 hrs.) Hr. Min.	D/M/Y	° 'N	° 'W		
X61	06:32	25/02/86	38 49	55 24	12	5200
X62	09:20	25/02/86	38 59	55 24	13	5200
X63	11:16	25/02/86	39 00	55 24	14	5200
X64	12:52	25/02/86	39 07	55 24	15	5200
X65	14:37	25/02/86	39 09	55 29		5200
X66	15:09	25/02/86	39 08	55 34		5200
X67	16:06	25/02/86	38 58	55 34		5200
X68	17:04	25/02/86	38 48	55 34		5000
X69	18:02	25/02/86	38 54	55 34		5000
X70	22:05	25/02/86	38 55	55 34		5000
X71	22:40	25/02/86	38 56	55 34	16	5200
X72	09:19	26/02/86	38 59	55 35	17	5200
X73	16:29	26/02/86	39 05	55 32	18	5200
X74	19:18	26/02/86	39 15	55 34	19	5200
X75	21:54	26/02/86	39 24	55 34	20	5000
X76	00:38	27/02/86	39 23	55 44		5000
X77	01:41	27/02/86	39 24	55 54		5000
X78	02:47	27/02/86	39 14	55 54		5000
X79	03:52	27/02/86	39 04	55 54		5000
X80	07:50	27/02/86	39 09	55 54	21	5000
X81	10:15	27/02/86	39 14	55 54		5000
X82	11:05	27/02/86	39 18	55 54	22	5000
X83	13:22	27/02/86	39 25	55 54	23	5000
X84	14:53	27/02/86	39 28	55 53		5000
X85	15:50	27/02/86	39 34	55 55	24	5000
X86	17:30	27/02/86	39 41	55 55	25	5000
X87	19:33	27/02/86	39 41	56 05		5000
X88	21:00	27/02/86	39 31	56 05		5000
X89	22:18	27/02/86	39 21	56 05		5000
X90	22:54	27/02/86	39 24	56 05		5000
X91	15:37	28/02/86	39 23	56 05		5000
X92	15:57	28/02/86	39 21	56 05		5000
X93	16:34	28/02/86	39 19	56 05	26	5000
X94	18:37	28/02/86	39 29	56 05	27	5000
X95	21:10	28/02/86	39 40	56 05	28	5000
X96	23:55	28/02/86	39 43	56 05	29	5000
X97	02:00	01/03/86	39 47	56 05		5000
X98	02:57	01/03/86	39 52	56 04	30	5000
X99	05:59	01/03/86	39 30	56 06	31	5000
X100	08:36	01/03/86	39 36	56 06	32	5000
X101	10:06	01/03/86	39 40	56 05		5000
X102	10:52	01/03/86	39 44	56 07	33	5000
X103	12:25	01/03/86	39 49	56 06	34	5000
X104	13:50	01/03/86	39 52	56 06	35	5000
X105	15:50	01/03/86	39 54	56 17		5000
X106	16:45	01/03/86	39 52	56 29		5000
X107	17:27	01/03/86	39 47	56 29		5000
X108	17:55	01/03/86	39 47	56 30	36	5000
X109	20:02	01/03/86	39 57	56 30	37	5000
X110	21:48	01/03/86	40 02	56 30	38	5000
X111	23:32	01/03/86	40 05	56 30	39	5000
X112	01:35	02/03/86	40 07	56 30	40	5000
X113	03:58	03/03/86	40 07	56 37		5000
X114	04:37	03/03/86	40 08	56 43		5000
X115	05:39	03/03/86	39 58	56 43		5000
X116	06:38	03/03/86	39 48	56 43		5000
X117	07:40	03/03/86	39 38	56 43	41	5000
X118	10:28	03/03/86	39 47	56 43	42	5000
X119	12:12	03/03/86	39 50	56 43	43	5000
X120	13:38	03/03/86	39 52	56 41		5000
X121	14:26	03/03/86	39 56	56 43	44	5000
X122	16:12	03/03/86	40 00	56 43	45	5000

Table 4. Continued

Hydro. Stn.No.	Ship time	Date	Position		Fishing Stn.No.	Bottom Depth (m)
	(UT-4 hrs.) Hr. Min.	D/M/Y	° 'N	° 'W		
X123	17:43	03/03/86	39 59	56 46		5000
X124	18:09	03/03/86	40 00	56 52		5000
X125	19:12	03/03/86	39 50	56 52		5000
X126	20:12	03/03/86	39 40	56 52		5000
X127	21:25	03/03/86	39 30	56 52		5000
X128	22:00	03/03/86	39 25	56 52		5000
X129	22:30	03/03/86	39 21	56 52		5000
X130	23:04	03/03/86	39 16	56 52		5000
X131	23:47	03/03/86	39 11	56 52		5000
X132	00:13	04/03/86	39 14	56 52	46	5000
X134	02:12	04/03/86	39 18	56 50		5000
X135	03:29	04/03/86	39 24	56 53	47	5000
X136	05:03	04/03/86	39 27	56 51		5000
X137	06:01	04/03/86	39 33	56 52	48	5000
X138	07:59	04/03/86	39 37	56 52	49	5000
X139	10:00	04/03/86	39 41	56 53	50	5000
X140	11:41	04/03/86	39 39	57 00		5000
X141	12:14	04/03/86	39 40	57 07		4800
X142	13:11	04/03/86	39 30	57 07		5000
X143	14:15	04/03/86	39 20	57 07		5000
X144	15:16	04/03/86	39 10	57 07		5000
X145	16:14	04/03/86	39 14	57 07	51	5000
X146	17:44	04/03/86	39 21	57 08	52	5000
X147	20:16	04/03/86	39 23	57 04	53	5000
X148	21:45	04/03/86	39 25	57 07	54	5000
X149	23:42	04/03/86	39 29	57 06	55	5000
X150	01:26	05/03/86	39 29	57 17		5000
X151	02:02	05/03/86	39 29	57 24		5000
X152	03:06	05/03/86	39 19	57 24	56	5000
X153	05:30	05/03/86	39 26	57 24	57	5000
X154	07:13	05/03/86	39 30	57 23		5000
X155	08:01	05/03/86	39 35	57 24	58	4900
X156	09:39	05/03/86	39 40	57 24		4800
X157	10:28	05/03/86	39 44	57 24	59	5000
X158	11:57	05/03/86	39 46	57 25	60	5000
X159	13:13	05/03/86	39 47	57 27		5000
X160	14:16	05/03/86	39 37	57 27		4800
X161	15:21	05/03/86	39 27	57 27		5000
X162	15:56	05/03/86	39 22	57 27		5000
X163	17:22	05/03/86	39 12	57 27		5000
X164	18:07	05/03/86	39 17	57 27		5000
X165	18:29	05/03/86	39 18	57 27	61	5000
X166	21:02	05/03/86	39 19	57 28	62	5000
X167	22:53	05/03/86	39 21	57 27		5000
X168	18:23	06/03/86	39 22	57 27		5000
X169	18:44	06/03/86	39 23	57 27	63	5000
X170	20:13	06/03/86	39 29	57 25		5000
X171	20:51	06/03/86	39 32	57 27	64	5000
X172	22:39	06/03/86	39 36	57 27	65	4900
X173	00:52	07/03/86	39 35	57 38		4900
X174	01:43	07/03/86	39 36	57 50		4900
X175	02:56	07/03/86	39 26	57 50		5000

Table 5. Hydrographic station data for cruise N067. (Bottom depths in parentheses are estimates from hydrographic charts for cast position).

Hydro Stn.No.	Ship time	Date	Position		Fishing Stn.No.	Bottom	Remarks
	(UT-3 hrs.) Hr. Min.	D/M/Y	°N	°W		Depth (m)	
X01	14:35	26/08/86	42 18	67 05	1	316	
X02	17:40	26/08/86	42 25	67 07	3	396	
X03	00:30	27/08/86	41 32	65 53	4	384	
X04	05:10	27/08/86	41 30	65 54	7	636	
X05	22:47	27/08/86	42 37	64 26	13	277	
X06	01:53	28/08/86	42 29	64 11	14	(1280)	
X07	03:55	28/08/86	42 23	63 57	15	(1554)	
X08	06:10	28/08/86	42 18	63 45	16	(1939)	
X09	07:38	28/08/86	42 08	63 31		(2300)	
X10	09:10	28/08/86	42 00	63 19		(2700)	
X11	10:37	28/08/86	42 11	63 13		(2300)	
X12	12:00	28/08/86	42 22	63 06		(2000)	
X13	13:05	28/08/86	42 32	63 00		(1700)	
X14	14:01	28/08/86	42 42	62 53		(1200)	
X15	14:45	28/08/86	42 49	62 50		549	
X16	16:15	28/08/86	42 53	62 44		144	
X17	22:13	28/08/86	42 58	62 25	20	401	
X18	00:20	29/08/86	42 46	62 19	21	(1050)	
X19	02:45	29/08/86	42 31	62 10	22	(1800)	
X20	04:50	29/08/86	42 18	62 01	23	(2500)	
X21	05:50	29/08/86	42 09	61 55		(3100)	
X22	07:05	29/08/86	42 00	61 48		(3600)	
X23	08:40	29/08/86	42 03	61 43	24	(3600)	1830 m XBT
X24	12:20	29/08/86	42 09	61 34		(3600)	
X25	13:29	29/08/86	42 18	61 23		(3200)	
X26	14:45	29/08/86	42 29	61 12		(2700)	
X27	16:01	29/08/86	42 39	61 00		(2700)	
X28	17:01	29/08/86	42 48	60 52		(2500)	
X29	18:20	29/08/86	42 57	60 42		(2100)	
X30	20:29	29/08/86	42 57	60 34	25	(2100)	1830 m XBT
X31	22:06	29/08/86	42 53	60 30	26	(2300)	
X32	00:40	30/08/86	42 42	60 14	27	(2900)	
X33	02:45	30/08/86	42 32	60 00	28	(3800)	
X34	04:50	30/08/86	42 21	59 47	29	(3800)	
X35	06:04	30/08/86	42 13	59 35		(4200)	
X36	07:16	30/08/86	42 05	59 25		(4300)	
X37	10:41	30/08/86	42 22	59 18	30	(4000)	1830 m XBT
X38	12:10	30/08/86	42 36	59 12		(3600)	
X39	13:10	30/08/86	42 43	59 06		(3600)	
X40	14:15	30/08/86	42 54	59 01		(3600)	
X41	15:20	30/08/86	43 06	58 56		(3600)	
X42	16:30	30/08/86	43 17	58 50		(2700)	
X43	17:40	30/08/86	43 29	58 44		(2700)	
X44	18:50	30/08/86	43 40	58 39		(3500)	
X45	20:55	30/08/86	43 44	58 35	31	(2500)	1830 m XBT
X46	22:41	30/08/86	43 42	58 28	32	(2500)	
X47	00:55	31/08/86	43 32	58 13	33	(3000)	
X48	03:15	31/08/86	43 21	57 57	34	(3500)	
X49	05:15	31/08/86	43 11	57 41	35	(3900)	
X50	06:29	31/08/86	43 01	57 26		(4000)	
X51	07:36	31/08/86	42 54	57 15		(4100)	

Table 5. Continued.

Hydro Stn.No.	Ship time (UT-3 hrs.) Hr. Min.	Date D/M/Y	Position		Fishing Stn.No.	Bottom Depth (m)	Remarks
			°N	°W			
X52	08:52	31/08/86	42 44	57 06		(4200)	
X53	10:04	31/08/86	42 32	57 06		(4200)	
X54	11:10	31/08/86	42 21	57 07		(4300)	
X55	12:15	31/08/86	42 09	57 07		(4400)	
X56	13:25	31/08/86	41 57	57 06		(4500)	
X57	15:30	31/08/86	41 51	57 05	36	(4500)	1830 m XBT
X58	17:24	31/08/86	41 38	57 04		(4600)	
X59	20:11	31/08/86	41 25	57 04	37	(4500)	
X60	22:58	31/08/86	41 06	57 05	38	(4500)	
X61	01:10	01/09/86	40 51	57 07	39	(4500)	
X62	03:00	01/09/86	40 36	57 09	40	(5000)	
X63	04:30	01/09/86	40 28	57 10	41	(5000)	
X64	06:00	01/09/86	40 36	57 01		(5000)	
X65	07:17	01/09/86	40 44	56 52		(4900)	
X66	08:22	01/09/86	40 51	56 44		(4900)	
X67	10:32	01/09/86	41 00	56 34	42	(4500)	
X68	14:10	01/09/86	41 06	56 26	44	(4500)	1830 m XBT
X69	15:20	01/09/86	41 15	56 18		(4800)	
X70	16:30	01/09/86	41 22	56 08		(4800)	
X71	17:45	01/09/86	41 31	55 57		(4800)	
X72	18:36	01/09/86	41 36	55 49		(4700)	
X73	19:43	01/09/86	41 44	55 40		(4700)	
X74	22:12	01/09/86	41 53	55 26	45	(4500)	
X75	00:30	02/09/86	42 02	55 12	46	(4000)	
X76	02:40	02/09/86	42 12	54 58	47	(4000)	
X77	04:45	02/09/86	42 23	54 45	48	(4000)	
X78	06:06	02/09/86	42 33	54 31		(4000)	
X79	07:22	02/09/86	42 41	54 20		(4000)	
X80	10:25	02/09/86	42 53	54 02	49	(4000)	1830 m XBT
X81	11:48	02/09/86	42 57	54 00	50	(4000)	
X82	13:10	02/09/86	43 12	54 00		(4000)	
X83	14:13	02/09/86	43 23	54 01		(4000)	
X84	15:10	02/09/86	43 34	54 01		(3800)	
X85	16:25	02/09/86	43 47	54 03		(3500)	
X86	20:31	02/09/86	44 04	54 01	51	(3200)	1830 m XBT
X87	21:53	02/09/86	44 05	54 19	52	(3000)	
X88	00:15	03/09/86	44 05	54 40	53	(3000)	
X89	02:00	03/09/86	44 05	54 57	54	(3000)	
X90	04:10	03/09/86	44 06	55 18	55	(3200)	
X91	05:10	03/09/86	44 07	55 32		(3000)	
X92	06:07	03/09/86	44 07	55 41		(3000)	
X93	07:26	03/09/86	44 07	55 57		(3000)	
X94	08:32	03/09/86	44 09	56 09		(1800)	
X95	09:29	03/09/86	44 18	56 11		(2200)	
X96	10:35	03/09/86	44 28	56 13		(2700)	
X97	14:10	03/09/86	44 50	56 14	56	377	
X98	16:25	03/09/86	44 55	56 07	57	310	
X99	18:46	03/09/86	44 48	56 08	58	479	
X100	21:15	03/09/86	44 39	56 24	59	454	
X101	00:10	04/09/86	44 34	56 47	60	373	
X102	02:50	04/09/86	44 35	57 09	61	380	

Table 6. Hydrographic station data for cruise N089. (Bottom depths in parentheses are estimates from hydrographic charts for cast position.)

Hydro Stn.No.	Ship time	Date	Position		Fishing Stn.No.	Bottom Depth (m)	Remarks
	(UT-3 hrs.) Hr. Min.	D/M/Y	°N	°W			
X01	19:04	23/09/87	43 19	60 37	8	440	
C01	21:14	23/09/87	43 14	60 30	9	(1800)	Max. CTD depth = 463 m
C02	00:50	24/09/87	43 10	60 14	10	(2000)	Max. CTD depth = 482 m
X02	02:50	24/09/87	42 59	59 59		(2400)	
X03	05:00	24/09/87	42 52	59 48		(3100)	
C03	07:15	24/09/87	42 42	59 33	11	(4000)	Max. CTD depth = 462 m
X04	09:00	24/09/87	42 42	59 24		(4000)	
X05	10:03	24/09/87	42 43	59 07		(4000)	
X06	13:40	24/09/87	42 42	58 36		(4000)	
X07	15:35	24/09/87	42 42	58 10		(4000)	
X08	18:00	24/09/87	42 41	57 33		(4500)	
C04	20:50	24/09/87	42 41	57 05	12	(4500)	
X09	23:30	24/09/87	42 41	56 46	13	(4000)	
X10	02:55	25/09/87	42 42	56 28	14	(4000)	
X11	05:15	25/09/87	42 43	56 08	15	(4000)	
X12	06:15	25/09/87	42 43	55 52		(4000)	
X13	08:15	25/09/87	42 44	55 23		(4000)	
X14	10:30	25/09/87	42 56	55 02		(4000)	
X15	12:45	25/09/87	43 10	54 44		(4000)	
X16	14:50	25/09/87	43 29	54 34		(3900)	
C05	17:20	25/09/87	43 39	54 33	16	(3600)	Max. CTD depth = 973 m
C06	20:42	25/09/87	44 00	54 31	17	(2900)	
C07	23:18	25/09/87	44 12	54 32	18	(2800)	
X17	02:10	26/09/87	44 24	54 32	19	(2300)	
C08	05:48	26/09/87	44 36	54 34	20	(1700)	
X18	08:50	26/09/87	44 36	54 04		(1000)	
X19	11:04	26/09/87	44 23	53 43		(1200)	
X20	13:10	26/09/87	44 10	53 20		(1500)	
X21	15:15	26/09/87	43 55	52 58		(1600)	
X22	17:20	26/09/87	43 41	52 33		(1000)	
X23	19:00	26/09/87	43 32	52 21	21	(1500)	1830 m XBT
X24	21:05	26/09/87	43 26	52 14	22	(1500)	
X25	23:05	26/09/87	43 18	52 02	23	(1500)	
X26	01:50	27/09/87	43 10	51 45	24	(1500)	
X27	04:05	27/09/87	43 03	51 27	25	(1000)	
C09	06:30	27/09/87	42 56	51 07	26	(1500)	
X28	09:44	27/09/87	42 48	50 30		611	
C10	11:05	27/09/87	42 37	50 30		(1500)	
C11	12:40	27/09/87	42 27	50 30		(2100)	

Table 6. Continued.

Hydro Stn.No.	Ship time	Date	Position		Fishing Stn.No.	Bottom	Remarks
	(UT-3 hrs.) Hr. Min.	D/M/Y	°N	°W		Depth (m)	
C12	14:15	27/09/87	42 15	50 30		(3100)	
X29	16:10	27/09/87	42 12	50 30	27	(3200)	1830 m XBT
C13	17:16	27/09/87	42 04	50 29		(3300)	
X30	19:00	27/09/87	41 51	50 24		(3400)	
X31	21:03	27/09/87	41 39	50 23	28	(3400)	
X32	23:15	27/09/87	41 28	50 27	29	(3700)	
X33	01:50	28/09/87	41 11	50 25	30	(4000)	
X34	04:05	28/09/87	40 57	50 25	31	(4000)	
X35	05:20	28/09/87	40 58	50 32		(4000)	
X36	06:25	28/09/87	41 07	50 45		(4000)	
X37	07:35	28/09/87	41 07	50 53		(4000)	
X38	10:00	28/09/87	41 10	51 19		(4000)	
X39	12:35	28/09/87	41 03	51 34		(4500)	
X40	14:45	28/09/87	41 04	51 52		(4500)	
X41	16:50	28/09/87	41 12	52 15		(4500)	
X42	19:00	28/09/87	41 17	52 35		(4500)	
C14	21:00	28/09/87	41 19	52 50	32	(4500)	
X43	23:30	28/09/87	41 23	53 07	33	(5000)	
X44	02:15	29/09/87	41 27	53 24	34	(5000)	1830 m XBT
X45	04:25	29/09/87	41 33	53 42	35	(5000)	
X46	06:30	29/09/87	41 40	54 07		(5000)	
X47	08:45	29/09/87	41 46	54 35		(4500)	
X48	10:51	29/09/87	41 48	54 49		(4500)	
X49	13:00	29/09/87	41 53	55 17		(4500)	
X50	16:50	29/09/87	42 00	55 44	36	(4500)	1830 m XBT
C15	21:20	29/09/87	42 09	56 22	37	(4500)	
C16	23:45	29/09/87	42 12	56 38	38	(4500)	
C17	02:25	30/09/87	42 14	56 56	39	(4500)	
C18	04:45	30/09/87	42 19	57 15	40	(4500)	Max. CTD depth = 250 m
X51	06:50	30/09/87	42 25	57 45		(4000)	
X52	08:55	30/09/87	42 32	58 12		(4000)	
X53	12:20	30/09/87	42 39	58 33		(4000)	
X54	14:25	30/09/87	42 48	58 56		(3900)	
X55	16:25	30/09/87	42 57	59 23		(3400)	
X56	18:30	30/09/87	43 07	59 49		(2300)	
X57	20:35	30/09/87	43 17	60 13		(1400)	
X58	22:30	30/09/87	43 24	60 34		250	

Table 7. Hydrographic station data for cruise N096. (Bottom depths in parentheses are estimates from hydrographic charts for cast position.)

Hydro Stn.No.	Ship time	Date	Position		Fishing Stn.No.	Bottom Depth (m)	Remarks
	(UT-4 hrs.) Hr. Min.	D/M/Y	°N	°W			
C01	18:17	17/02/88	43 30	59 00	1	(1900)	Max CTD depth = 1000 m
C02	20:45	17/02/88	43 30	58 58	2	(1900)	
C03	23:25	17/02/88	43 20	59 01	3	(2500)	
C04	02:02	18/02/88	43 10	59 00	4	(3000)	
C05	04:44	18/02/88	43 00	58 56	5	(3600)	
X01	06:00	18/02/88	42 49	59 00		(3700)	
X02	06:55	18/02/88	42 40	59 00		(4000)	
X03	07:55	18/02/88	42 30	59 00		(4000)	
X04	08:55	18/02/88	42 20	59 00		(4000)	
X05	09:50	18/02/88	42 10	59 01		(4100)	
X06	11:05	18/02/88	42 00	59 00		(4200)	
C06	13:30	18/02/88	41 52	58 57	6	(4500)	Max CTD depth = 1000 m
X07	16:10	18/02/88	41 40	59 00		(4500)	
X08	17:19	18/02/88	41 30	59 00		(4600)	
X09	18:00	18/02/88	41 20	59 00		(4700)	
C07	20:10	18/02/88	41 19	59 00	7	(4700)	
C08	22:15	18/02/88	41 09	59 01	8	(4800)	
C09	00:01	19/02/88	40 59	59 02	9	(4800)	
C10	02:34	19/02/88	40 48	59 00	10	(4800)	
C11	04:43	19/02/88	40 38	58 59	11	(4900)	
C12R	18:02	19/02/88	41 00	59 00	12	(4800)	Max CTD depth = 1000 m
C12S	04:53	20/02/88	41 00	59 00	12	(4800)	Max CTD depth = 1000 m
X10	06:35	20/02/88	41 09	59 11		(4800)	
X11	07:40	20/02/88	41 17	59 22		(4700)	
X12	08:40	20/02/88	41 25	59 33		(4600)	
C13	11:40	20/02/88	41 36	59 50	13	(4500)	Max CTD depth = 975 m
X13	13:35	20/02/88	41 48	60 06		(4200)	
X14	16:45	20/02/88	42 02	60 22	14	(4100)	1830 m XBT
X15	23:40	20/02/88	42 27	60 54	15	(3400)	
X16	02:03	21/02/88	42 32	61 01	16	(3000)	
X17	04:15	21/02/88	42 42	61 16	17	(2500)	
C14	17:03	21/02/88	42 48	61 19	18	(2000)	Max CTD depth = 1000 m
C15	20:53	22/02/88	42 47	61 20	19	(2000)	
C16	23:25	22/02/88	42 38	61 21	20	(2500)	
C17	01:46	23/02/88	42 26	61 17	21	(3000)	
C18	04:46	23/02/88	42 15	61 16	22	(3600)	
X18	06:05	23/02/88	42 05	61 20		(3800)	
X19	07:15	23/02/88	41 53	61 20		(4000)	
X20	08:25	23/02/88	41 43	61 20		(4100)	
X21	09:40	23/02/88	41 32	61 20		(4200)	
X22	10:45	23/02/88	41 22	61 20		(4300)	
C19	14:00	23/02/88	41 07	61 15	23	(4400)	Max CTD depth=990 m

Table 7. Continued.

Hydro Stn.No.	Ship time	Date	Position		Fishing Stn.No.	Bottom Depth (m)	Results
	(UT-4 hrs.) Hr. Min.	D/M/Y	°N	°W			
C20	17:30	23/02/88	40 57	61 18	24	(4500)	Max CTD depth = 990 m
X23	19:55	23/02/88	41 00	61 22	25	(4500)	
X24	21:55	23/02/88	41 08	61 33	26	(4400)	
X25	23:42	23/02/88	41 14	61 43	27	(4300)	
X26	01:45	24/02/88	41 19	61 53	28	(4200)	
X27	03:45	24/02/88	41 26	62 04	29	(4100)	
X28	06:05	24/02/88	41 31	62 11		(4000)	
X29	07:14	24/02/88	41 37	62 24		(3700)	
X30	11:38	24/02/88	41 44	62 36	30	(3400)	1830 m XBT
X31	12:37	24/02/88	41 50	62 44		(3200)	
X32	16:05	24/02/88	42 03	63 05	31	(2700)	
X33	20:00	24/02/88	41 41	63 00	32	(3400)	
X34	22:00	24/02/88	41 51	63 01	33	(3200)	
X35	23:32	24/02/88	42 01	63 00	34	(2700)	
X36	01:36	25/02/88	42 12	62 59	35	(2400)	
X37	03:27	25/02/88	42 21	62 59	36	(2100)	
X38	06:55	25/02/88	42 31	63 06	37	(1700)	1830 m XBT
X39	11:30	25/02/88	42 31	63 19	38	(1600)	1830 m XBT
X40	14:49	25/02/88	42 33	63 38	39	(1300)	1830 m XBT

Table 8. Hydrographic station data for cruise N110. (Bottom depths in parentheses are estimates from hydrographic charts for cast position.)

Hydro Stn.No.	Ship time	Date	Position		Fishing Stn.No.	Bottom Depth (m)	Results
	(UT-3 hrs.) Hr. Min.	D/M/Y	°N	°W			
C01	19:02	18/10/88	43 31	59 04	1+2	(1900)	Max. CTD depth = 1000
C02	00:20	19/10/88	43 13	58 58	3	(2800)	
C03	03:05	19/10/88	42 58	58 58	4	(3700)	
C04	05:14	19/10/88	42 47	59 00	5	(3700)	
X01	06:41	19/10/88	42 36	59 01		(3800)	
X02	08:06	19/10/88	42 25	59 00		(4200)	
X03	09:25	19/10/88	42 13	59 00		(4600)	
X04	10:45	19/10/88	42 01	59 00		(4600)	
X05	13:35	19/10/88	41 42	59 00		(4600)	
X06	14:25	19/10/88	41 32	59 00		(4700)	
X07	15:40	19/10/88	41 22	59 00		(4600)	
X08	16:41	19/10/88	41 14	59 01		(4600)	
C05	18:55	19/10/88	41 01	58 59	7+8	(4700)	Max. CTD depth = 1000
C06	06:40	20/10/88	41 09	58 59	9	(4600)	
X09	07:58	20/10/88	41 07	59 07		(4800)	
X10	09:07	20/10/88	41 13	59 17		(4600)	
X11	10:22	20/10/88	41 22	59 27		(4600)	
C07	13:25	20/10/88	41 32	59 40	10	(4600)	Max. CTD depth = 1000
C08/X12	16:05	20/10/88	41 39	59 49	11	(4600)	
X13	17:40	20/10/88	41 45	60 00		(4500)	
X14	18:55	20/10/88	41 52	60 09		(4400)	
C09	21:30	20/10/88	42 02	60 21	12	(4200)	
C10	00:12	21/10/88	42 12	60 32	13	(3800)	
C11	02:37	21/10/88	42 19	60 46	14	(3600)	
C12	04:45	21/10/88	42 27	60 55	15	(3000)	
X15	06:15	21/10/88	42 34	61 03		(2700)	
X16	08:20	21/10/88	42 27	61 30		(2900)	
X17	09:30	21/10/88	42 16	61 30		(3300)	
X18	10:37	21/10/88	42 06	61 30		(3700)	
C13	13:10	21/10/88	41 51	61 33	16	(3800)	Max. CTD depth = 1000
X19	14:25	21/10/88	41 41	61 31		(4000)	
X20	15:28	21/10/88	41 31	61 30		(4100)	
X21	16:31	21/10/88	41 21	61 30		(4300)	
X22	17:35	21/10/88	41 11	61 30		(4400)	
X23	18:45	21/10/88	41 00	61 29		(4500)	
C14	20:35	21/10/88	40 54	61 26	17	(4500)	
C15	23:08	21/10/88	41 06	61 39	18	(4300)	
C16	01:22	22/10/88	41 13	61 51	19	(4200)	
C17	03:35	22/10/88	41 20	62 04	20	(4000)	
C18	05:45	22/10/88	41 28	62 16	21	(3800)	
X24	07:19	22/10/88	41 35	62 28		(3700)	
X25	08:49	22/10/88	41 44	62 35		(3400)	

Table 8. Continued.

Hydro Stn.No.	Ship time (UT-3 hrs.)		Date		Position		Fishing Stn.No.	Bottom Depth (m)	Remarks
	Hr.	Min.	D/M/Y	°N	°W				
B01	11:05		22/10/88	41 50	62 46	22	(3200)		
X26	20:52		22/10/88	42 01	63 03	23	(2700)		
X27	23:12		22/10/88	42 16	63 00	24	(2300)		
X28	01:30		23/10/88	42 30	63 01	25	(1900)		
X29	05:32		23/10/88	42 44	63 01	26	(1300)		
C19	10:10		23/10/88	42 48	62 09	27	868	Max CTD depth = 900 m	
X30	12:50		23/10/88	42 58	62 04	28	176		
C20	18:12		23/10/88	42 55	61 48	32	530		
C21	20:48		23/10/88	42 51	61 31	33	(1200)		
C22	23:10		23/10/88	42 39	61 29	34	(2000)		
C23	01:51		24/10/88	42 30	61 29	35	(2800)		
C24	03:50		24/10/88	42 19	61 30	36	(3100)		
C25	06:20		24/10/88	42 08	61 31	37	(3700)		
X31	07:35		24/10/88	42 02	61 41		(3800)		
X32	08:40		24/10/88	41 55	61 51		(3700)		
C26	10:15		24/10/88	41 48	62 02		(3700)		
C27	13:06		24/10/88	41 39	62 16	38	(3700)	Max CTD depth = 1000 m	
X33	14:50		24/10/88	41 32	62 27		(3700)		
X34	15:44		24/10/88	41 27	62 35		(3800)		
X35	17:00		24/10/88	41 19	62 47		(3900)		
X36	18:10		24/10/88	41 11	62 58		(3900)		
C28	20:35		24/10/88	41 06	63 12	39	(3900)		
C29	22:40		24/10/88	40 57	63 20	40	(3900)		
C30	00:55		25/10/88	40 50	63 30	41	(4000)		
C31	03:06		25/10/88	40 43	63 42	42	(4200)		
C32	05:15		25/10/88	40 36	63 54	43	(4300)		
X37	06:26		25/10/88	40 45	63 54		(4200)		
X38	07:30		25/10/88	40 55	63 54		(4000)		
X39	08:40		25/10/88	41 05	63 53		(3800)		
C33	11:15		25/10/88	41 17	63 56	44	(3700)	Max CTD depth = 1000 m	
X40	12:30		25/10/88	41 25	63 53		(3300)		
C34	15:00		25/10/88	41 38	63 54	45	(3100)	Max CTD depth = 1000 m	
C35	17:45		25/10/88	41 49	63 55	46	(2700)	Max CTD depth = 1000 m	
C36	21:15		25/10/88	42 04	63 53	47	(2400)	Max CTD depth = 600 m	
C37	23:15		25/10/88	42 15	63 55	48	(2000)		
C38	01:15		26/10/88	42 25	63 53	49	(1700)		
C39	03:20		26/10/88	42 33	63 51	50	(1400)		
C40	05:37		26/10/88	42 41	63 55	51	(900)		
C41	09:10		26/10/88	42 47	63 49	52	320	Max CTD depth = 304 m	
C42	19:50		26/10/88	43 41	63 07		270	Max CTD depth = 262 m	

Table 9. Hydrographic station data for cruise N112. (Bottom depths in parentheses are estimates from hydrographic charts for cast position.)

Hydro Stn.No.	Ship time	Date	Position		Fishing Stn.No.	Bottom Depth (m)	Results
	(UT-4 hrs.) Hr. Min.	D/M/Y	°N	°W			
C01	13:58	30/11/88	43 33	59 26	1	(1200)	
C02	17:07	30/11/88	43 21	59 20	2	(2200)	Max CTD depth = 1000
C03	20:40	30/11/88	43 28	58 59	3	(2000)	
C04	23:40	30/11/88	43 21	58 59	4	(2600)	
C05	02:15	01/12/88	43 09	59 01	5	(3000)	
C06	04:37	01/12/88	42 59	59 01	6	(3500)	
X01	06:55	01/12/88	42 49	59 00	7	(3800)	
X02	08:15	01/12/88	42 40	59 00		(4100)	
X03	09:30	01/12/88	42 30	59 00		(4100)	
X04	11:10	01/12/88	42 21	59 00		(4400)	
X05	12:30	01/12/88	42 28	59 00		(4100)	
X06	15:25	01/12/88	42 15	58 59	8	(4400)	1830 m XBT
X07	19:15	01/12/88	41 49	59 00	9	(4700)	
X08	21:15	01/12/88	41 40	59 00	10	(4800)	
X09	23:30	01/12/88	41 32	58 59	11	(4700)	
X10	02:01	02/12/88	41 19	59 00	12	(4500)	
X11	04:17	02/12/88	41 10	59 01	13	(4700)	
X12	06:30	02/12/88	41 00	59 01	14	(4900)	
X13	15:30	02/12/88	41 10	59 02	15	(4700)	1830 m XBT
X14	07:45	03/12/88	41 10	59 00	15	(4700)	1830 m XBT
X15	12:09	03/12/88	41 19	59 07		(4500)	
X16	15:08	03/12/88	41 28	59 19	16	(4600)	1830 m XBT
X17	16:23	03/12/88	41 33	59 30		(4700)	
X18	18:48	03/12/88	41 37	59 45	17	(4600)	
X19	20:50	03/12/88	41 44	59 53	18	(4500)	
X20	22:57	03/12/88	41 52	60 06	19	(3800)	
X21	01:27	04/12/88	41 59	60 18	20	(3900)	
X22	03:30	04/12/88	42 07	60 27	21	(4200)	
X23	05:40	04/12/88	42 13	60 40	22	(3800)	
X24	07:30	04/12/88	42 20	60 50		(3500)	
X25	08:40	04/12/88	42 28	61 00		(3300)	
X26	10:10	04/12/88	42 34	61 14		(2700)	
X27	13:50	04/12/88	42 50	61 31	23	(1500)	1830 m XBT
X28	12:31	05/12/88	42 52	61 33	24	1063	
X29	14:42	05/12/88	42 44	61 40	25	1410	1830 m XBT
X30	18:55	05/12/88	42 42	61 30	26	(1800)	
X31	20:50	05/12/88	42 33	61 33	27	(2400)	
X32	23:50	05/12/88	42 24	61 28	28	(3000)	
X33	02:00	06/12/88	42 12	61 31	29	(3500)	
X34	03:55	06/12/88	42 02	61 28	30	(4000)	
X35	05:55	06/12/88	41 51	61 30	31	(4200)	
X36	07:06	06/12/88	41 43	61 30		(4200)	
X37	08:15	06/12/88	41 33	61 29		(4200)	
X38	12:36	06/12/88	41 21	61 28	32	(4300)	1830 m XBT
X39	18:50	06/12/88	41 48	61 41	33	(4200)	
X40	20:40	06/12/88	41 50	61 55	34	(3800)	
X41	22:29	06/12/88	41 51	62 10	35	(3600)	
X42	00:25	07/12/88	41 50	62 24	36	(3300)	
X43	02:24	07/12/88	41 51	62 40	37	(3300)	
X44	04:42	07/12/88	41 51	62 53	38	(3300)	
X45	15:01	07/12/88	41 41	62 57	39	(3400)	1830 m XBT
X46	18:55	07/12/88	41 30	63 00	40	(3600)	
X47	20:35	07/12/88	41 39	62 59	41	(3300)	
X48	22:28	07/12/88	41 49	63 01	42	(3100)	
X49	01:06	08/12/88	42 00	62 59	43	(2900)	
X50	03:40	08/12/88	42 11	63 00	44	(2600)	
X51	05:26	08/12/88	42 19	63 01	45	(2200)	
X52	11:20	08/12/88	42 26	62 59	46	(1800)	1830 m XBT

Table 10. Hydrographic station data for cruise N119. (Bottom depths in parentheses are estimates from hydrographic charts for cast position.)

Hydro Stn.No.	Ship time	Date	Position		Fishing Stn.No.	Bottom Depth (m)	Remarks
	(UT-3 hrs.) Hr. Min.	D/M/Y	°N	°W			
C01	22:27	12/04/89	43 26	59 01	1	(2100)	
C02	01:17	13/04/89	43 11	59 00	2	(3000)	
C03	04:03	13/04/89	42 56	59 00	3	(3700)	
C04	07:58	13/04/89	42 36	59 00		(4000)	
C05	10:20	13/04/89	42 15	59 00		(4500)	
C06	11:33	13/04/89	42 04	59 00		(4500)	
C07	13:13	13/04/89	41 52	59 00		(4600)	
C08	14:50	13/04/89	41 41	59 00	4	(4600)	Max. CTD depth = 705 m
C09	20:09	13/04/89	41 31	59 00	5	(4500)	
C10	23:04	13/04/89	41 18	58 59	6	(4400)	
X01	23:55	14/04/89	41 34	59 24	7	(4600)	
X02	16:45	15/04/89	42 05	60 07	8	(3800)	760 m XBT
C11	20:15	15/04/89	42 29	60 39	9	(3100)	
C12	05:09	16/04/89	42 43	60 58	10	(2700)	
C13	09:30	16/04/89	43 07	61 17	11	(1100)	
C14	12:17	16/04/89	42 57	61 20	12	(1900)	Max. CTD depth = 700 m
C15	14:35	16/04/89	42 42	61 31		(1900)	Max. CTD depth = 700 m
X03	02:41	17/04/89	42 26	61 28	13	(2800)	
X04	04:41	17/04/89	42 14	61 28	14	(3300)	
X05	19:01	17/04/89	41 36	61 30		(4300)	
X06	21:09	17/04/89	41 12	61 30		(4400)	
C16	19:18	18/04/89	40 59	61 30	15	(4500)	Max. CTD depth = 700 m
C17	06:25	19/04/89	41 02	61 31	15	(4500)	Max. CTD depth = 700 m
C18	19:55	19/04/89	41 00	61 30	15	(4500)	Max. CTD depth = 700 m
C19	06:26	20/04/89	40 57	61 30	15	(4500)	Max. CTD depth = 700 m
C20	20:02	20/04/89	41 30	62 00		(3900)	Max. CTD depth = 700 m

Table 11. Hydrographic station data for cruise N122. (Bottom depths in parentheses are estimates from hydrographic charts for cast position.)

Hydro Stn.No.	Ship time	Date	Position		Fishing Stn.No.	Bottom Depth (m)	Remarks
	(UT-3 hrs.) Hr. Min.	D/M/Y	°N	°W			
C01	21:01	06/06/89	43 30	58 59	1	(1900)	
C02	03:08	07/06/89	43 17	59 03	2	(2800)	
C03	05:25	07/06/89	43 00	59 00		(3600)	
C04	07:34	07/06/89	42 45	59 00		(3900)	
C05	14:55	07/06/89	42 22	59 00	3	(4400)	
C06	18:21	07/06/89	41 52	59 00		(4600)	
C07	20:45	07/06/89	41 33	59 01	4	(4600)	
C08	01:33	08/06/89	41 12	58 59	5	(4600)	
C09	04:03	08/06/89	40 57	59 01	6	(4800)	
C10	06:55	08/06/89	41 15	59 20		(4600)	
C11	11:05	08/06/89	41 36	59 41		(4600)	Max. CTD depth = 800 m
C12	14:30	08/06/89	41 48	60 02	7	(4400)	Max. CTD depth = 750 m
C13	20:55	08/06/89	42 09	60 33	8	(4000)	
C14	01:25	09/06/89	42 23	60 51	9	(3400)	
C15	04:14	09/06/89	42 32	61 03	10	(2900)	
C16	08:30	09/06/89	42 44	61 26	11	(1900)	Max. CTD depth = 950 m
C17	12:10	09/06/89	42 47	61 29	12	(1500)	Max. CTD depth = 800 m
C18	14:59	09/06/89	42 47	61 37	13	(1300)	Max. CTD depth = 450 m
C19	18:40	09/06/89	42 31	61 36		(2600)	Max. CTD depth = 700 m
C20	21:00	09/06/89	42 30	61 33	14	(2700)	
C21	09:30	10/06/89	41 55	61 30		(4000)	Max. CTD depth = 900 m
X01	12:45	10/06/89	41 38	61 32		(4300)	
C22	20:55	10/06/89	41 00	61 29	15	(4500)	
C23	06:15	11/06/89	41 00	61 29	15	(4500)	
C24	21:20	11/06/89	41 00	61 30	15	(4500)	Max. CTD depth = 600 m
C25	04:50	12/06/89	41 00	61 29	15	(4500)	Max. CTD depth = 600 m
C26	06:55	13/06/89	41 00	61 30	15	(4500)	Max. CTD depth = 600 m
C27	20:30	13/06/89	41 00	61 30	15	(4500)	Max. CTD depth = 600 m
C28	04:35	14/06/89	41 00	61 30	15	(4500)	Max. CTD depth = 600 m
X02	10:40	14/06/89	41 09	61 52		(4400)	
X03	12:20	14/06/89	41 21	62 08		(4200)	
X04	13:25	14/06/89	41 29	62 17		(3800)	
X05	15:10	14/06/89	41 42	62 35		(3400)	
X06	16:32	14/06/89	41 51	62 50		(3100)	
C29	20:20	14/06/89	41 56	63 00	16	(2900)	Max. CTD depth = 900 m
C30	01:35	15/06/89	42 12	63 00	17	(2300)	
C31	04:25	15/06/89	42 28	63 01	18	2160	
C32	10:35	15/06/89	42 45	63 15	19	700	Max. CTD depth = 600 m

Table 12. Hydrographic station data for cruise N126. (Bottom depths in parentheses are estimates from hydrographic charts for cast position.)

Hydro Stn.No.	<u>Ship time</u>	<u>Date</u>	<u>Position</u>		Fishing Stn.No.	Bottom Depth (m)	Remarks
	(UT-3 hrs.) Hr. Min.	D/M/Y	°N	°W			
C01	18:38	10/08/89	43 39	59 10	4	440	Max. CTD depth = 400 m
C02	20:23	10/08/89	43 32	59 02	5	(1900)	
C03	00:35	11/08/89	43 15	58 57	6	(2800)	
C04	03:09	11/08/89	43 02	58 58	7	(3500)	
C05	08:50	11/08/89	42 29	59 01		(3800)	
C06	12:25	11/08/89	42 09	59 02		(4600)	
C07	16:41	11/08/89	41 51	58 57		(4600)	
C08	20:10	11/08/89	41 36	59 00	8	(4600)	
C09	00:30	12/08/89	41 17	59 01	9	(4400)	
C10	03:50	12/08/89	41 04	58 54	10	(4900)	
C11	09:30	12/08/89	41 26	59 29		(4600)	
C12	10:55	12/08/89	41 31	59 40		(4600)	
C13	15:00	12/08/89	41 35	60 02		(4600)	
C14	16:25	12/08/89	41 44	60 09		(4400)	Max. CTD depth = 800 m
C15	20:45	12/08/89	41 59	60 29	11	(4200)	
C16	00:20	13/08/89	42 11	60 50	12	(3800)	
C17	02:56	13/08/89	42 24	60 57	13	(3300)	
C18	05:25	13/08/89	42 36	61 11	14	(2700)	
C19	08:45	13/08/89	42 57	61 40	15	495	Max. CTD depth = 450 m
C20	15:50	13/08/89	43 14	61 40	20	80	Max. CTD depth = 75 m
C21	20:15	13/08/89	42 42	61 30	22	(1900)	
C22	00:23	14/08/89	42 24	61 29	23	(3000)	
C23	04:37	14/08/89	42 10	61 28	24	(3700)	
C24	06:30	14/08/89	41 54	61 30		(3800)	
C25	08:09	14/08/89	41 40	61 30		(4200)	
C26	09:50	14/08/89	41 26	61 30		(4200)	
C27	11:40	14/08/89	41 10	61 30		(4400)	
C28	13:05	14/08/89	41 01	61 30	25	(4500)	Max. CTD depth = 600 m
C29	20:05	14/08/89	41 00	61 29	25	(4500)	
C30	06:04	15/08/89	40 59	61 32	25	(4500)	
C31	19:00	15/08/89	41 00	61 30	25	(4500)	
C32	07:00	16/08/89	41 00	61 29	25	(4500)	
C33	20:46	16/08/89	41 00	61 29	25	(4500)	
X01	01:25	17/08/89	41 16	61 46	26	(4400)	
X02	03:55	17/08/89	41 22	62 01	27	(4200)	
C34	09:40	17/08/89	41 36	62 24	28	(3700)	
C35	13:00	17/08/89	41 48	62 35		(3300)	
C36	16:30	17/08/89	41 53	62 51		(3100)	
C37	20:25	17/08/89	42 08	63 00		(2600)	
C38	00:01	18/08/89	42 19	63 01	29	(2200)	
C39	02:10	18/08/89	42 30	63 00	30	(1800)	

Table 13. Oceanographic casts deeper than 500 m.

Cruise	XBT	CTD	Total
H127	-	-	-
N057	4	-	4
G121	-	-	-
N067	8	-	8
N089	4	1	5
N096	5	8	13
N110	1	10	11
N112	9	1	10
N119	1	8	9
N122	-	13	13
N126	-	2	2
Totals	32	43	75

Table 14. Mean temperatures and salinities at 500-1800 m for stations grouped by water mass in upper 500 m. (Numbers of observations given in parentheses.)

Depth (m)	Gulf Stream	Warm Slope Water	Labrador Slope Water
Mean Temperature °C			
500	11.61 (3)	6.58 (51)	4.91 (21)
600	9.10 (3)	5.76 (50)	4.71 (21)
700	7.34 (3)	5.23 (44)	4.55 (19)
800	6.04 (3)	4.97 (35)	4.38 (16)
900	5.56 (2)	4.74 (32)	4.25 (16)
1000	5.15 (2)	4.69 (26)	4.19 (13)
1100	4.88 (2)	4.66 (17)	4.03 (7)
1200	4.64 (2)	4.54 (17)	3.95 (7)
1300	4.46 (2)	4.43 (17)	3.80 (5)
1400	4.32 (2)	4.36 (17)	3.78 (5)
1500	4.21 (2)	4.28 (17)	3.75 (5)
1600	4.14 (2)	4.20 (17)	3.72 (4)
1700	4.08 (2)	4.13 (16)	3.67 (4)
1800	3.99 (2)	4.08 (16)	3.66 (4)
Mean Salinity ‰			
500	-	35.03 (32)	34.92 (11)
600	-	35.03 (32)	34.94 (11)
700	-	35.02 (26)	34.98 (9)
800	-	35.01 (18)	34.98 (7)
900	-	35.01 (15)	34.98 (7)
1000	-	35.01 (8)	34.98 (6)

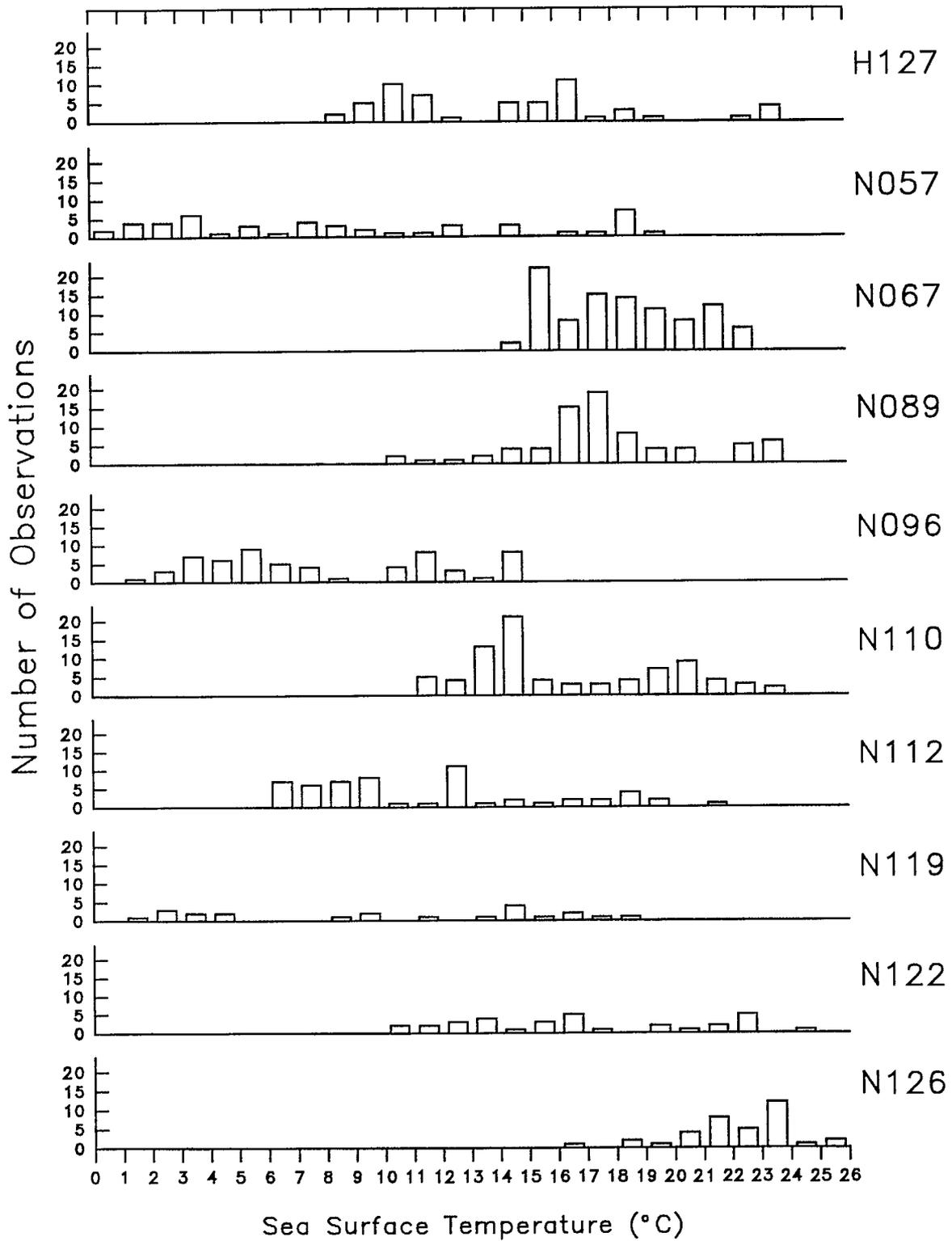


Figure 1a. Frequency distribution of sea surface temperature data collected on each cruise by 1 C intervals. (When more than one observation was taken at the same location only the first is included. The interval between 0 and 1 C contains observations from 0.0 to 0.9 C and so on.)

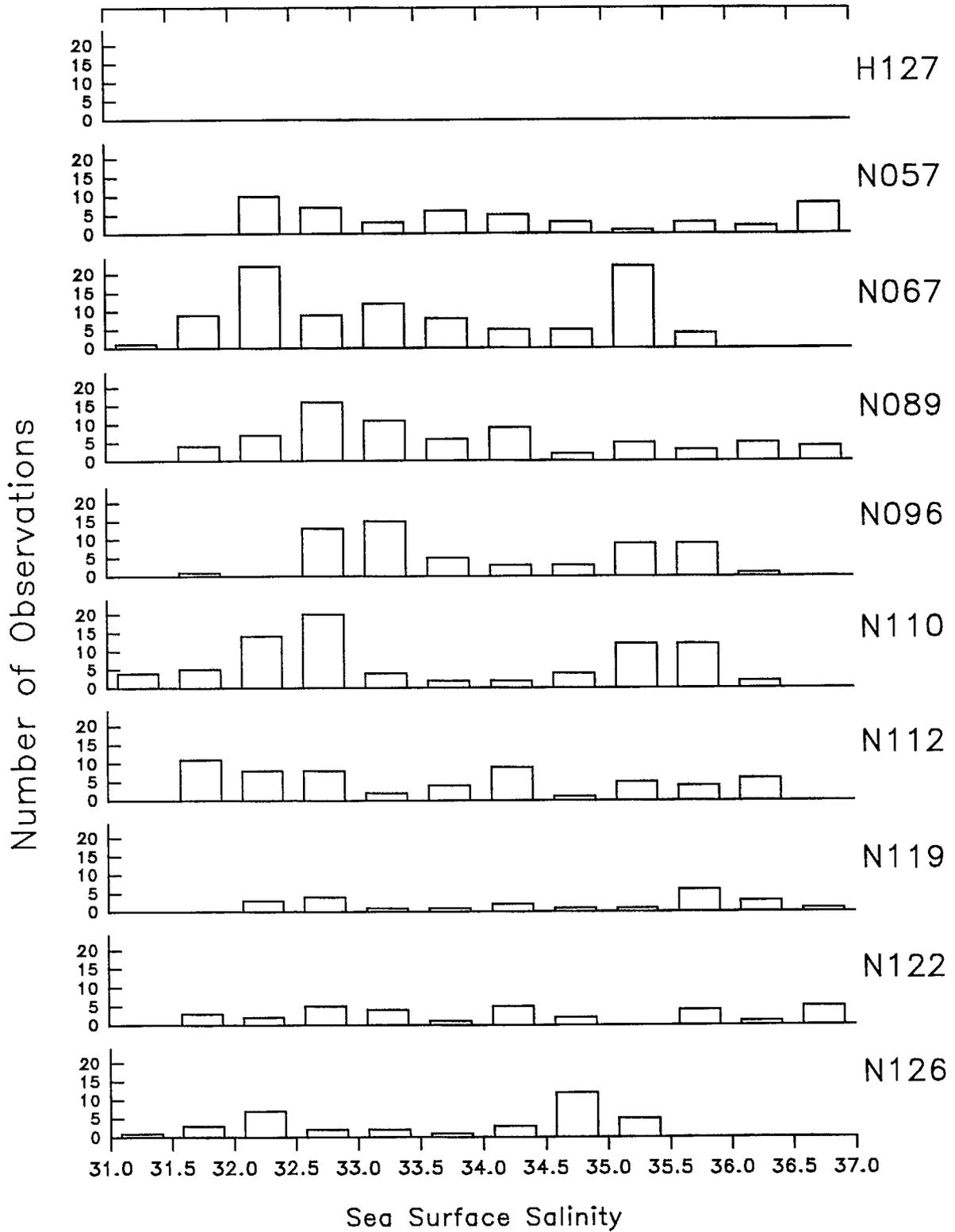


Figure 1b. Frequency distribution of sea surface salinity data collected on each cruise, by 0.5 intervals. (When more than one observation was taken at the same location only the first is included. The interval between 31.0 and 31.5 contains observations from 31.0 to 31.4, and so on.)

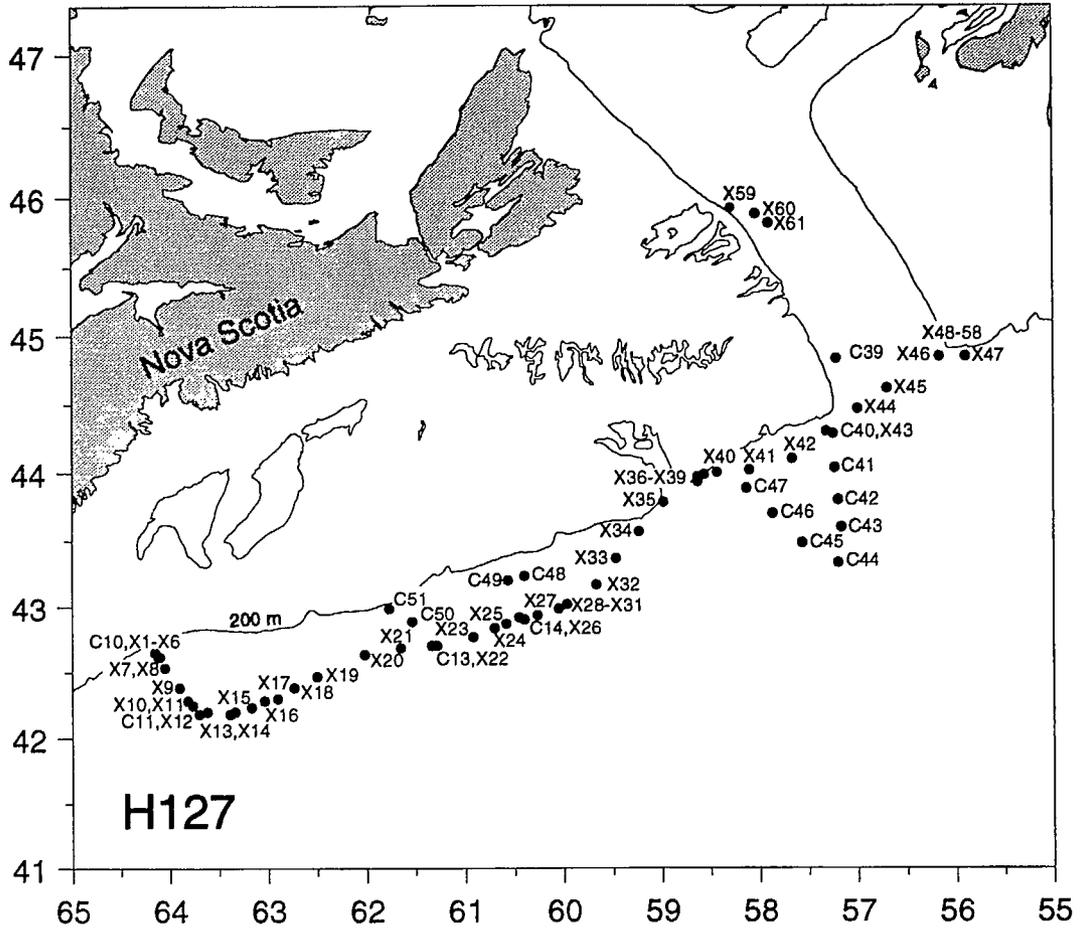


Figure 2. Station locations, cruise H127.

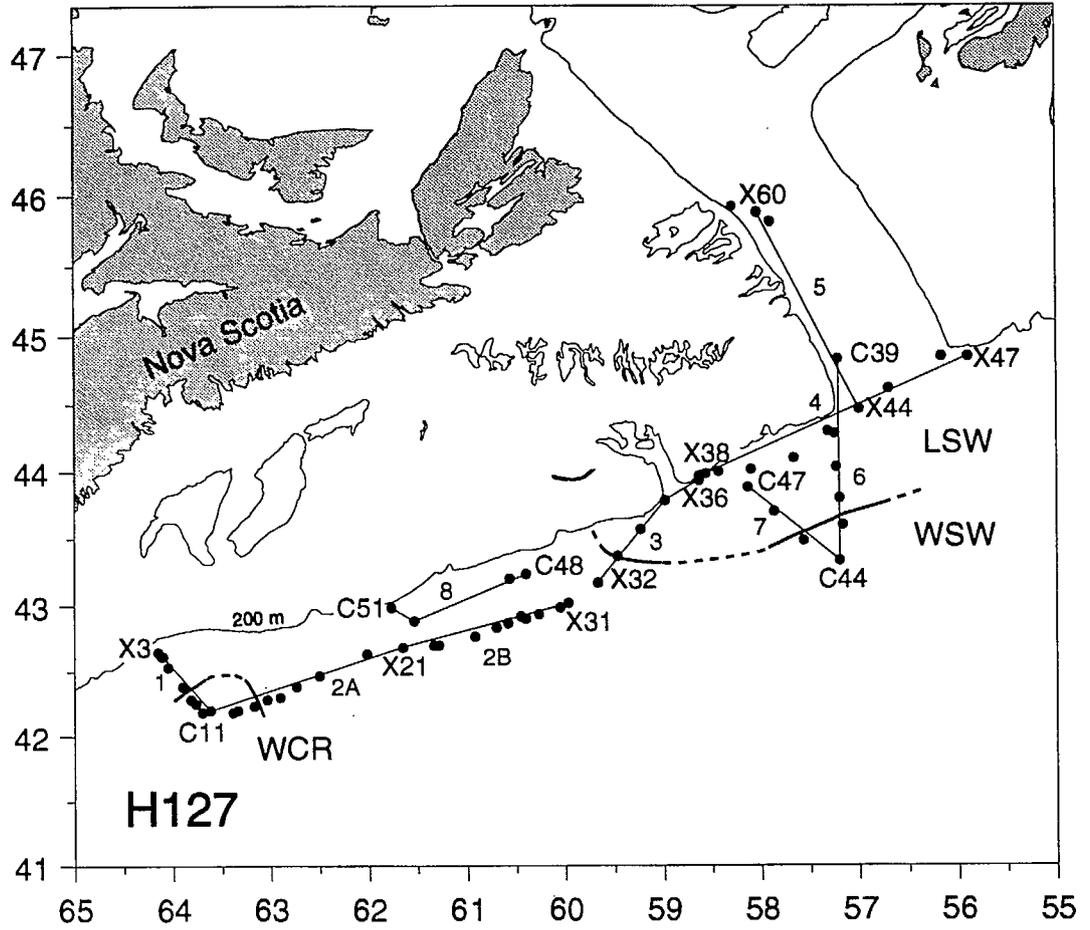


Figure 3. Locations of transects and fronts at 200 m, cruise H127.

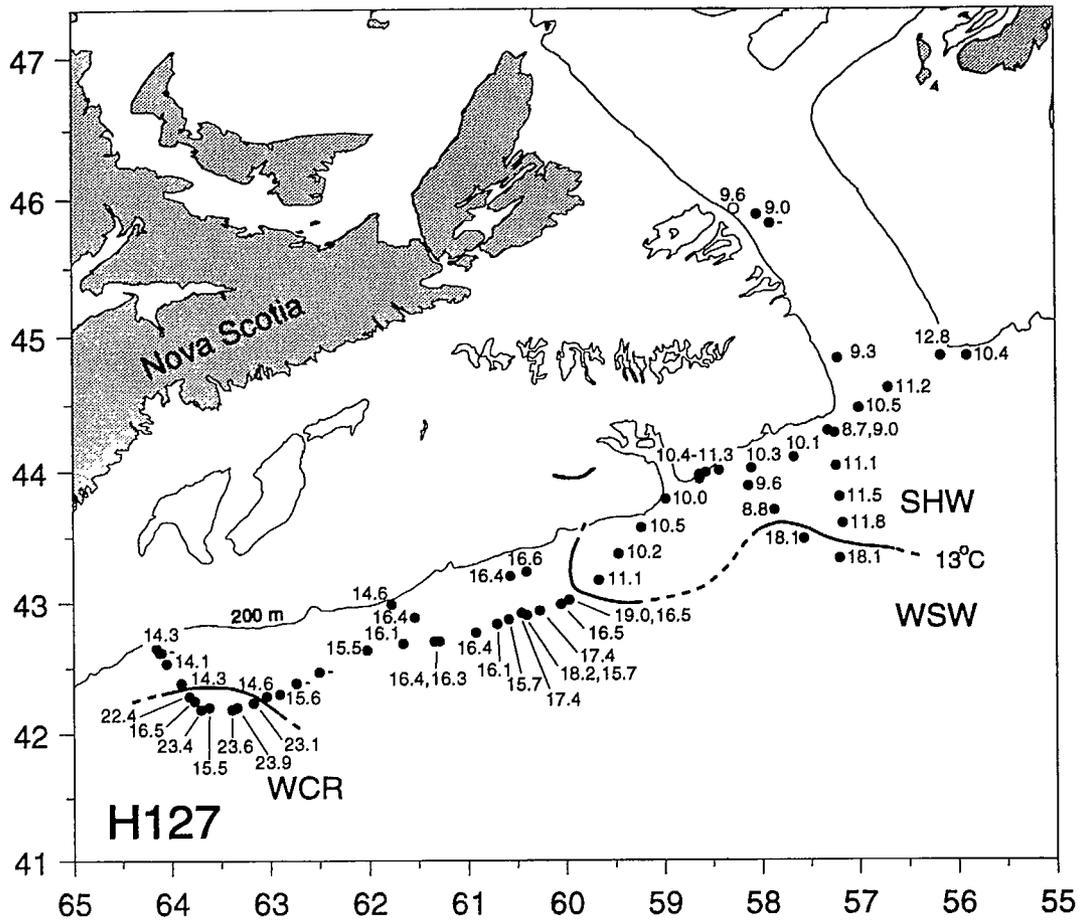


Figure 4. Sea surface temperatures (°C) and fronts, cruise H127.

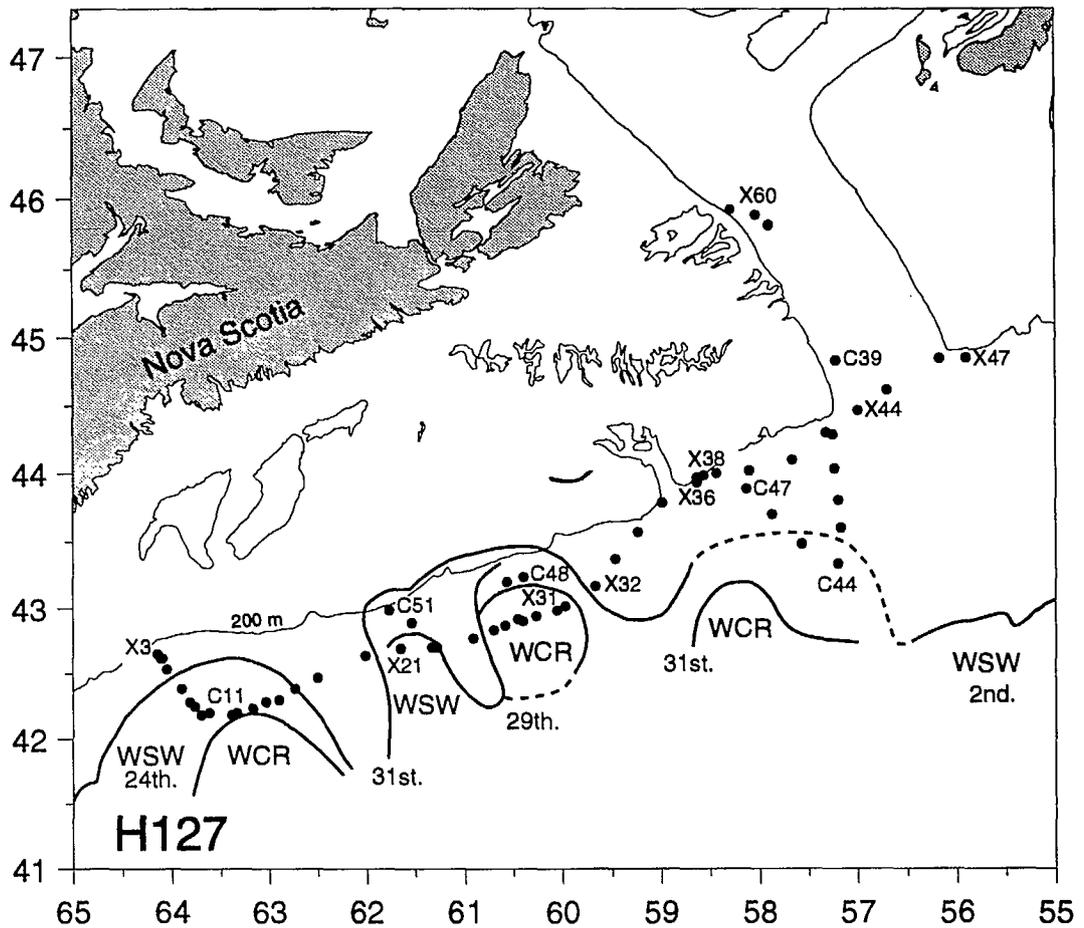


Figure 5. Fronts based on NOAA satellite charts for 24 October (west of 62°W), 29 and 31 October (57-62°W) and 2 November (east of 57°W), 1984, coincident with cruise H127.

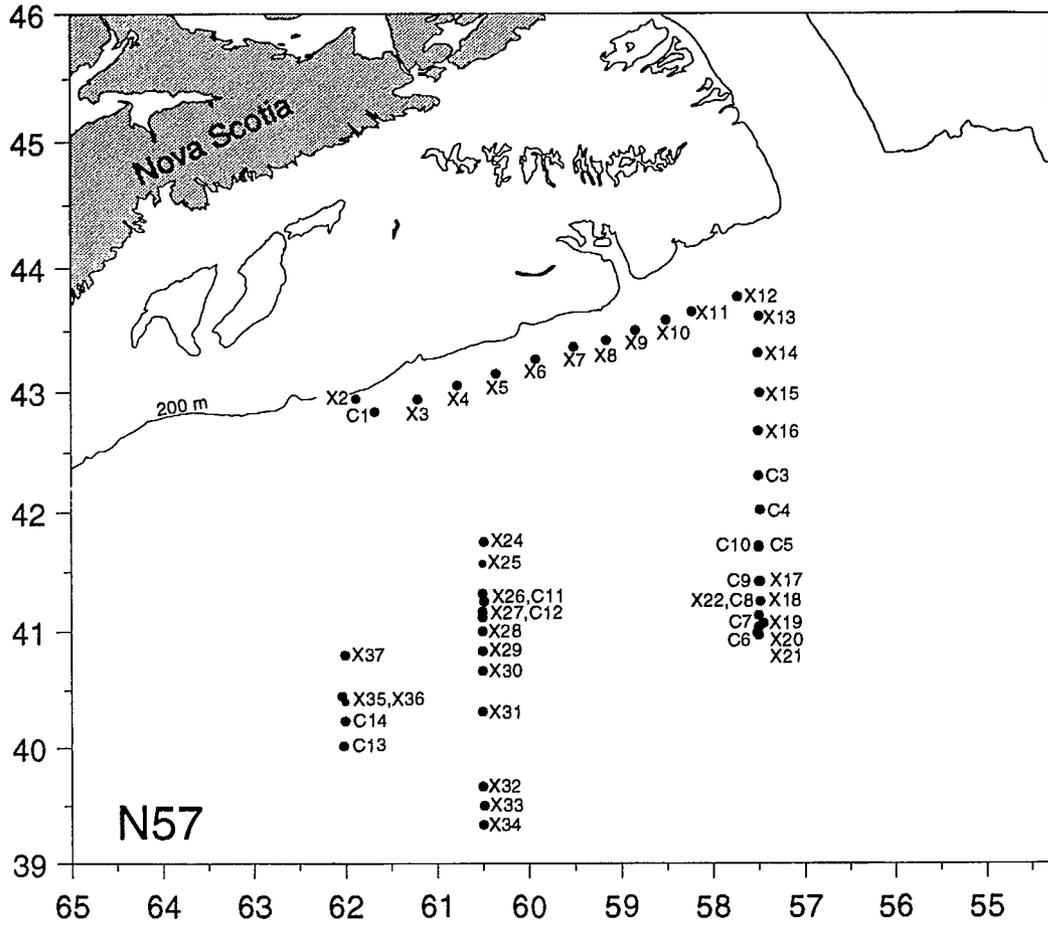


Figure 6. Station locations, cruise N057.

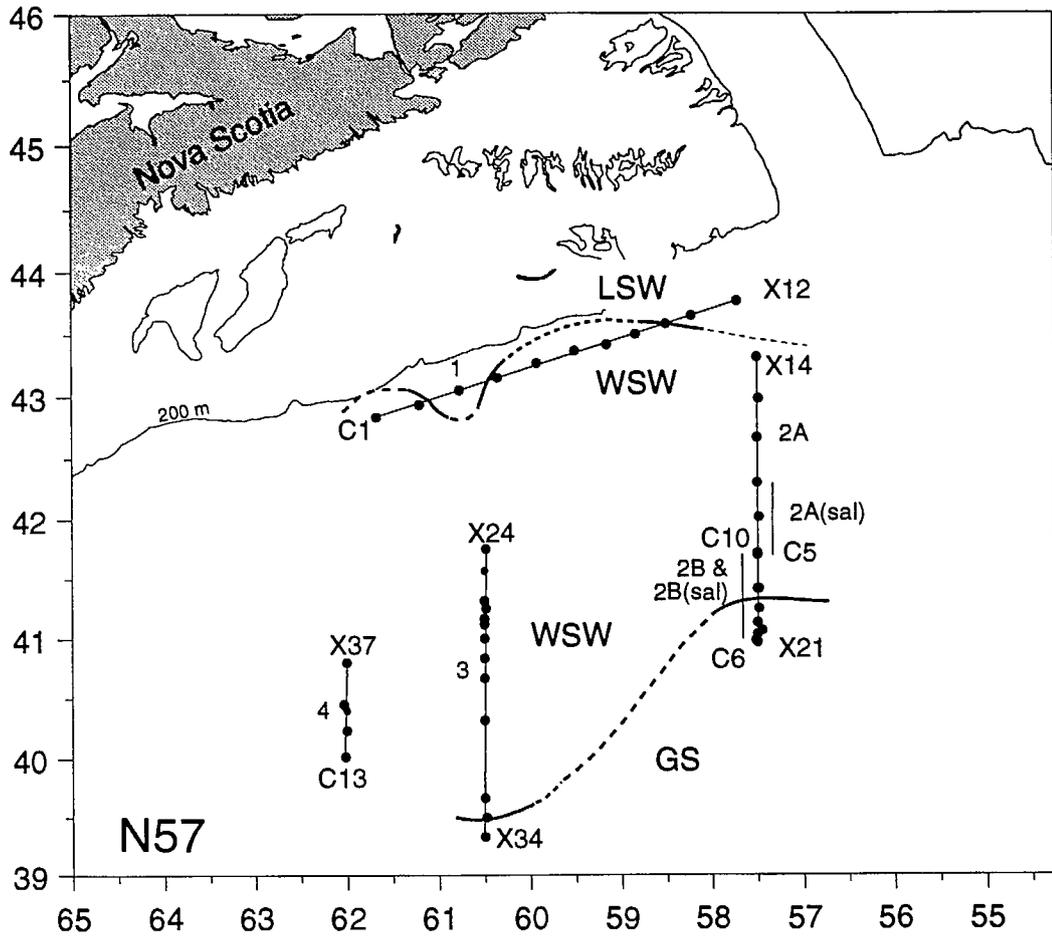


Figure 7. Locations of transects and fronts at 200m, cruise N057.

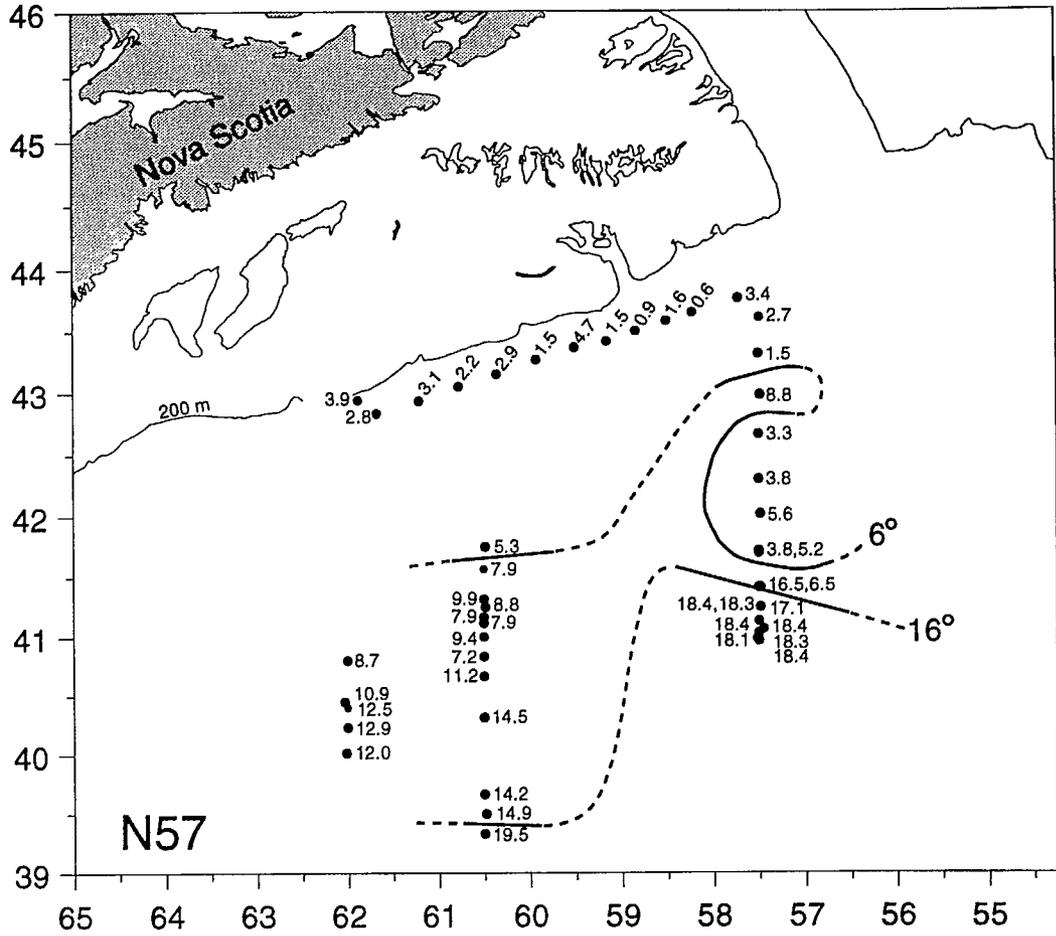


Figure 8. Sea surface temperatures (°C) and fronts, cruise N057.

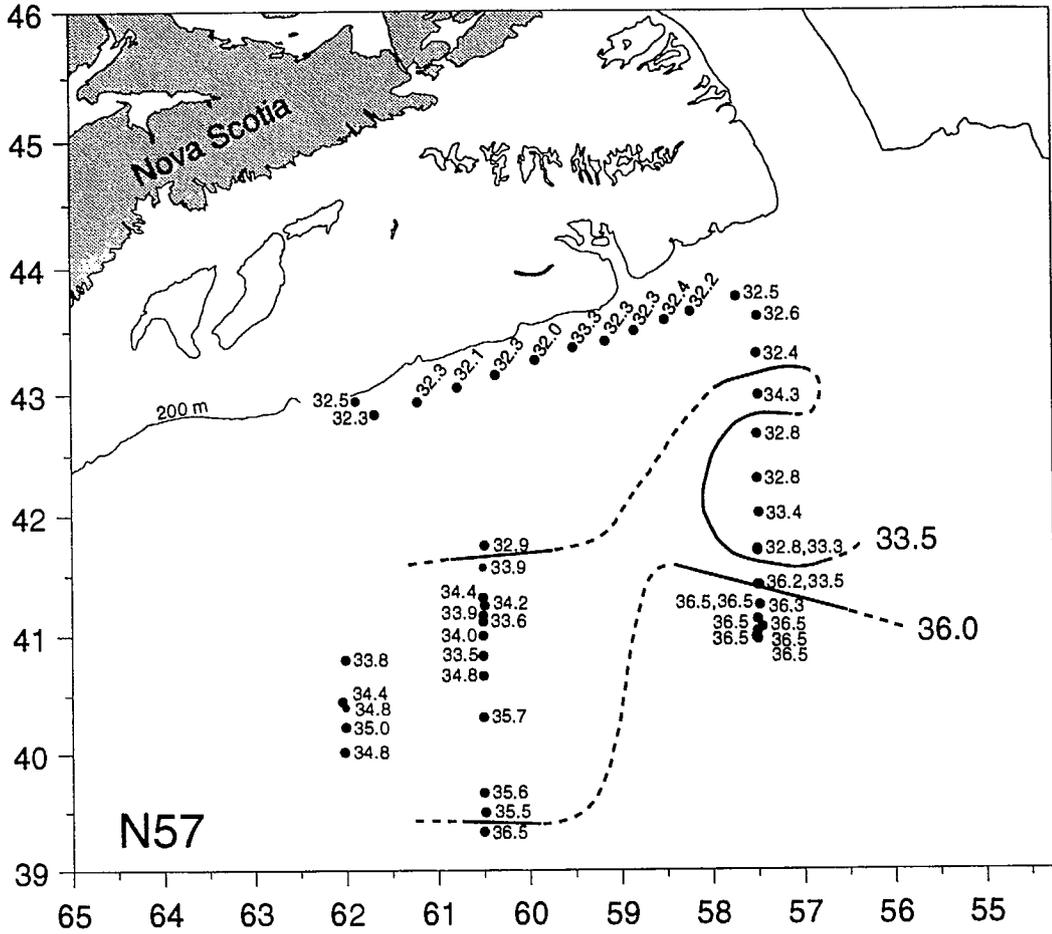


Figure 9. Sea surface salinity and fronts, cruise N057.

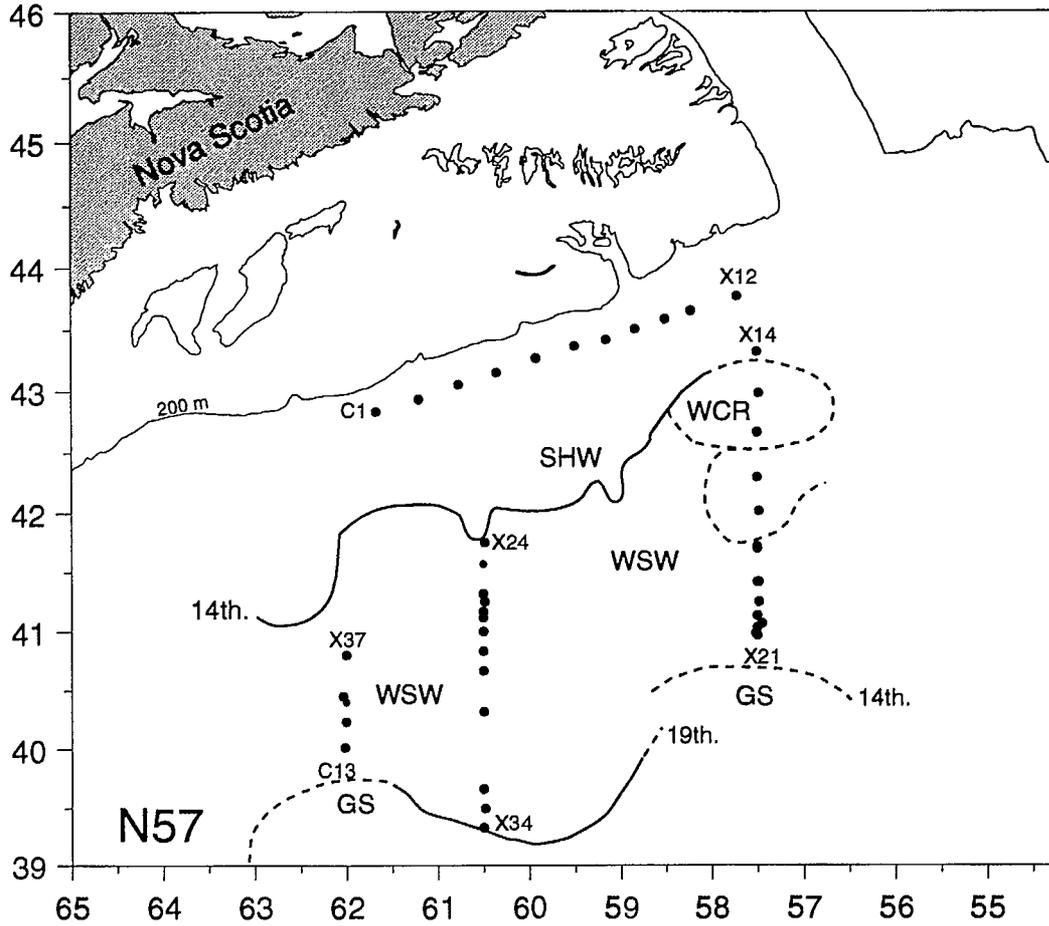


Figure 10. Fronts based on NOAA satellite charts for 14 and 19 February 1986 (as indicated), coincident with cruise N057.

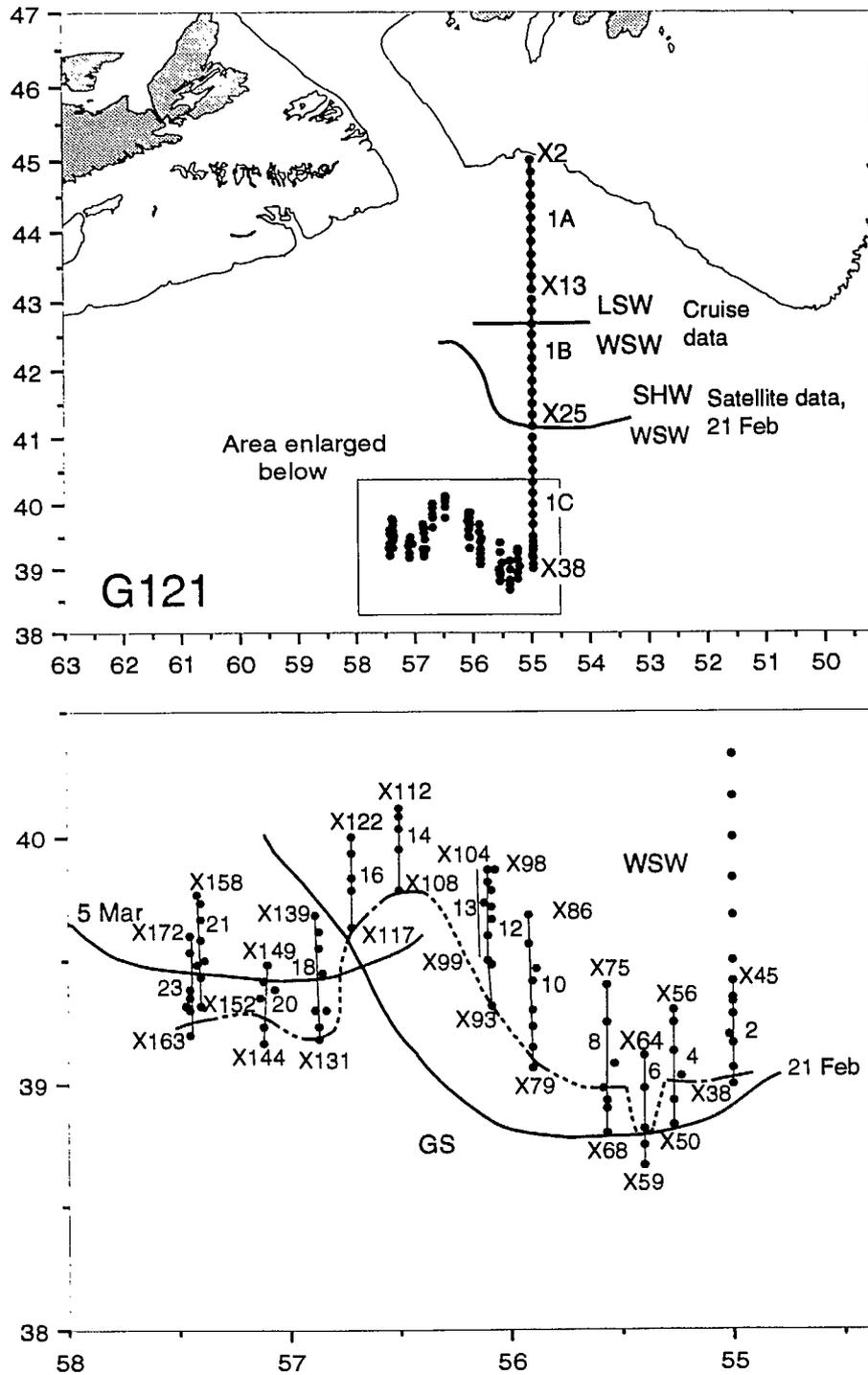


Figure 11. Locations of transects and fronts at 200 m, cruise G121, and surface fronts based on NOAA satellite charts for 21 February and 5 March 1986 (as indicated), coincident with this cruise. (Undated line in lower panel is GS front at 200 m from cruise data.)

Halliday, R.G., D.E. Themelis, C.E. Dale, and G.D. Harrison. 1995. Oceanographic conditions off the Scotian Shelf during mesopelagic resource inventory cruises, 1984-89. *Can. Manuscr. Rep. Fish. aquat. Sci.* 2327:303p

Erratum: This figure replaces Figure 12, page 54.

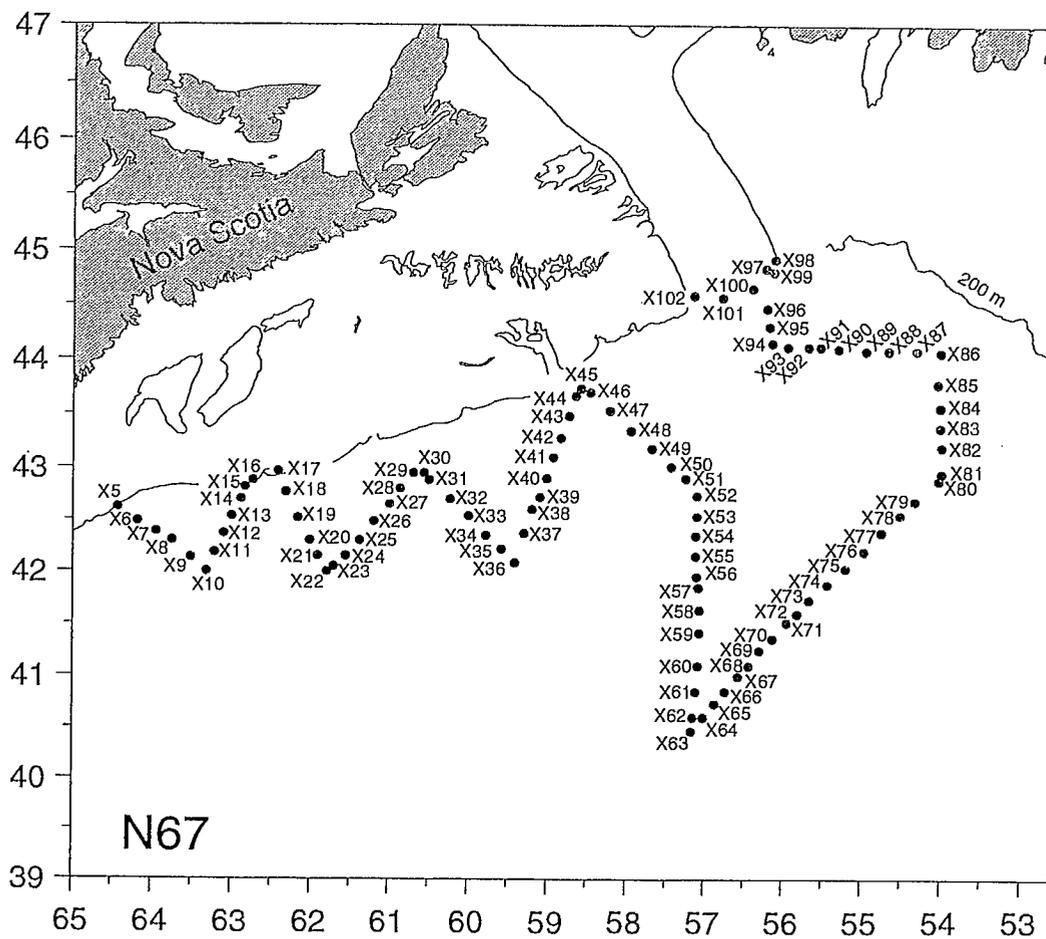


Figure 12. Station locations, cruise N67.

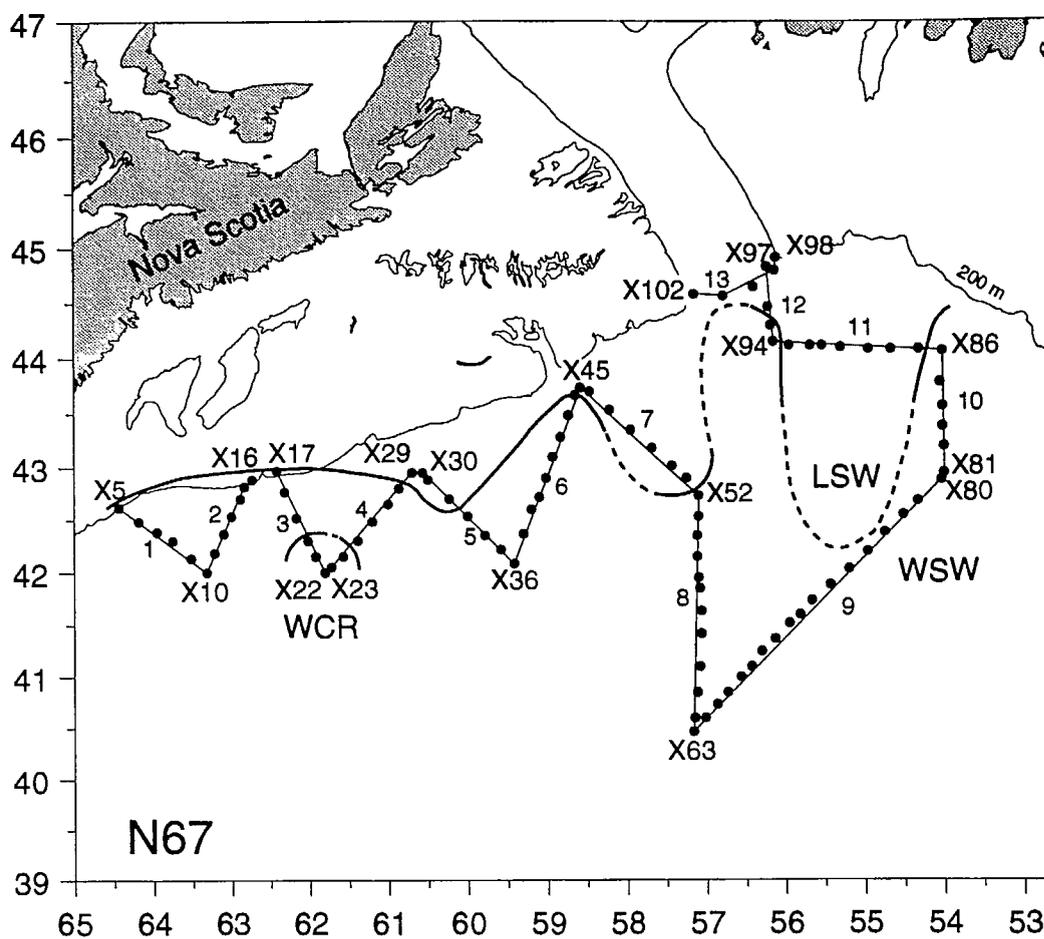


Figure 13. Locations of transects and fronts at 200 m, cruise N067.

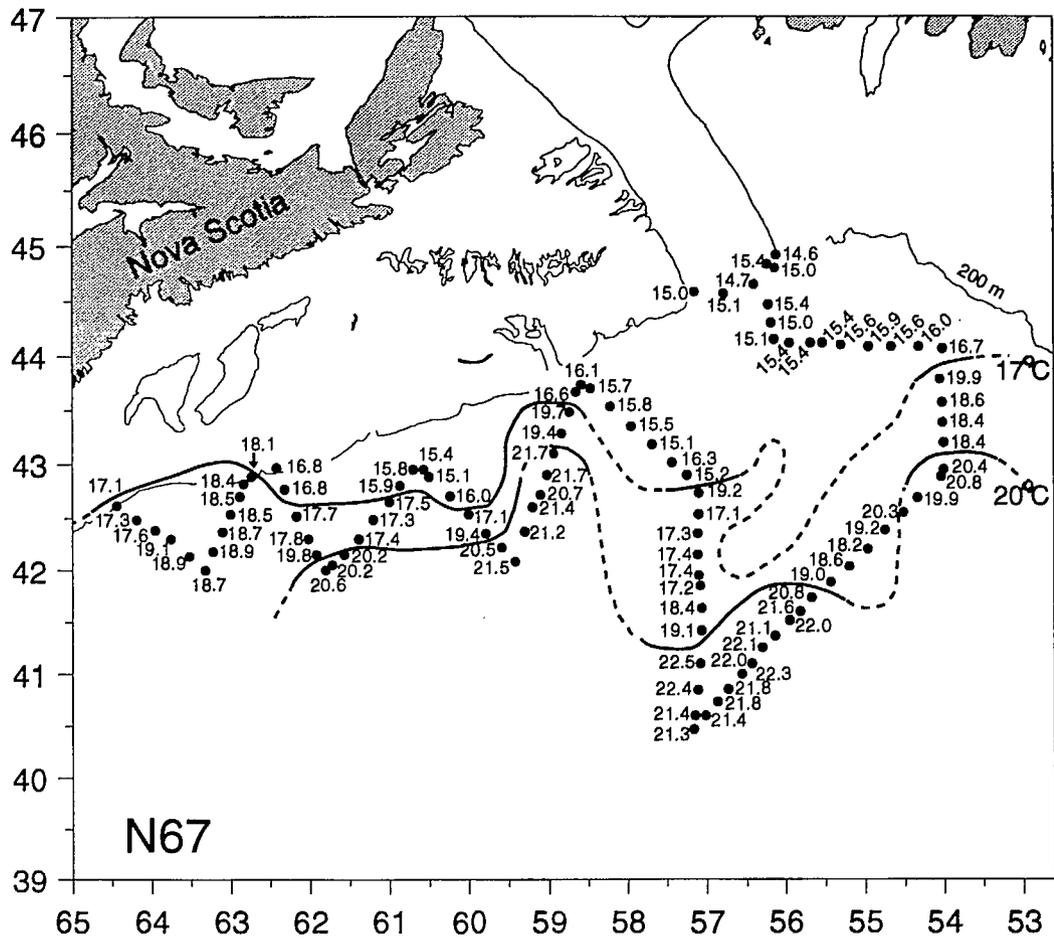


Figure 14. Sea surface temperatures (°C) and fronts, cruise N067.

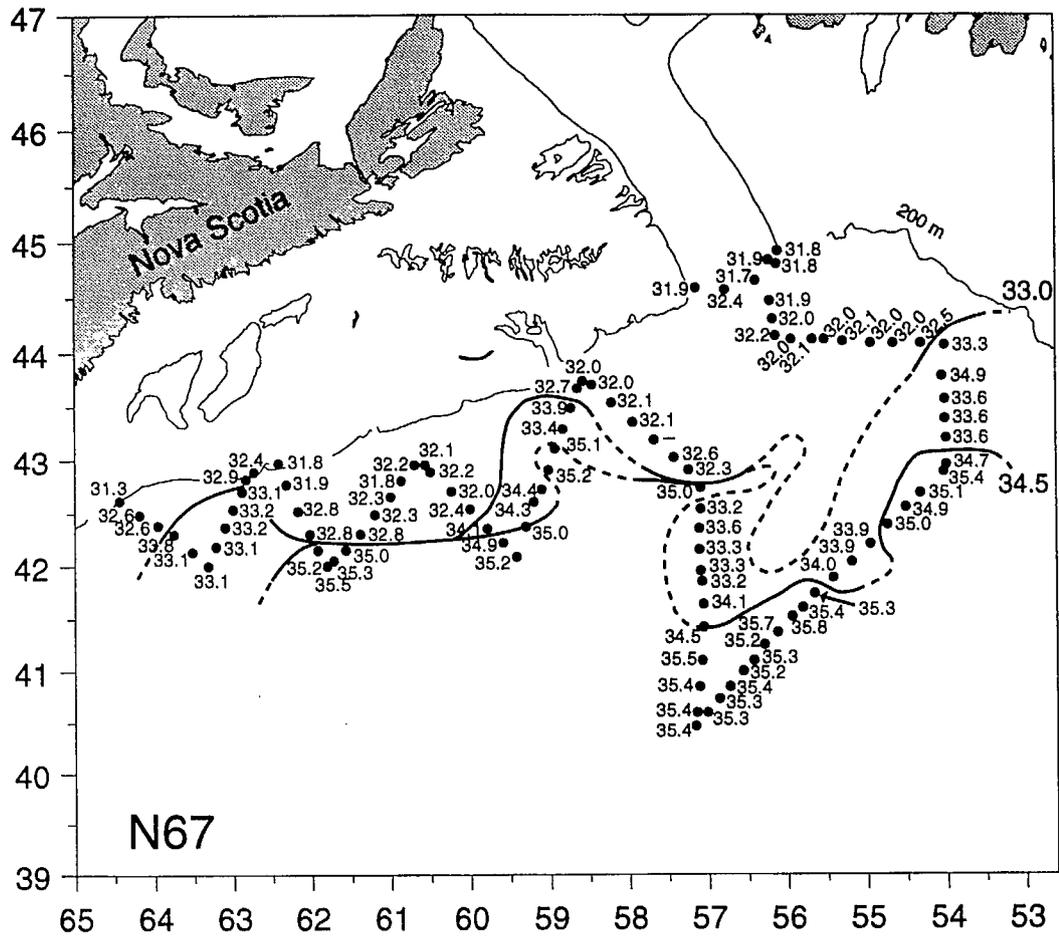


Figure 15. Sea surface salinity and fronts, cruise N067.

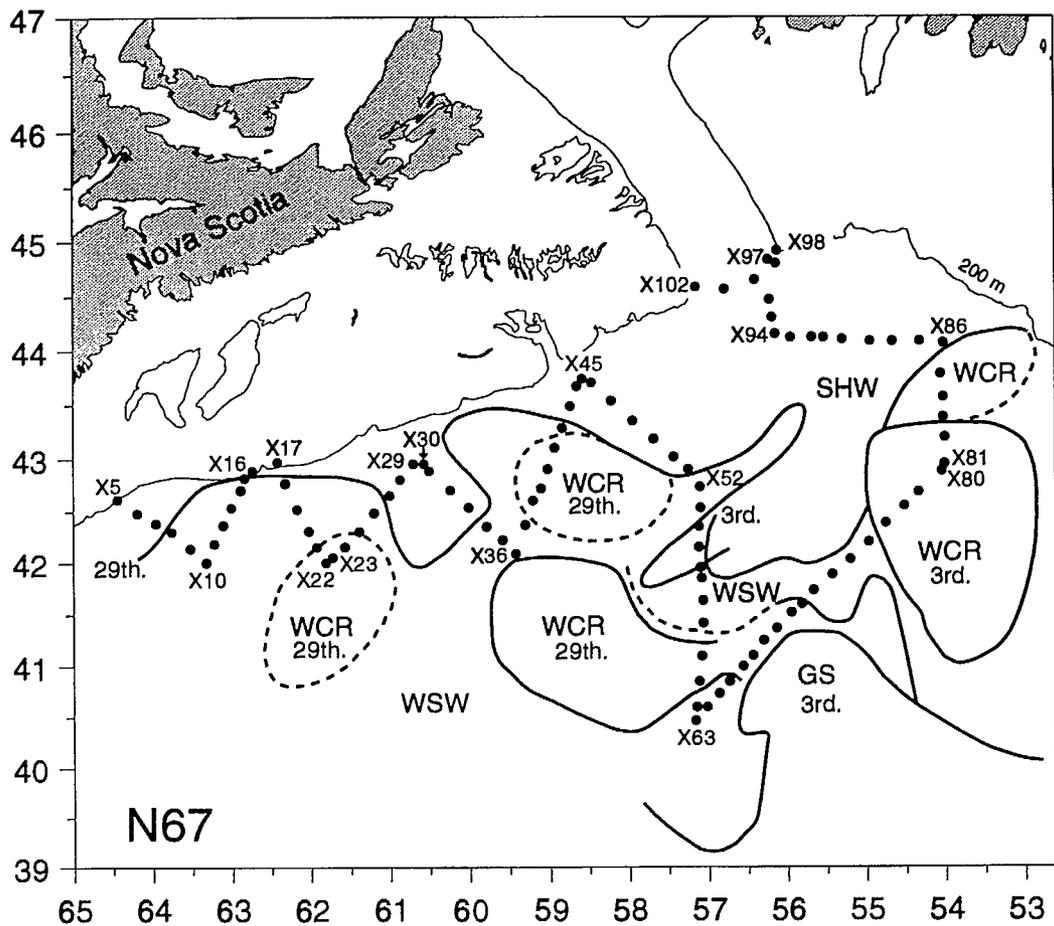


Figure 16. Fronts based on NOAA satellite charts for 29 August (west of about 57°W) and 3 September 1986 (east of about 57°W), coincident with cruise N067.

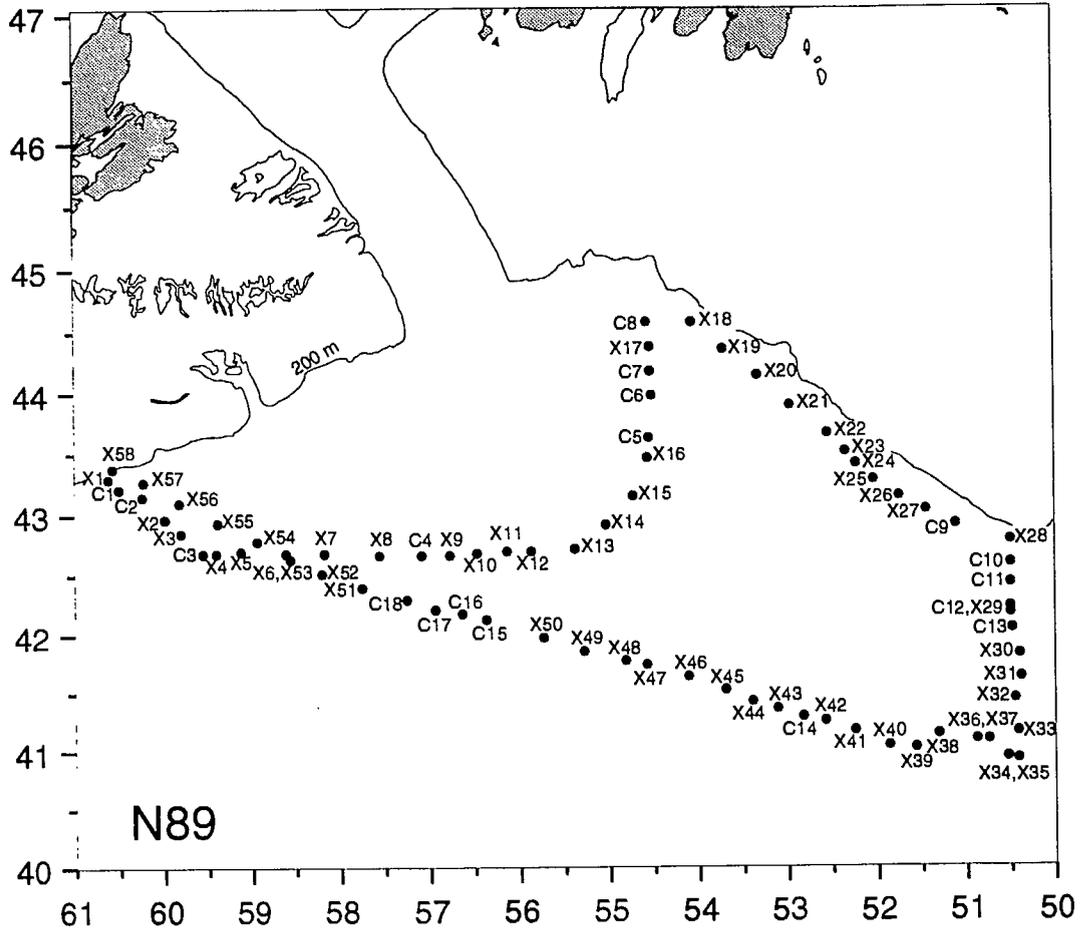


Figure 17. Station locations, cruise N089.

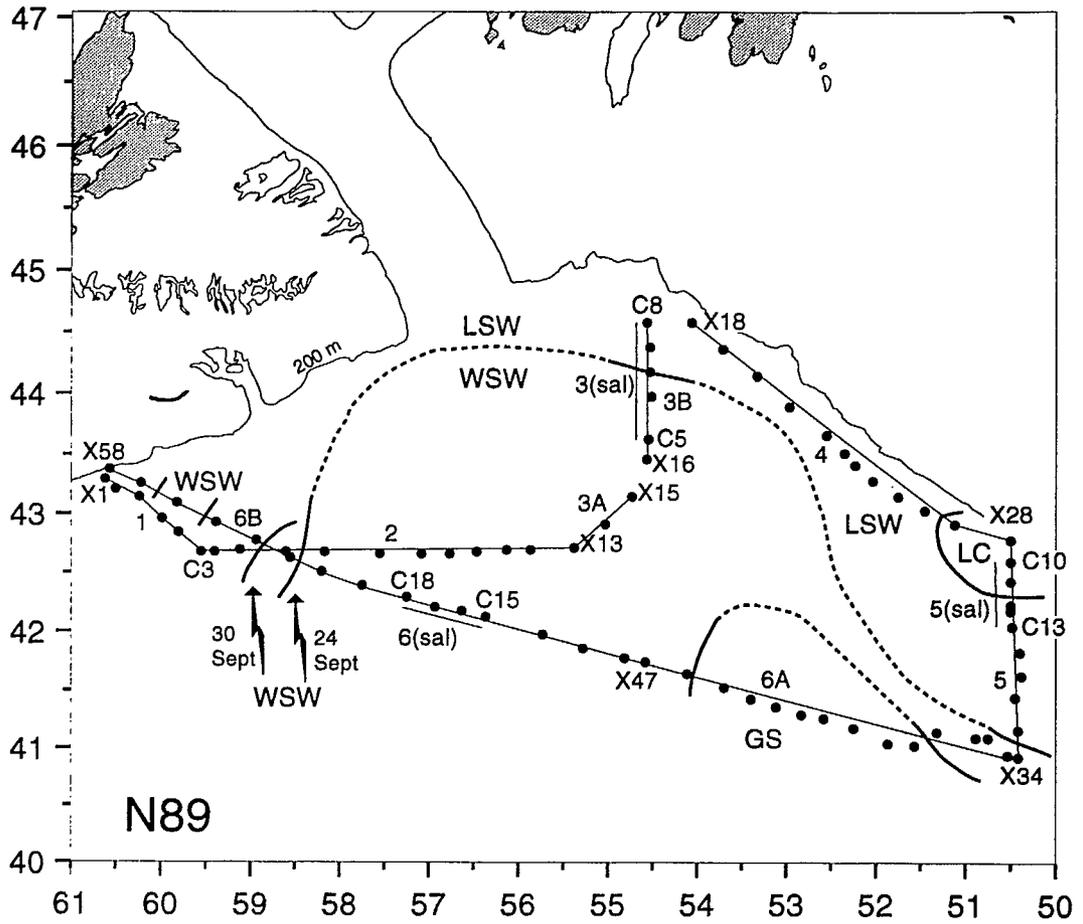
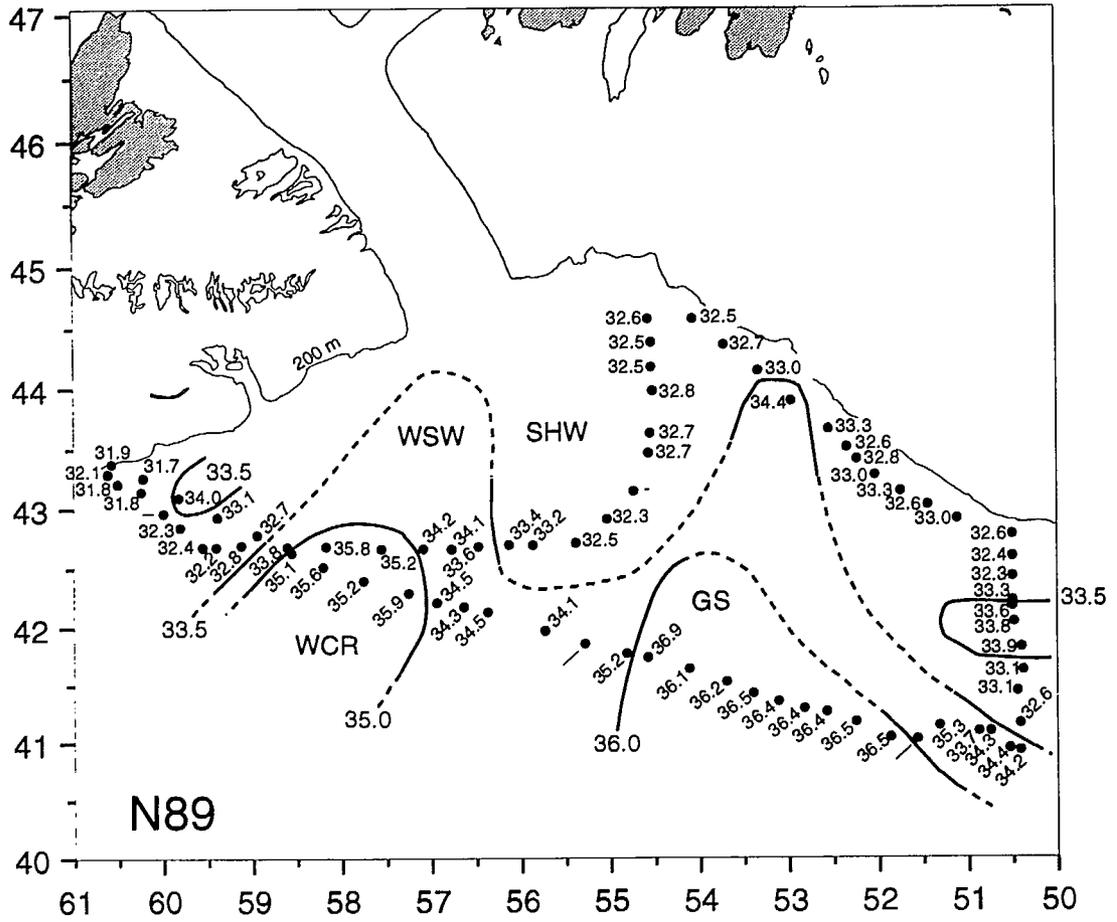


Figure 18. Locations of transects and fronts at 200 m, cruise N089.



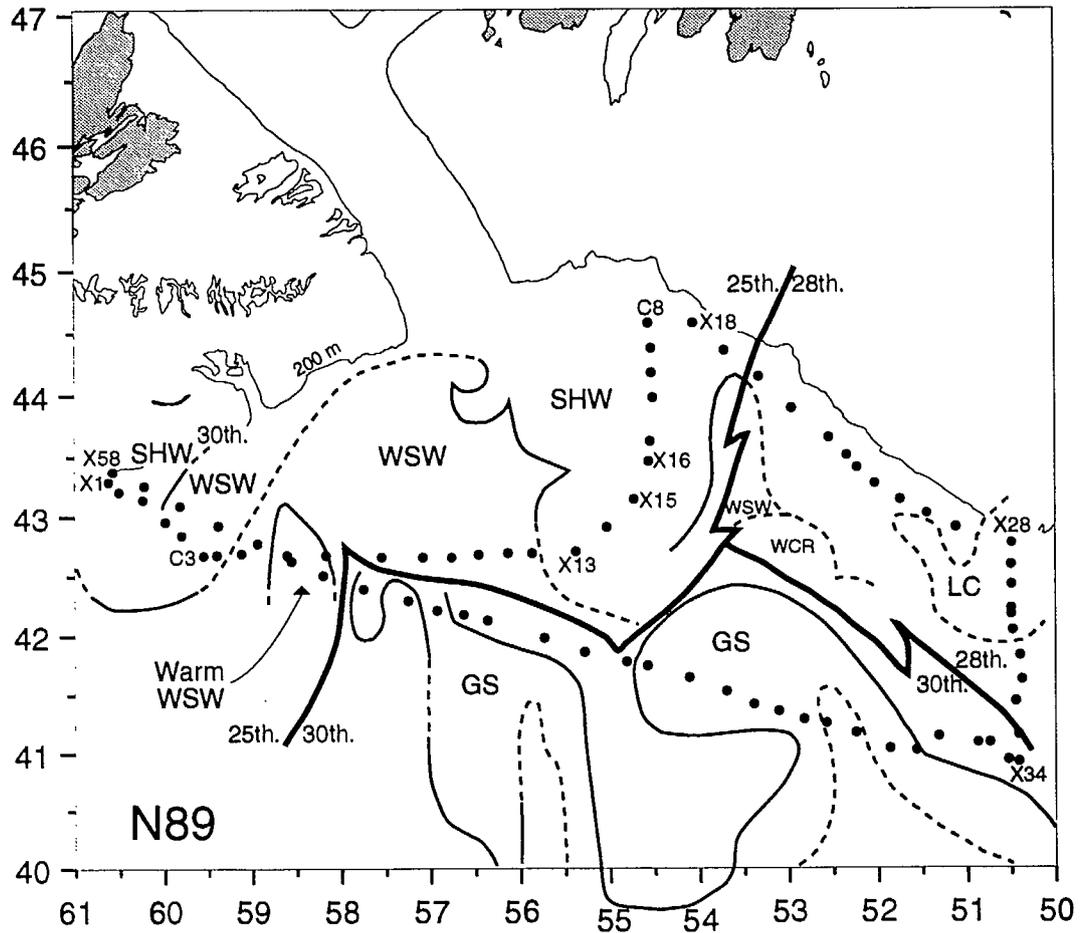


Figure 21. Fronts based on NOAA satellite charts for 25, 28 and 30 September 1987 (as indicated), coincident with cruise N089. Dashed lines south of WSW/GS boundary represent estimated locations of GS/Sargasso Sea boundary.

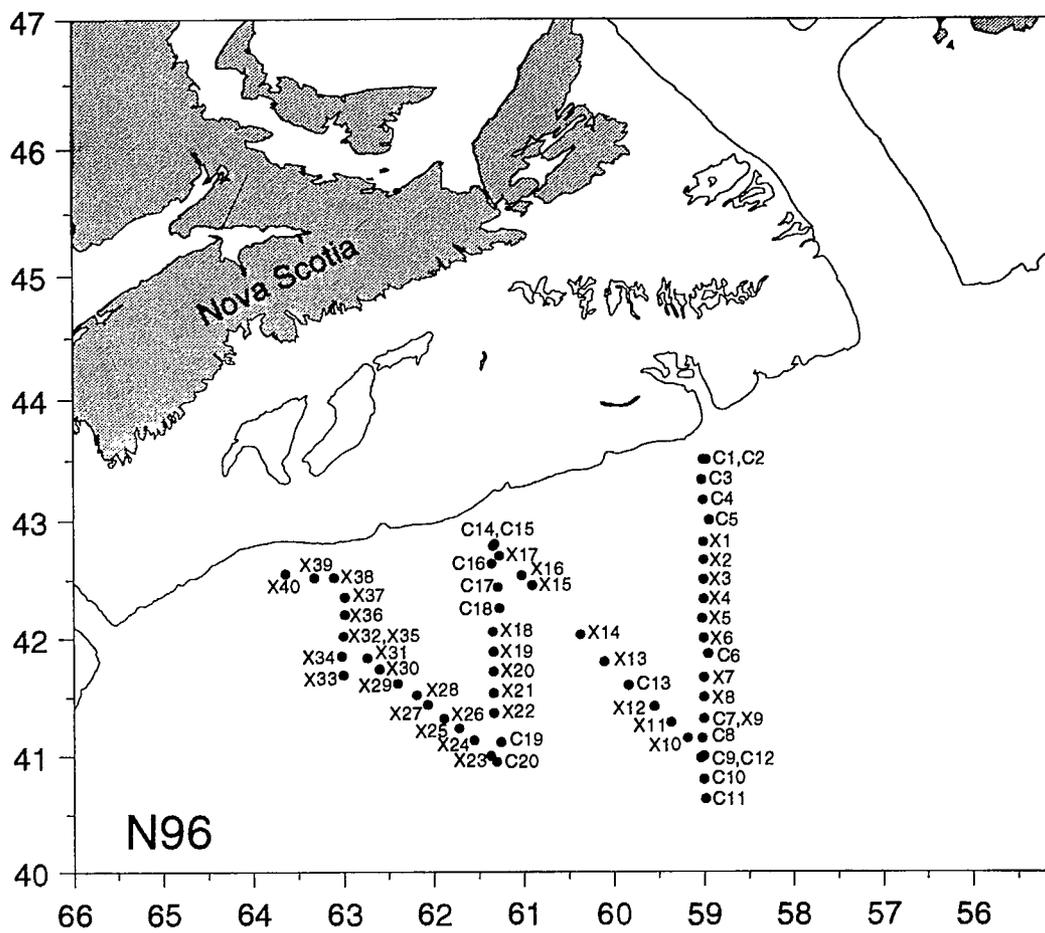


Figure 22. Station locations, cruise N096.

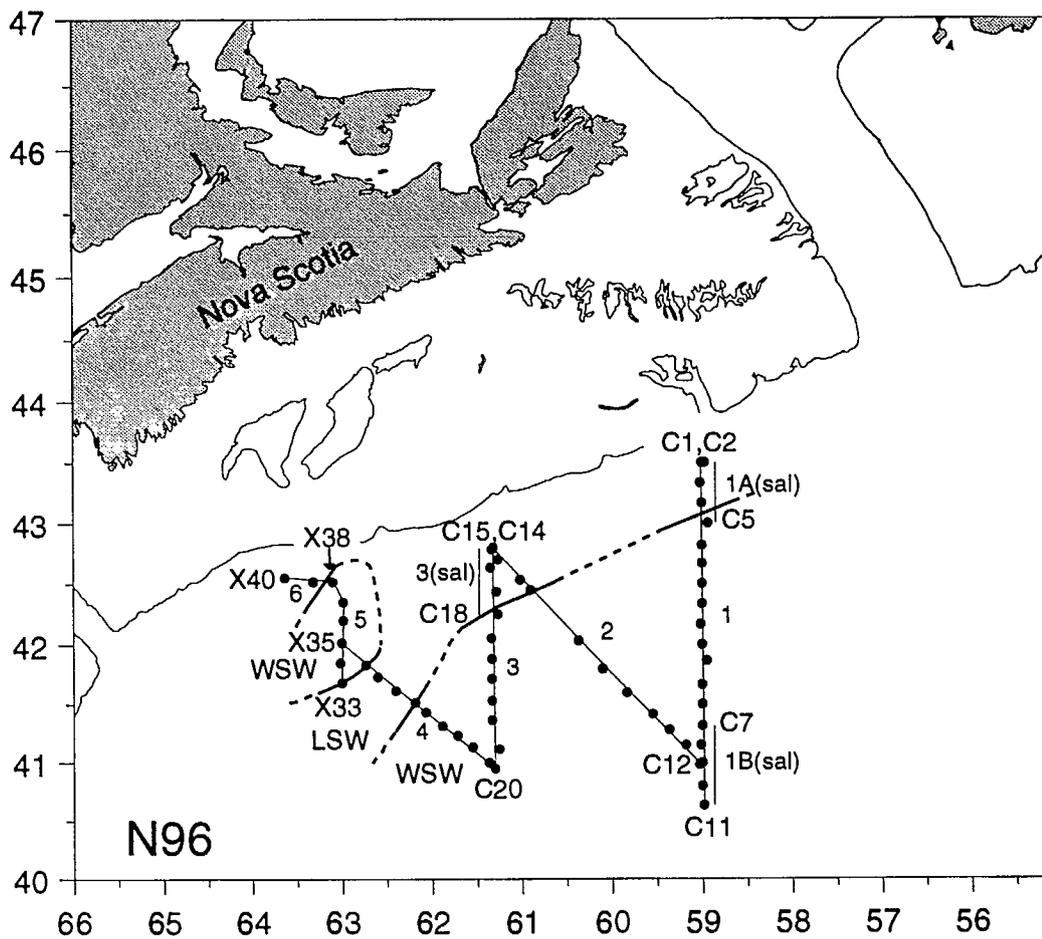
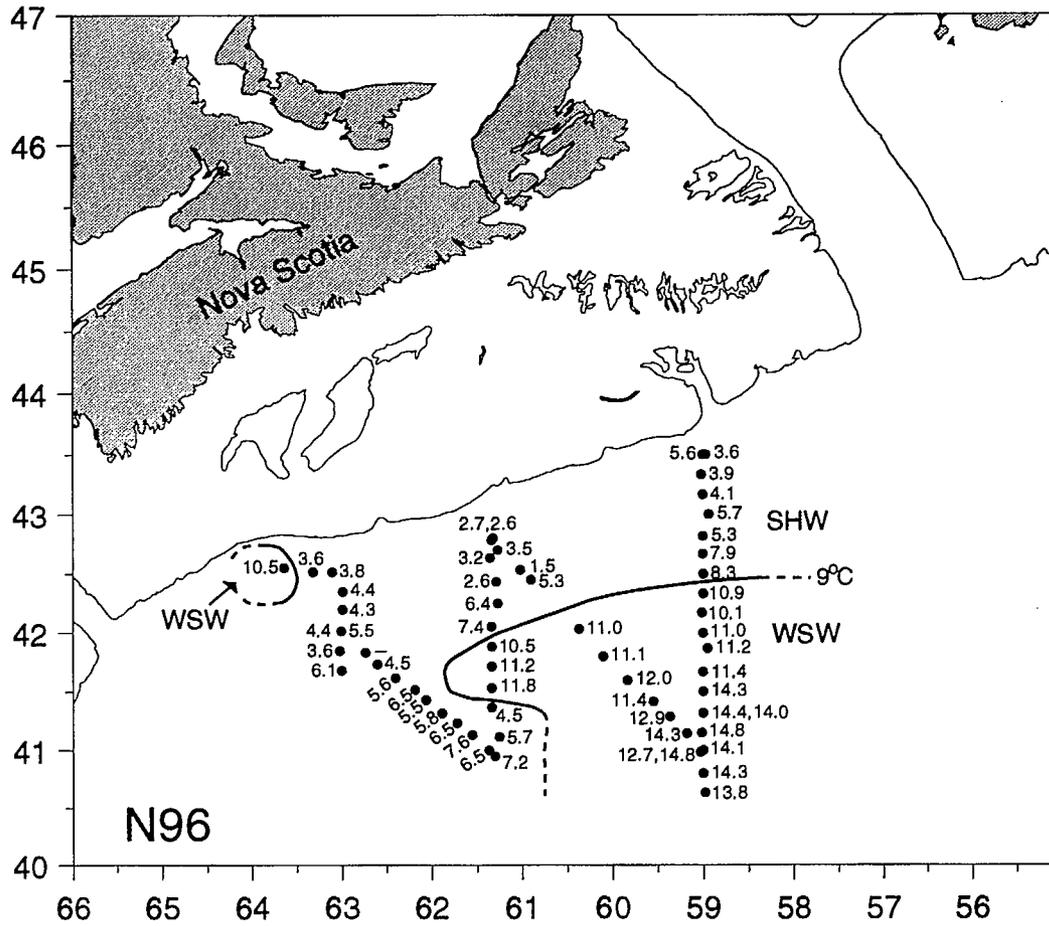


Figure 23. Locations of transects and fronts at 200 m, cruise N096.



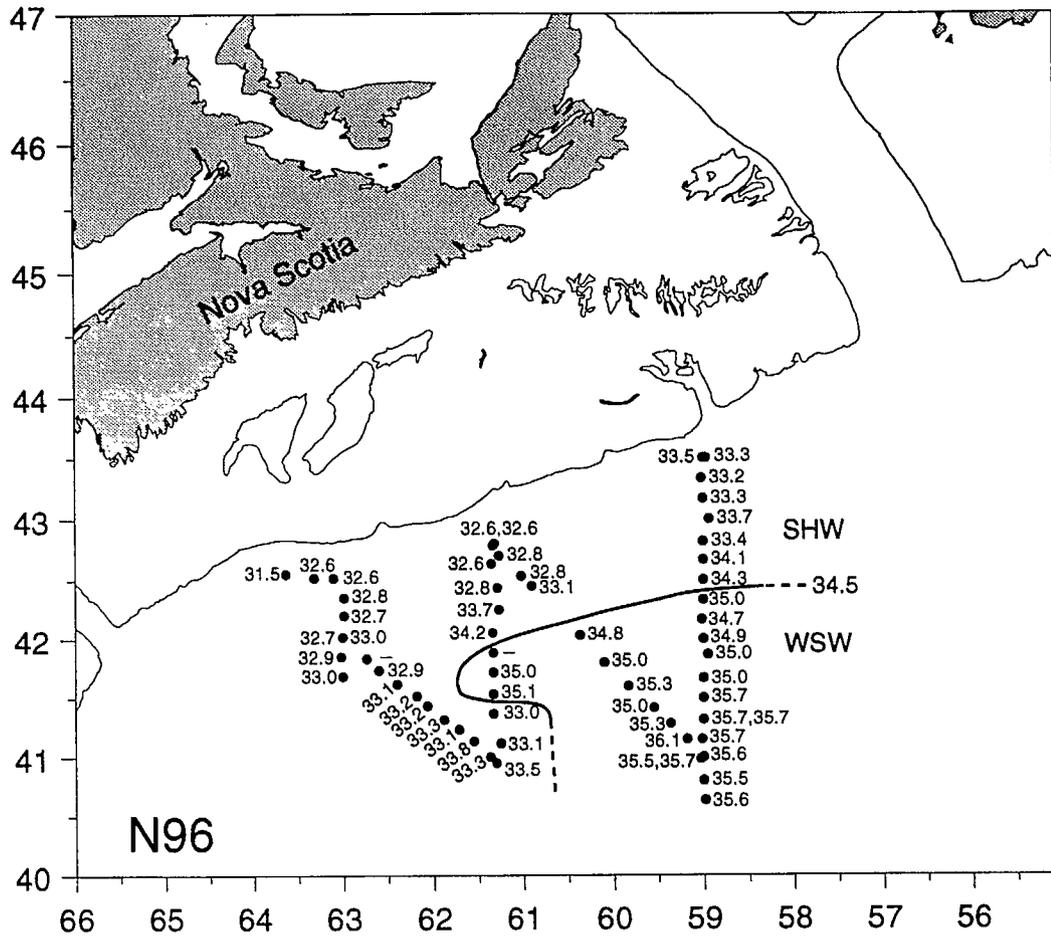


Figure 25. Sea surface salinity and fronts, cruise N096.

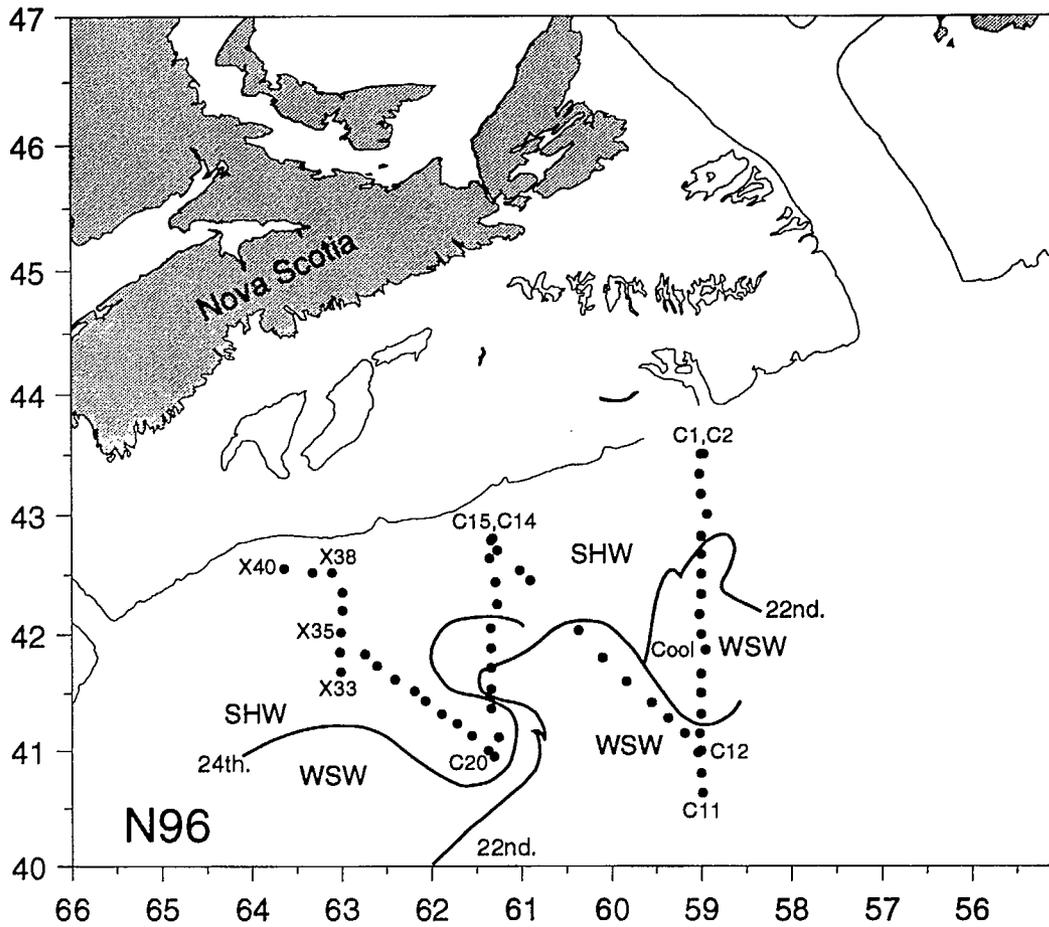


Figure 26. Fronts based on NOAA satellite charts for 22 and 24 February 1988 (as indicated), coincident with cruise N096.

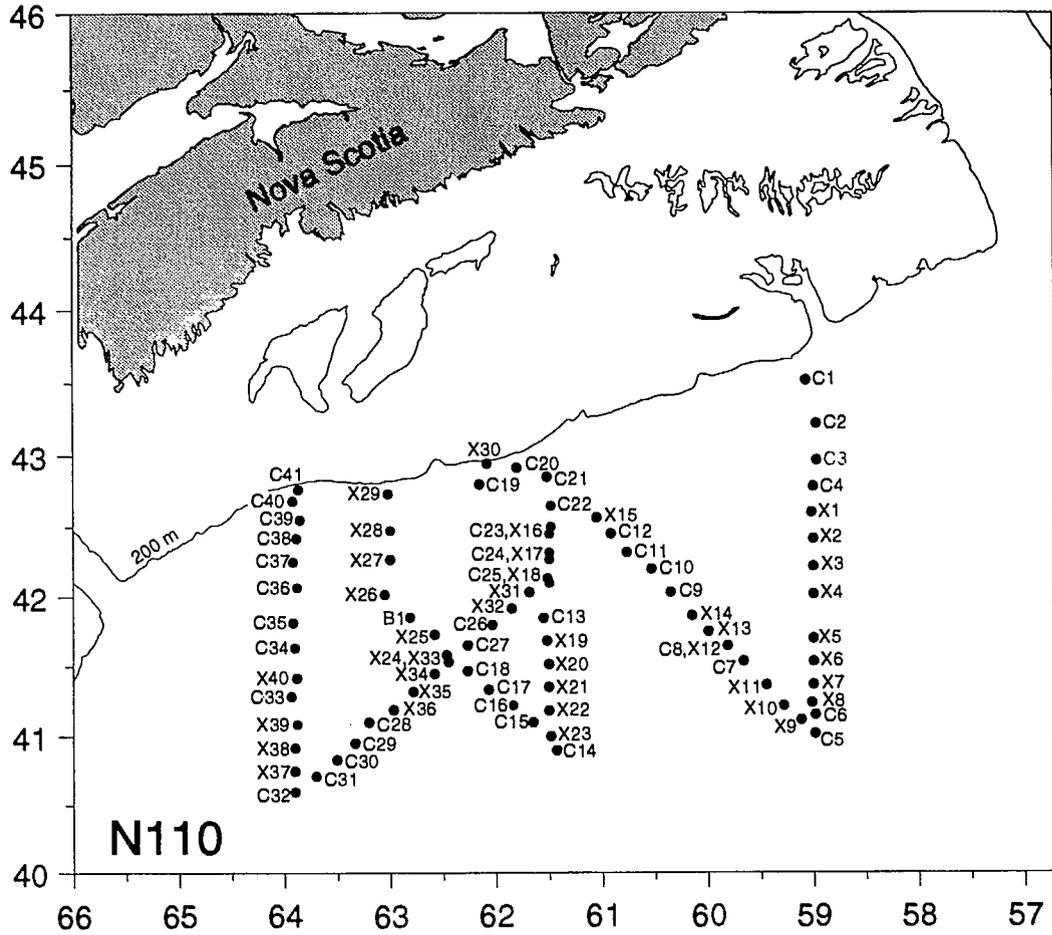


Figure 27. Station locations, cruise N110.

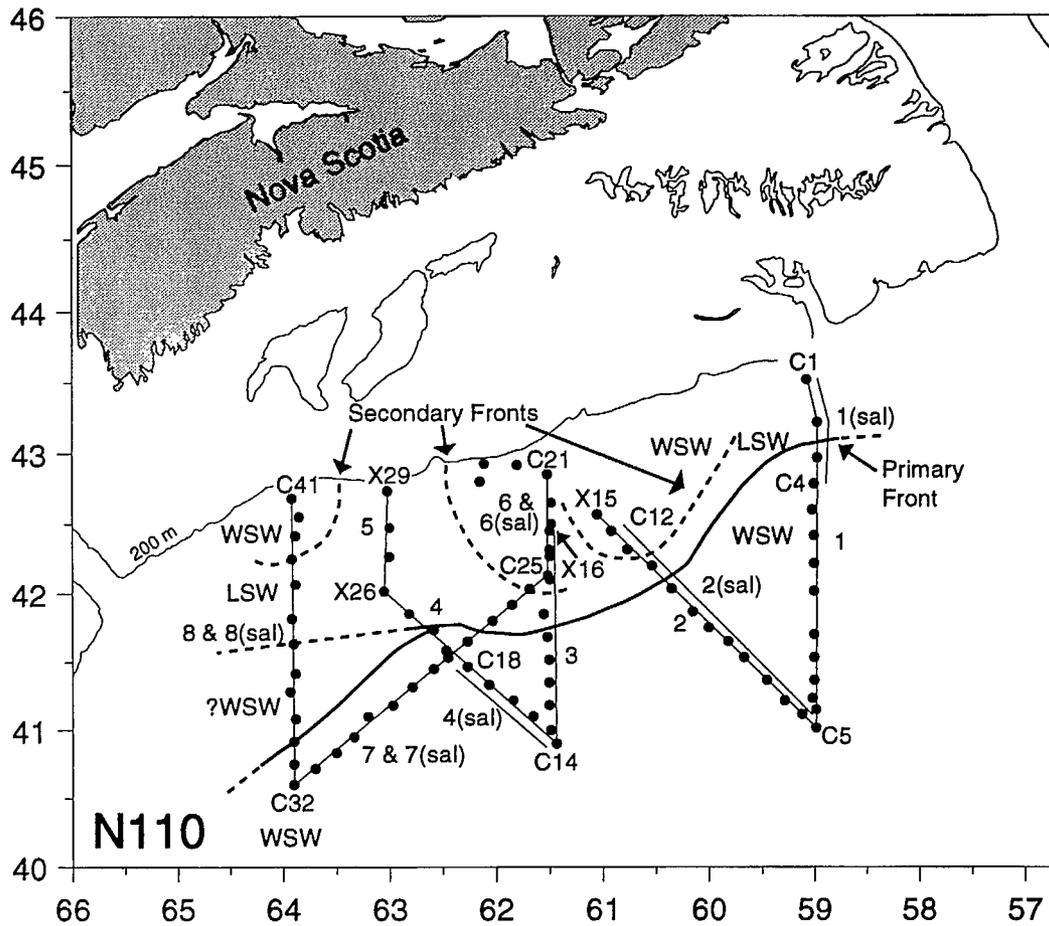
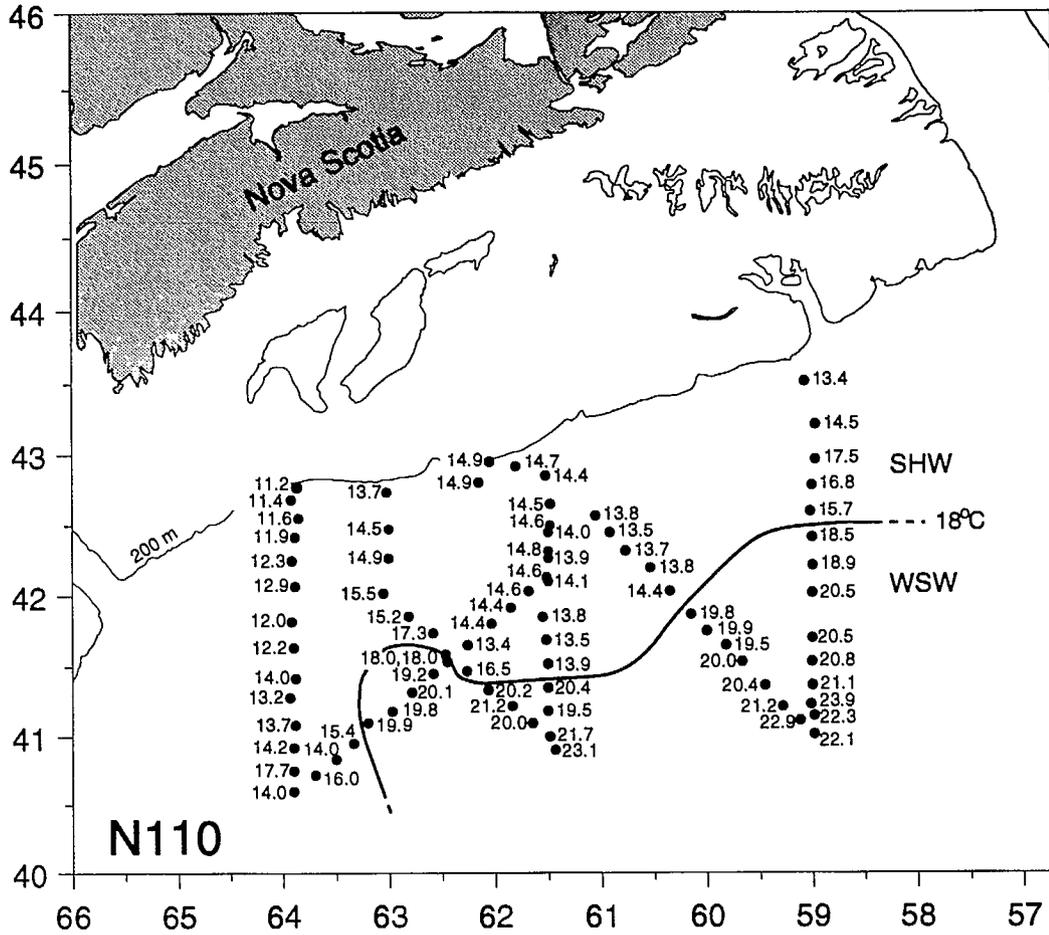


Figure 28. Locations of transects and fronts at 200 m, cruise N110. Seaward boundaries of cool WSW occurring along shelf slope are labelled "secondary fronts".



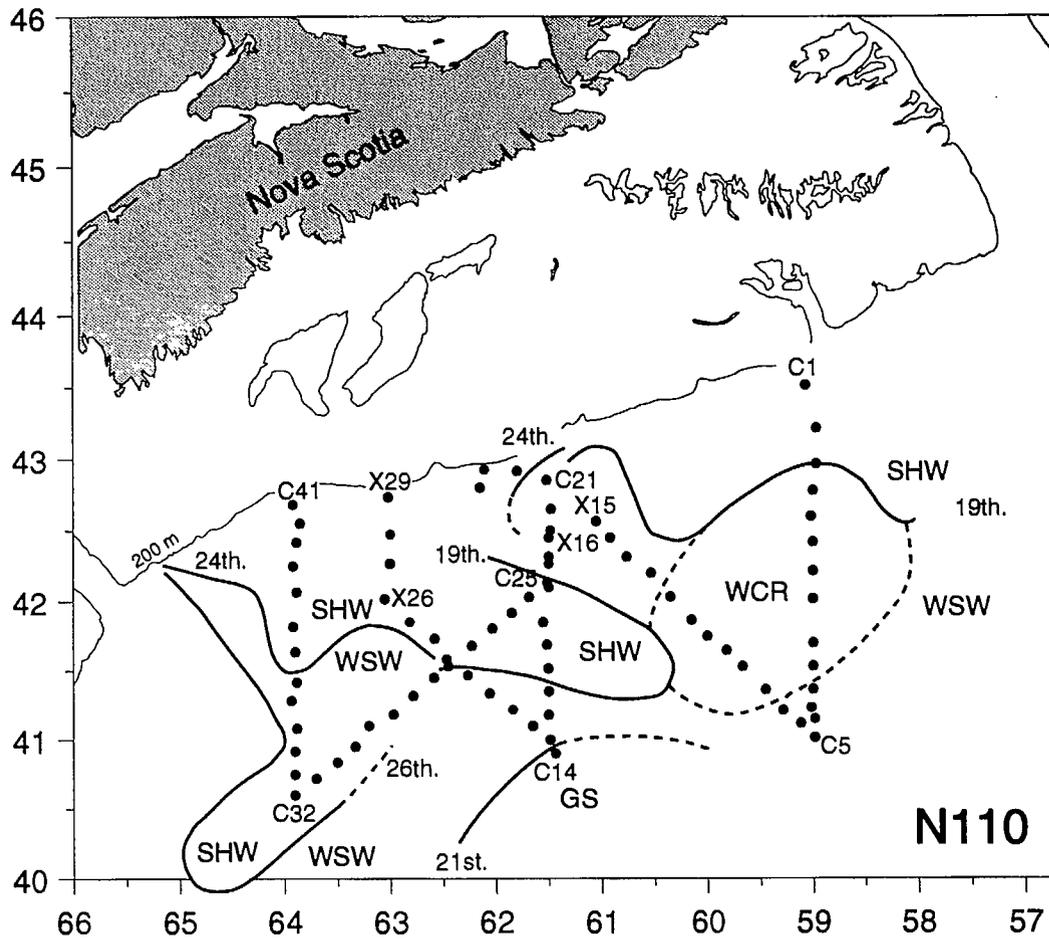


Figure 31. Fronts based on NOAA satellite charts of 19, 21, 24 and 26 October 1988 (as indicated), coincident with cruise N110.

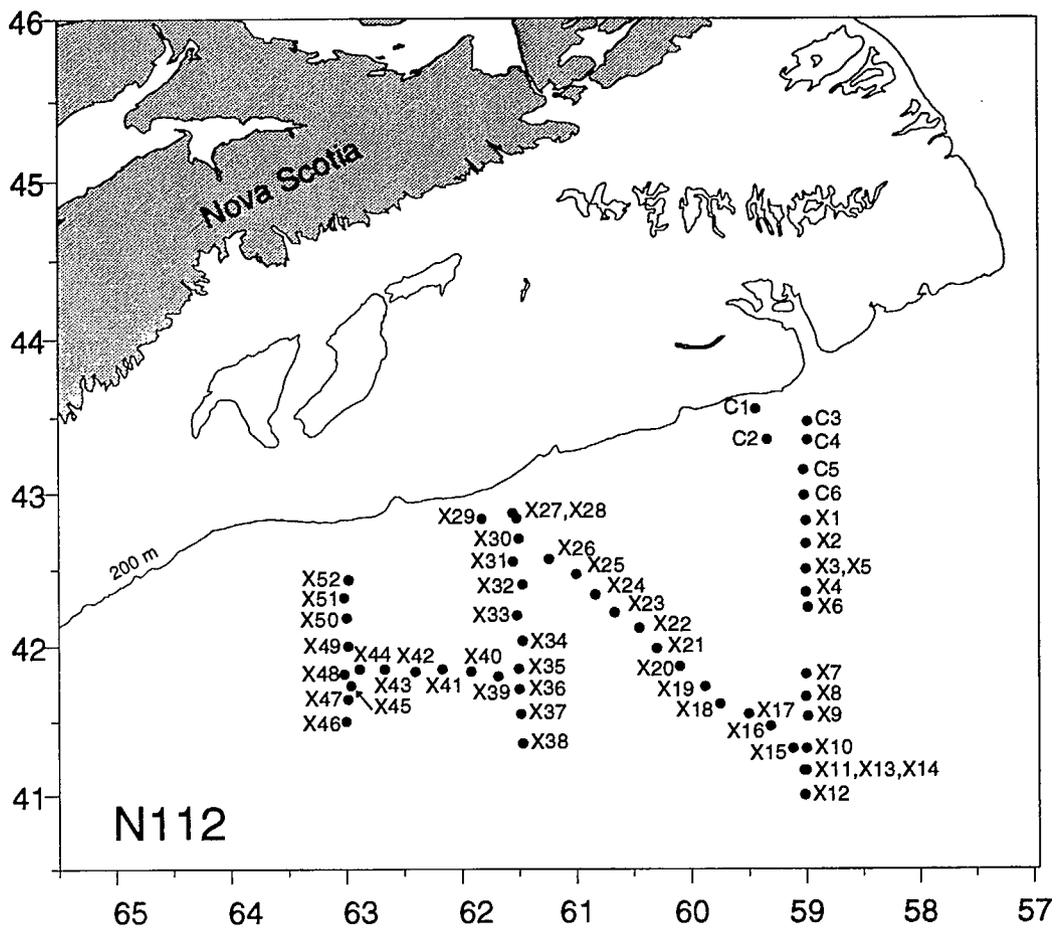


Figure 32. Station locations, cruise N112.

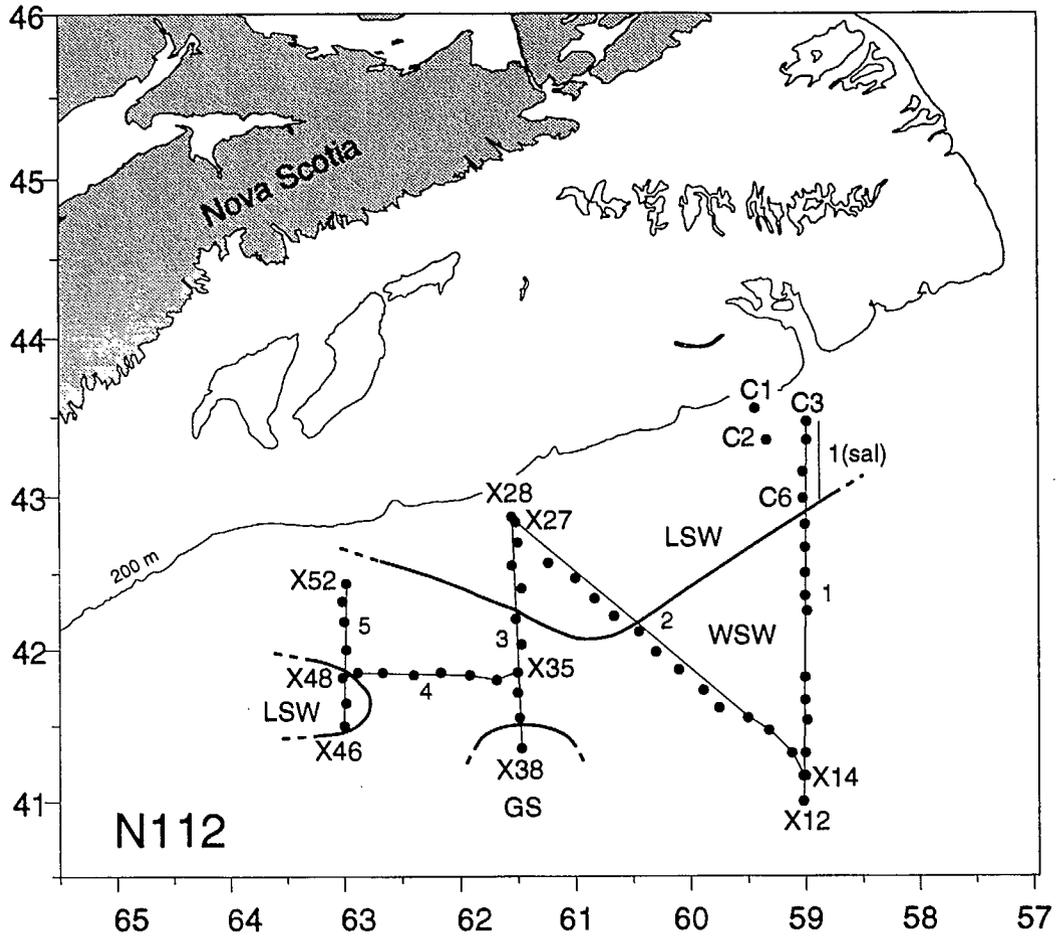


Figure 33. Locations of transects and fronts at 200 m, cruise N112.

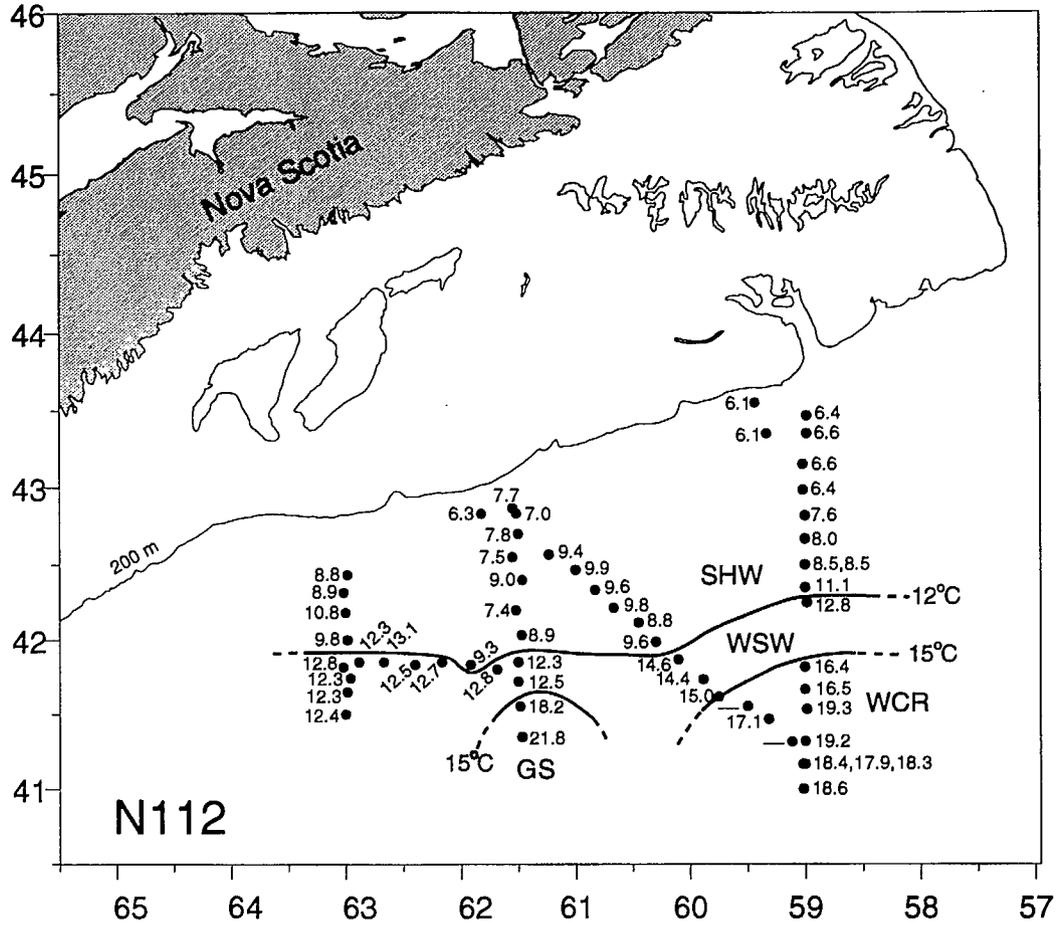


Figure 34. Sea surface temperatures (°C) and fronts, cruise N112.

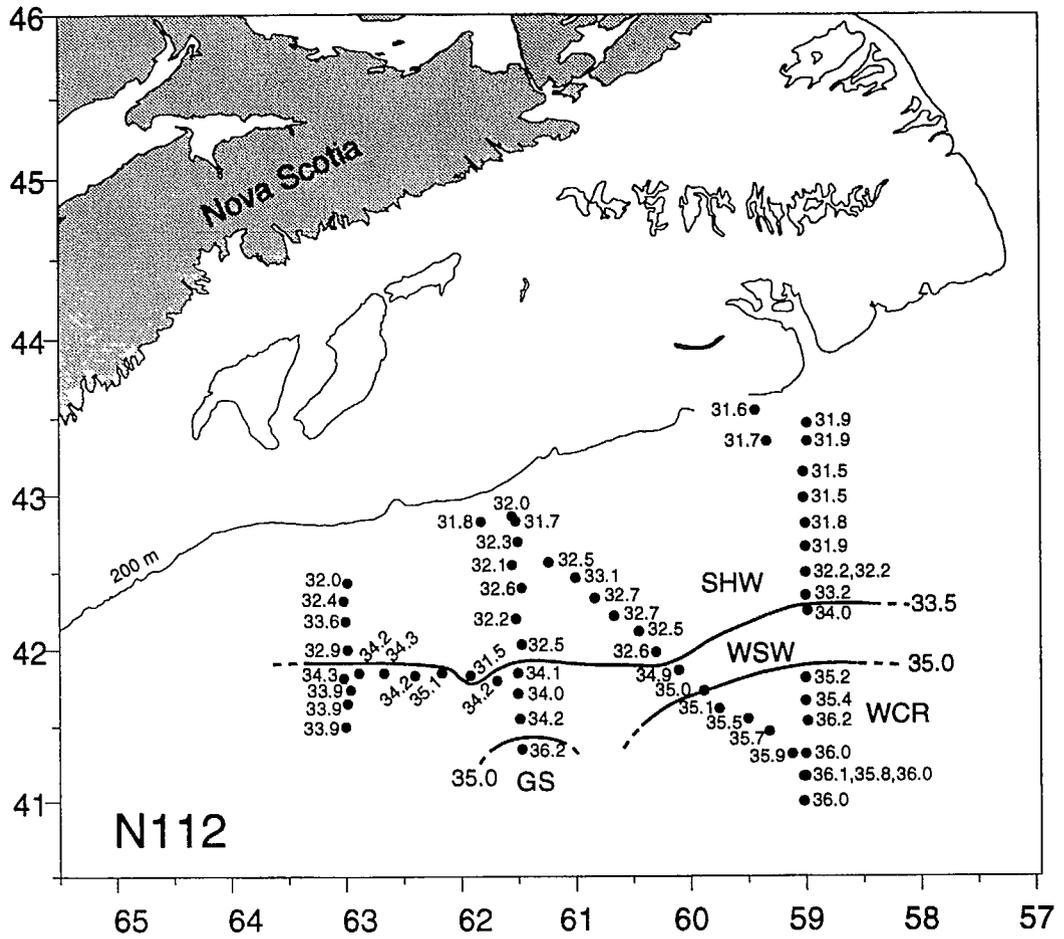


Figure 35. Sea surface salinity and fronts, cruise N112.

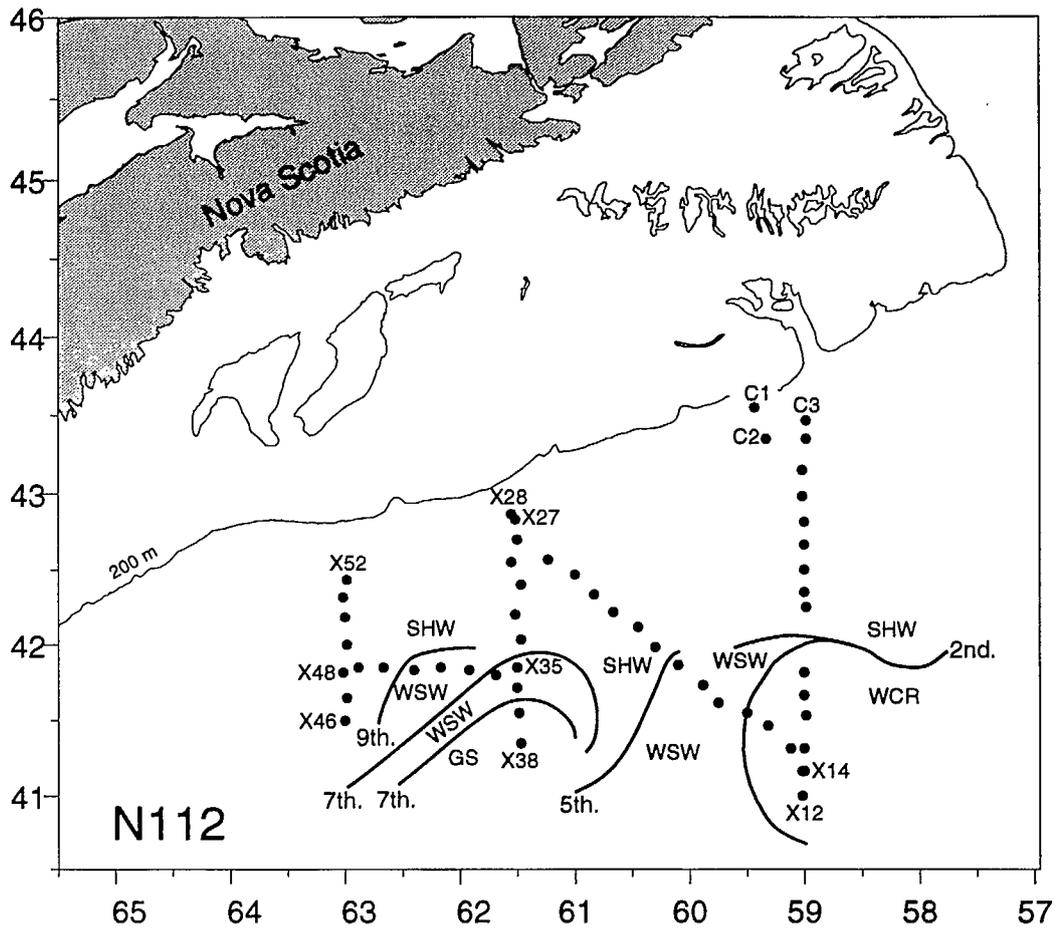


Figure 36. Fronts based on NOAA satellite charts of 2, 5, 7 and 9 December 1988 (as indicated), coincident with cruise N112.

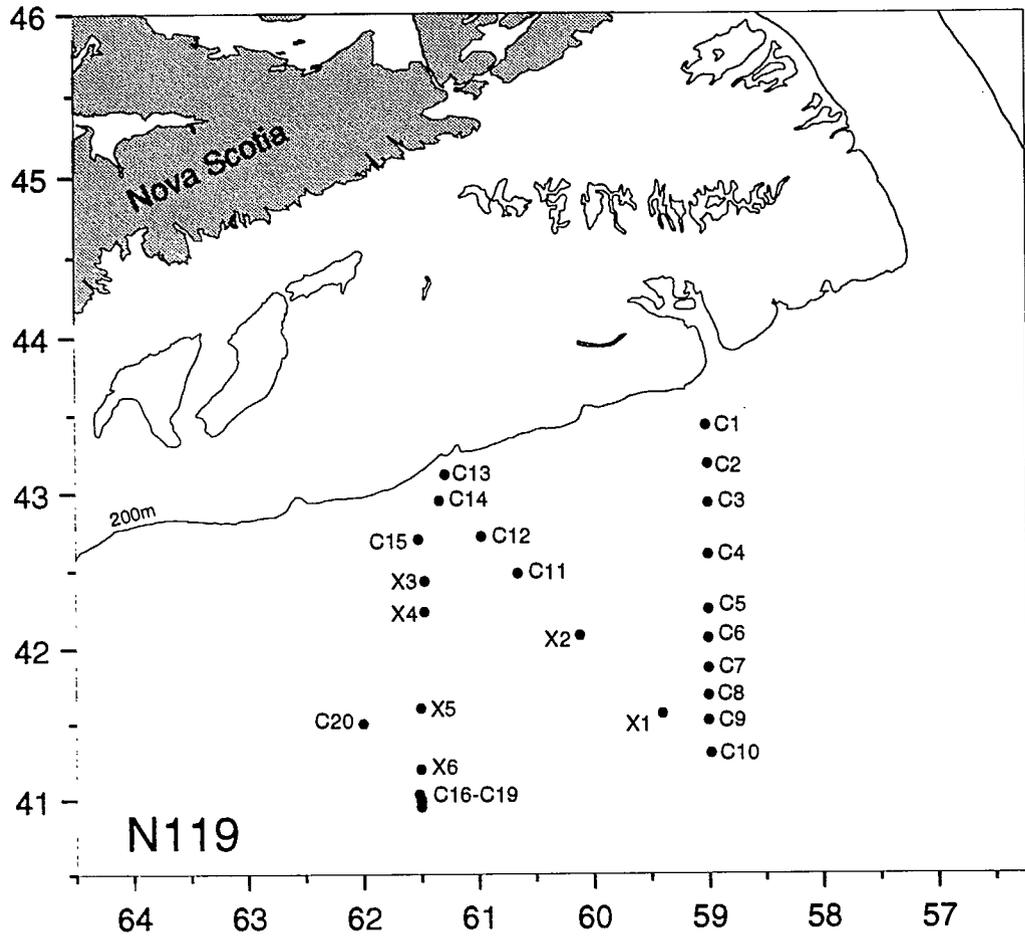


Figure 37. Station locations, cruise N119.

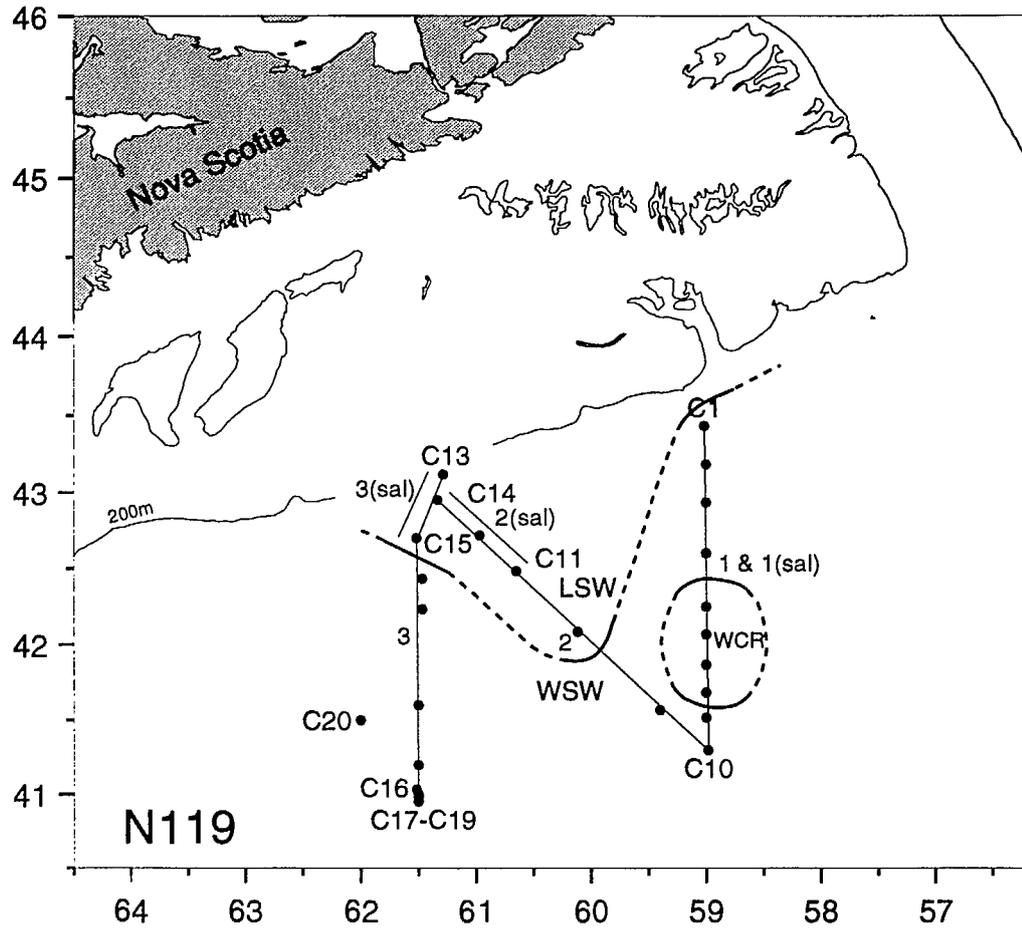
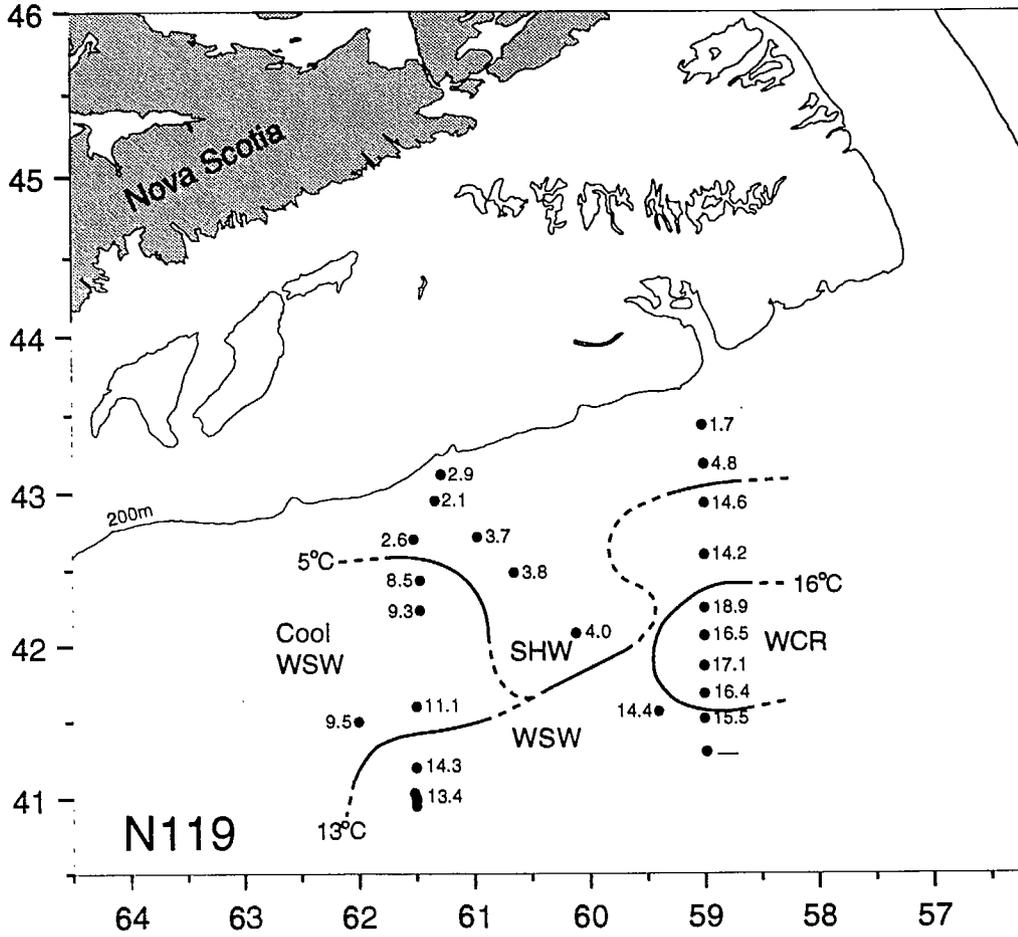


Figure 38. Locations of transects and fronts at 200 m, cruise N119.



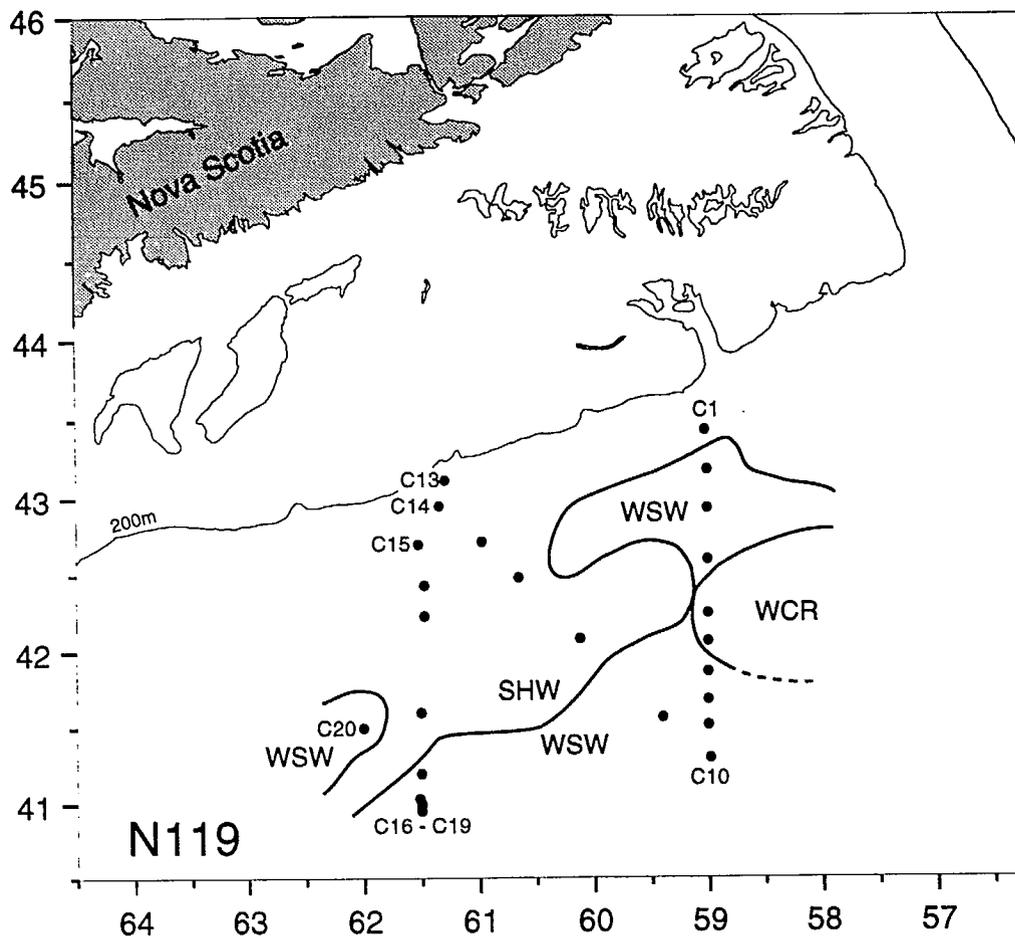


Figure 41. Fronts based on the NOAA satellite chart of 14 April 1989, coincident with cruise N119.

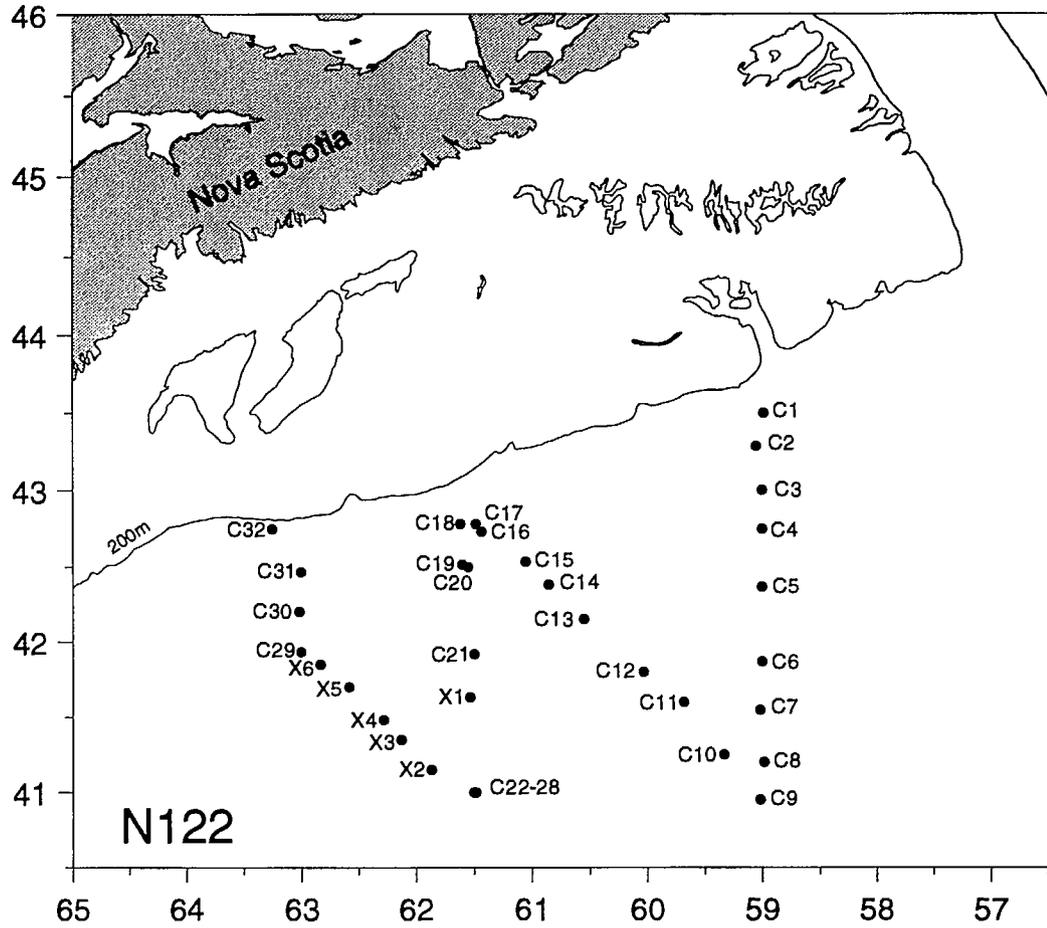


Figure 42. Station locations, cruise N122.

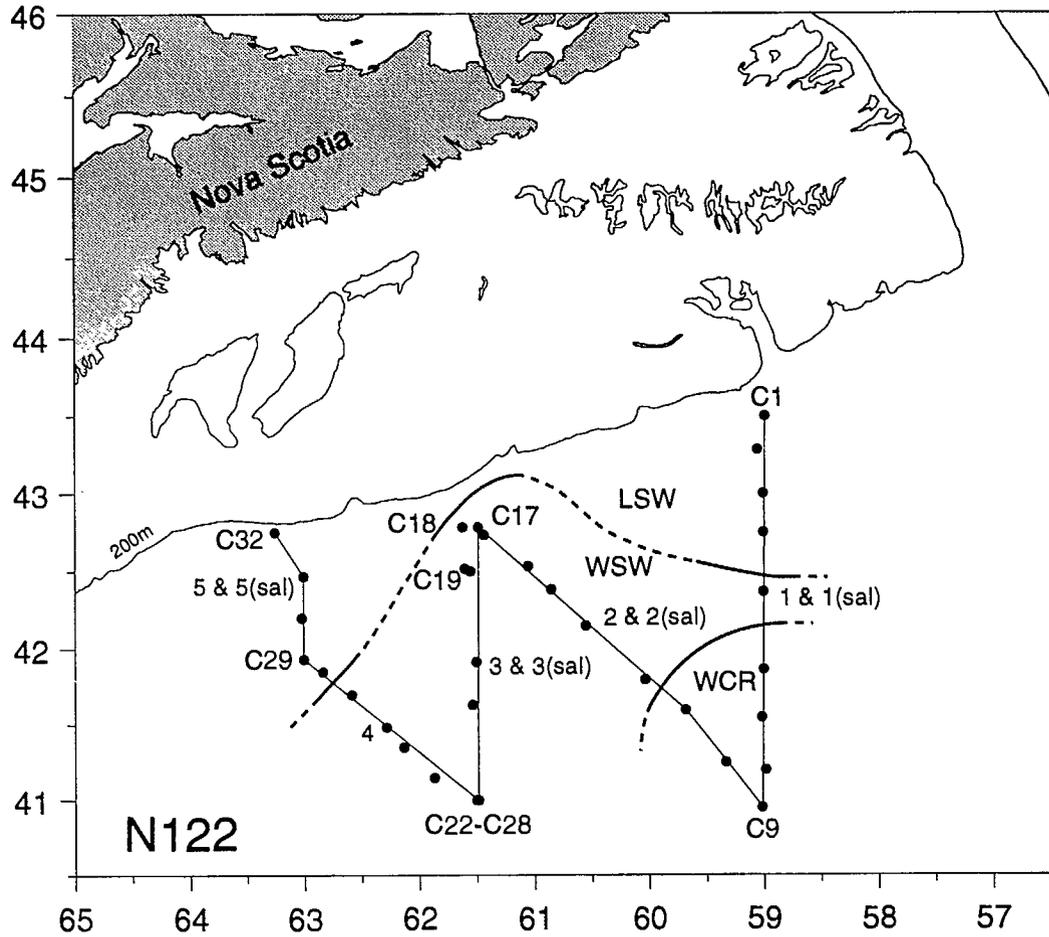


Figure 43. Locations of transects and fronts at 200 m, cruise N122.

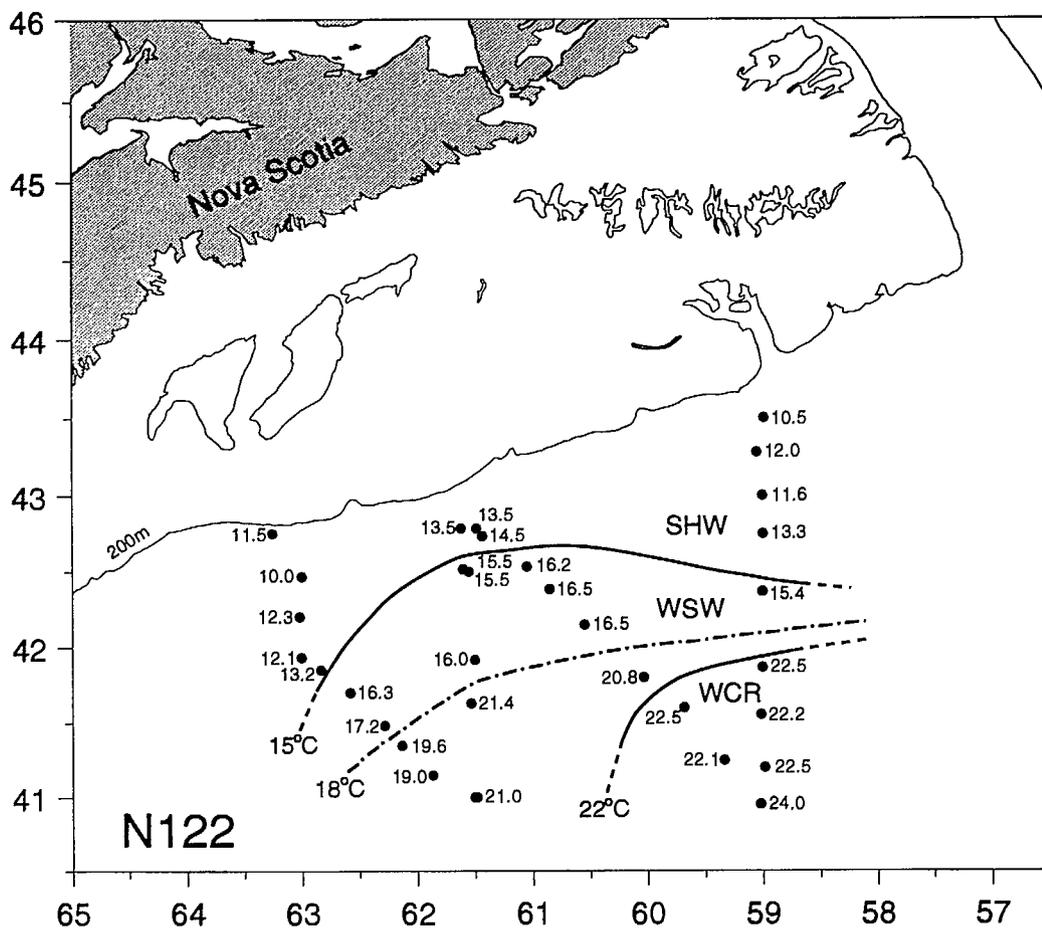


Figure 44. Sea surface temperatures (°C) and fronts, cruise N122.

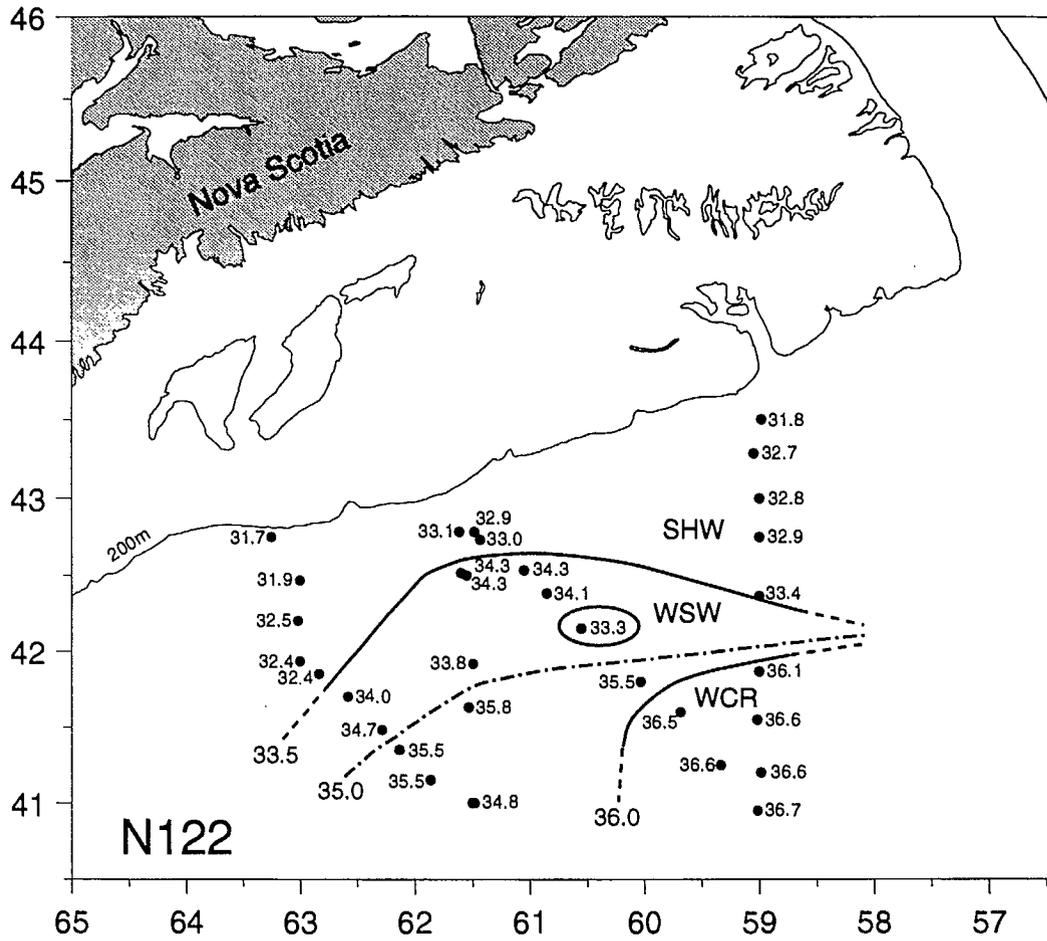


Figure 45. Sea surface salinity and fronts, cruise N122. (Note salinity of 33.3 at C13 is a minor anomaly.)

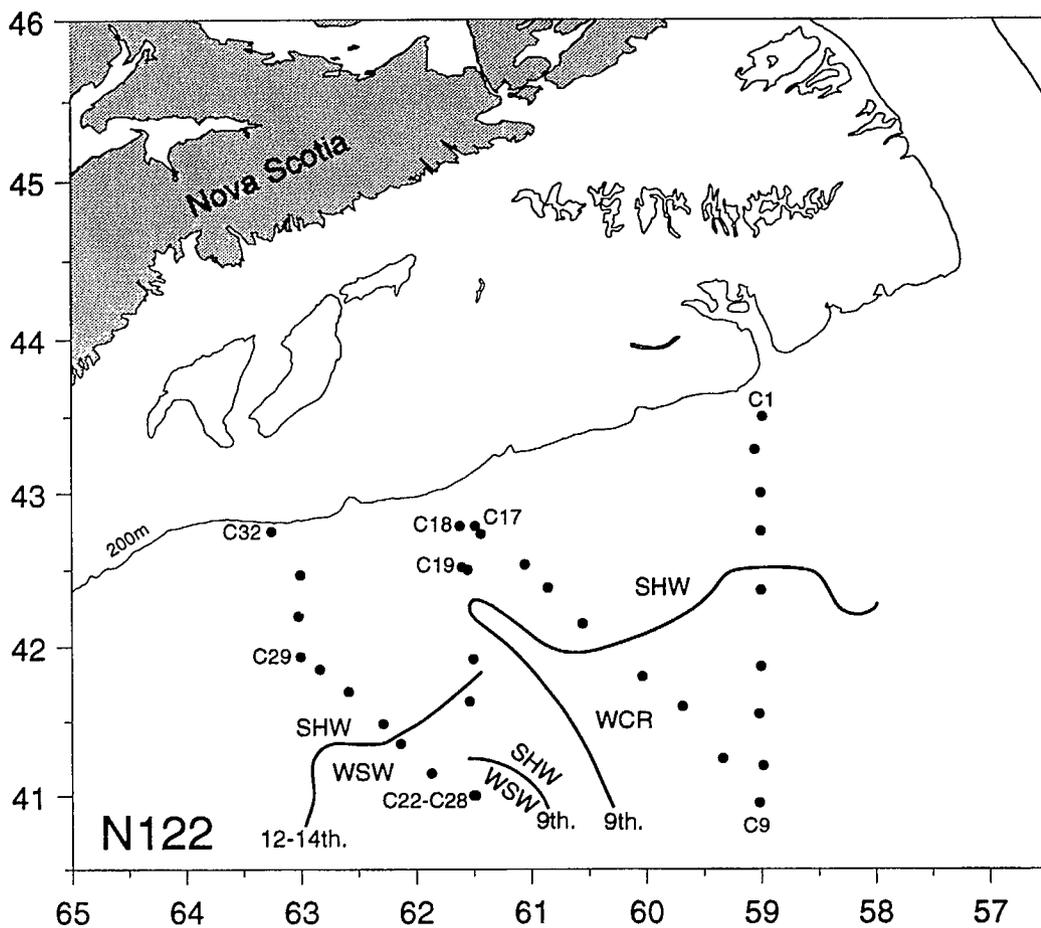


Figure 46. Fronts based on NOAA satellite charts of 9, 12 and 14 June 1989 (as indicated), coincident with cruise N122.

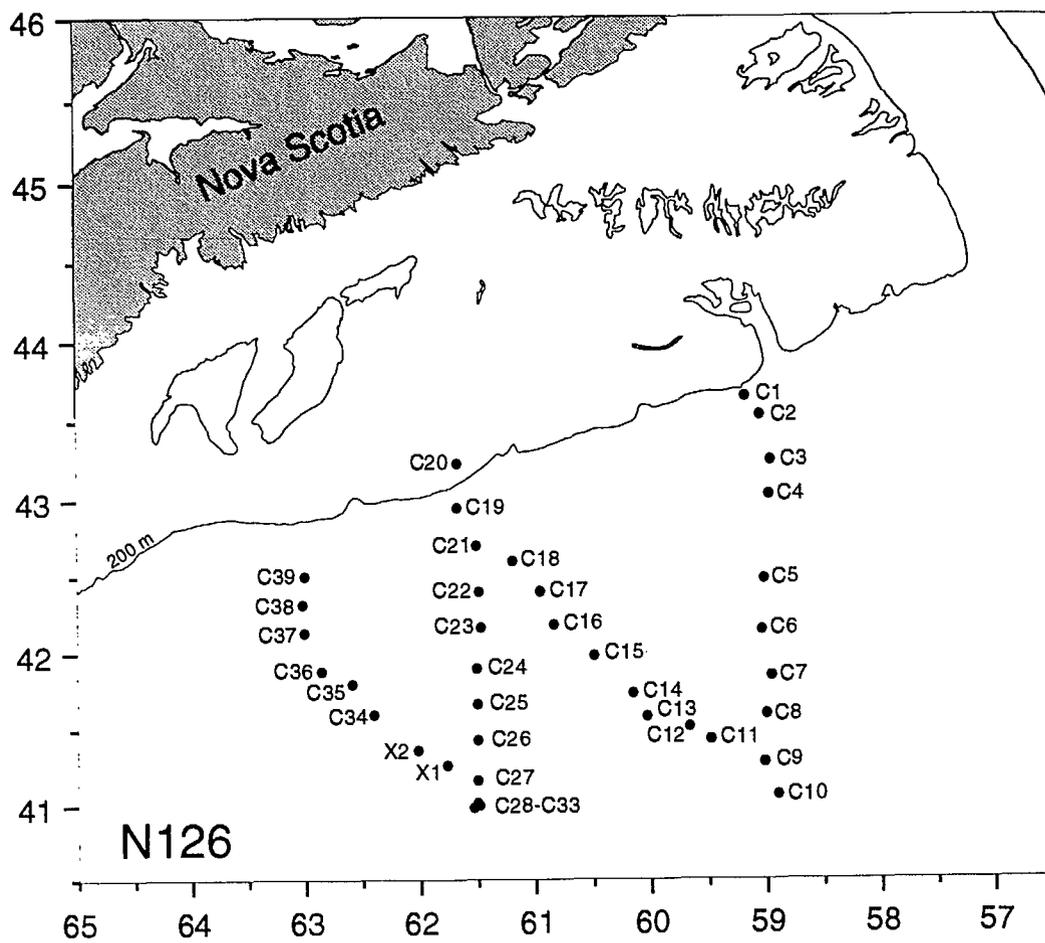


Figure 47. Station locations, cruise N126.

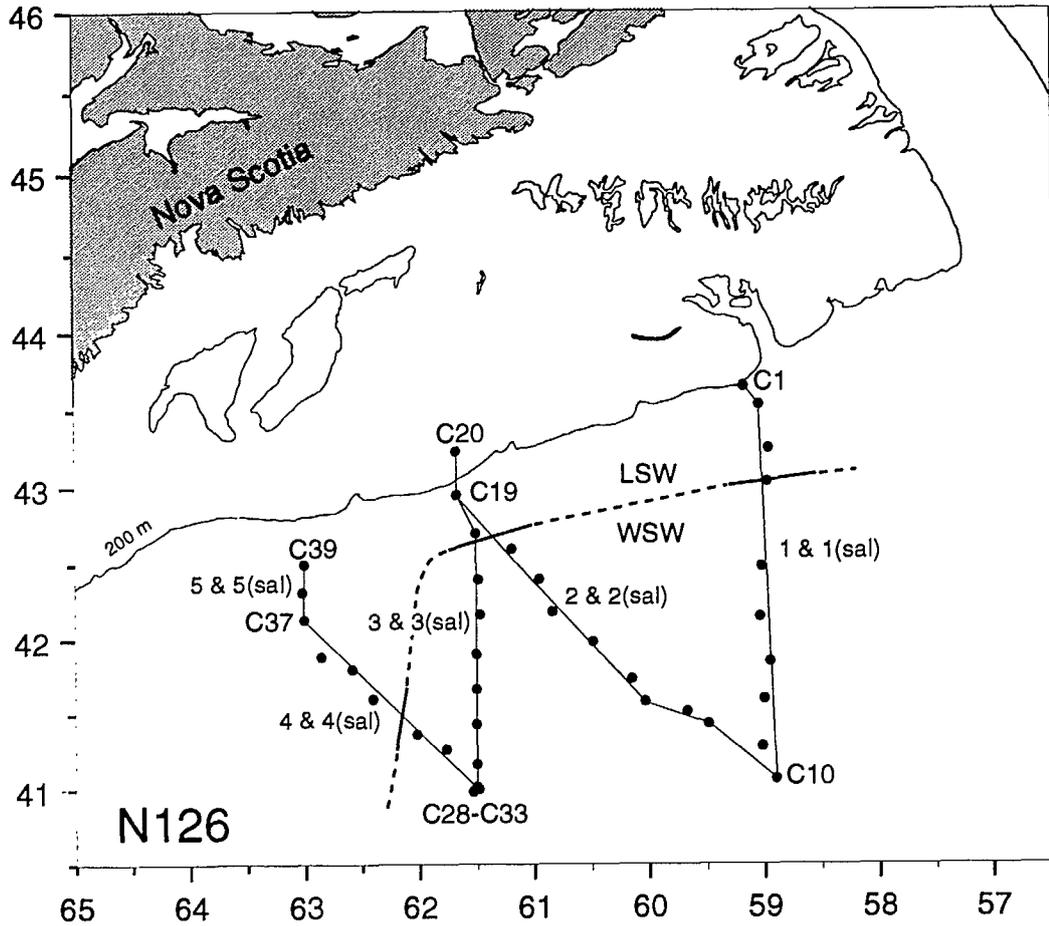


Figure 48. Location of transects and fronts at 200 m, cruise N126.

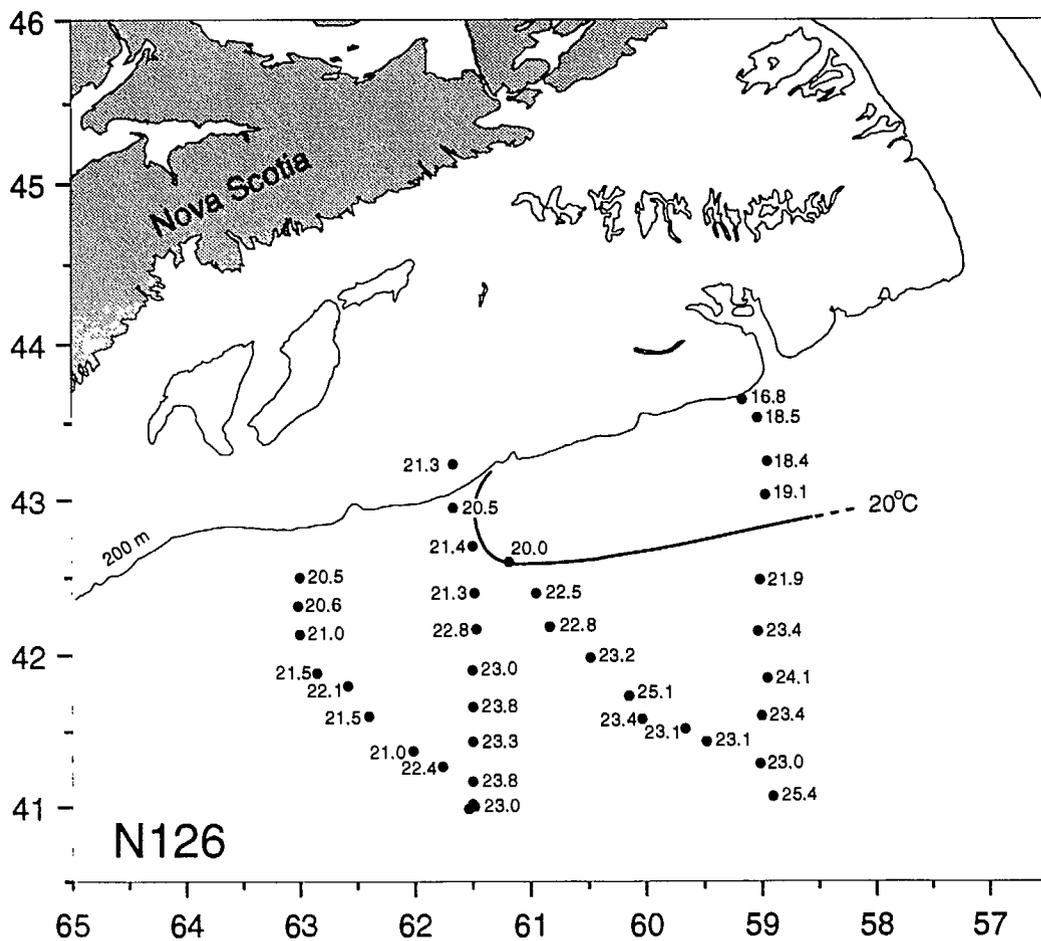


Figure 49. Sea surface temperatures (°C) and fronts, cruise N126.

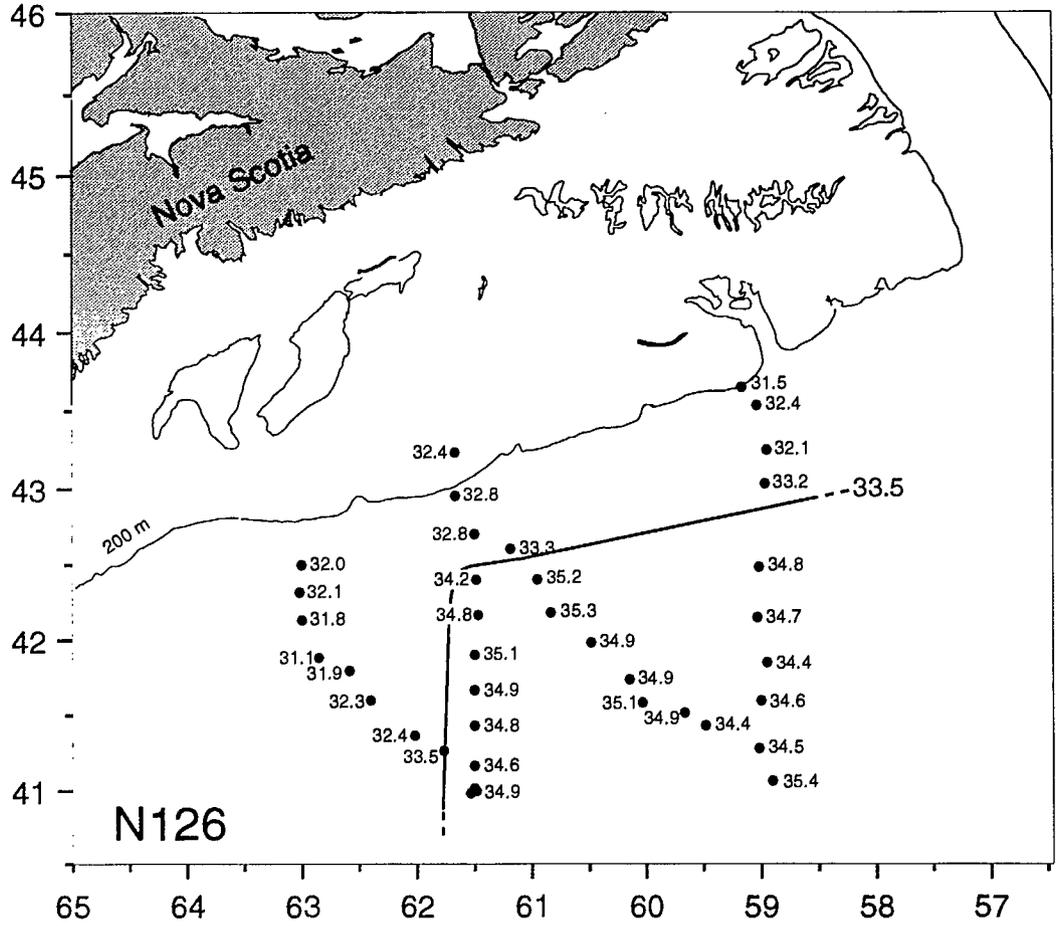


Figure 50. Sea surface salinity and fronts, cruise N126.

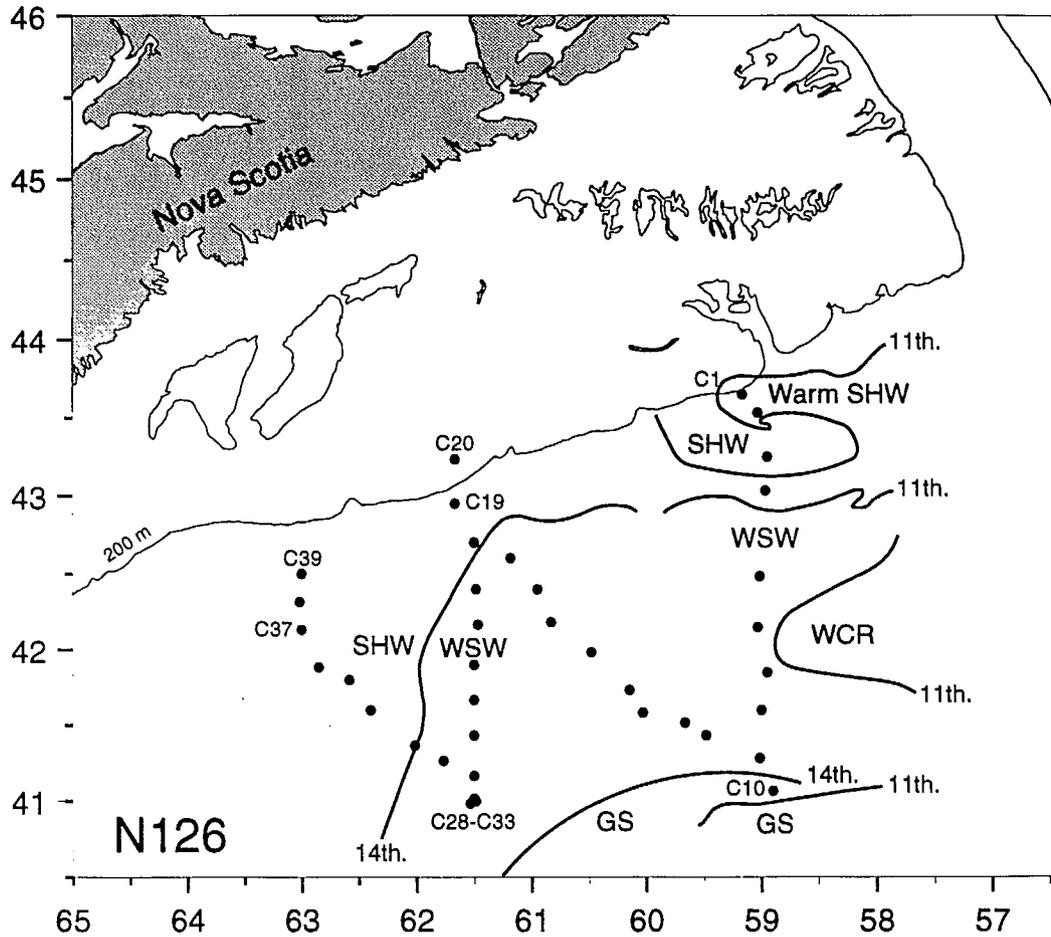


Figure 51. Fronts based on NOAA satellite charts of 11 and 14 August 1989 (as indicated), coincident with cruise N126.

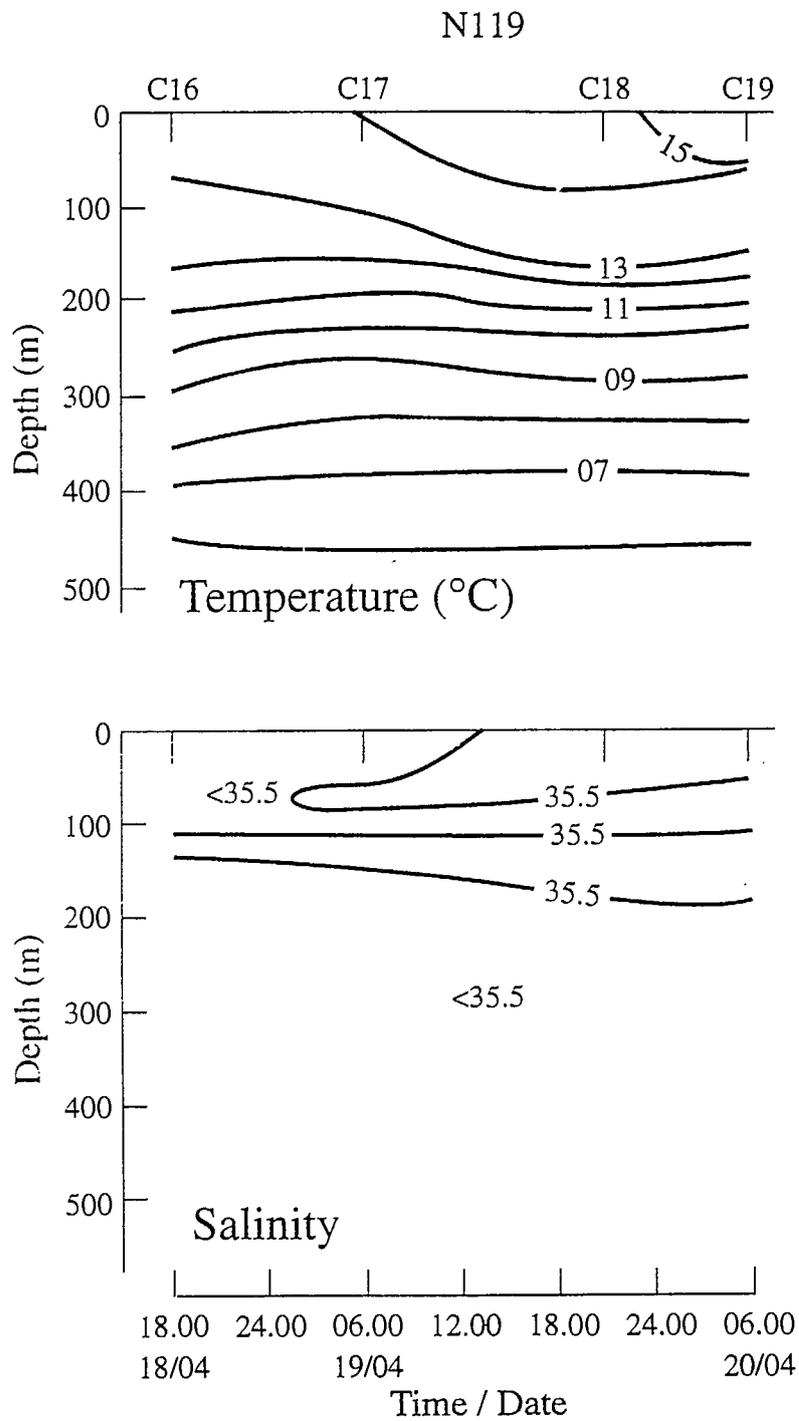


Figure 52. Temporal variation in temperature and salinity at 41°00' N 61°30'W, 18-20 April 1989, cruise N119.

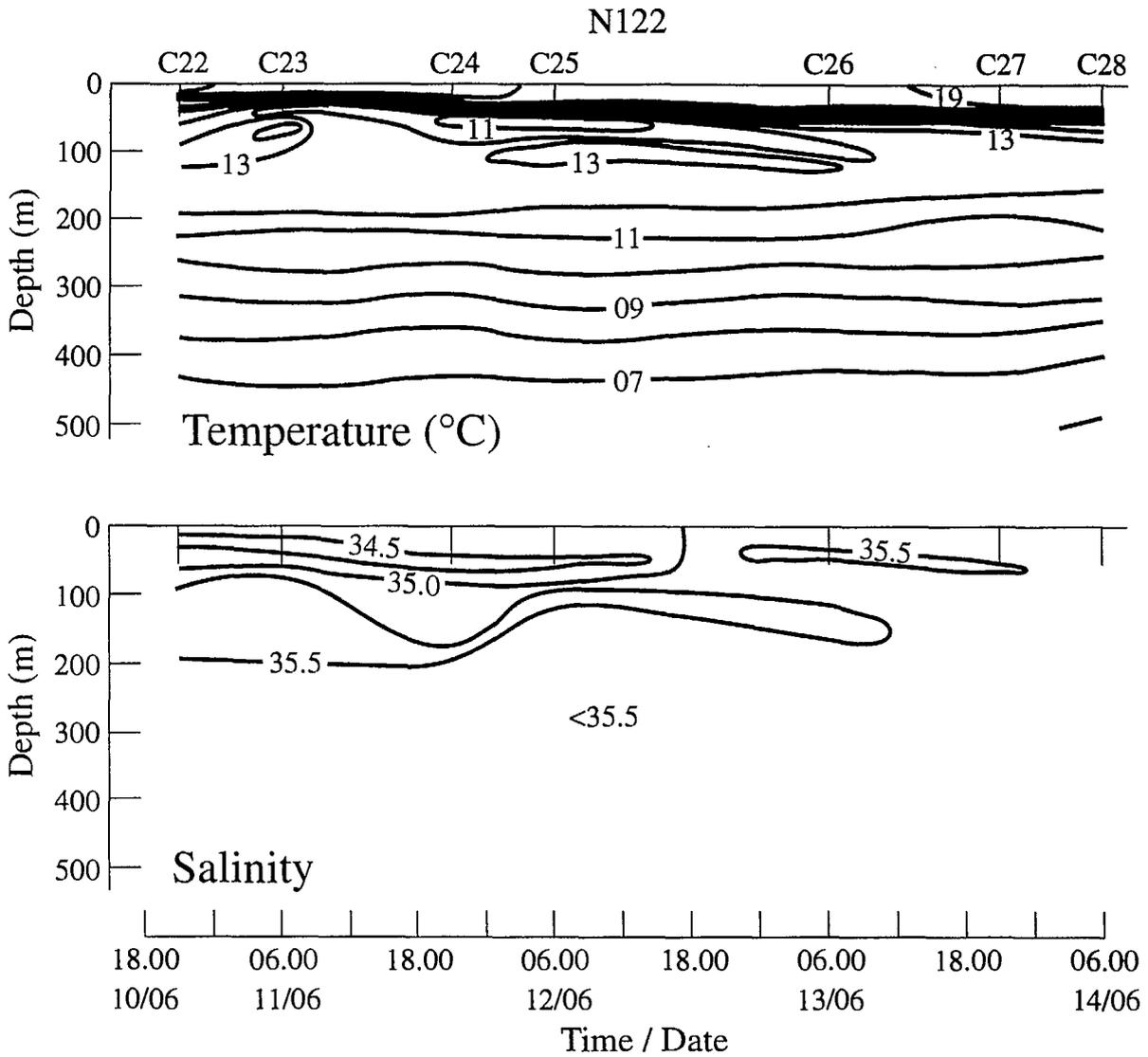


Figure 53. Temporal variation in temperature and salinity at 41°00' N 61°30'W, 10-14 June 1989, cruise N122.

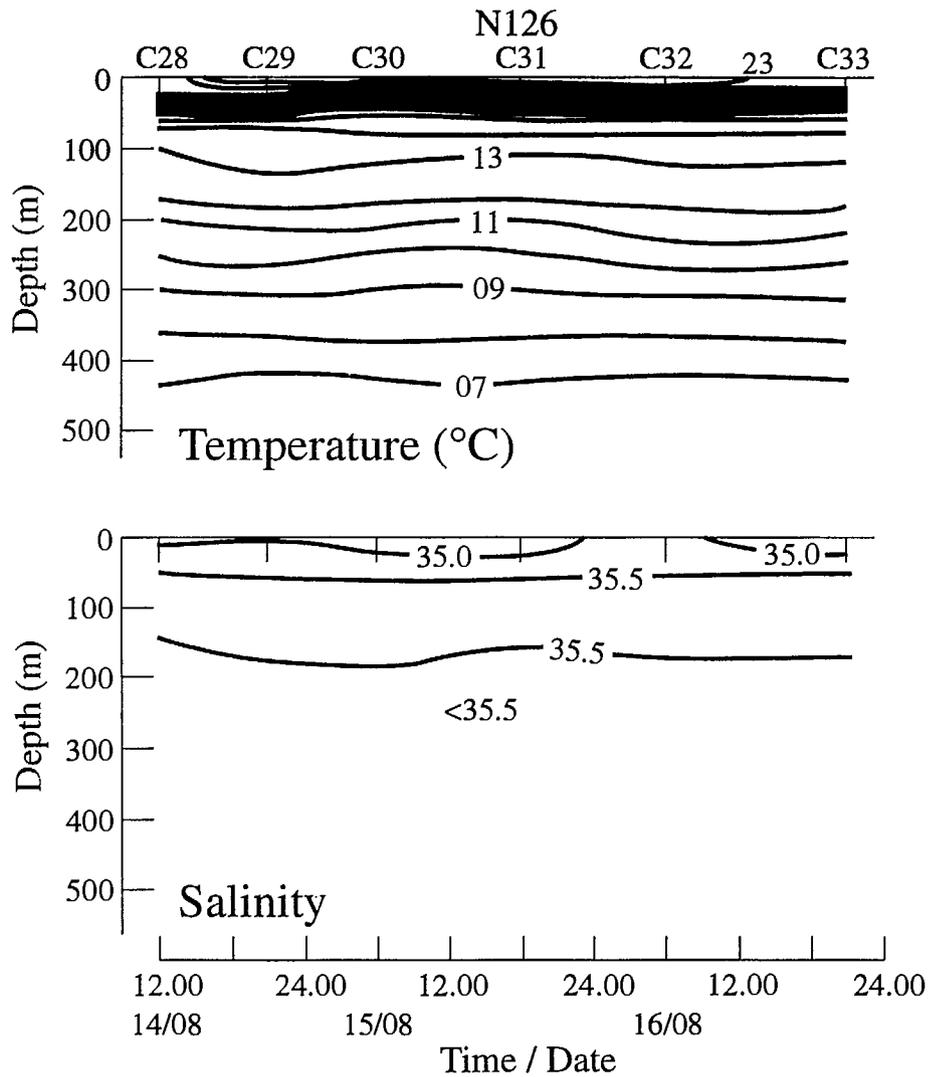


Figure 54. Temporal variation in temperature and salinity at $41^{\circ}00' \text{ N } 61^{\circ}30' \text{ W}$, 14-16 August 1989, cruise N126.

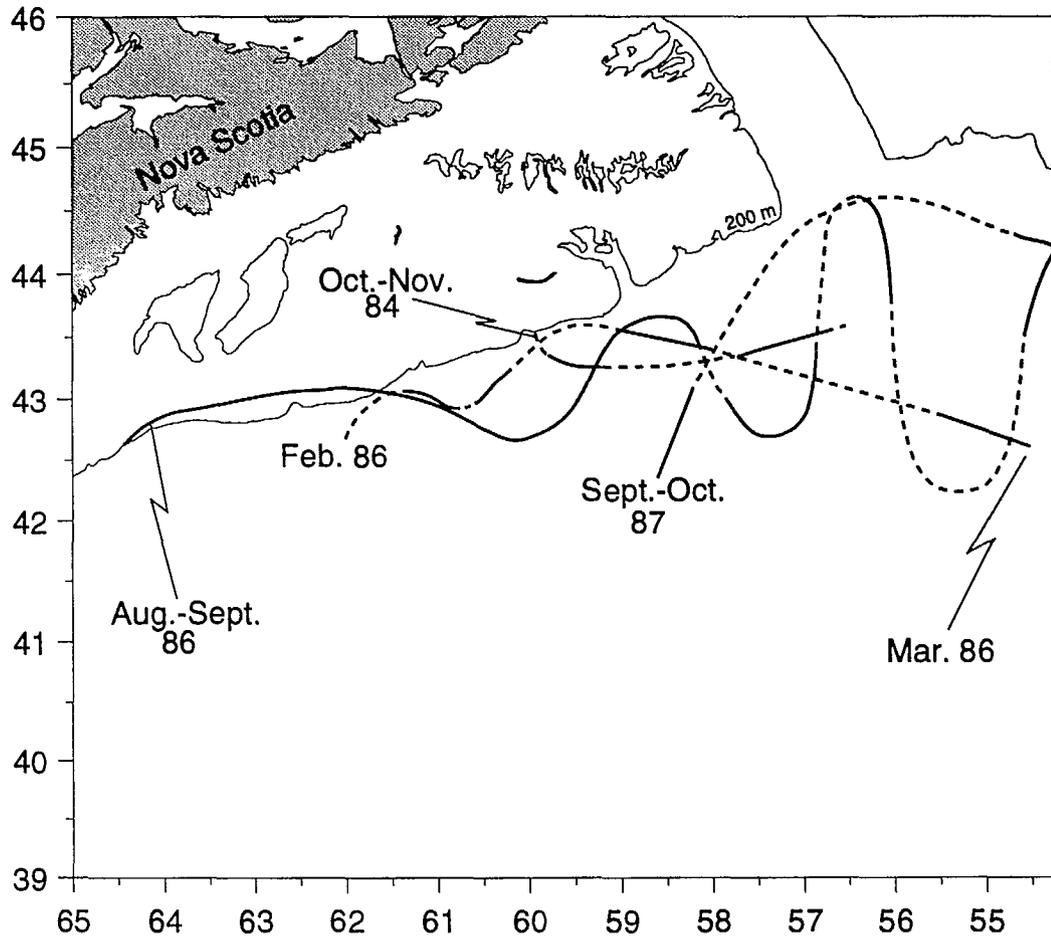


Figure 55. The front between Warm Slope Water and Labrador Slope/Shelf Water at 200 m during exploratory cruises, October-November 1984 to September-October 1987. (Cruises N057 and G121 in February-March 1986 are treated here as one cruise.)

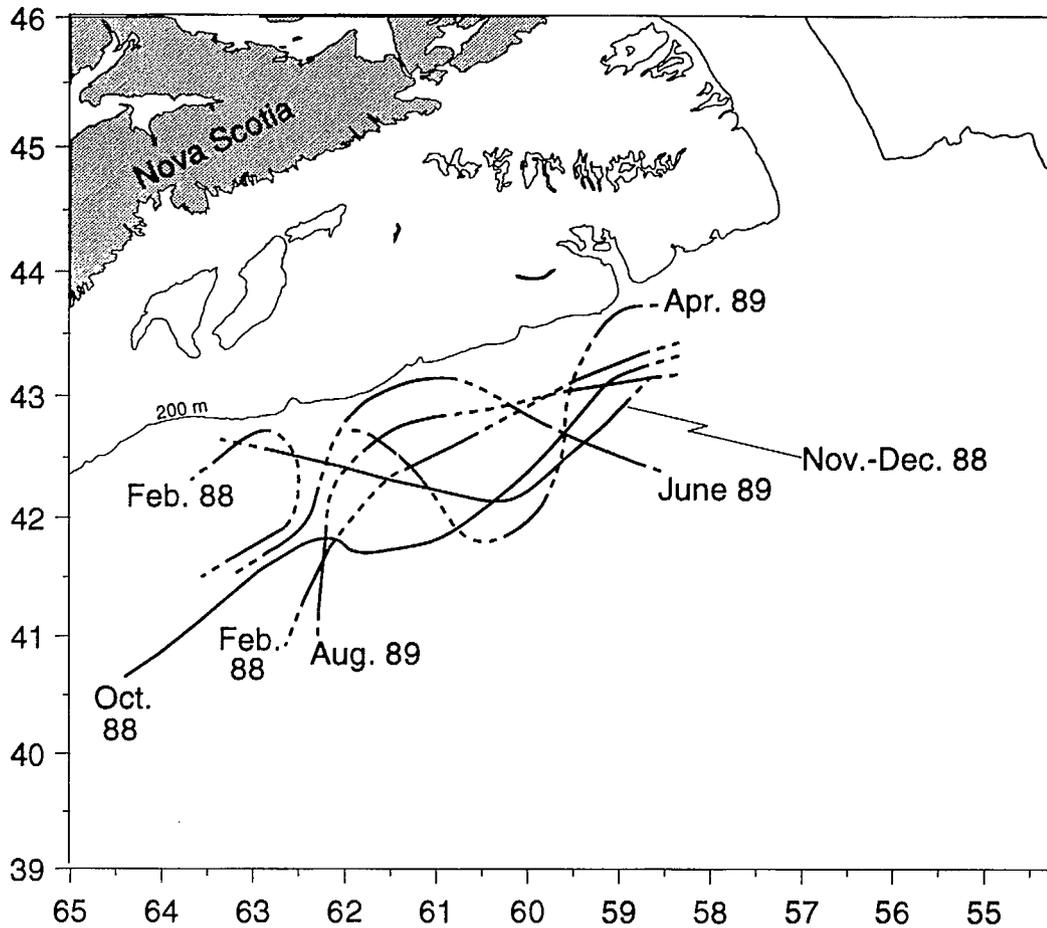


Figure 56. The front between Warm Slope Water and Labrador Slope/Shelf Water at 200 m during standard cruises in 1988-89.

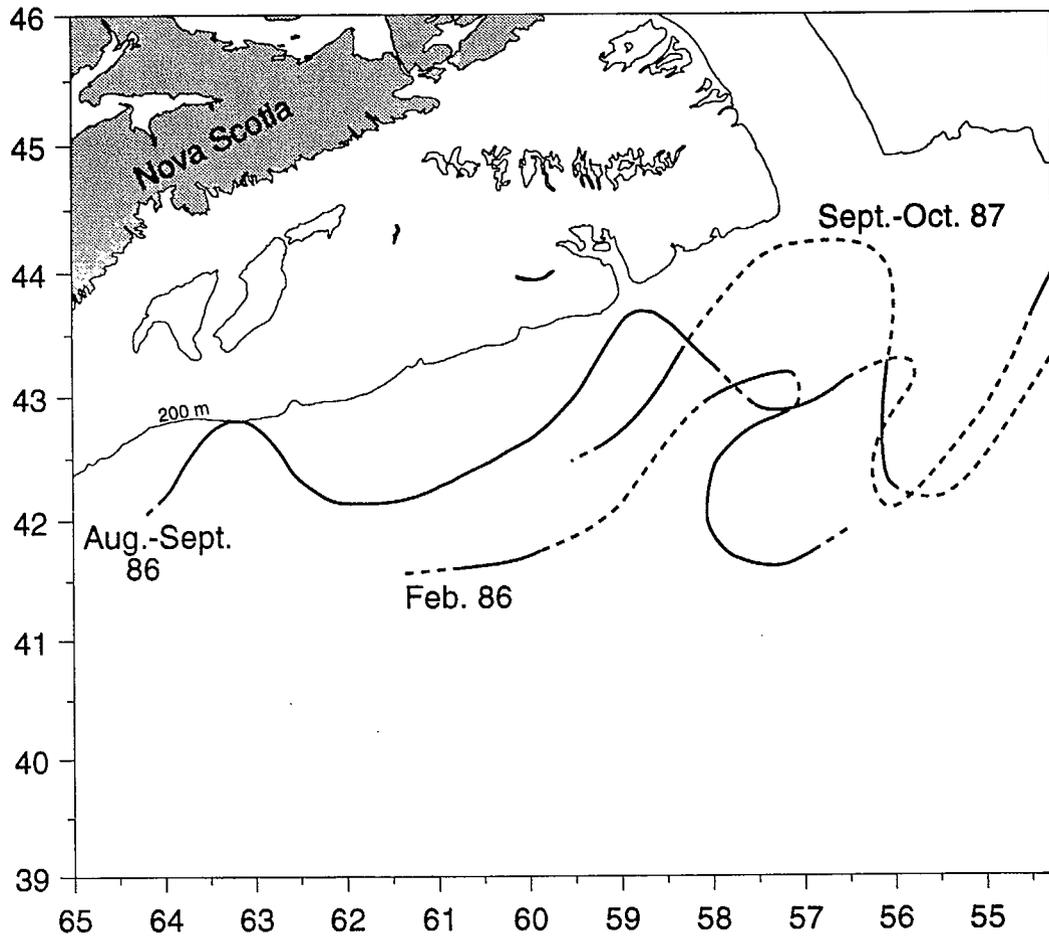


Figure 57. The front between Warm Slope Water and Labrador Slope/Shelf Water at the surface, based on surface salinity, during exploratory cruises, February 1986 to September-October 1987. (No surface salinity data collected on H127, October-November 1984, or available for G121, March 1986.)

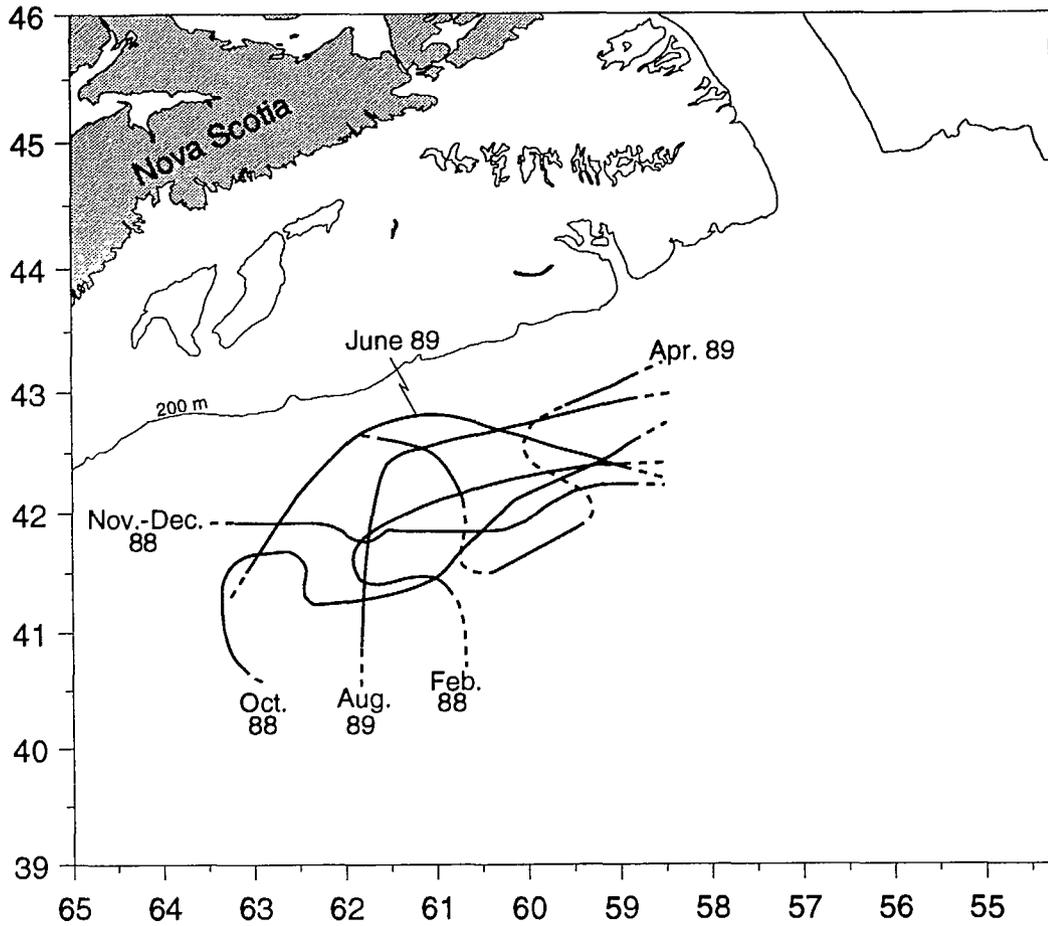


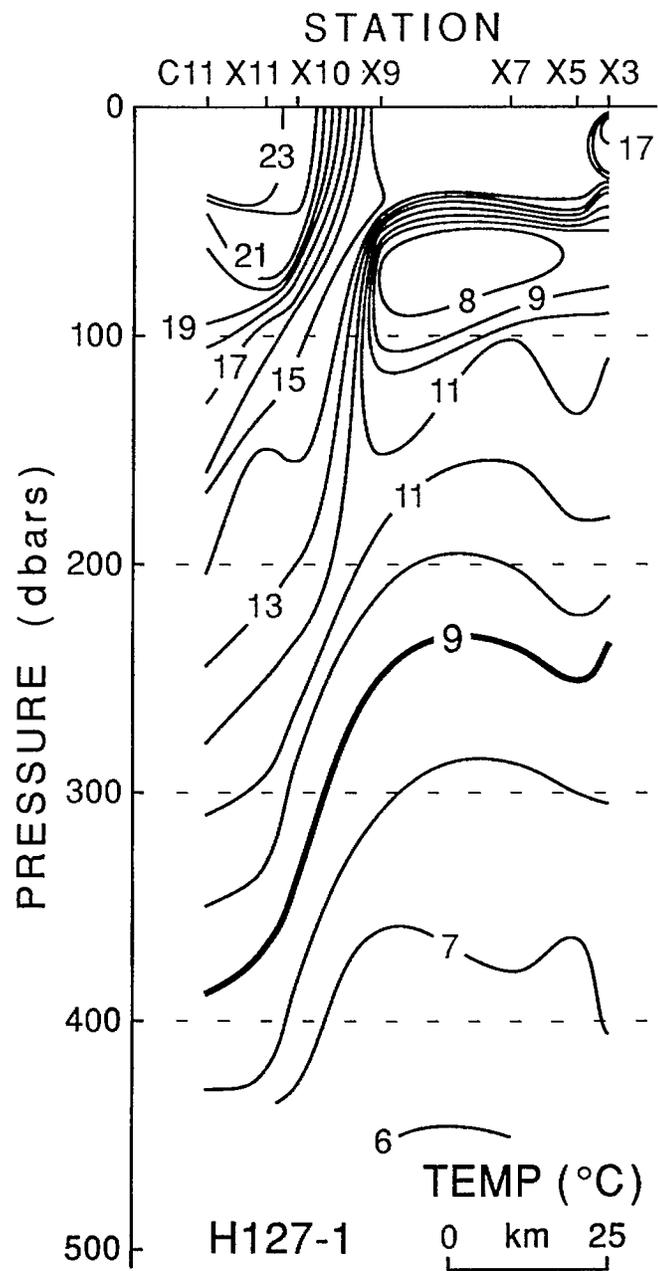
Figure 58. The front between Warm Slope Water and Labrador Slope/Shelf Water at the surface, based on surface salinity, during standard cruises in 1988-89.

APPENDIX 1**Vertical Temperature and Salinity Sections**

Sections are arranged by cruise and transect number. A cruise-transect identifier occurs at the lower left of each section (e.g. H127-1, N110-4). Some particularly long temperature sections are split into subsections, each of which is given a letter designation (e.g. N089-3A, N089-3B, etc.). Salinity sections, when available, follow immediately the temperature section with the same identifier. A distance scale (km) is provided at the foot of each section.

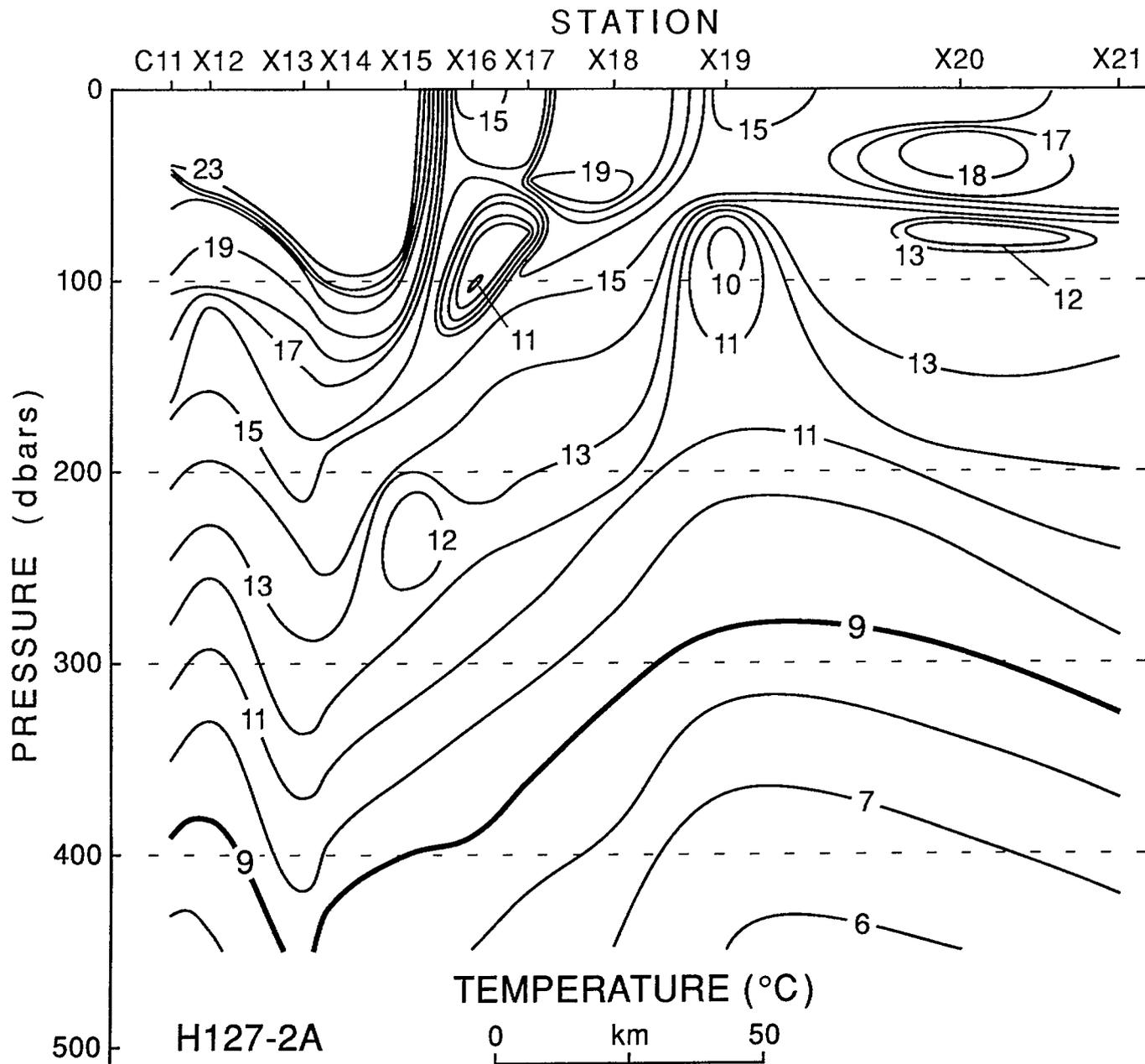
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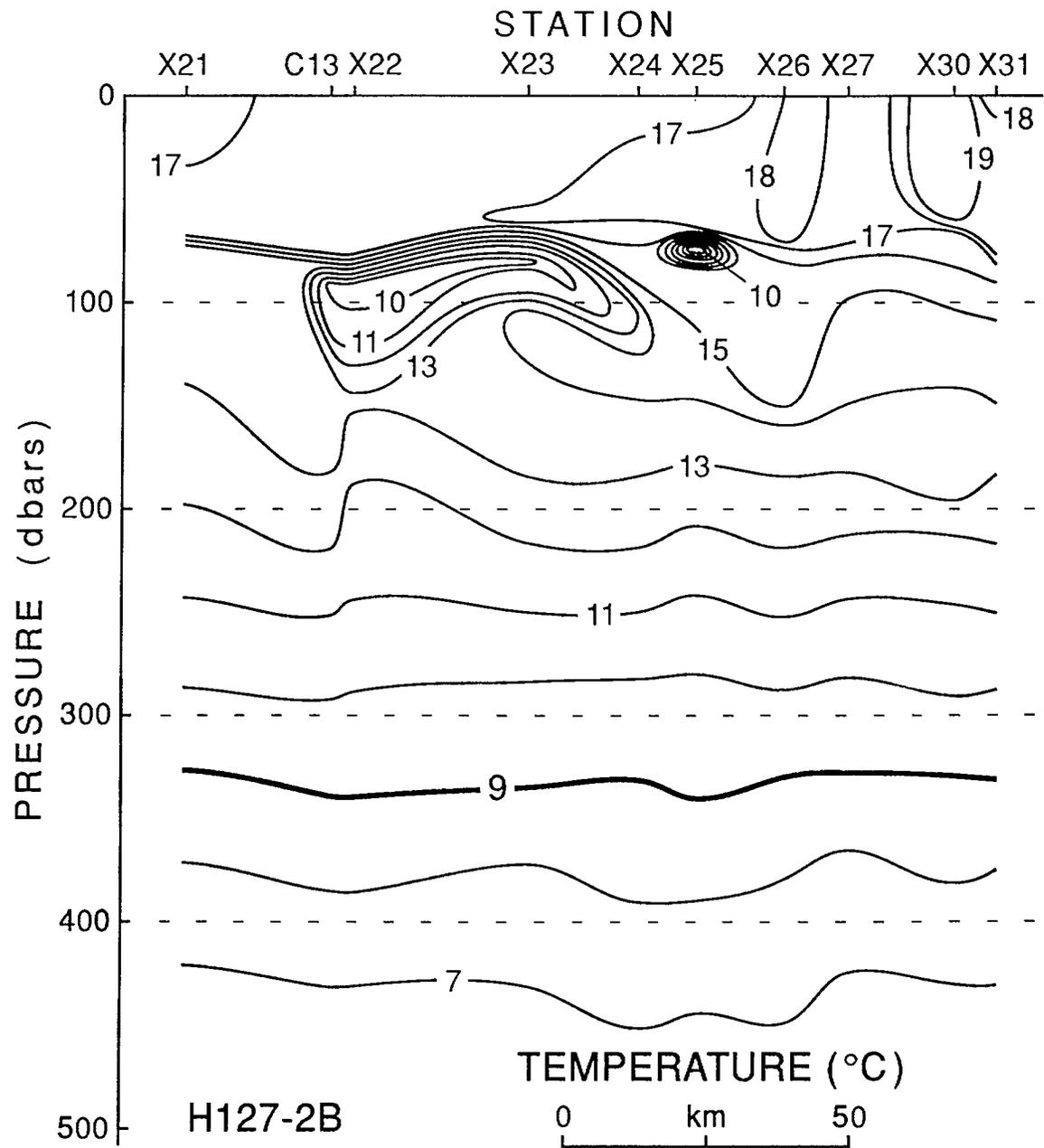
<u>Cruise No.</u>	<u>Page No.</u>
H127	102
N057	111
G121	118
N067	128
N089	140
N096	151
N110	158
N112	171
N119	177
N122	183
N126	191



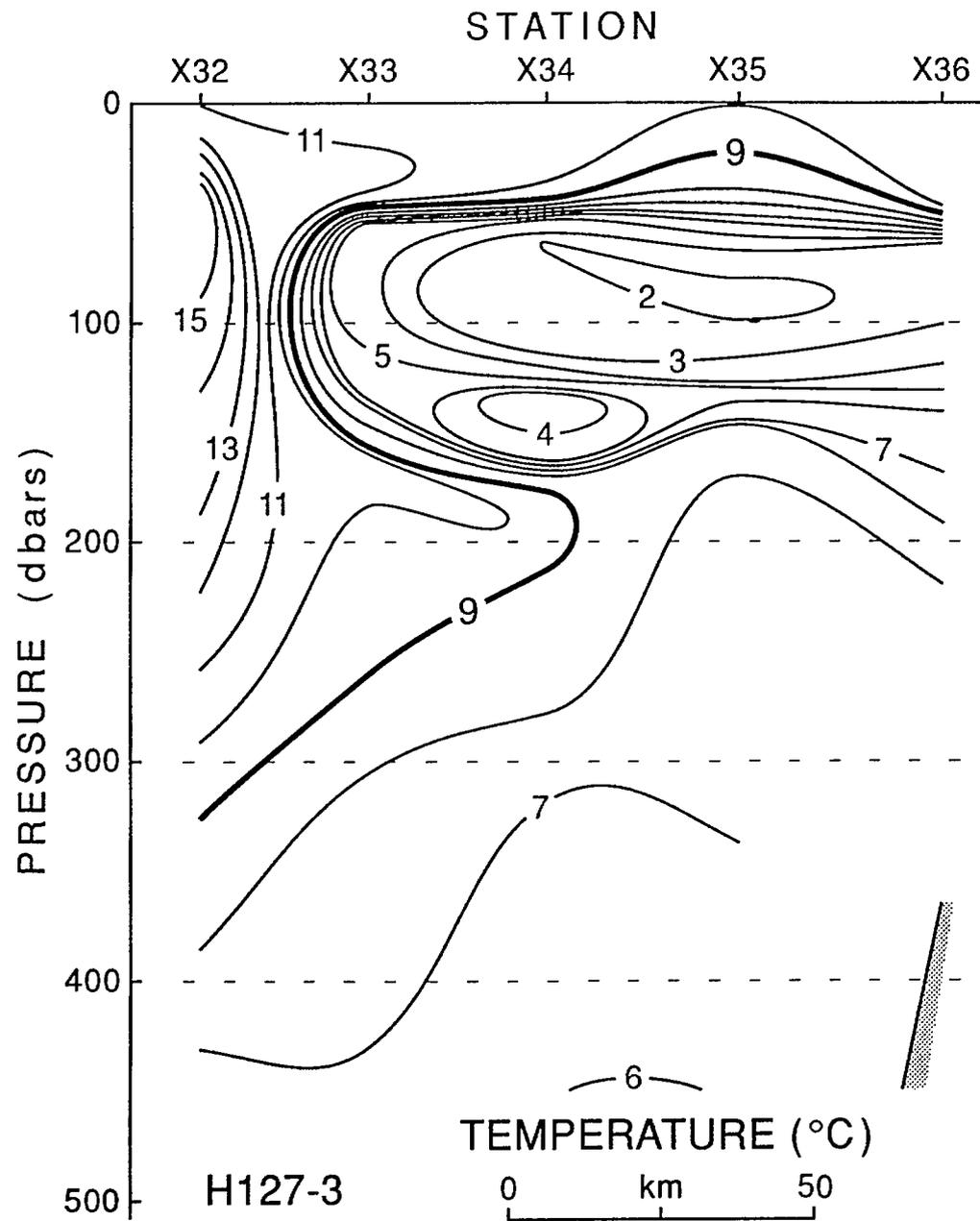
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HA75



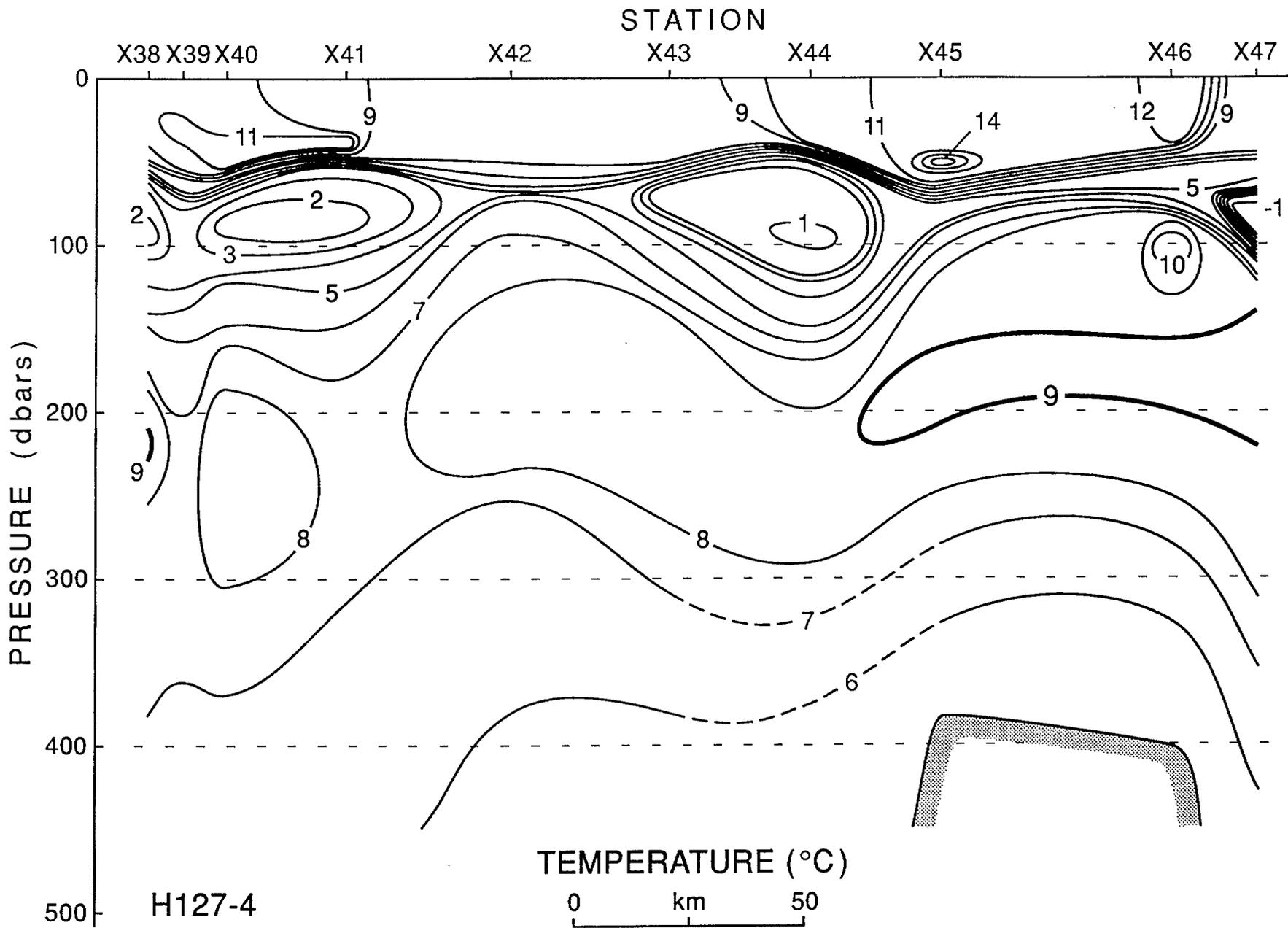


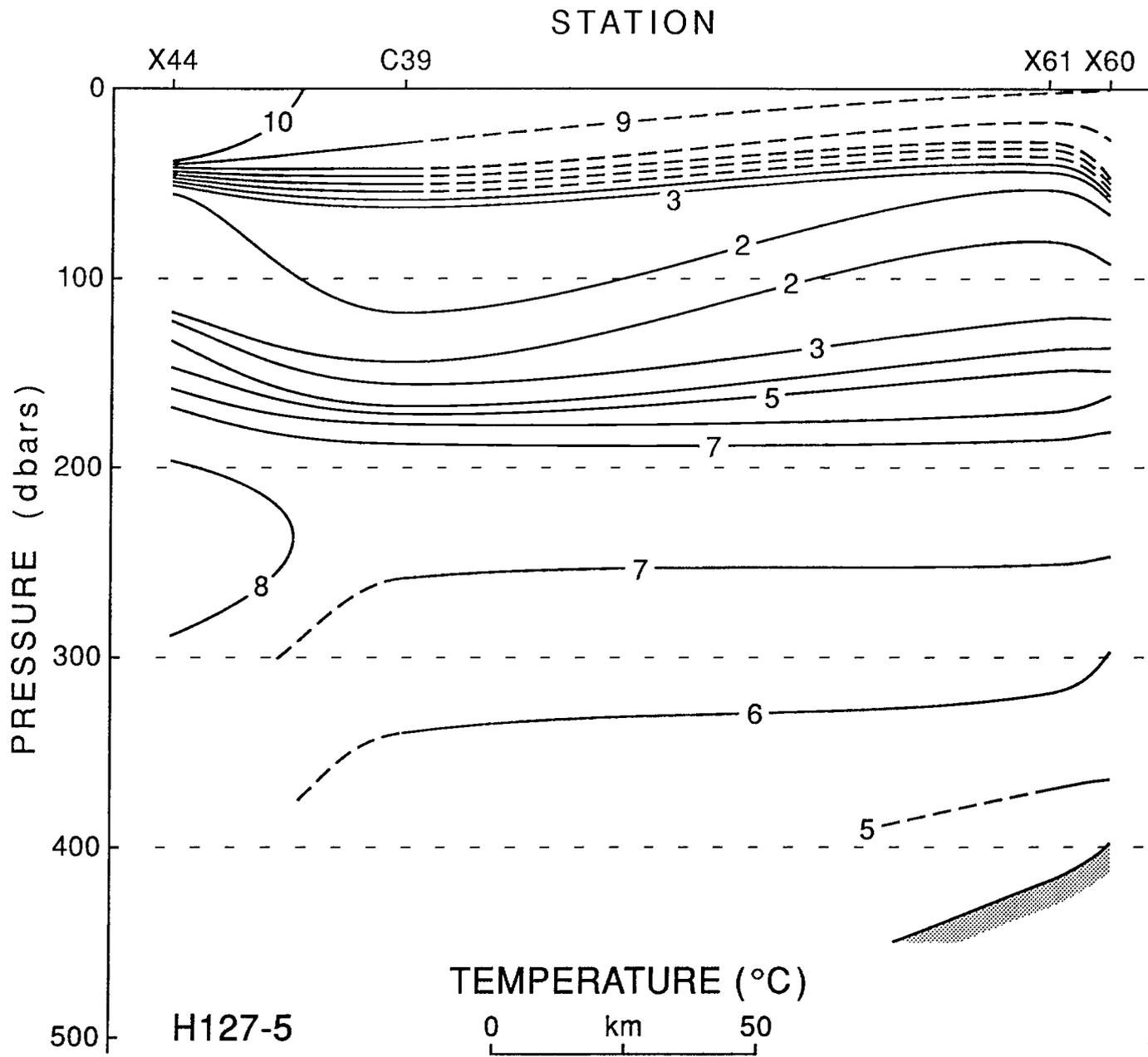
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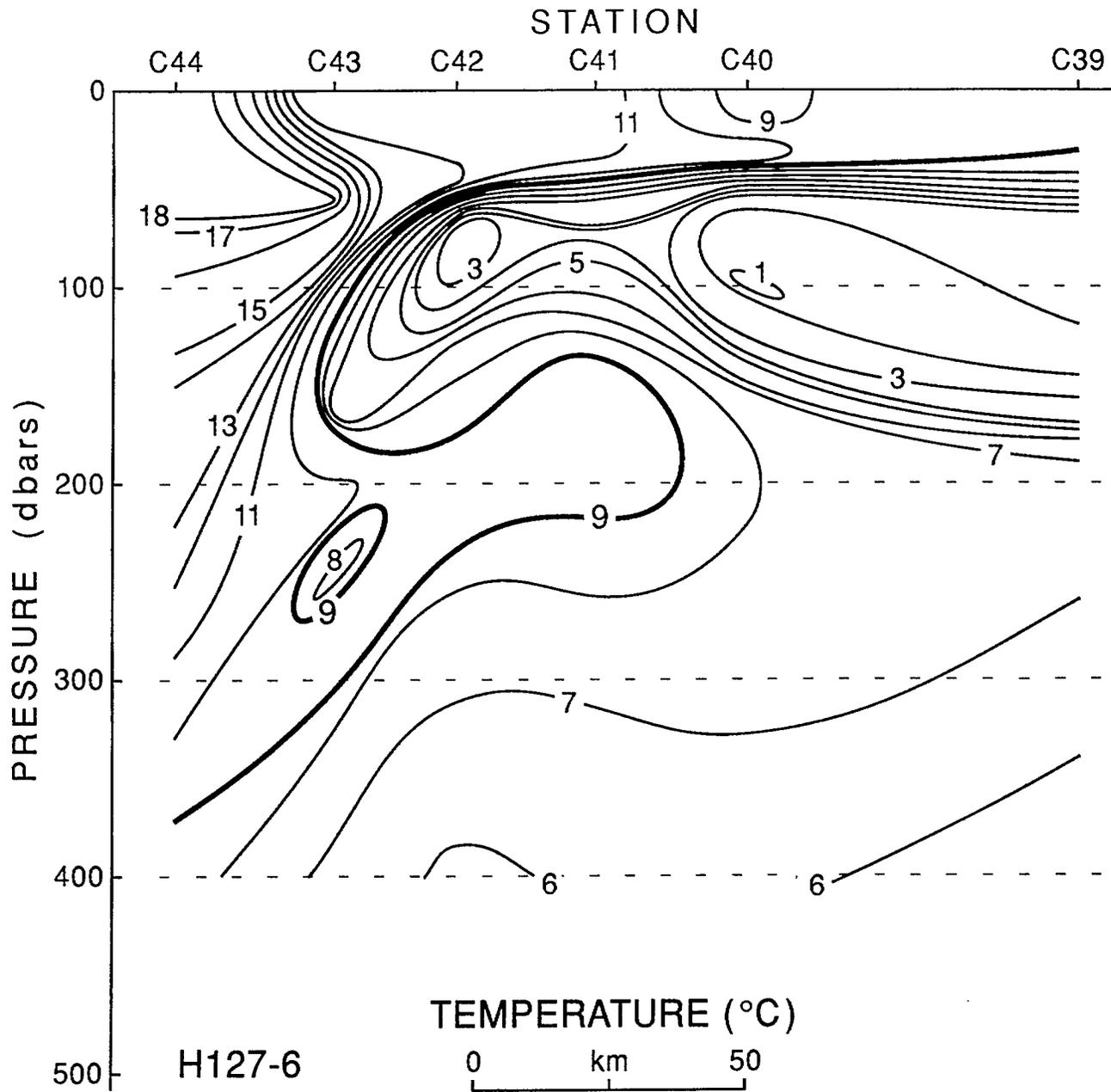
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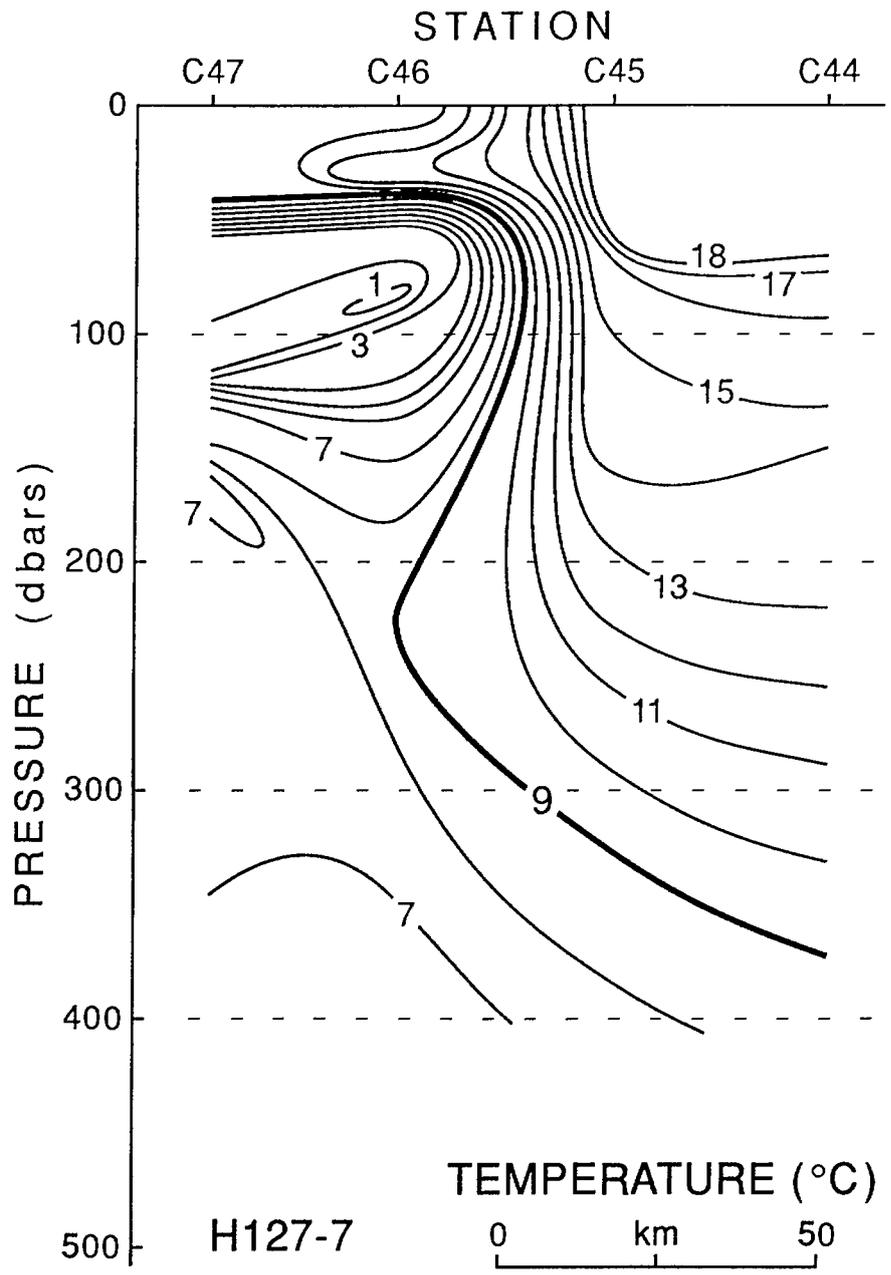
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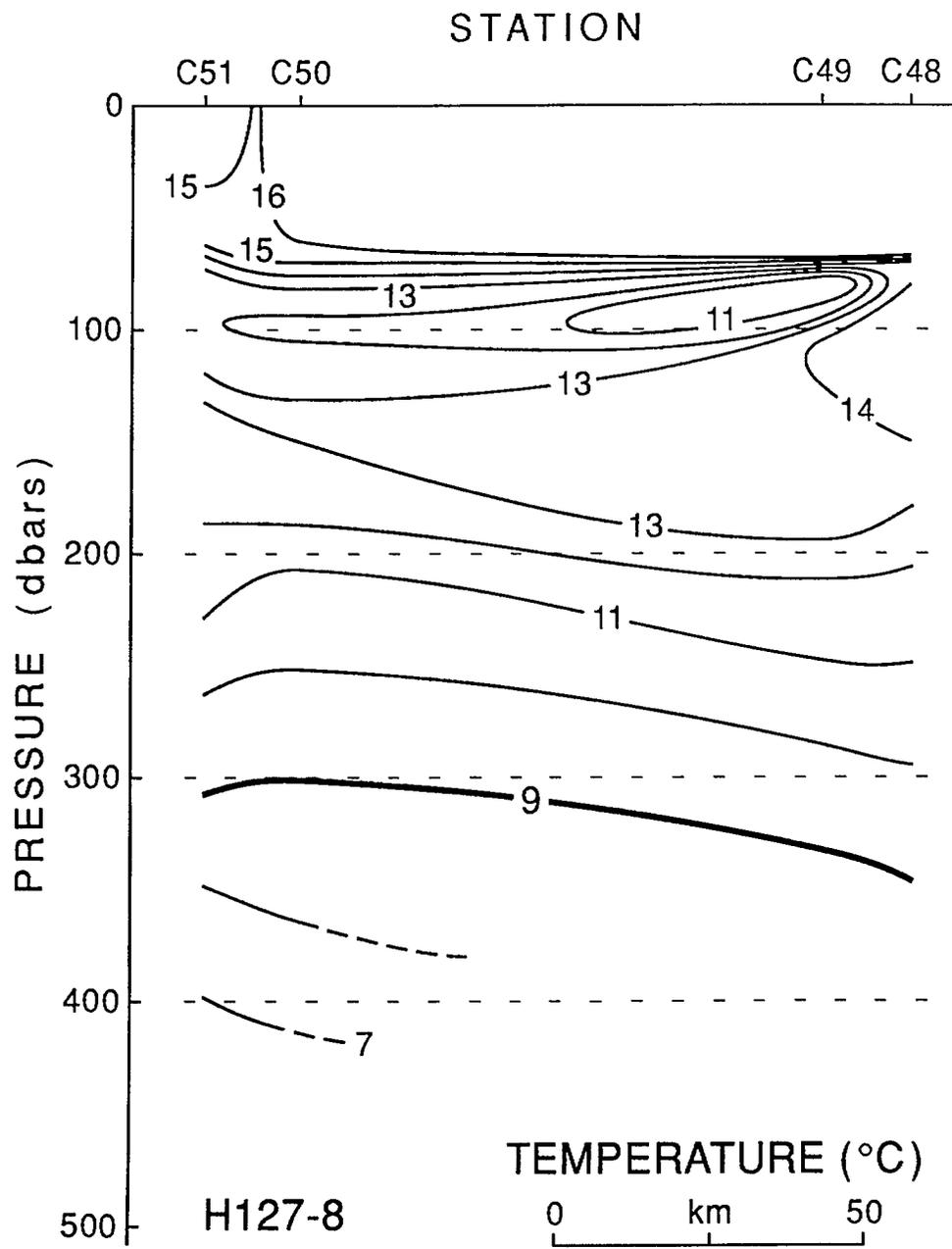


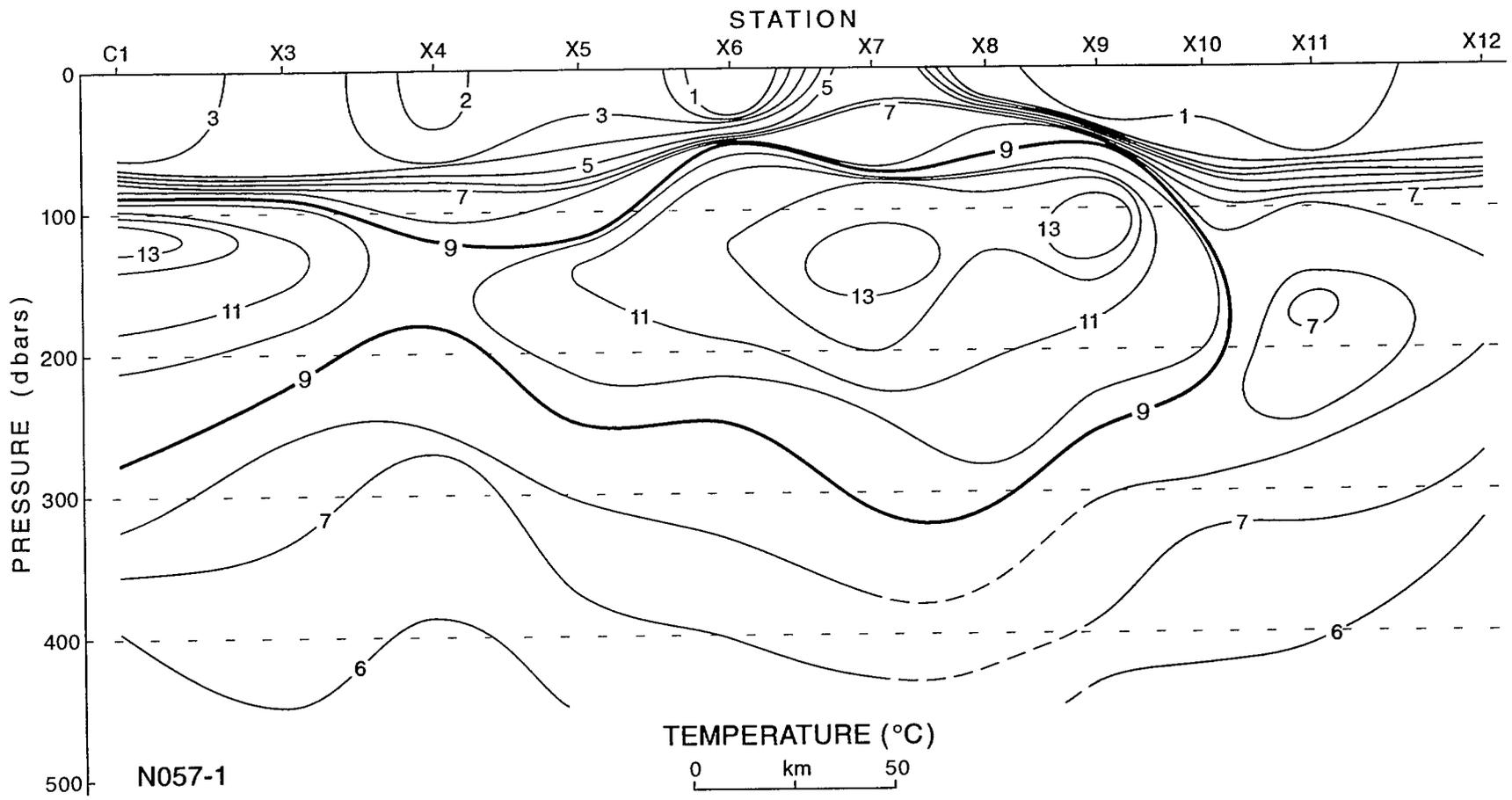
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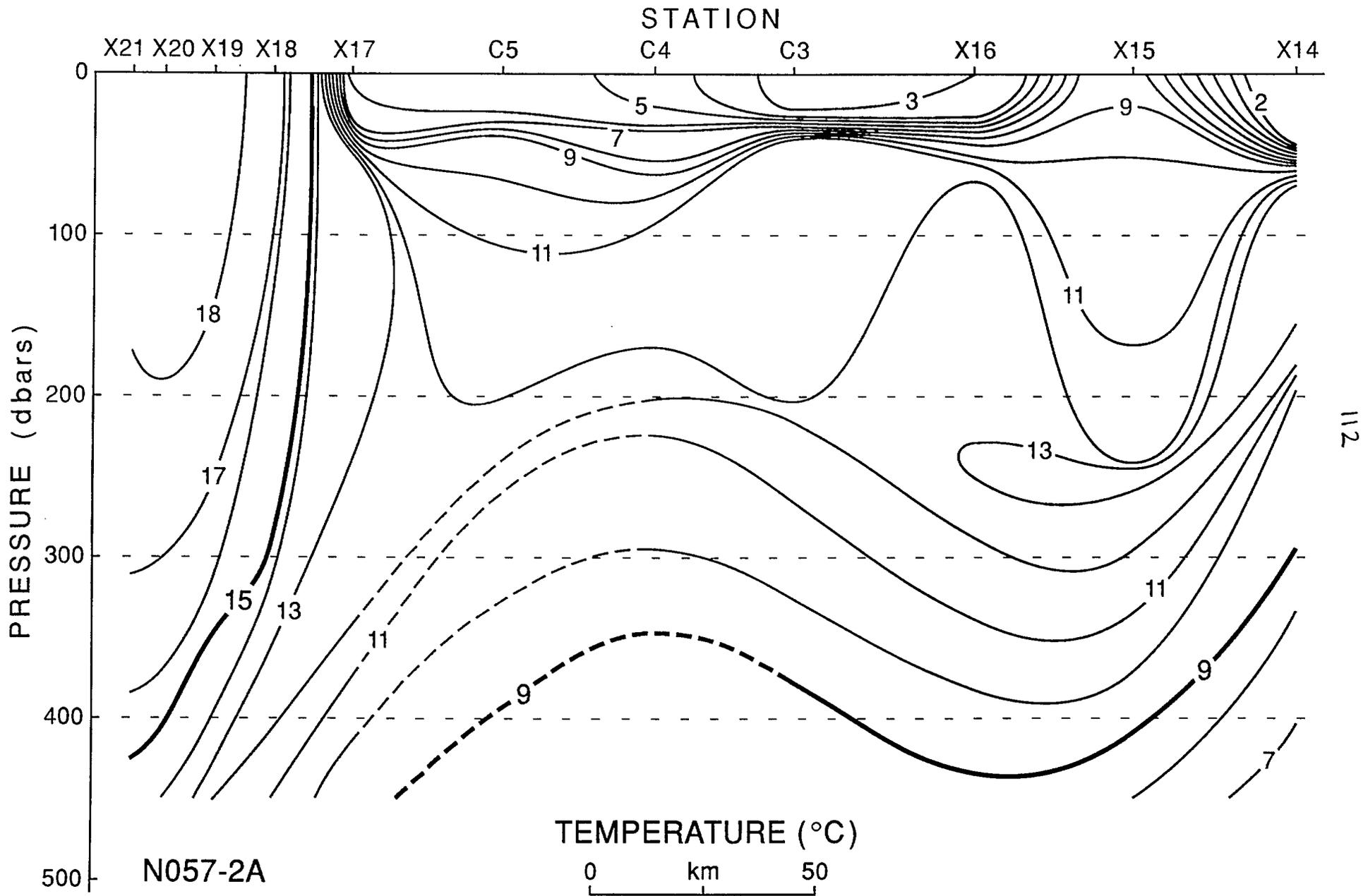
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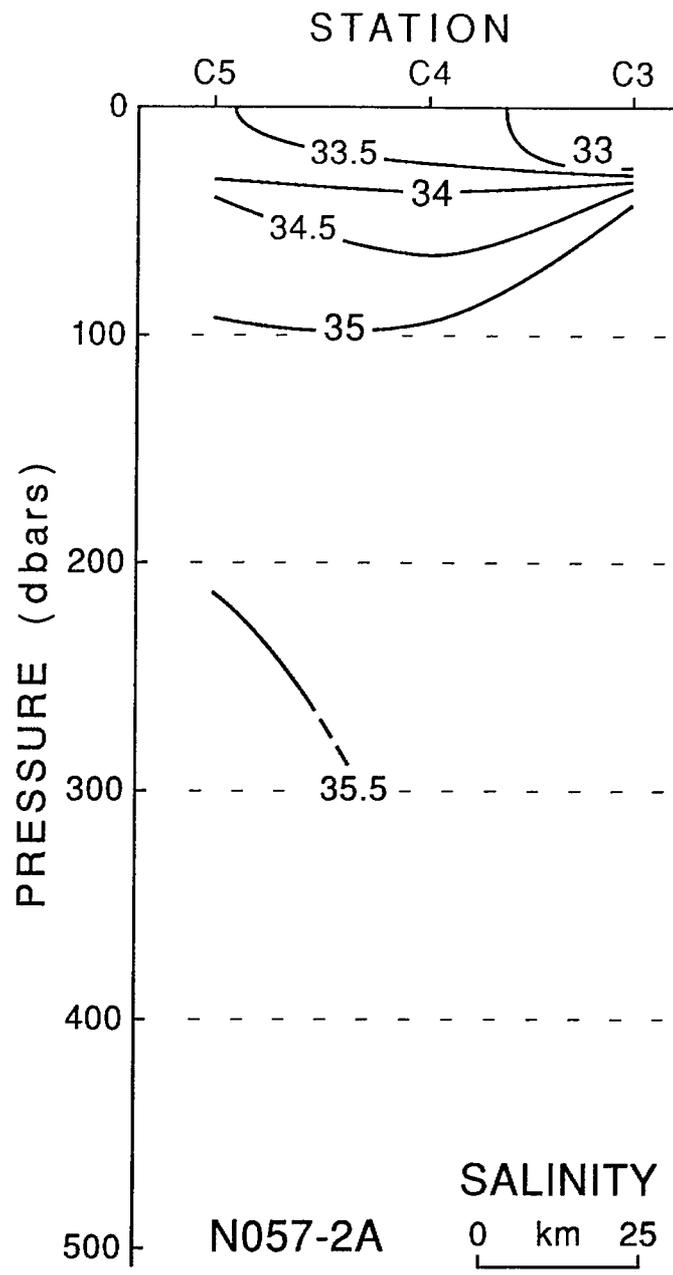


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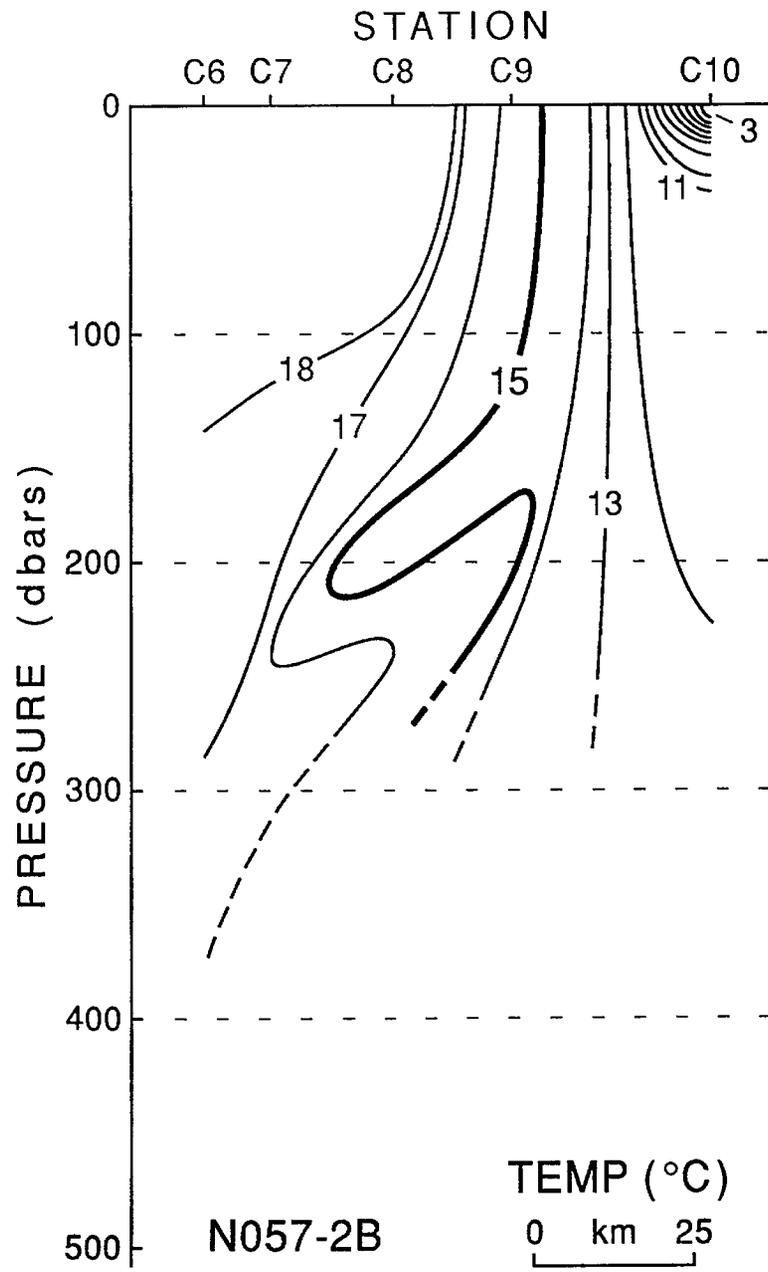






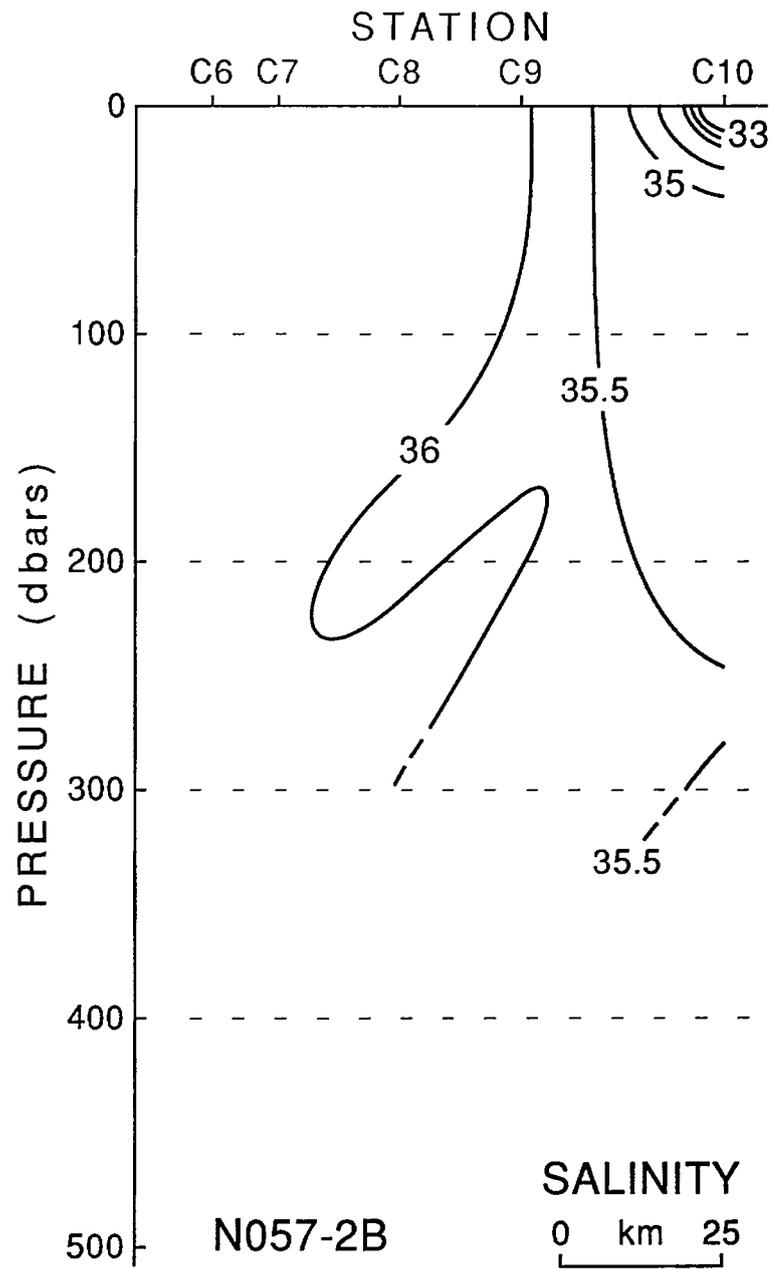


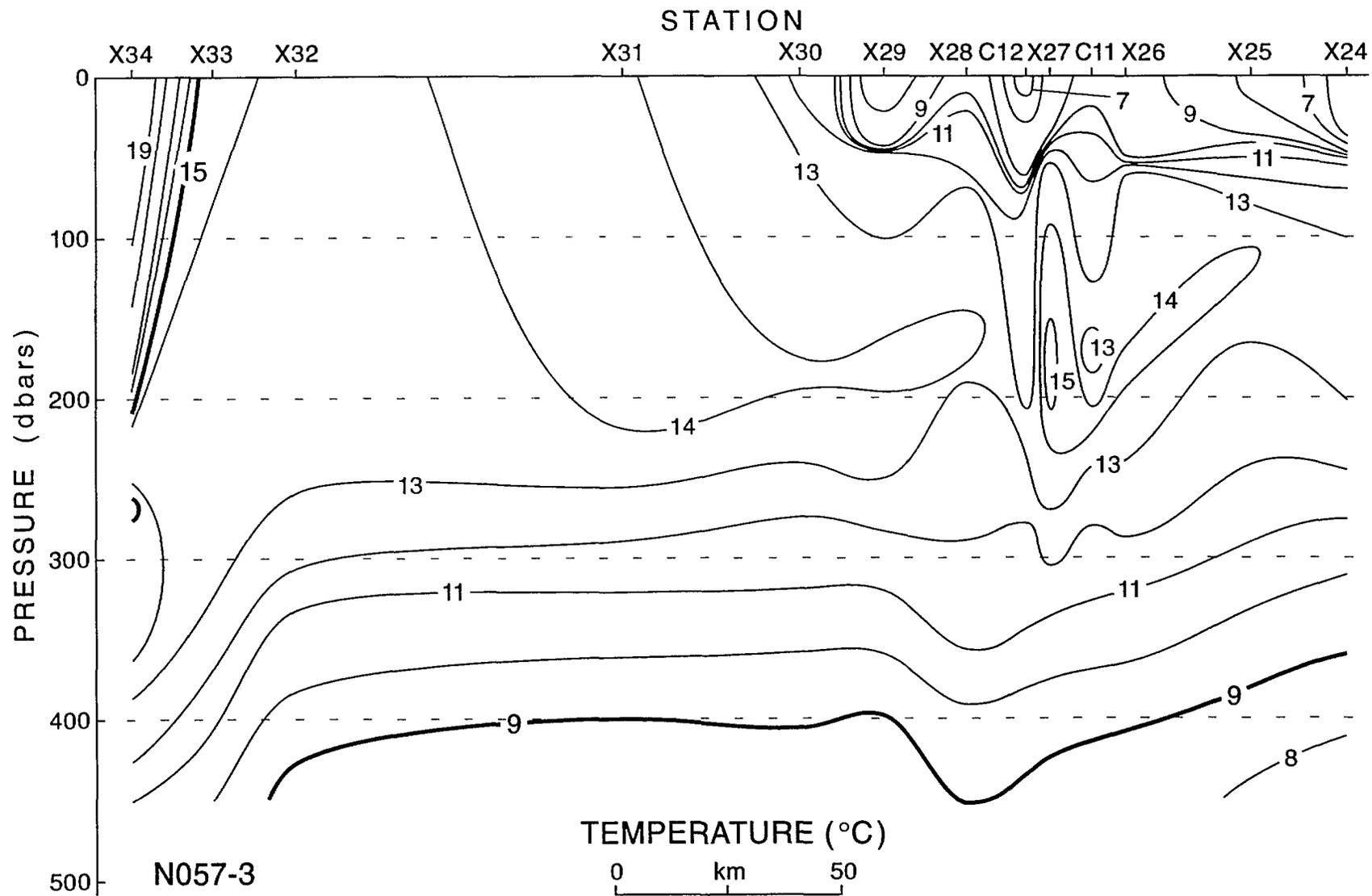
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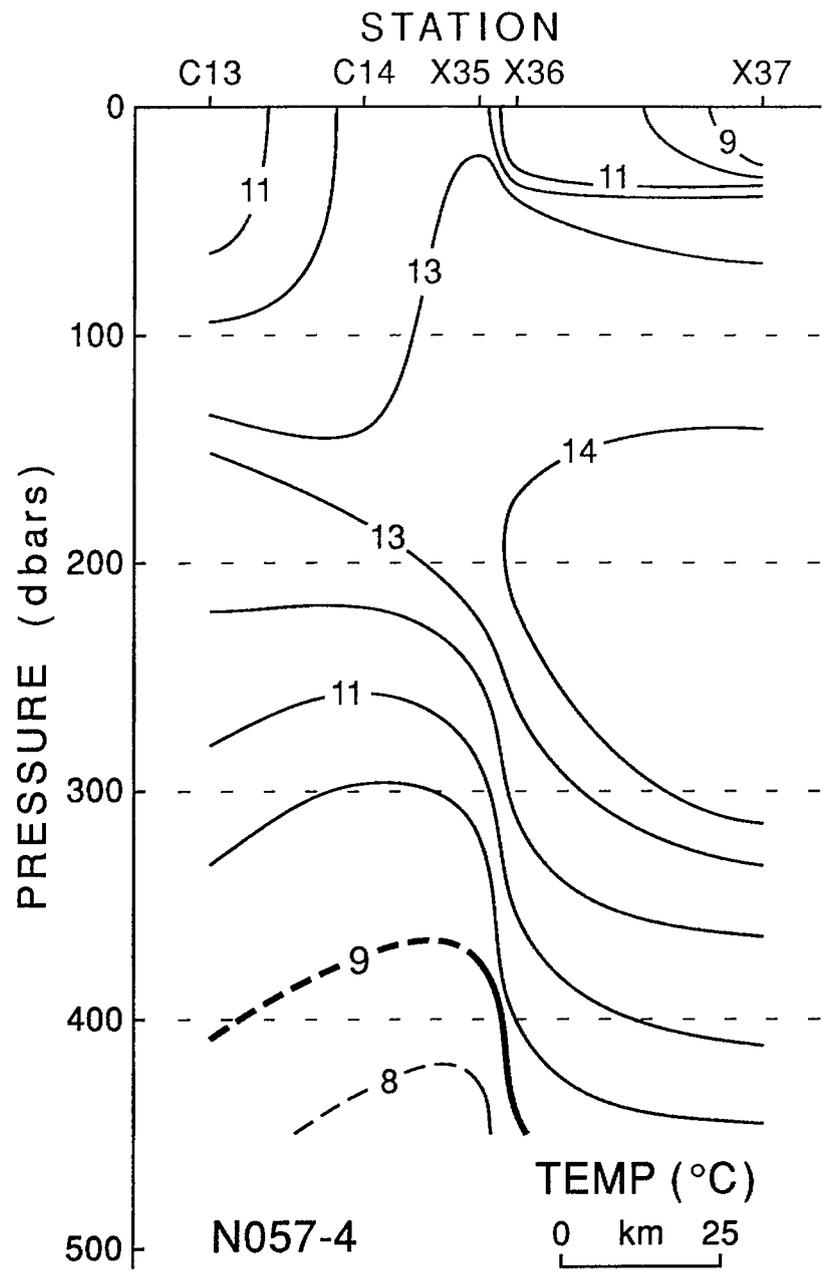


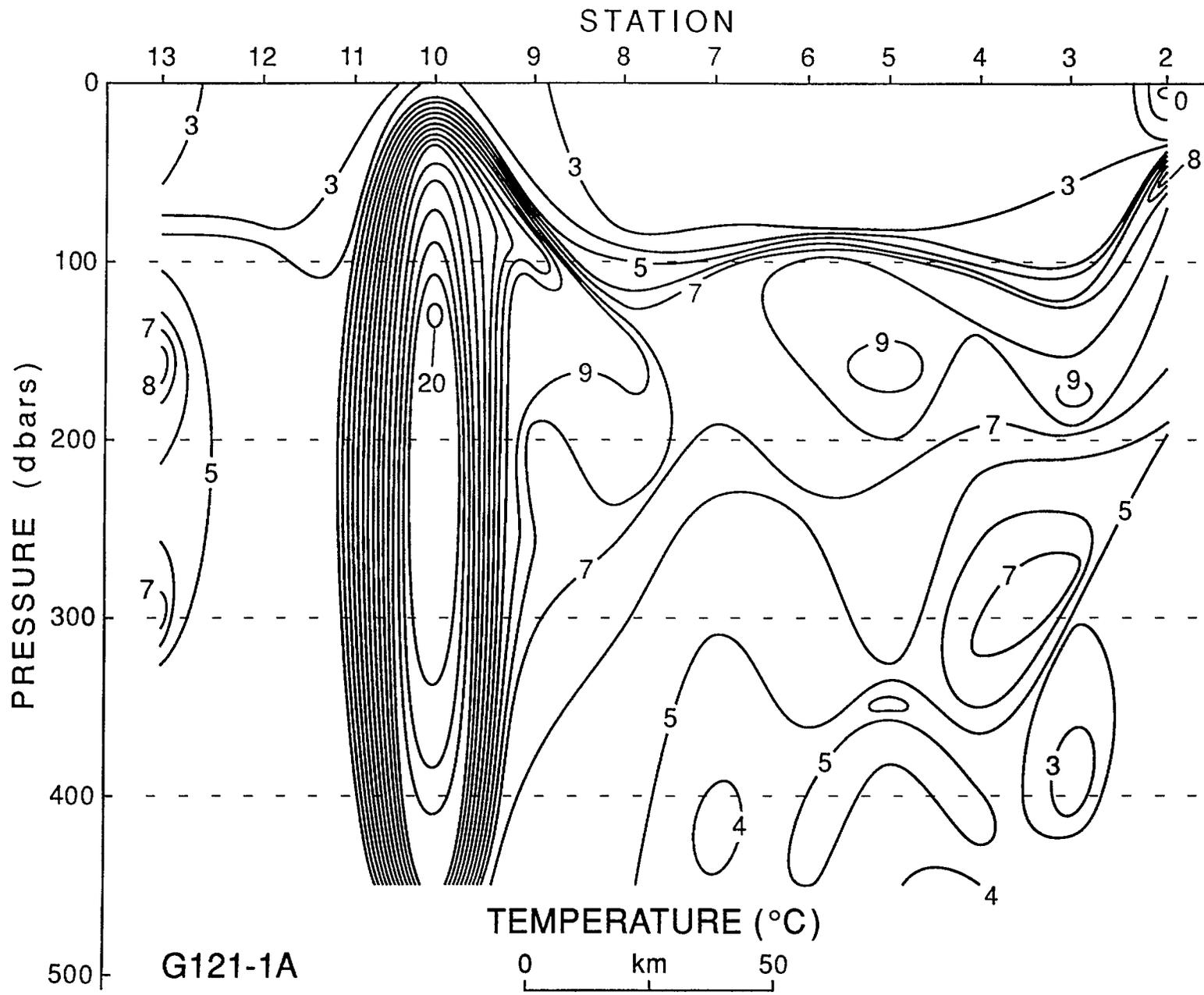
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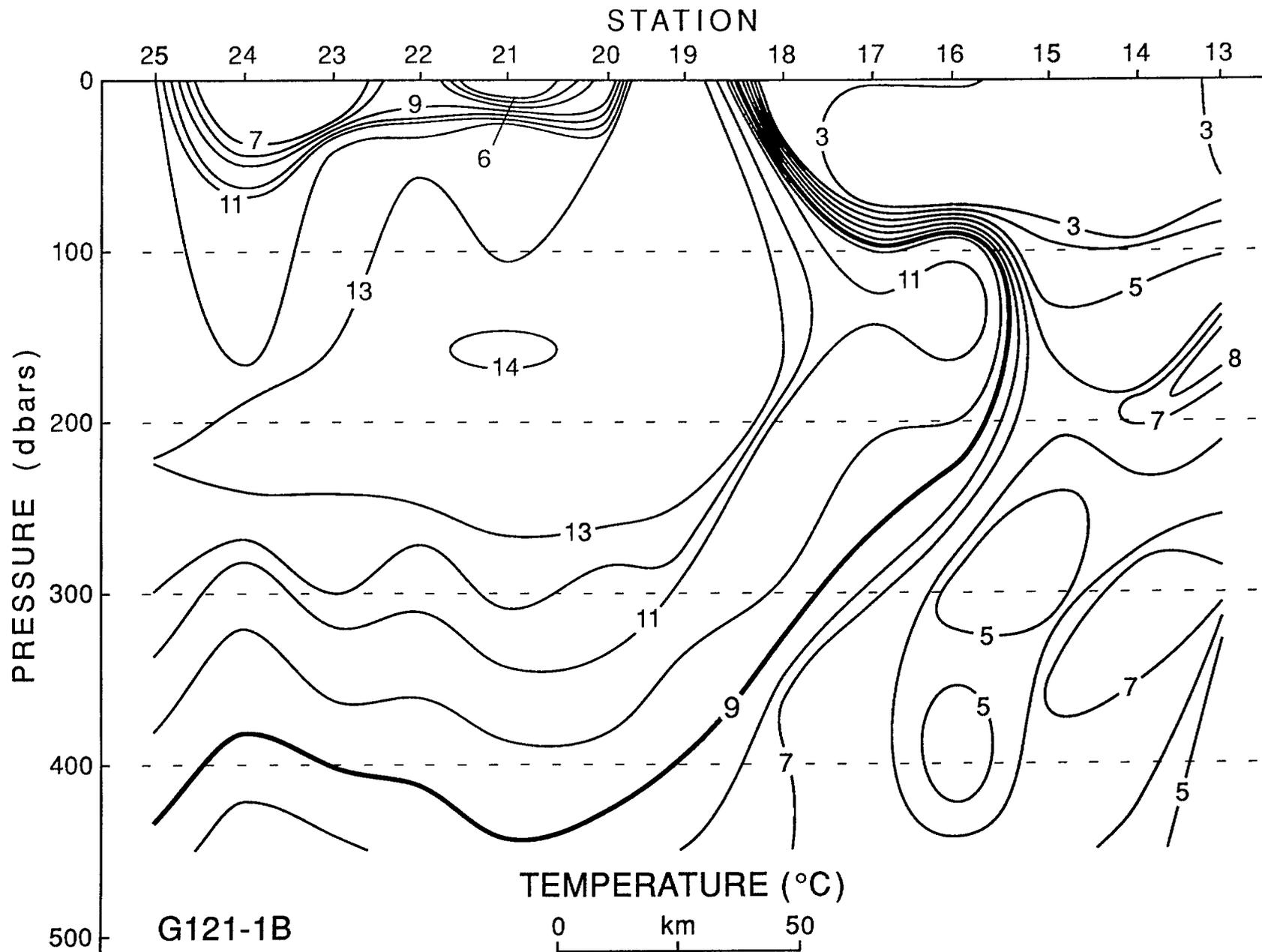




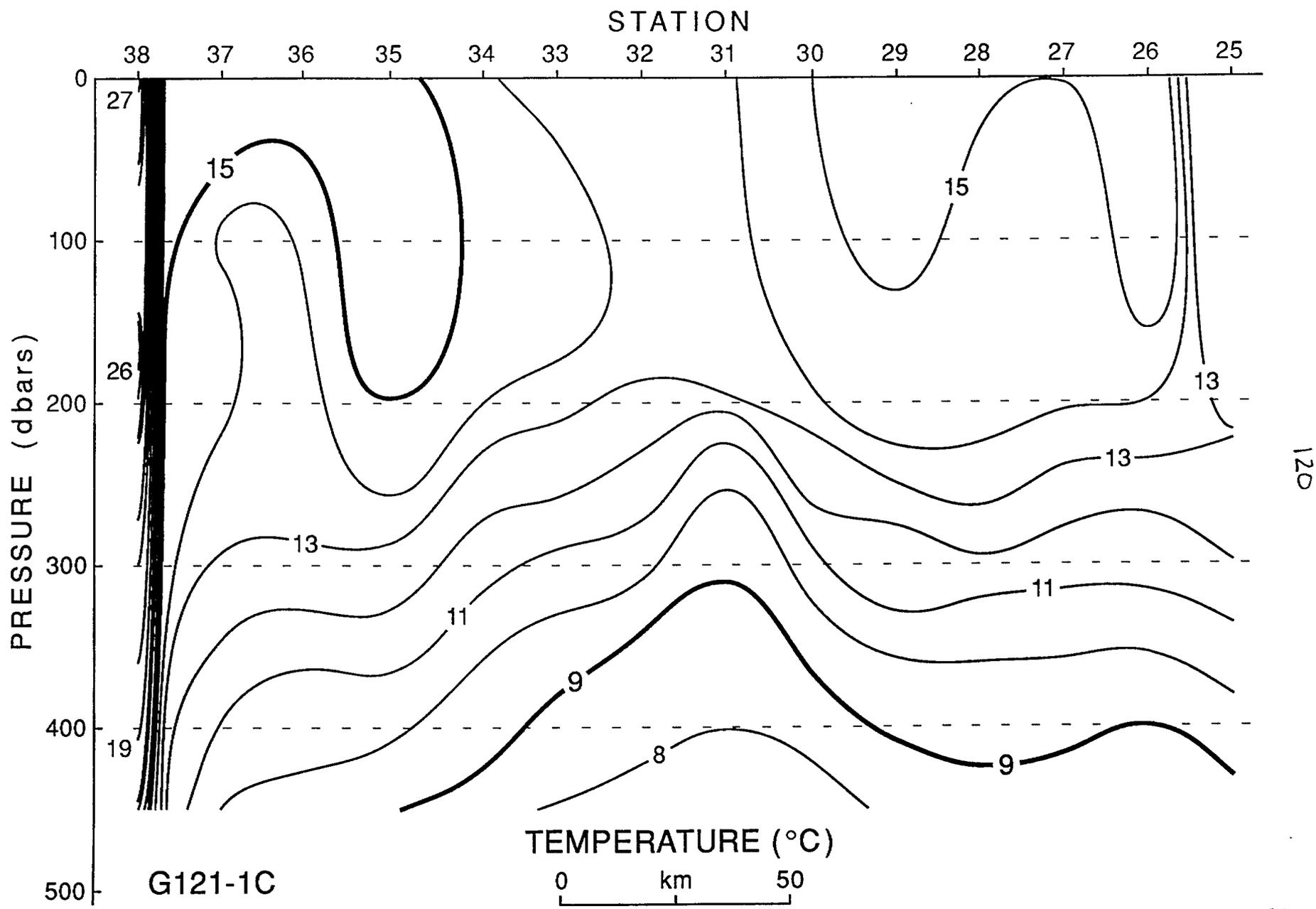
G121-1A

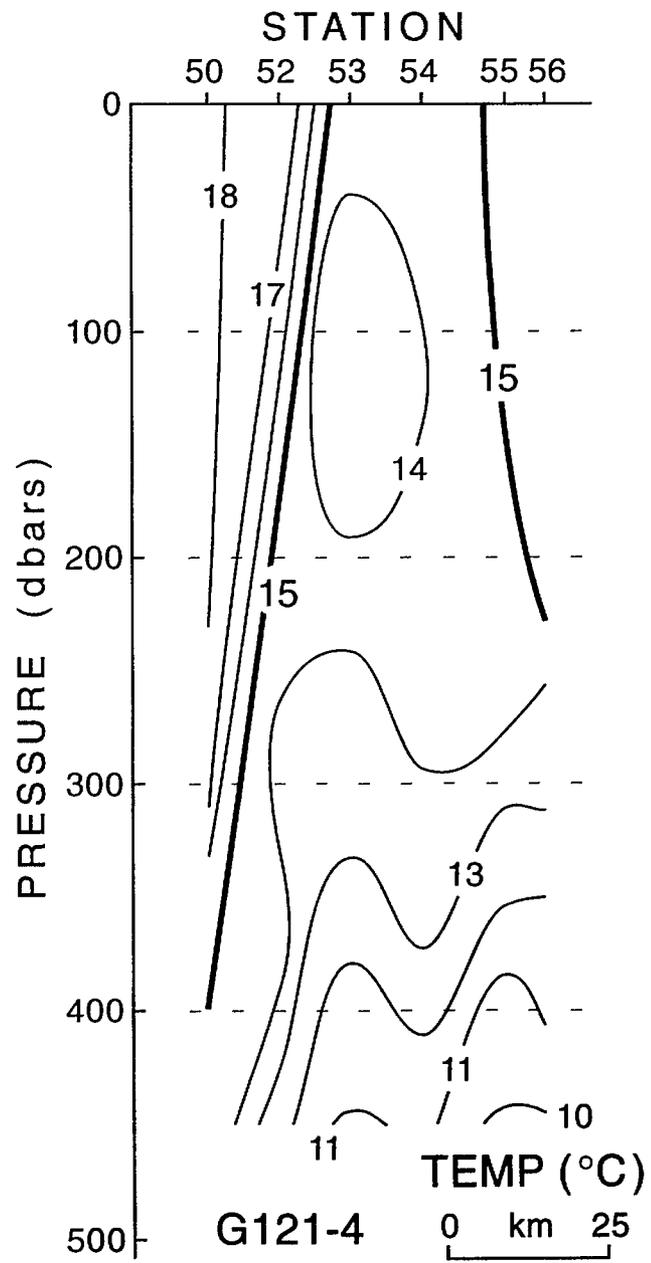
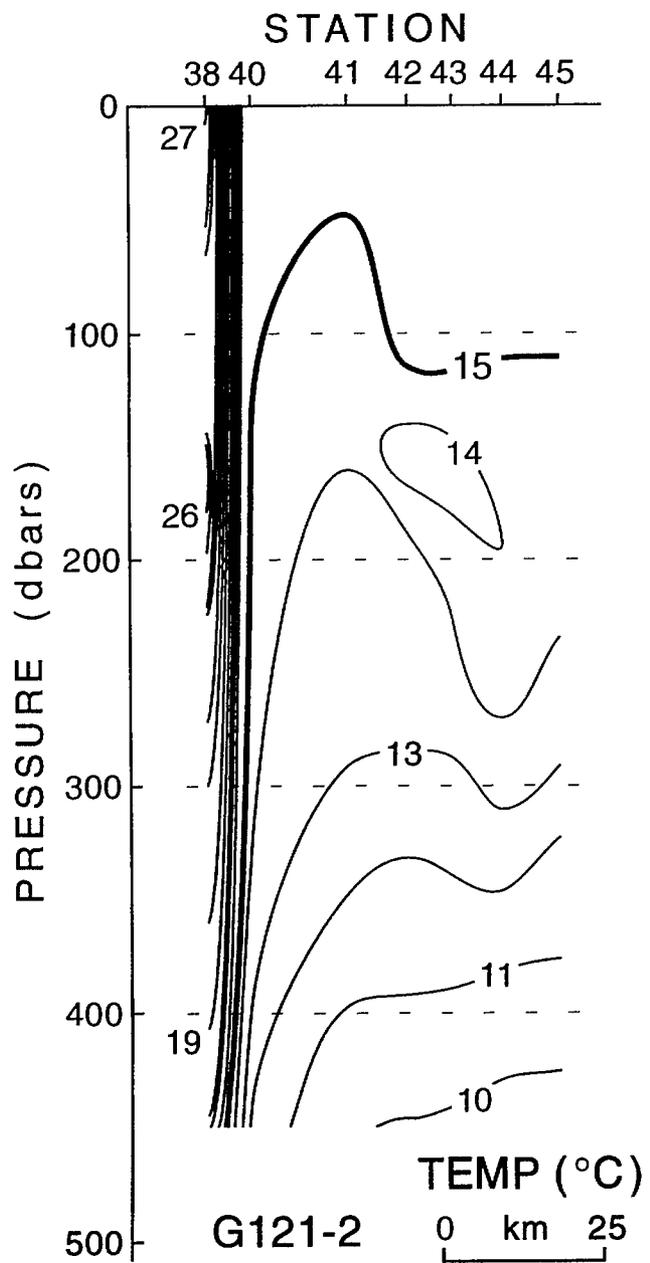
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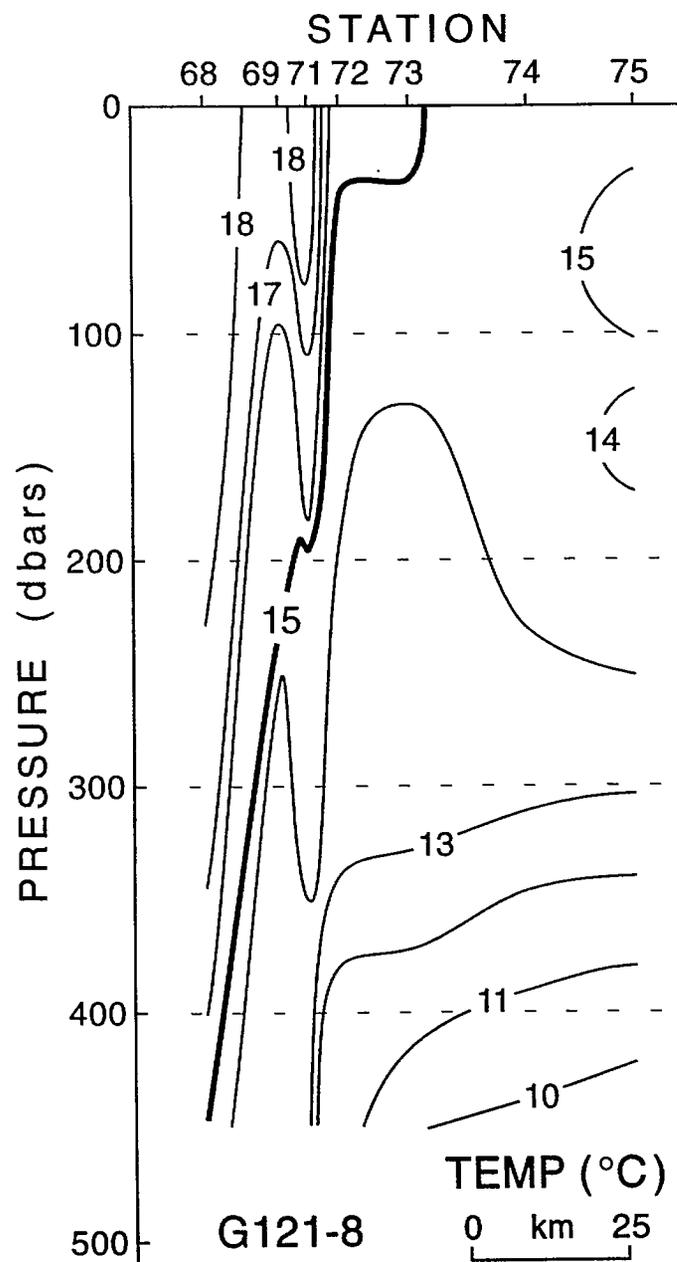
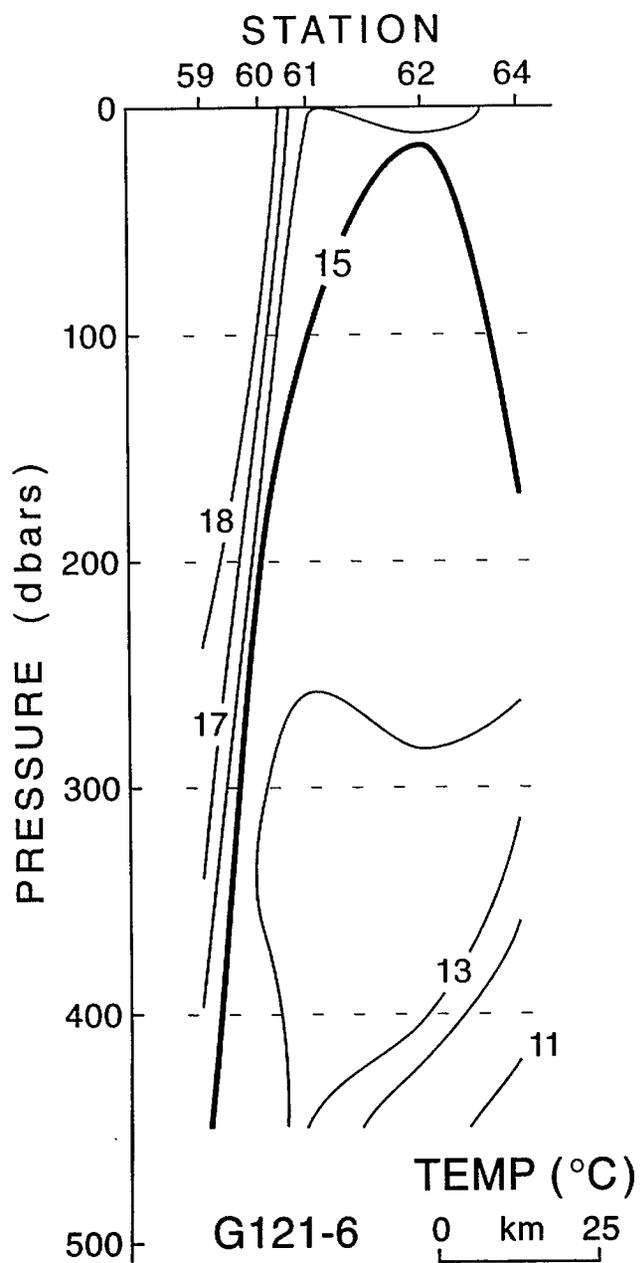
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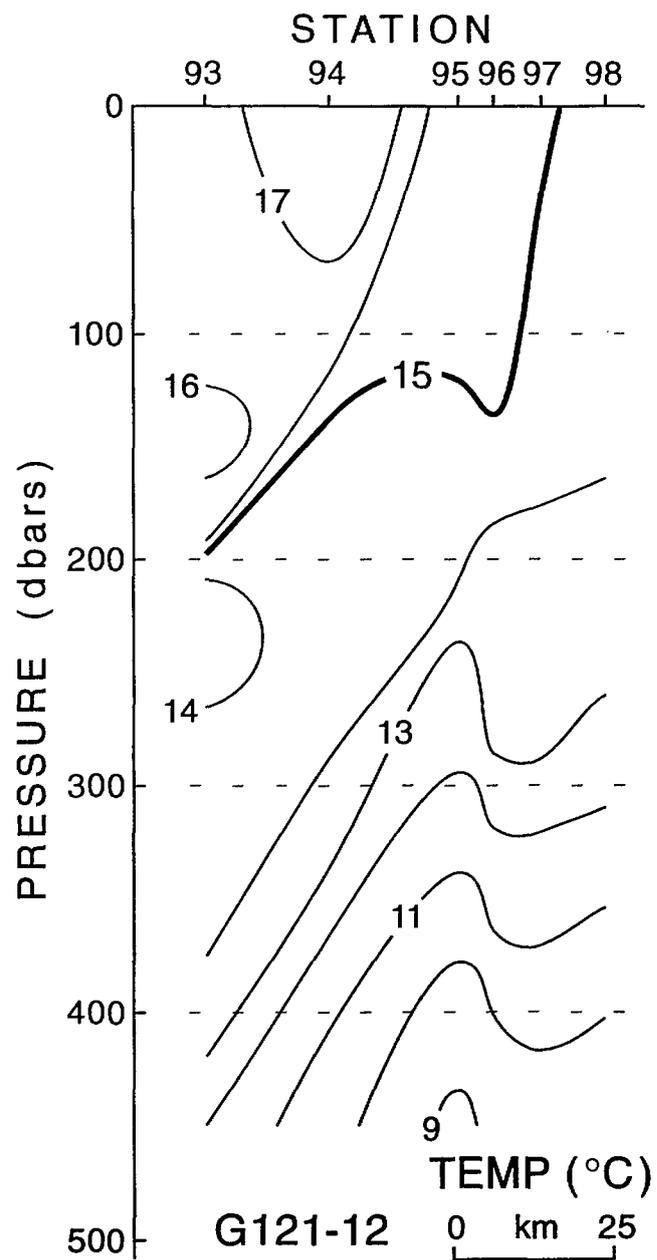
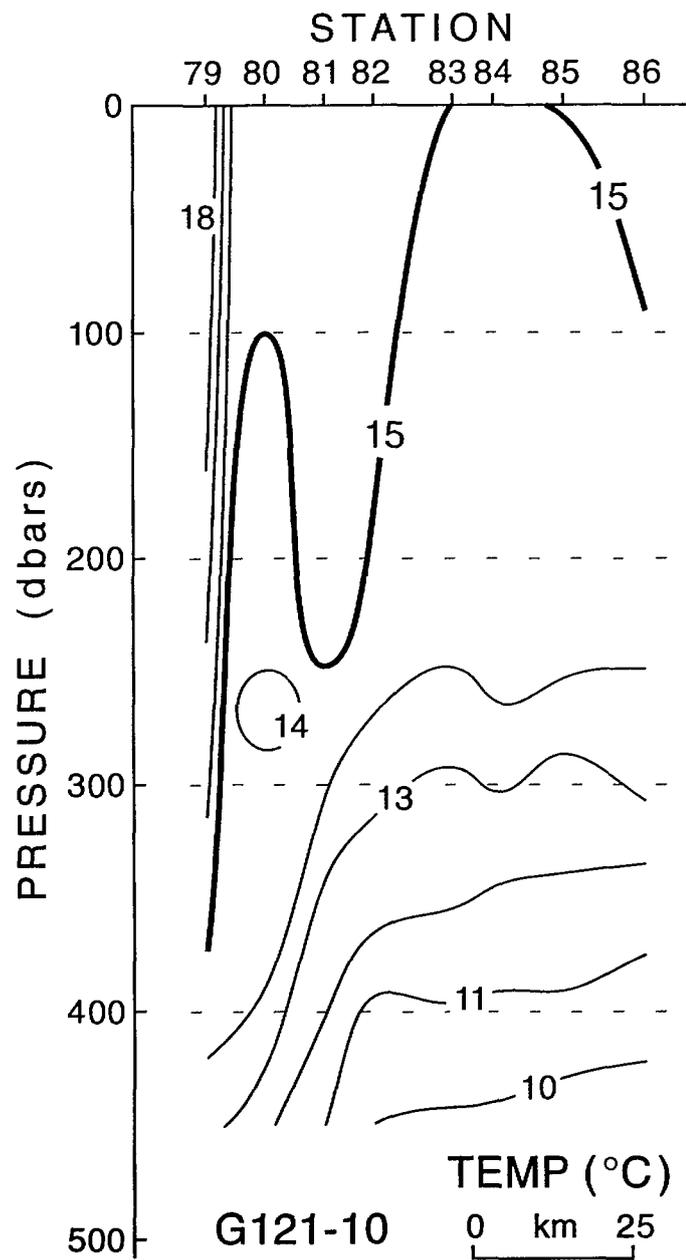


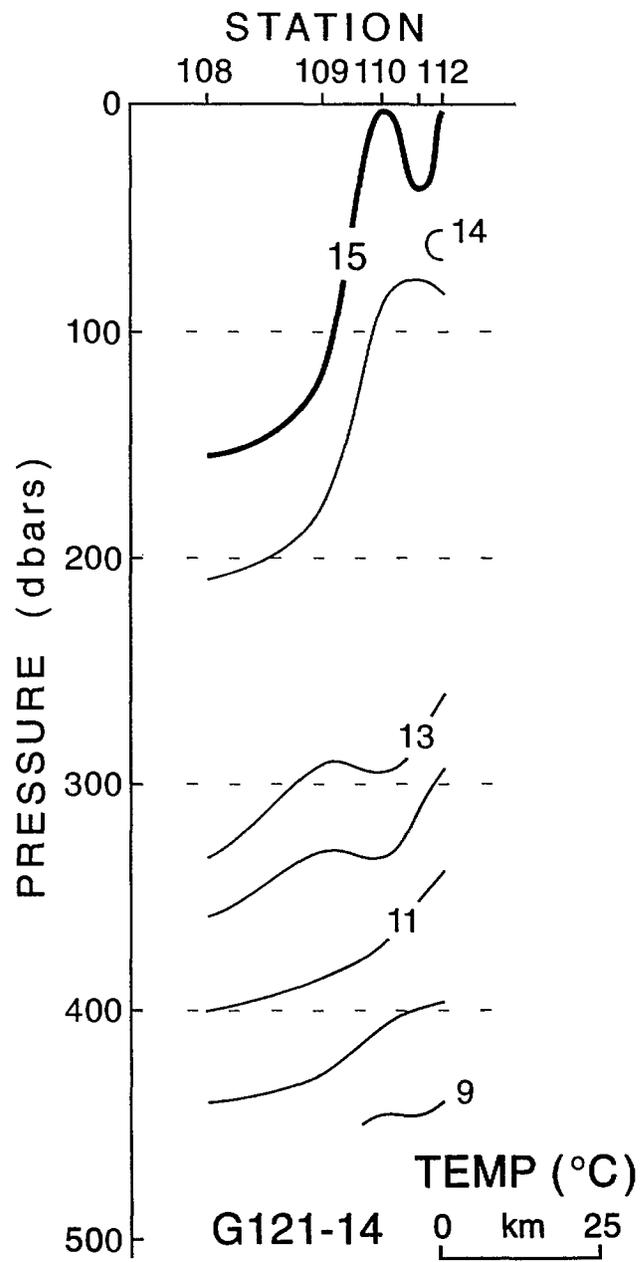
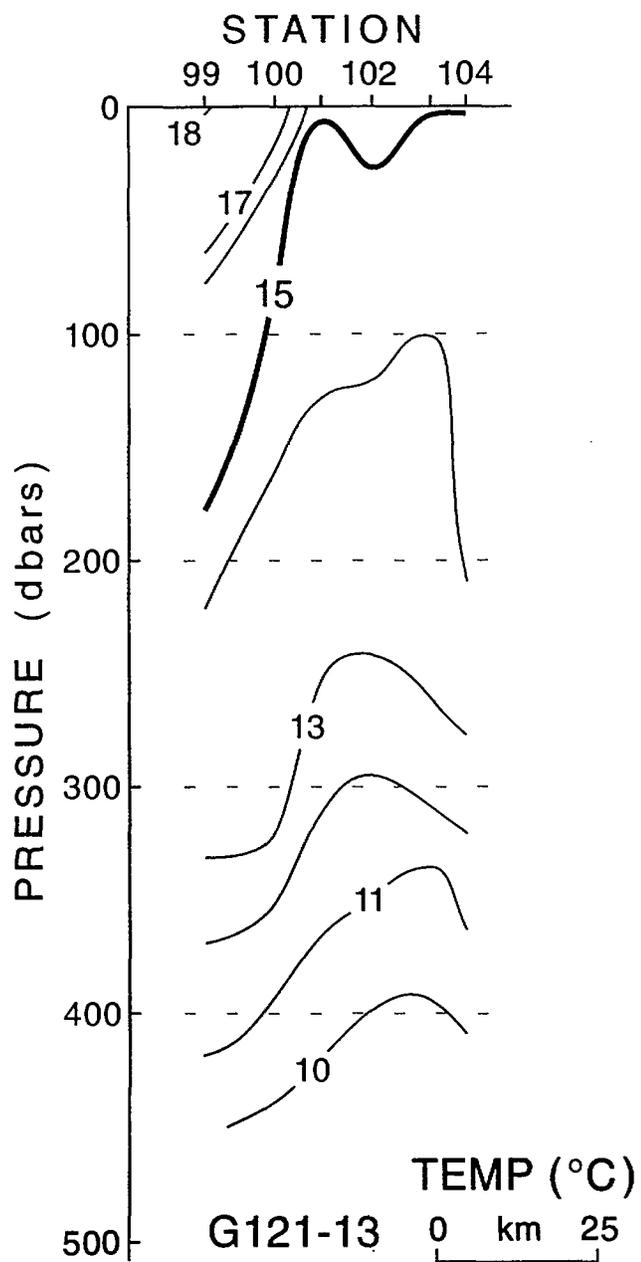
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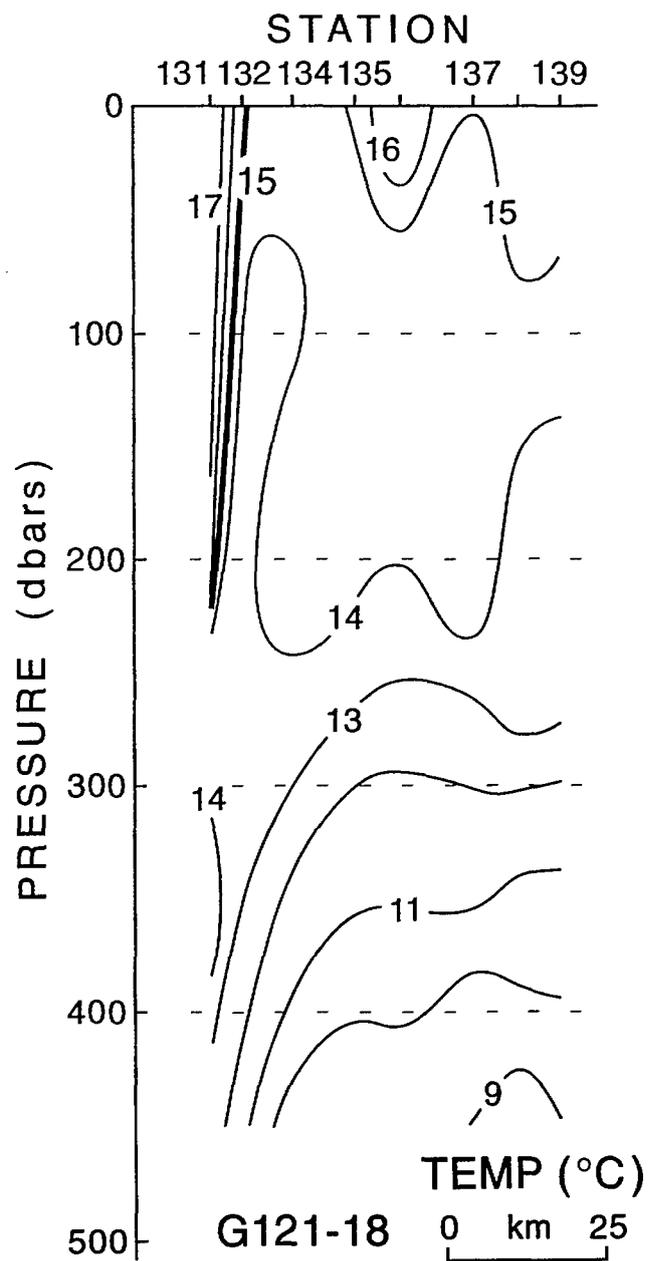
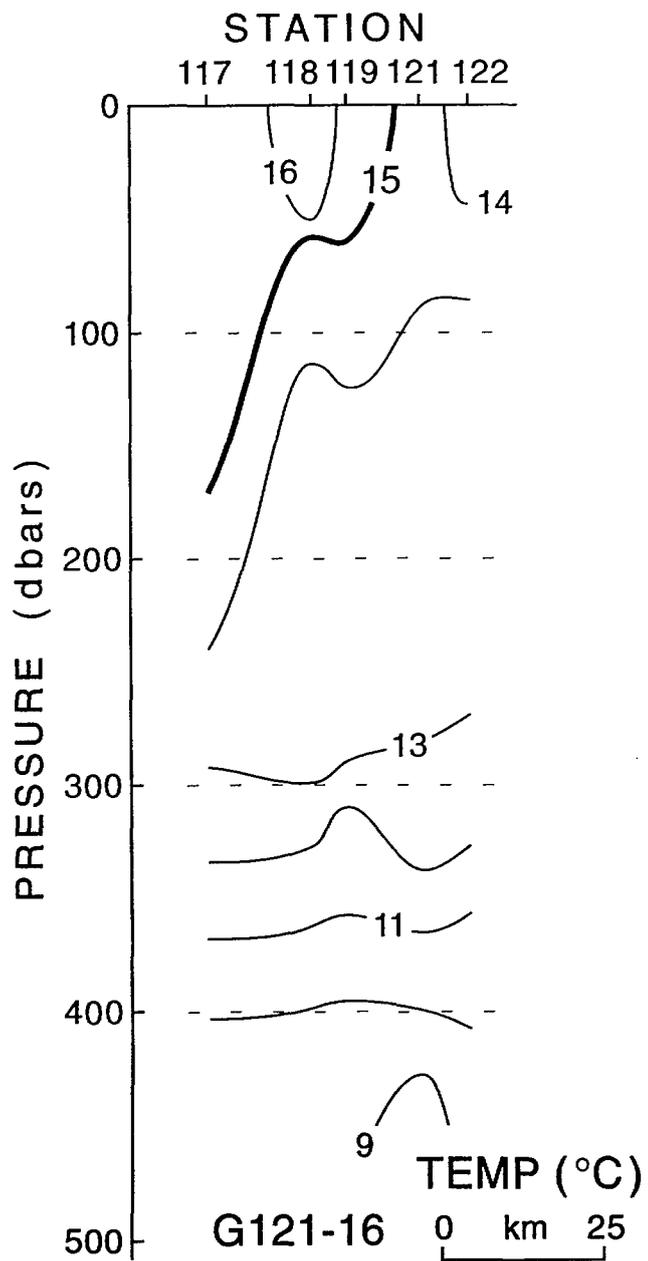


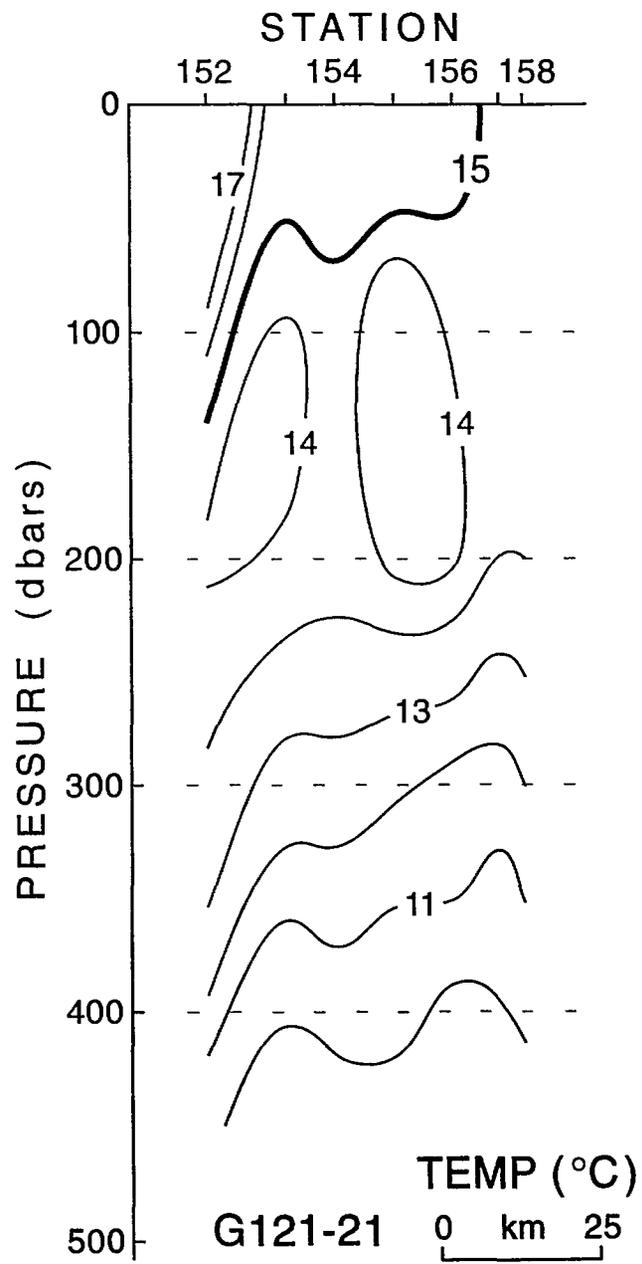
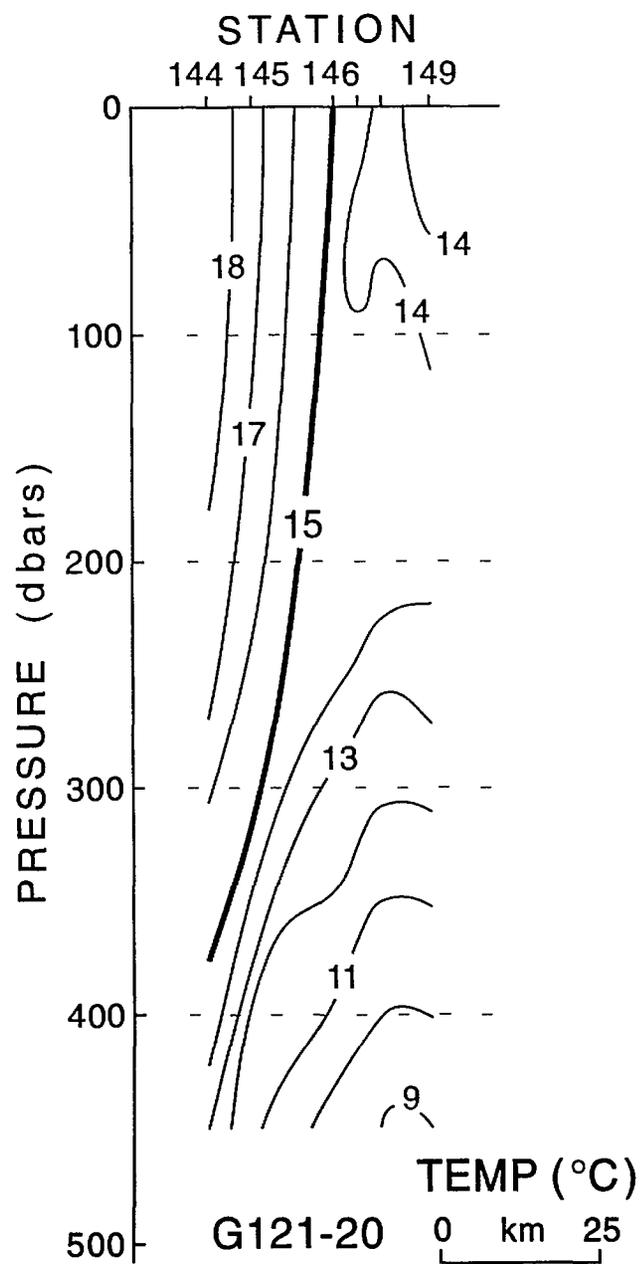


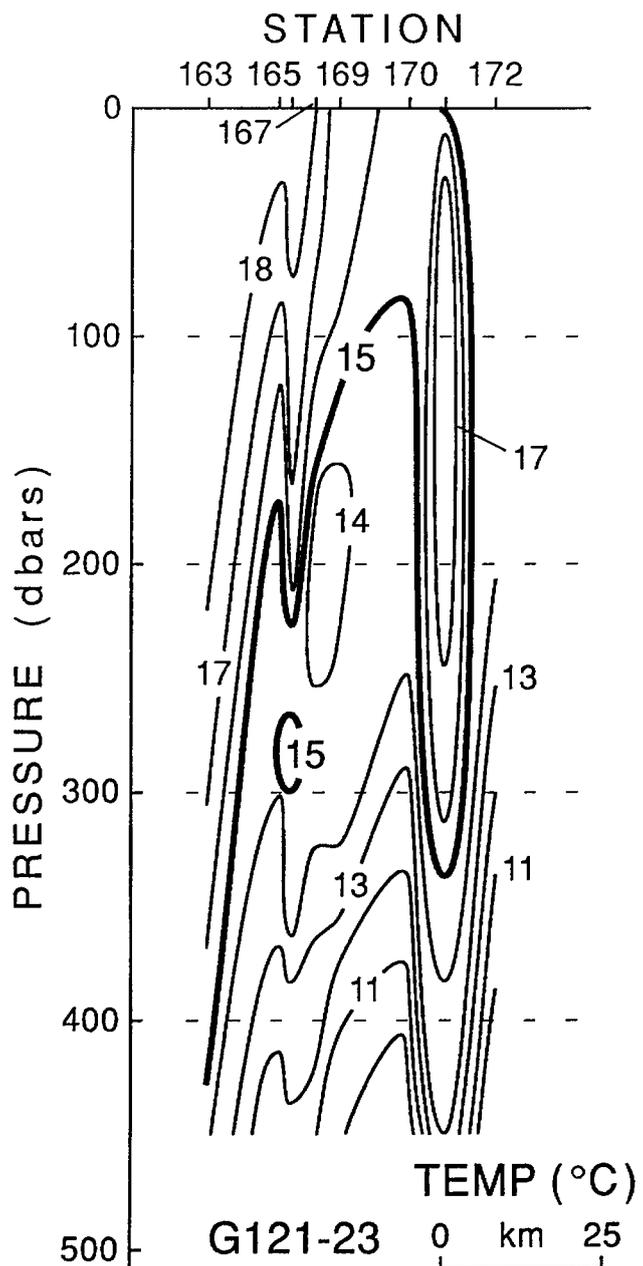




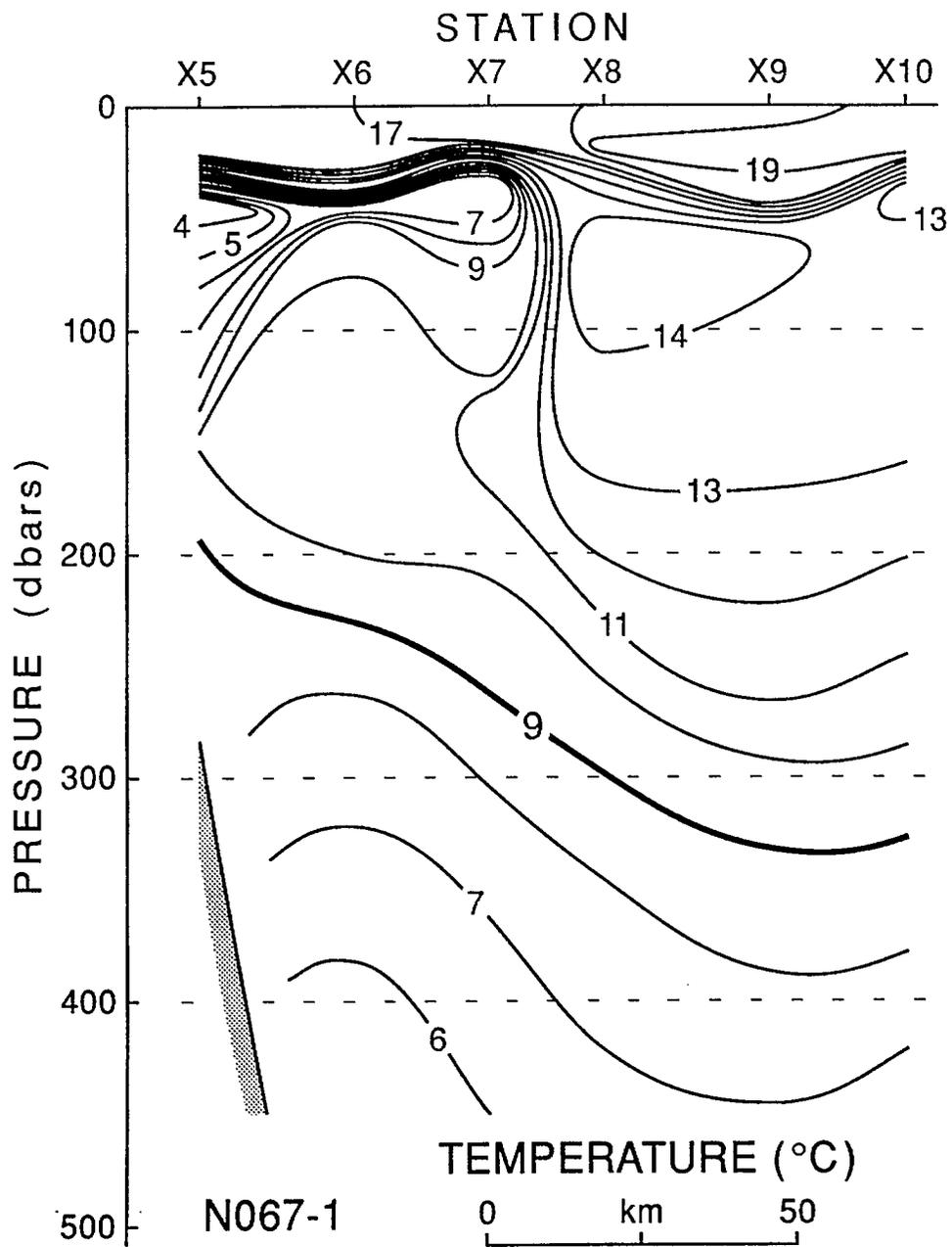






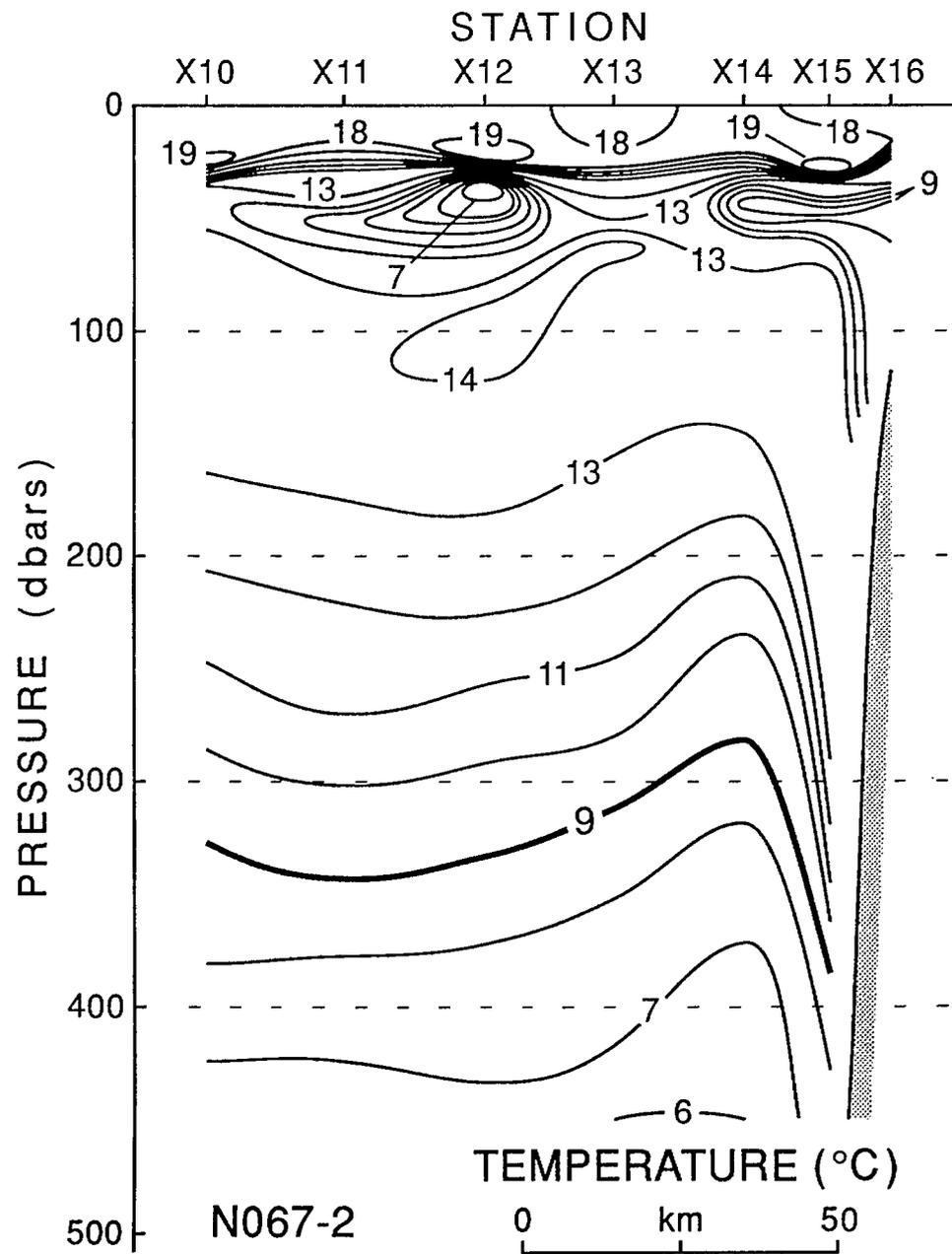


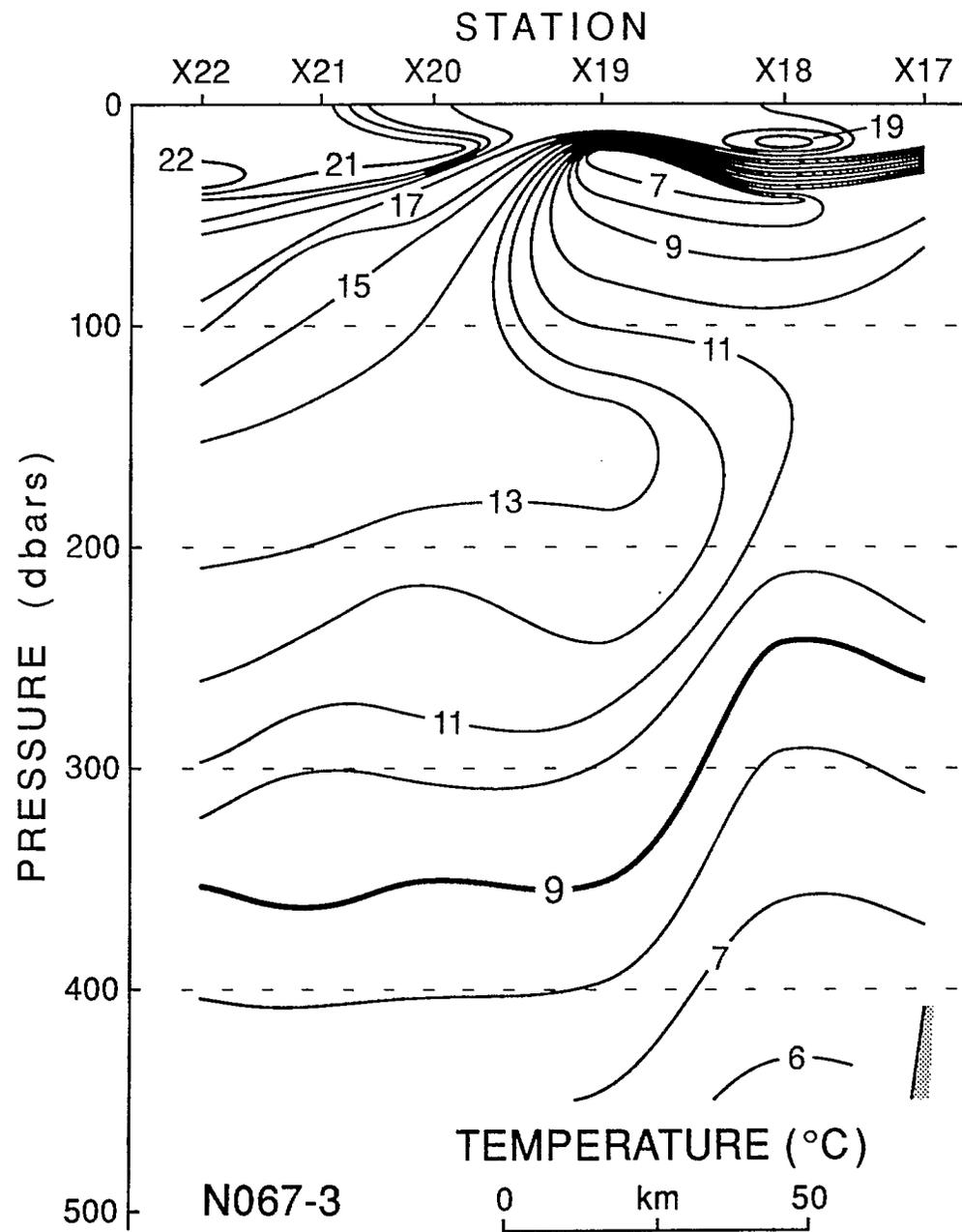
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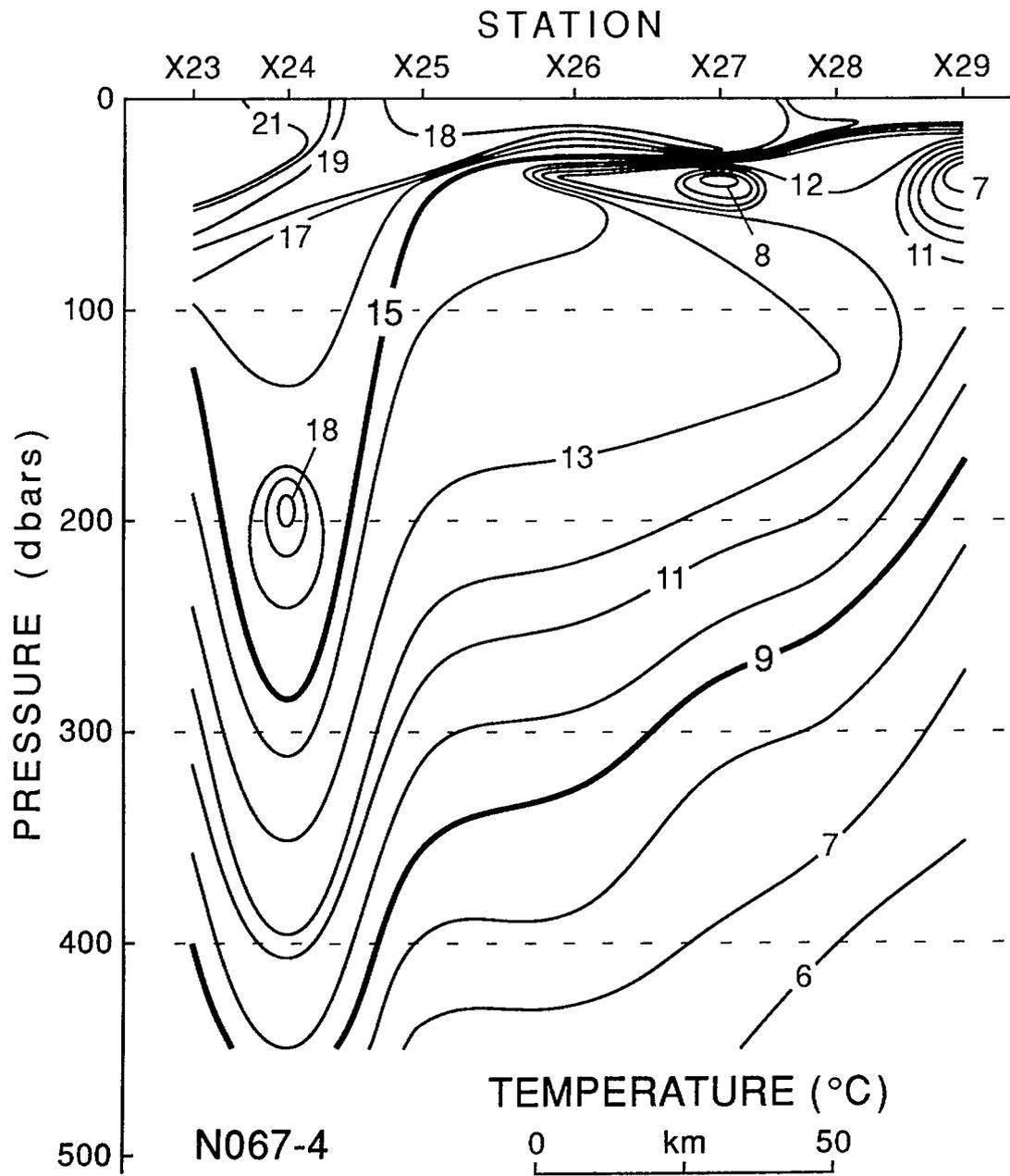
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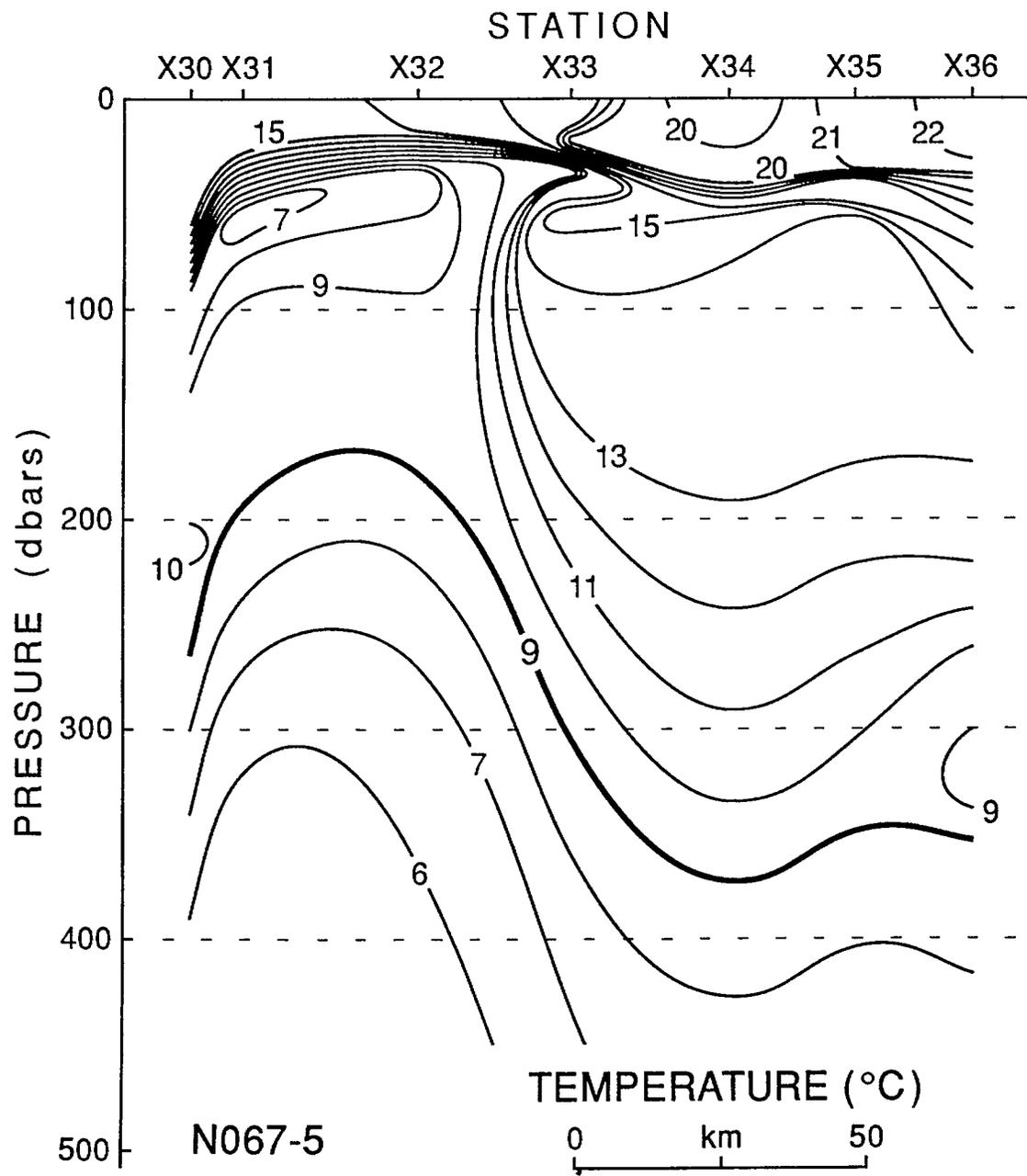




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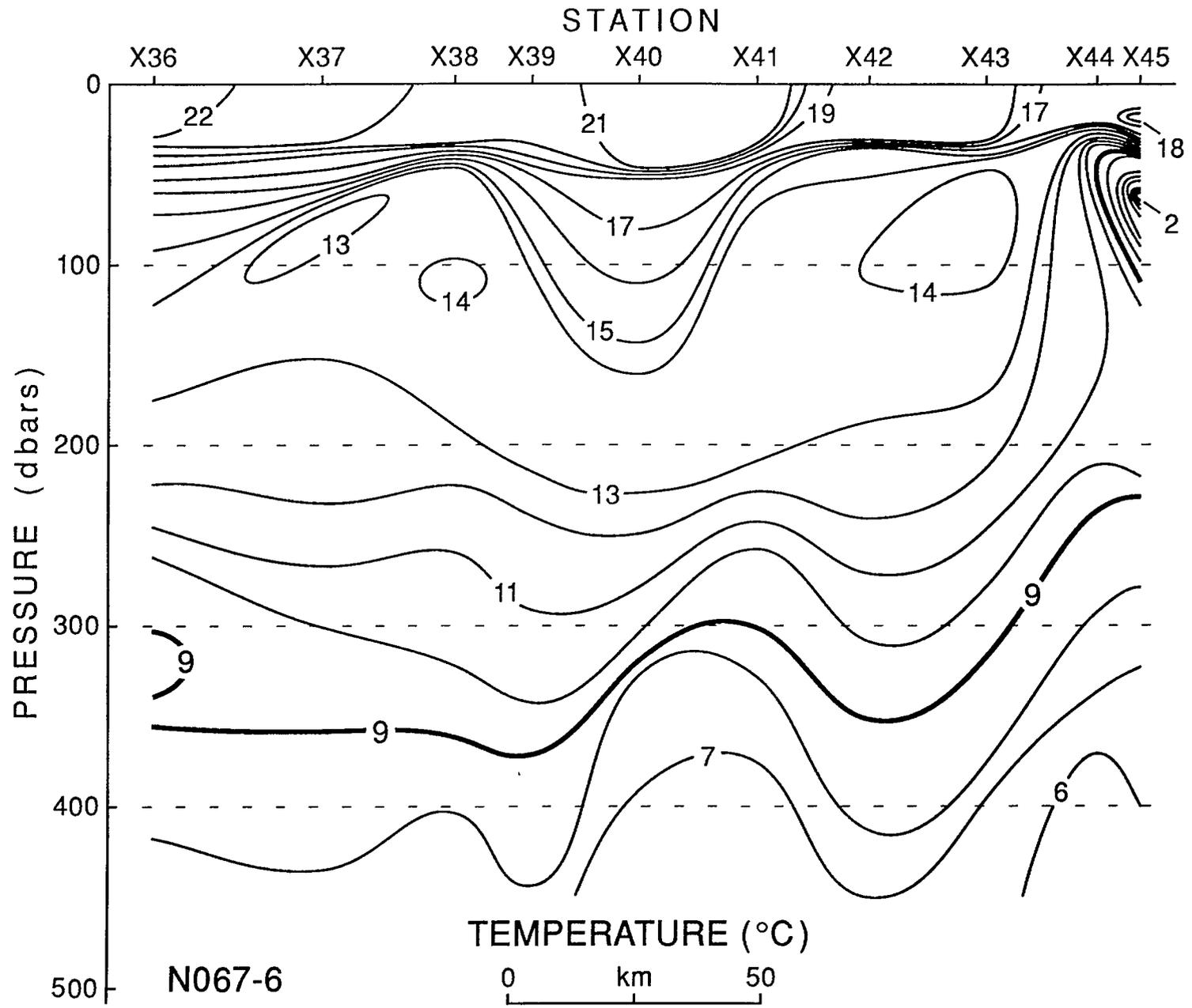
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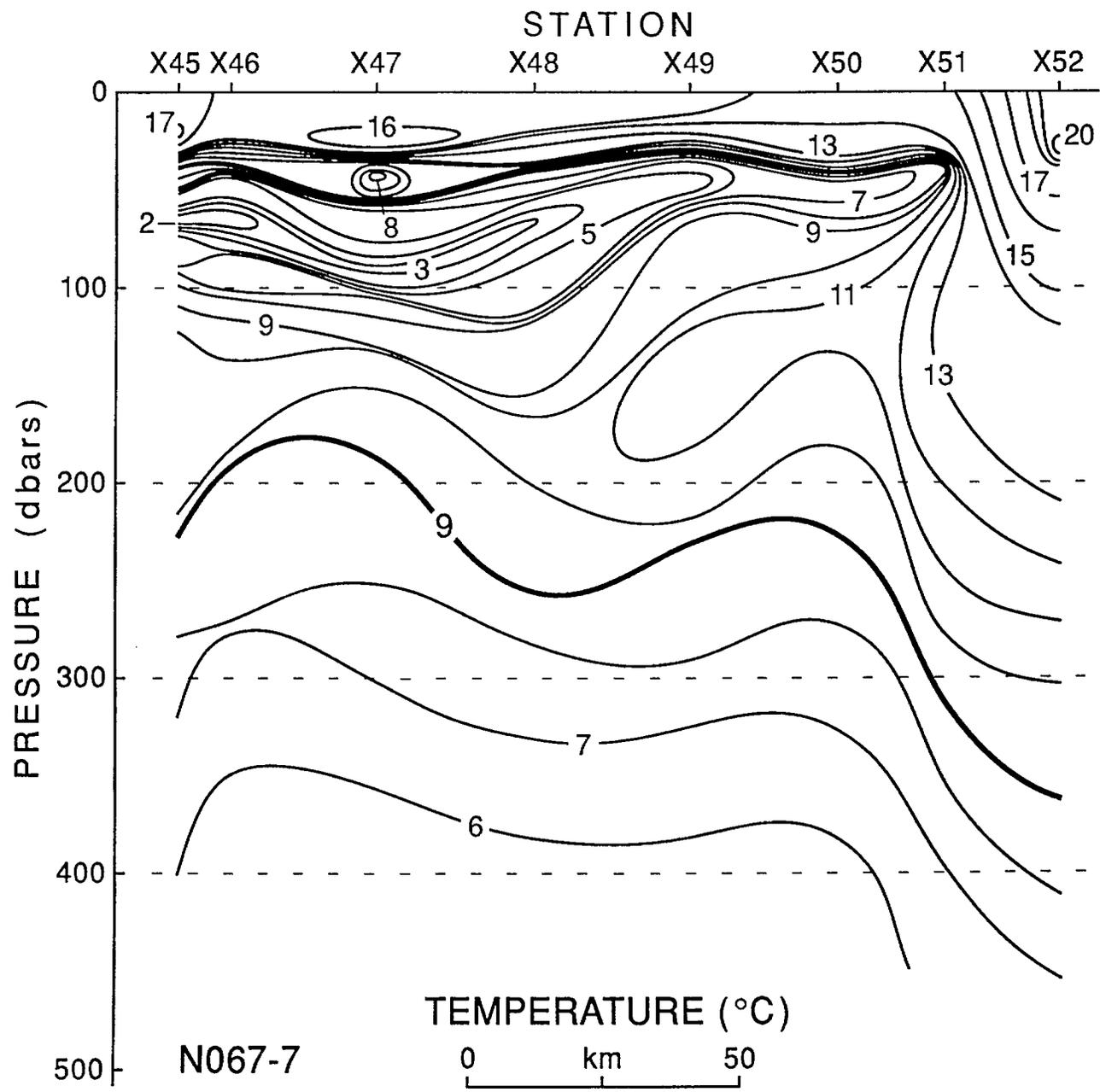


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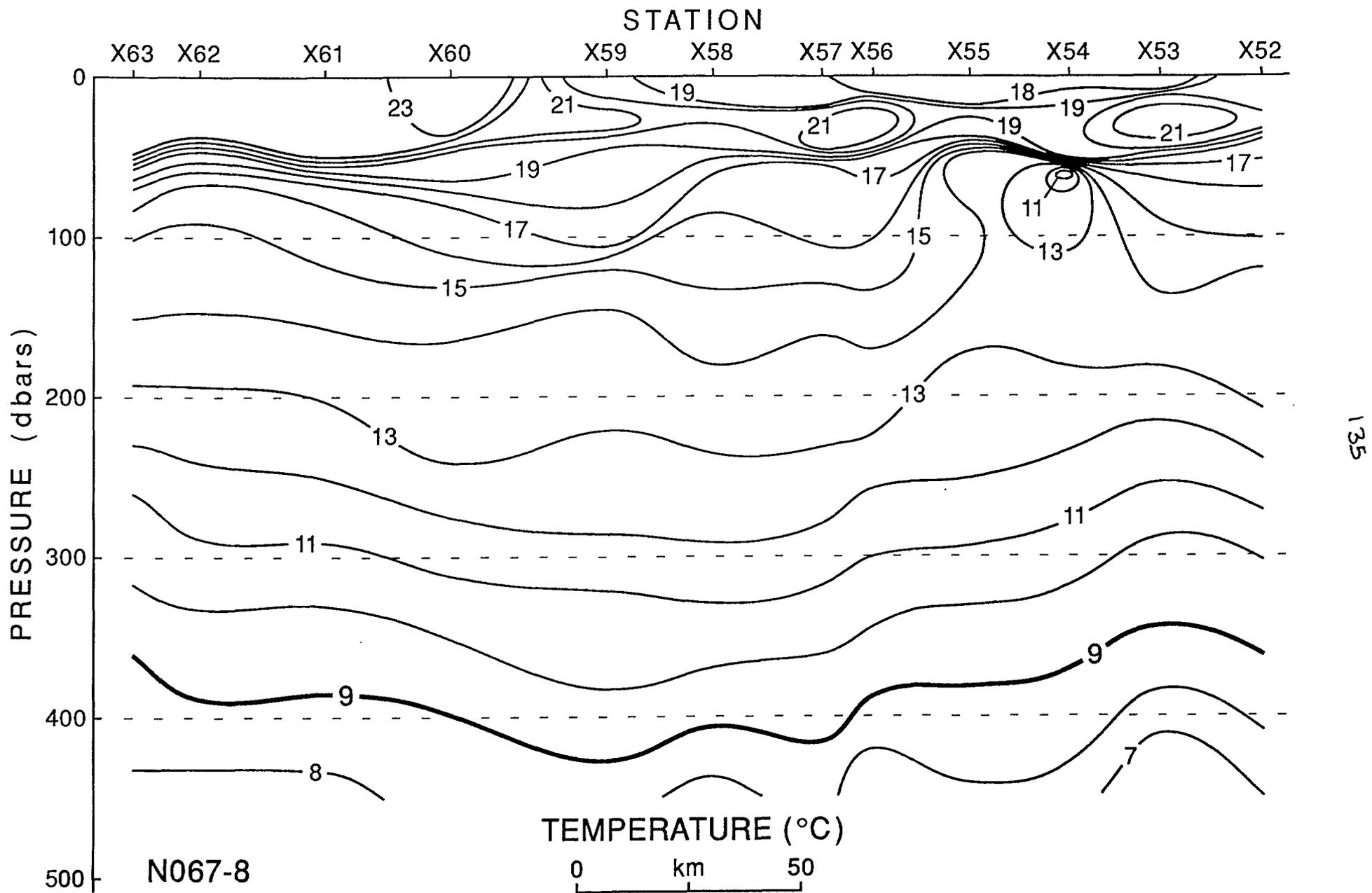
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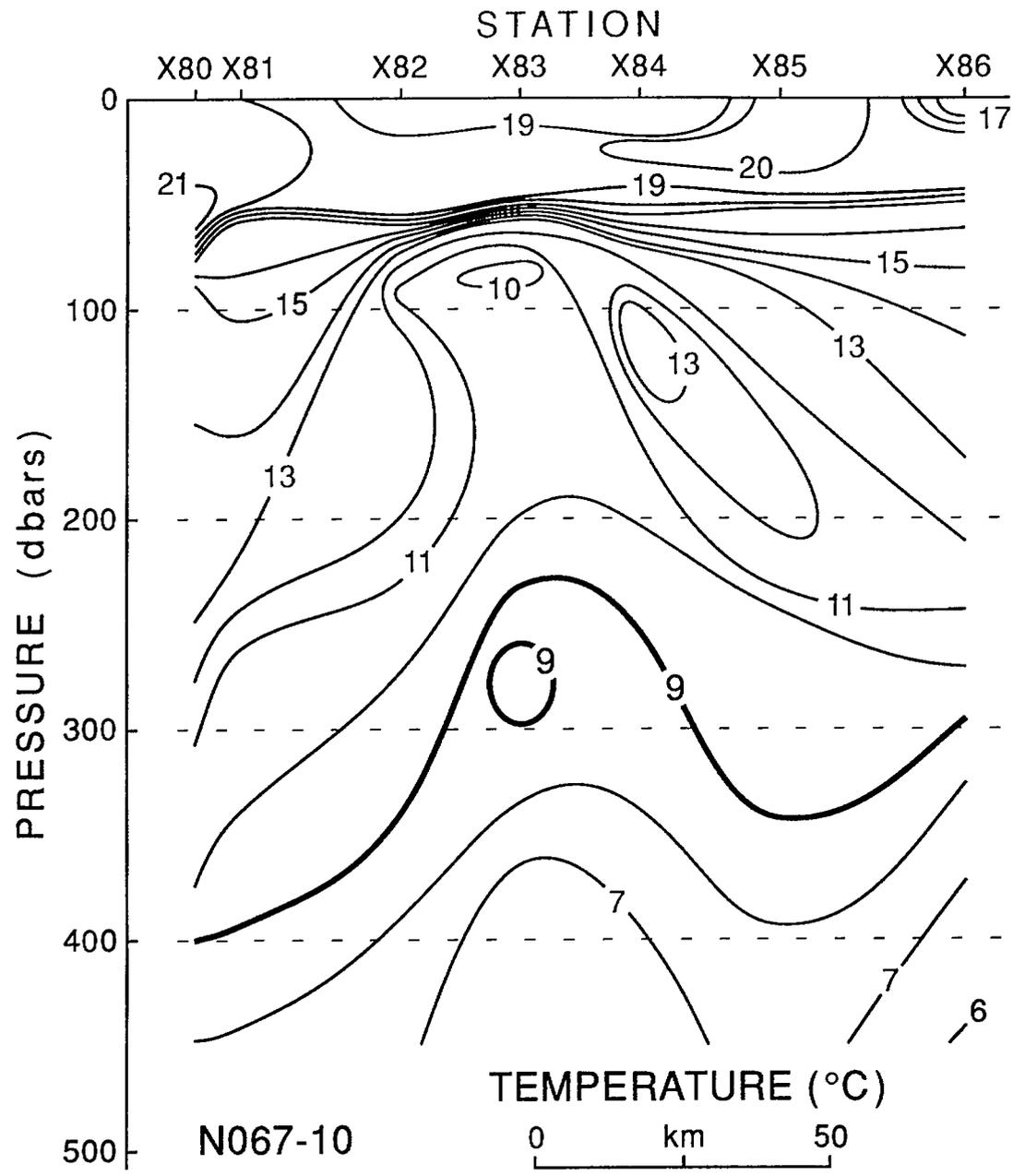


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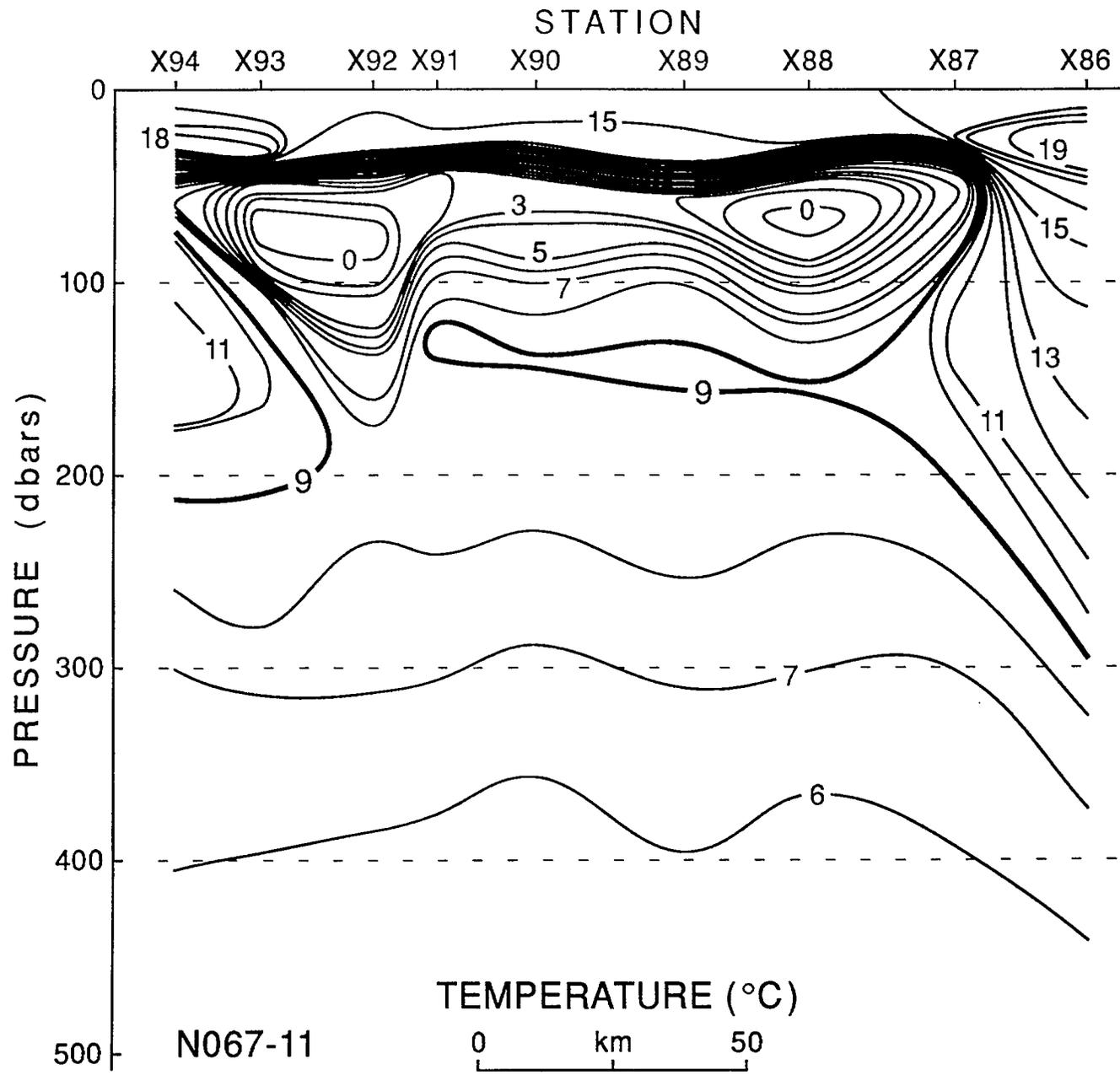


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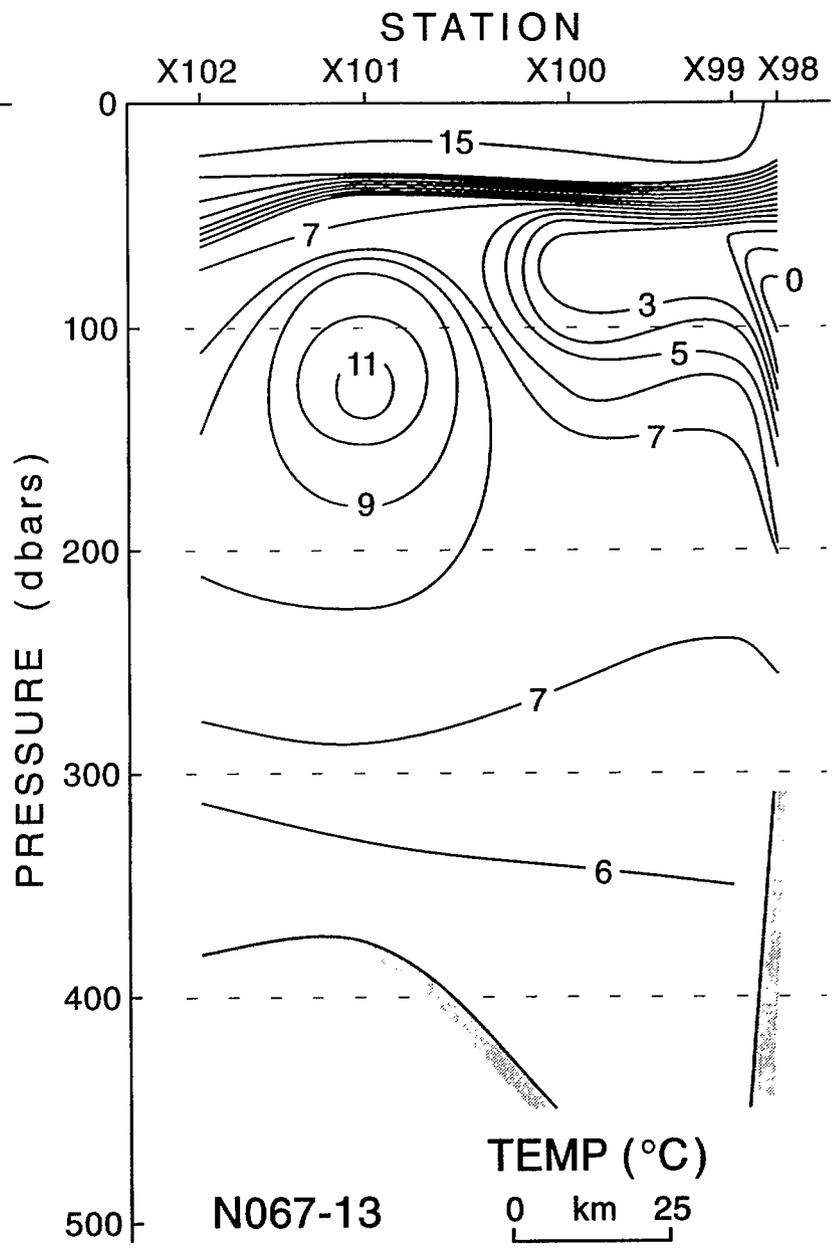
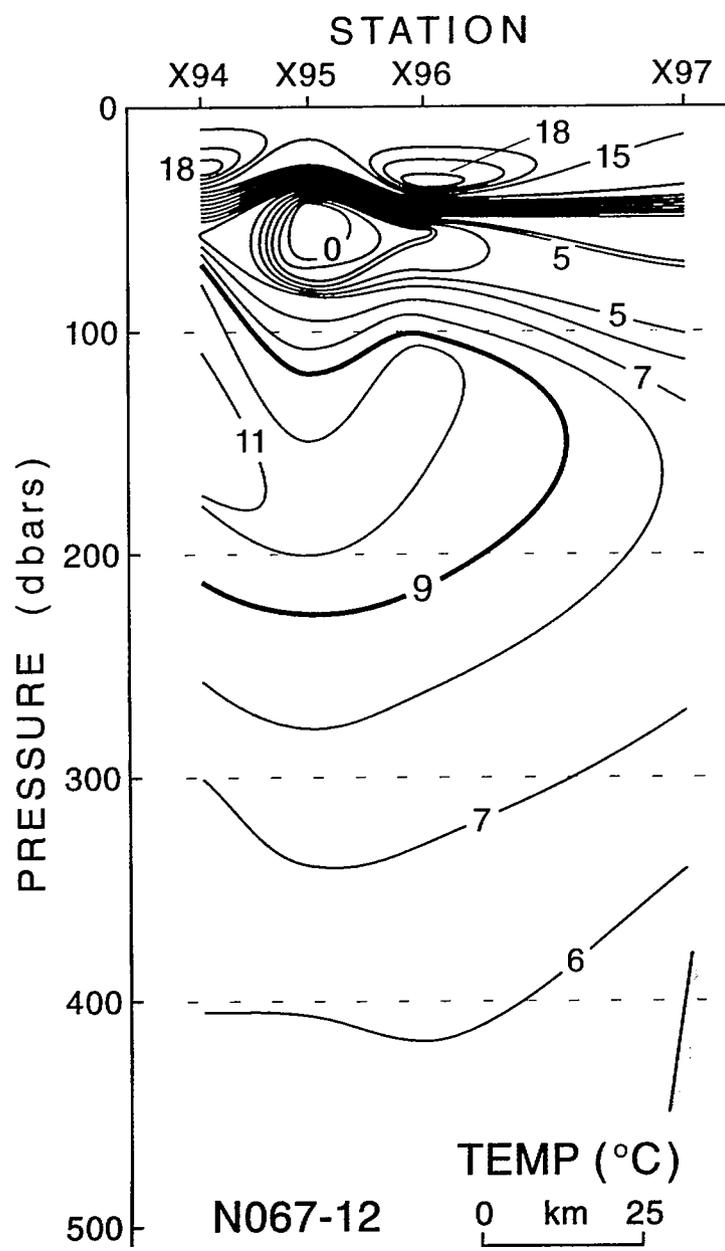


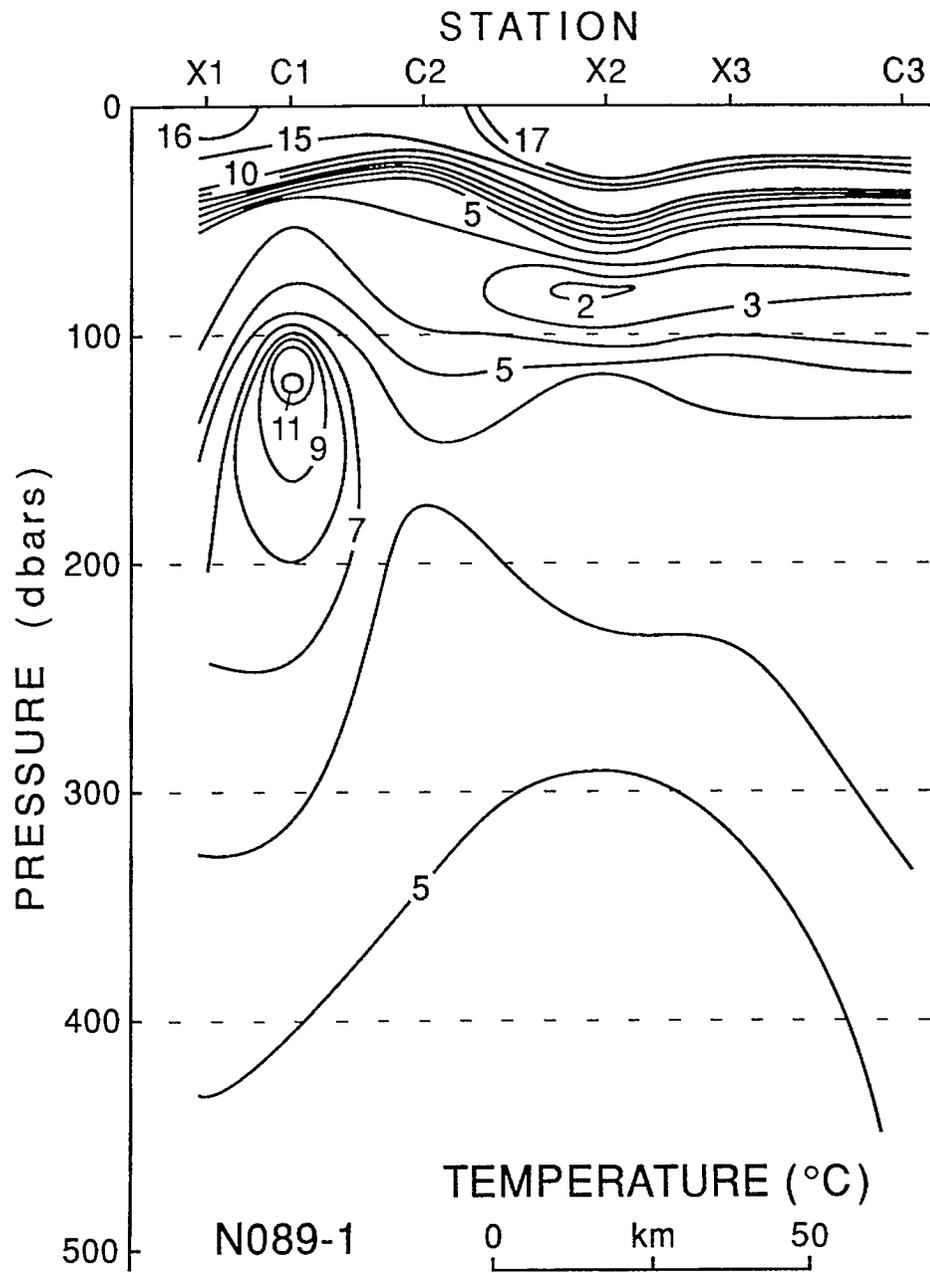


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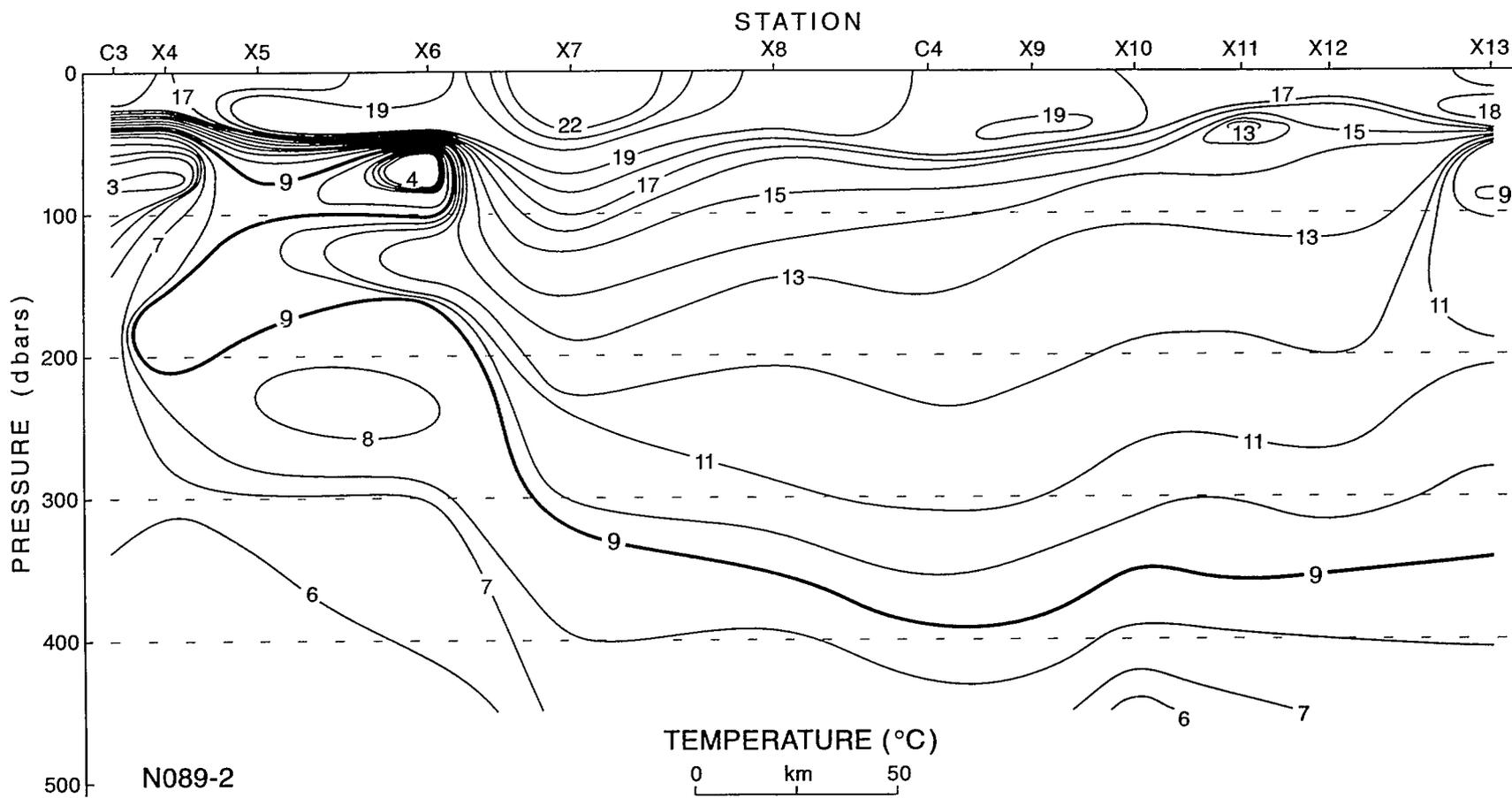


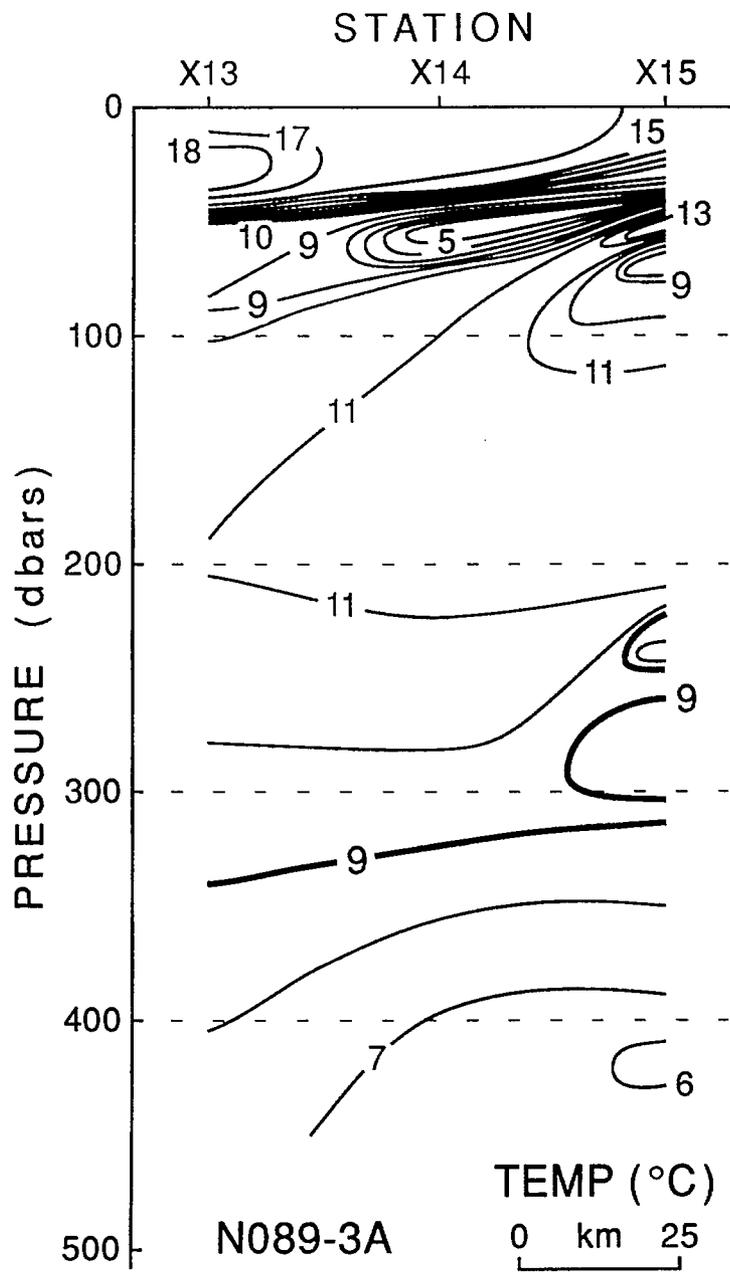
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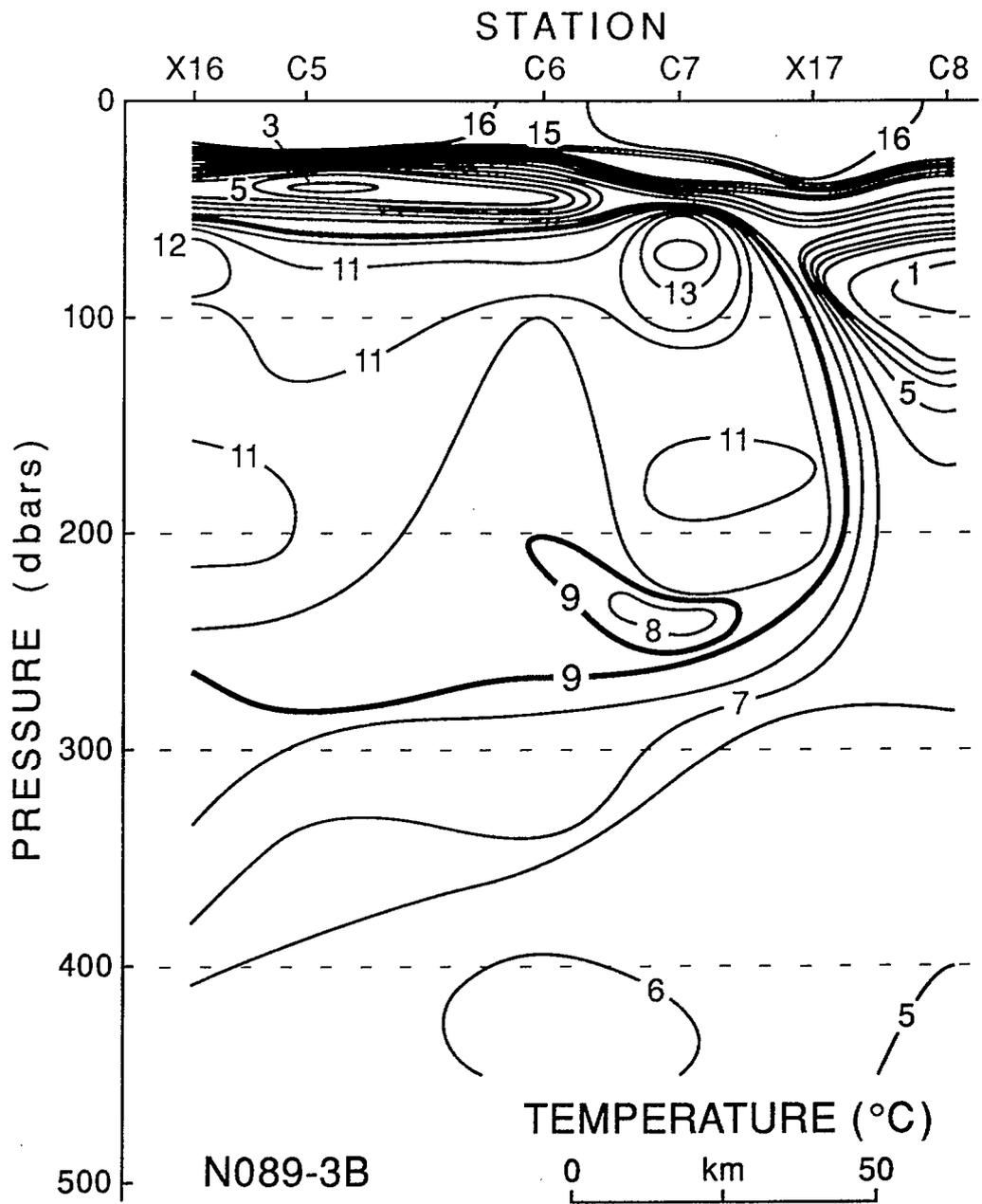


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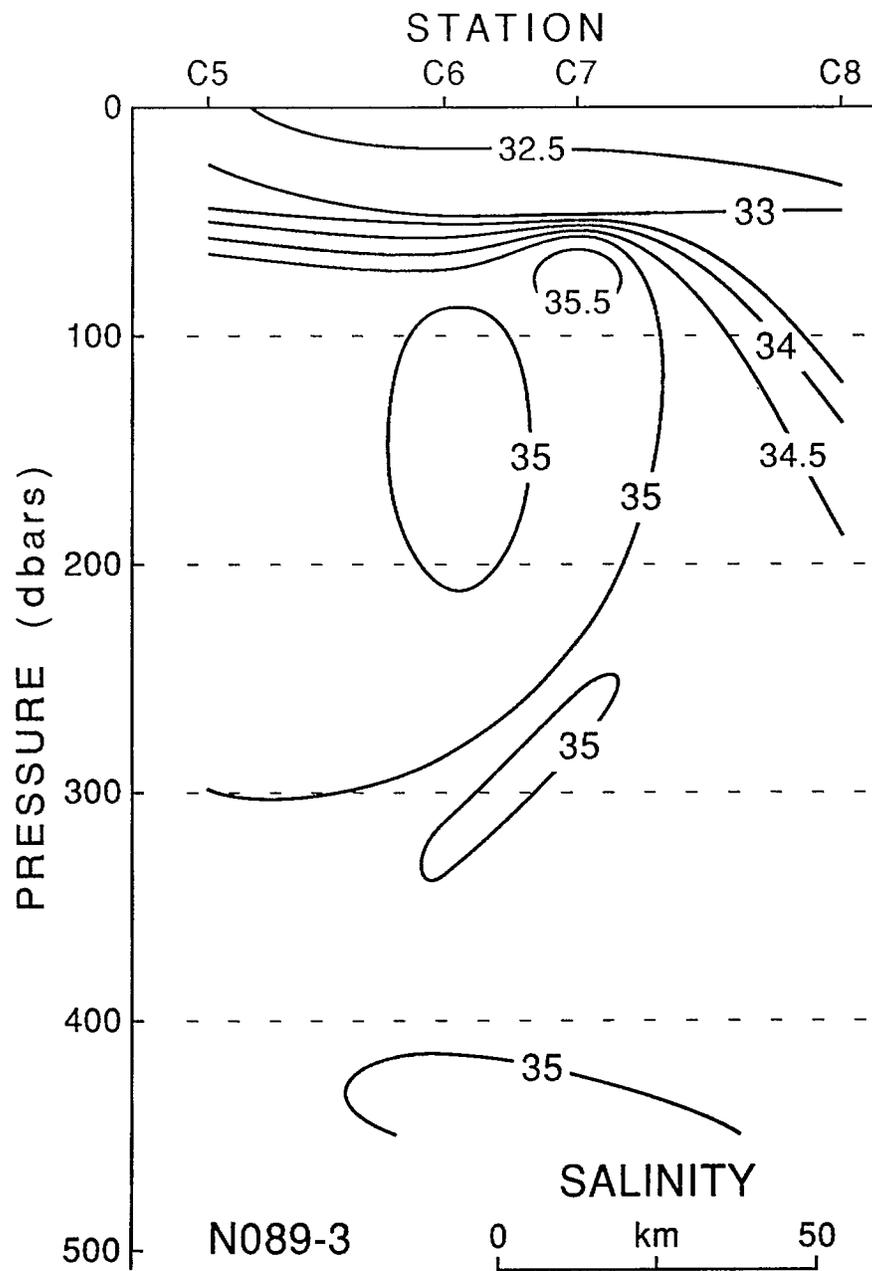




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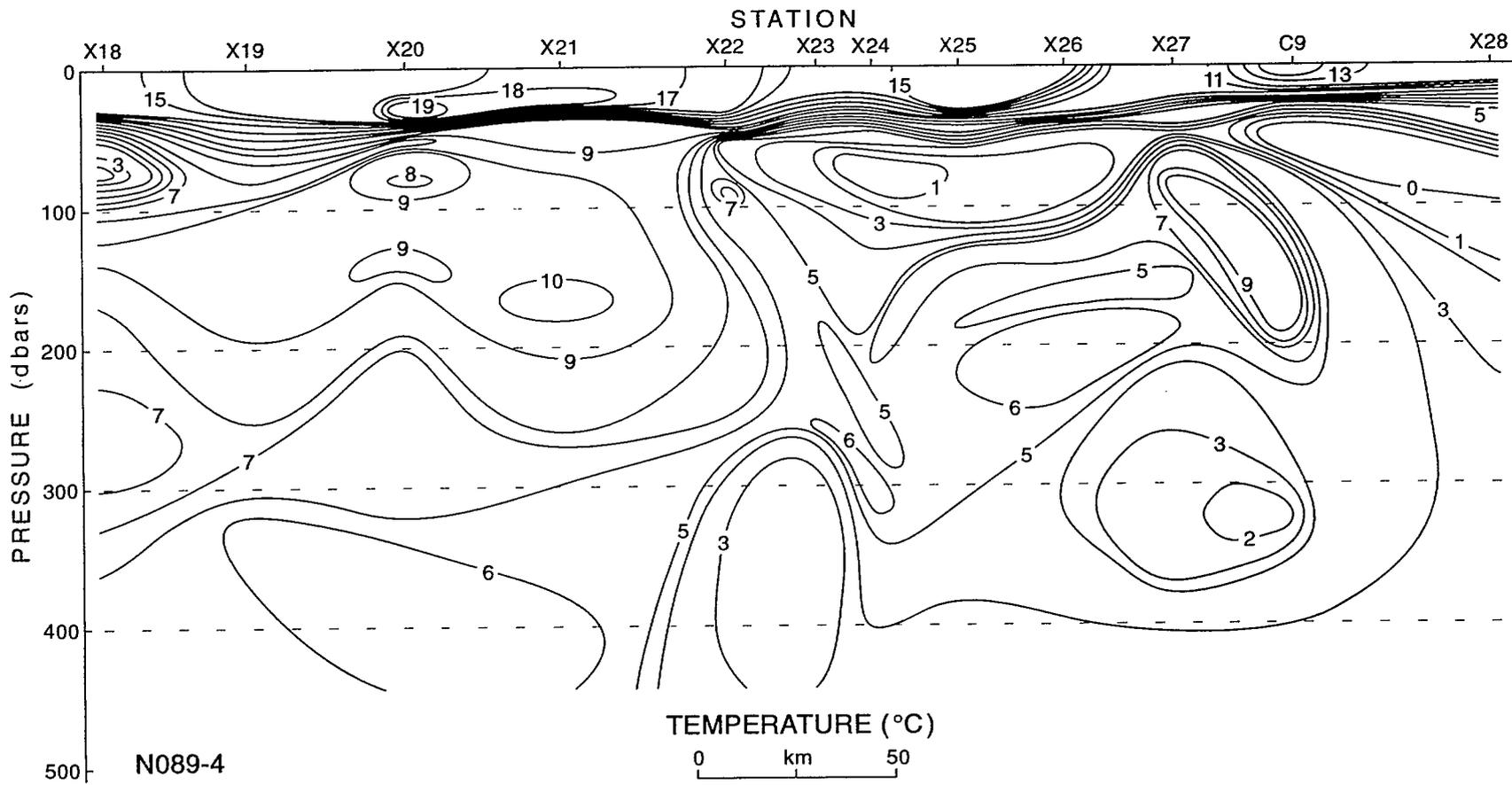


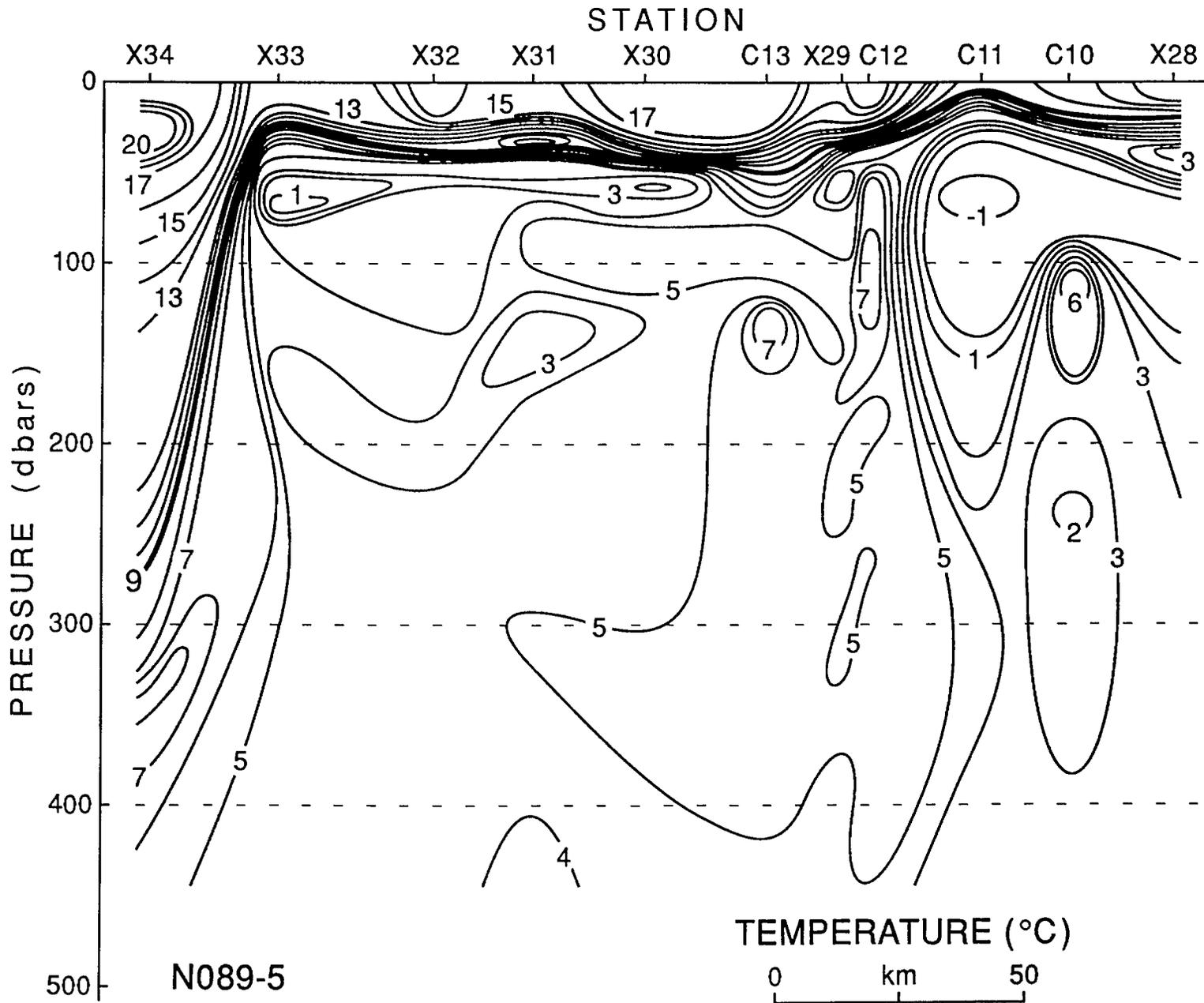
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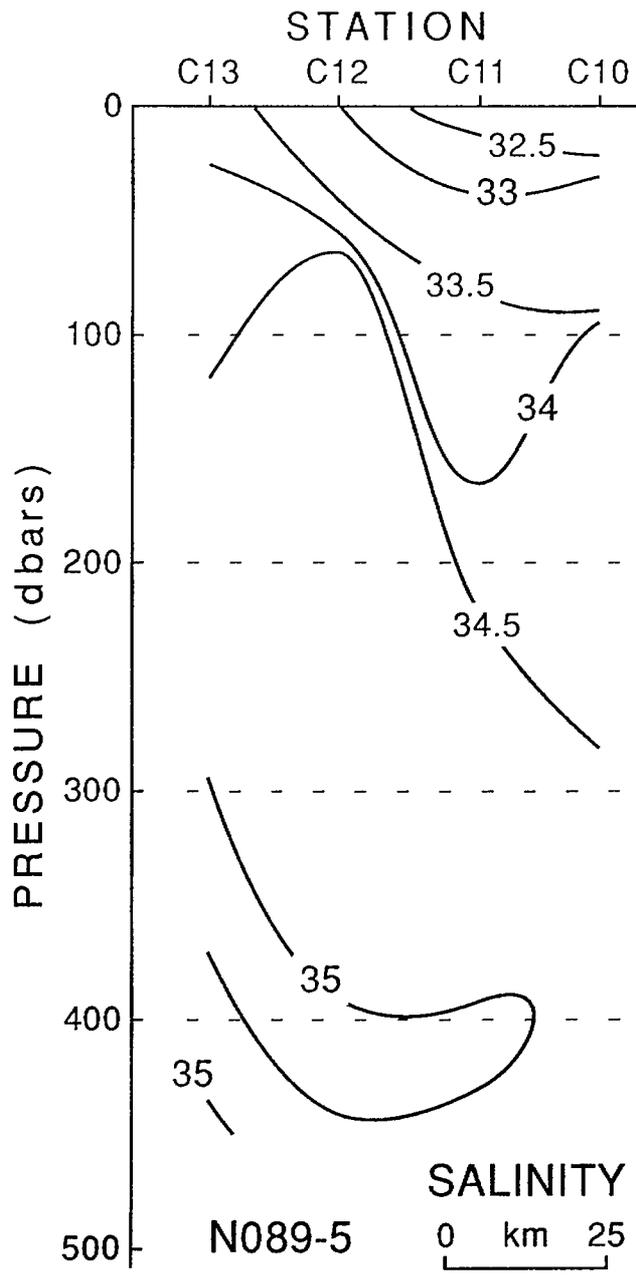
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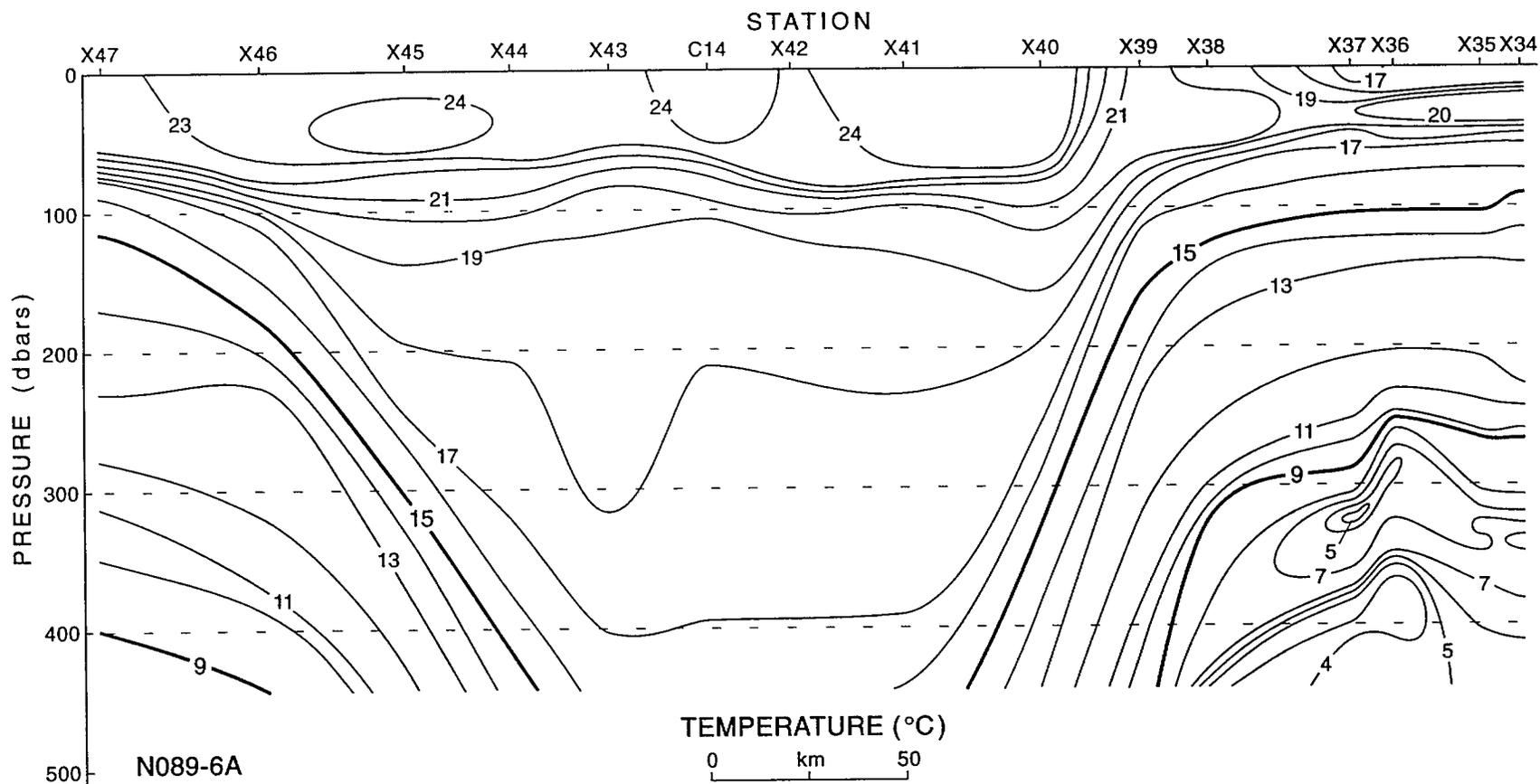


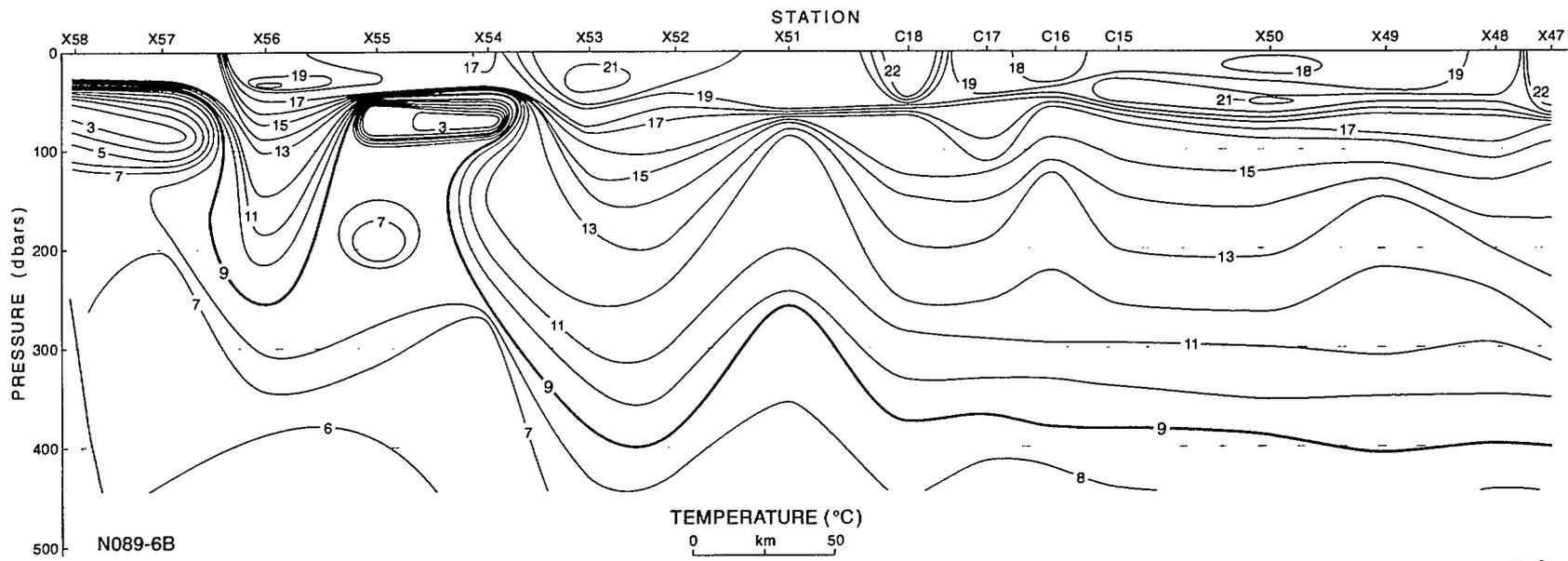
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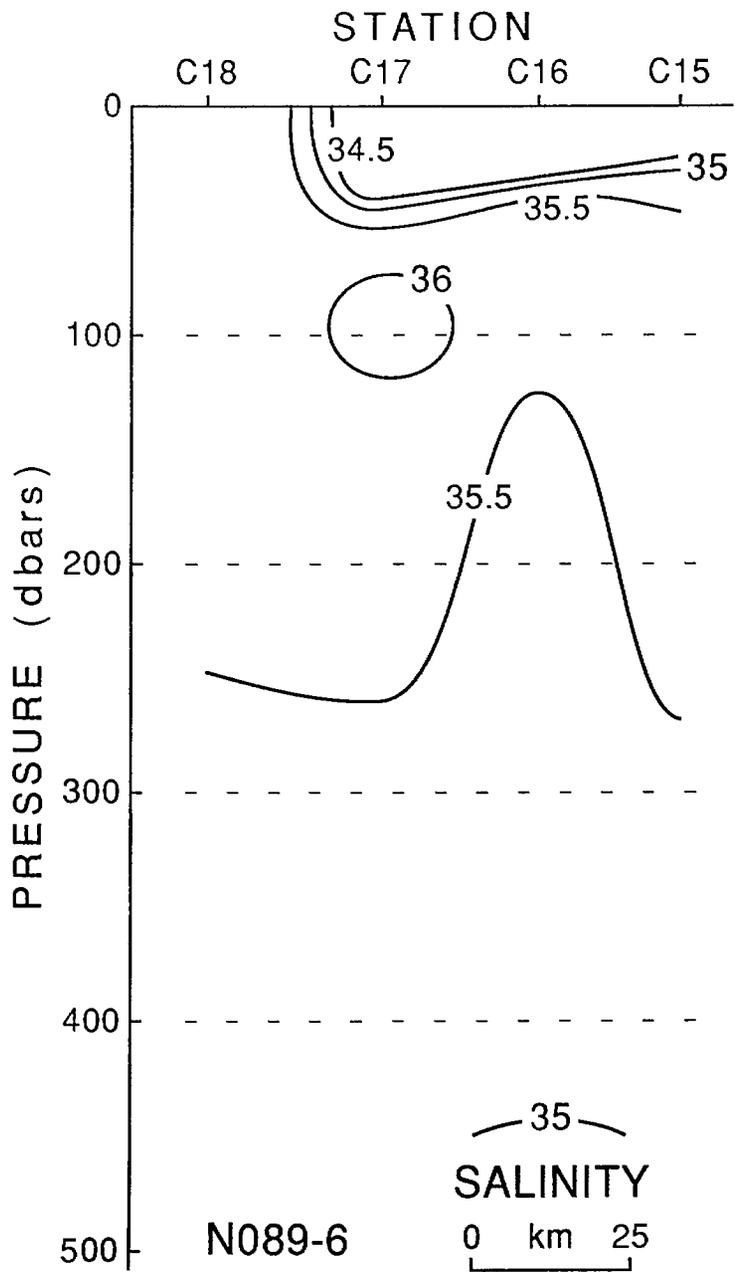
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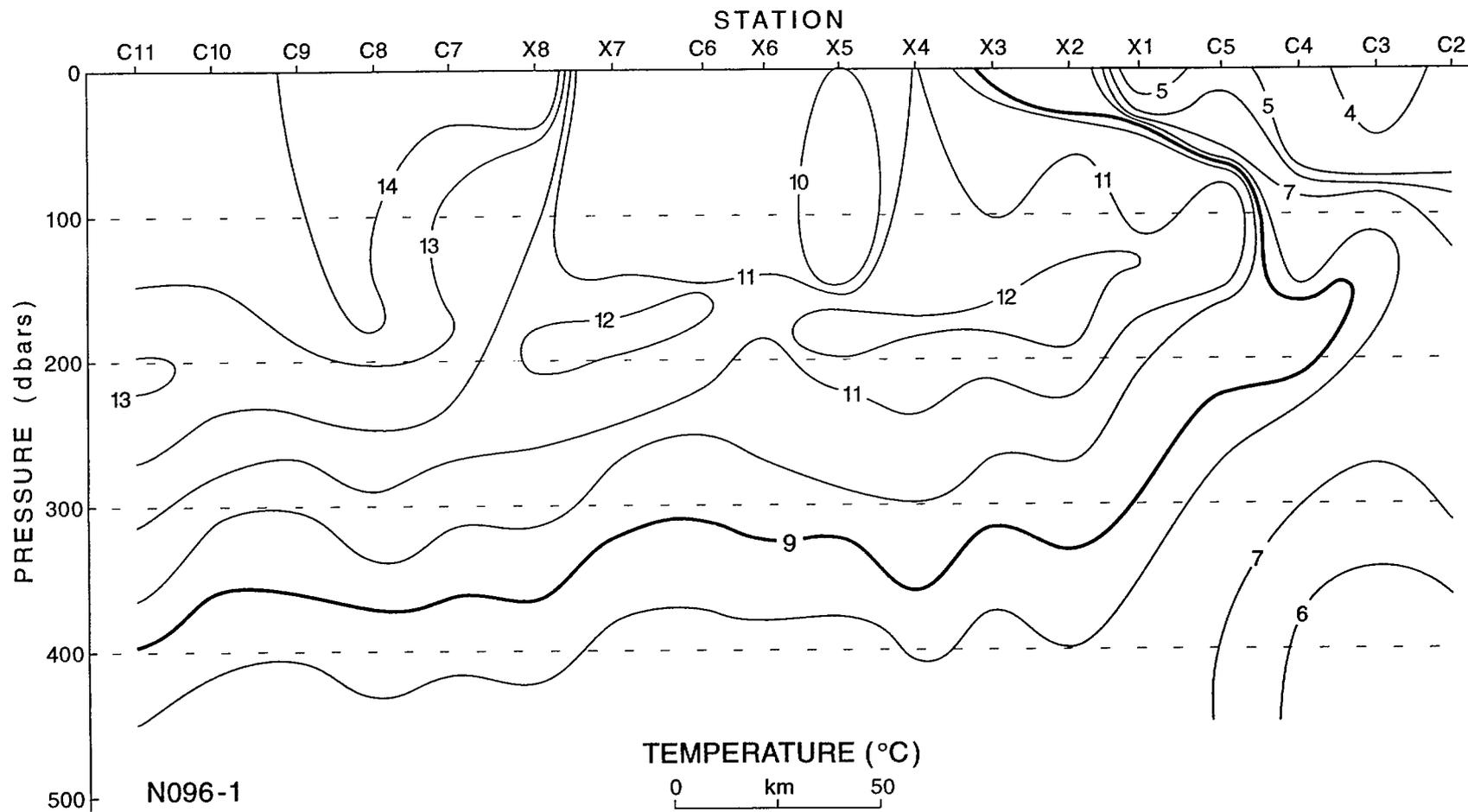


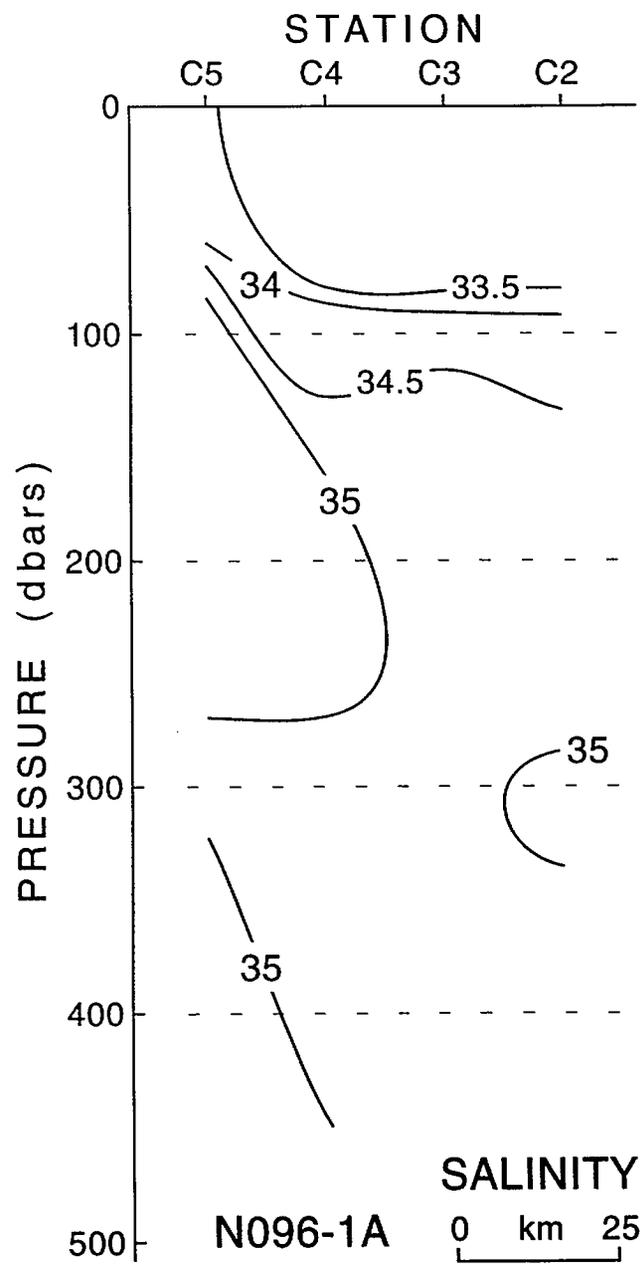
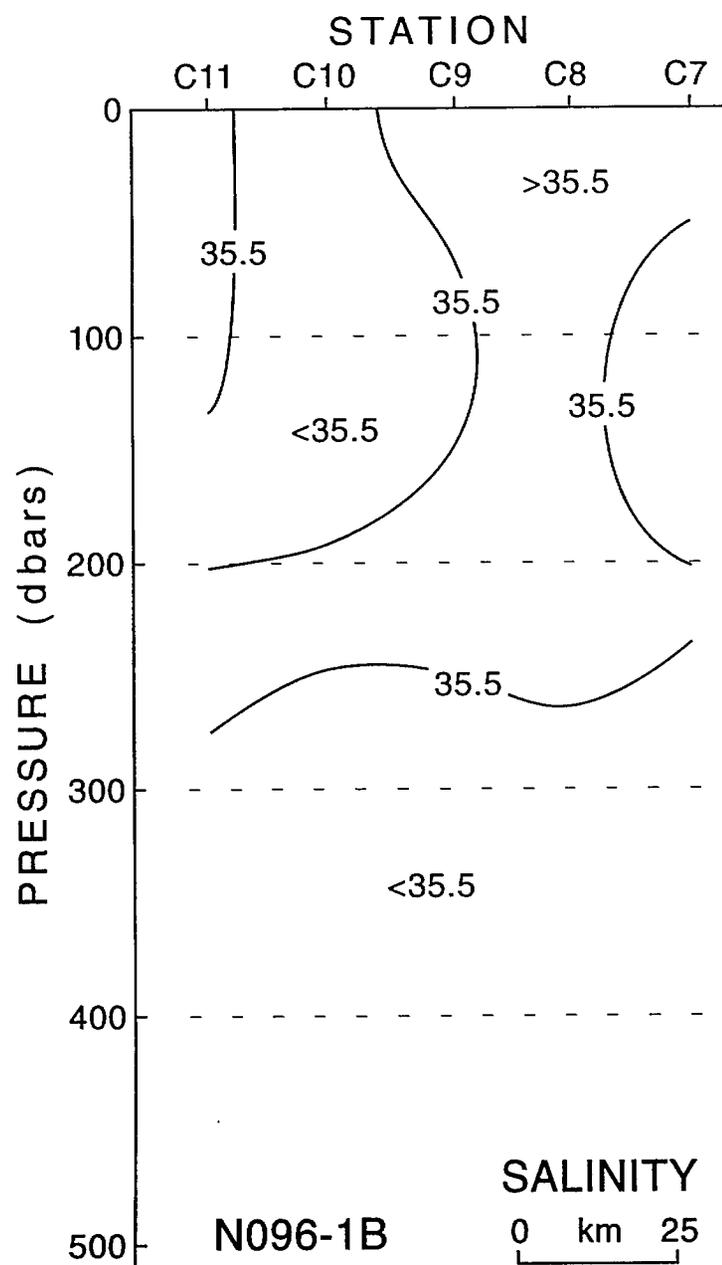
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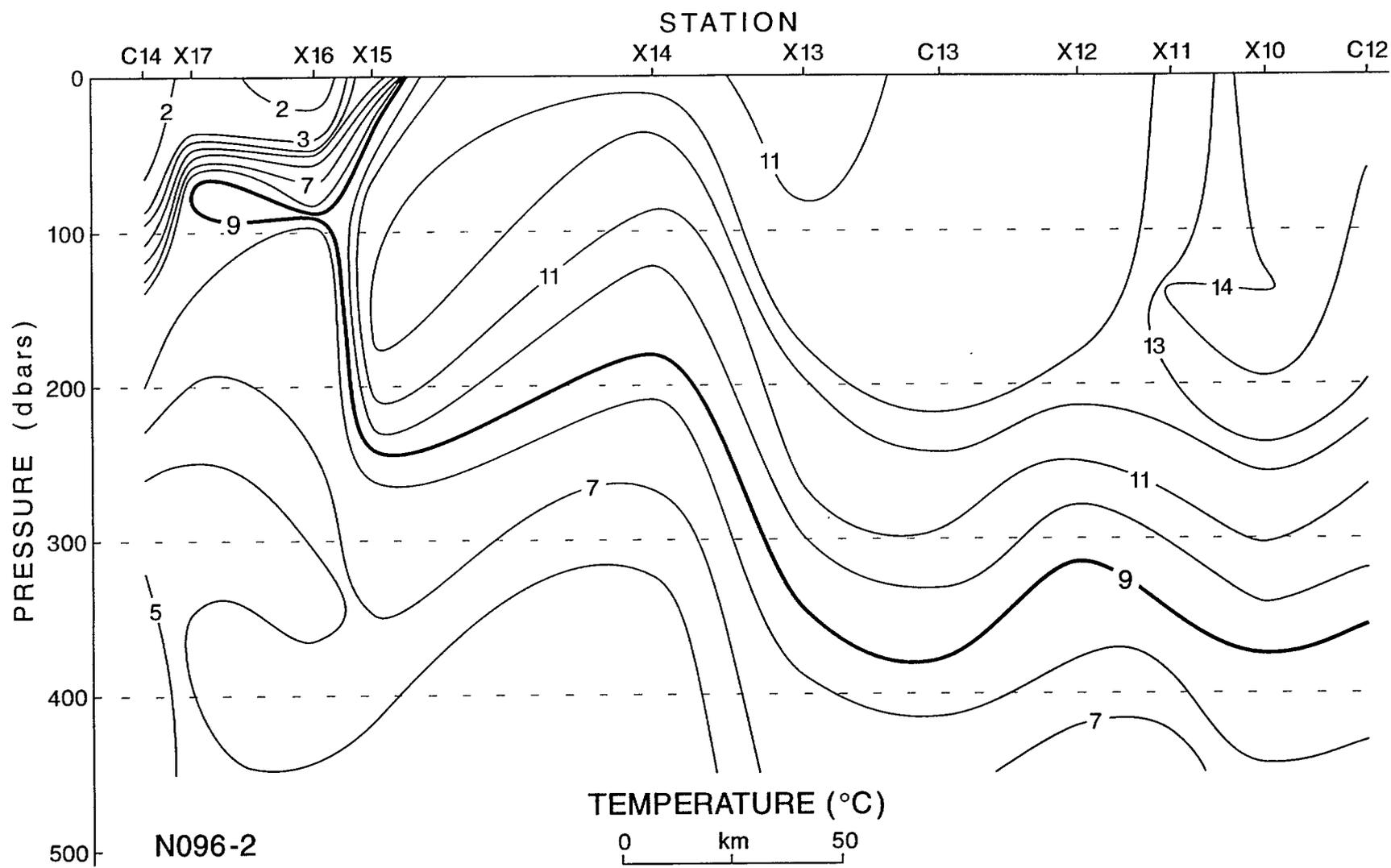


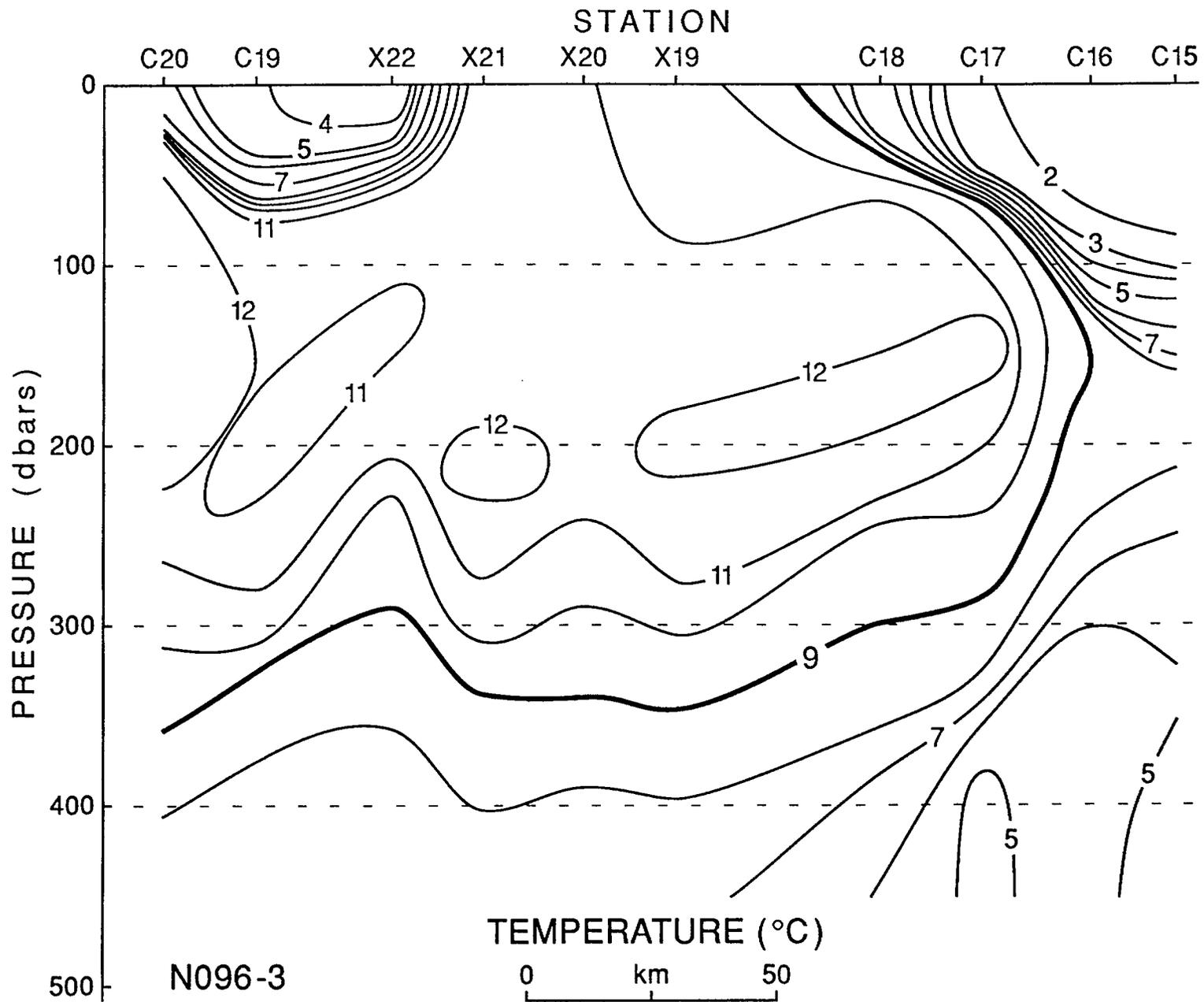
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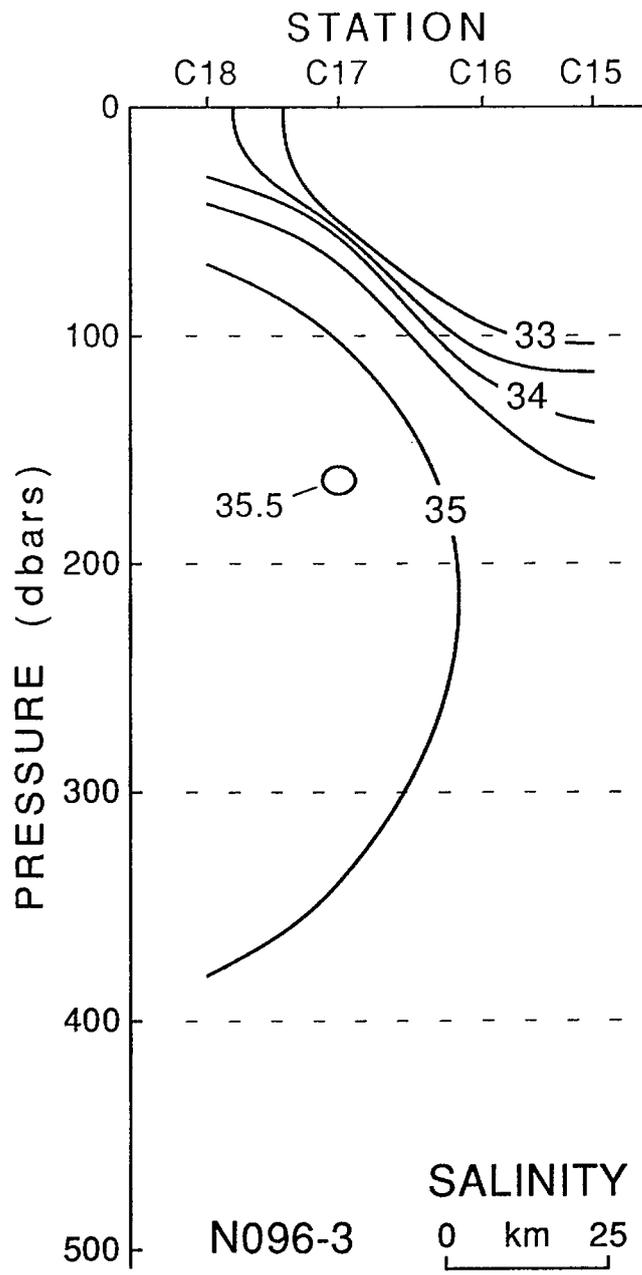
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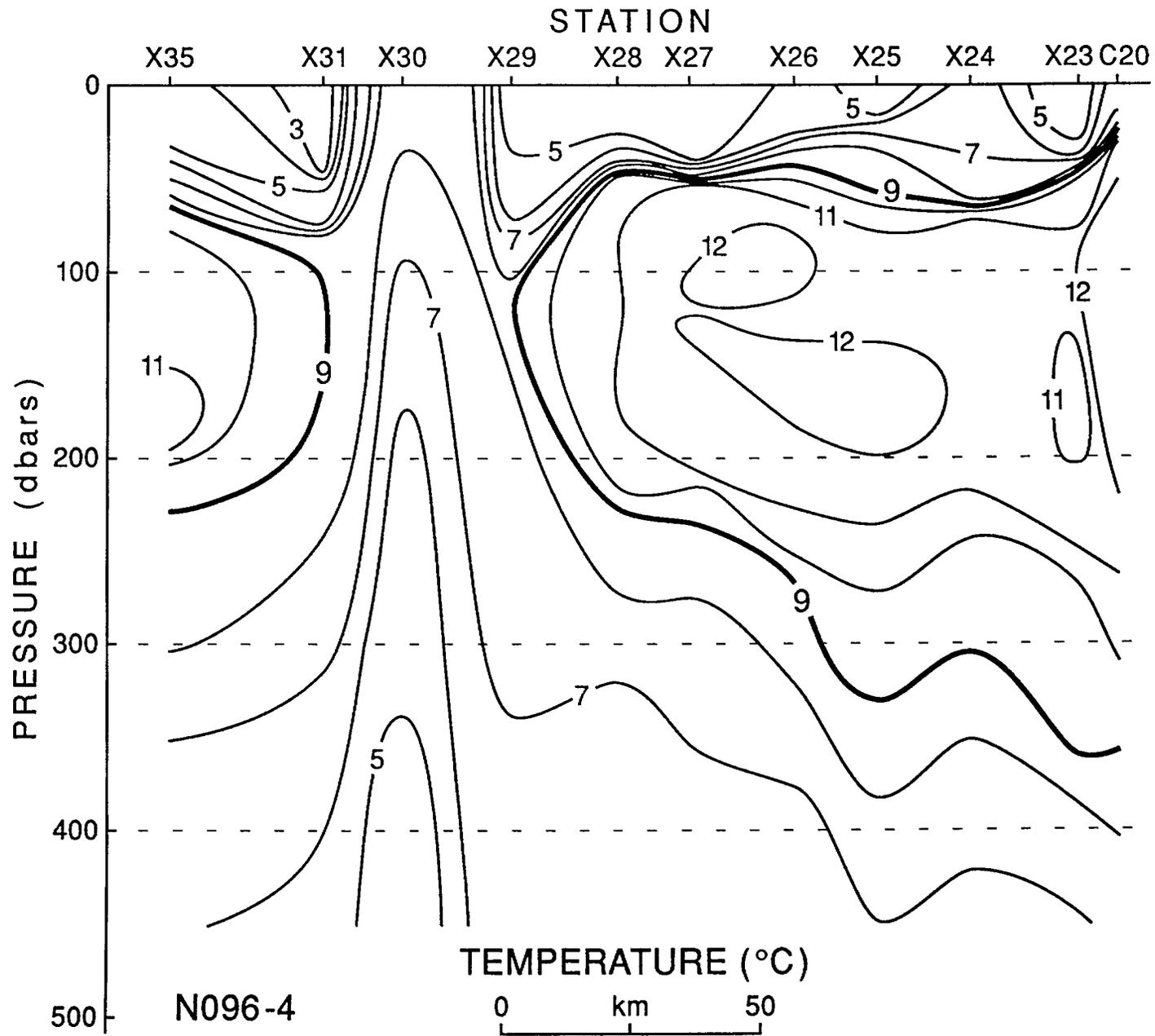




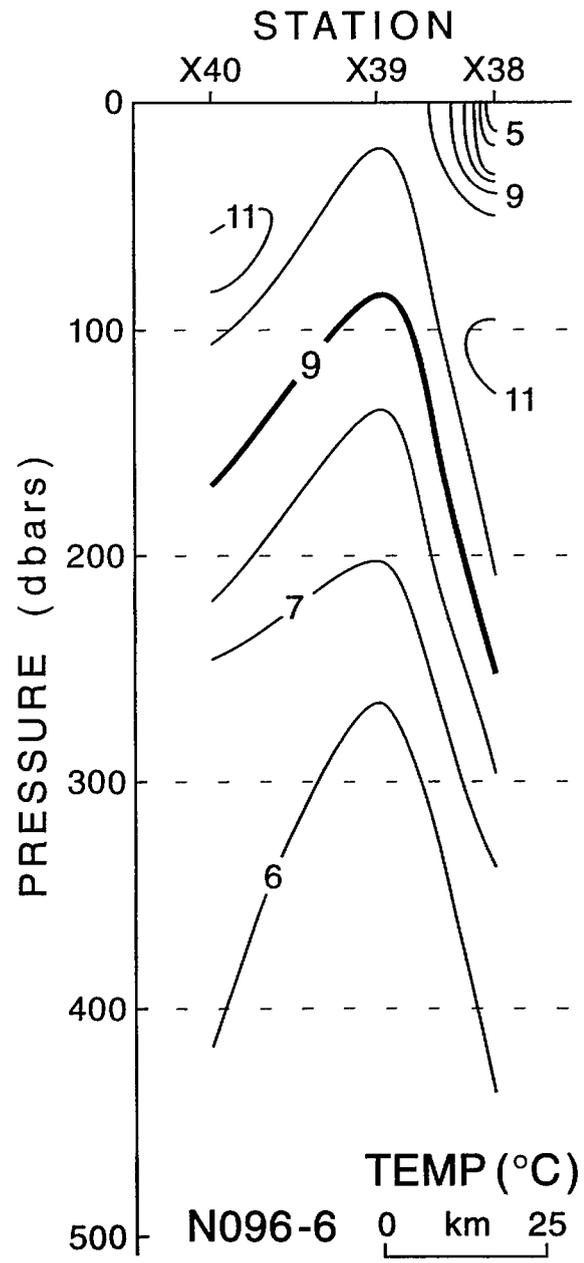
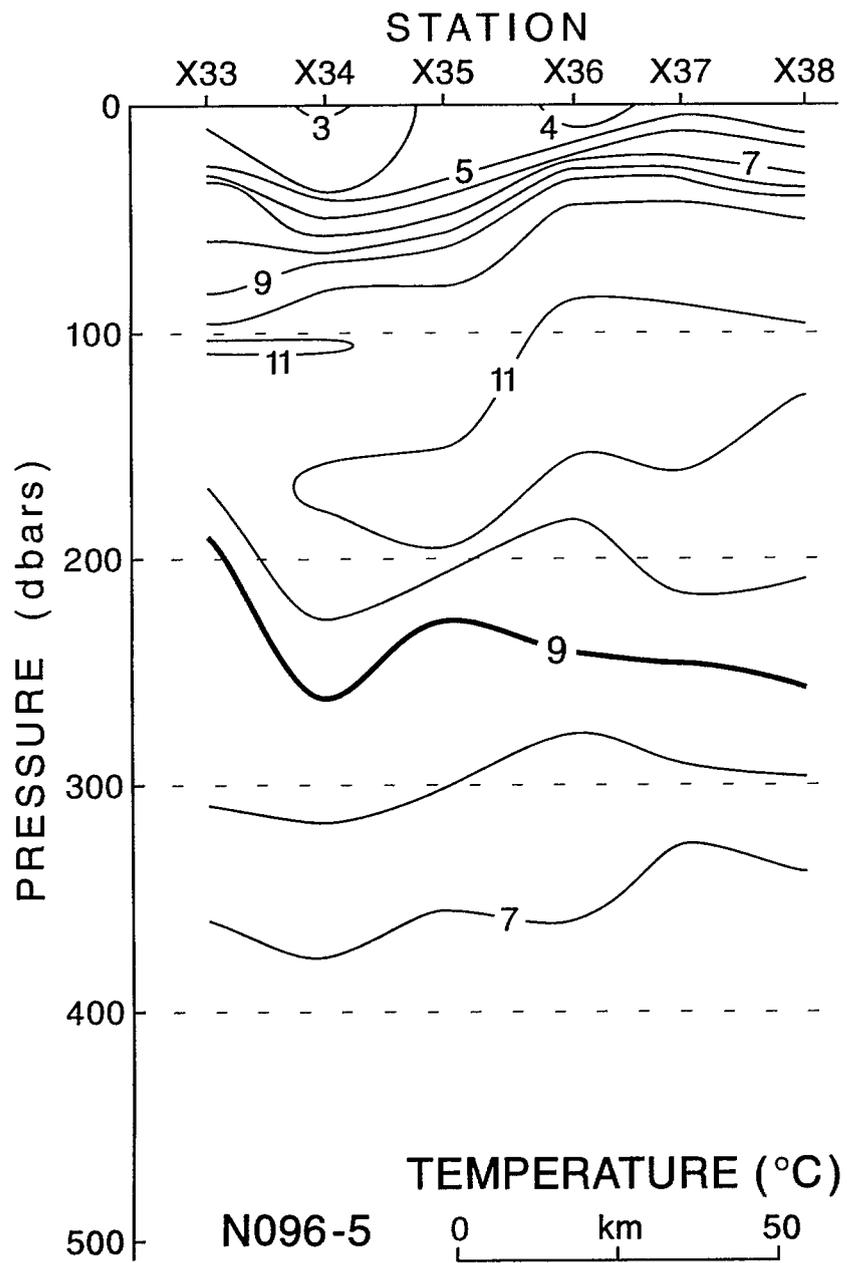


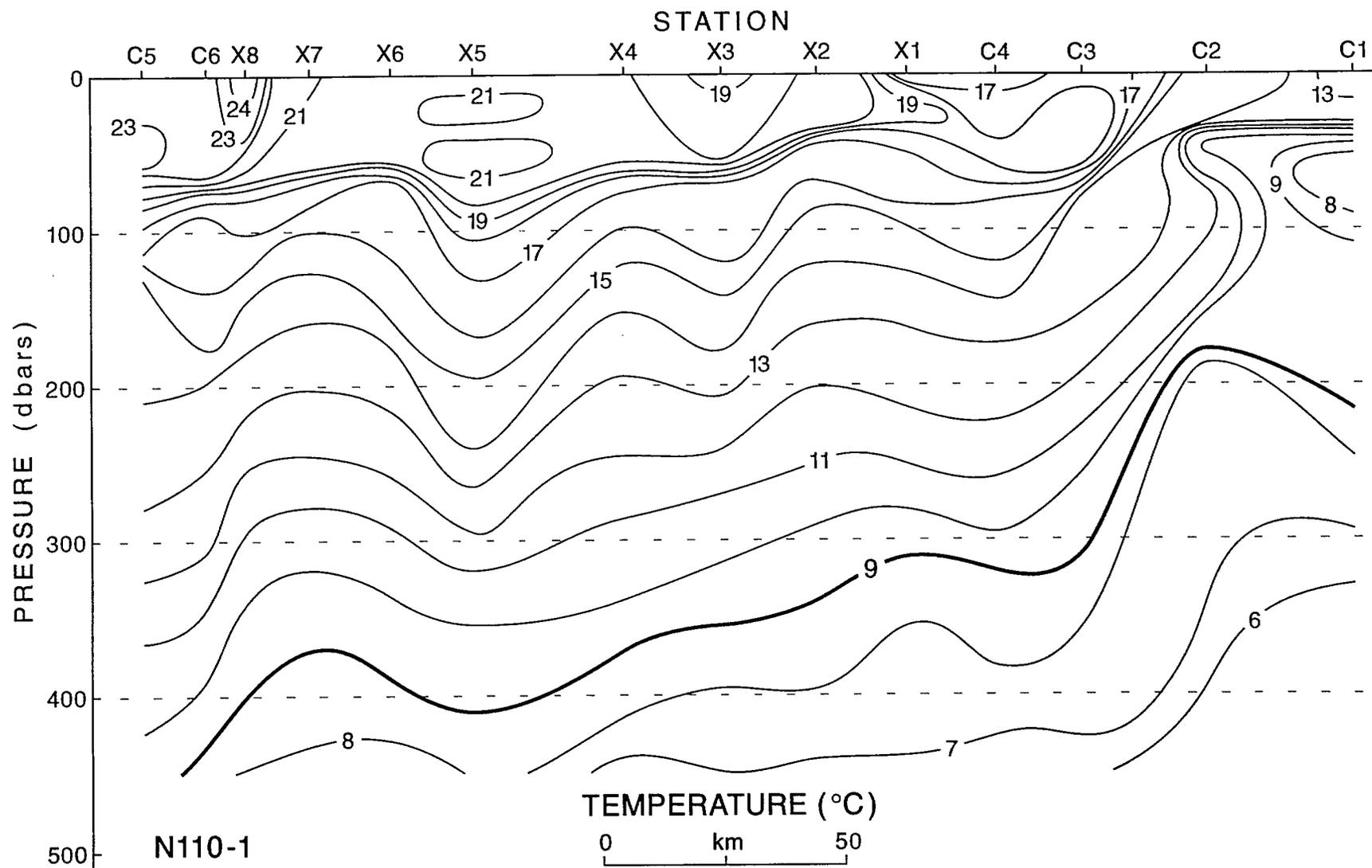
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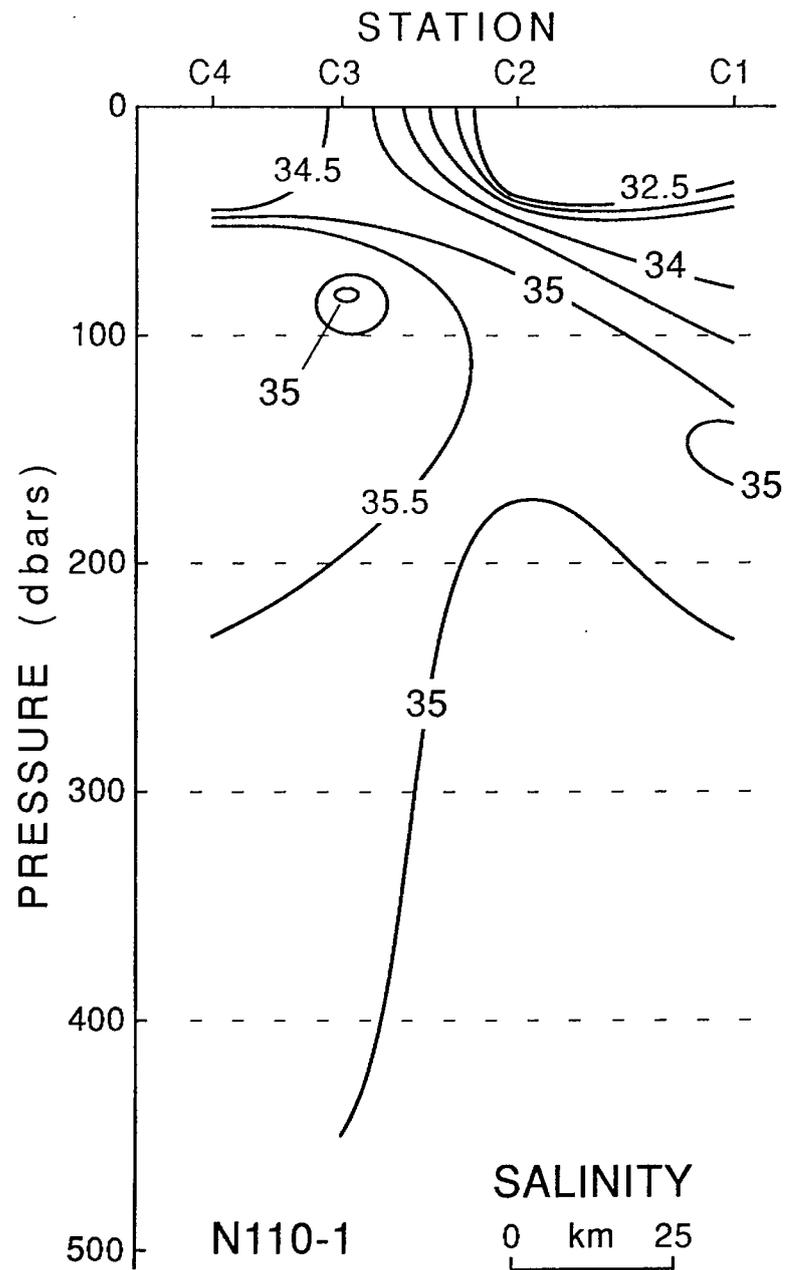
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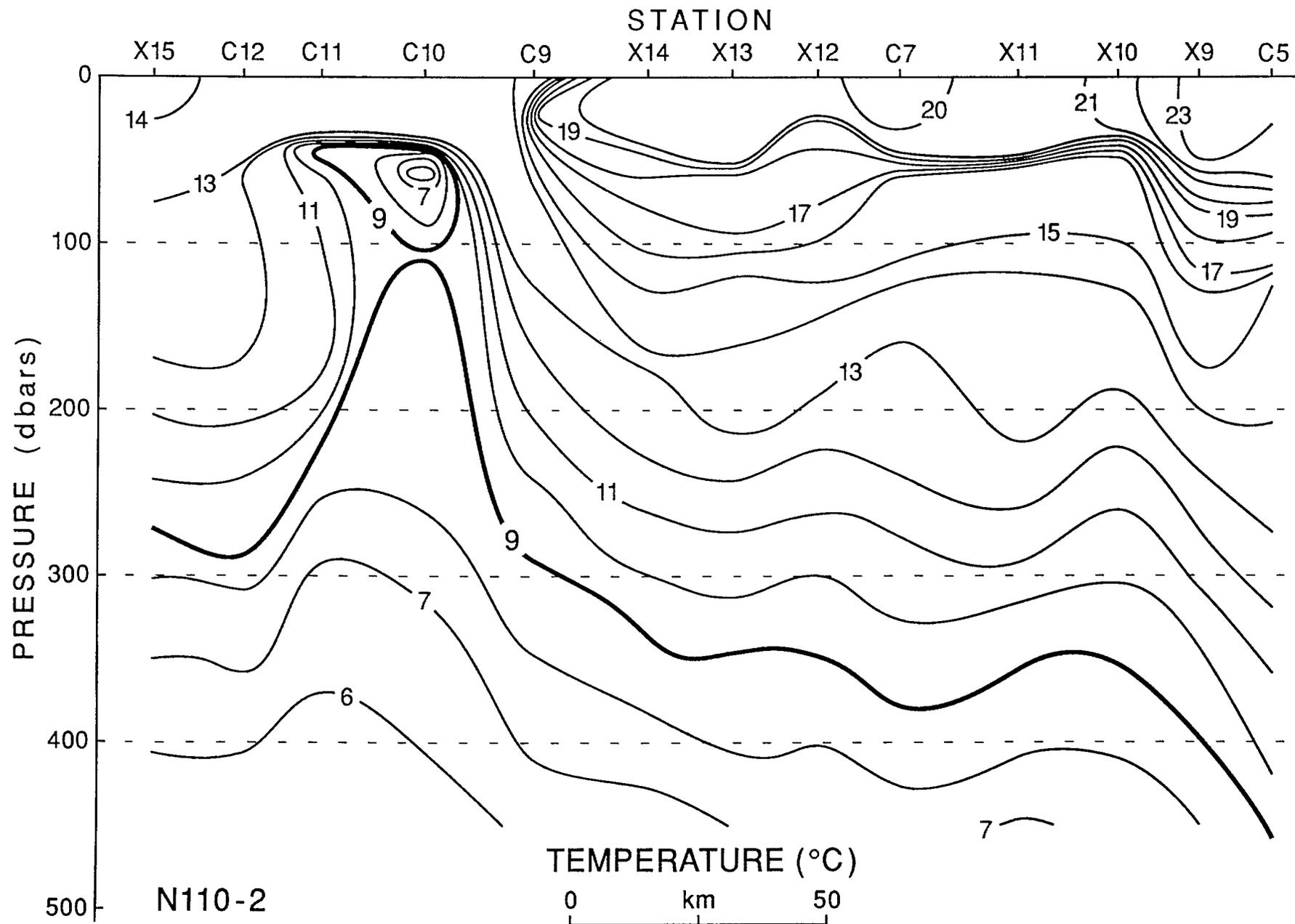
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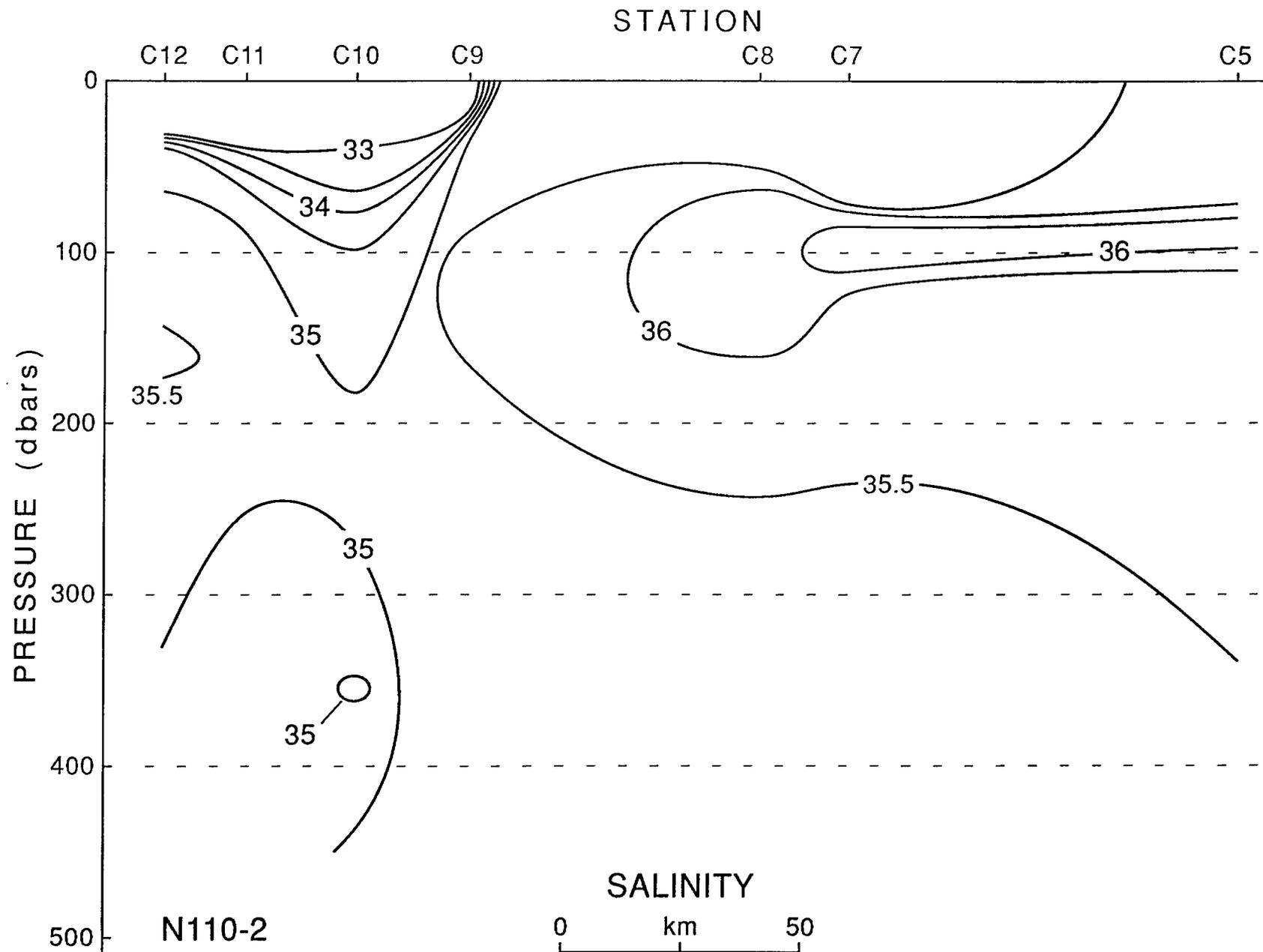




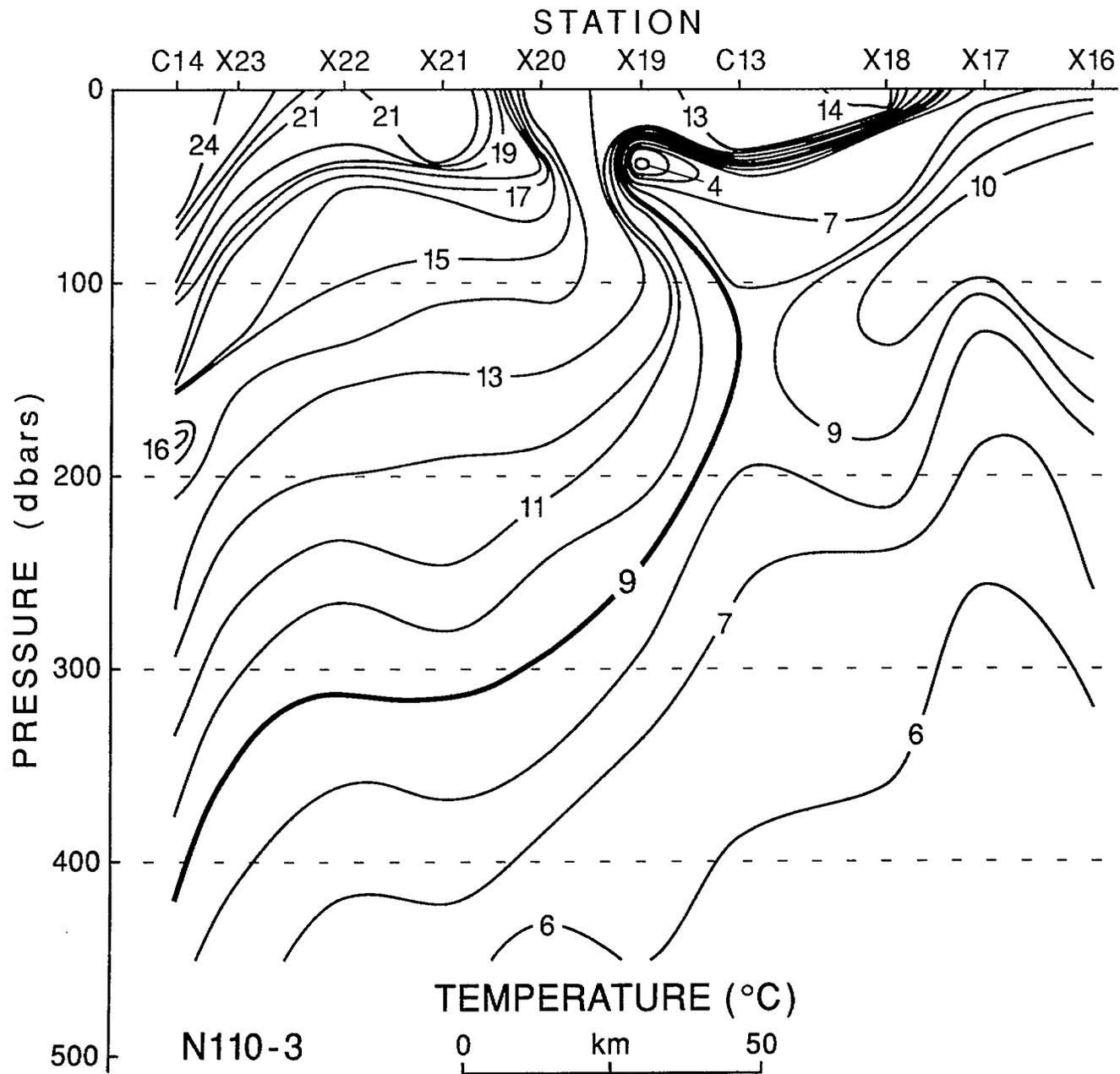


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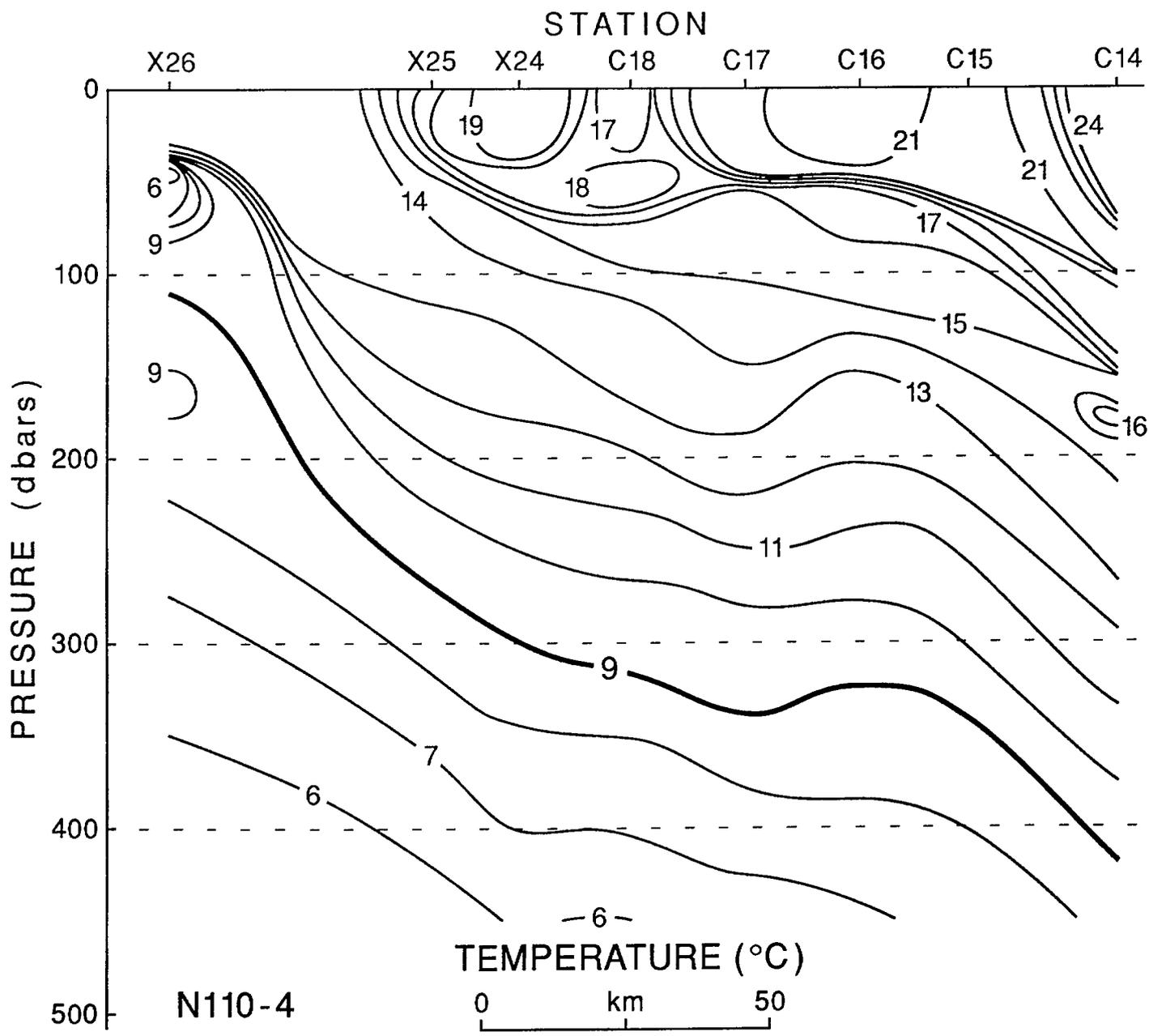


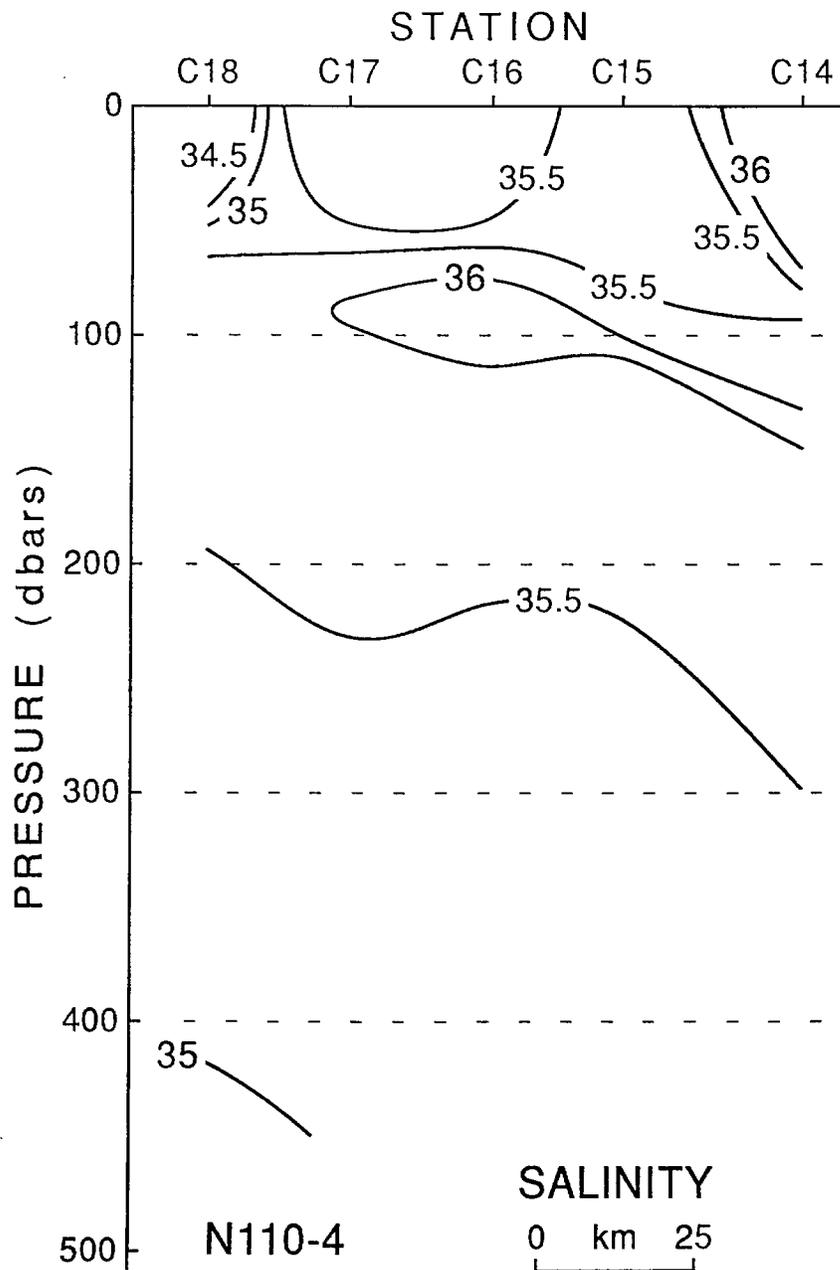


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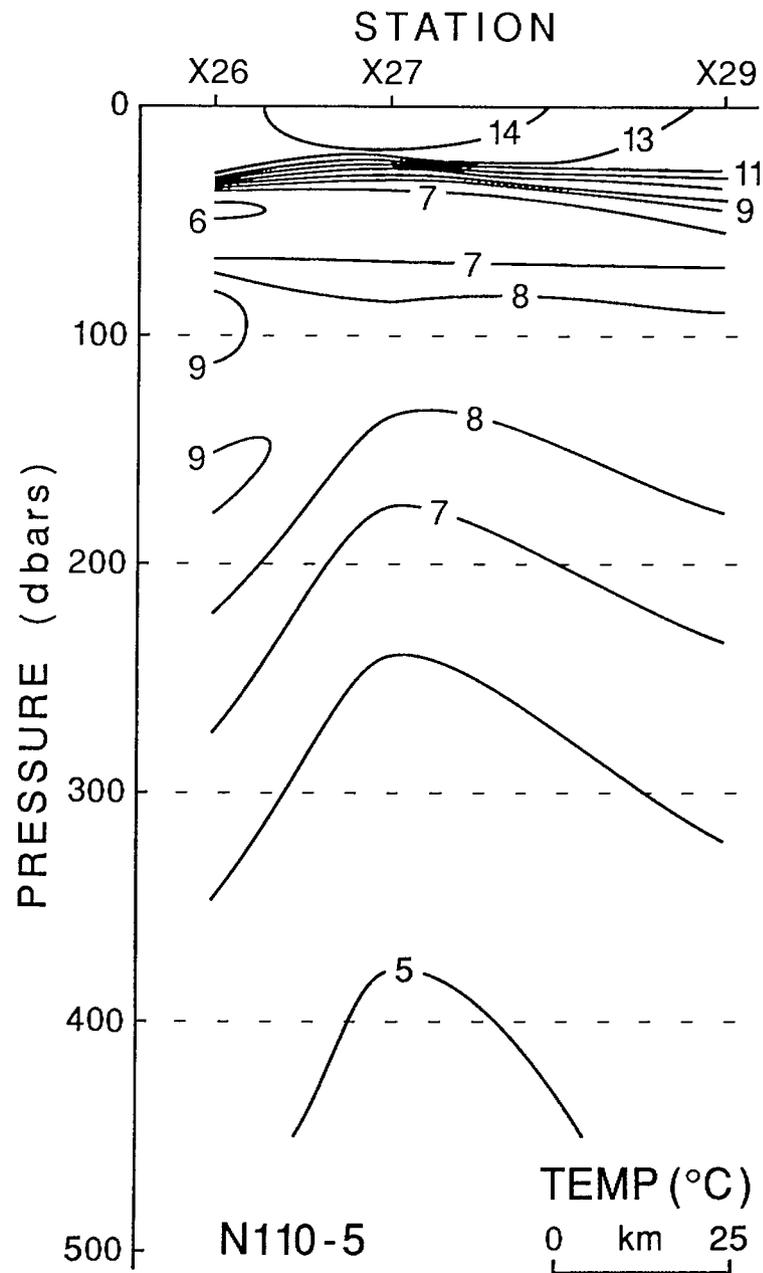
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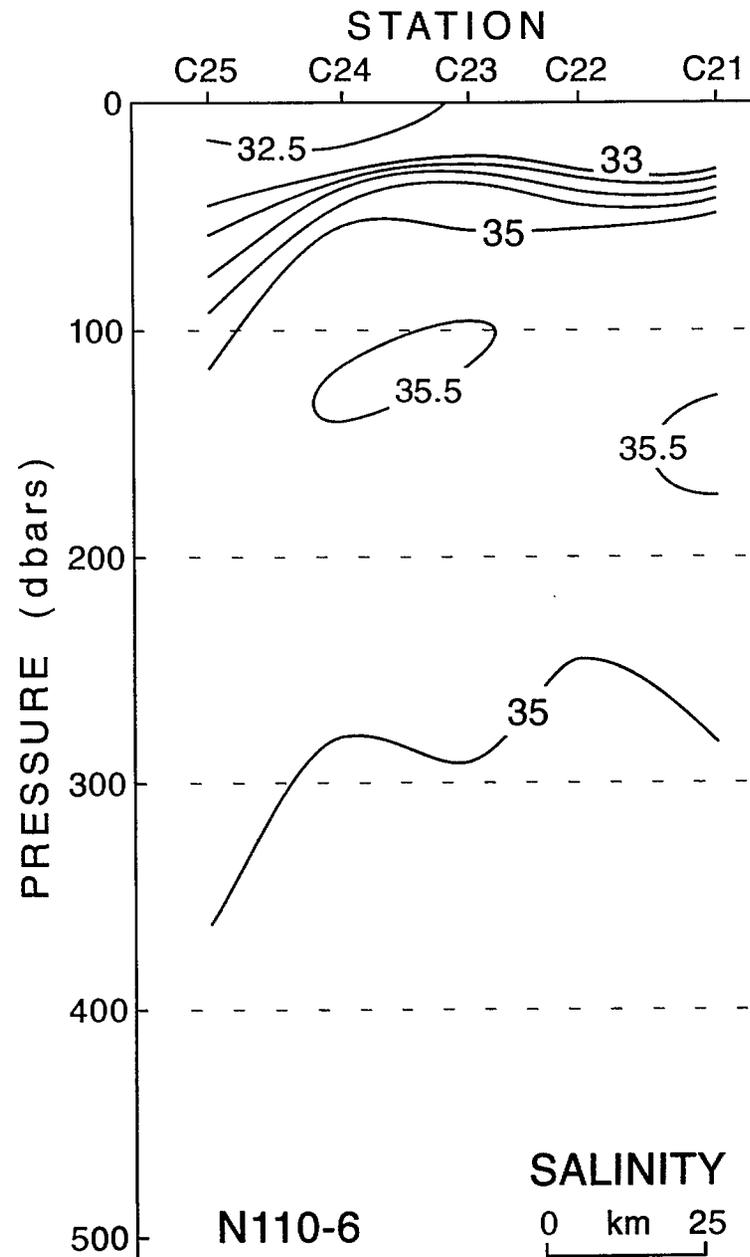
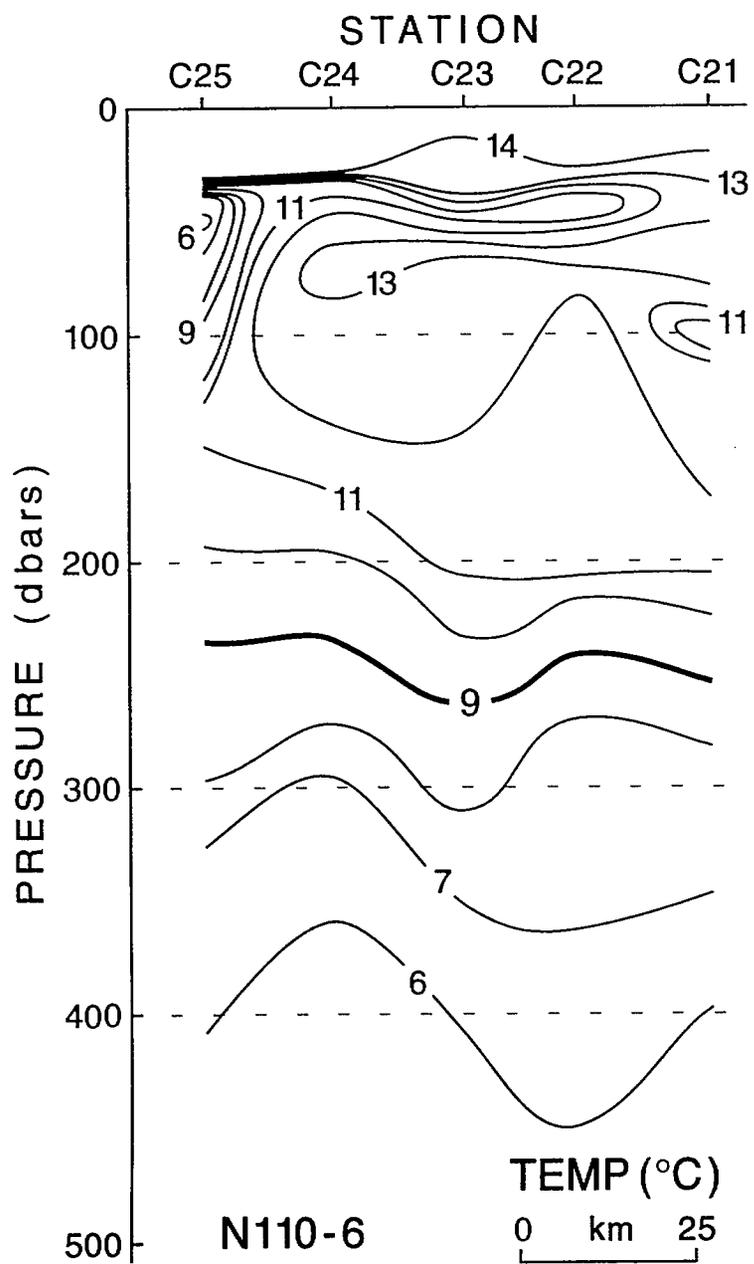


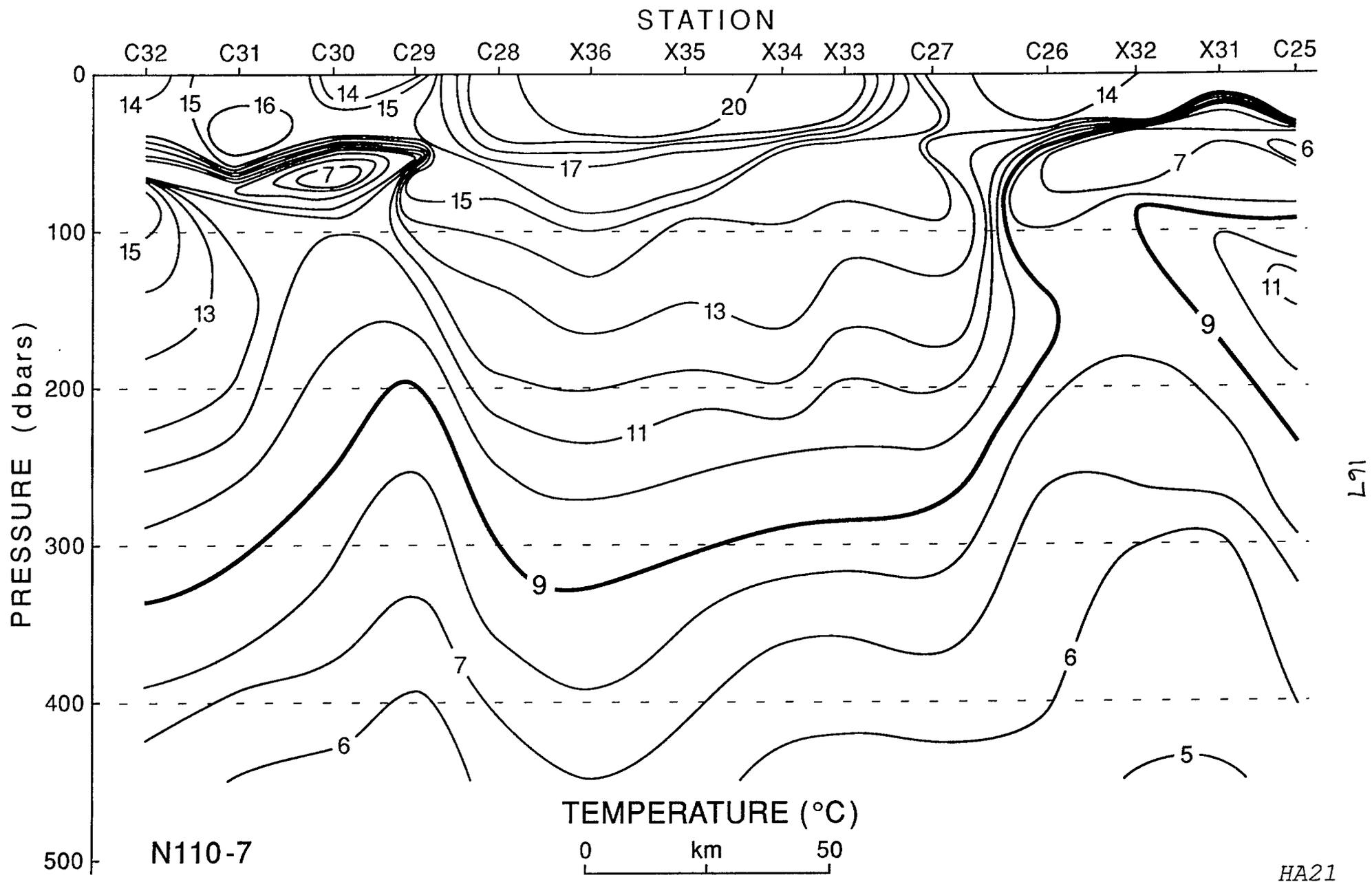
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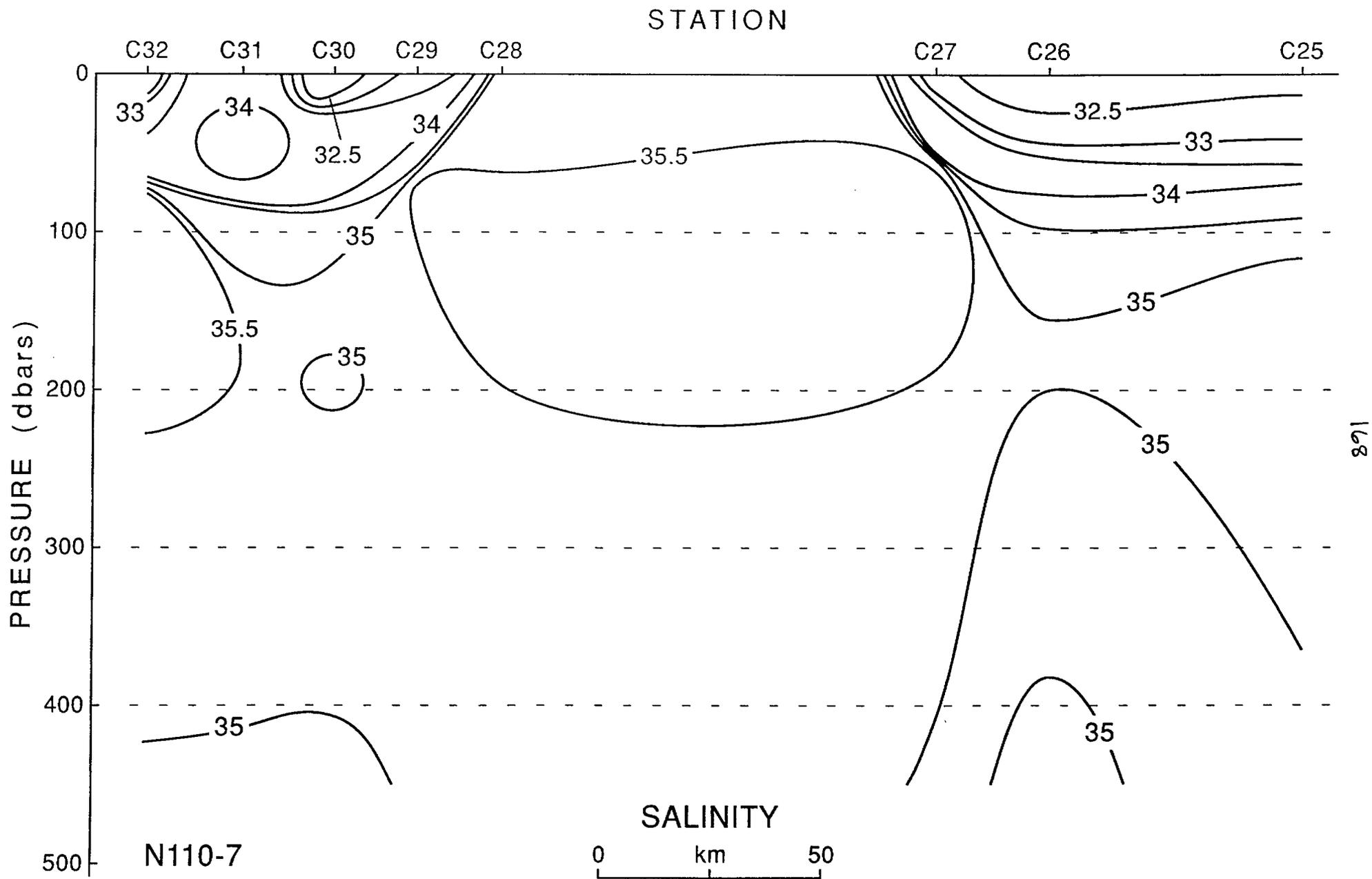
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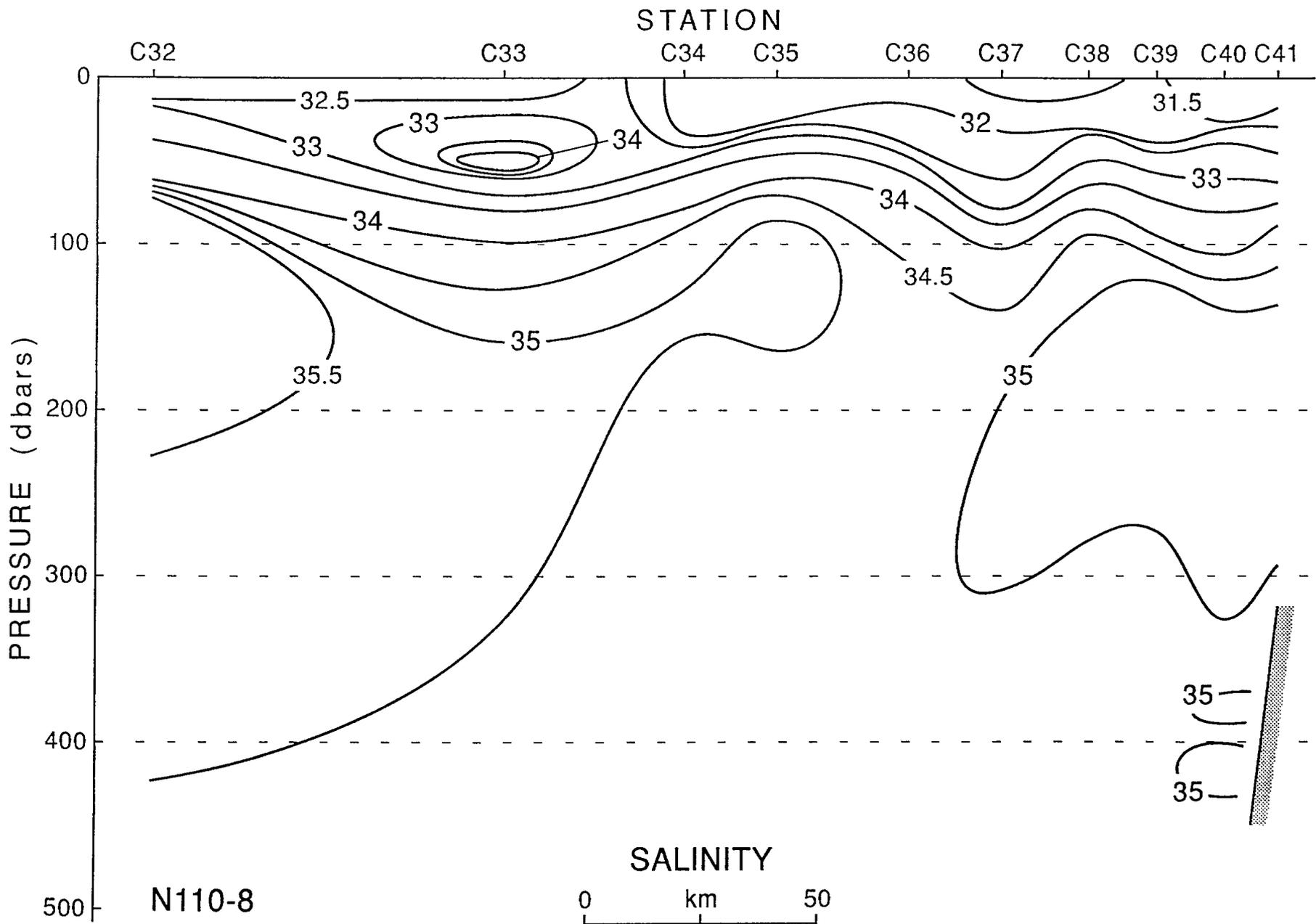
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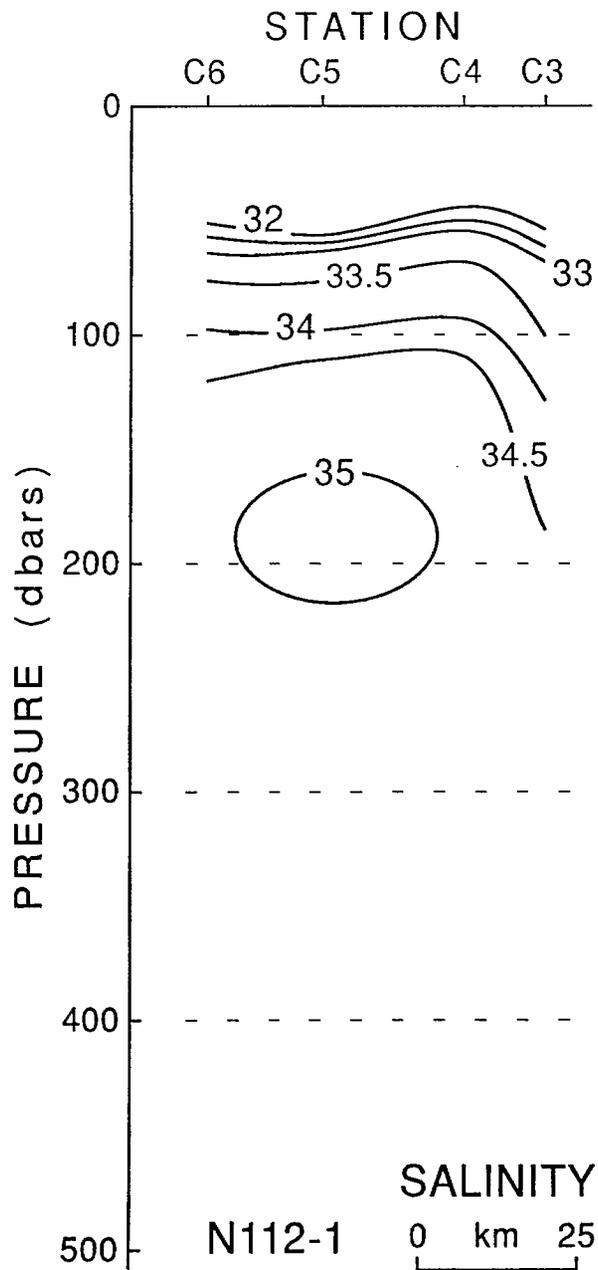




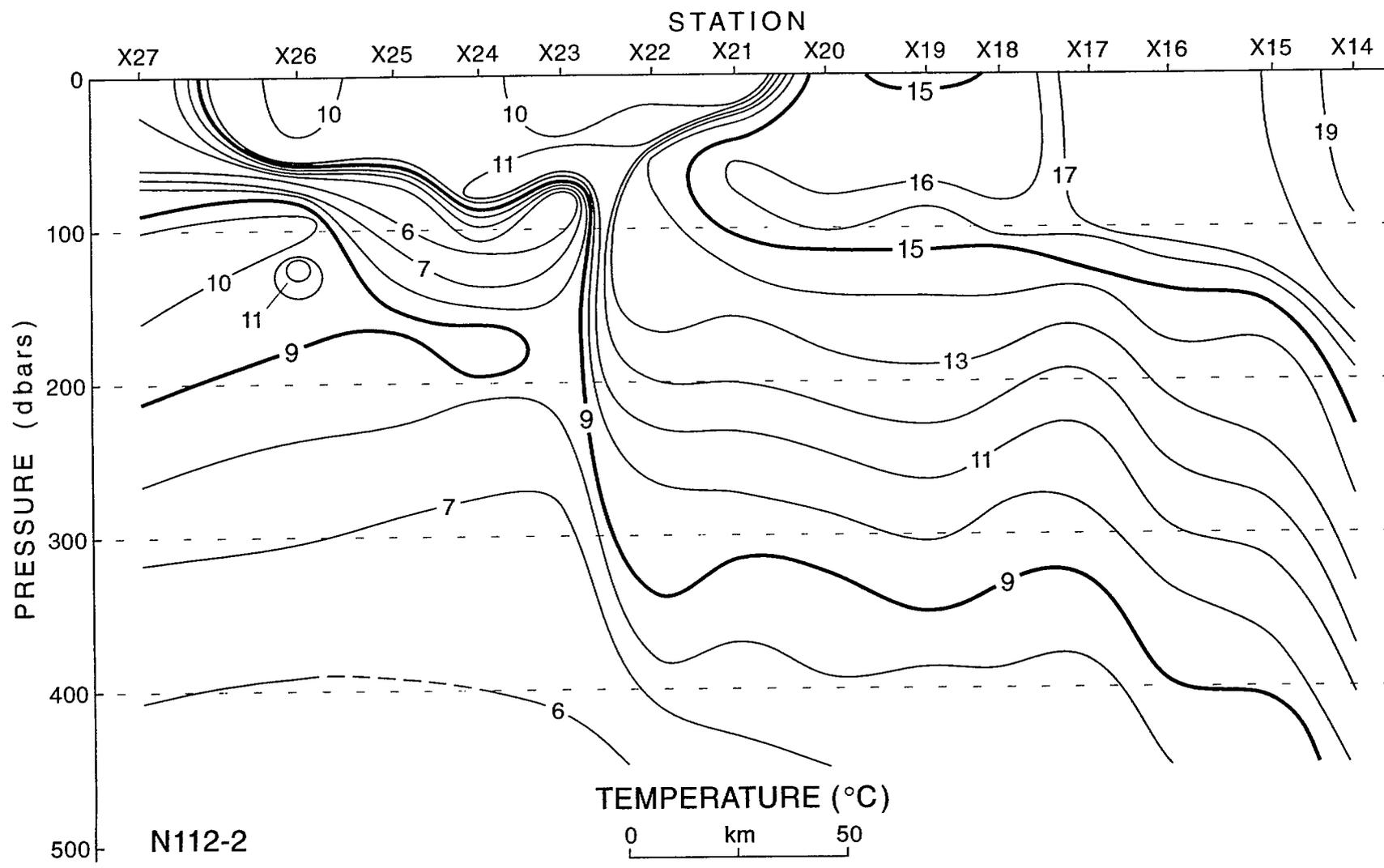


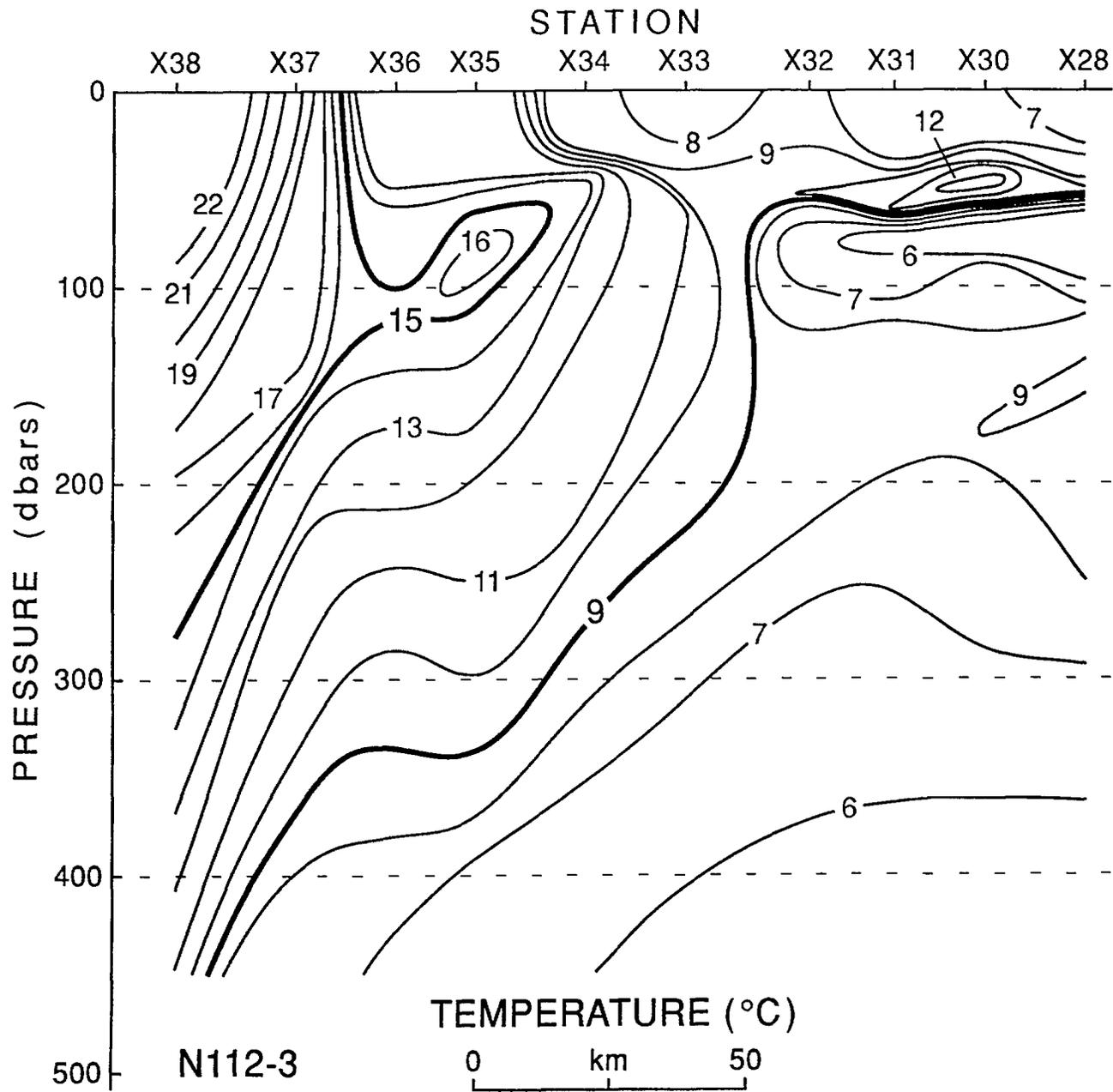
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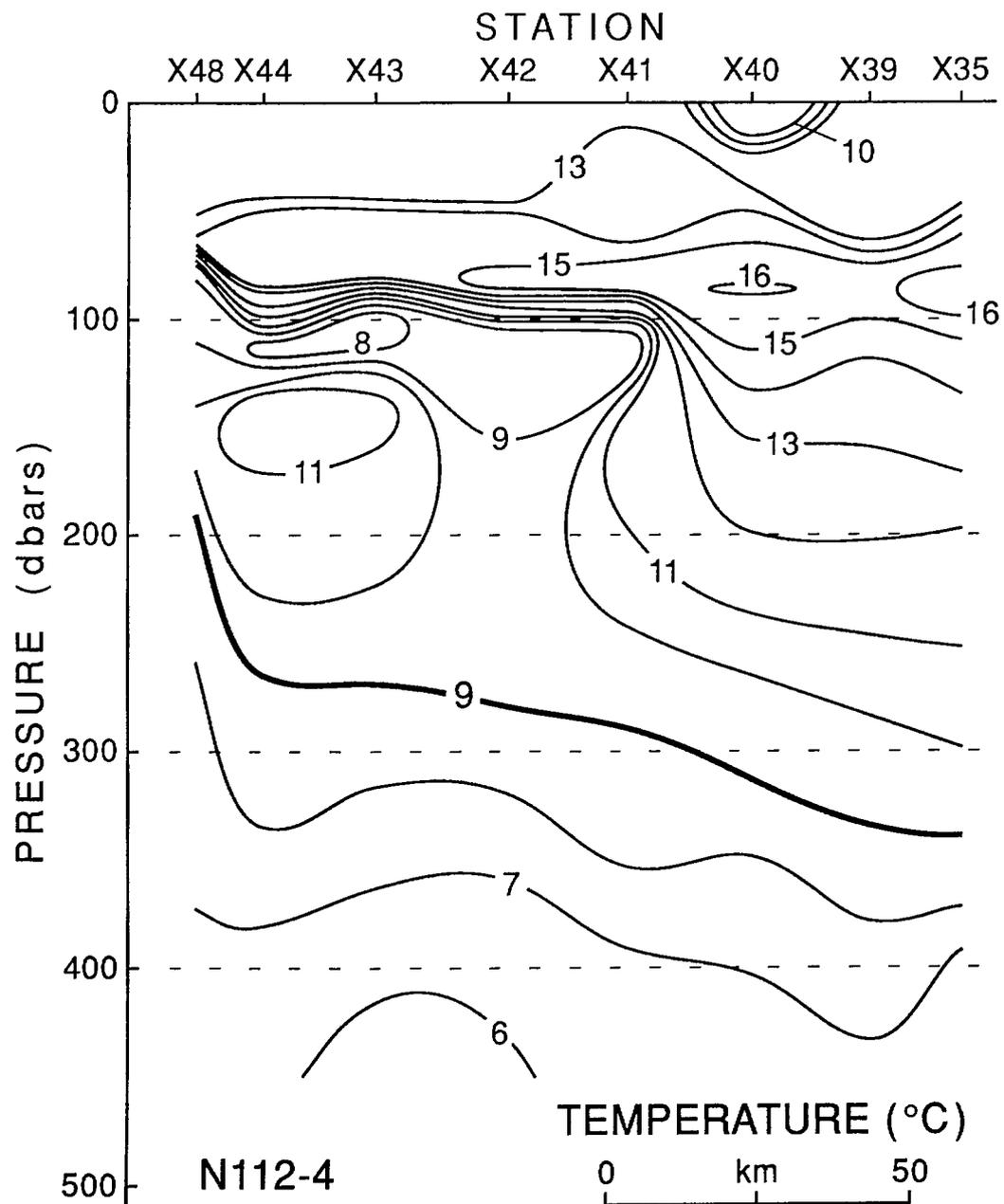
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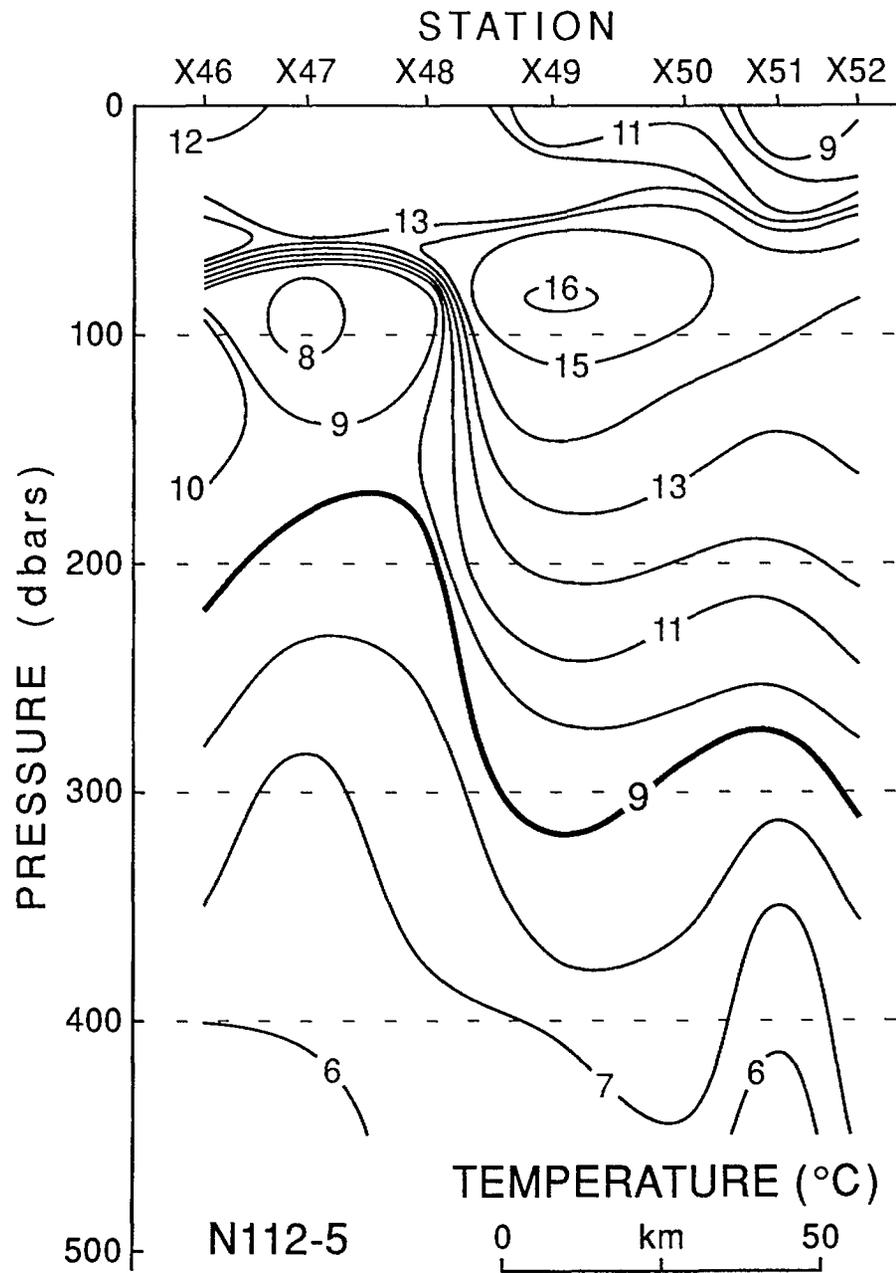


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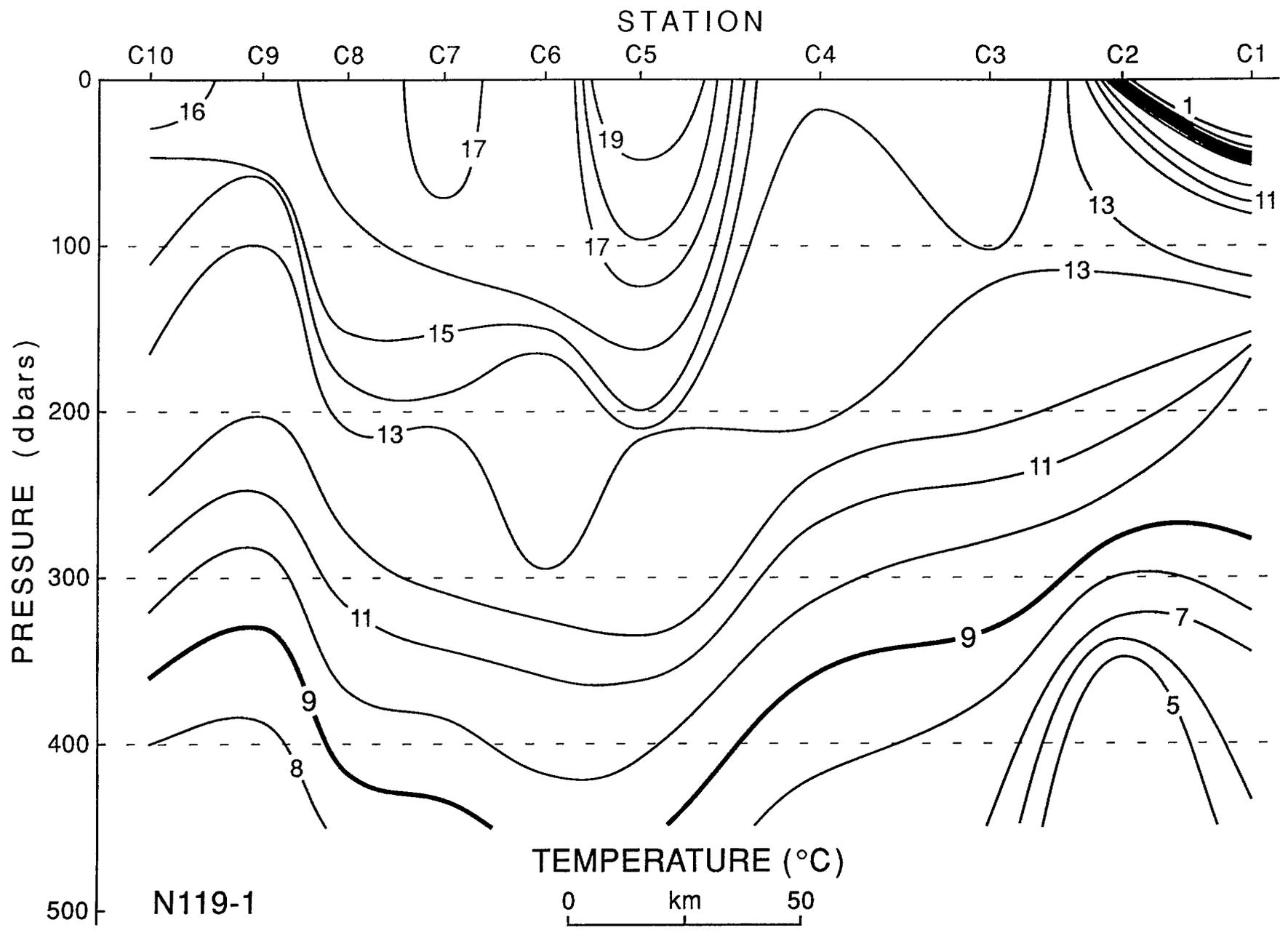


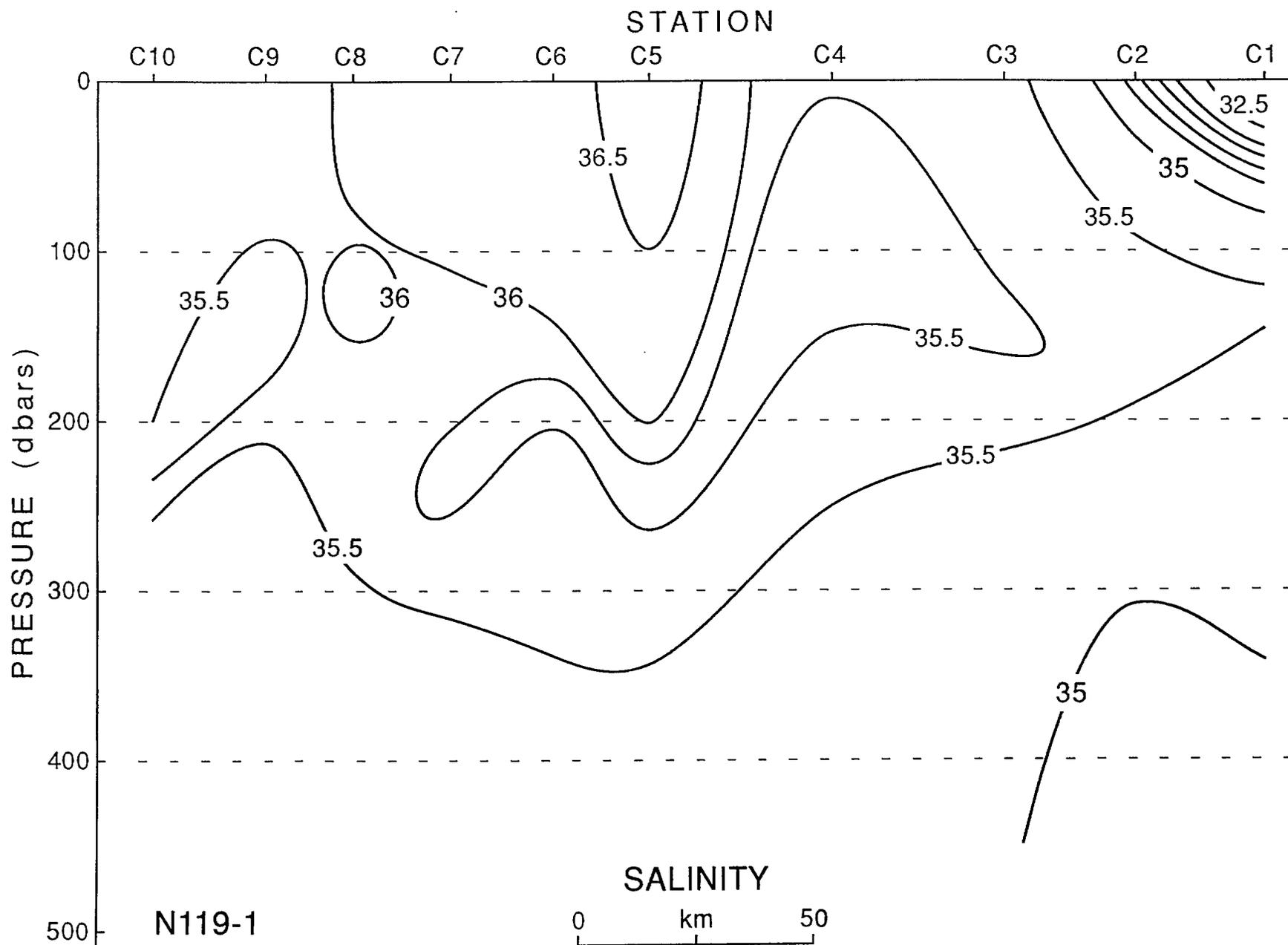
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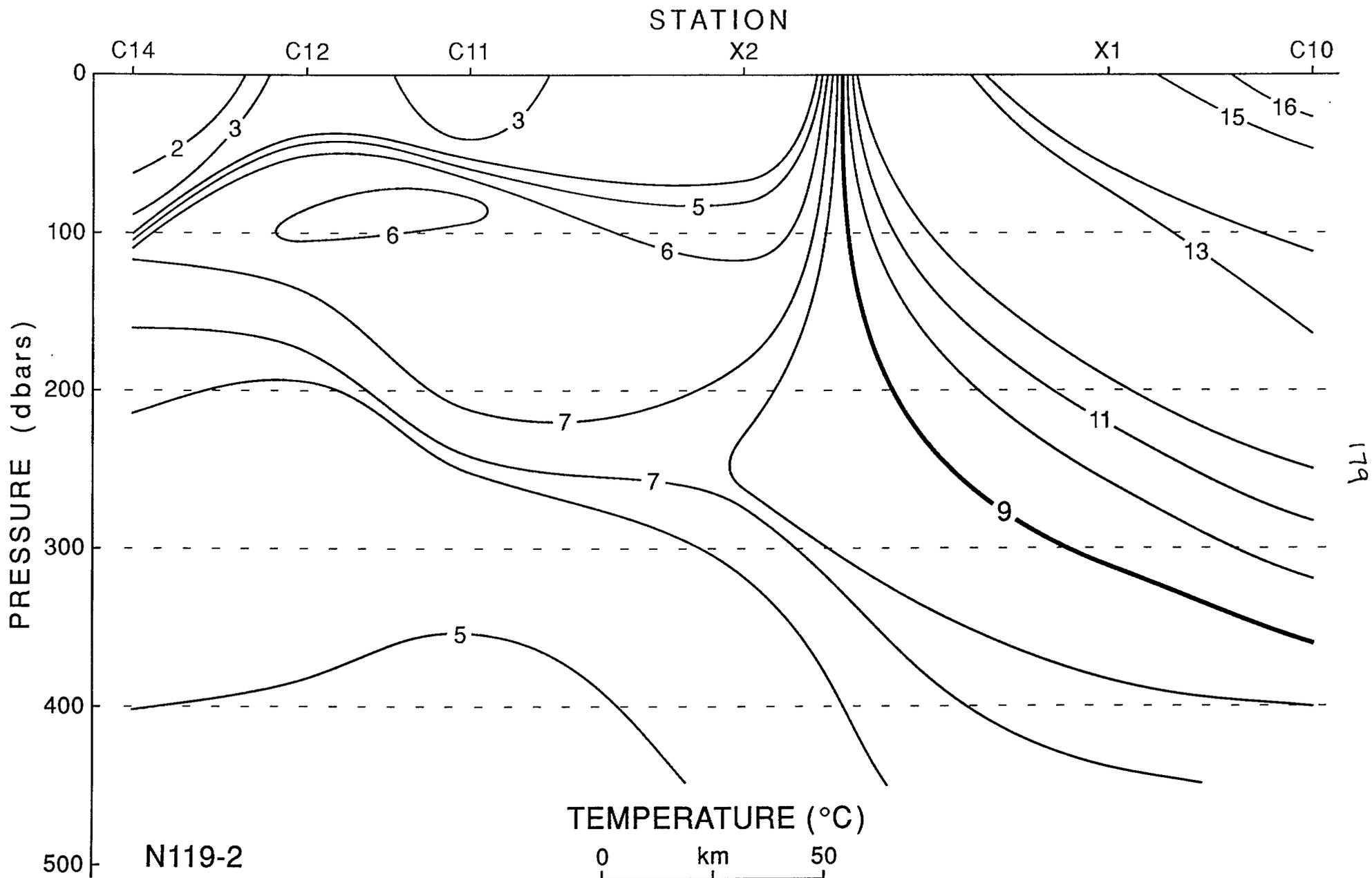
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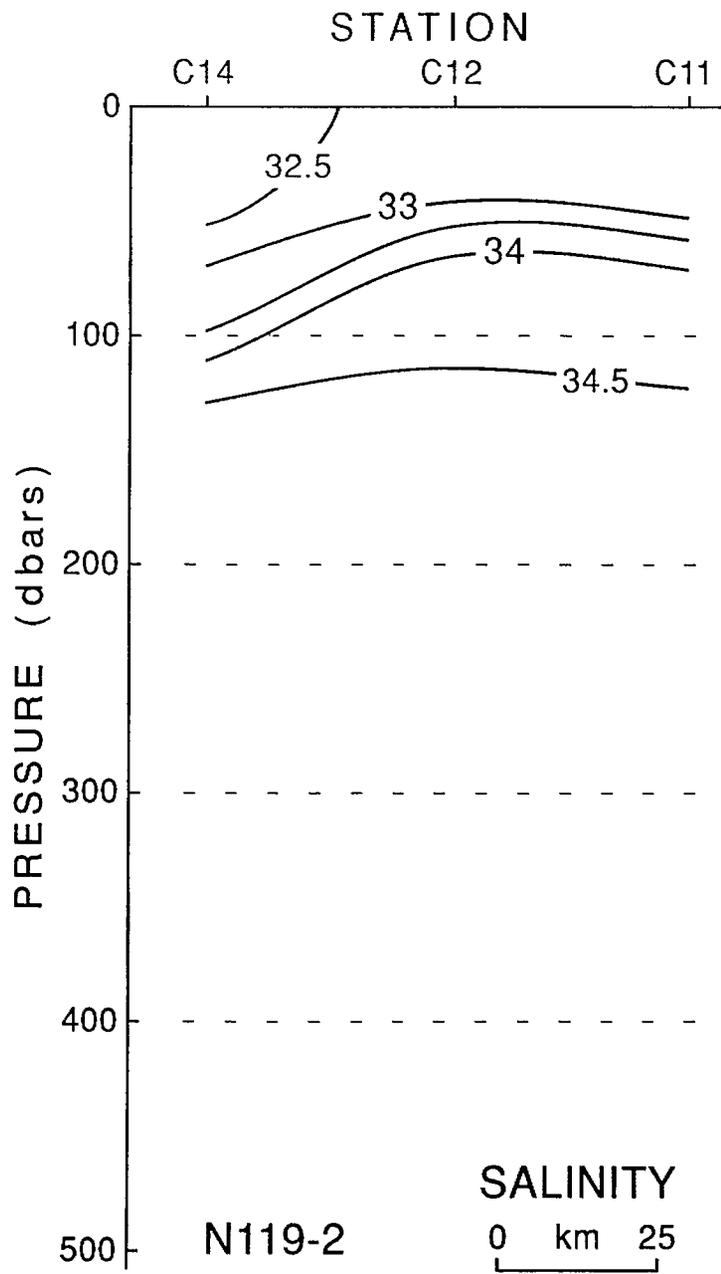
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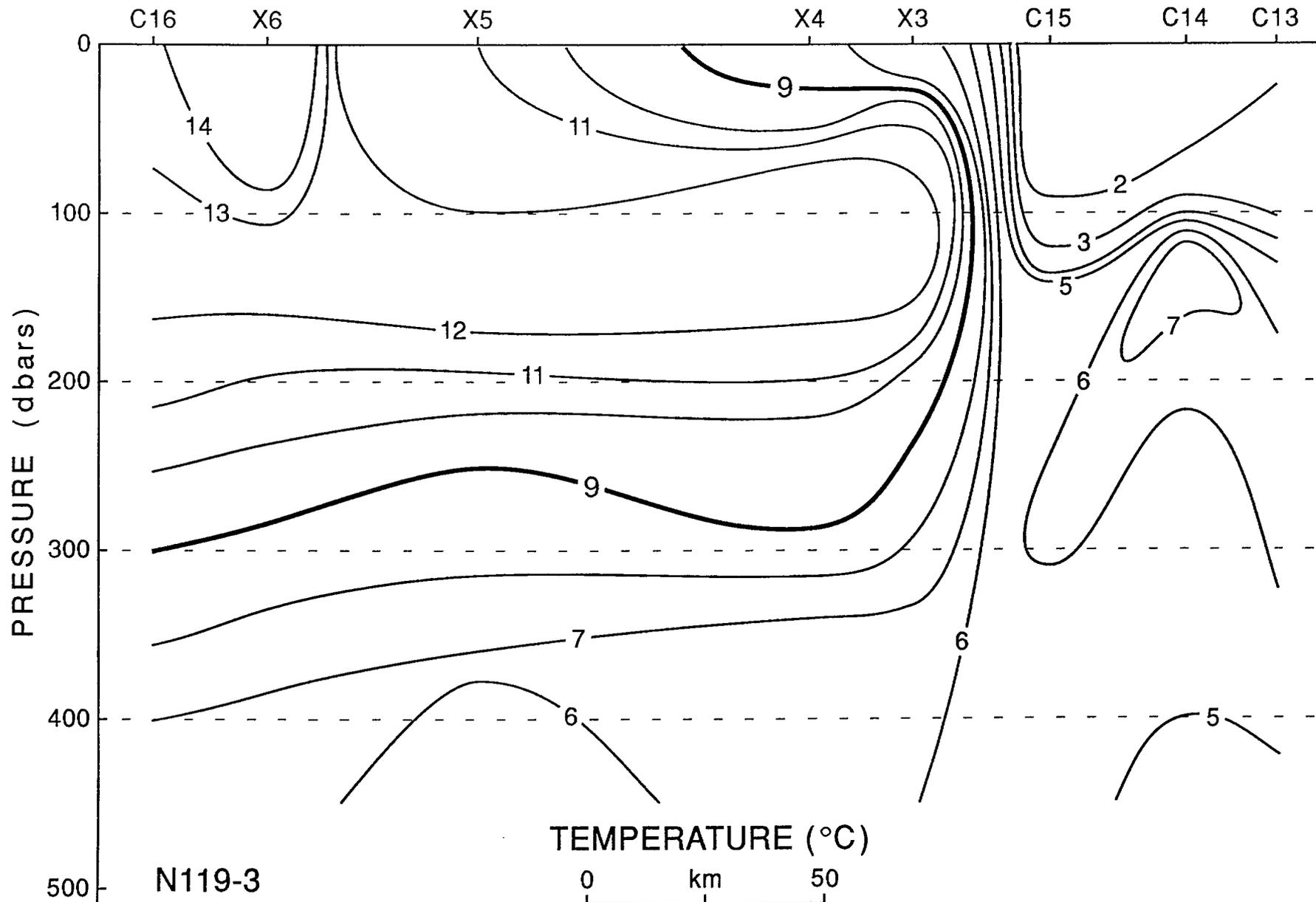


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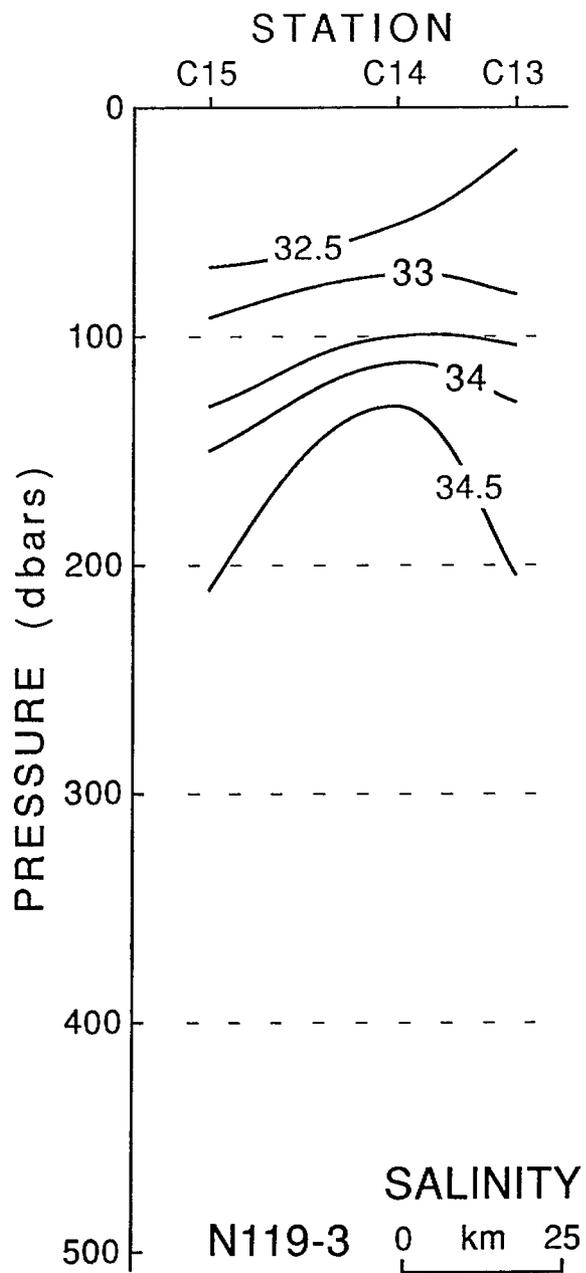




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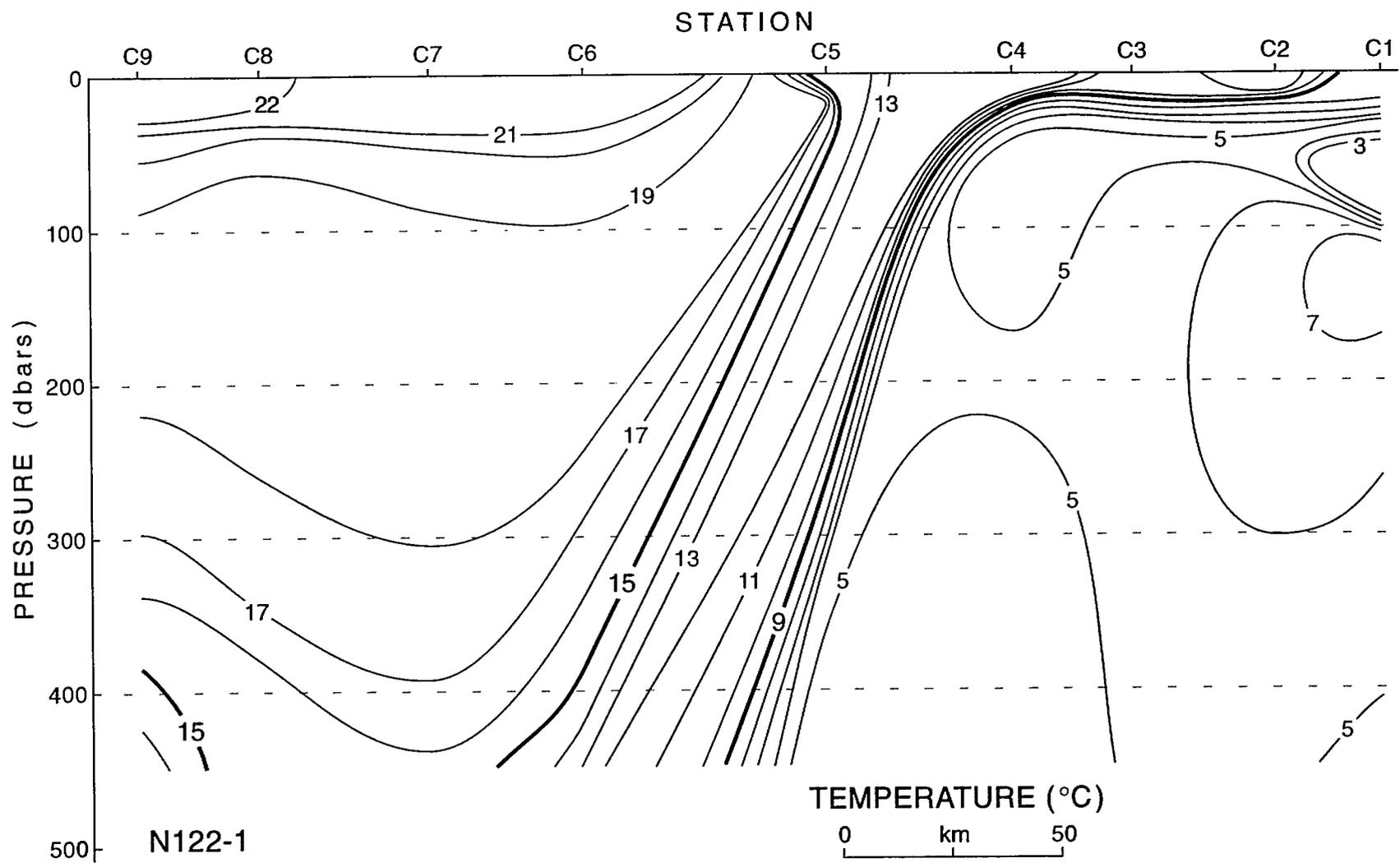


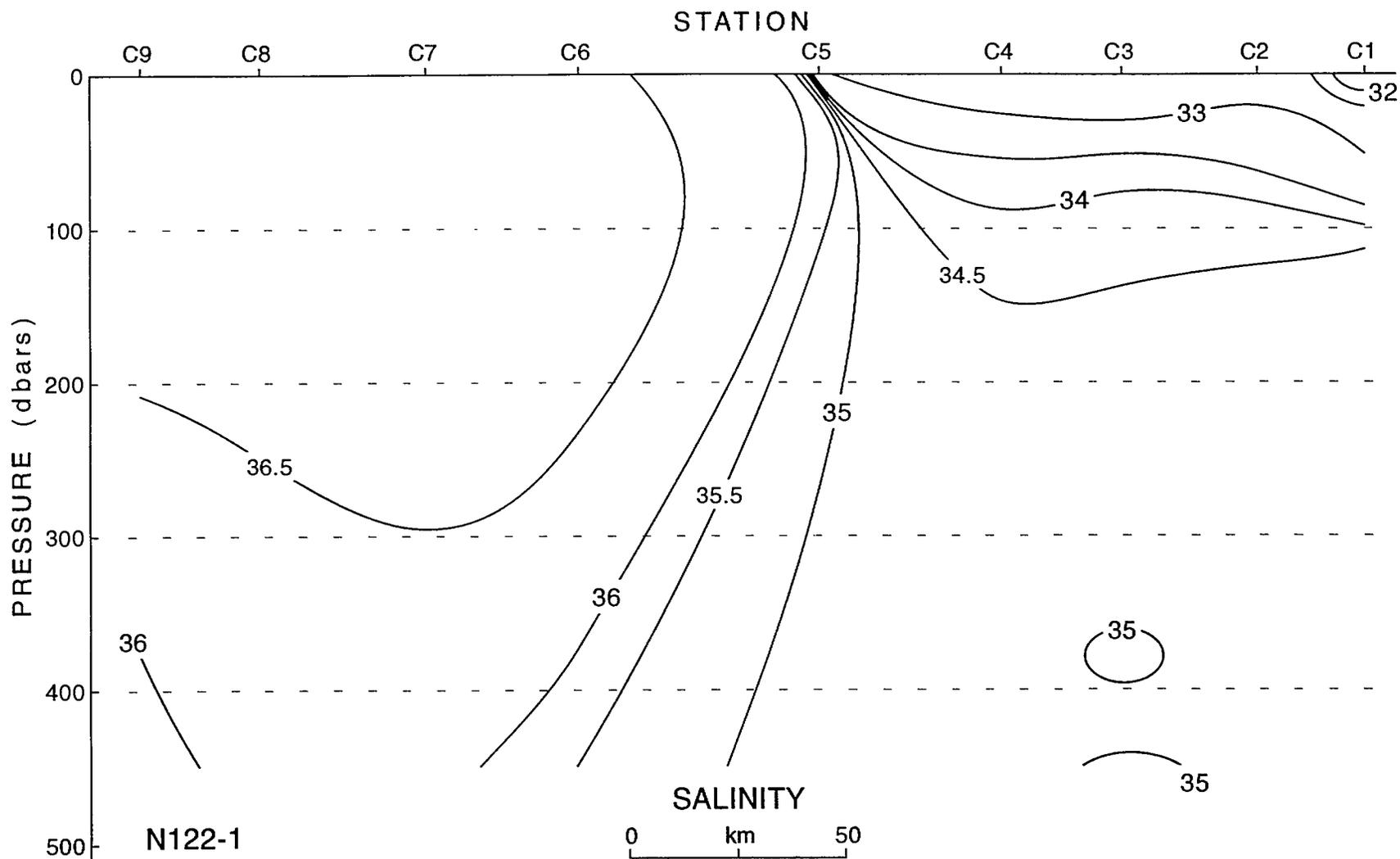
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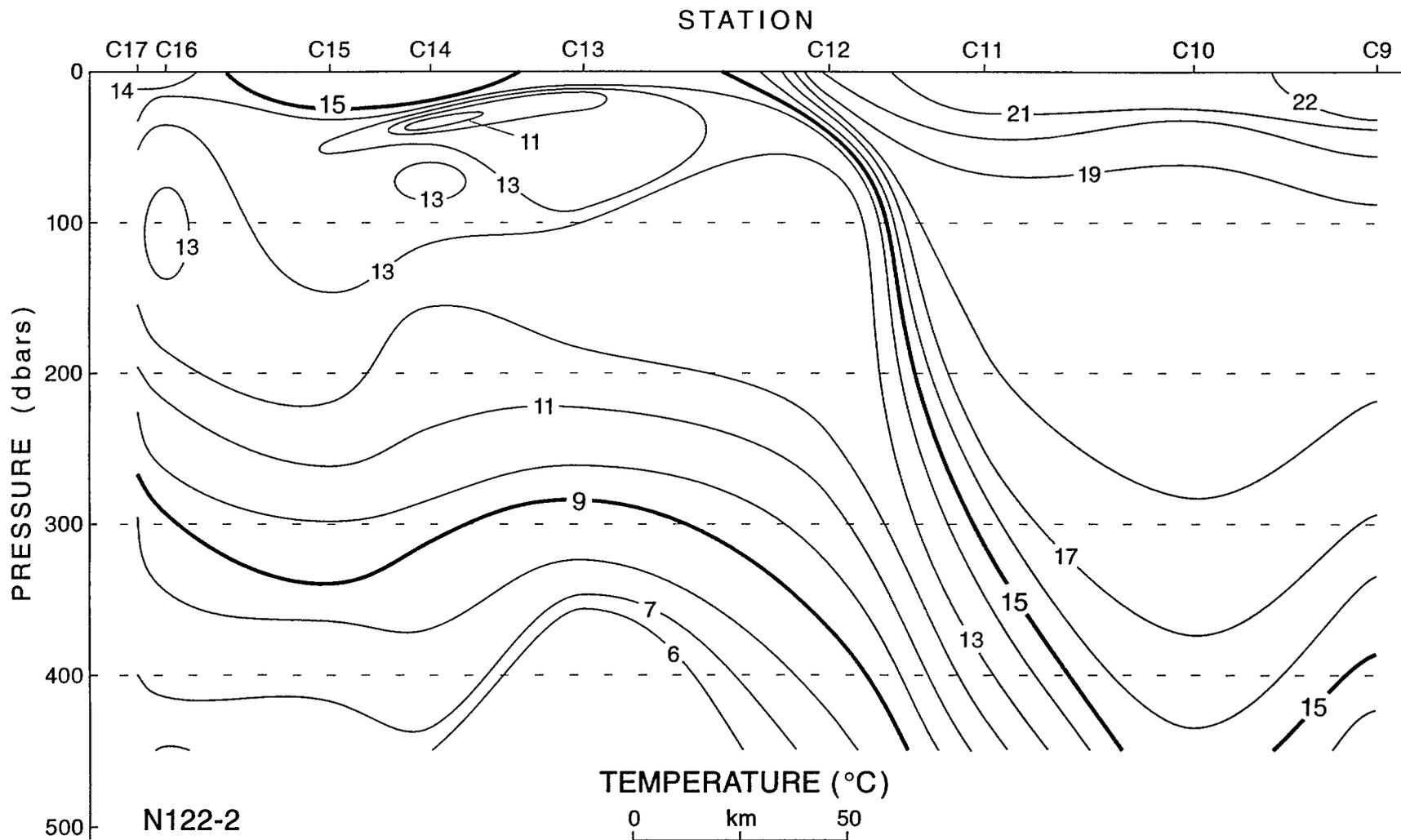


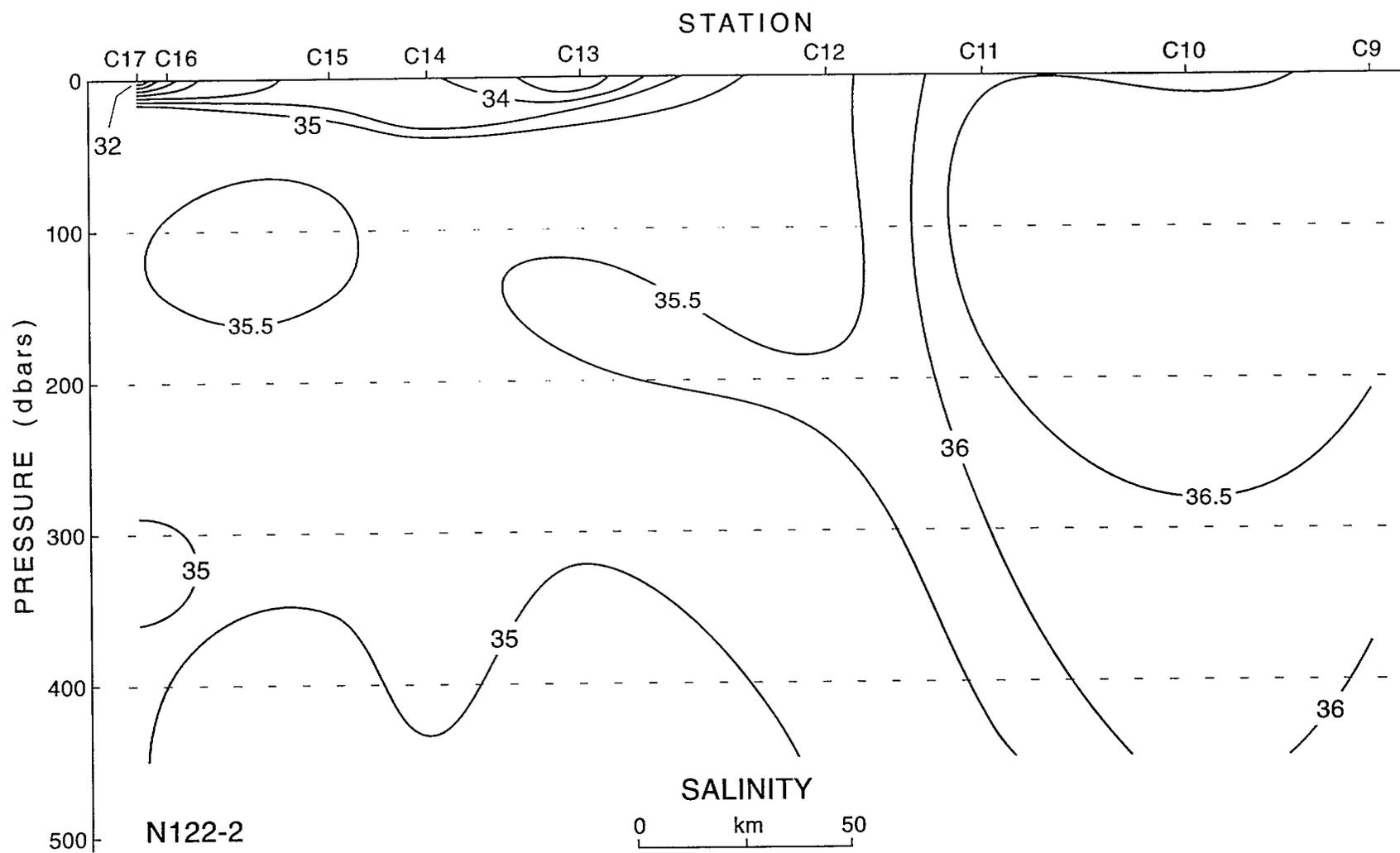
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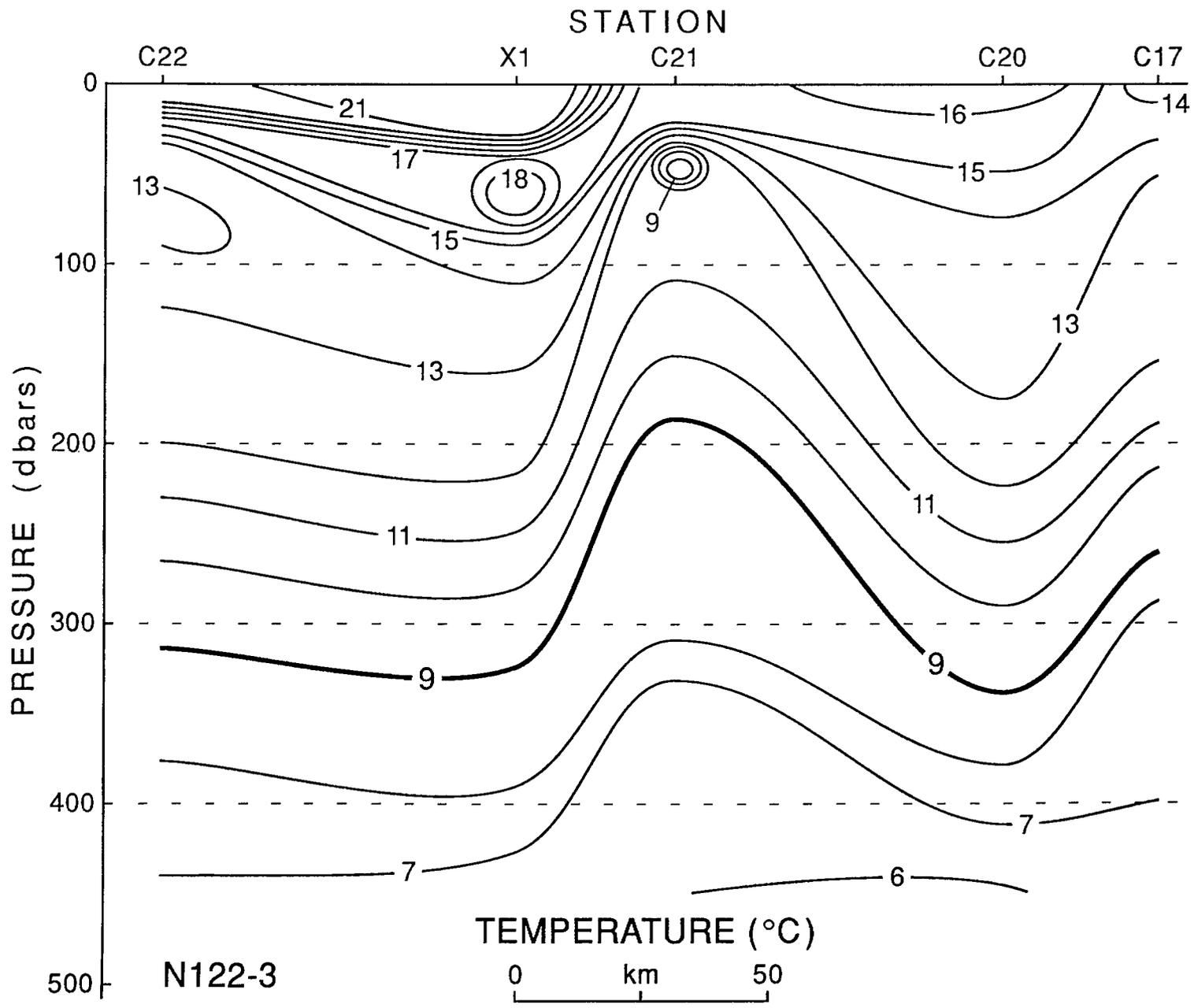




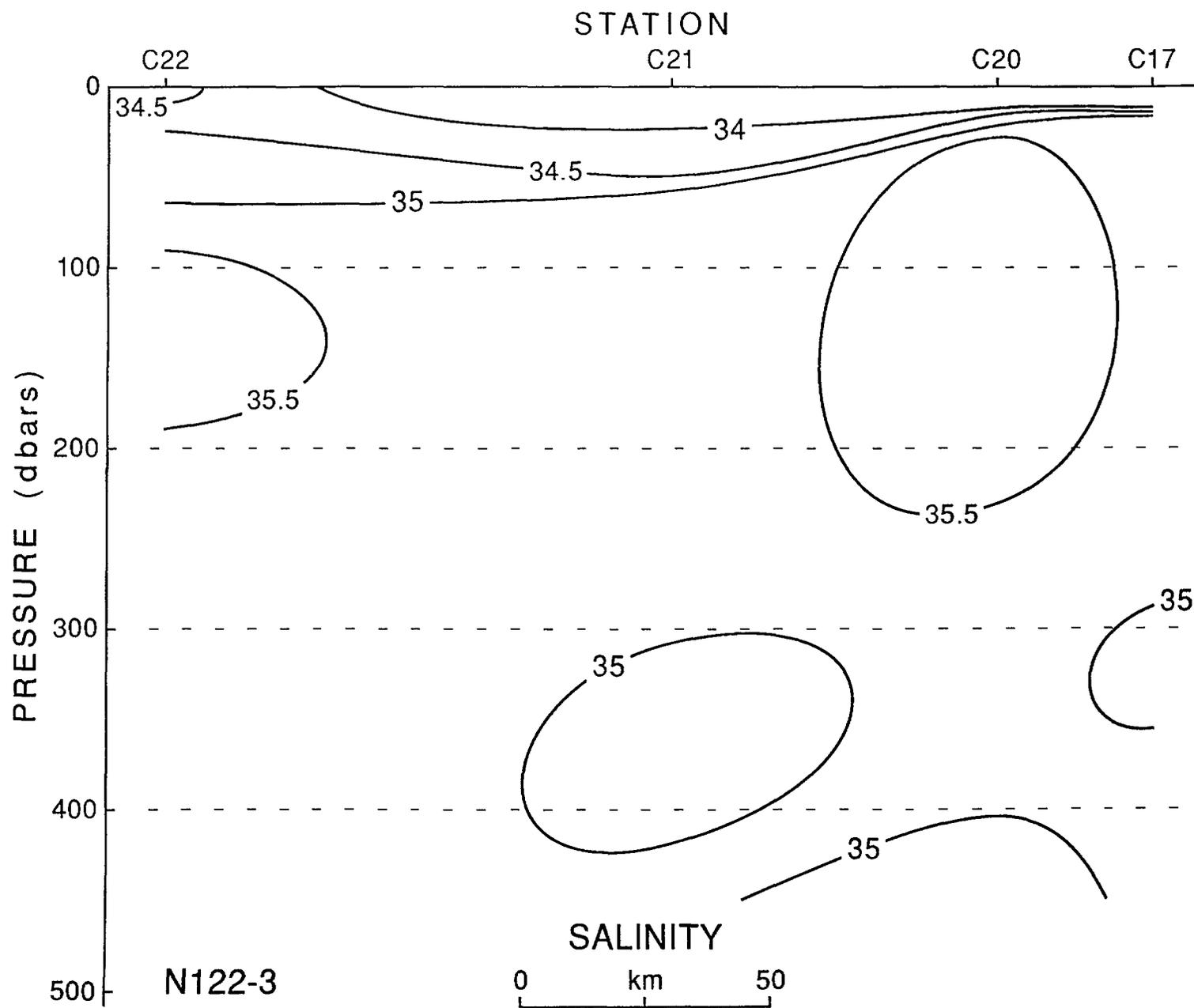


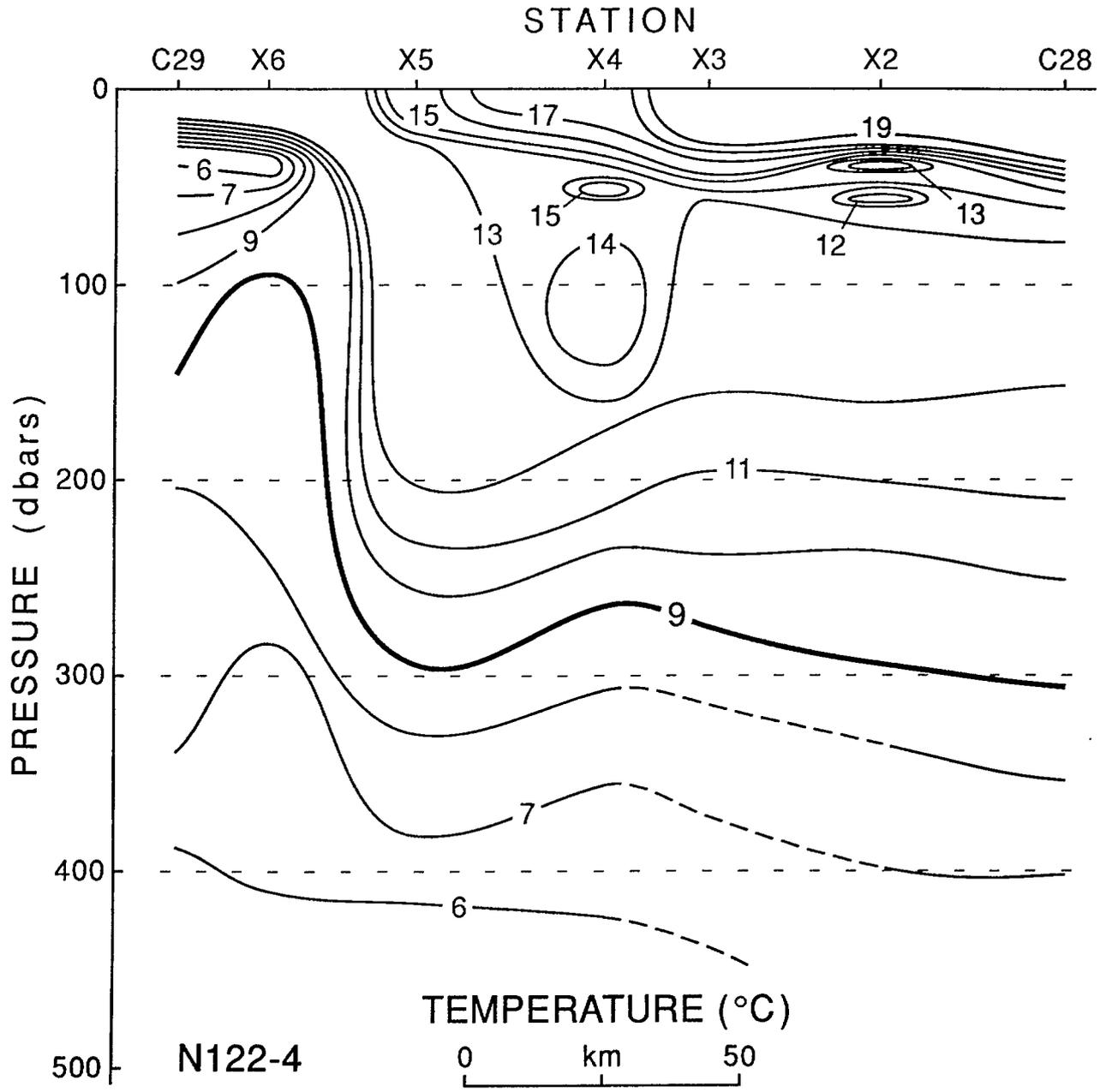


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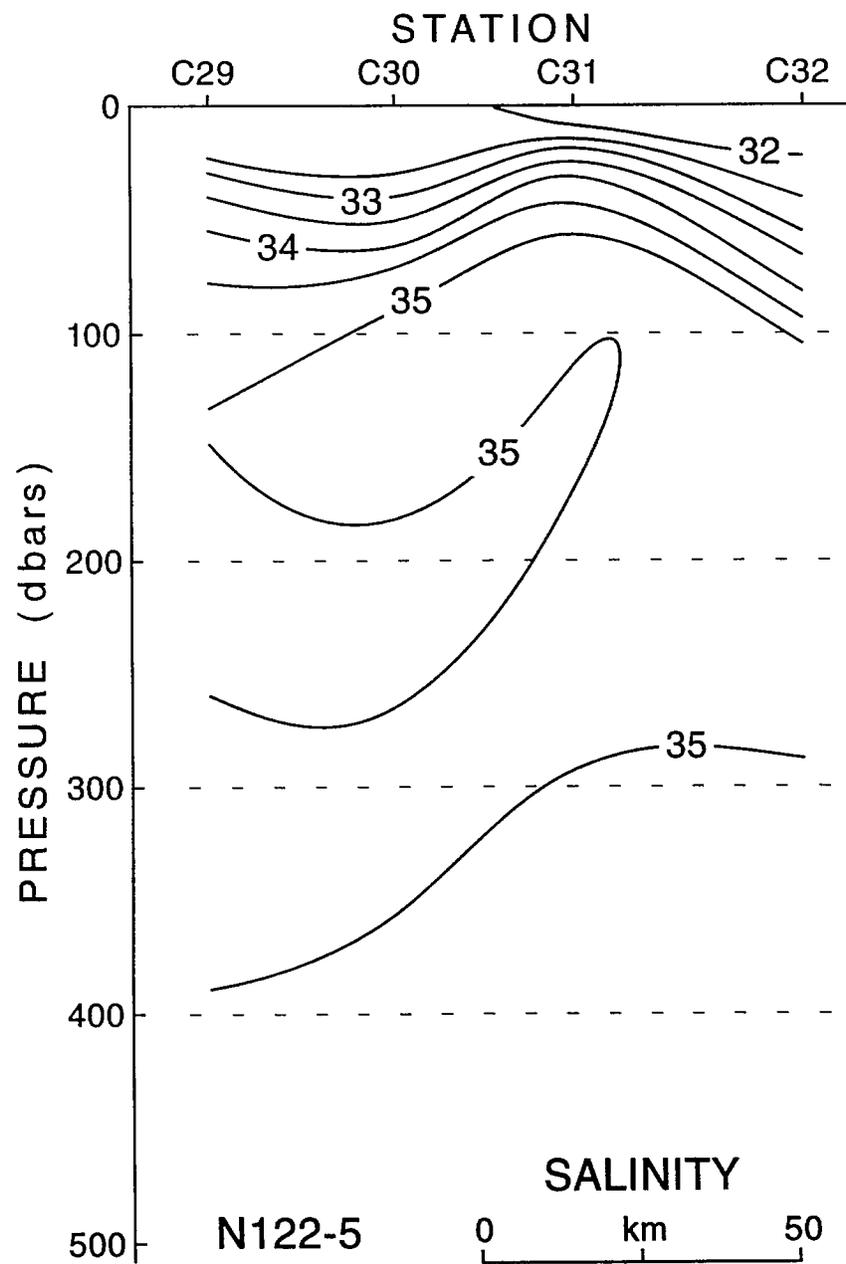
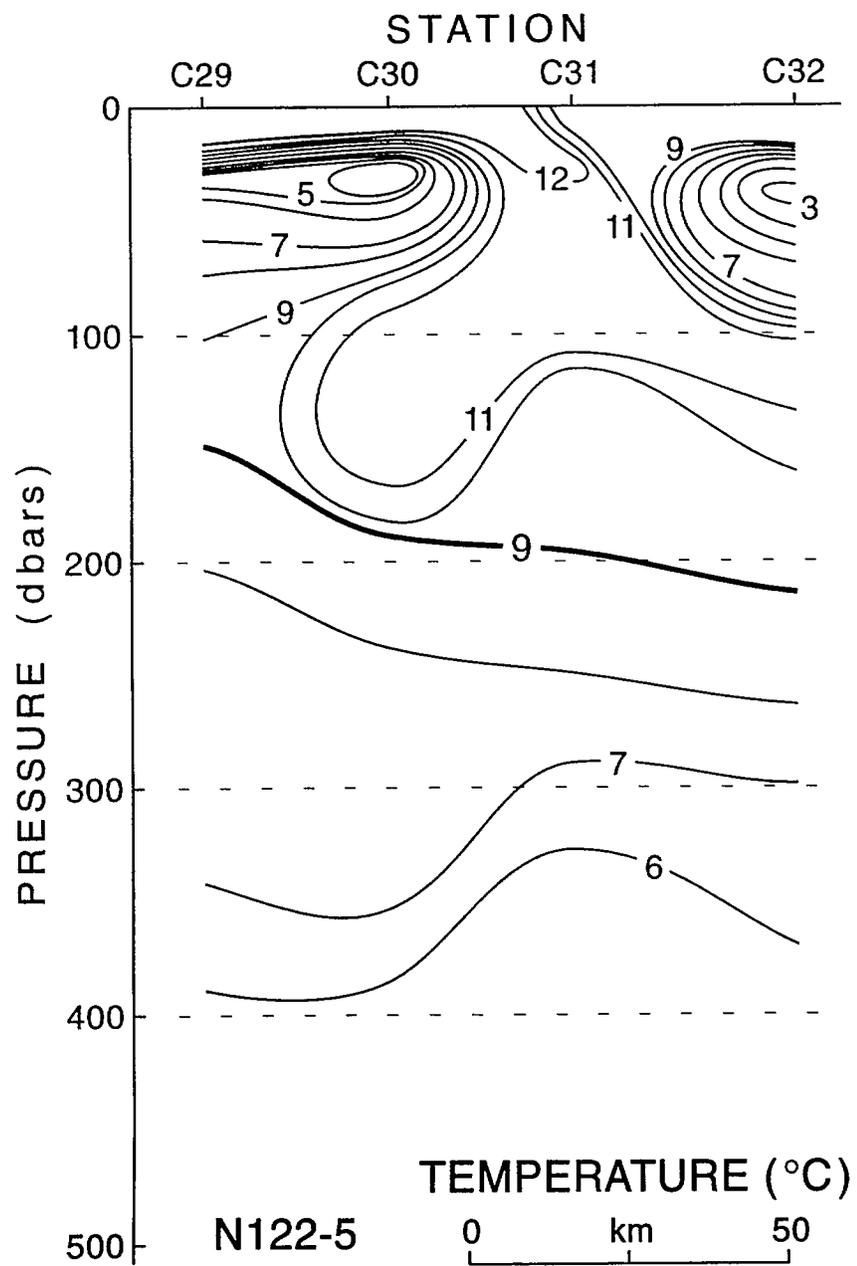


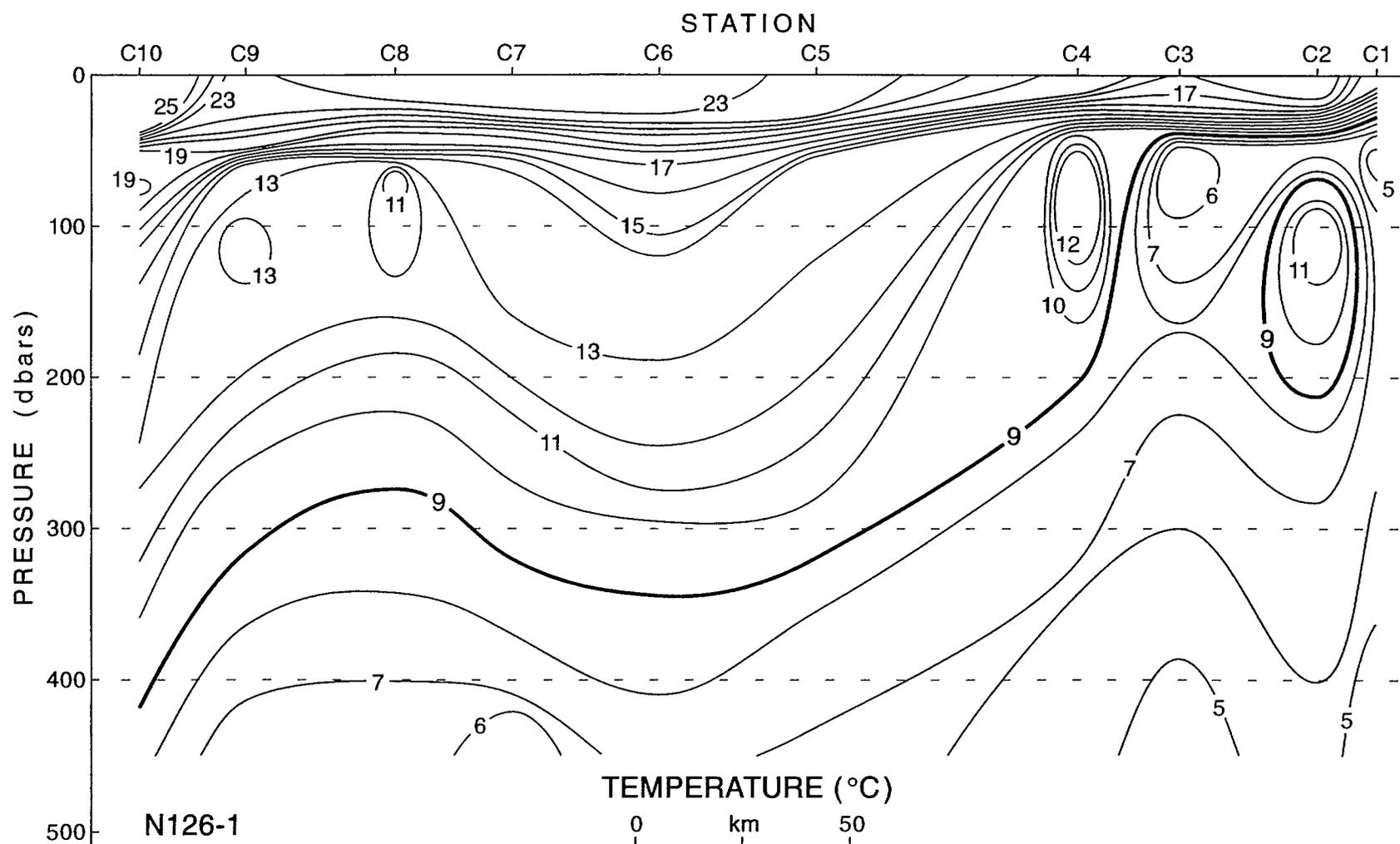
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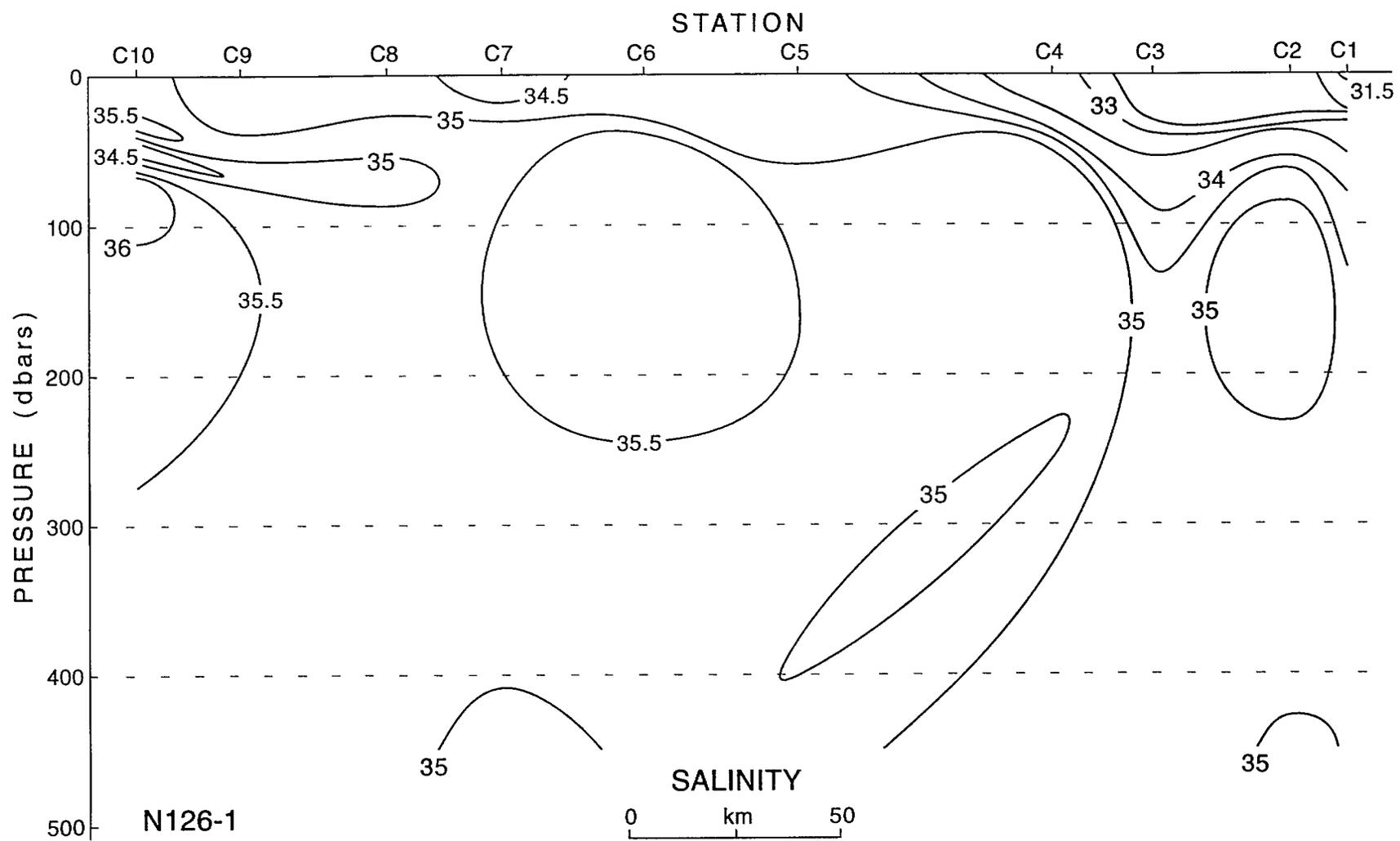


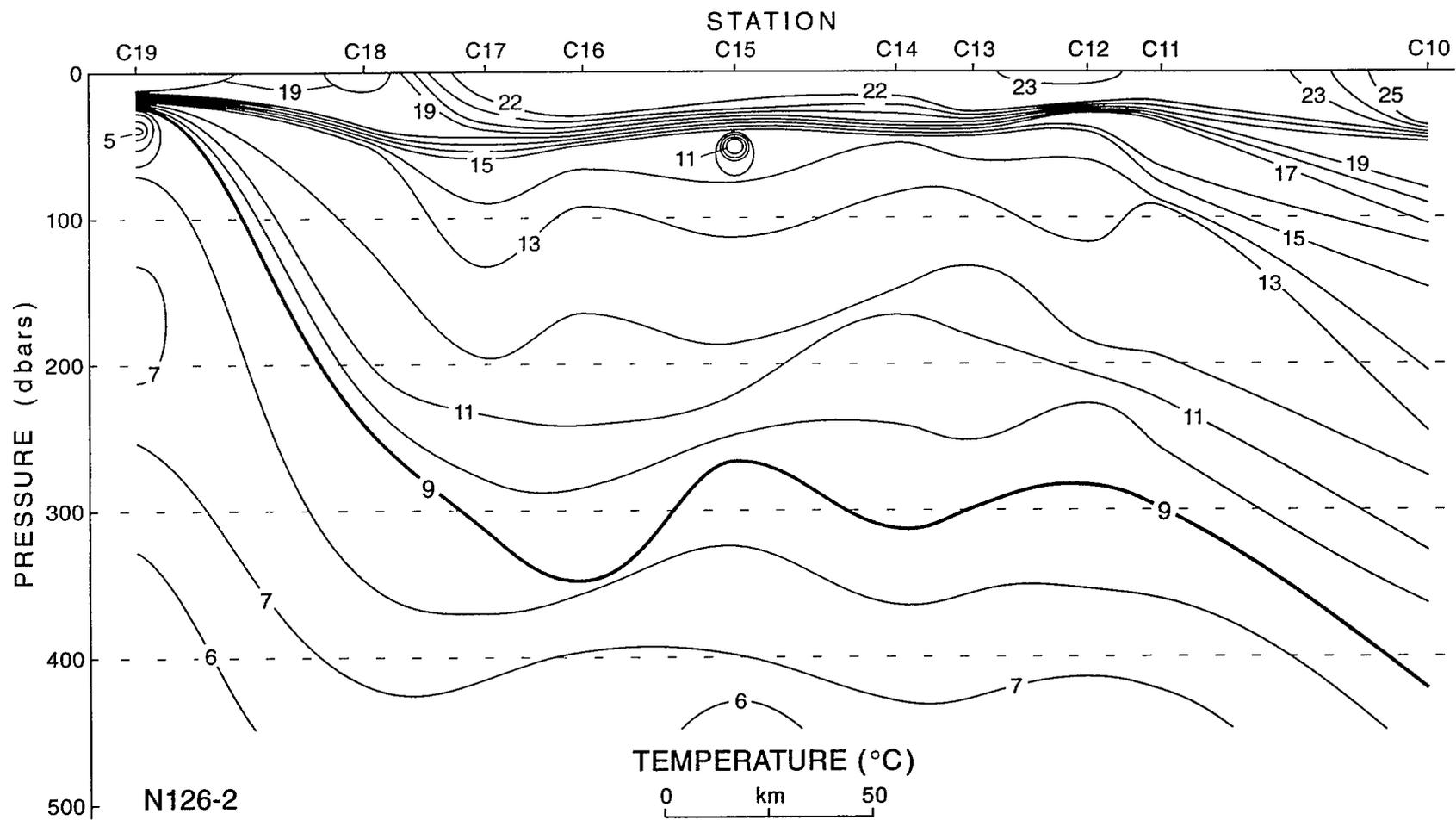


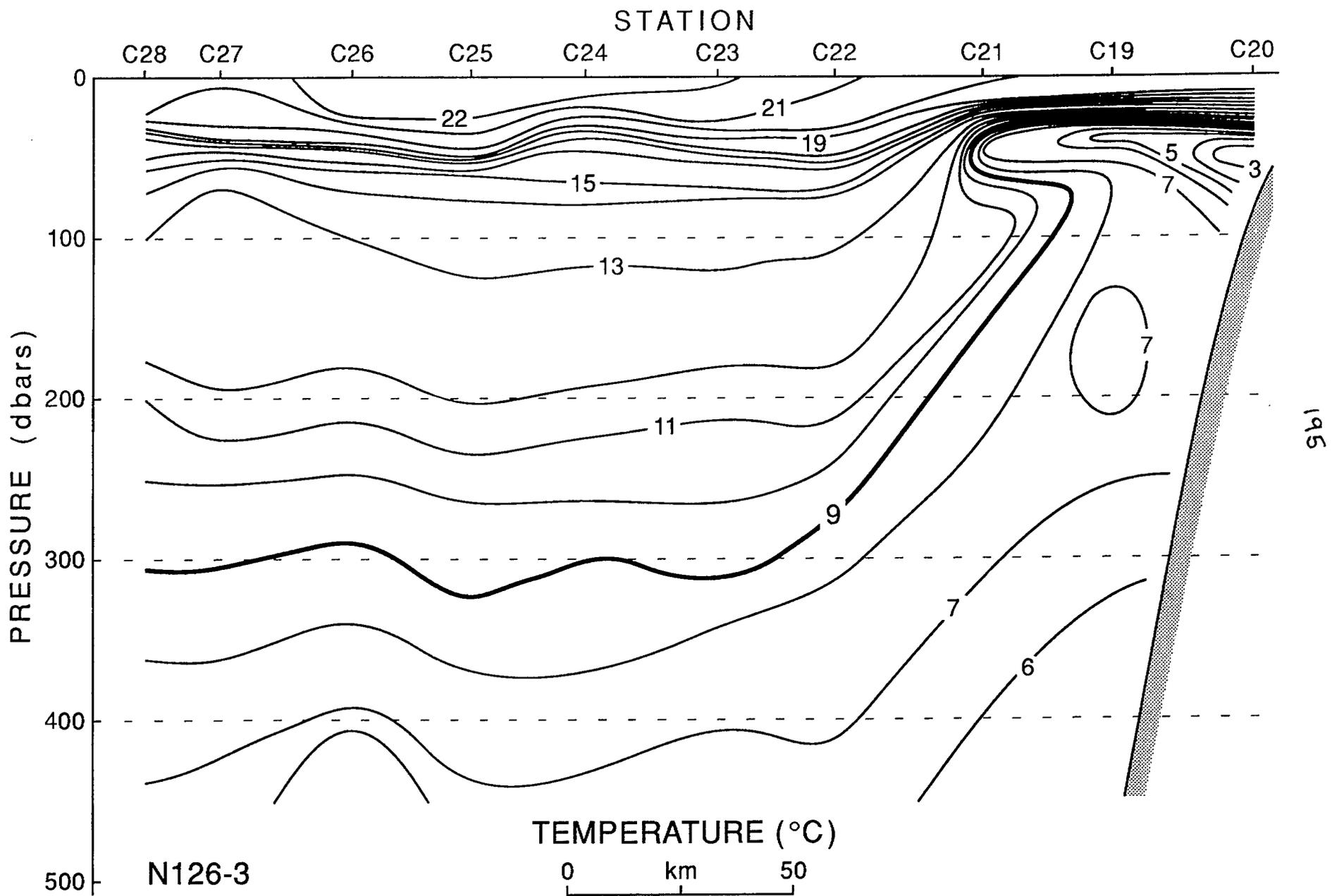
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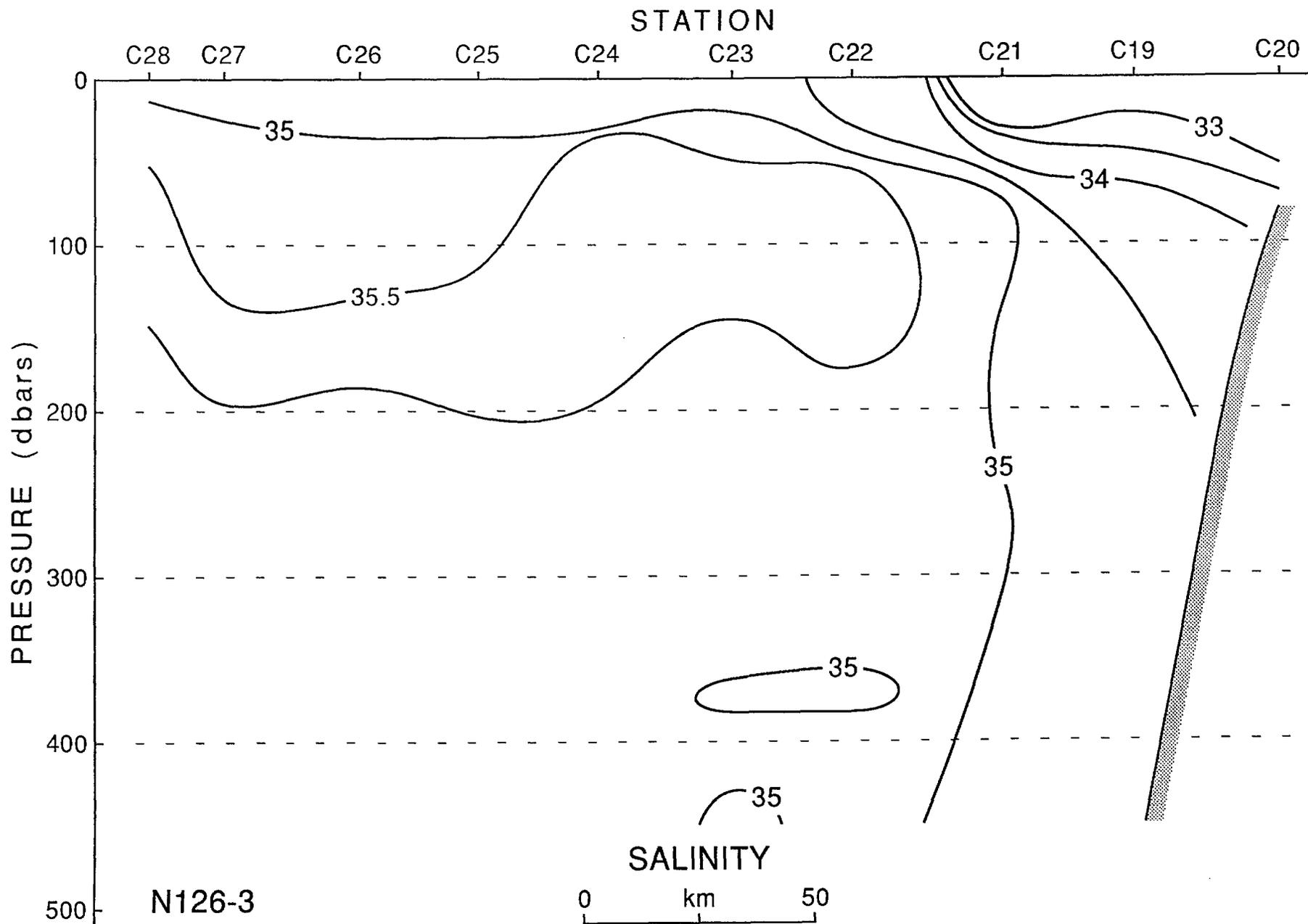


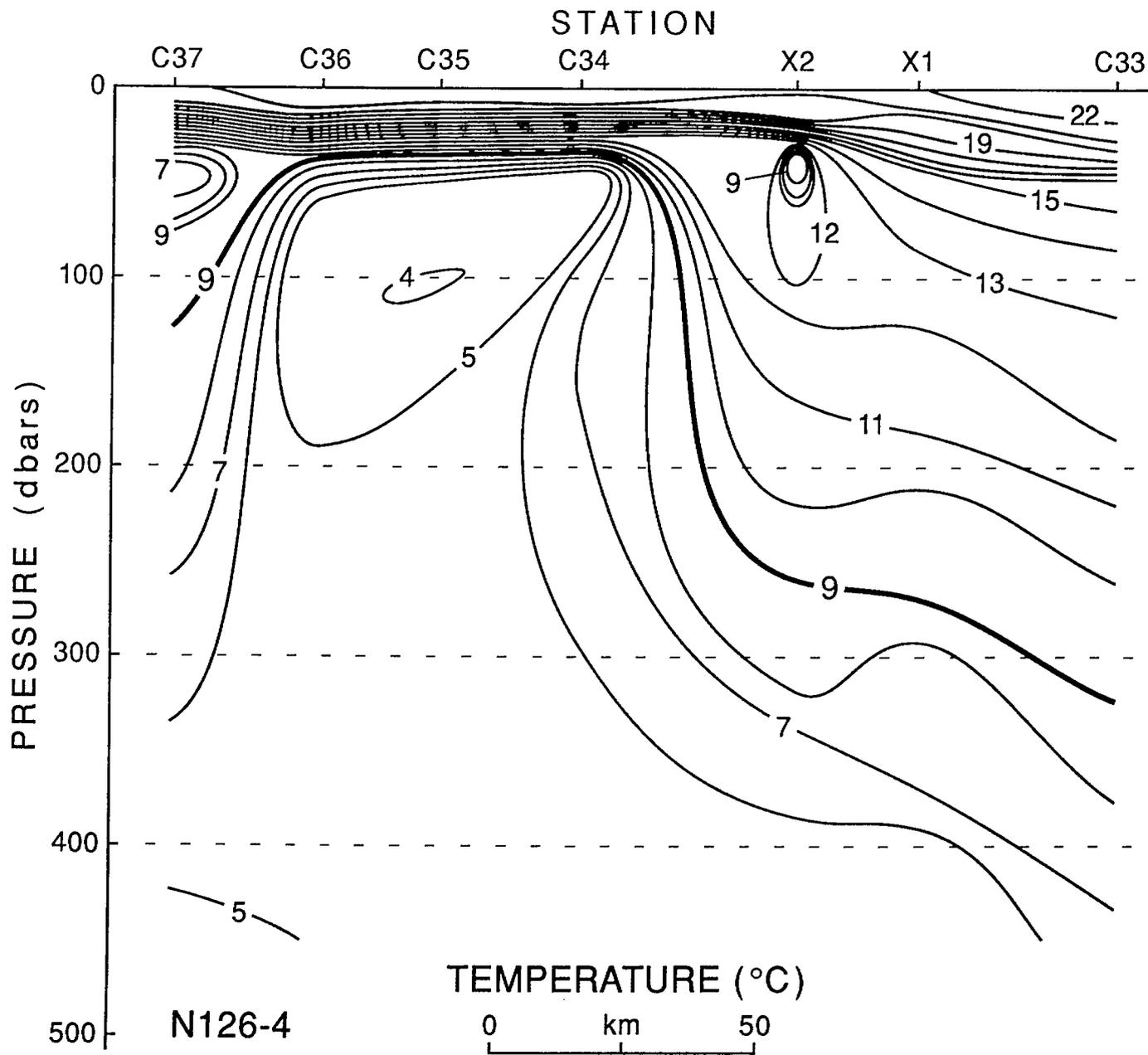






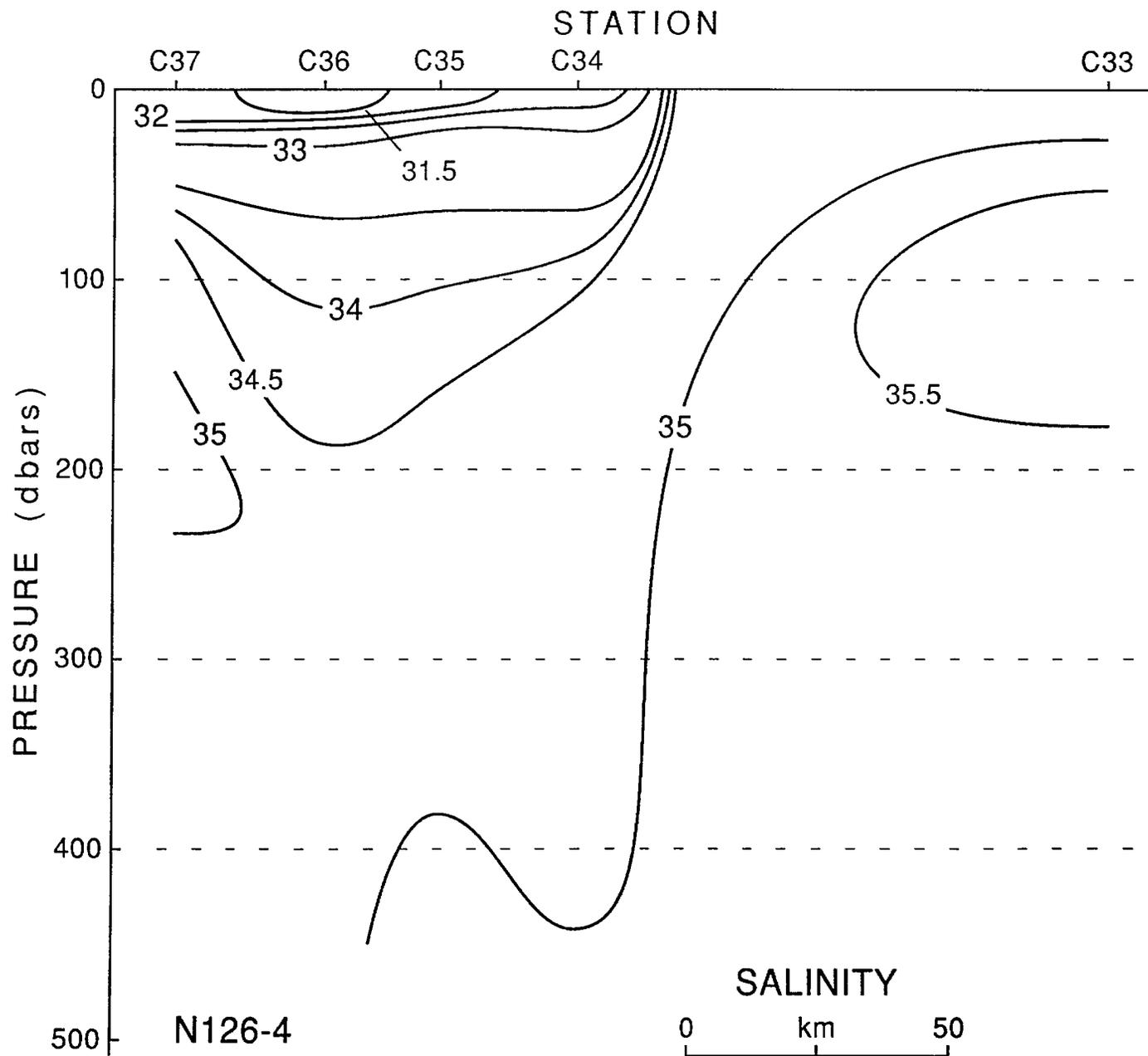






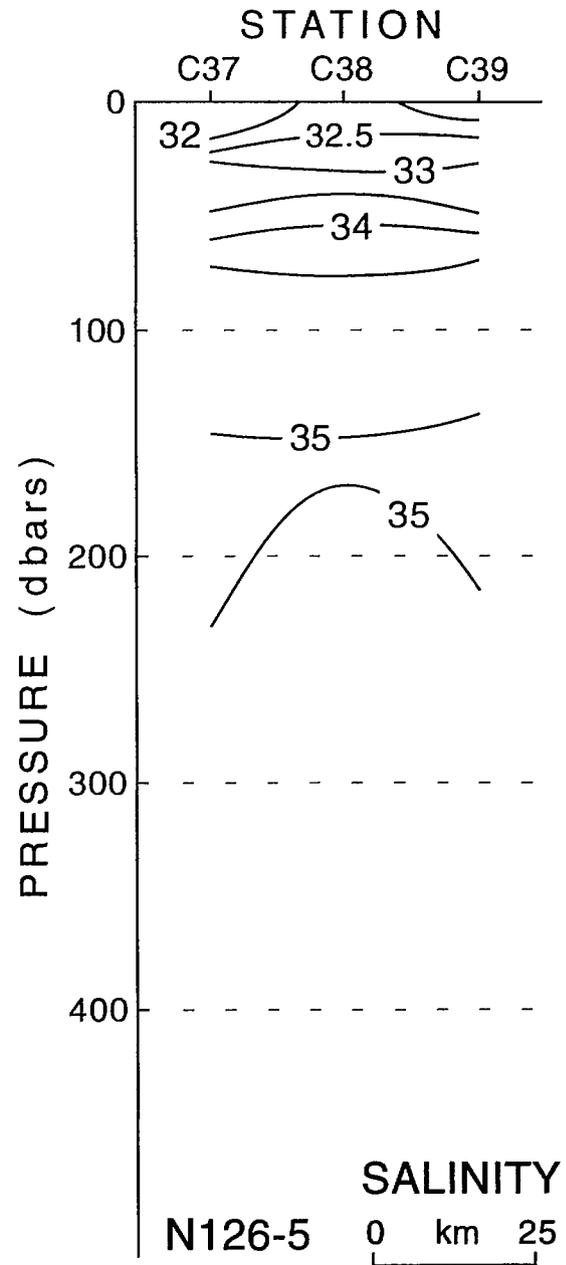
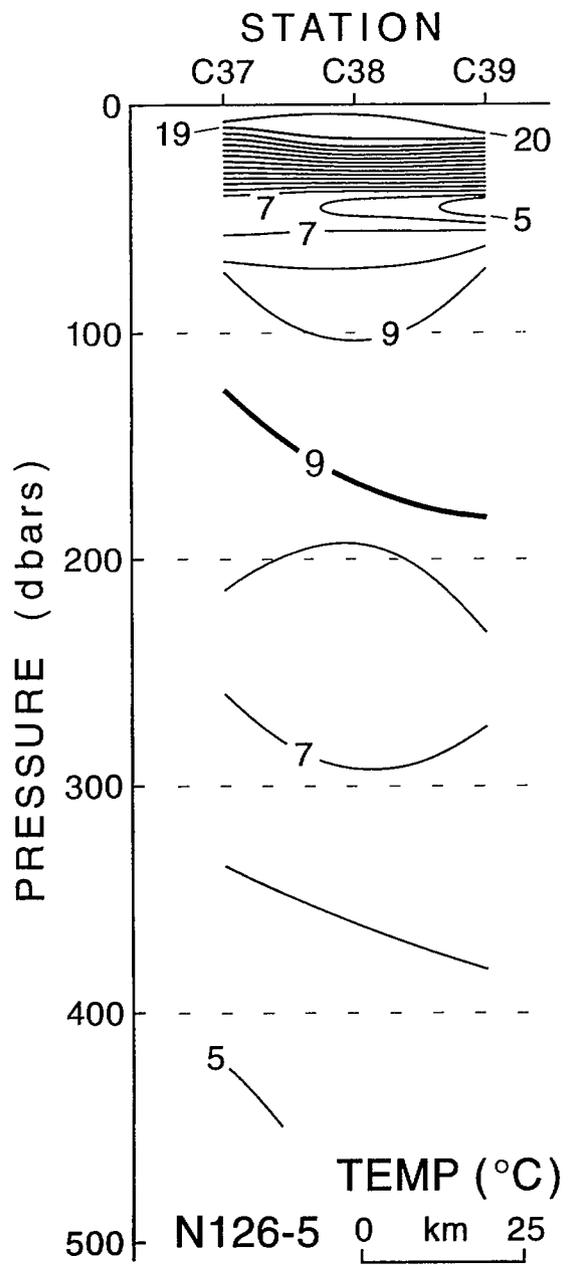
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HA39



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HA109



APPENDIX 2

Temperature-Salinity Plots

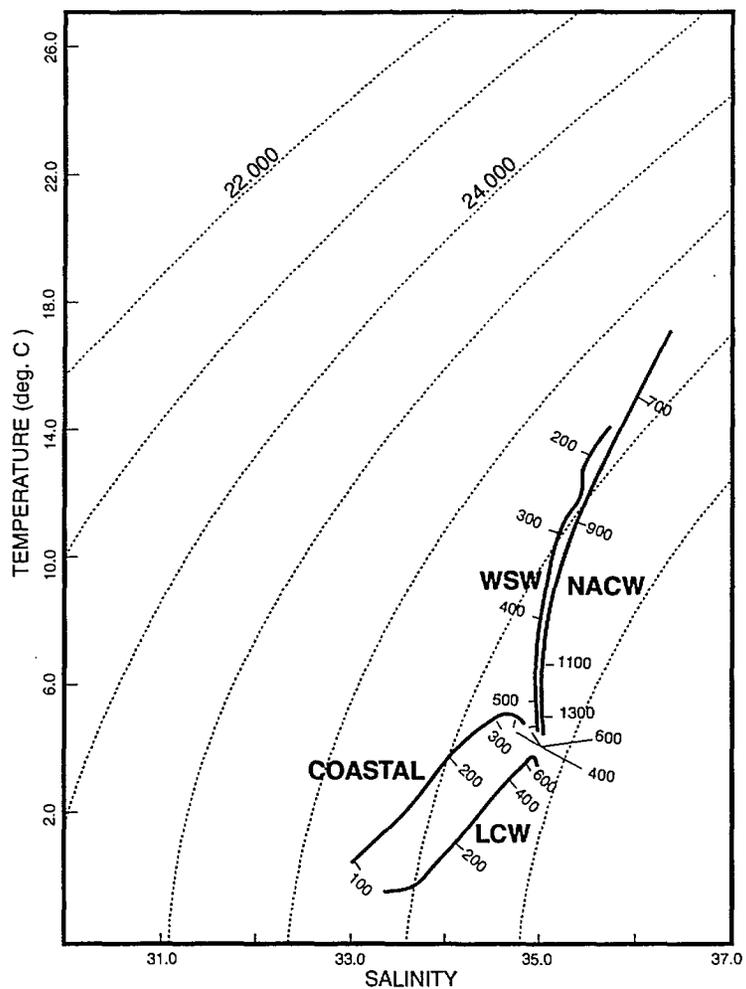
Plots are arranged by cruise and CTD cast number. Designators are placed above each plot. Lines of equal density are provided as background in each plot. The T-S relationships illustrated include data from the surface to 500 m, the standard cast, unless otherwise indicated. If the cast was terminated shallower than 500 m, the maximum depth reached is indicated at the end of the plot. When casts exceed 500 m, the location of 500 m on the plot is indicated and the maximum depth is also given at the end of the plot. The location of 200 m is indicated on all plots with an asterisk.

Published T-S curves characteristic of the water masses in the Slope Sea are provided for comparison with observational data. McLellan's (1957) curves for Atlantic (NACW), Slope (WSW), Labrador (LCW), and Coastal waters are included in the first figure. Petrie's and Drinkwater's (1993) curves for NACW and LCW and T-S envelopes for Warm Slope Water (WSW) and Labrador Slope Water (LSW) are in the second figure. McLellan's Coastal Water curve was derived from data collected in Cabot Strait and he points out that this curve is more characteristic of the waters found in the Laurentian Channel and Gulf of St. Lawrence. He found the water between the continental shelf and the Slope Water boundary more variable. The Petrie and Drinkwater plots of Gatien's (1976) data are based on observations actually in LSW as well as in WSW, and present data conform better with these than with McLellan's T-S plots.

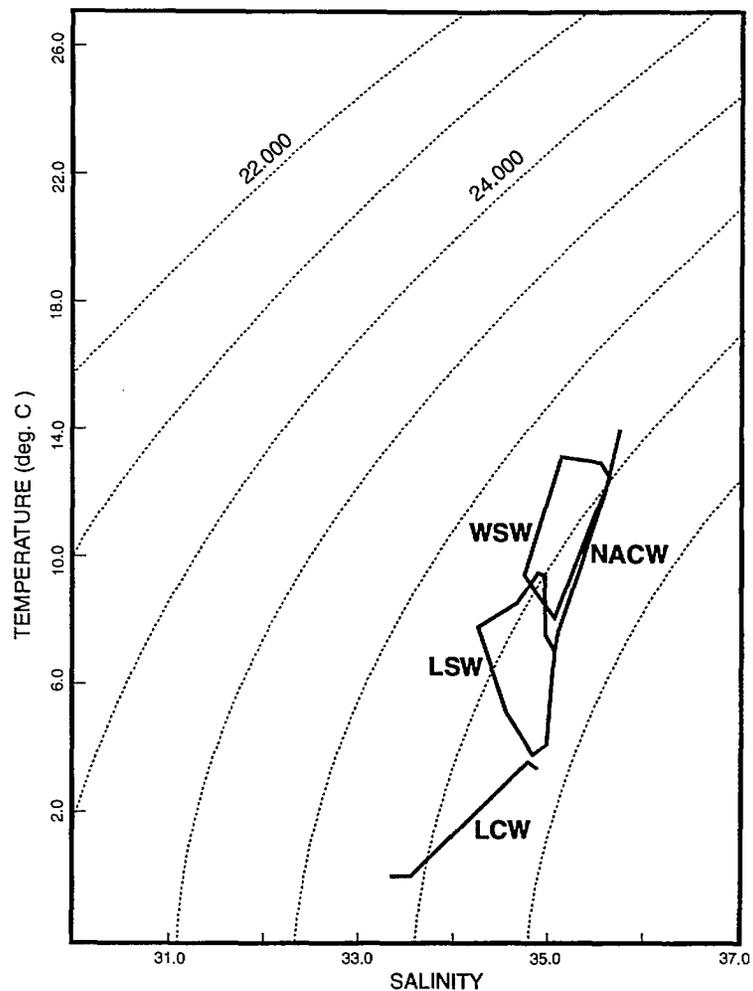
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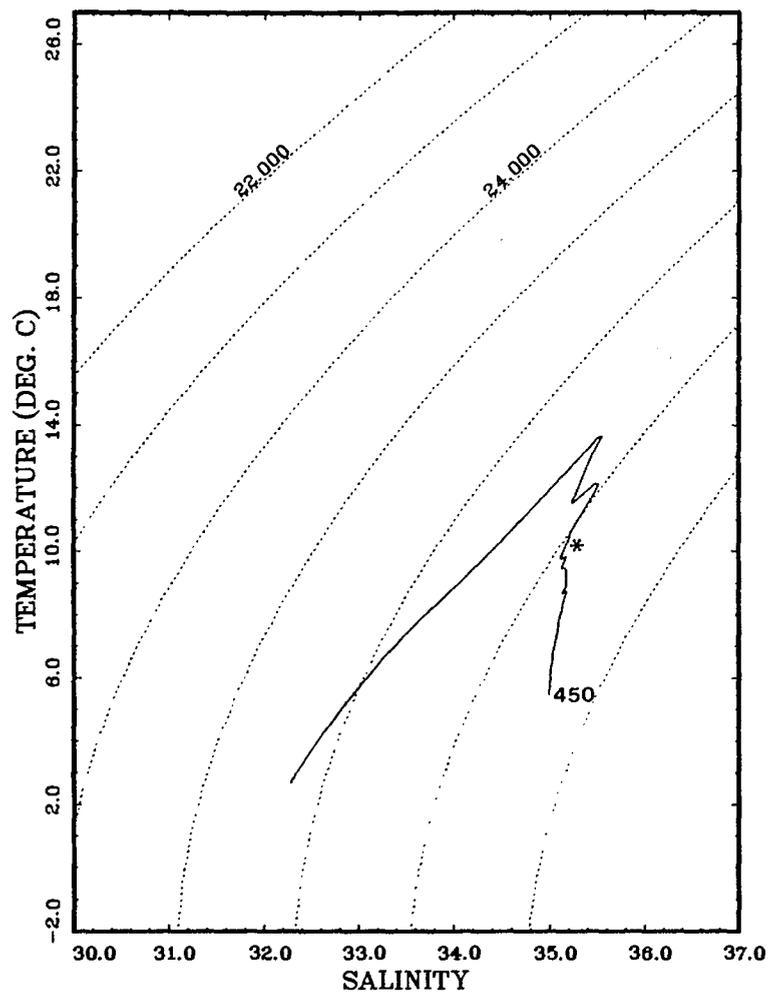
Appendix 2 - Figure 1: McLellan's (1957) T-S curves for Atlantic (NACW), Slope (WSW), Labrador (LCW), and Coastal waters.



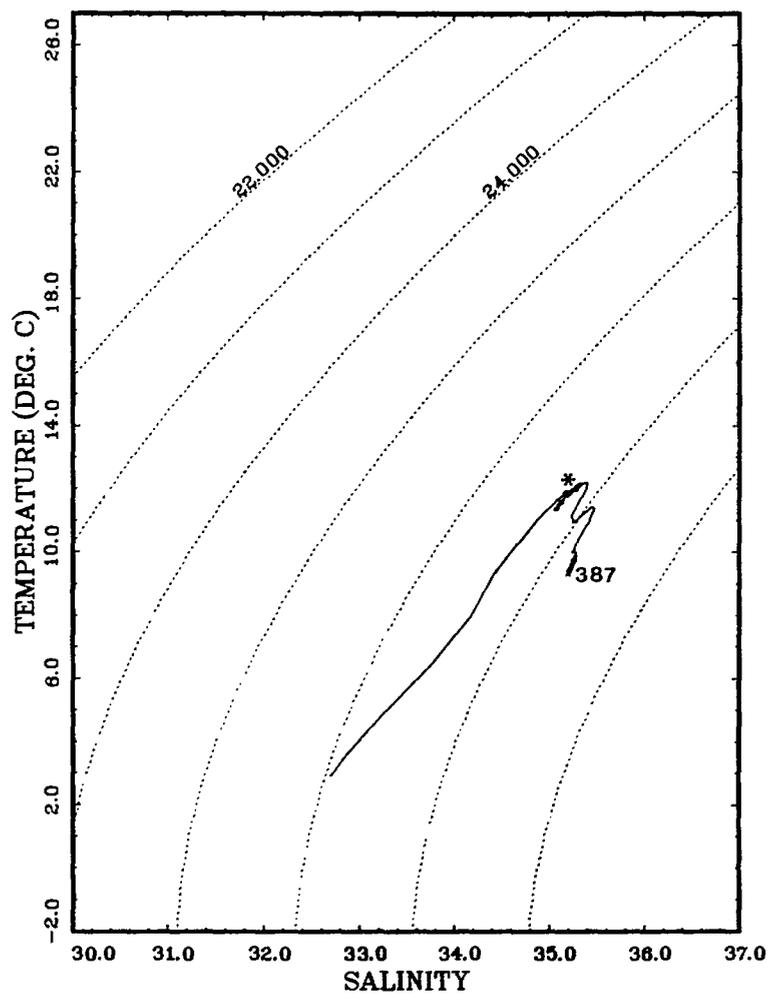
Appendix 2 - Figure 2: Petrie and Drinkwater's (1993) T-S curves for NACW and LCW, and T-S envelopes for Warm Slope Water (WSW) and Labrador Slope Water (LSW) at depths ≥ 100 m.



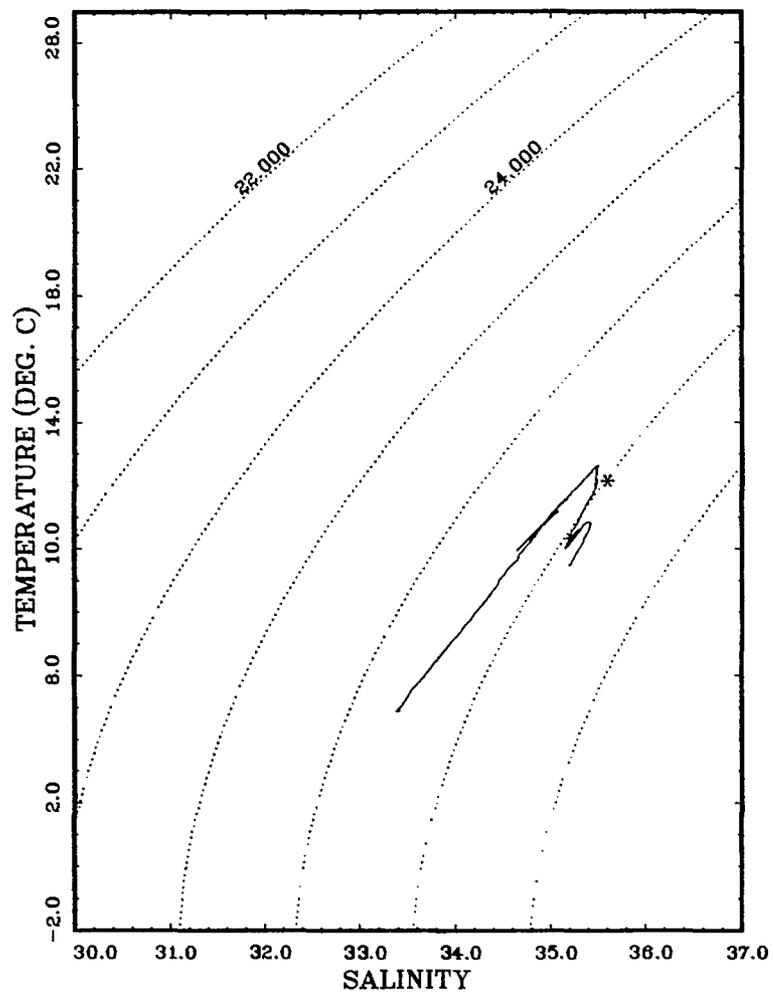
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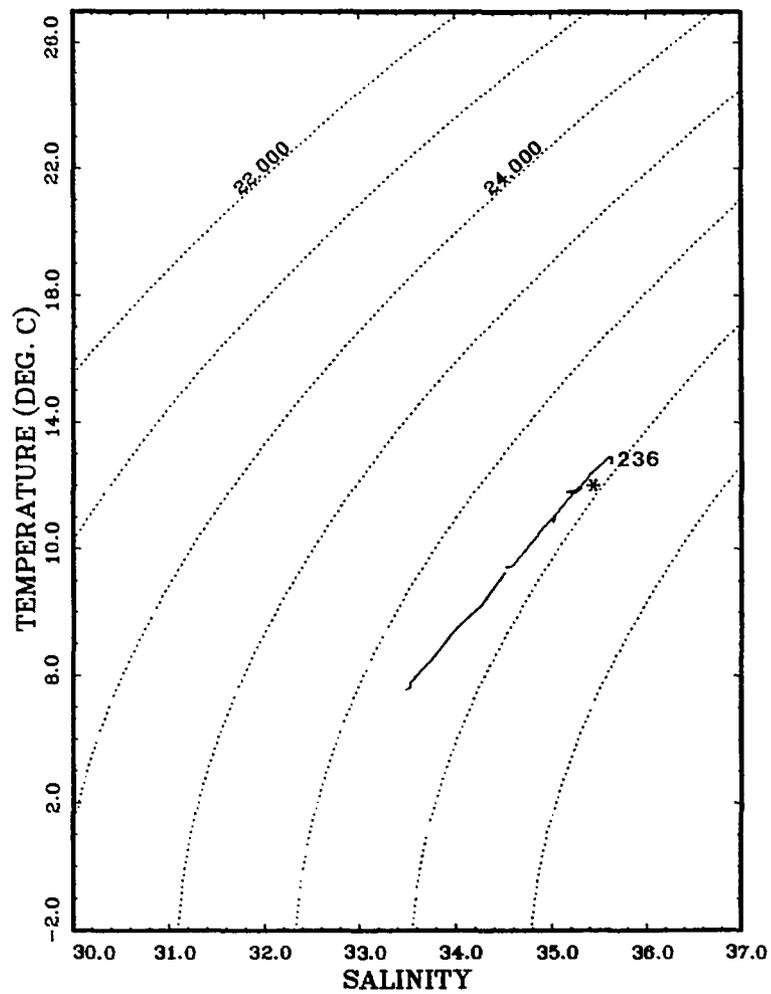
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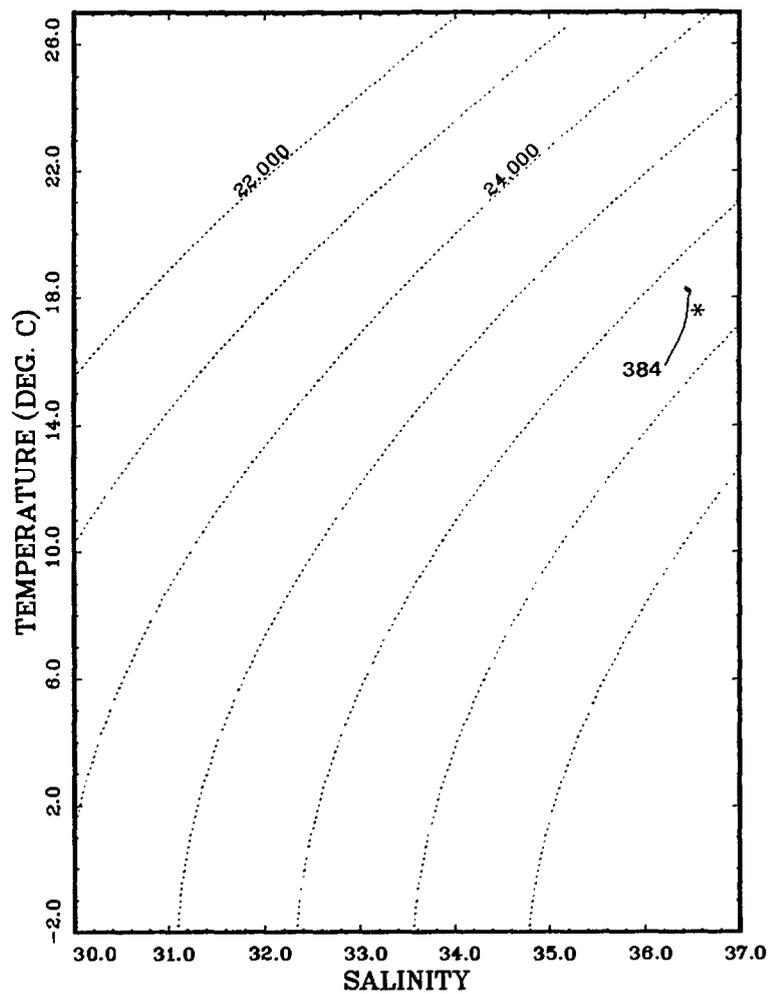
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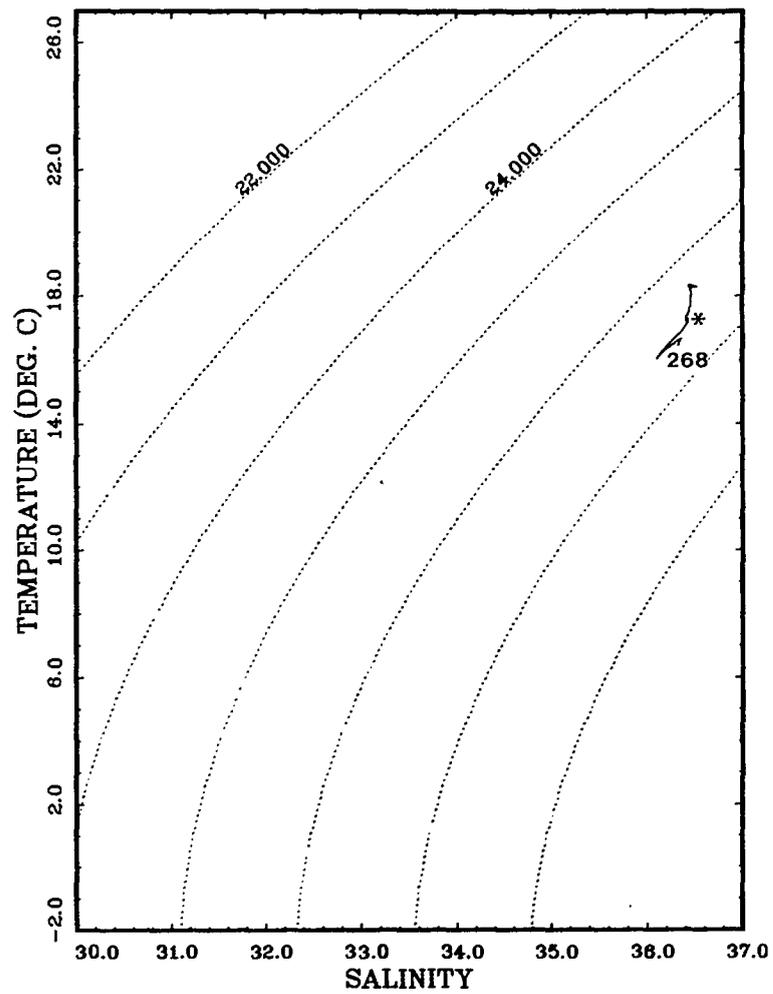
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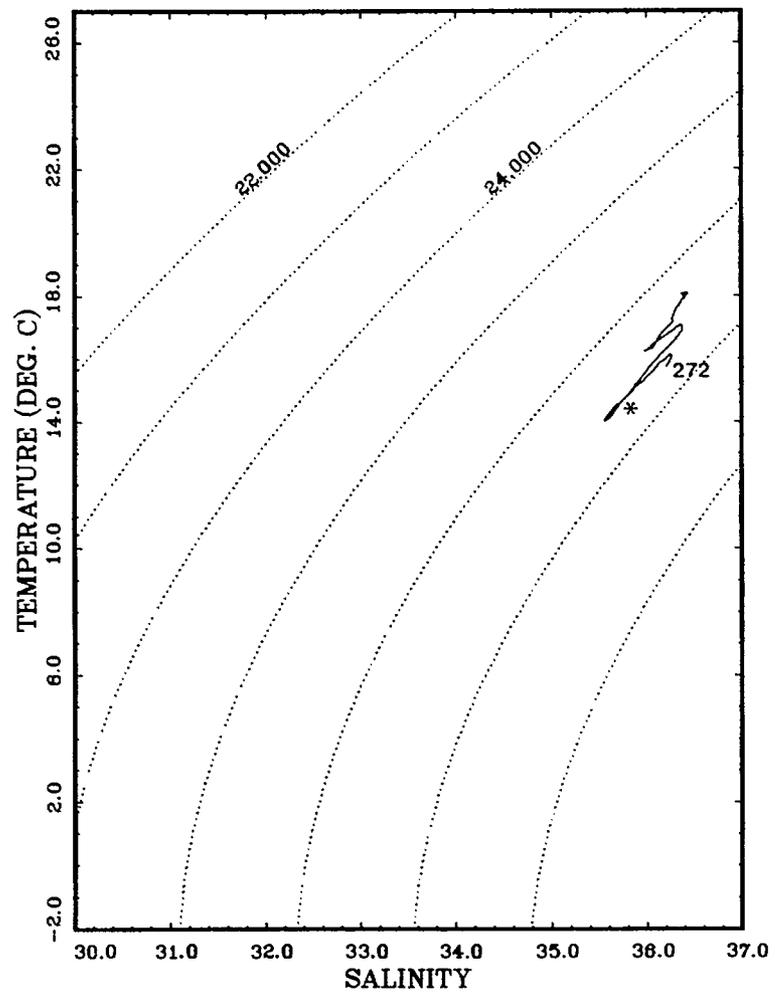
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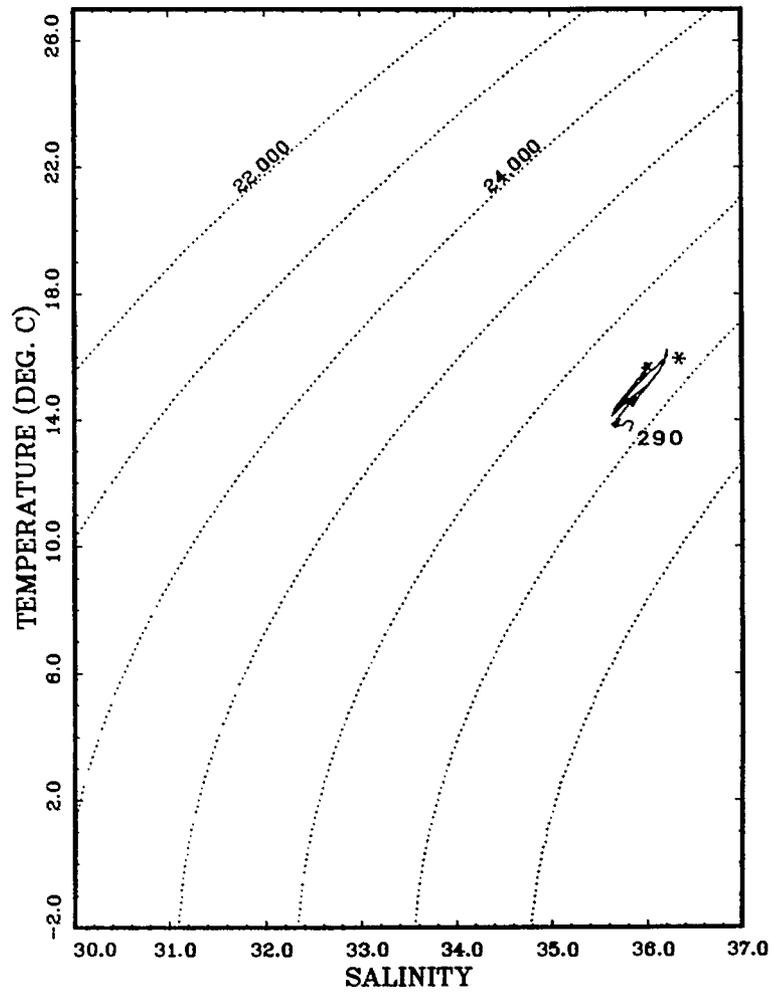
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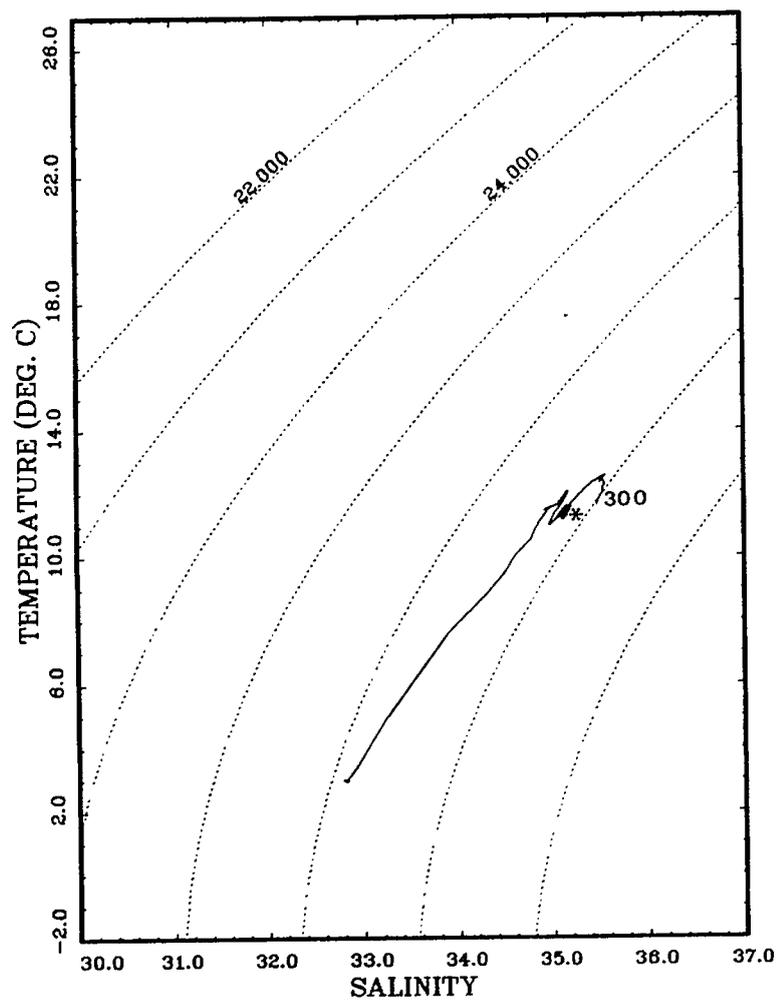
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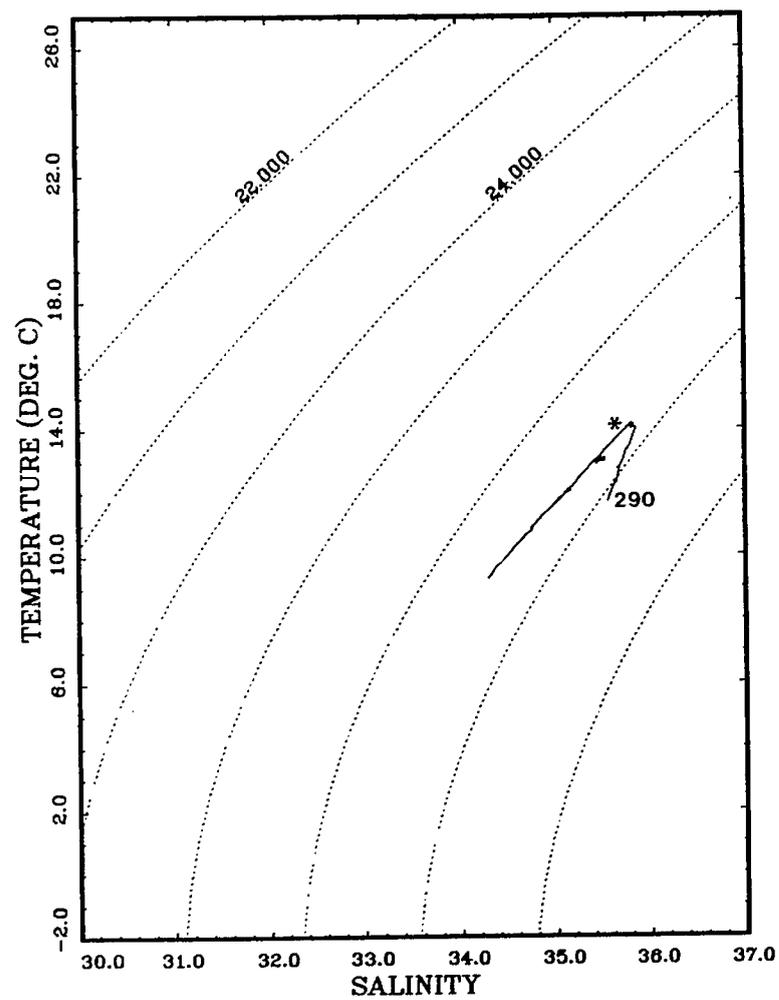
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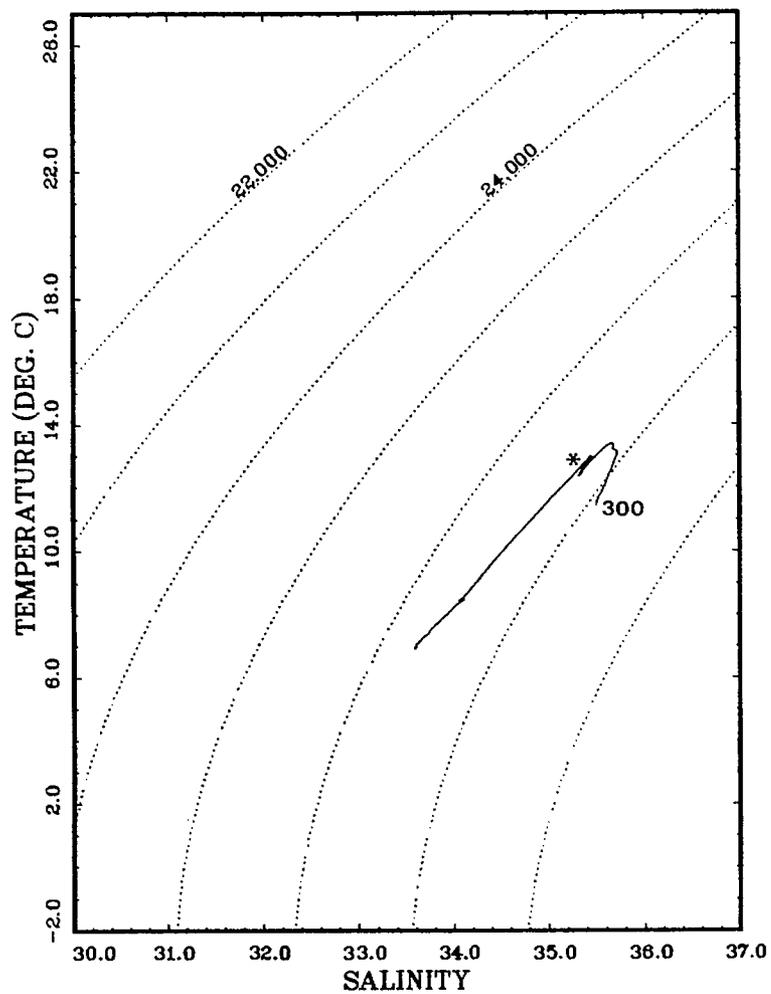
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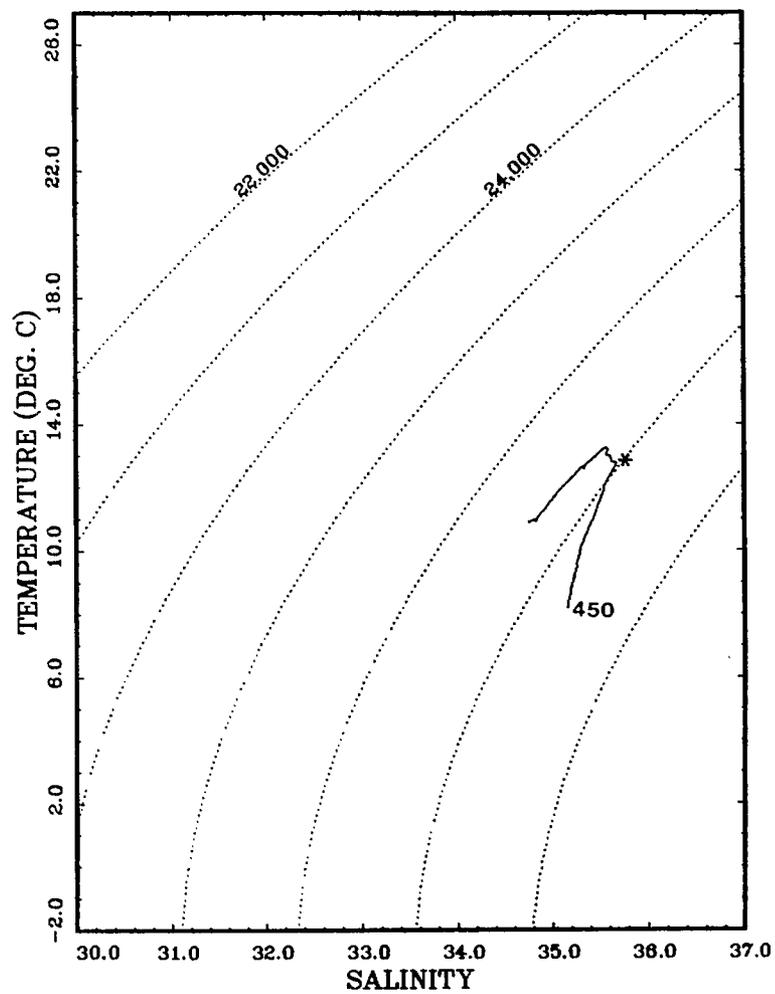
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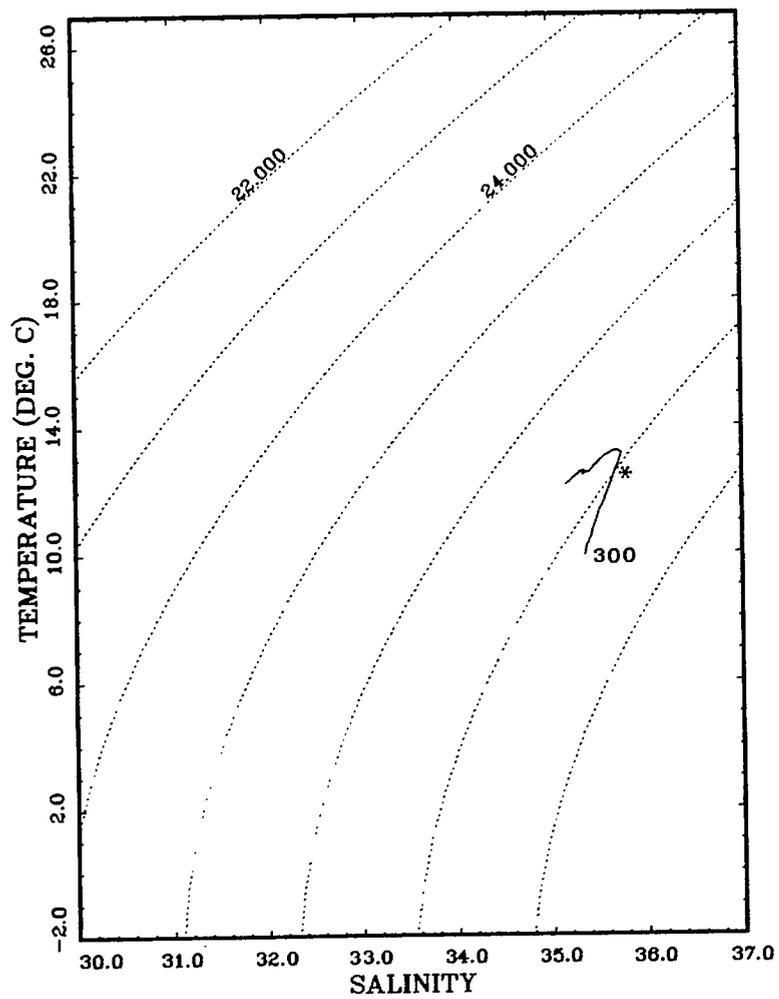
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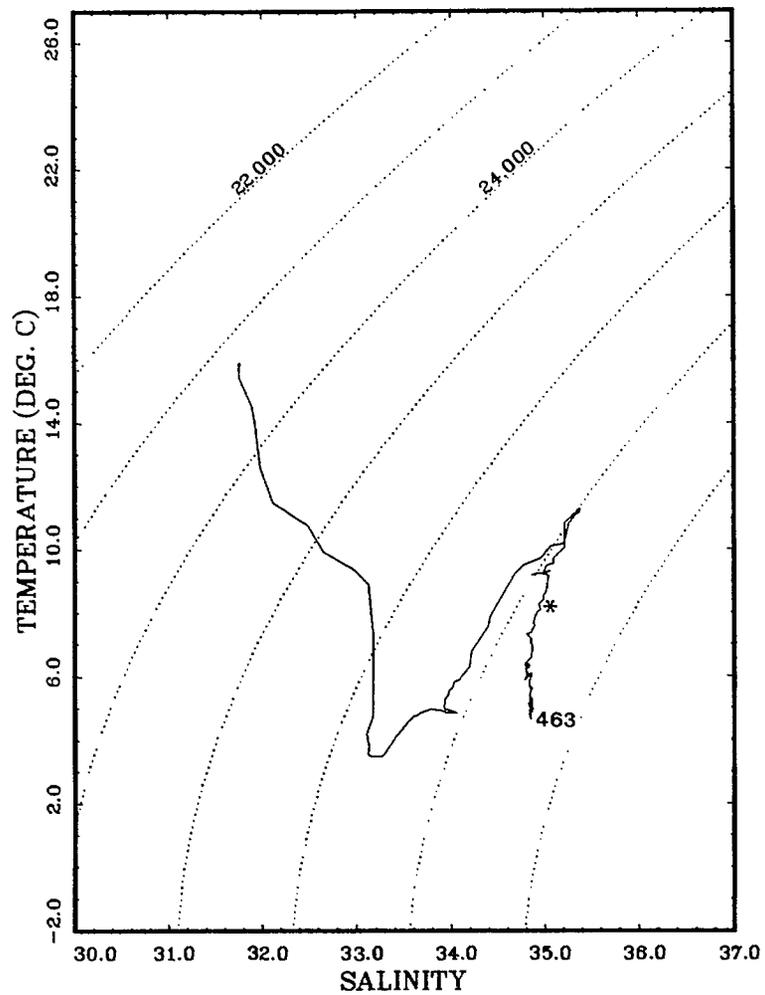
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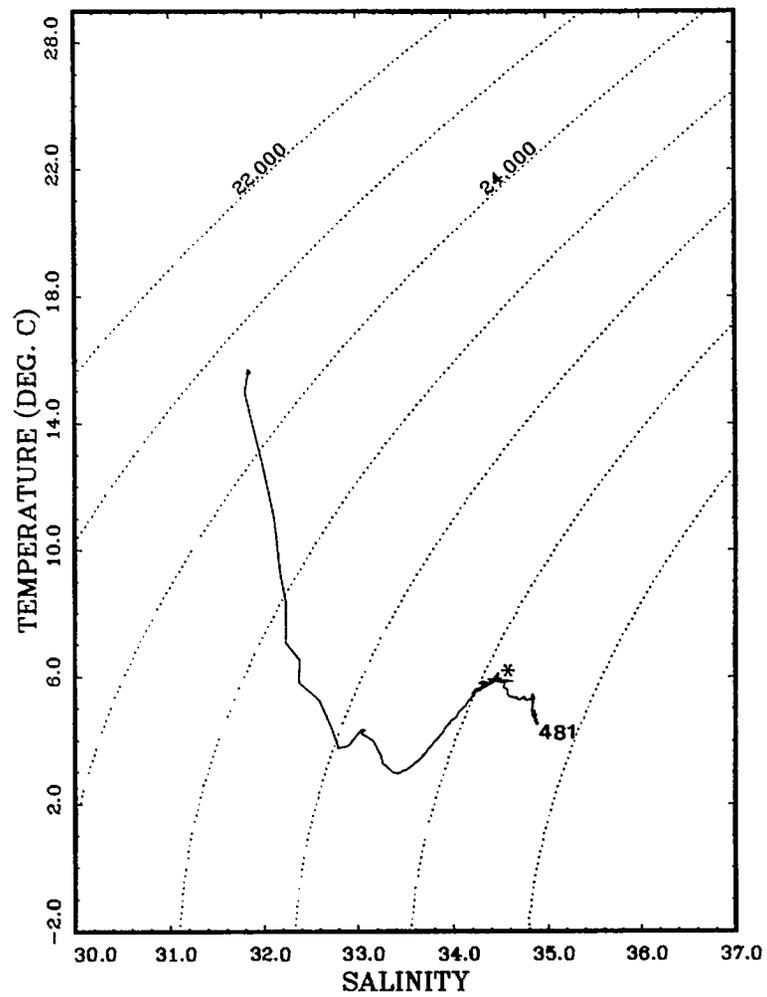
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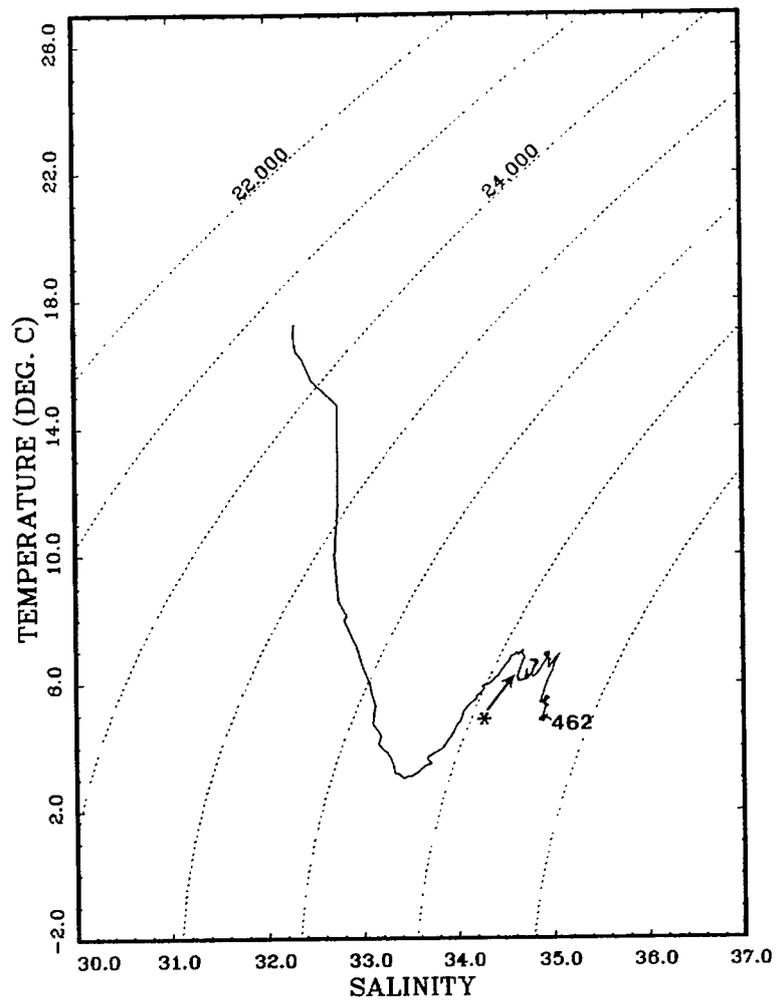
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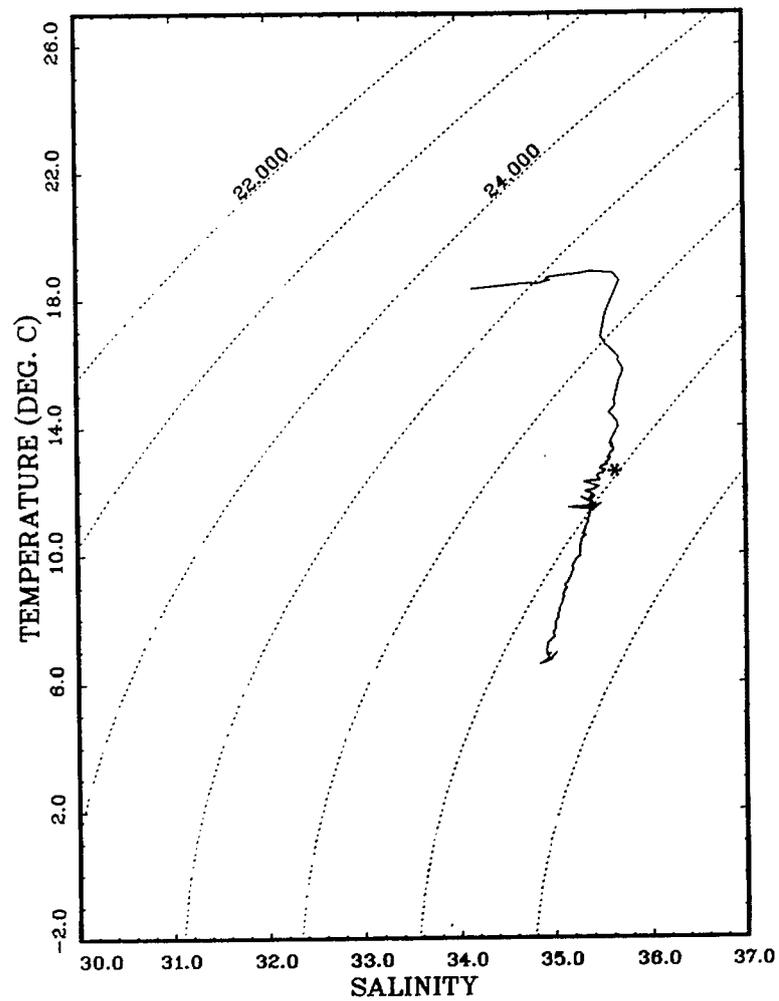
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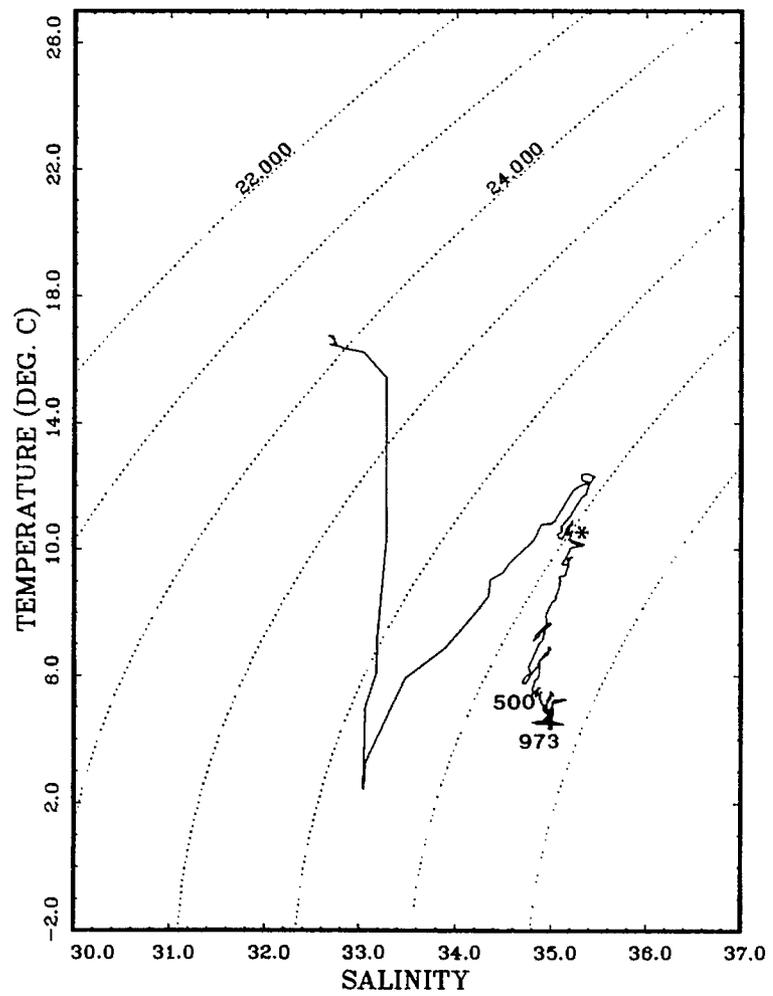
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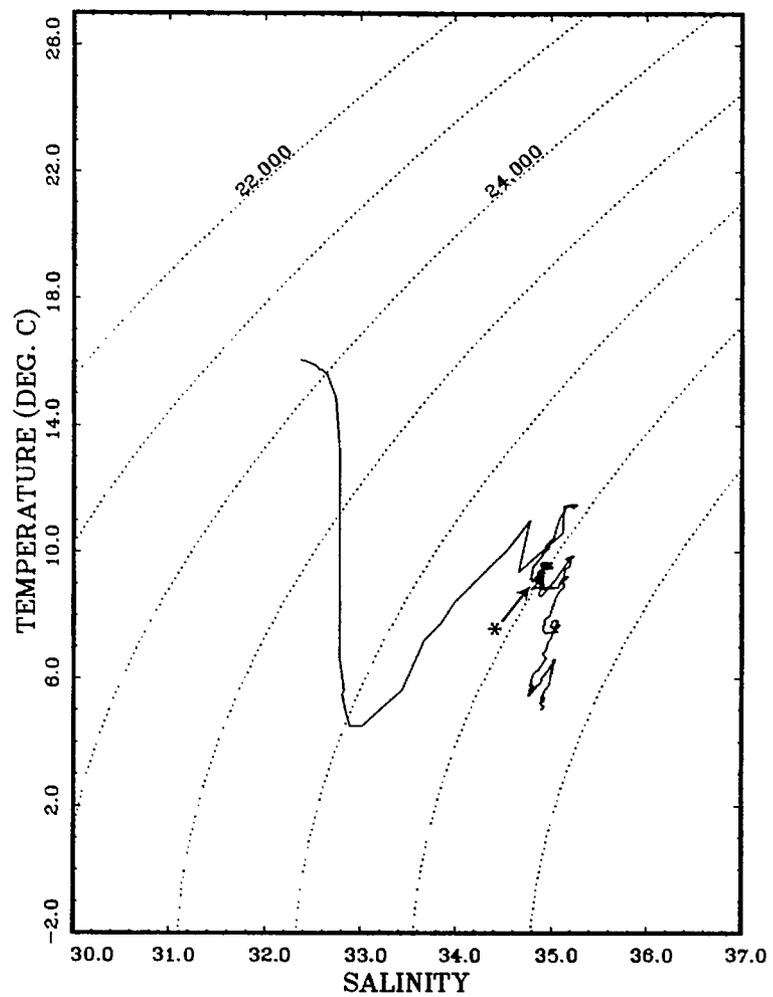
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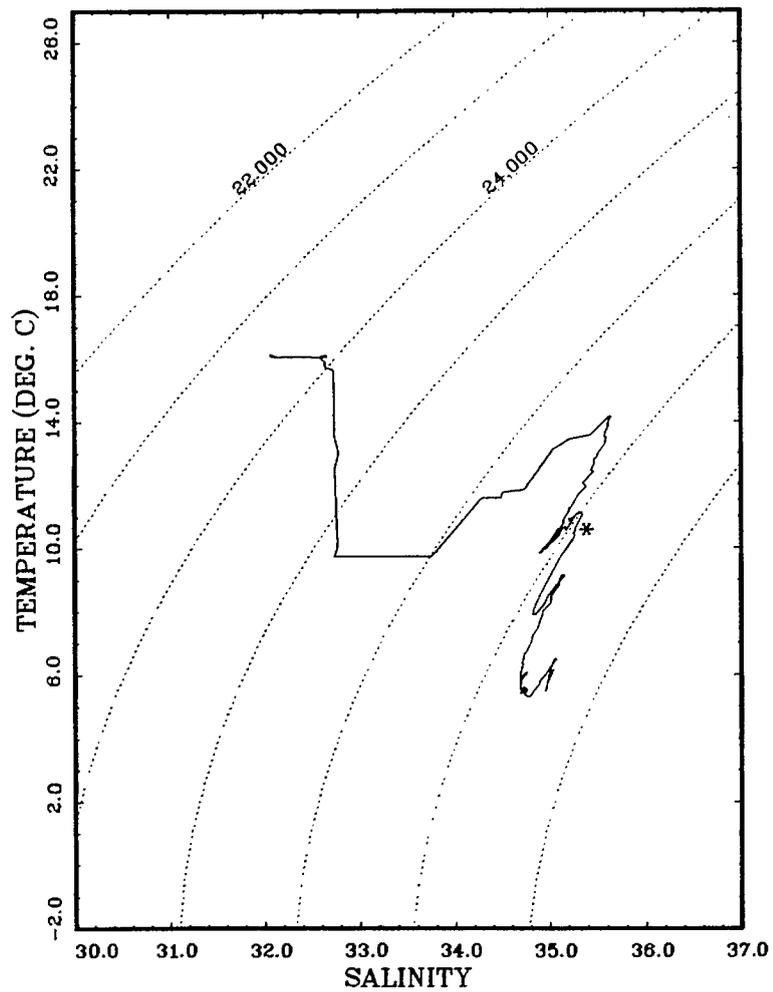
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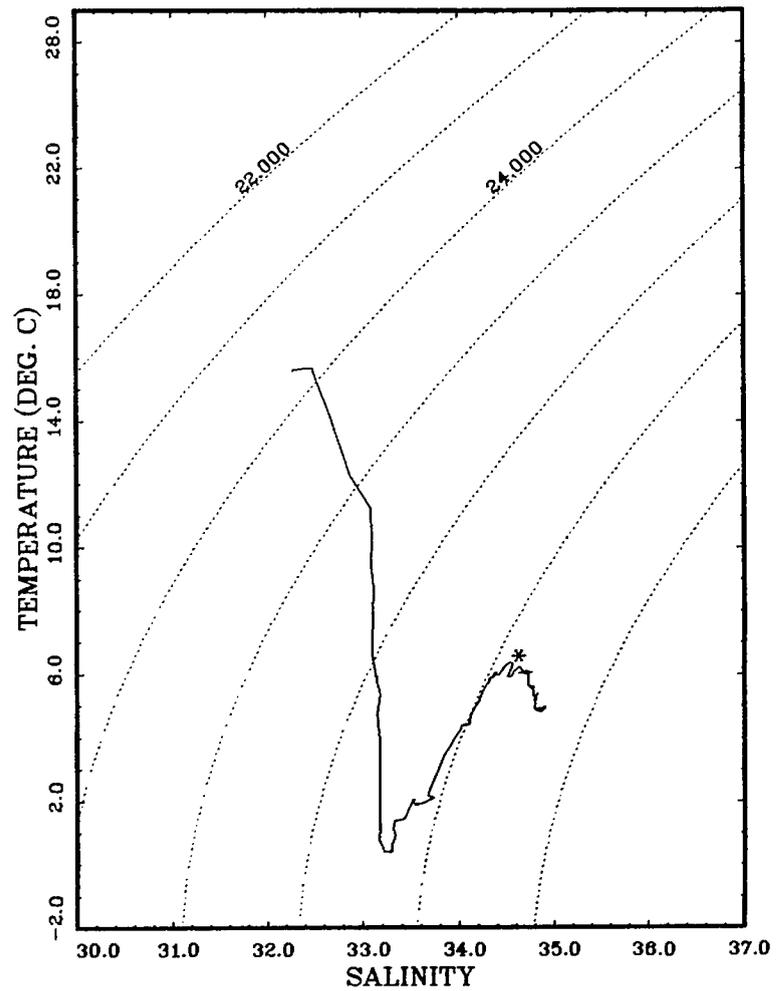
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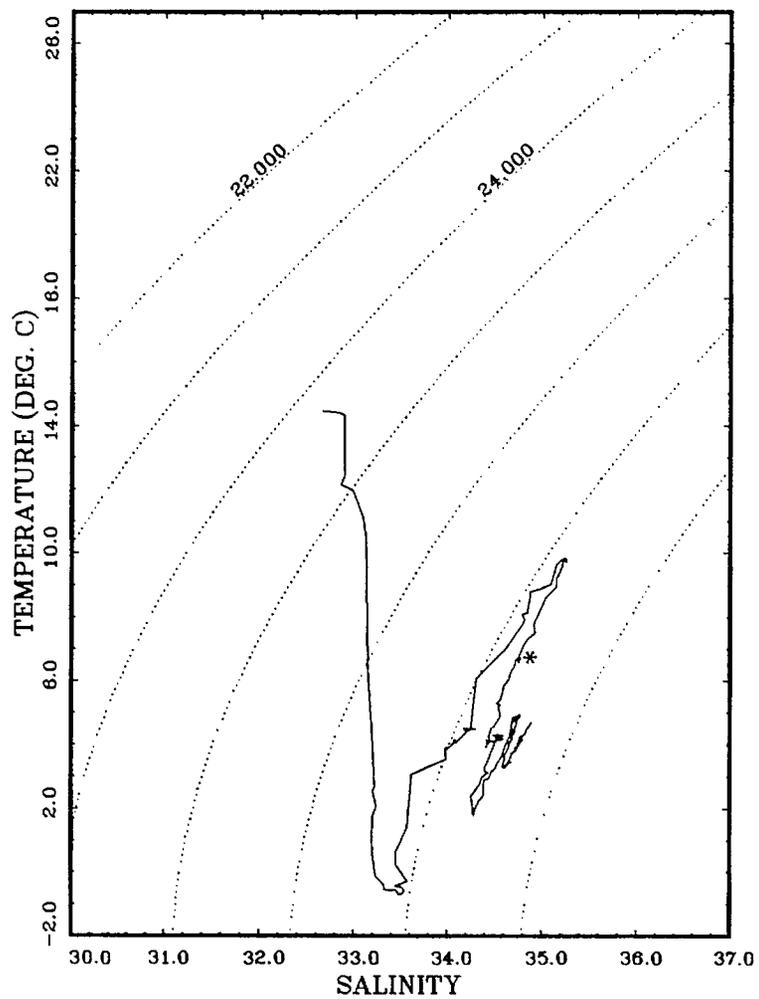
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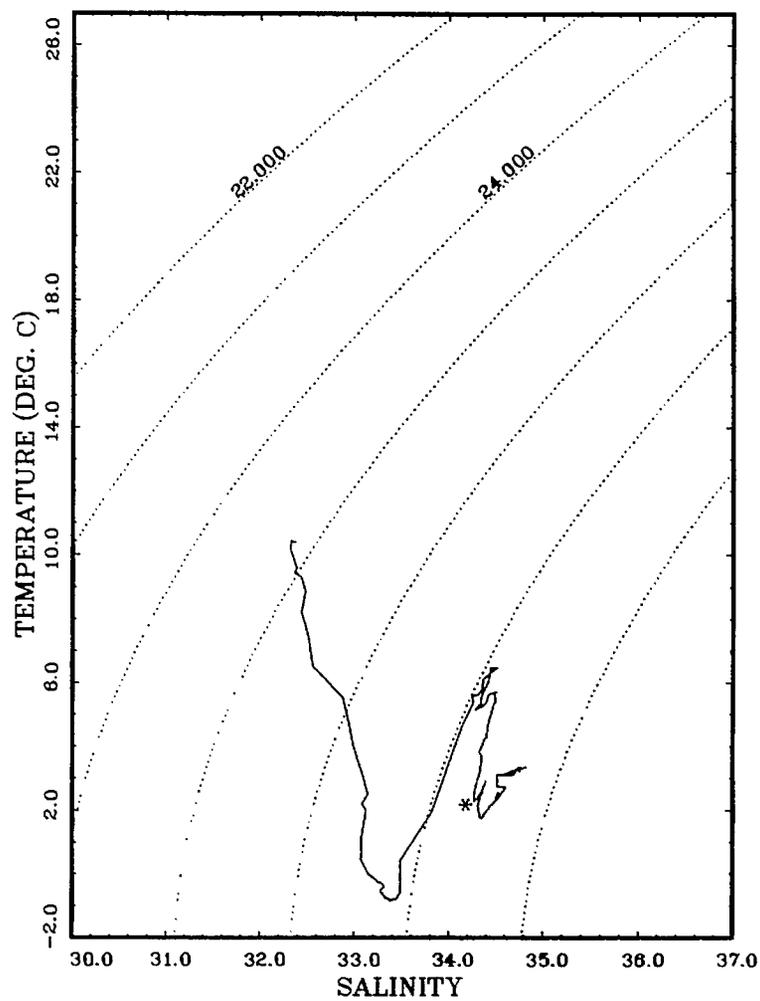
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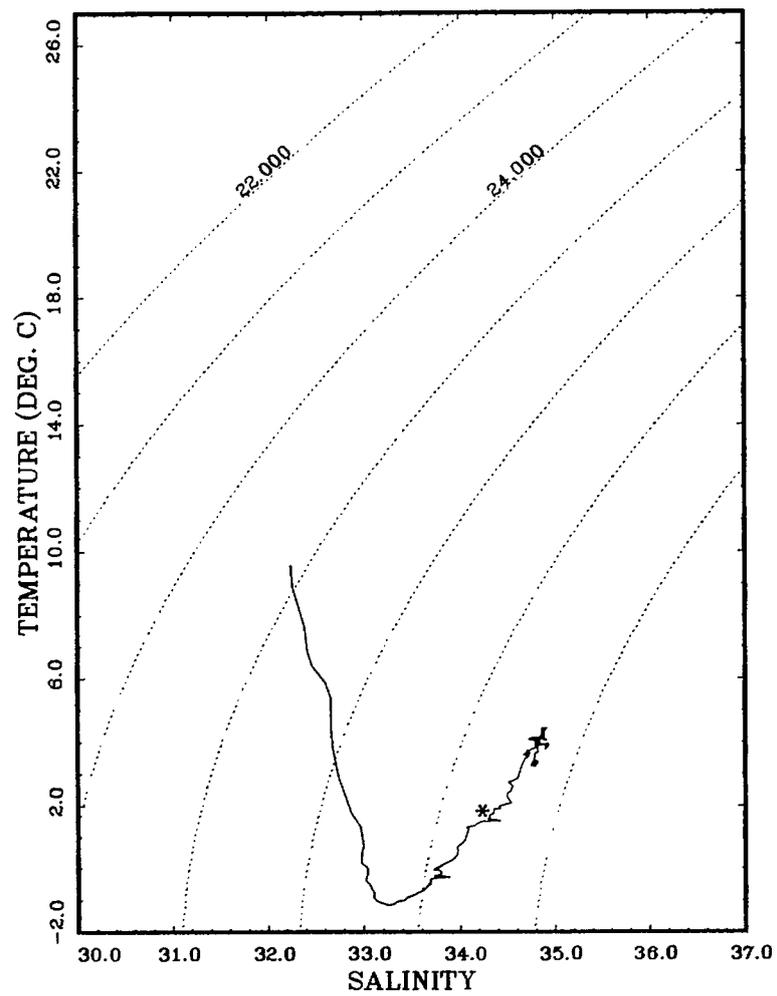
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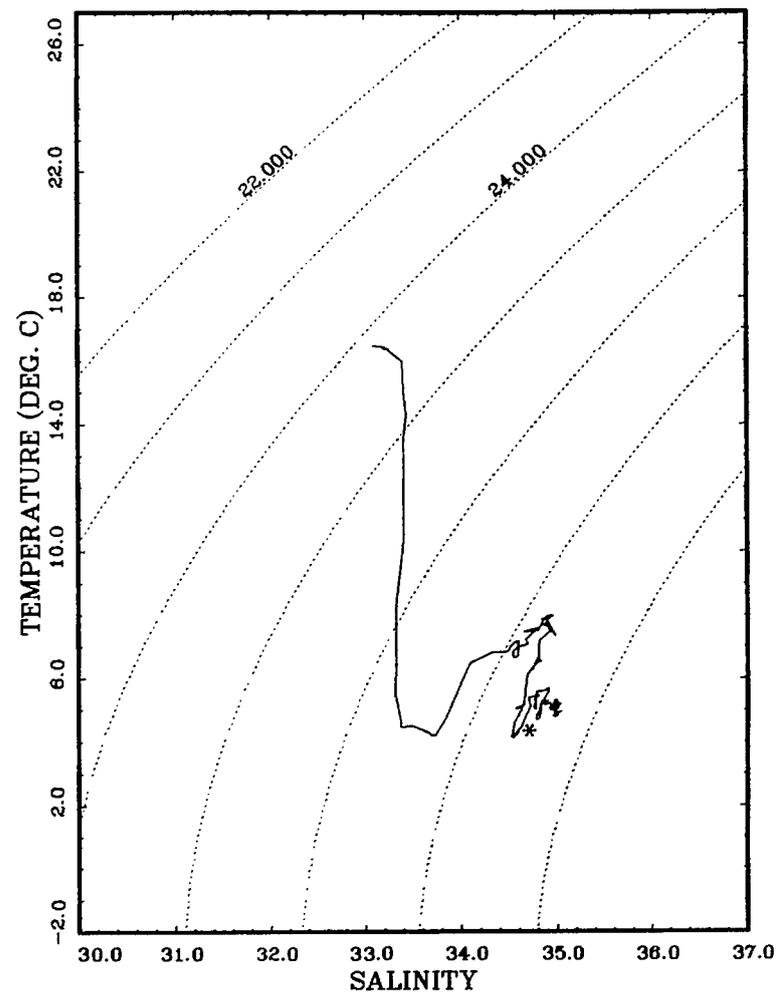
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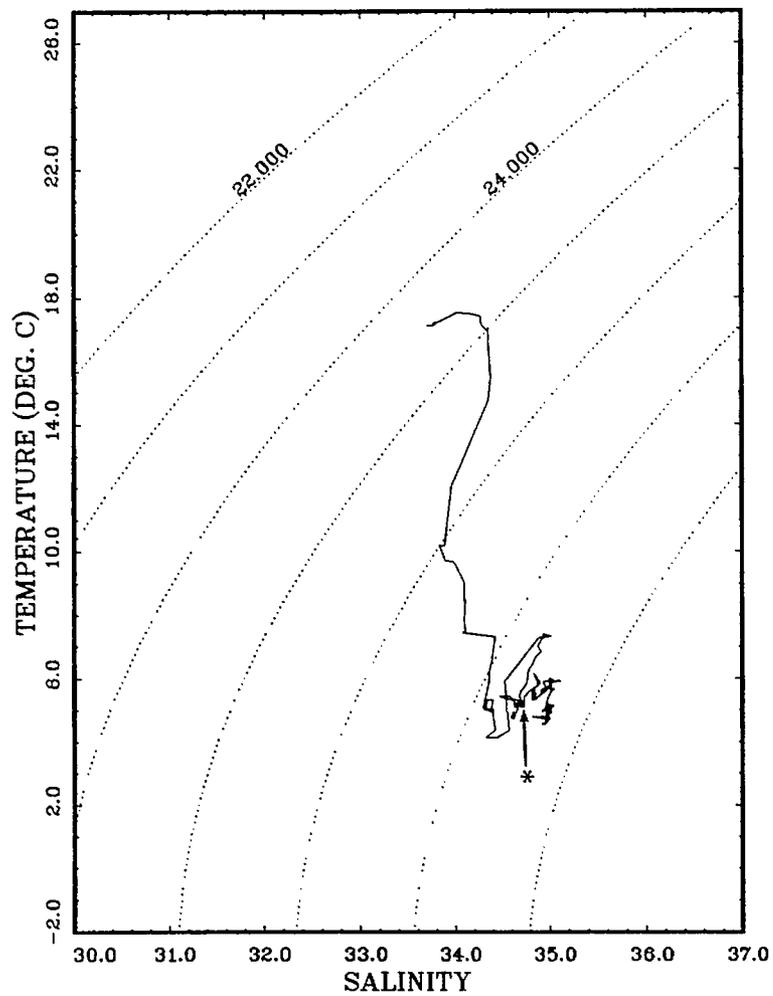
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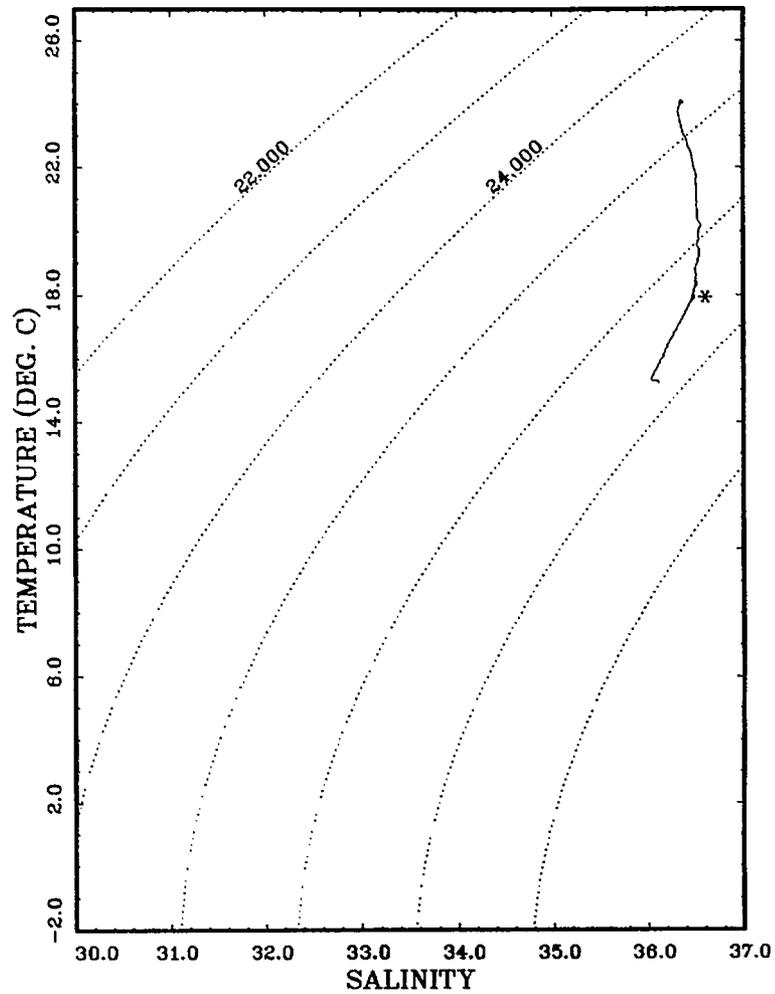
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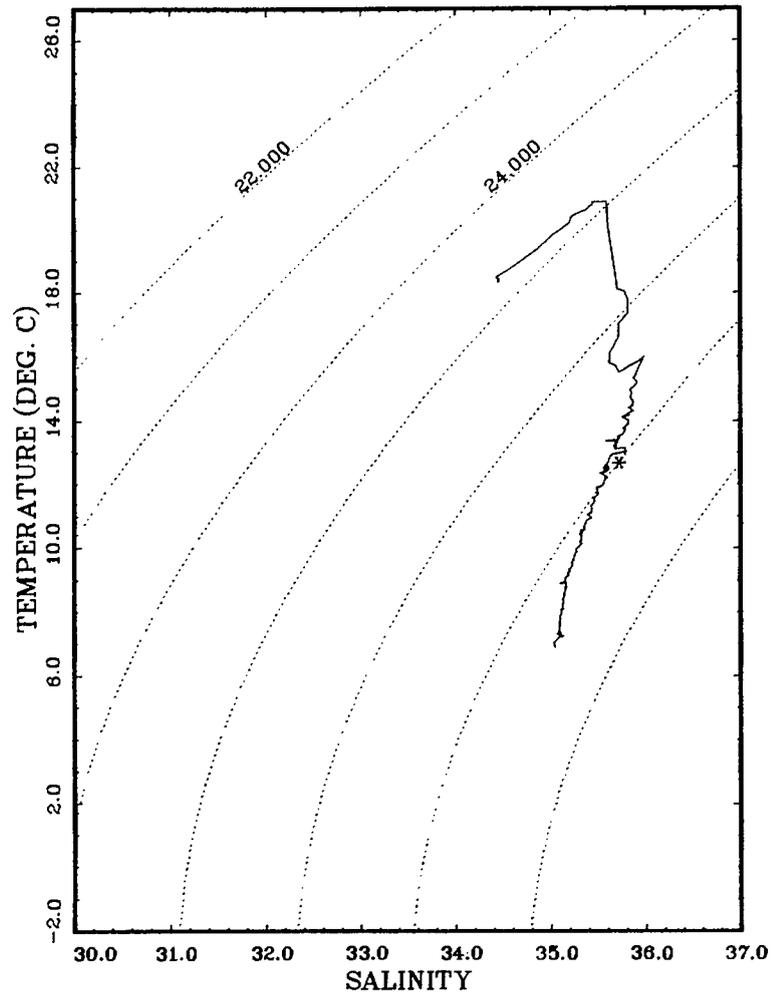
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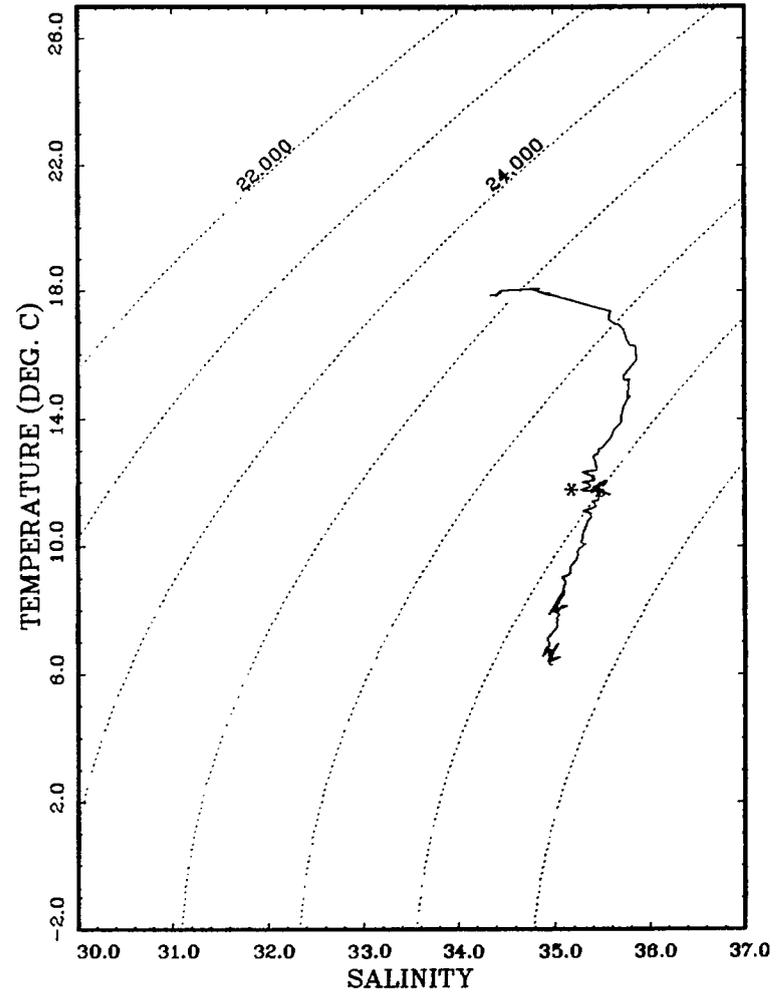
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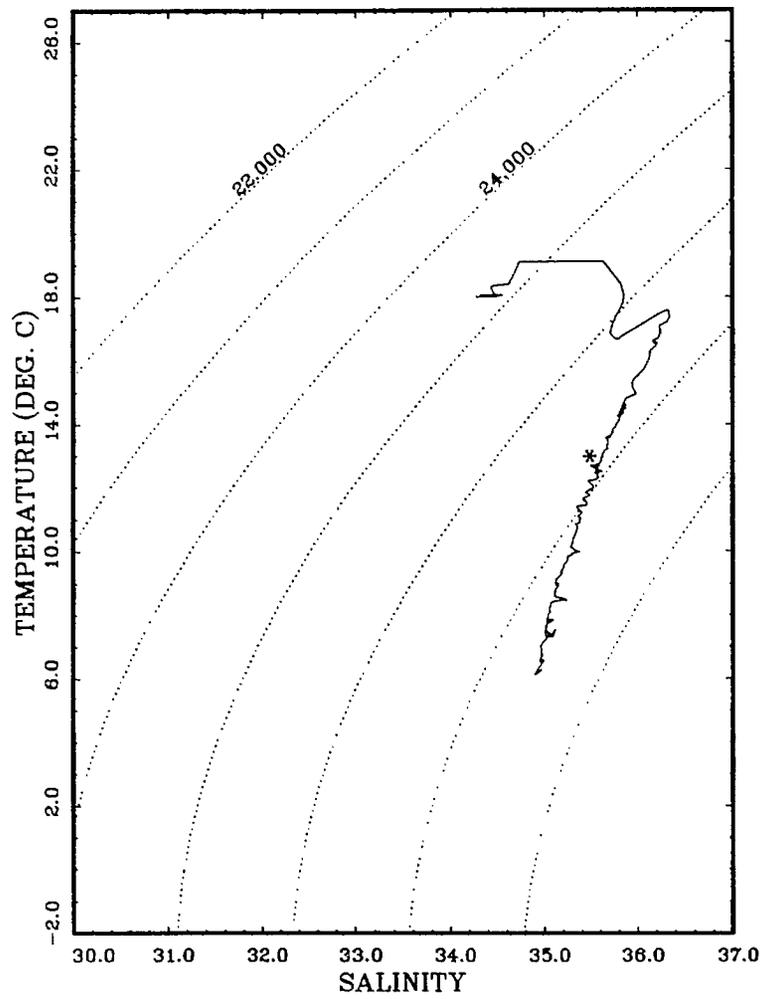
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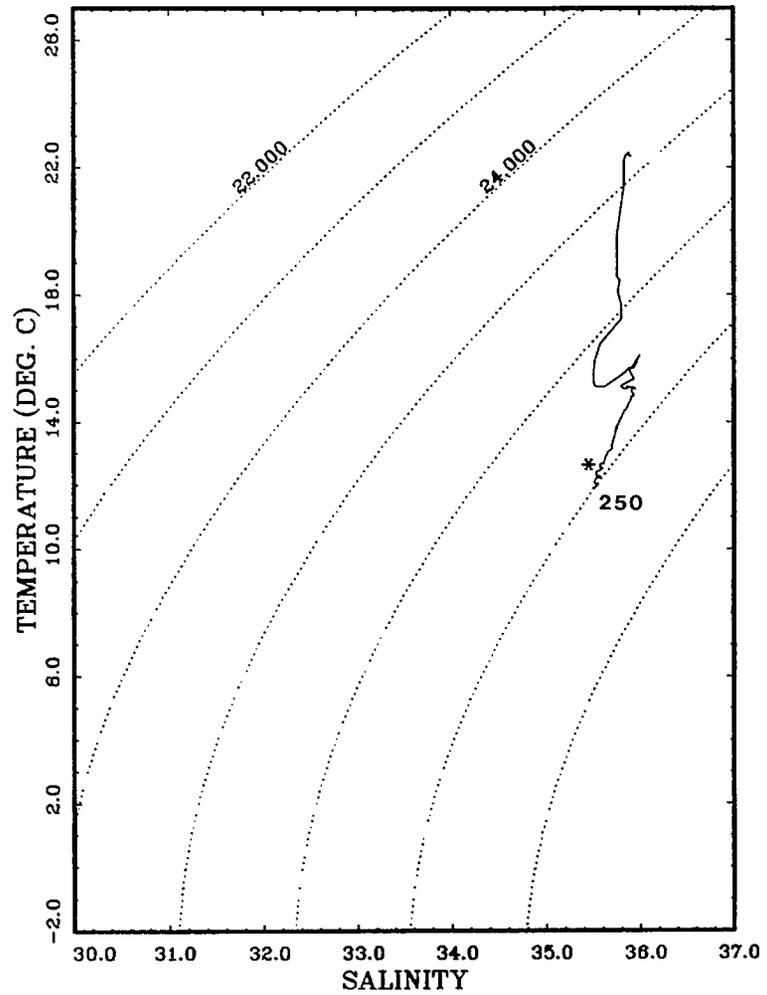
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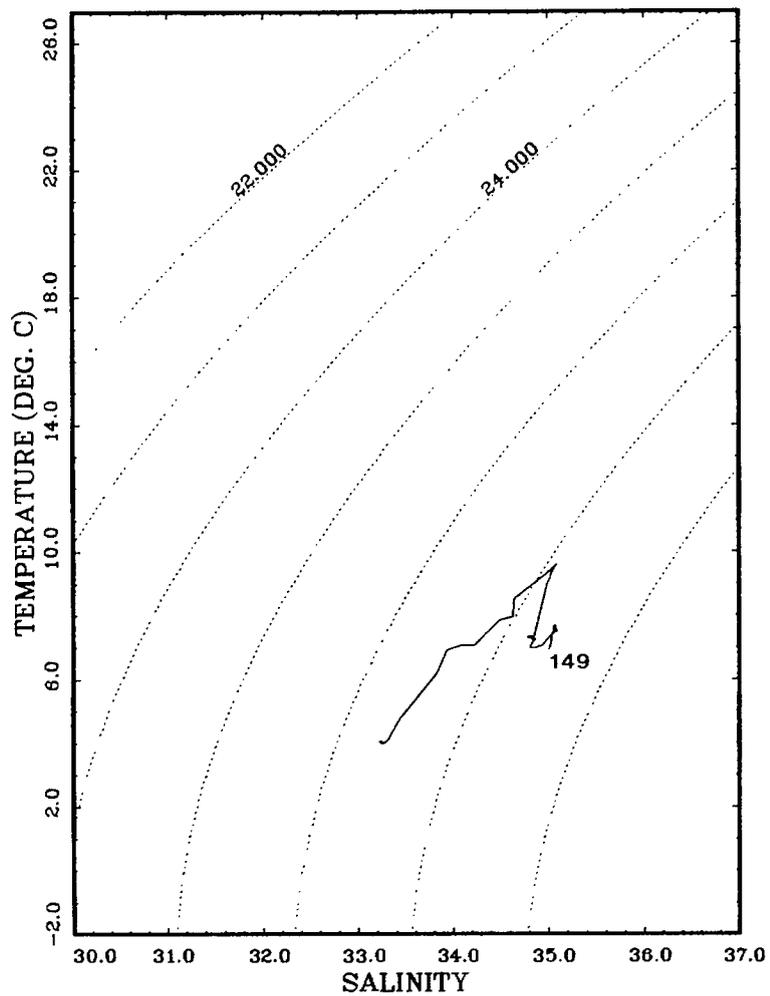
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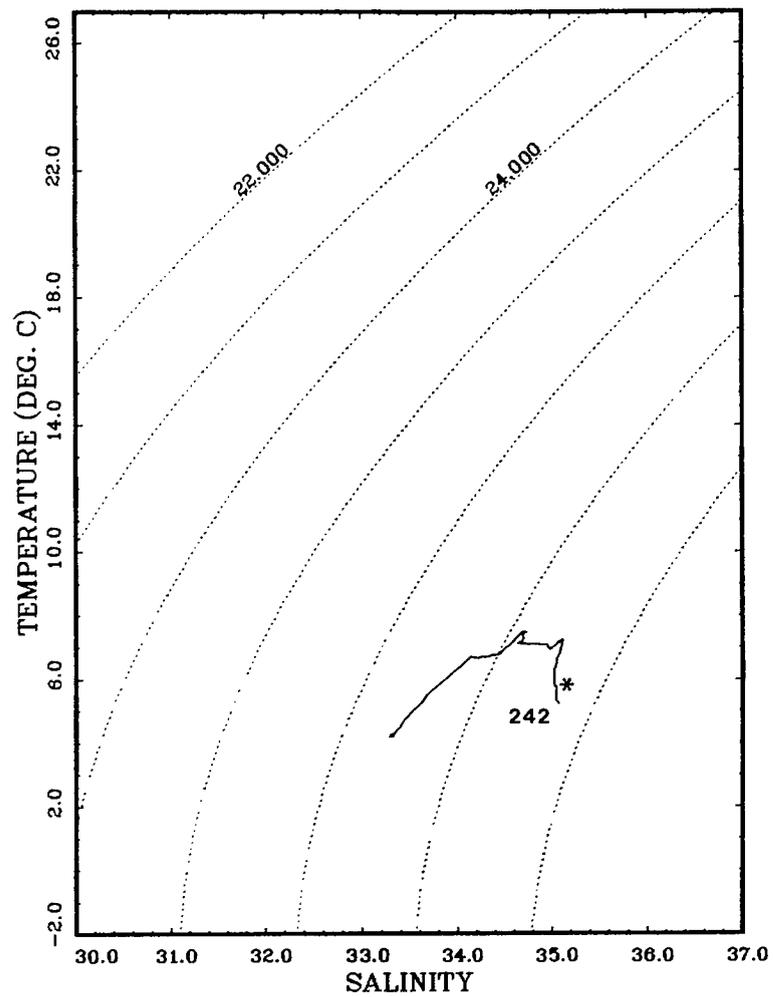
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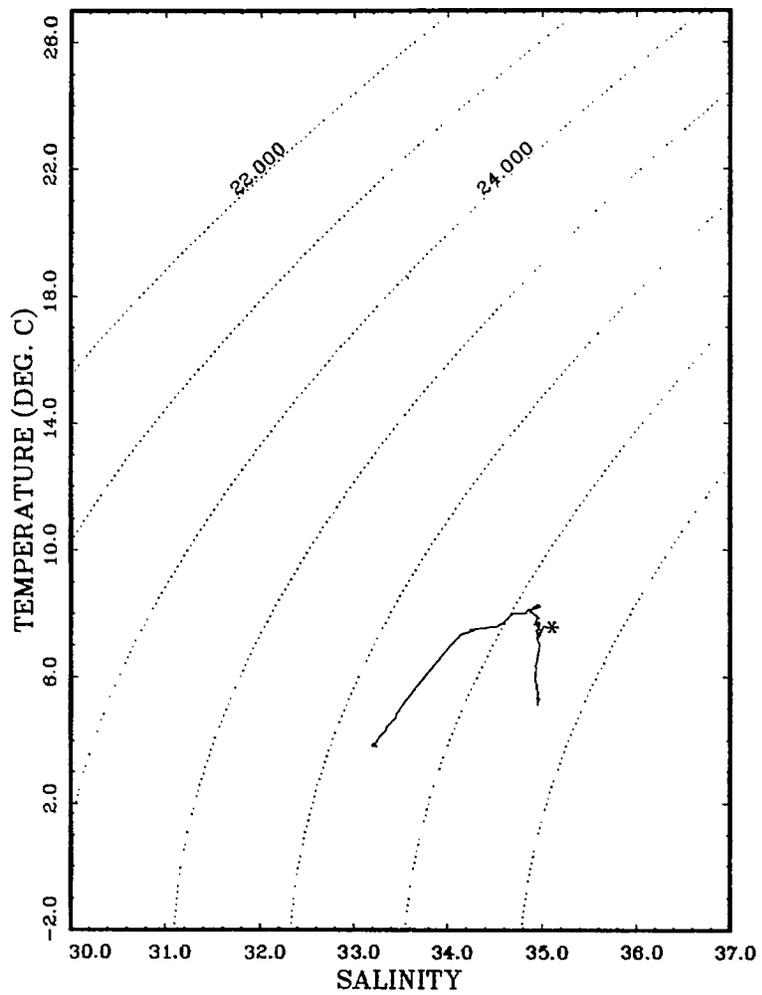
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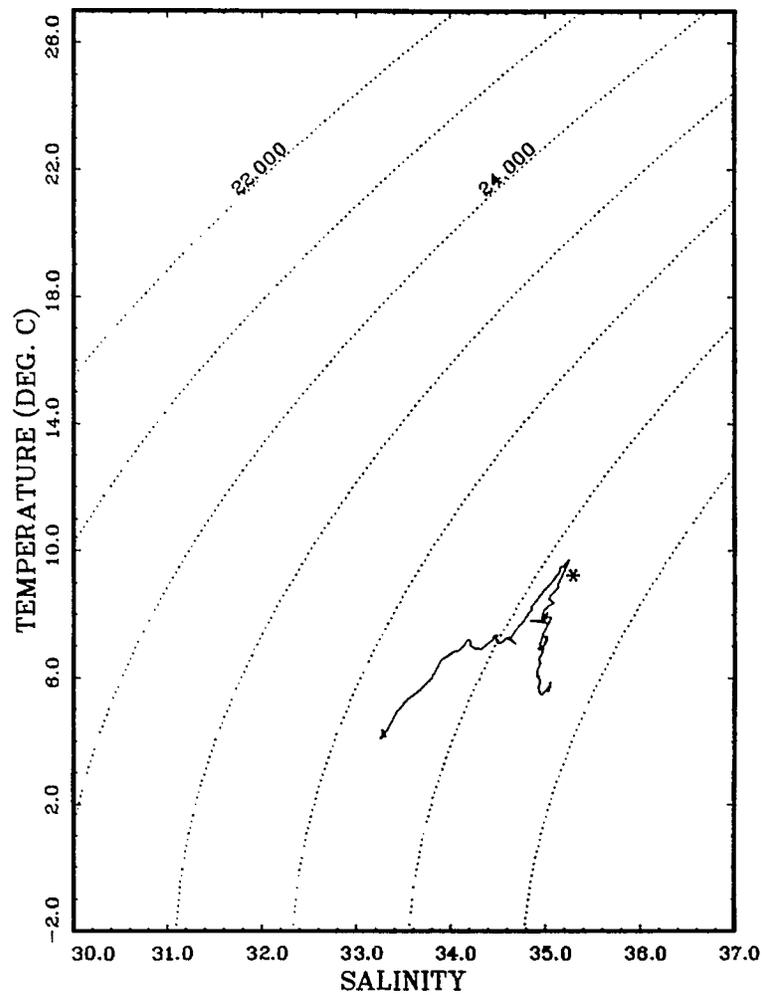
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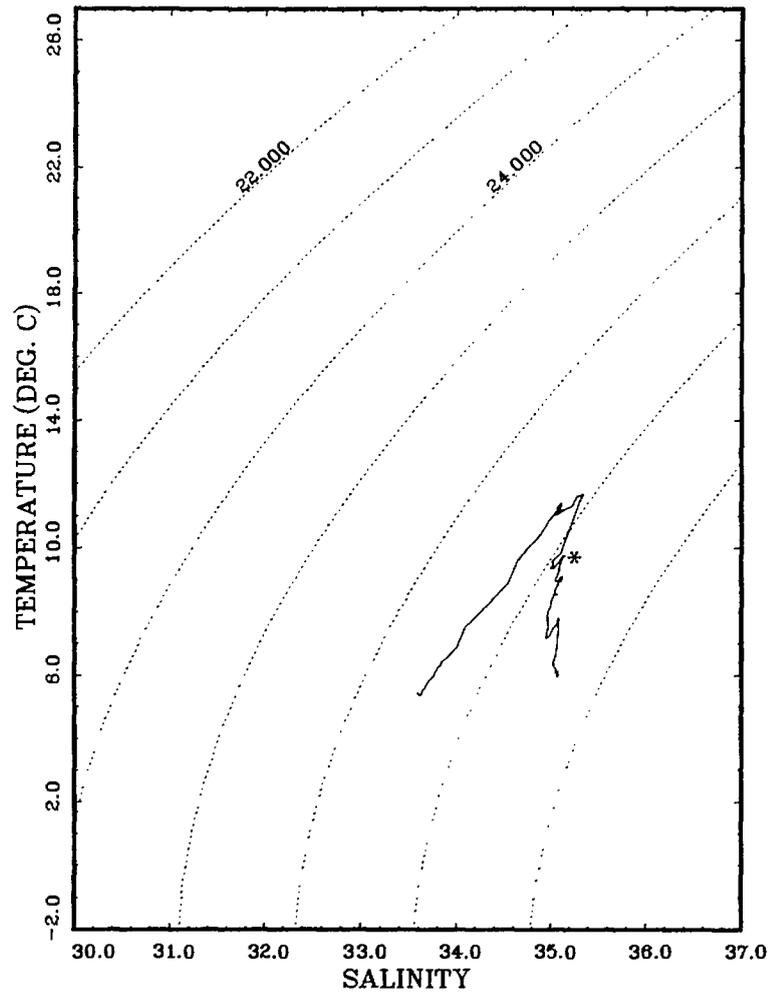
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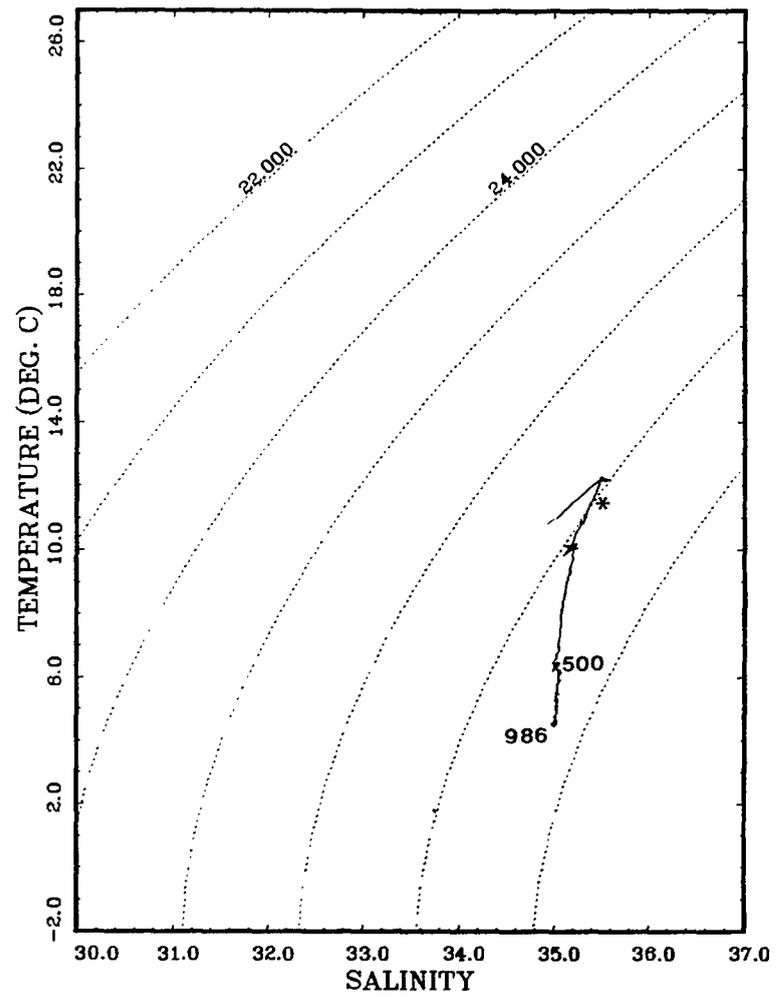
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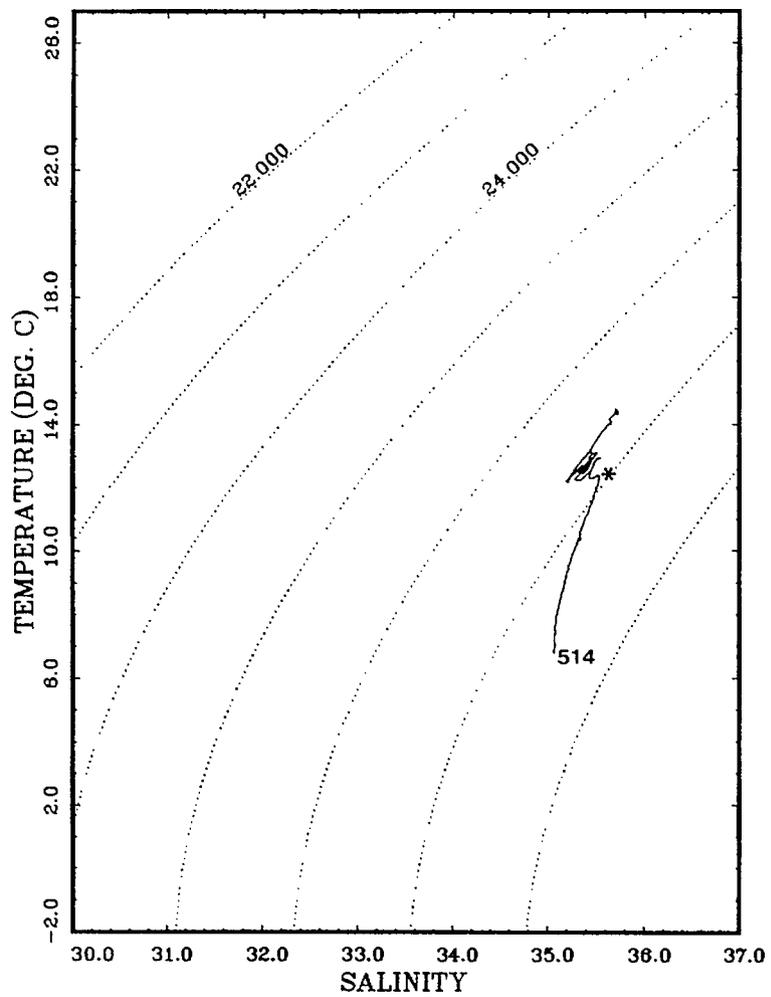
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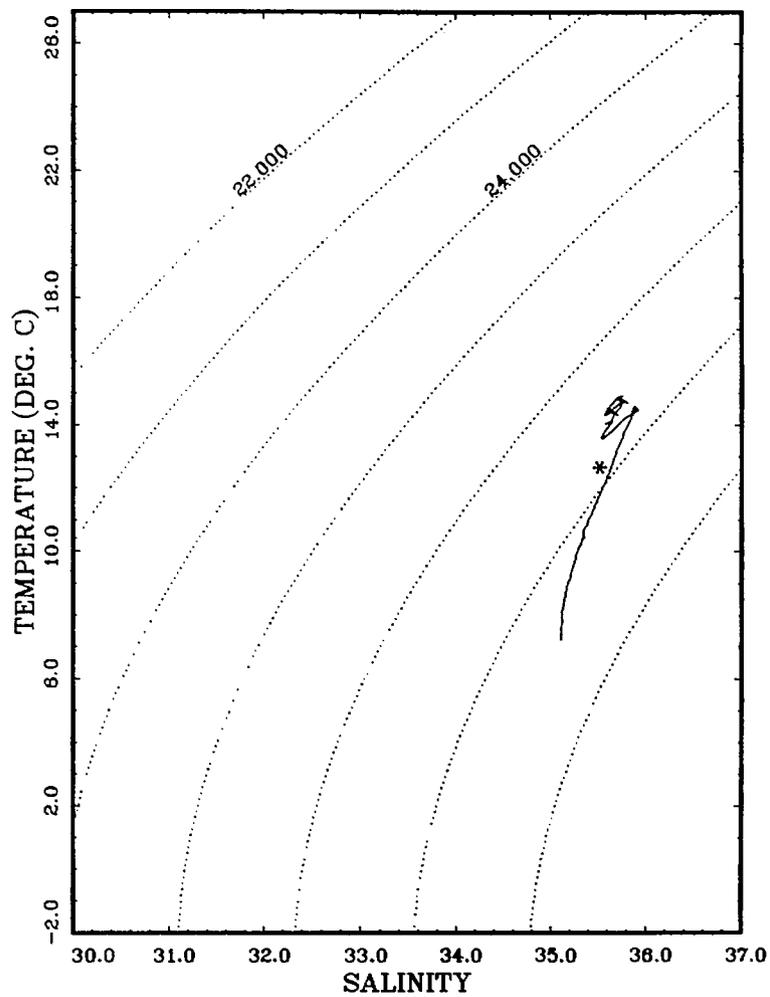
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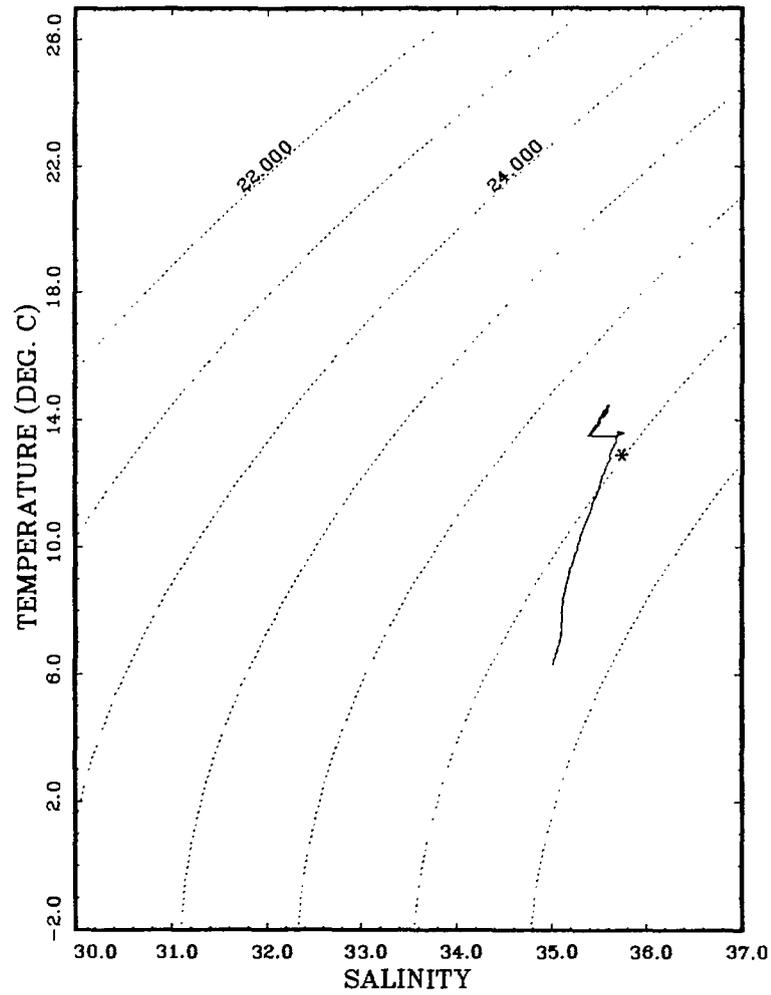
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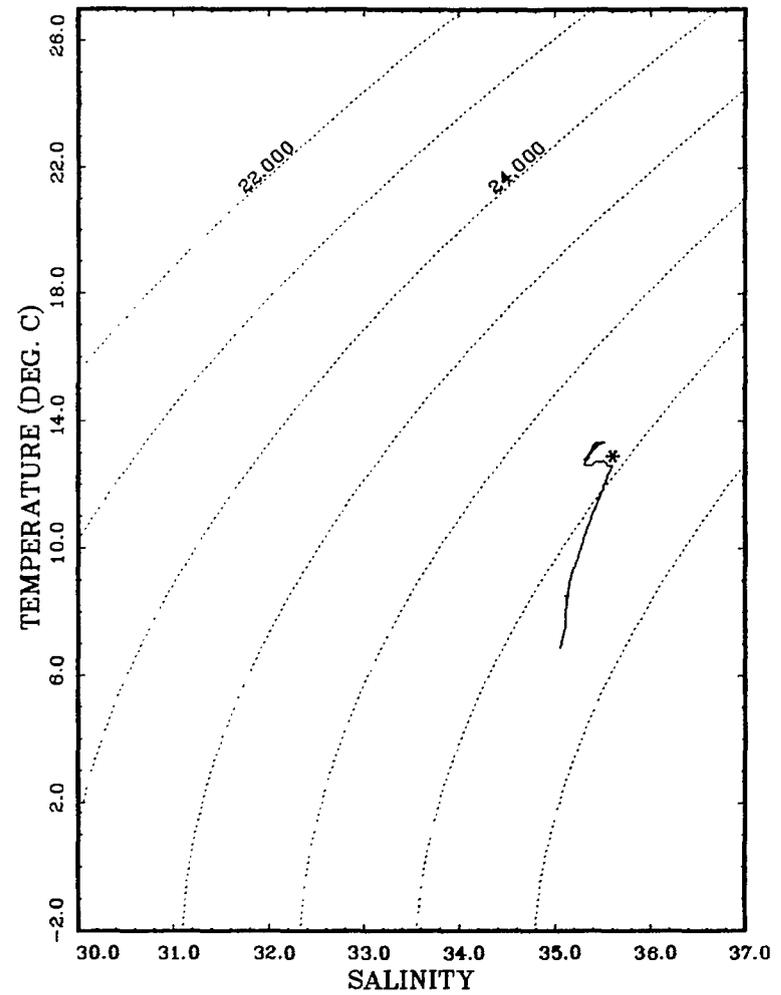
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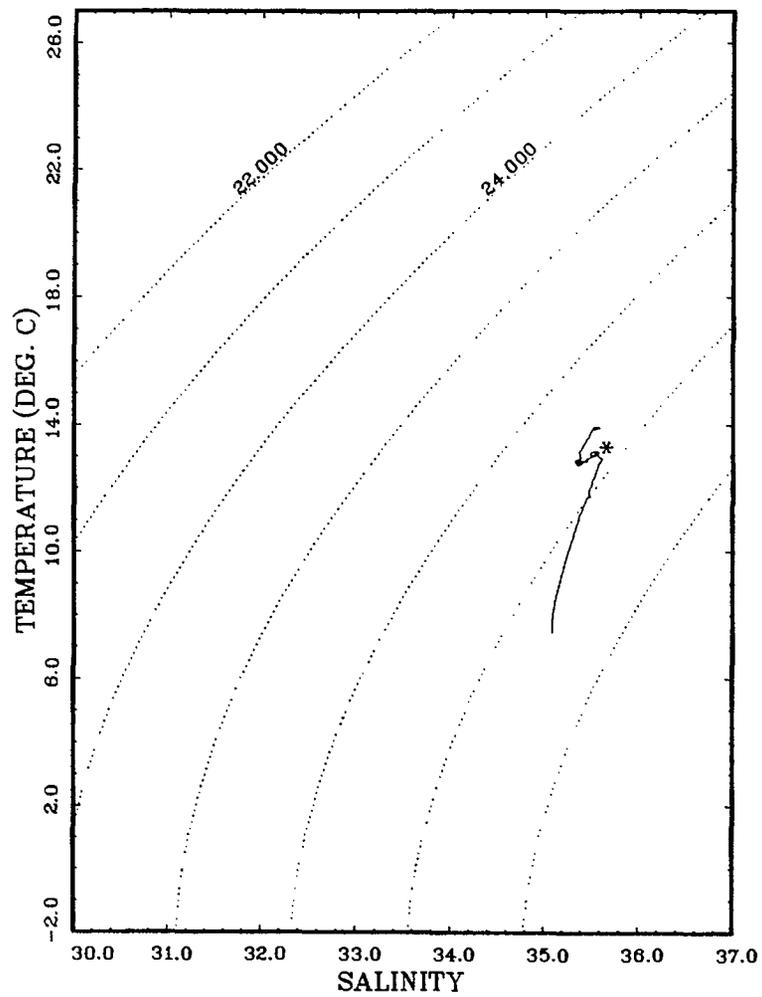
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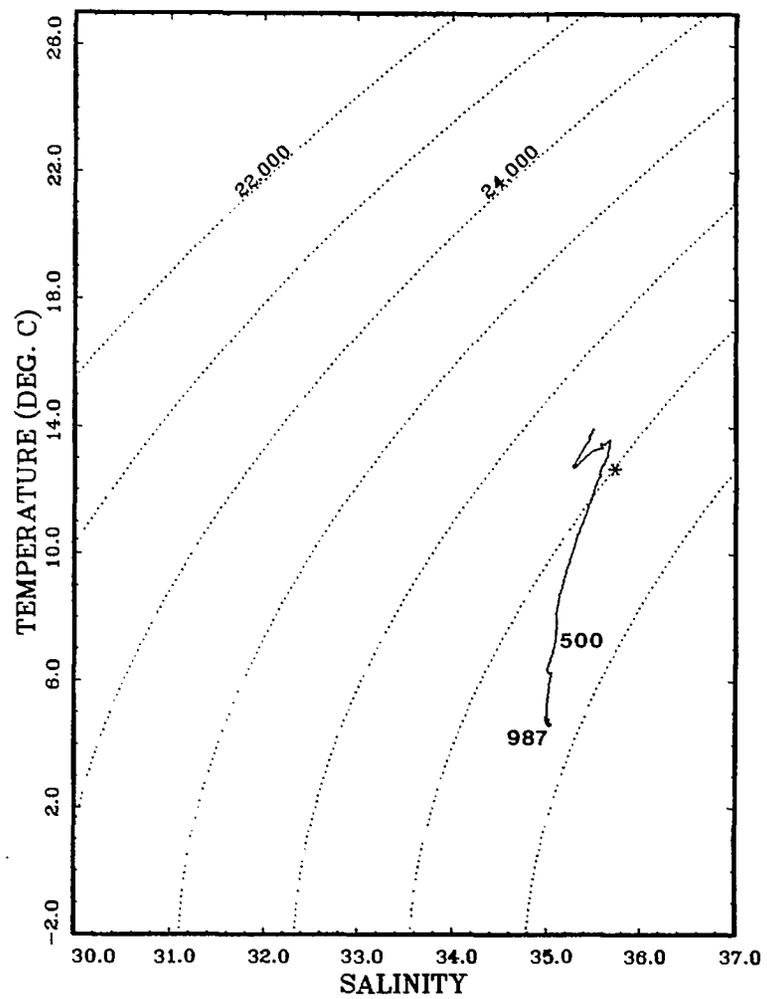
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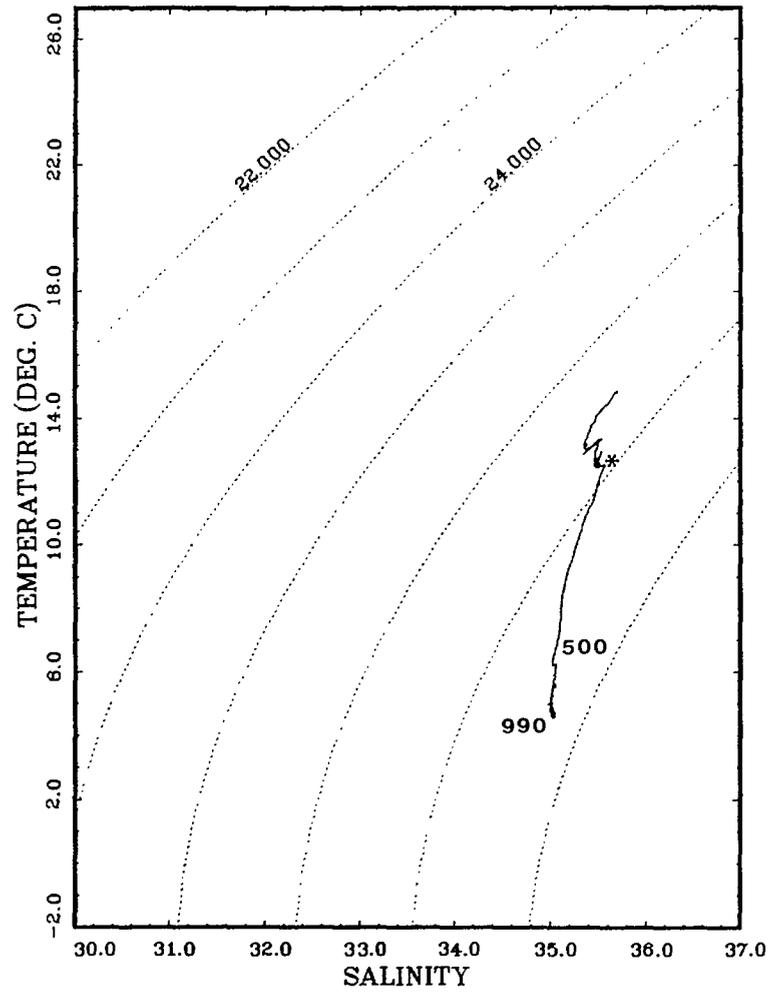
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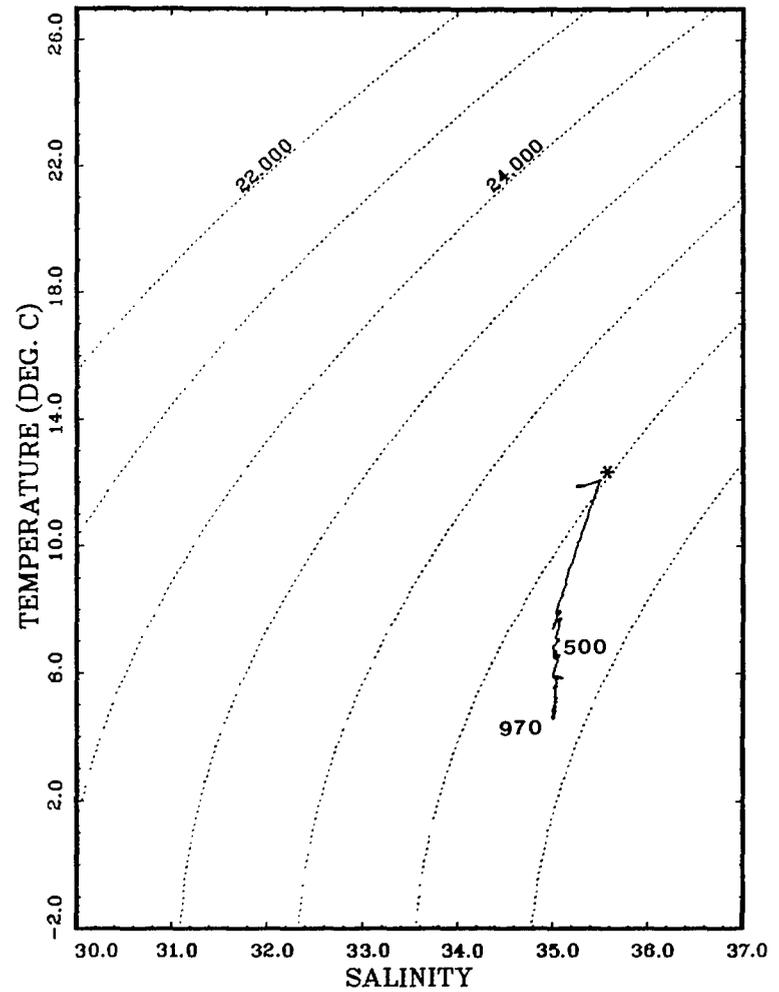
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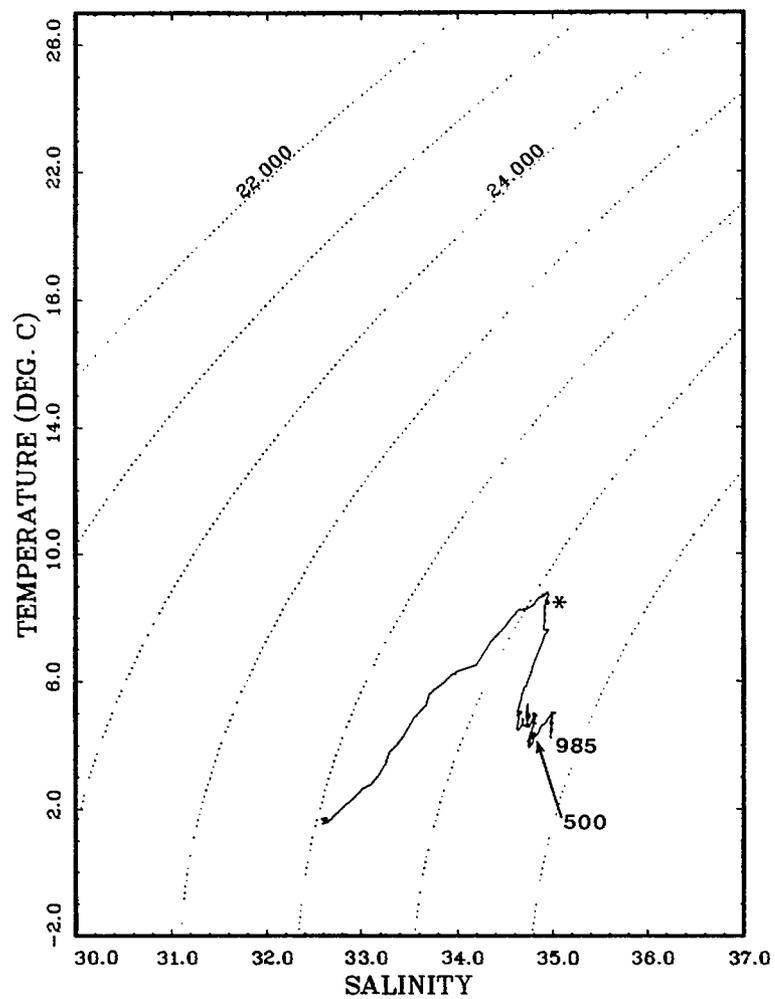
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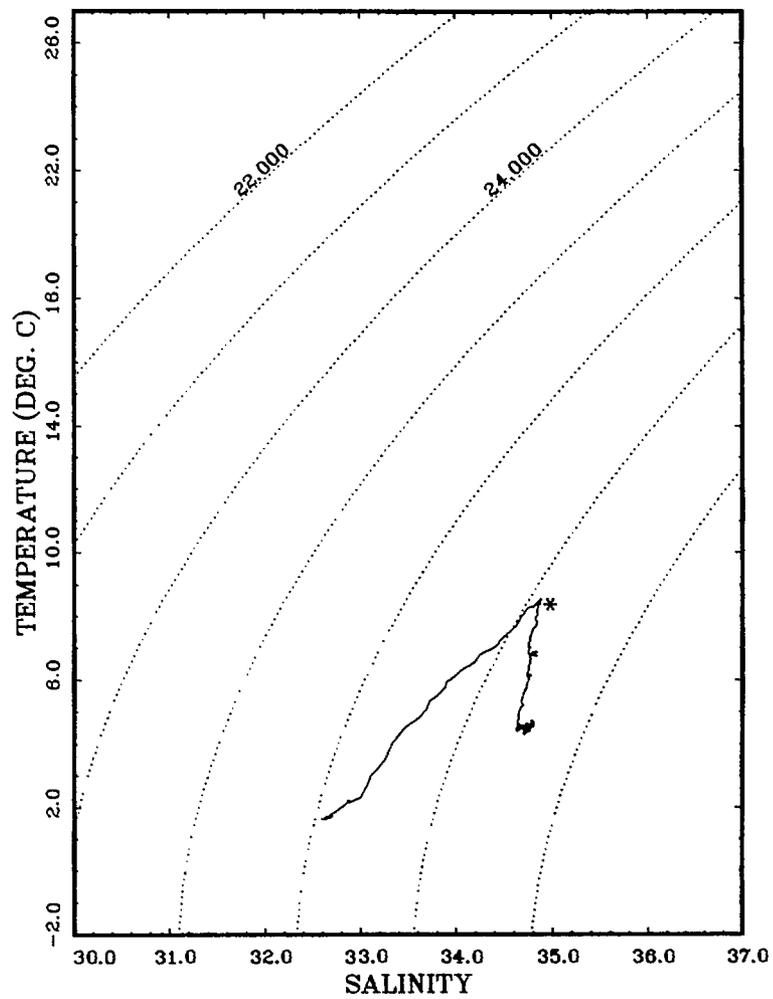
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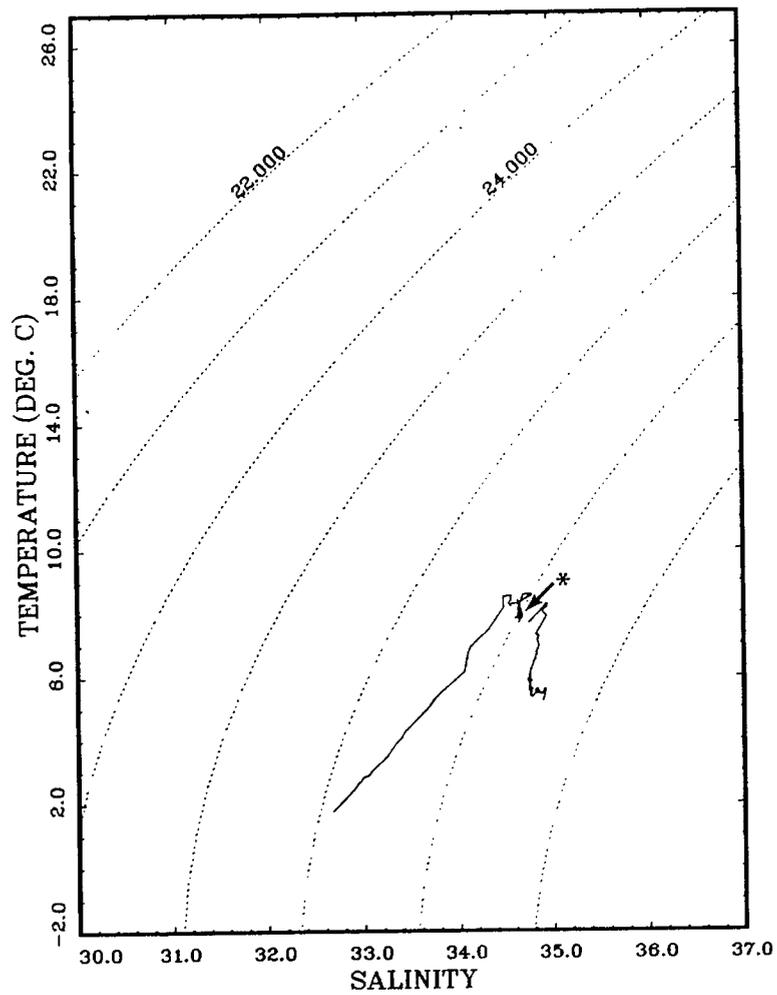
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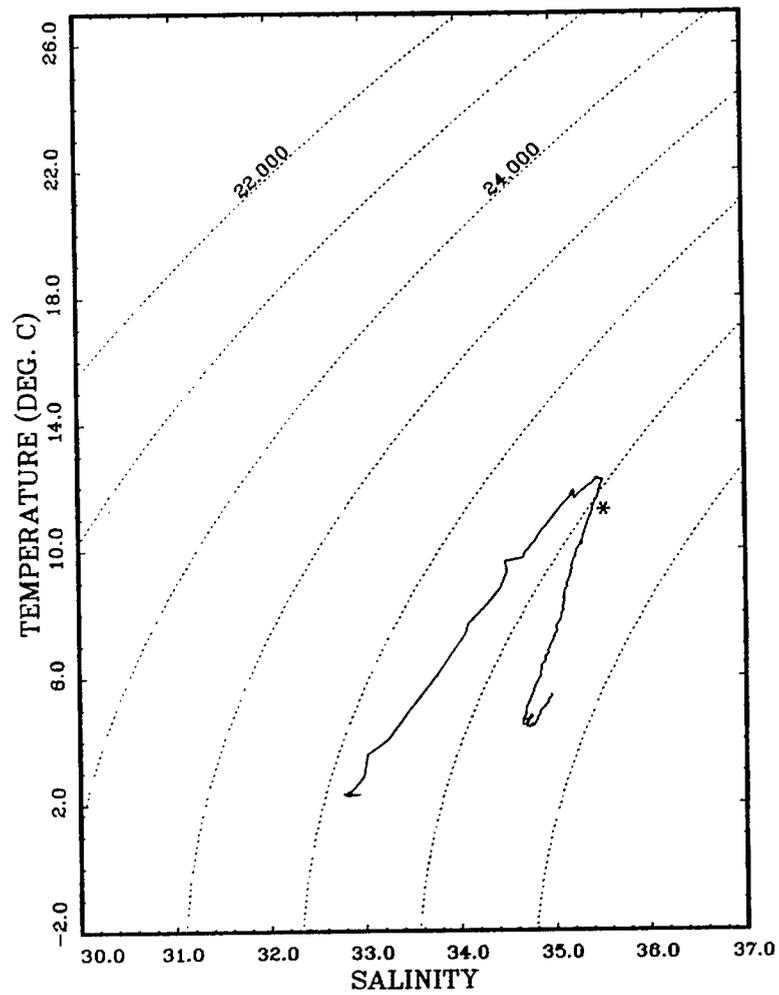
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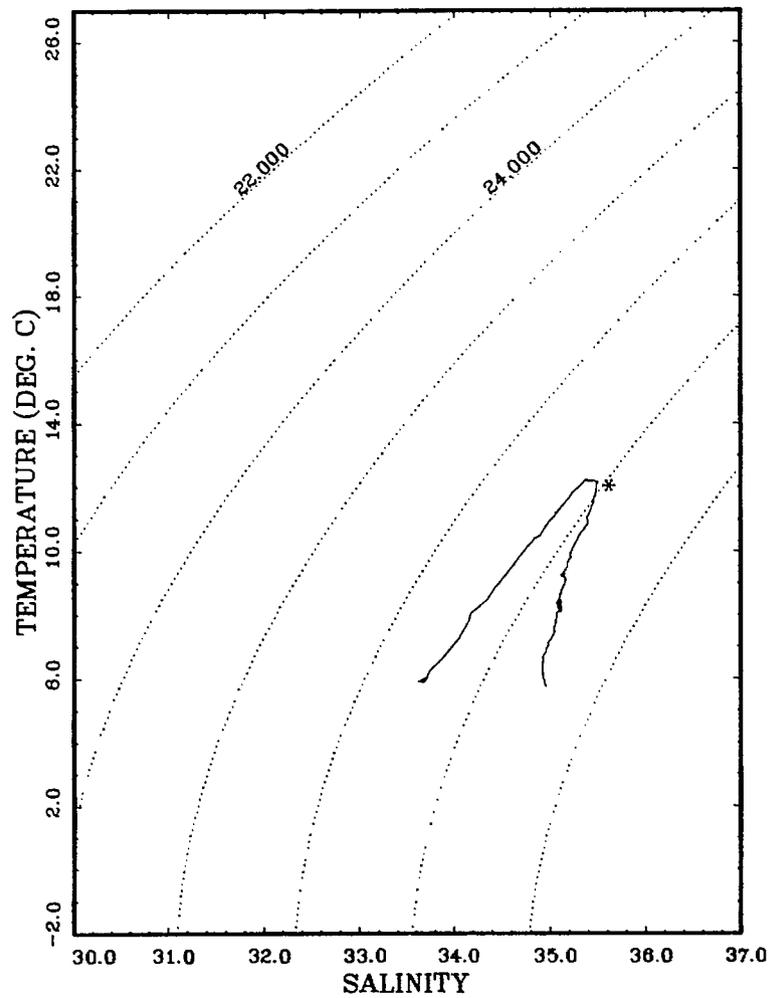
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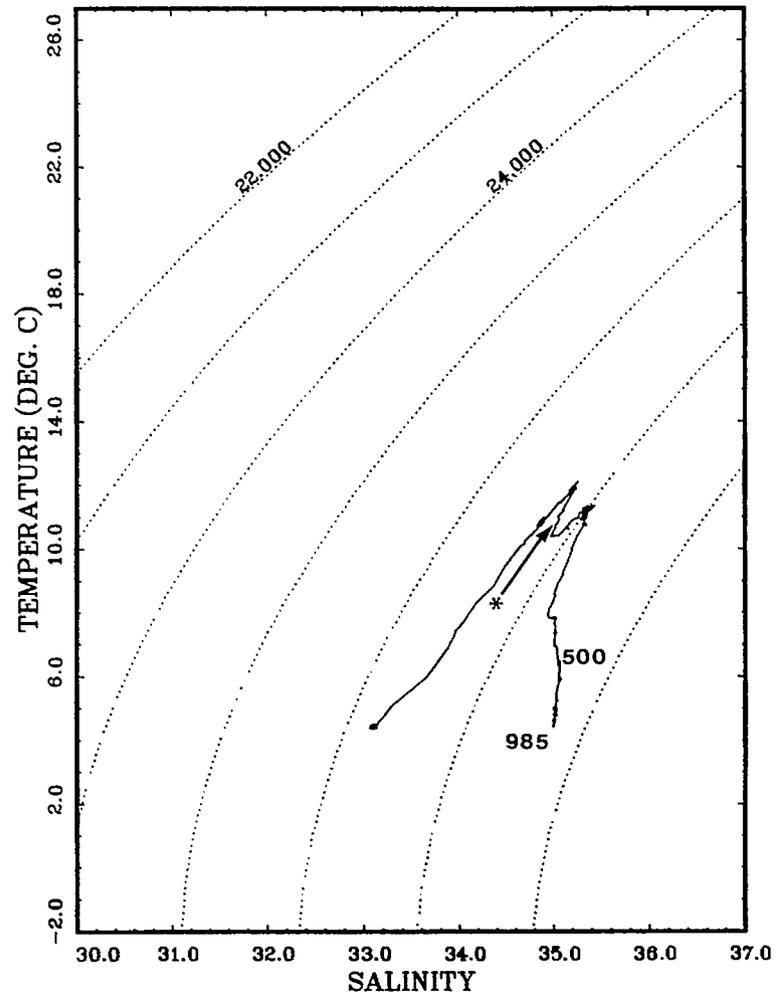
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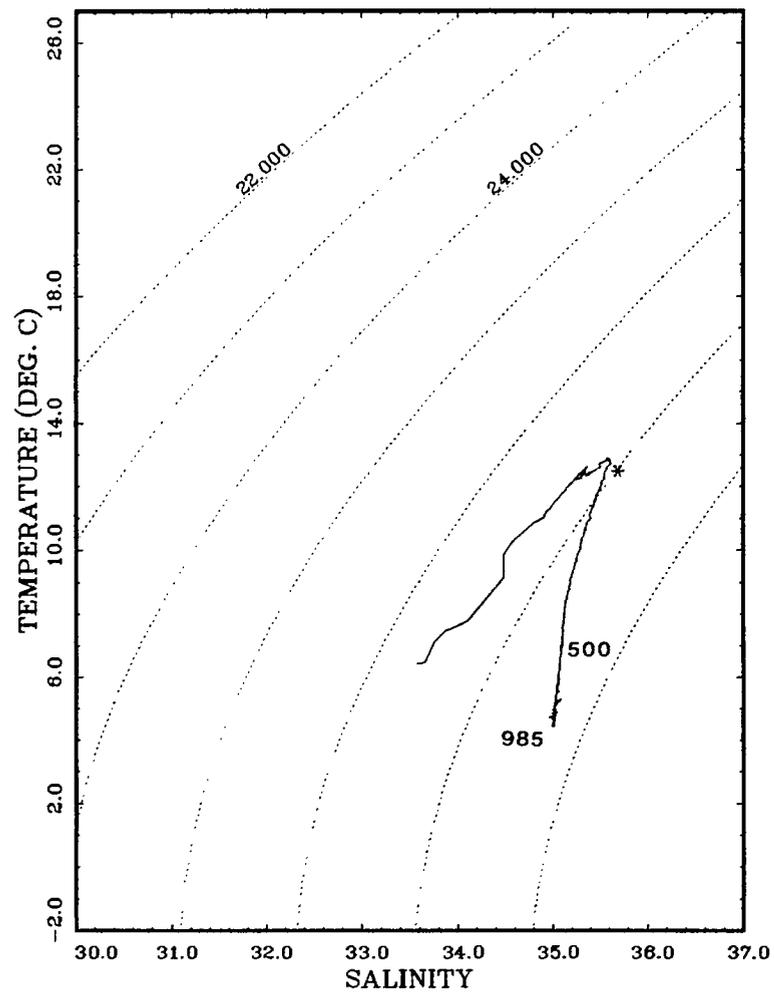
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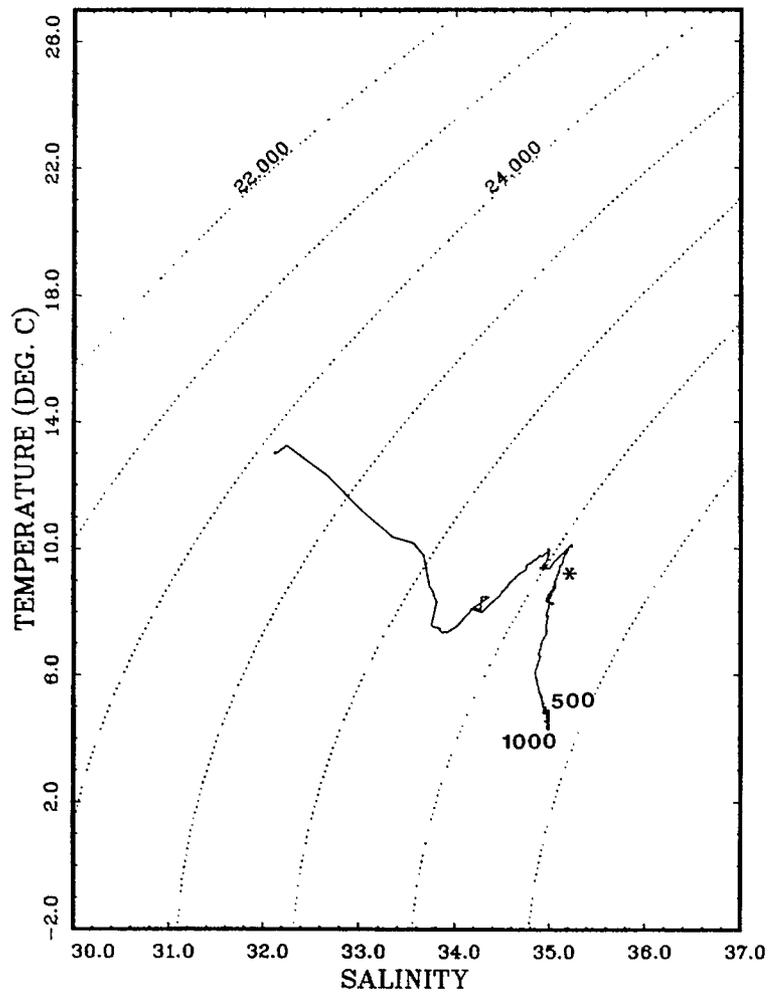
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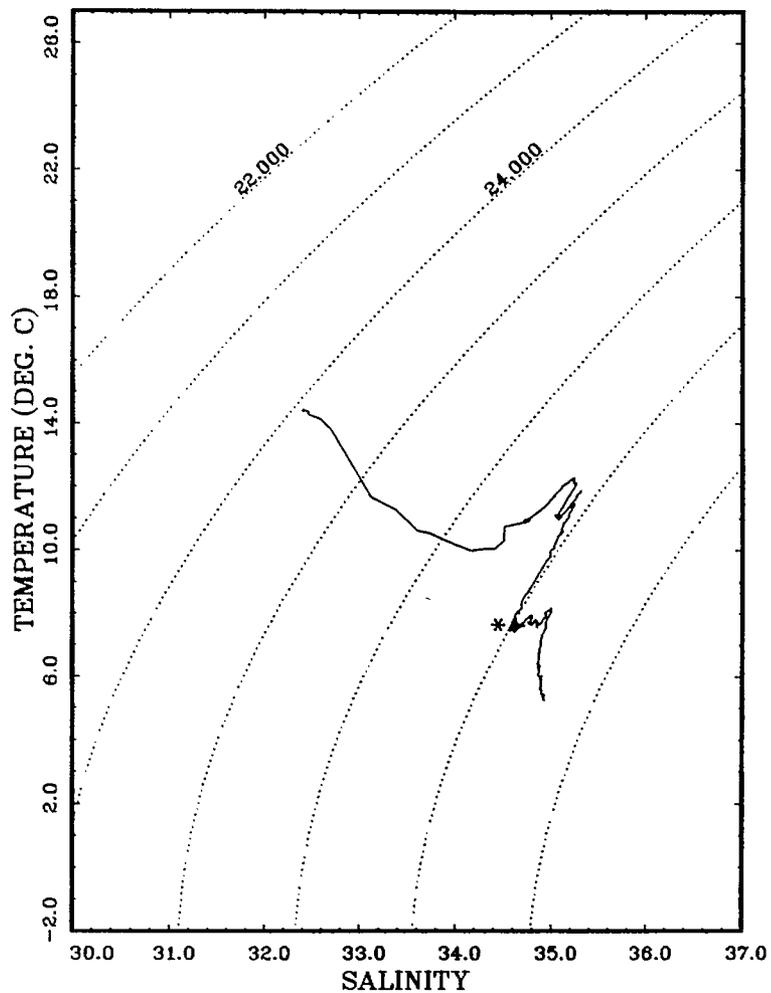
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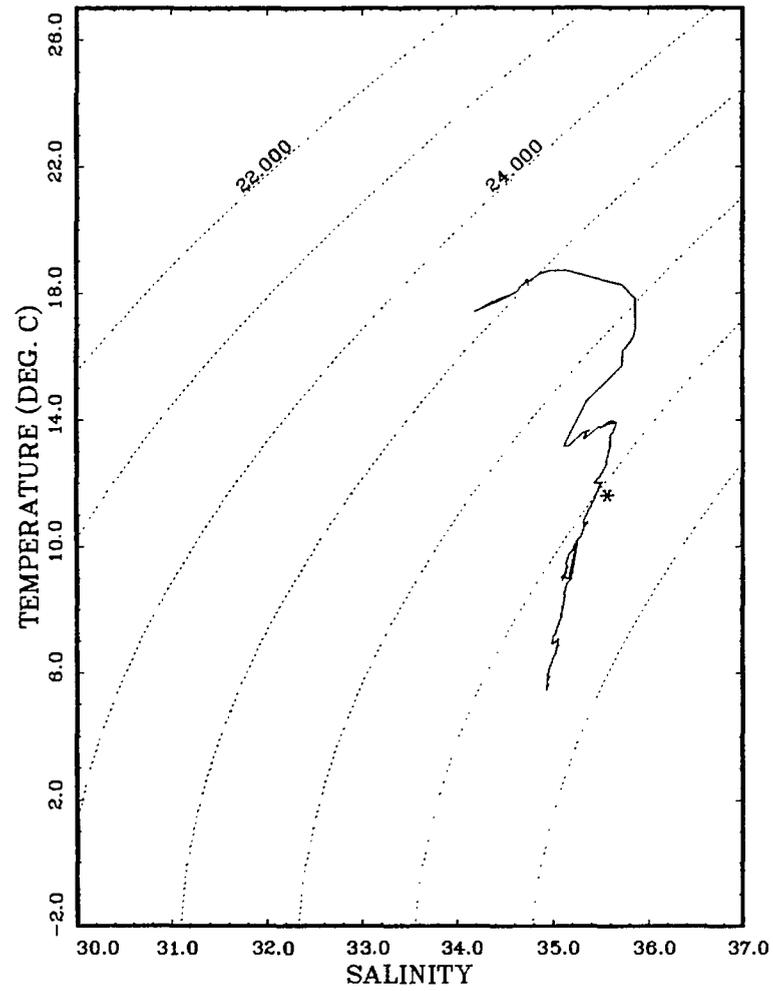
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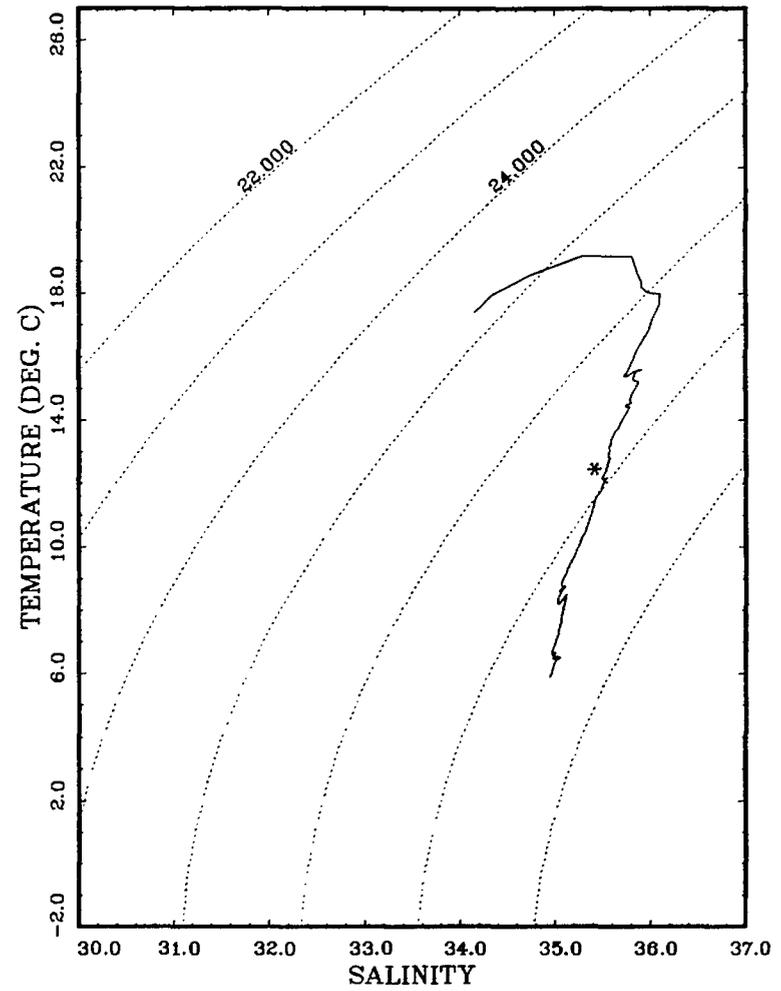
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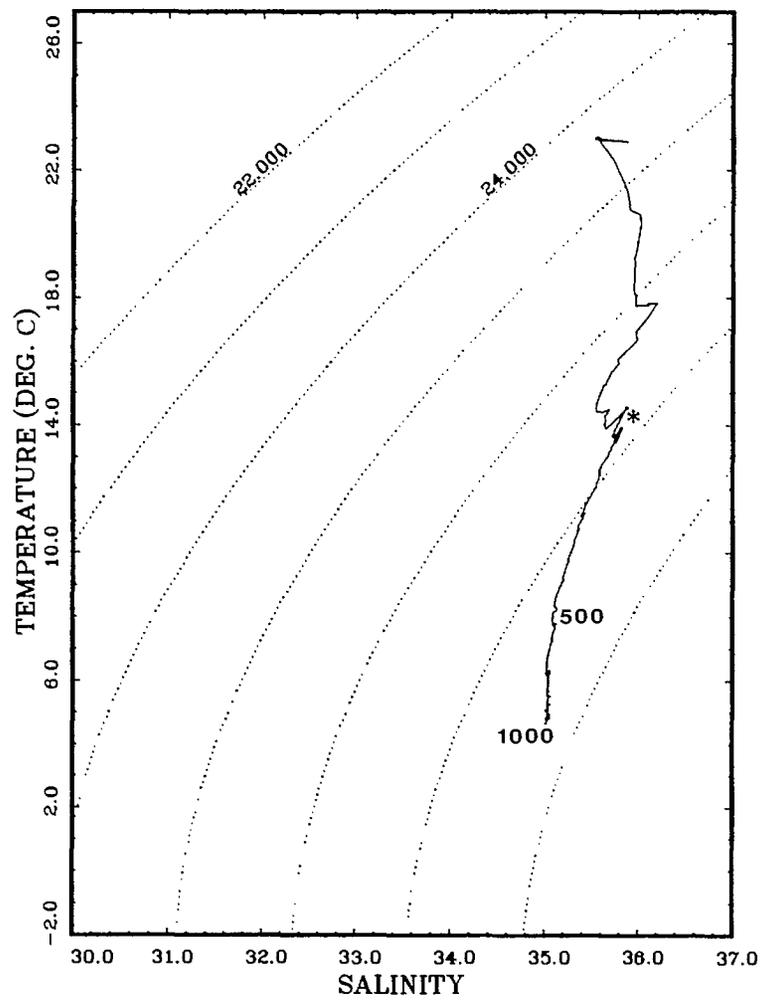
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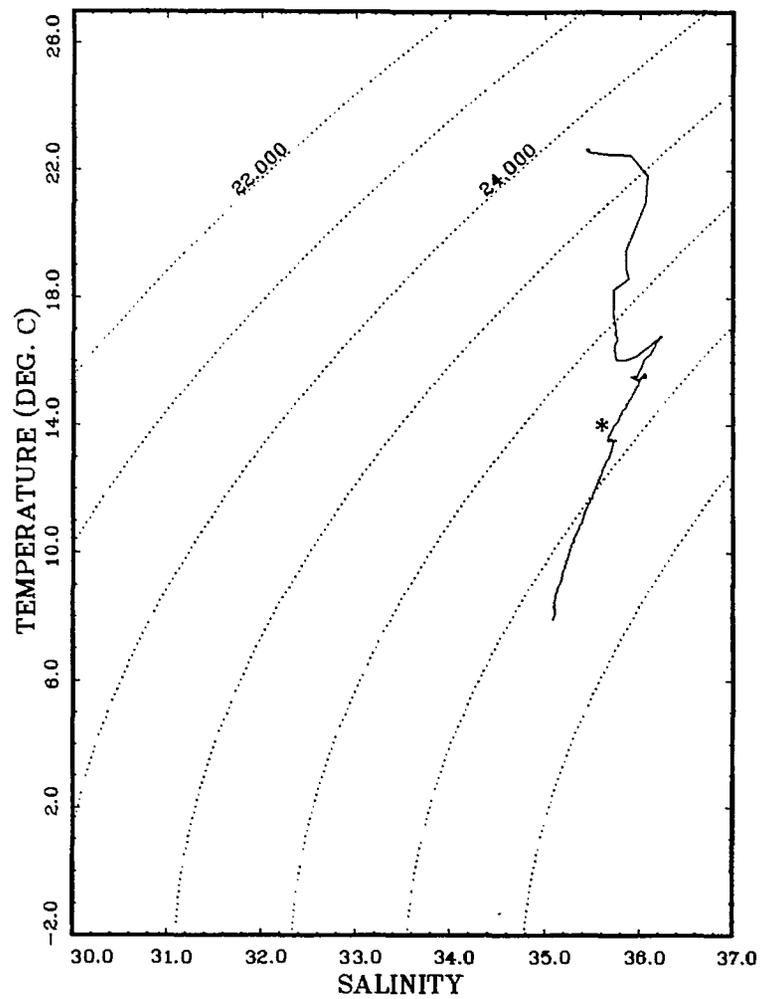
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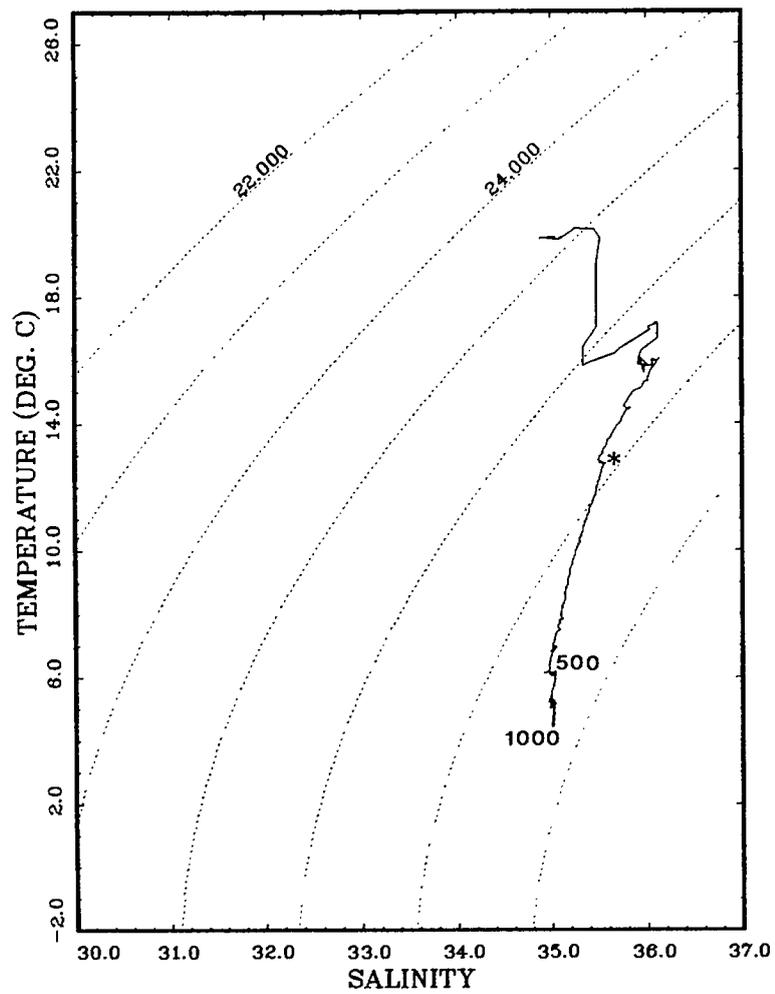
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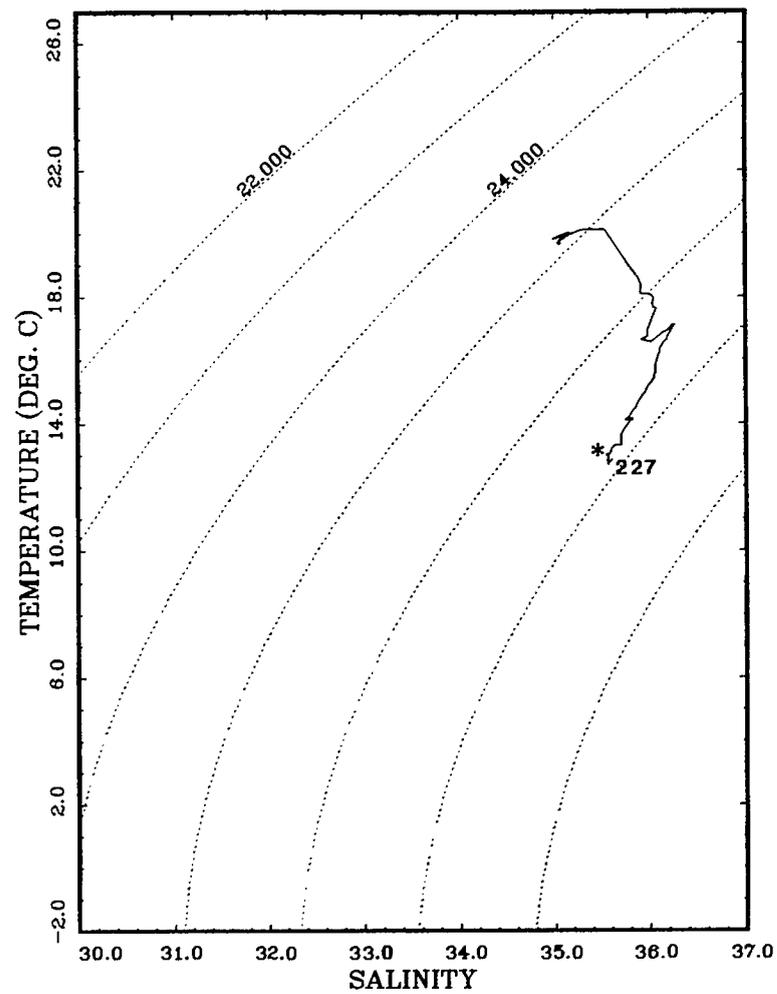
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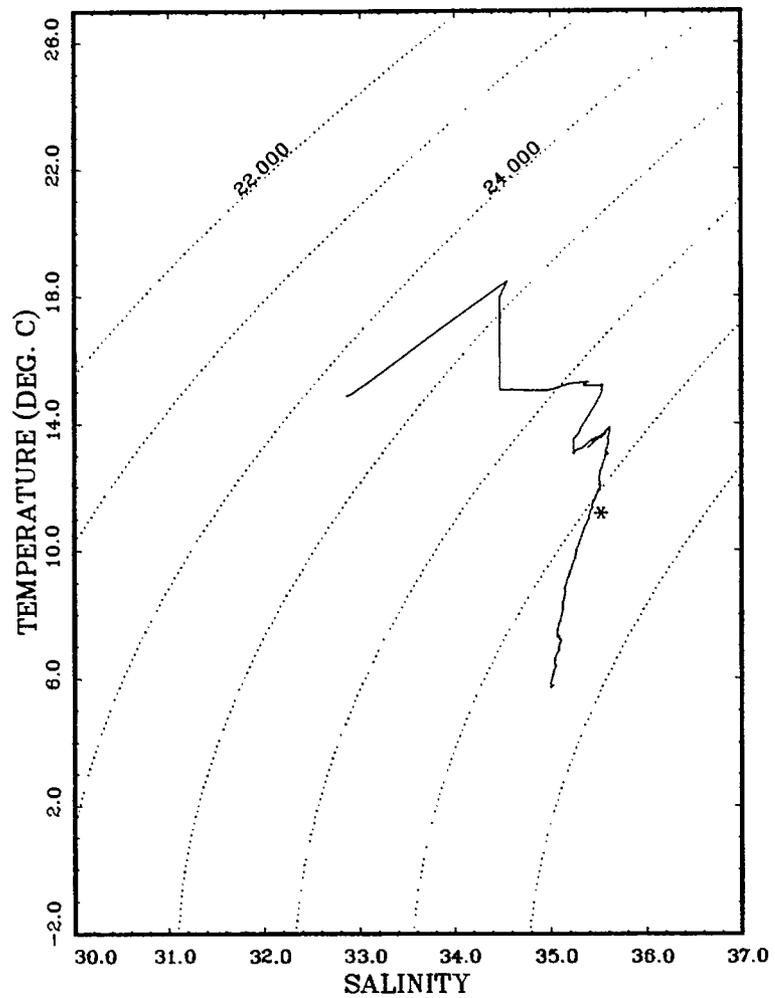
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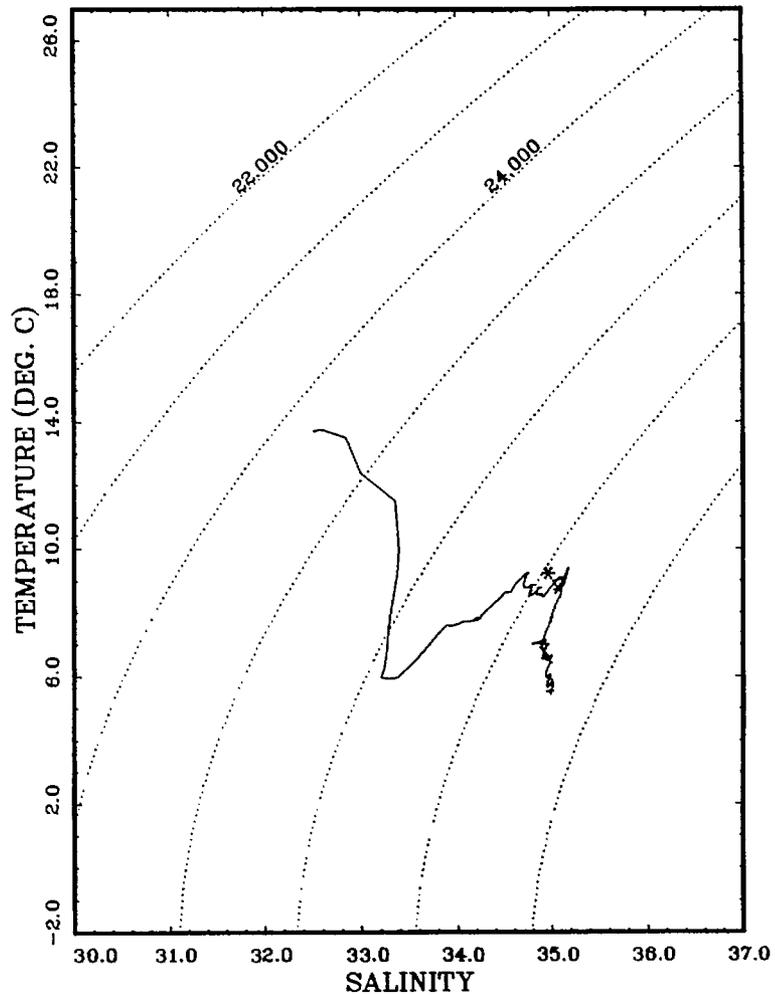
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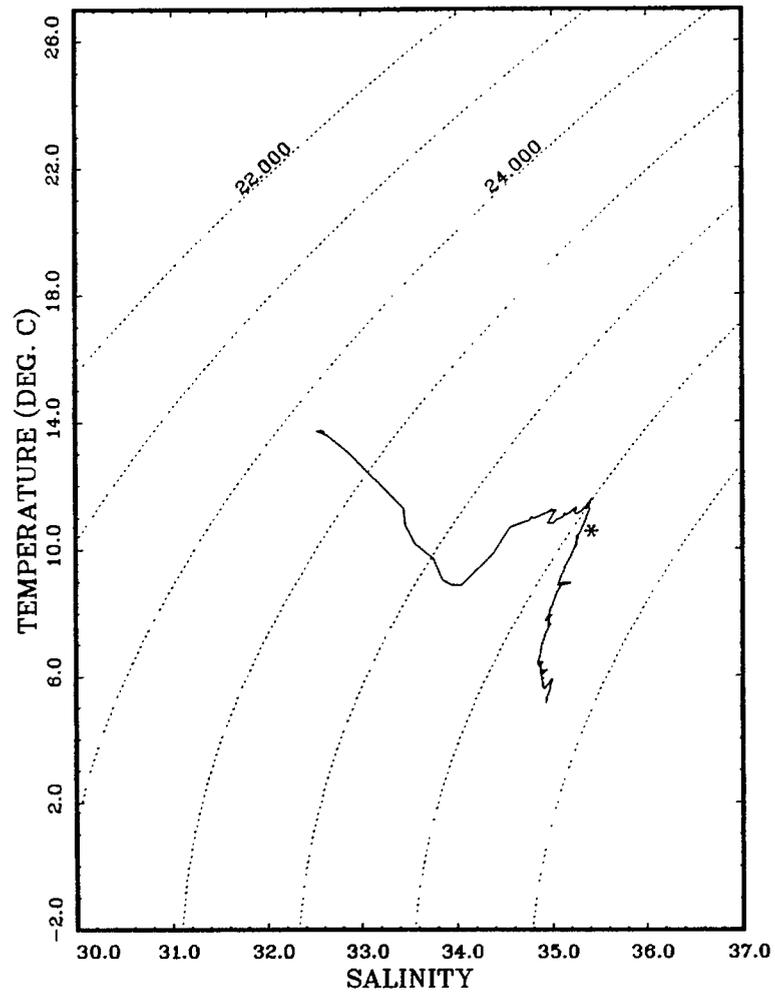
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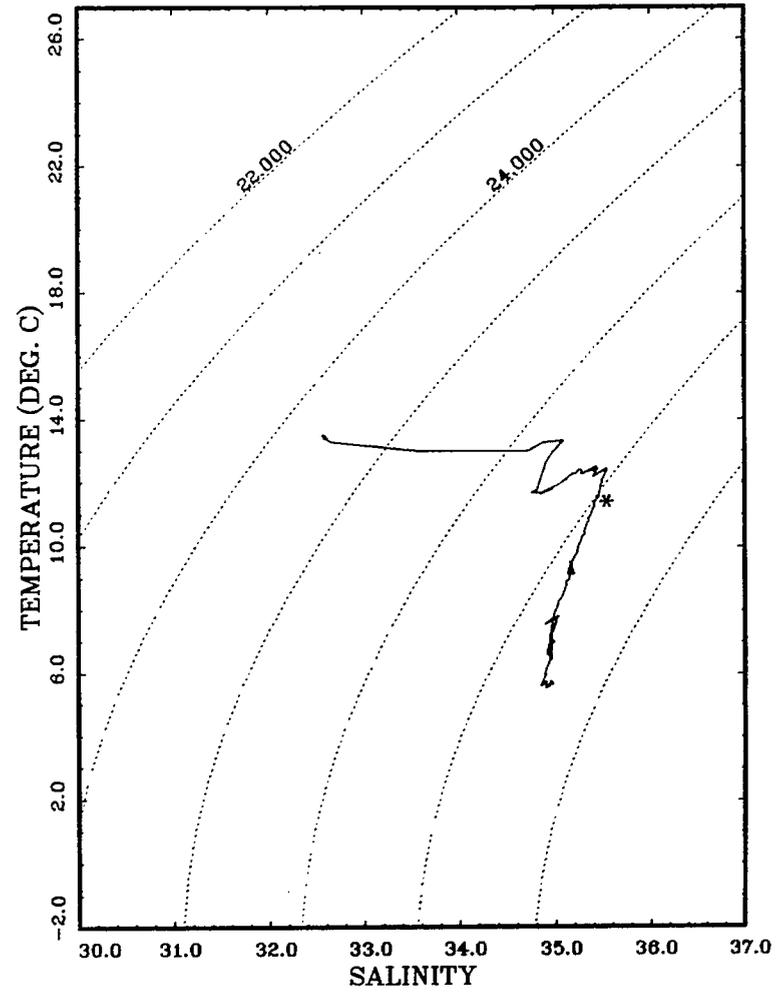
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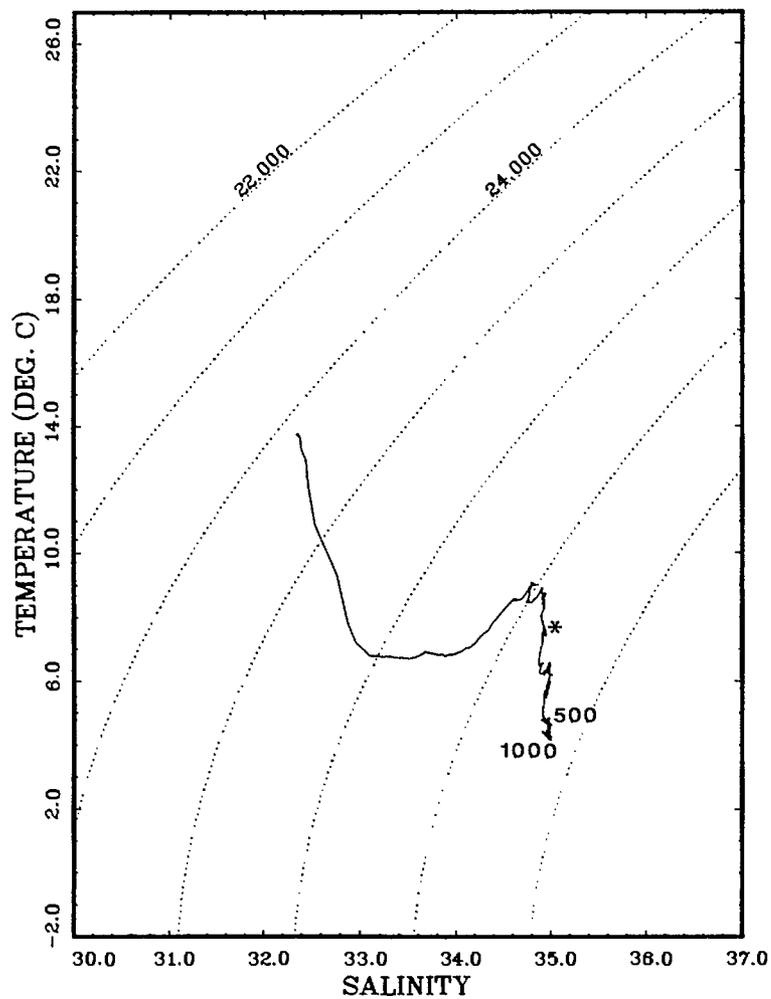
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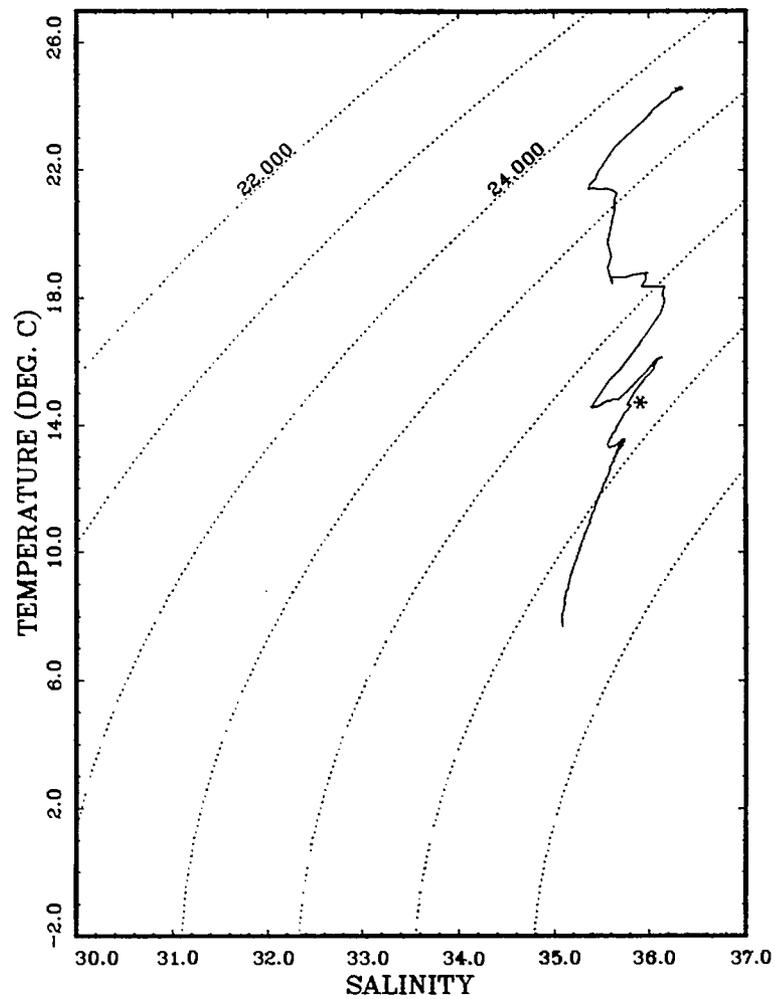
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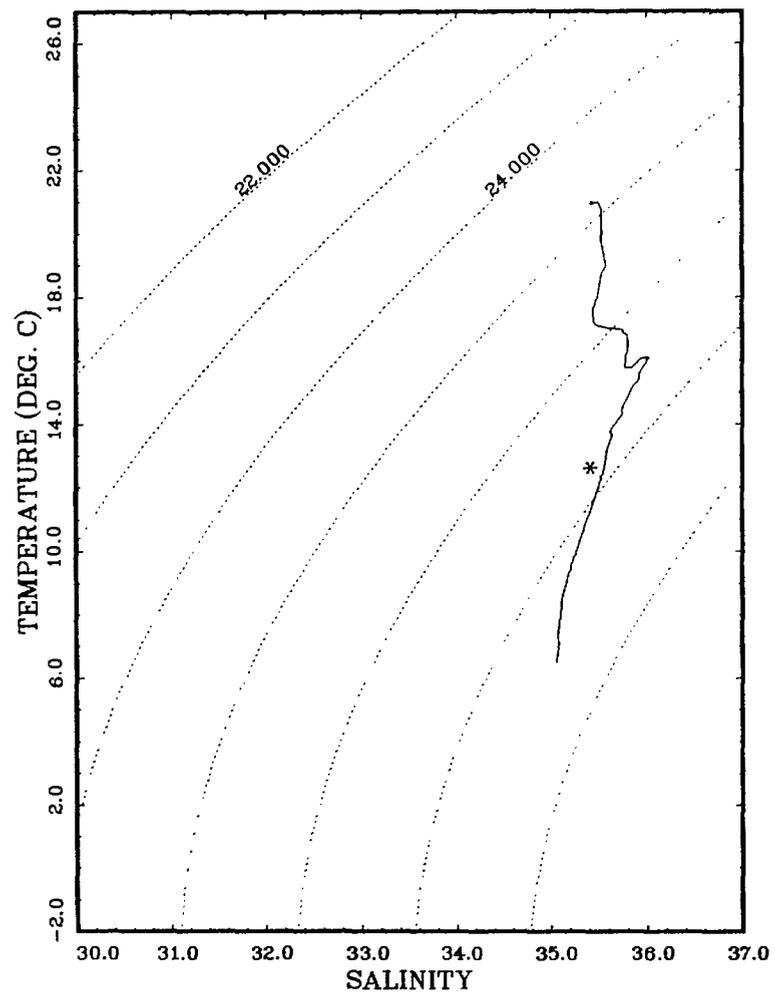
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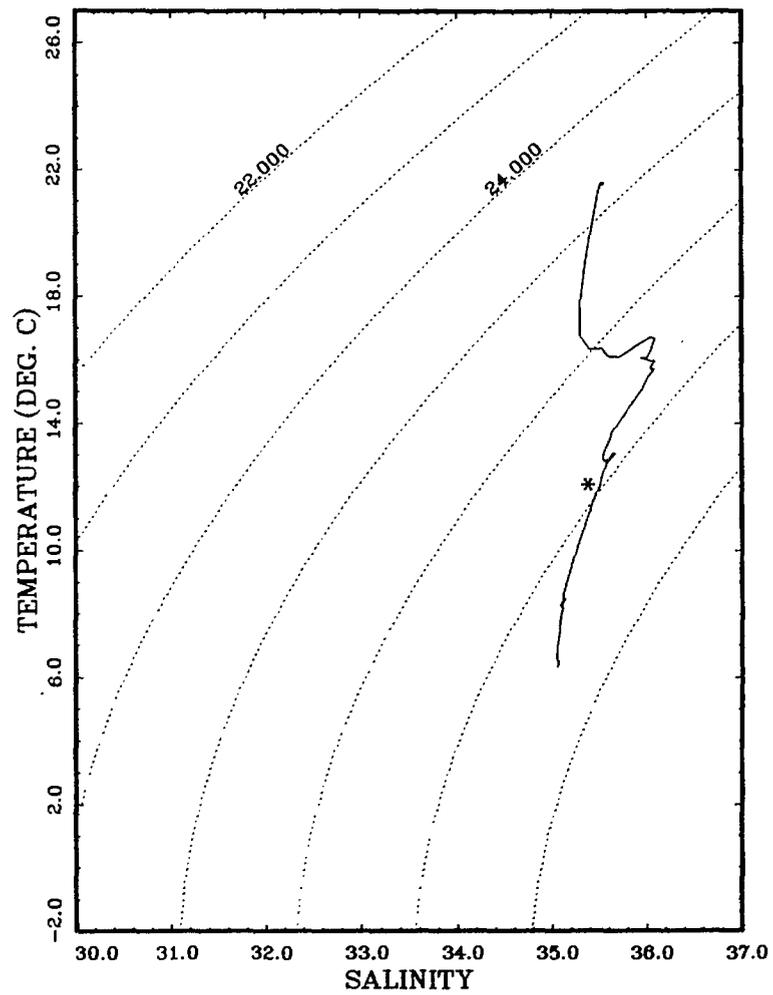
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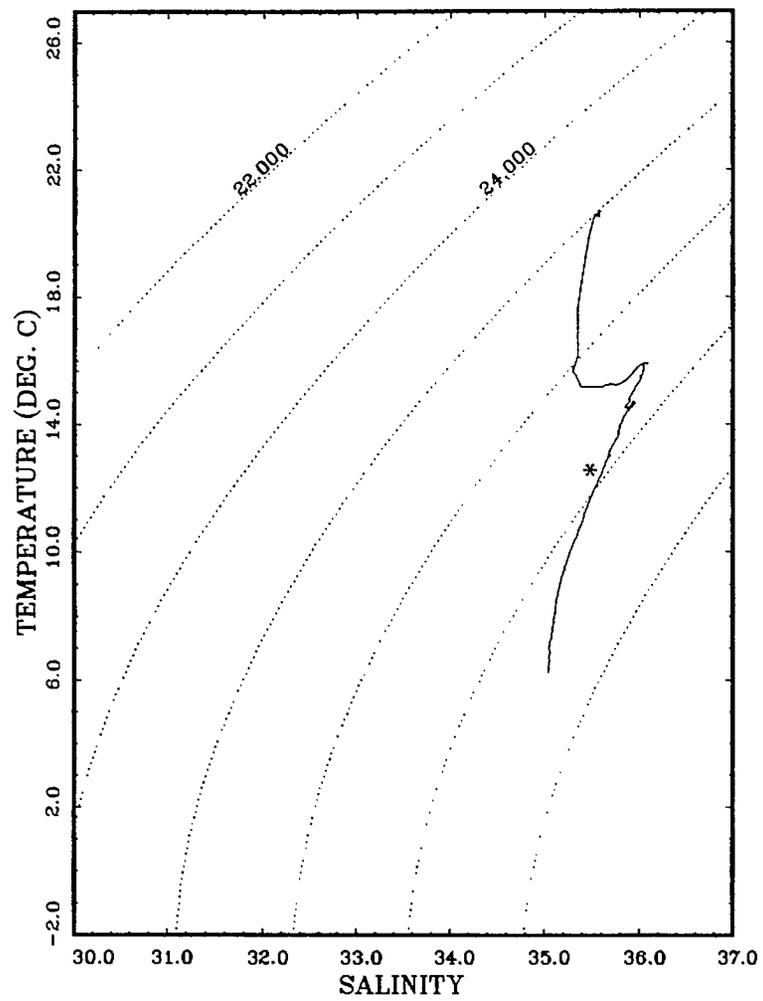
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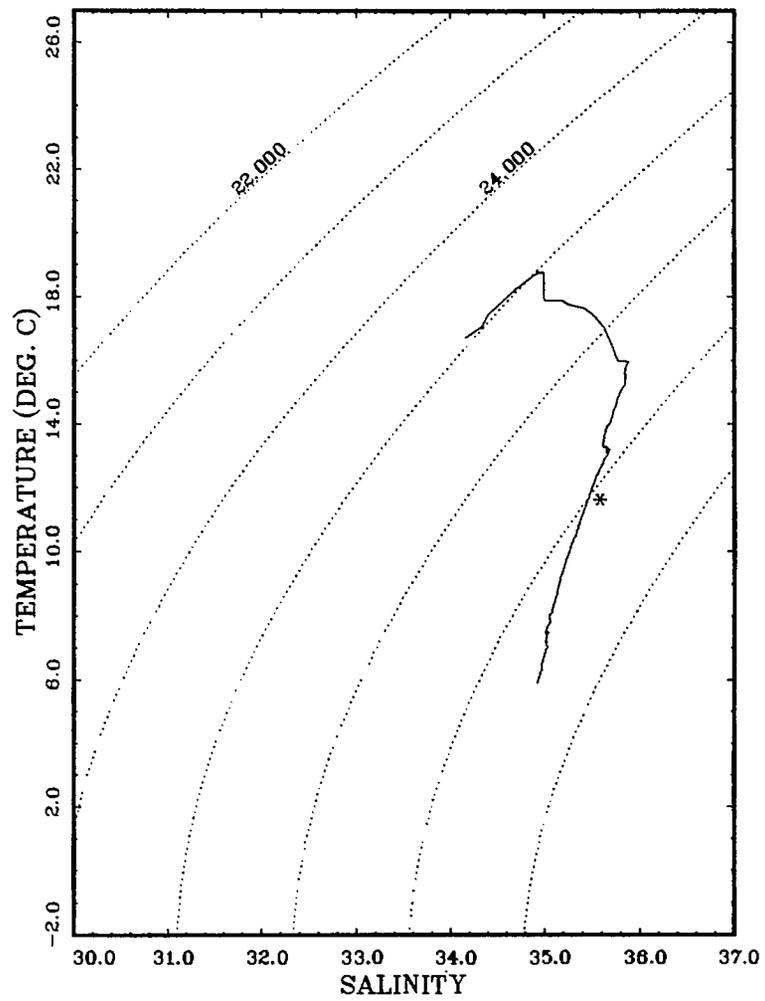
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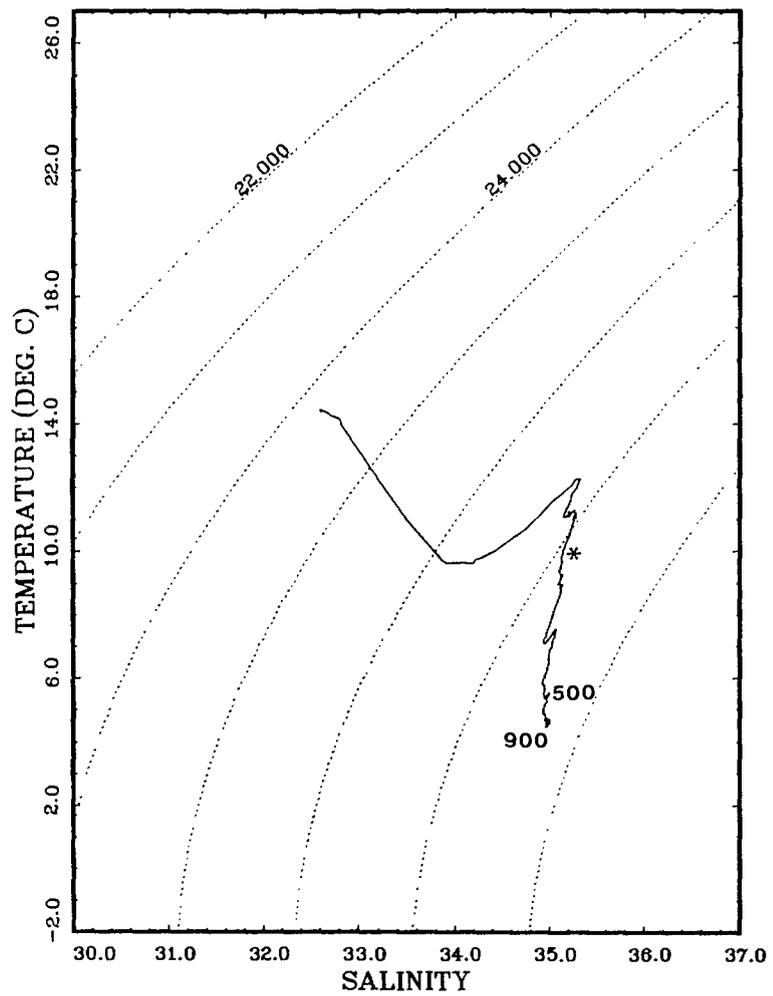
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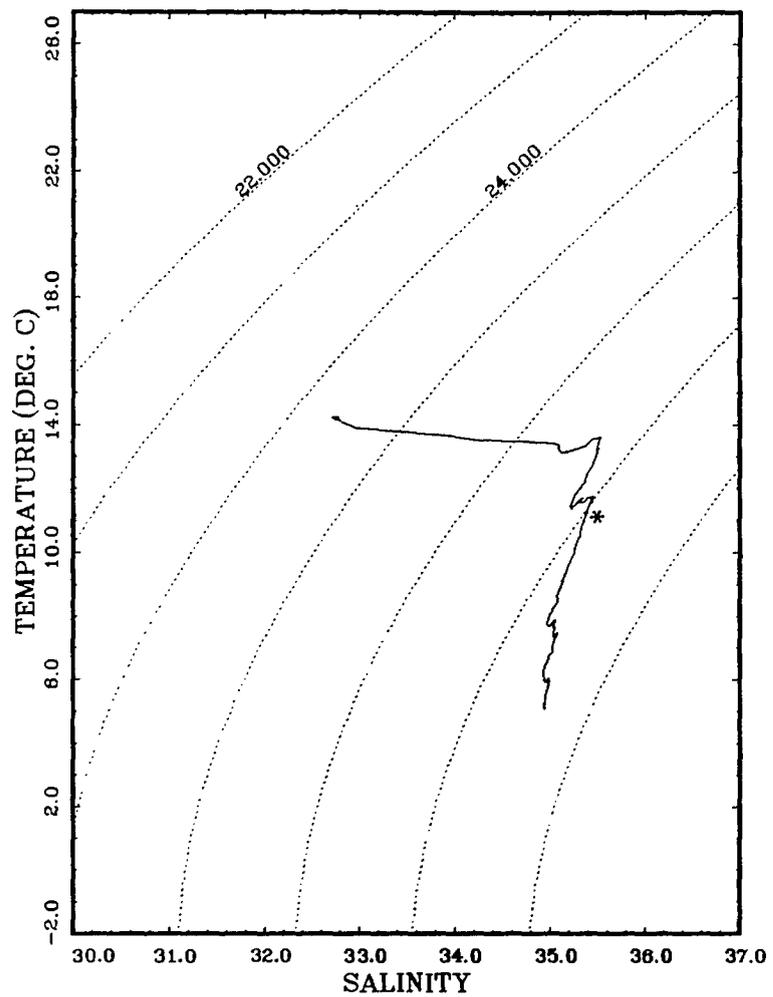
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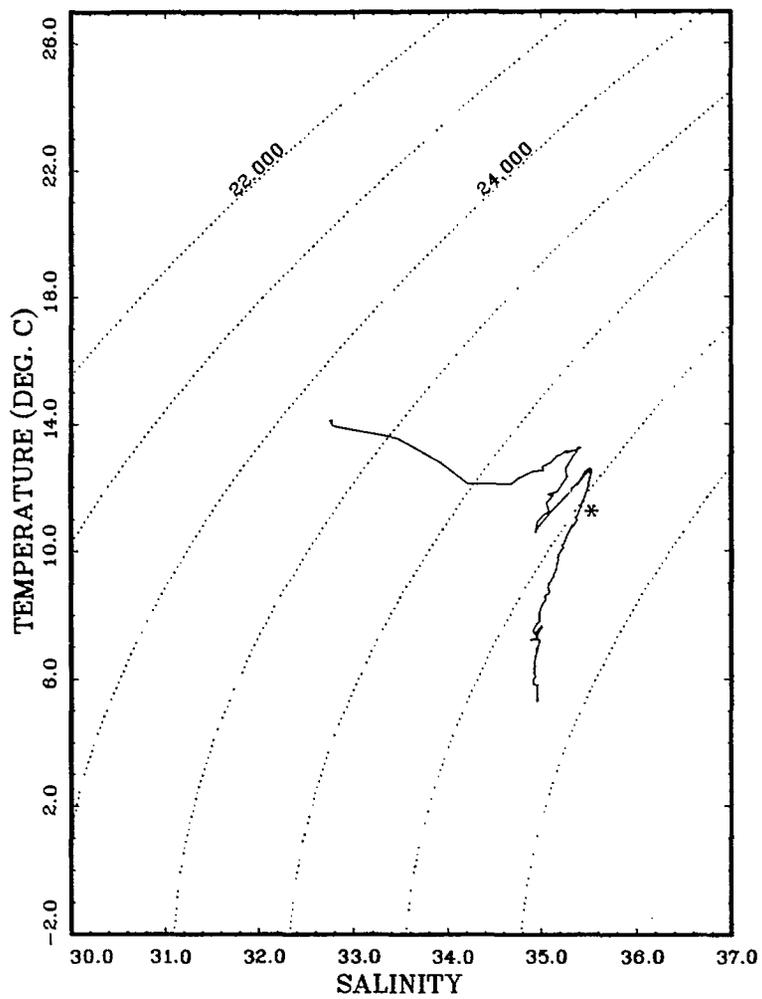
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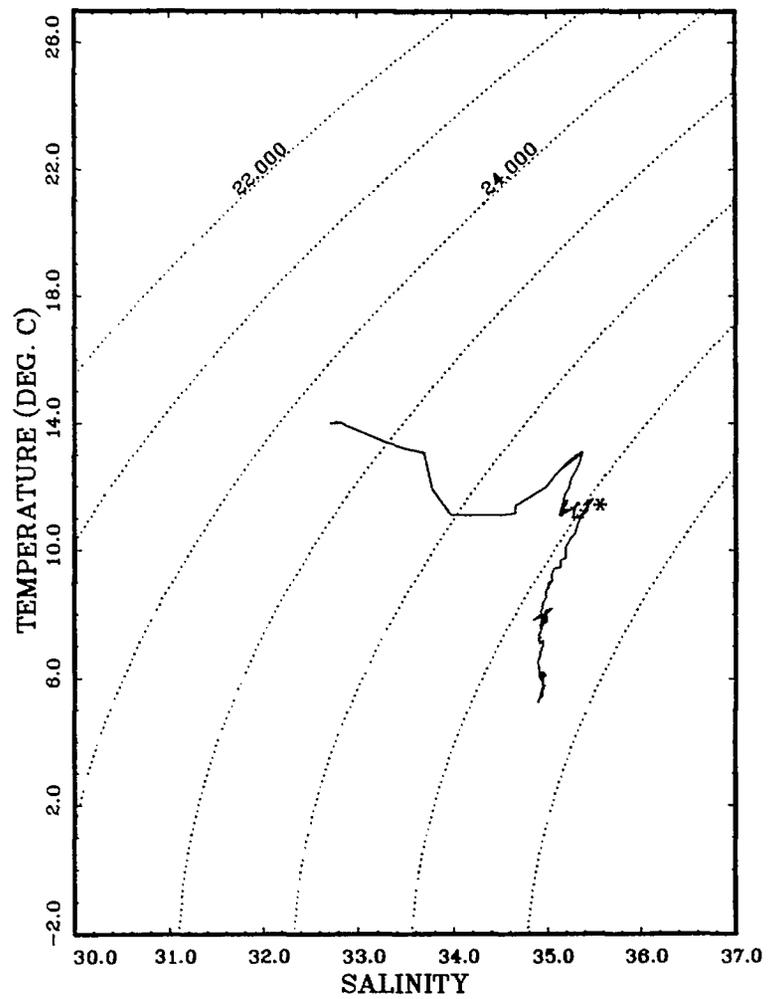
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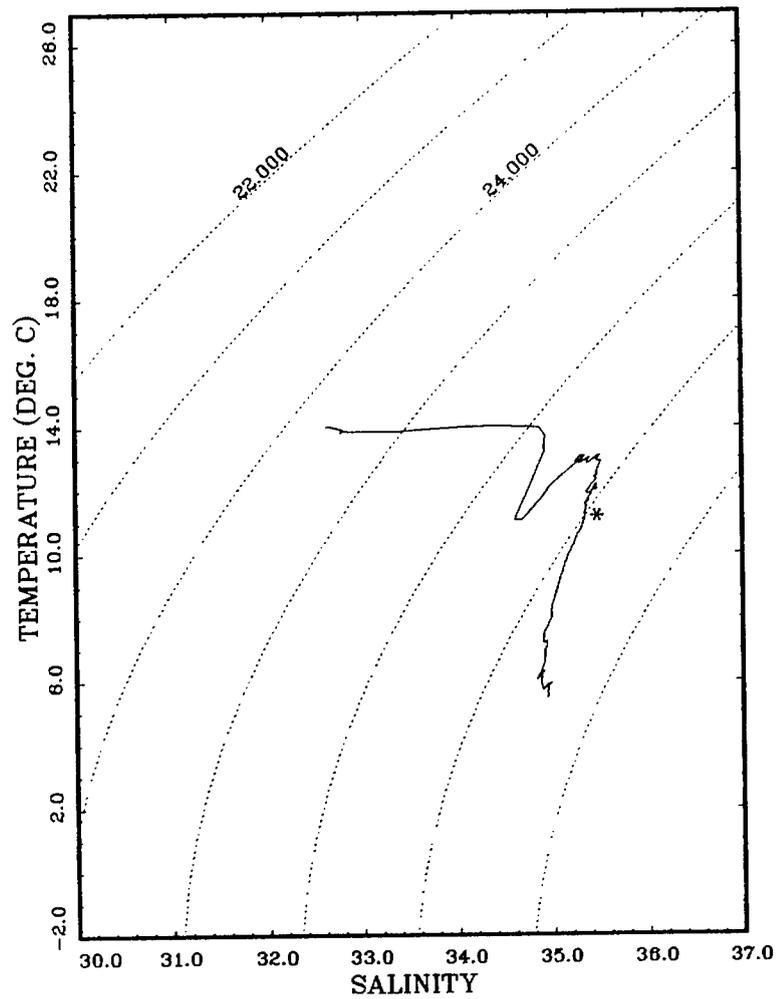
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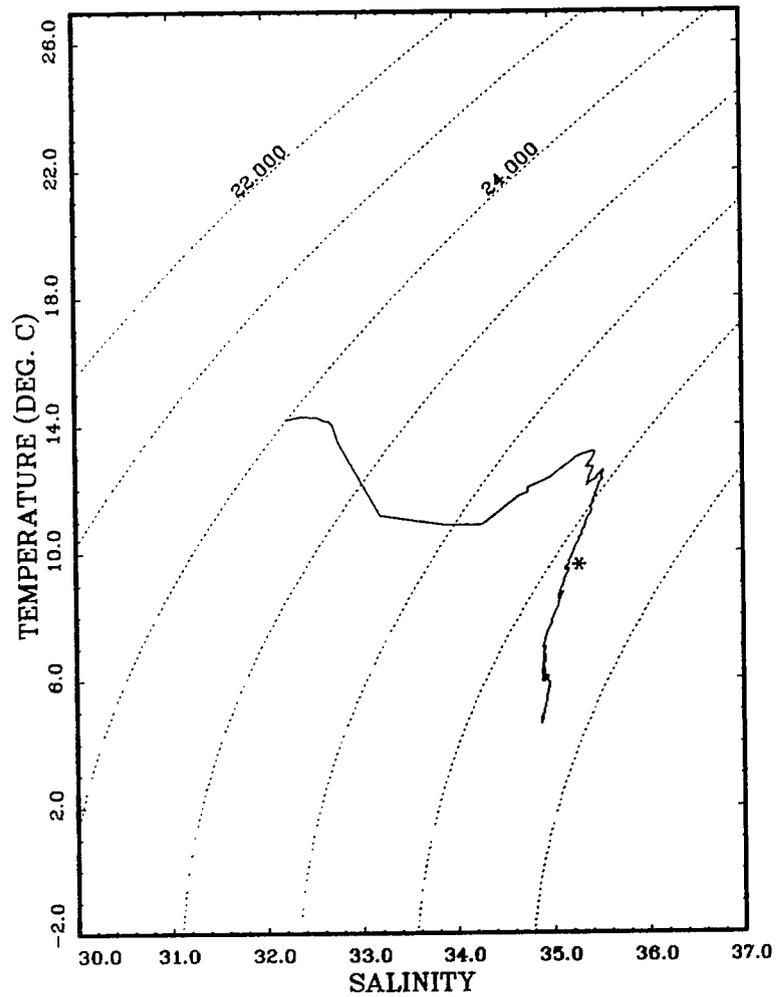
NEEDLER 110 - CTD 22



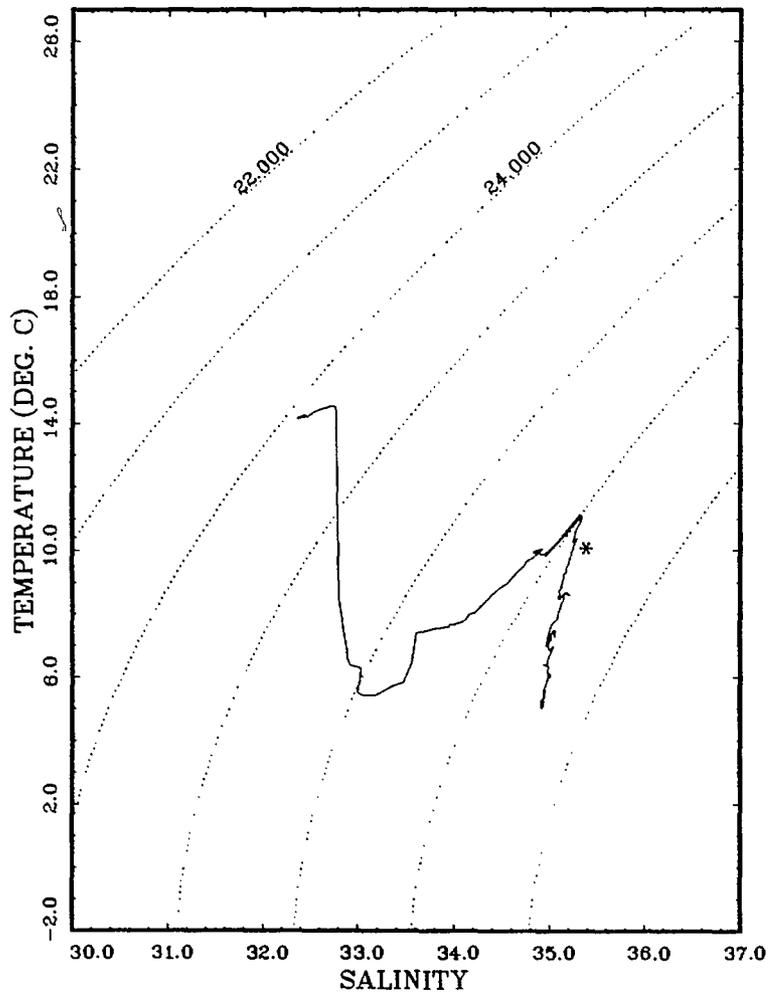
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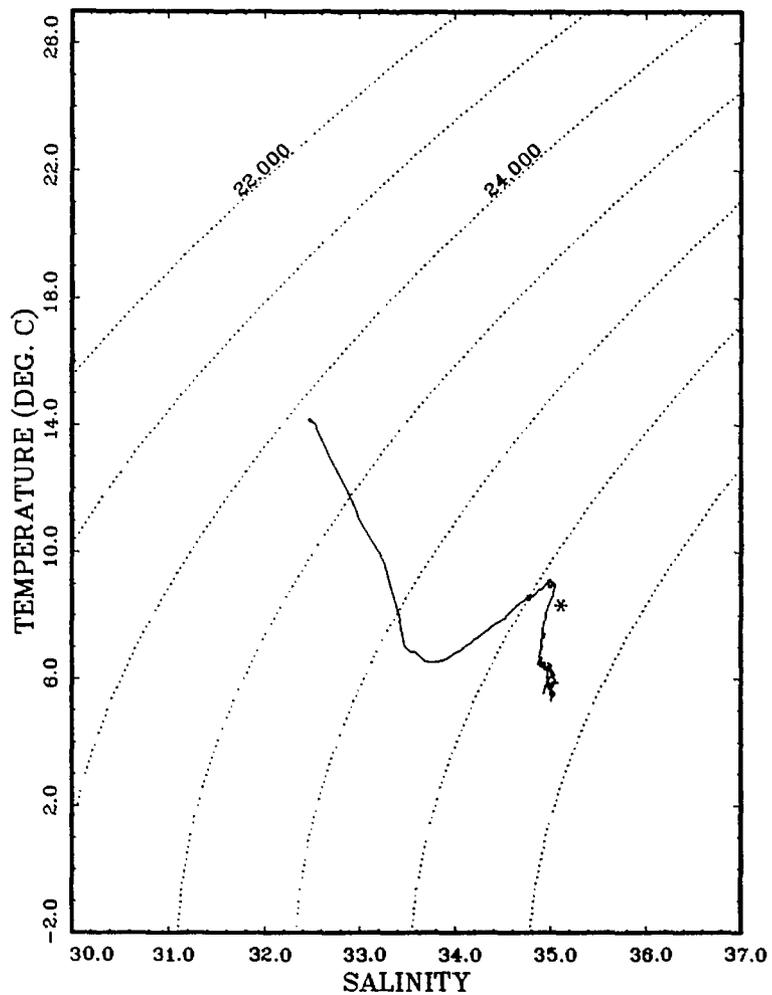
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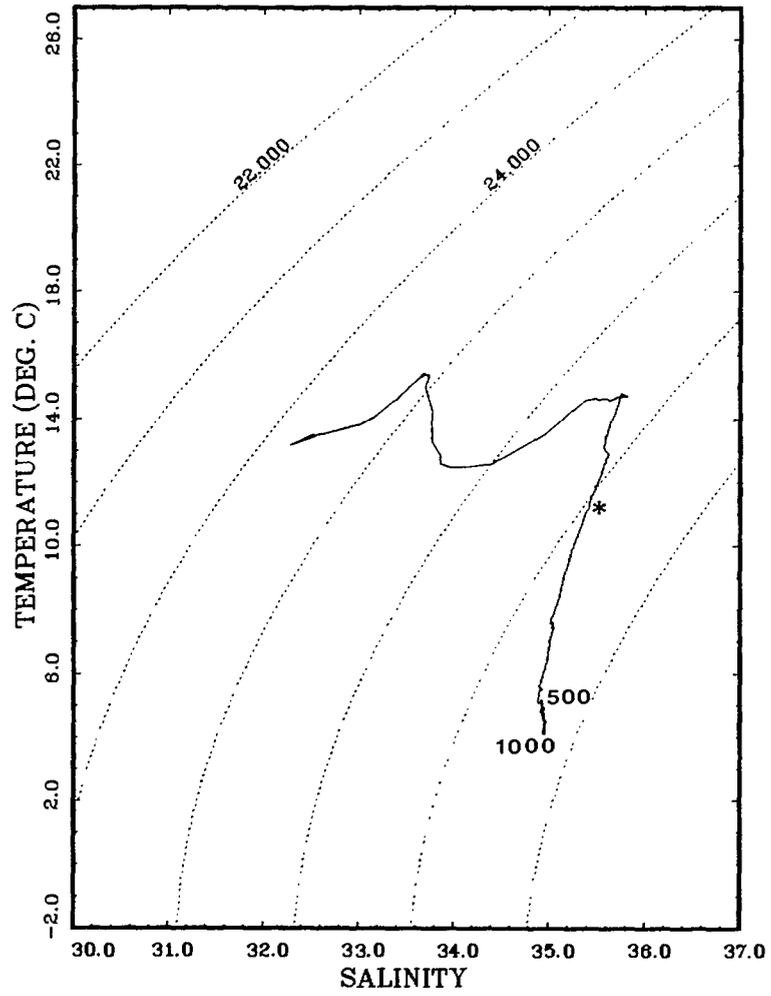
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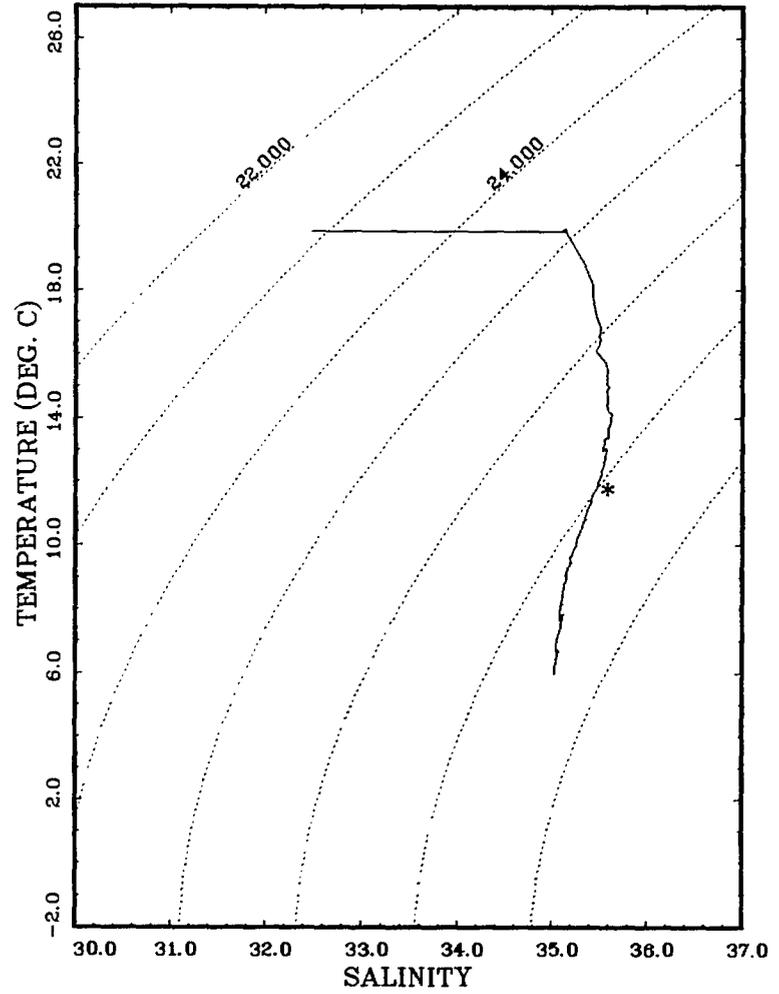
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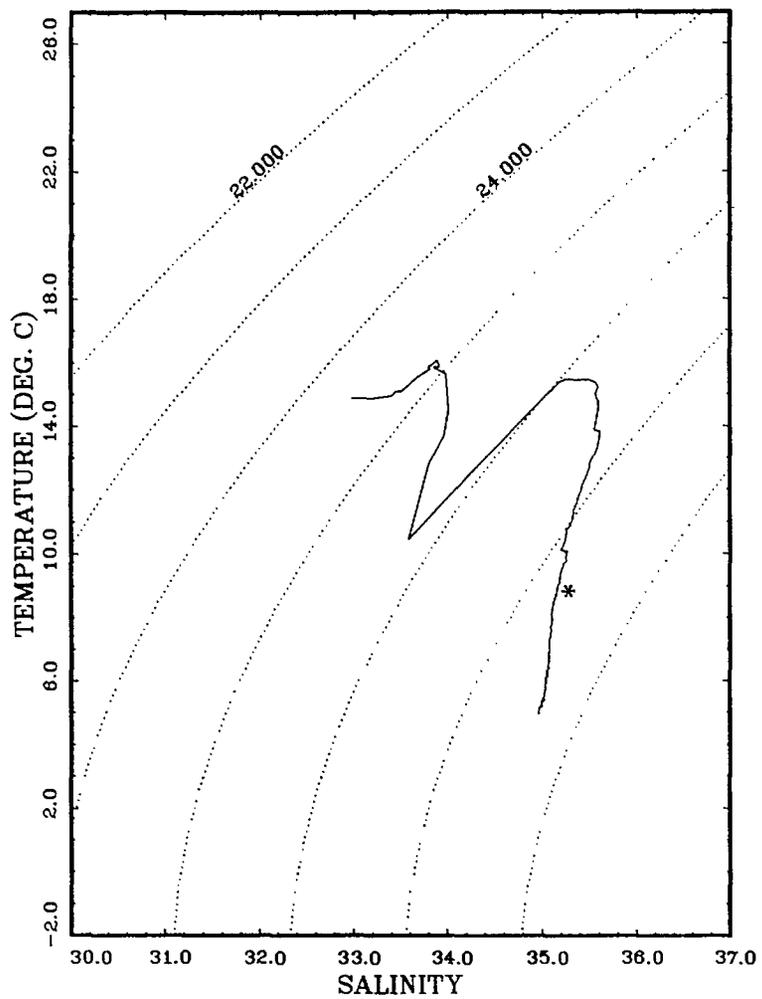
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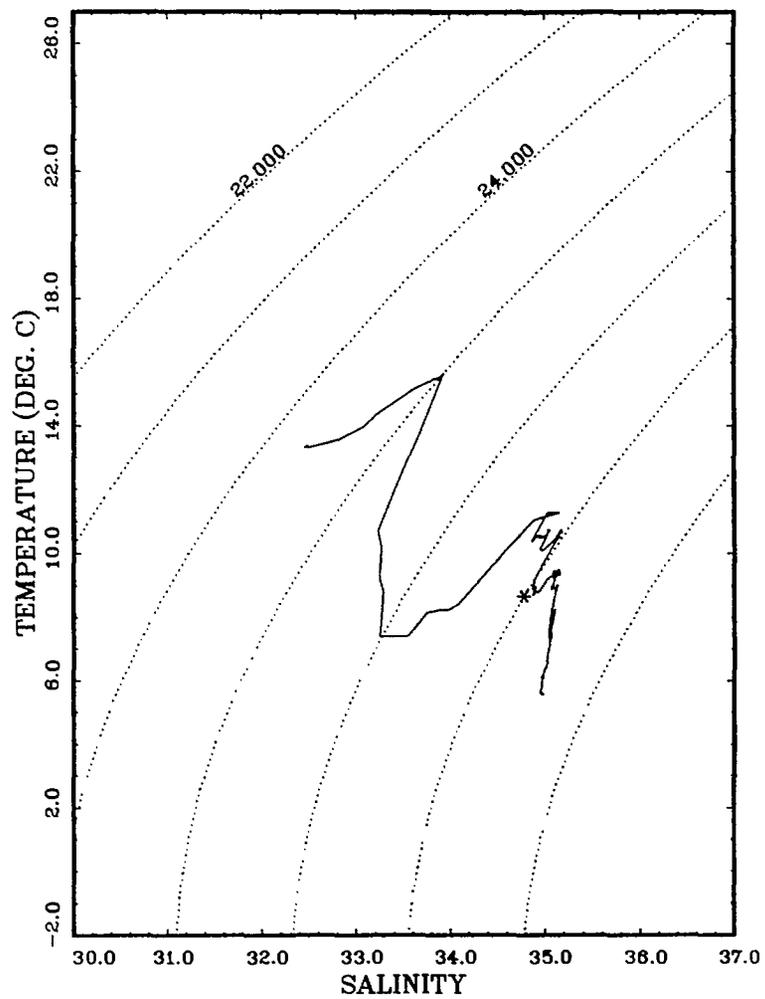
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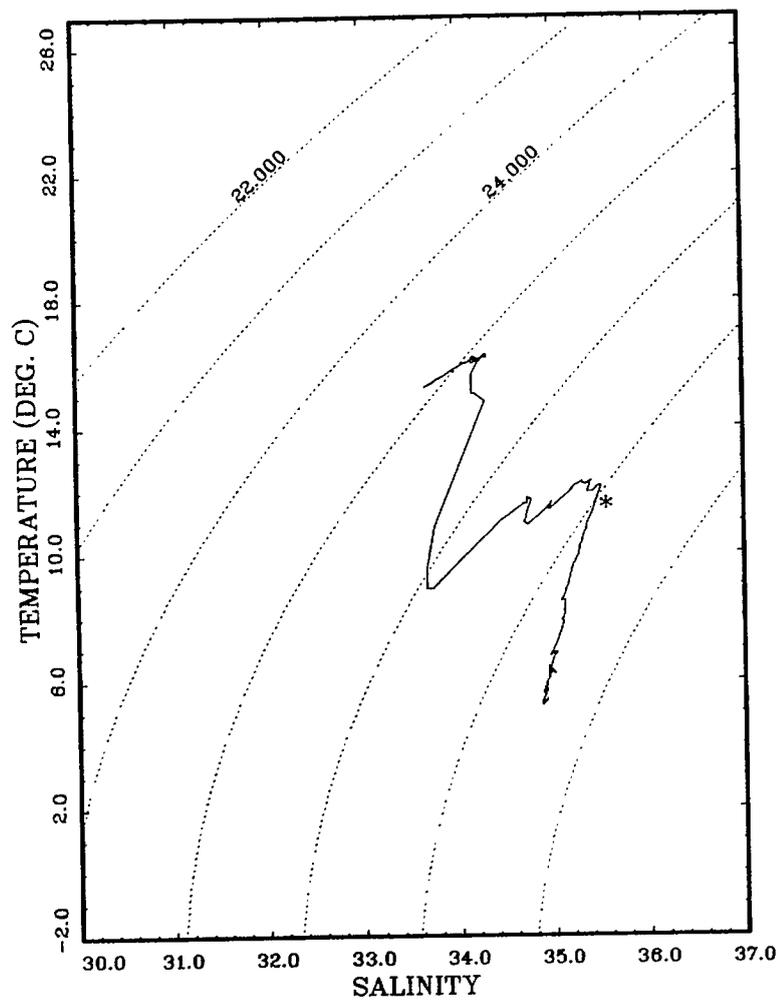
NEEDLER 110 - CTD 29



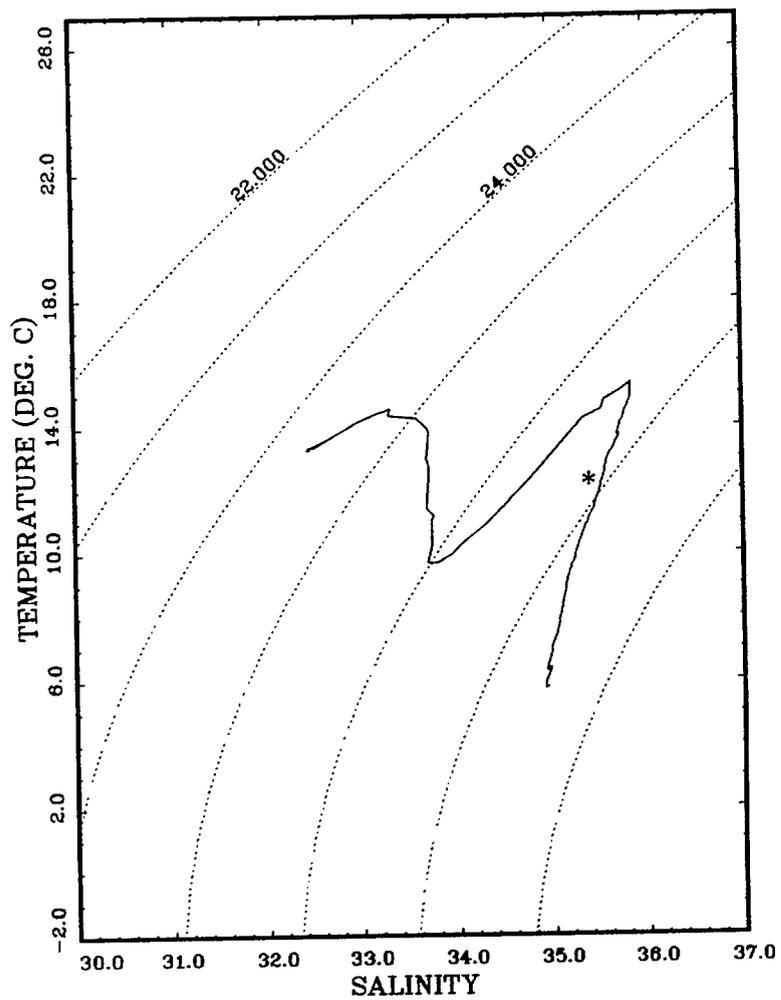
NEEDLER 110 - CTD 30



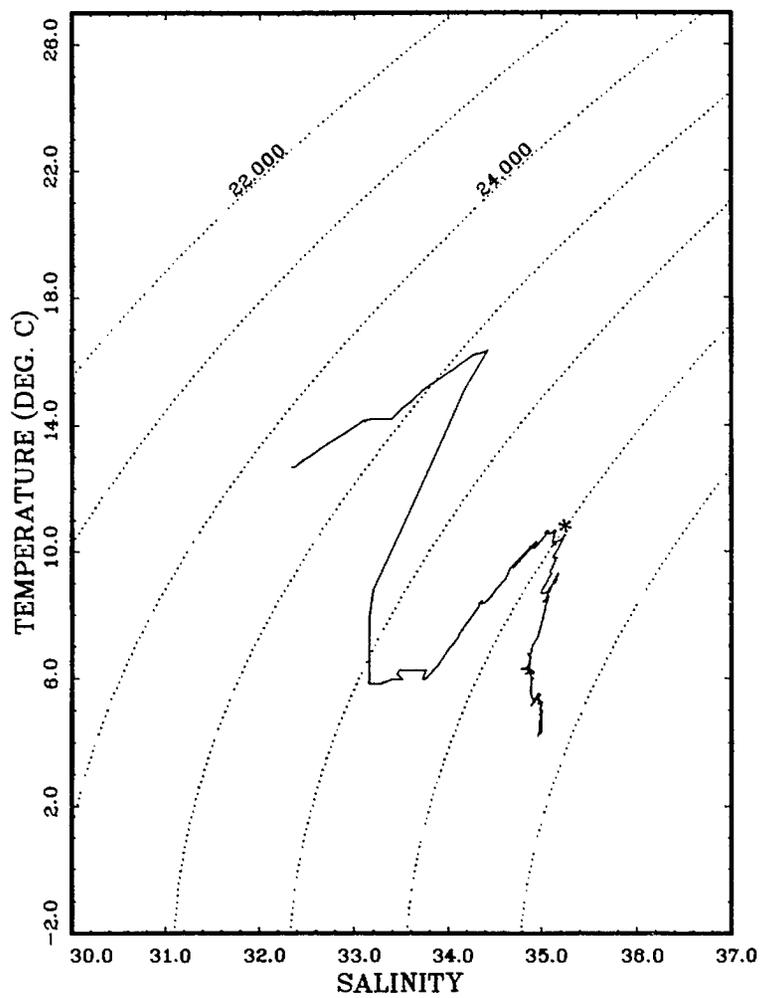
NEEDLER 110 - CTD 31



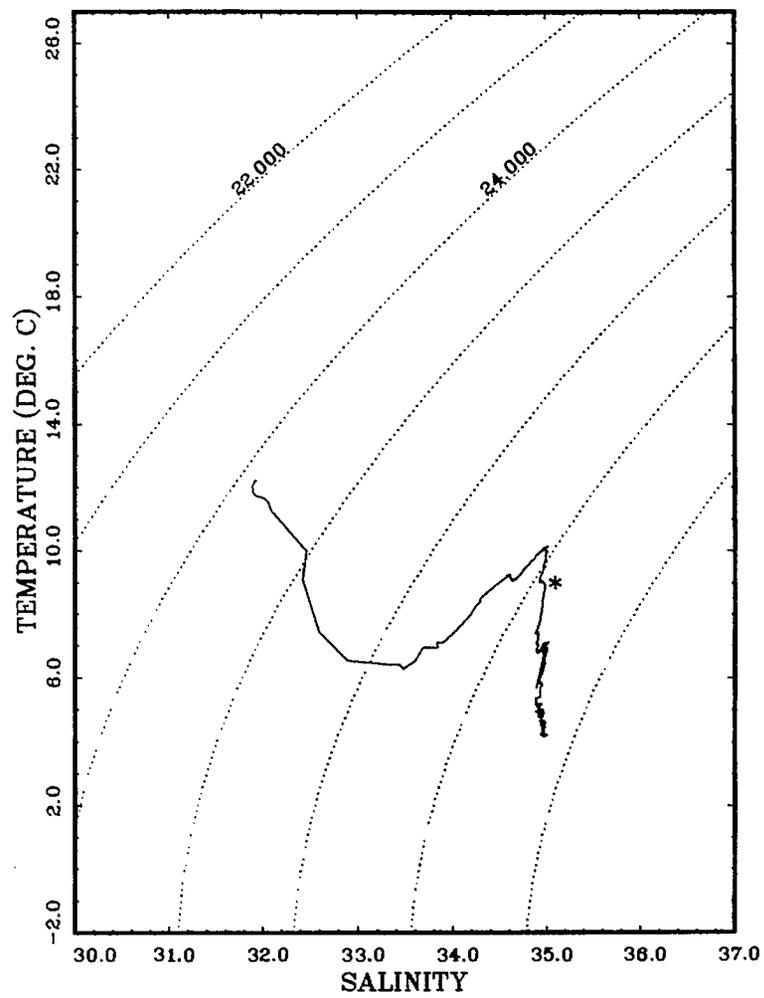
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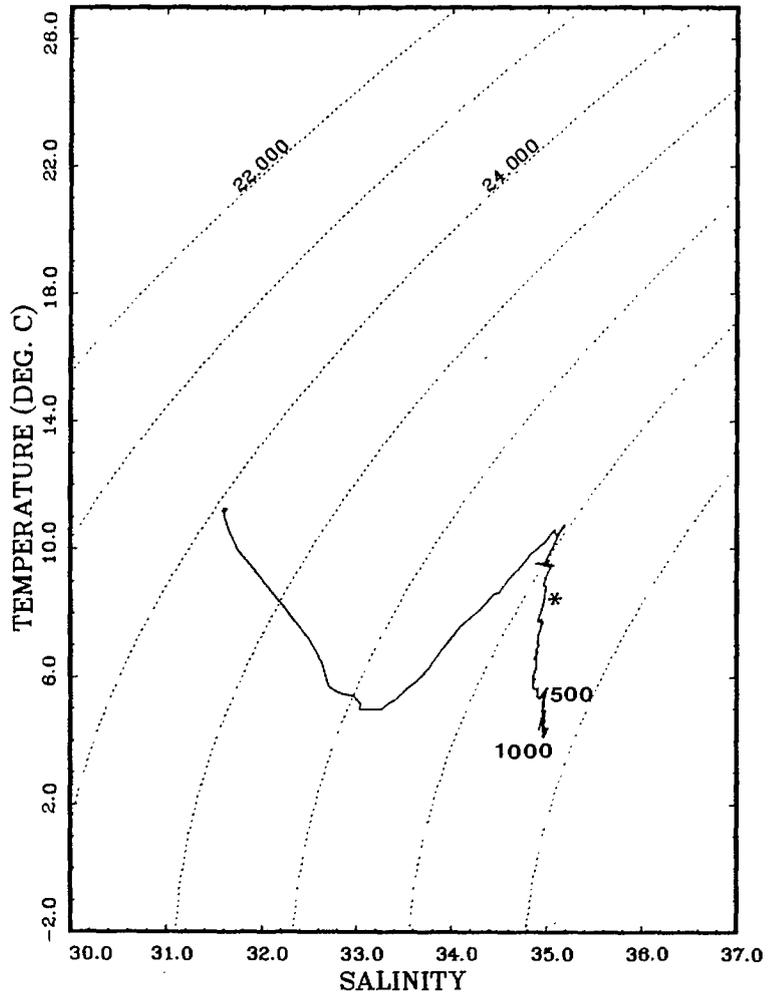
NEEDLER 110 - CTD 33



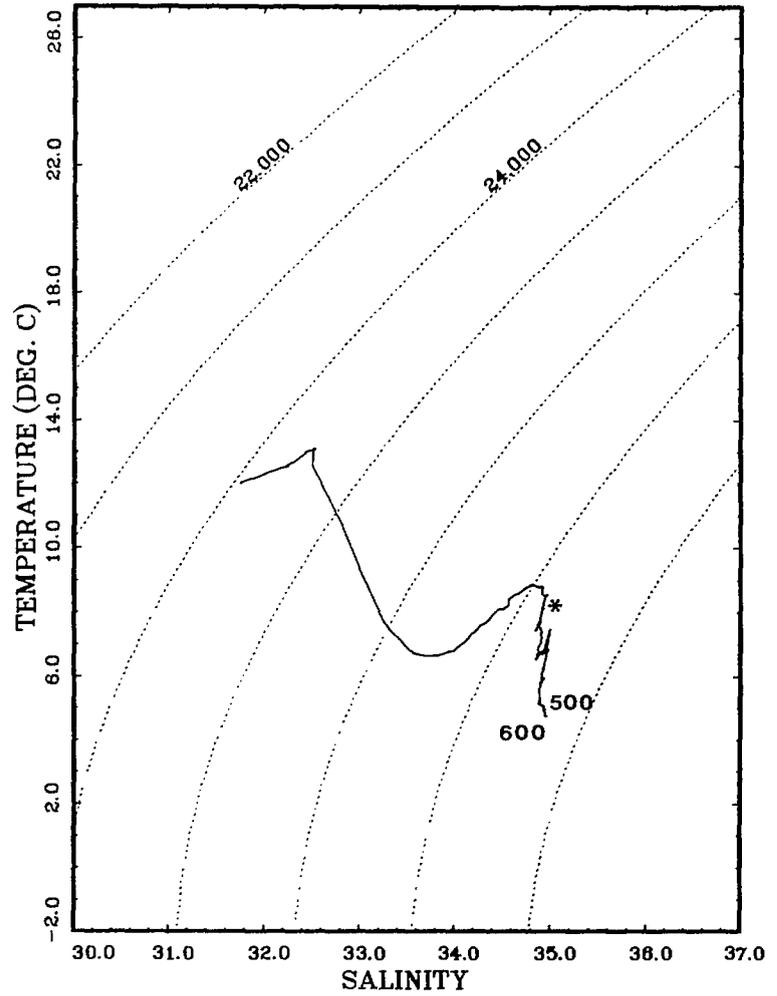
NEEDLER 110 - CTD 34



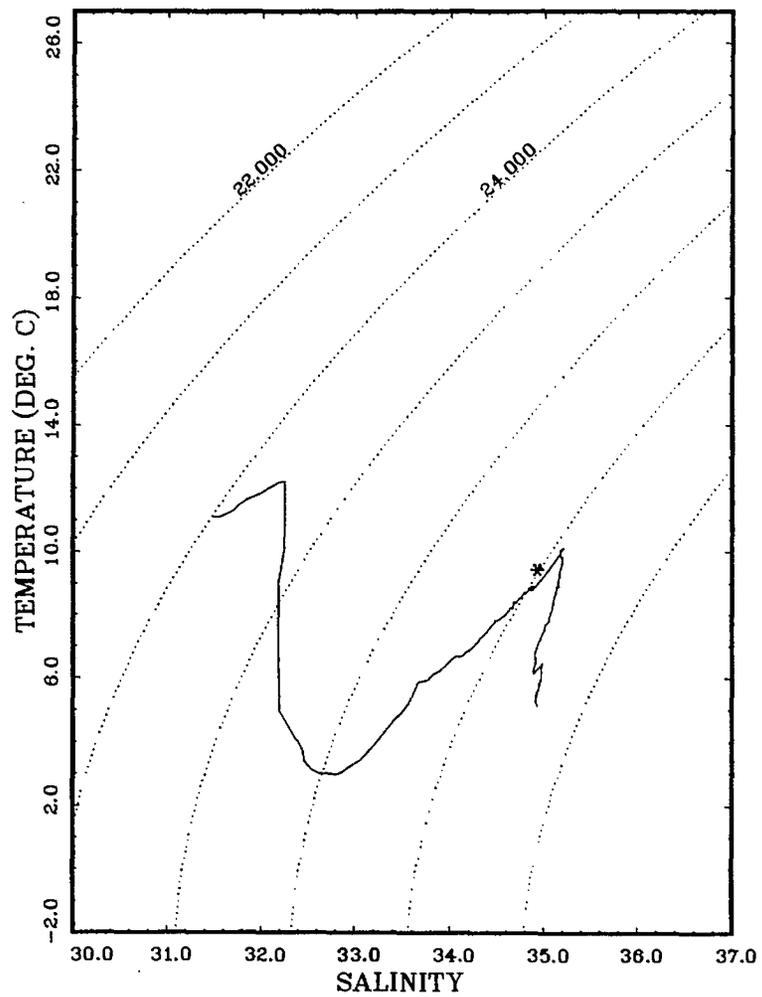
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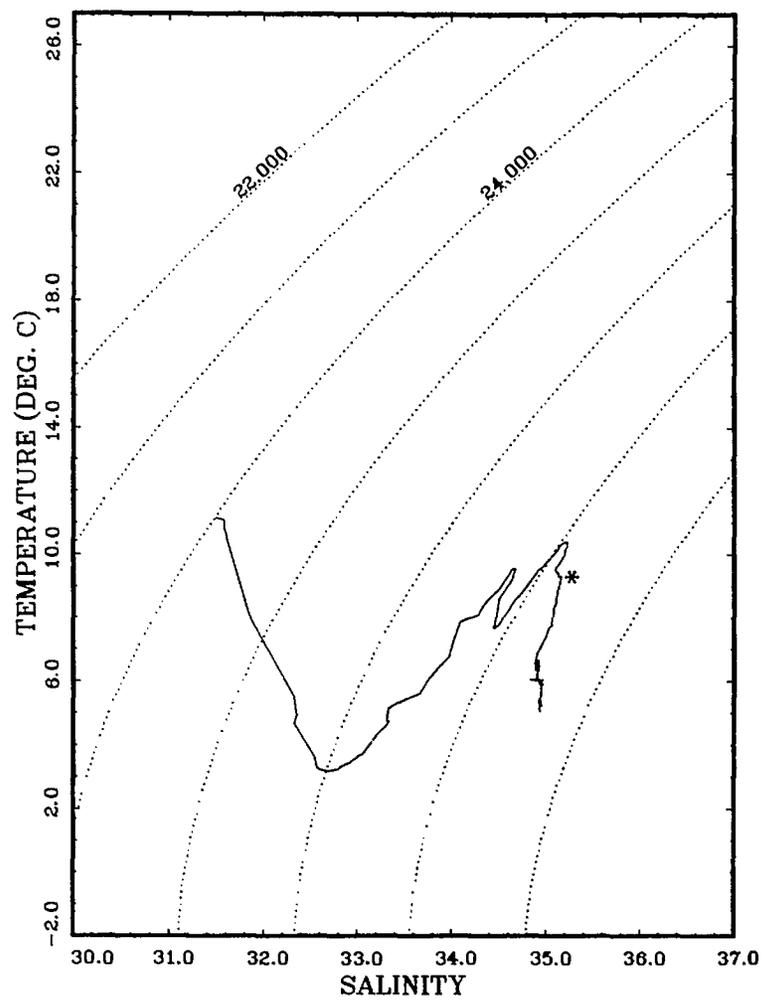
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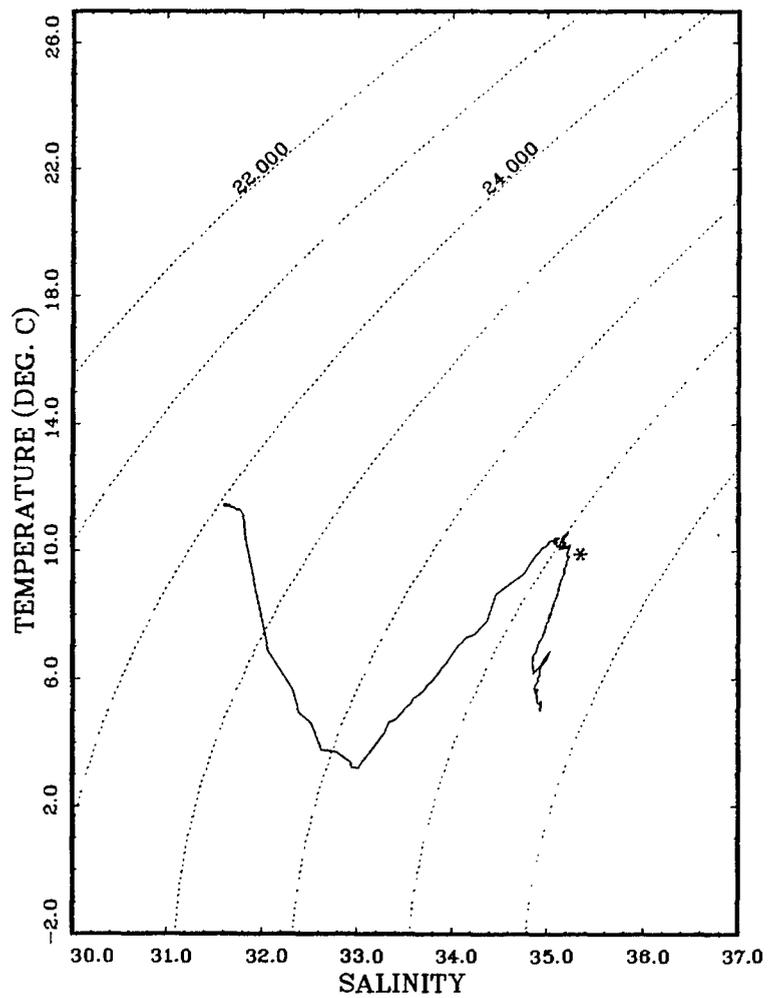
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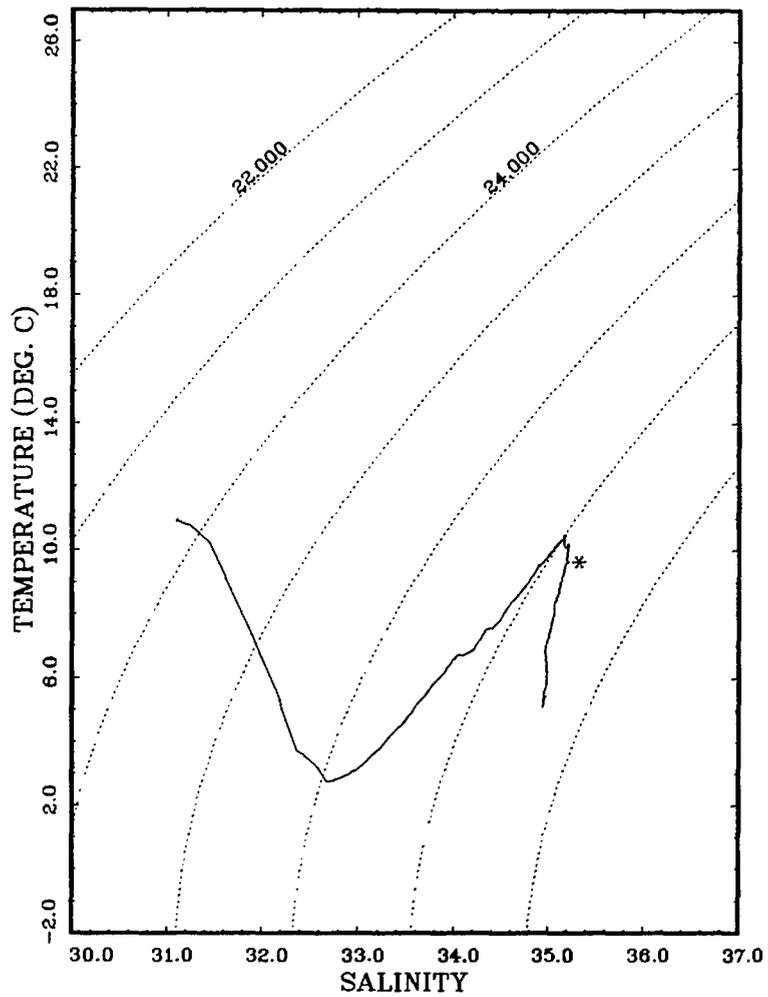
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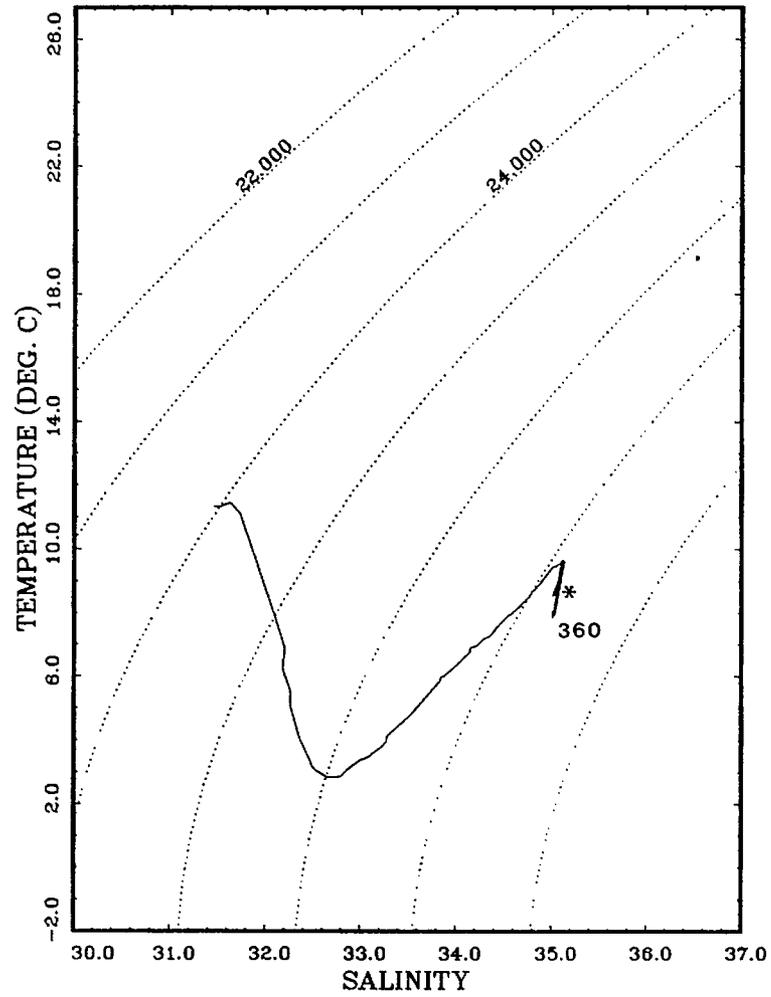
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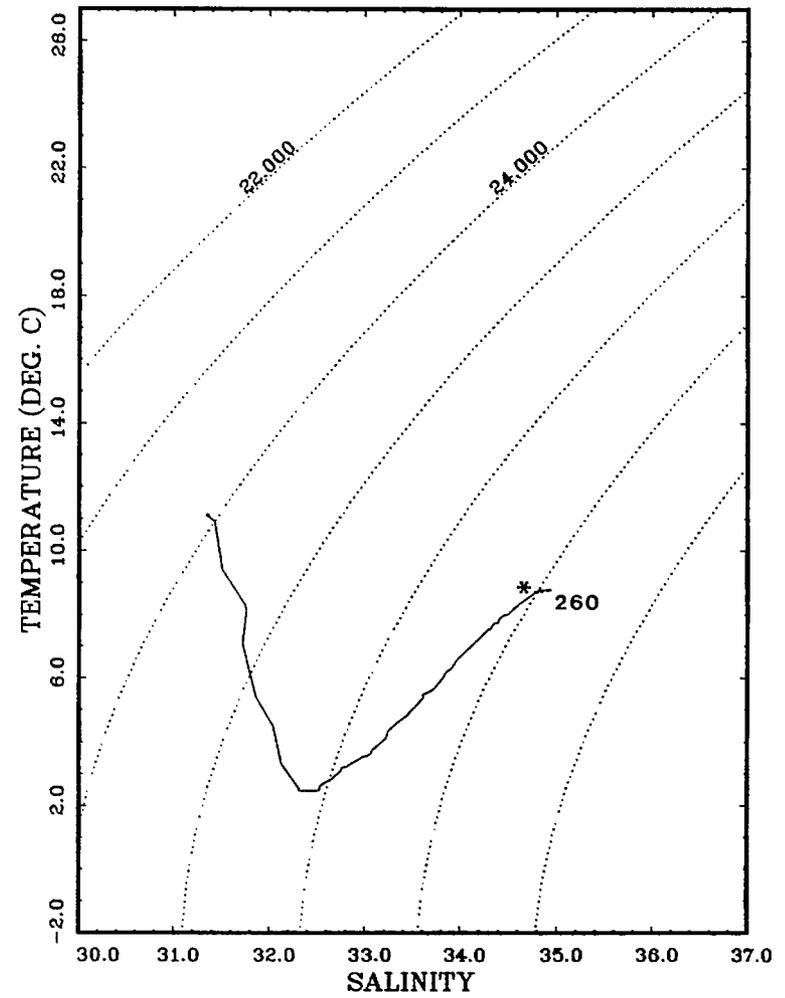
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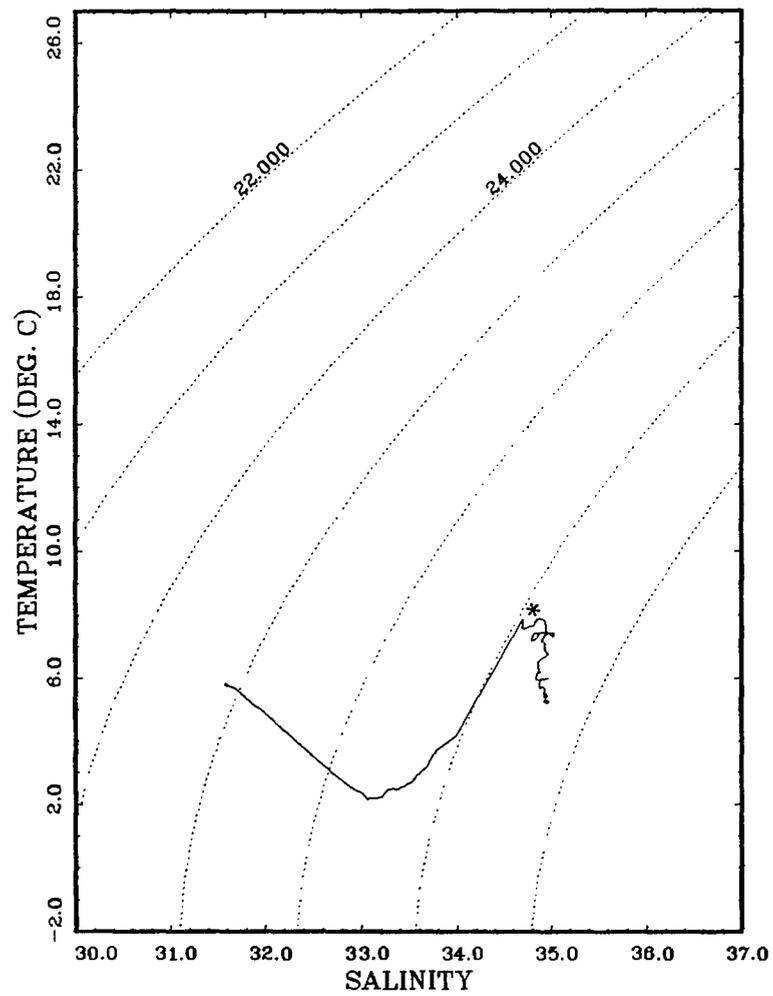
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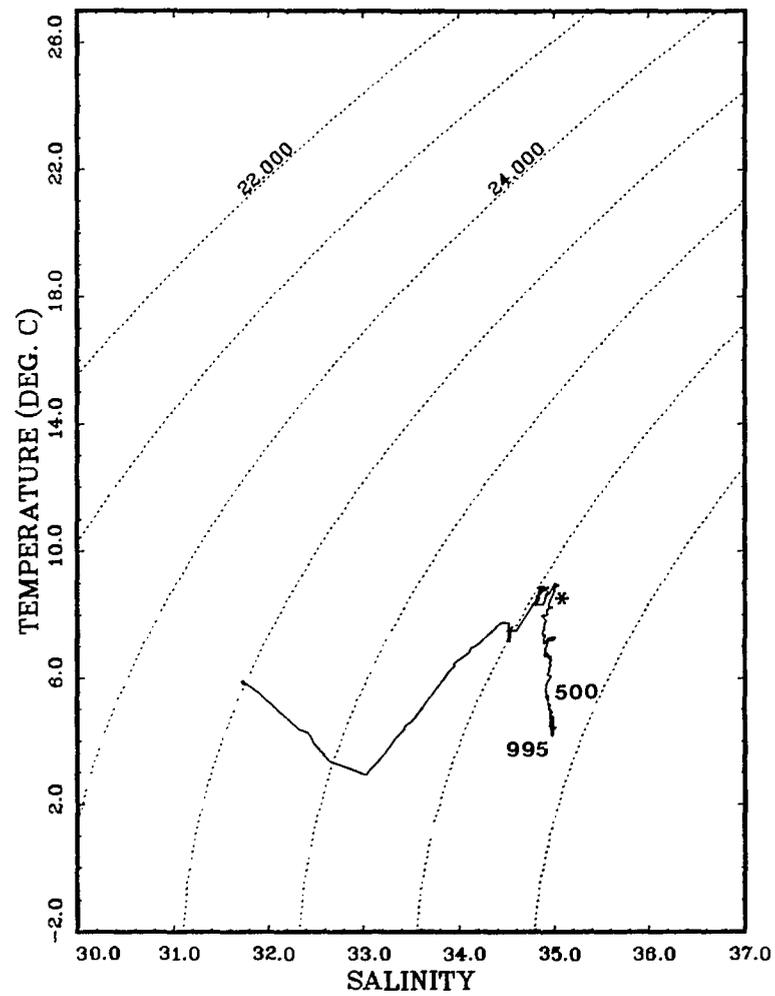
NEEDLER 110 - CTD 42



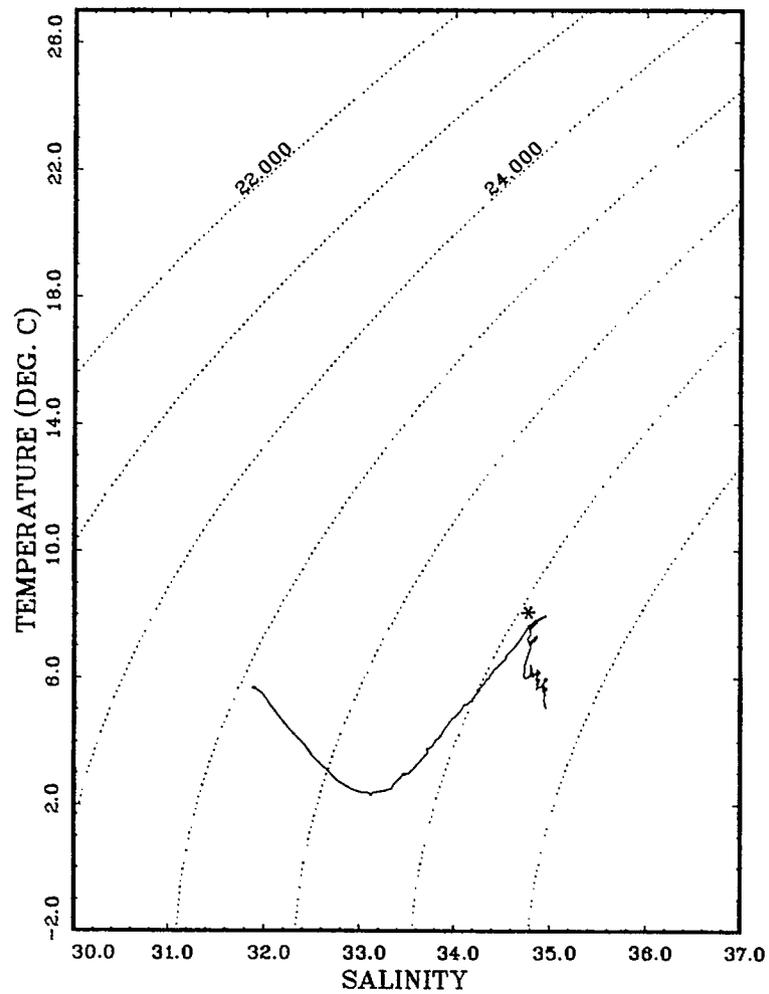
NEEDLER 112 - CTD 1



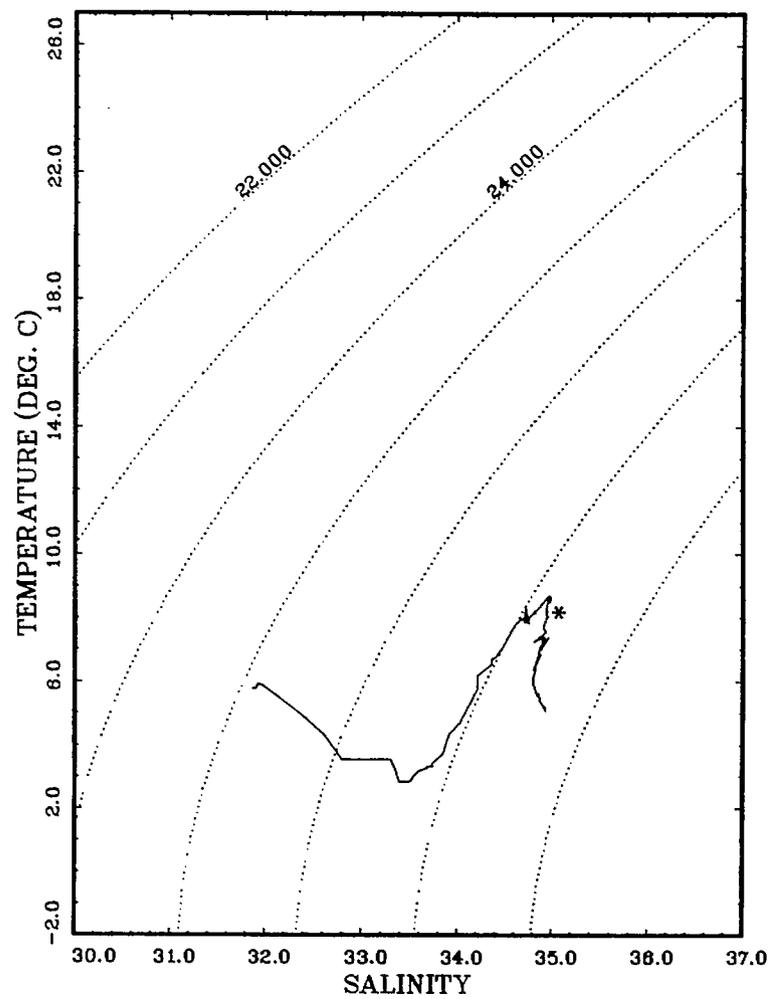
NEEDLER 112 - CTD 2



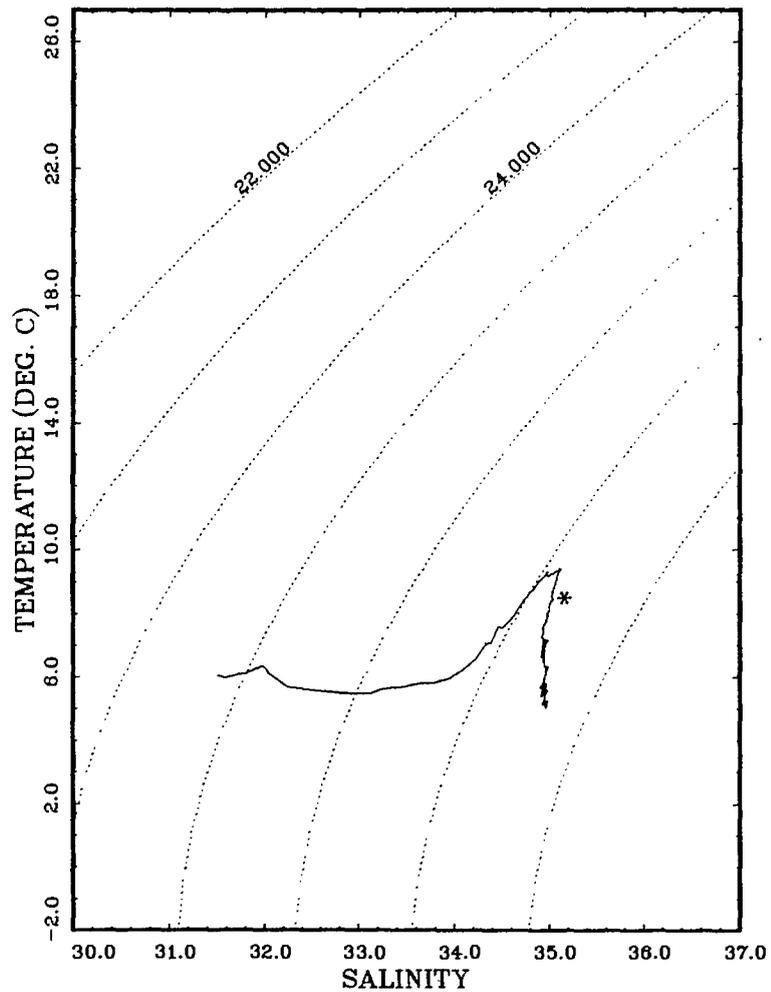
NEEDLER 112 - CTD 3



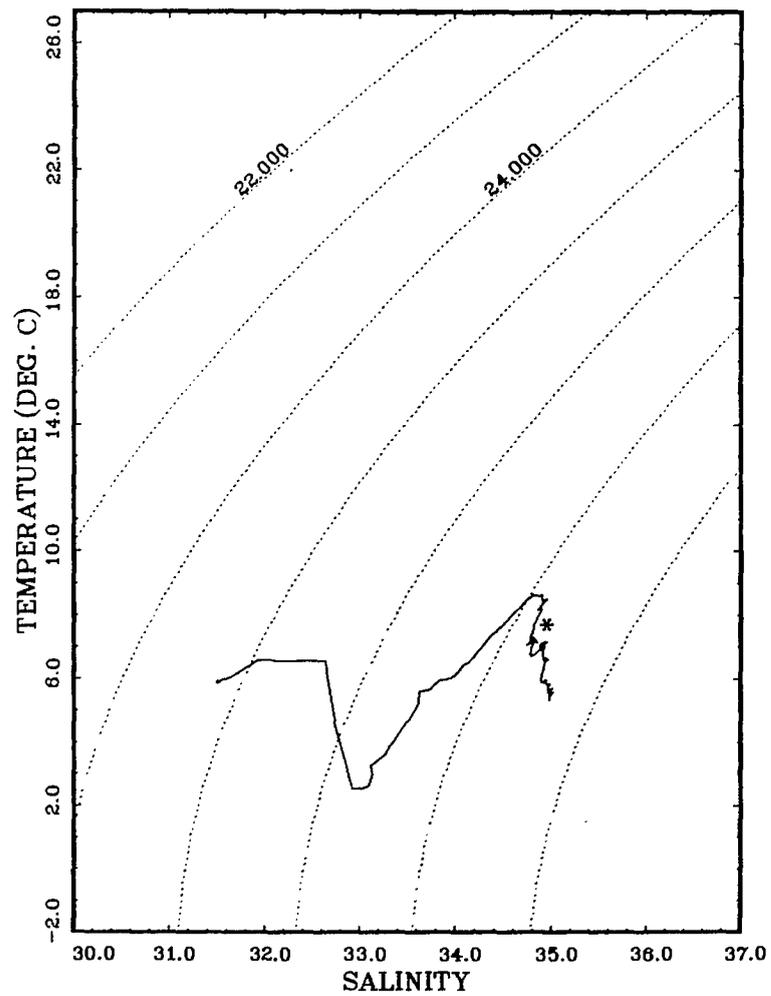
NEEDLER 112 - CTD 4



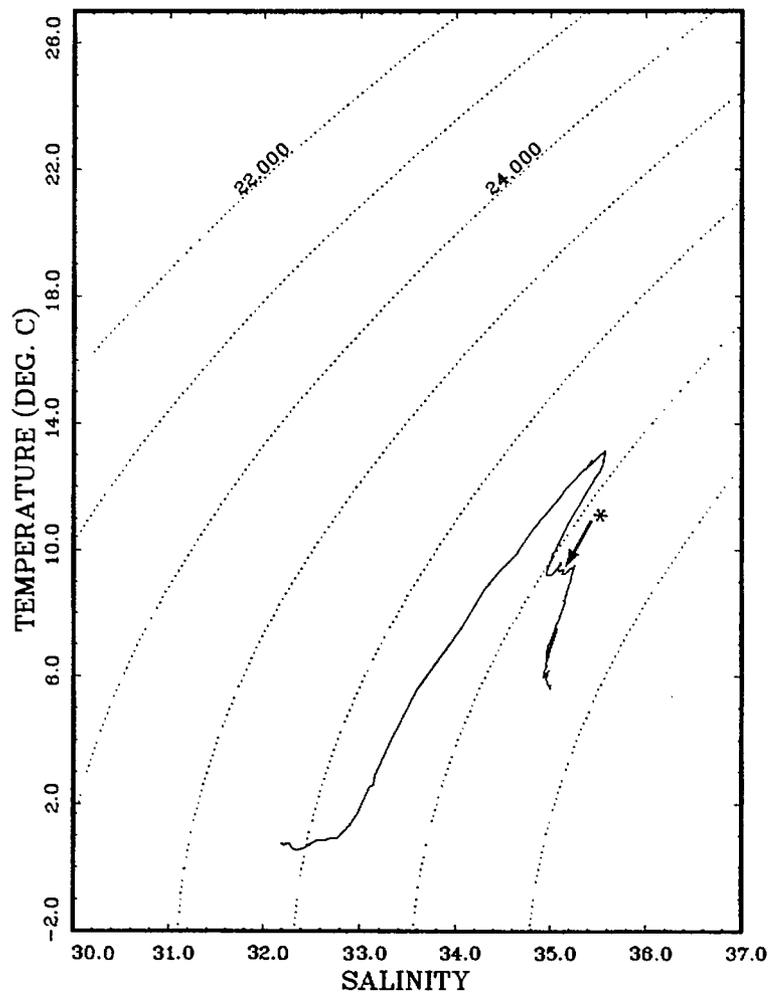
NEEDLER 112 - CTD 5



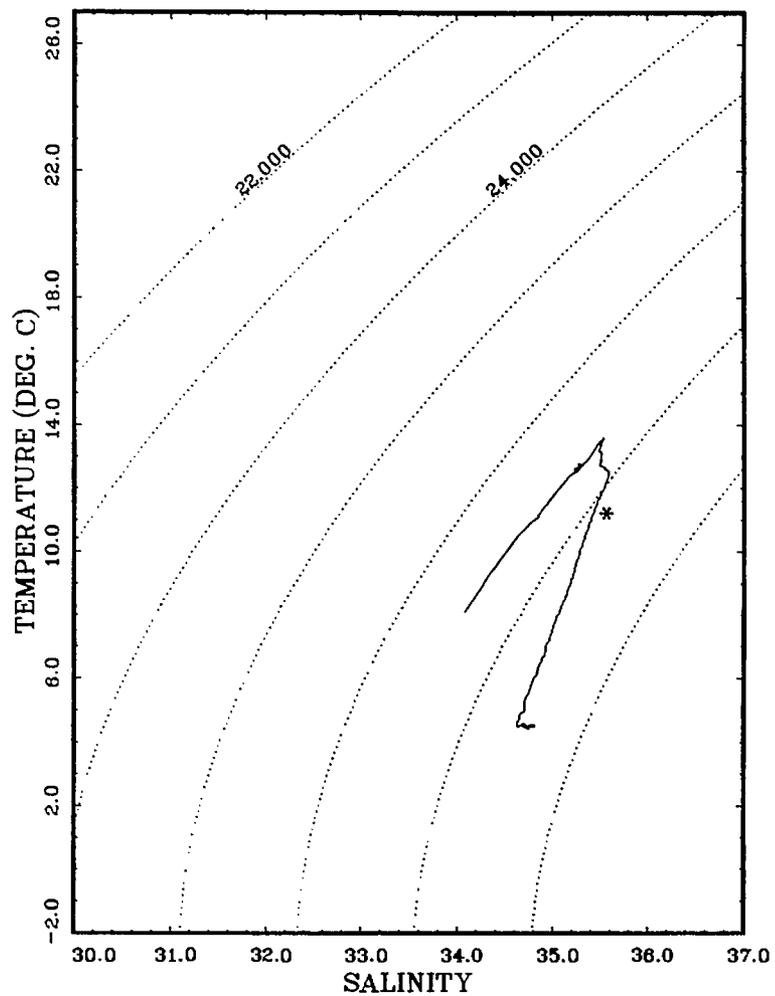
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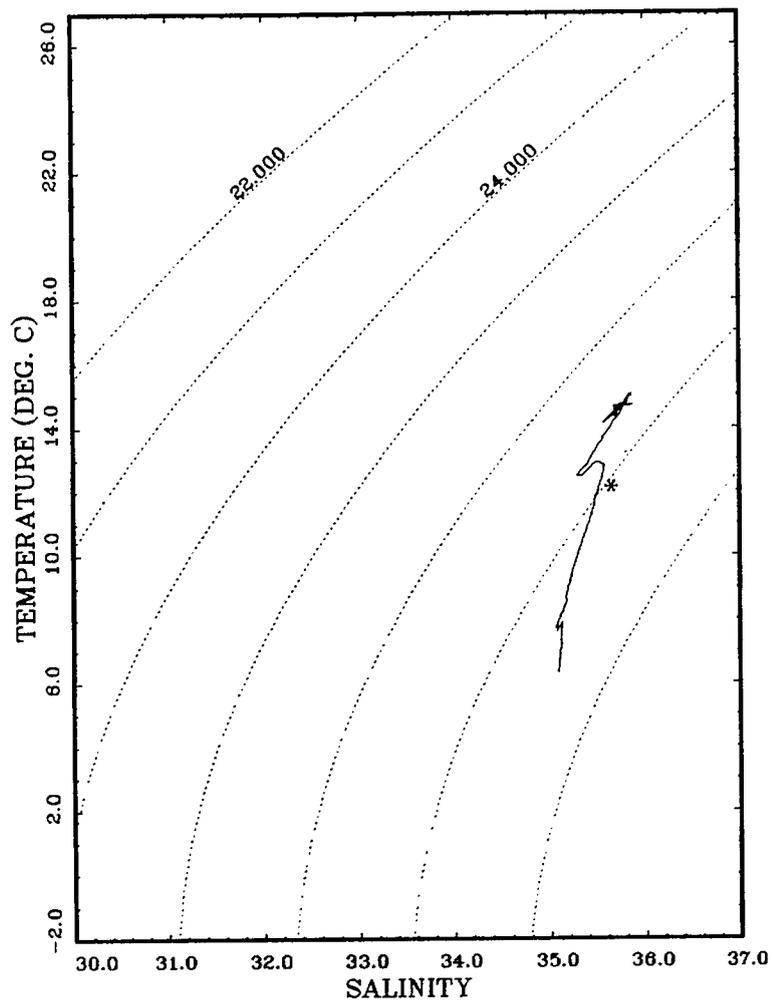
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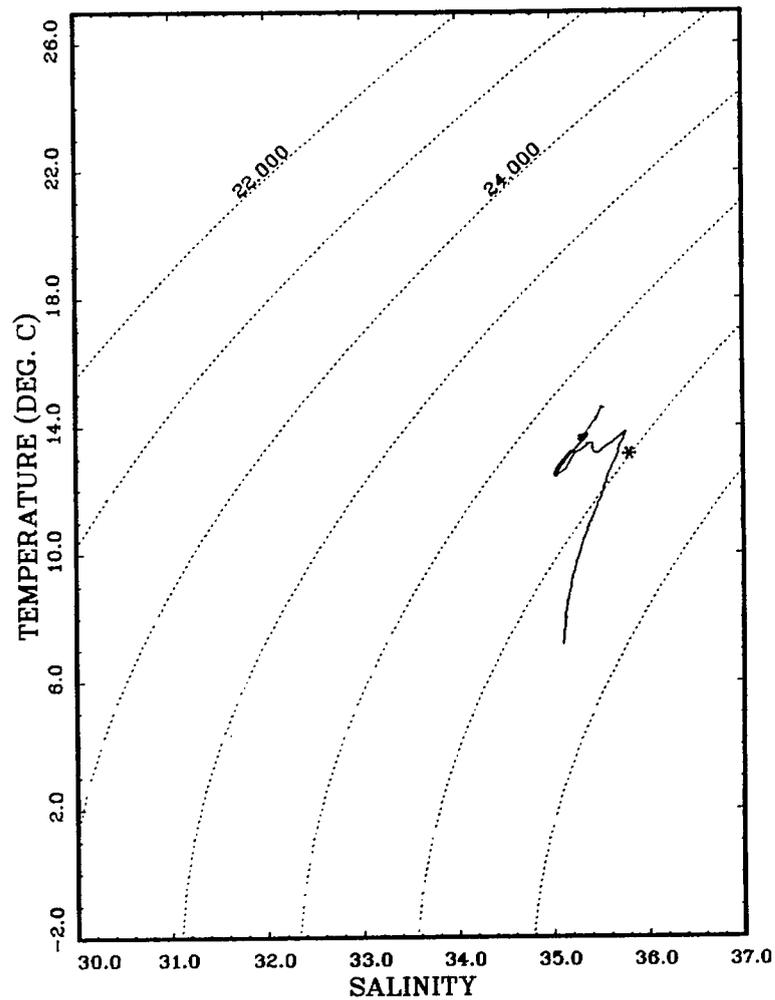
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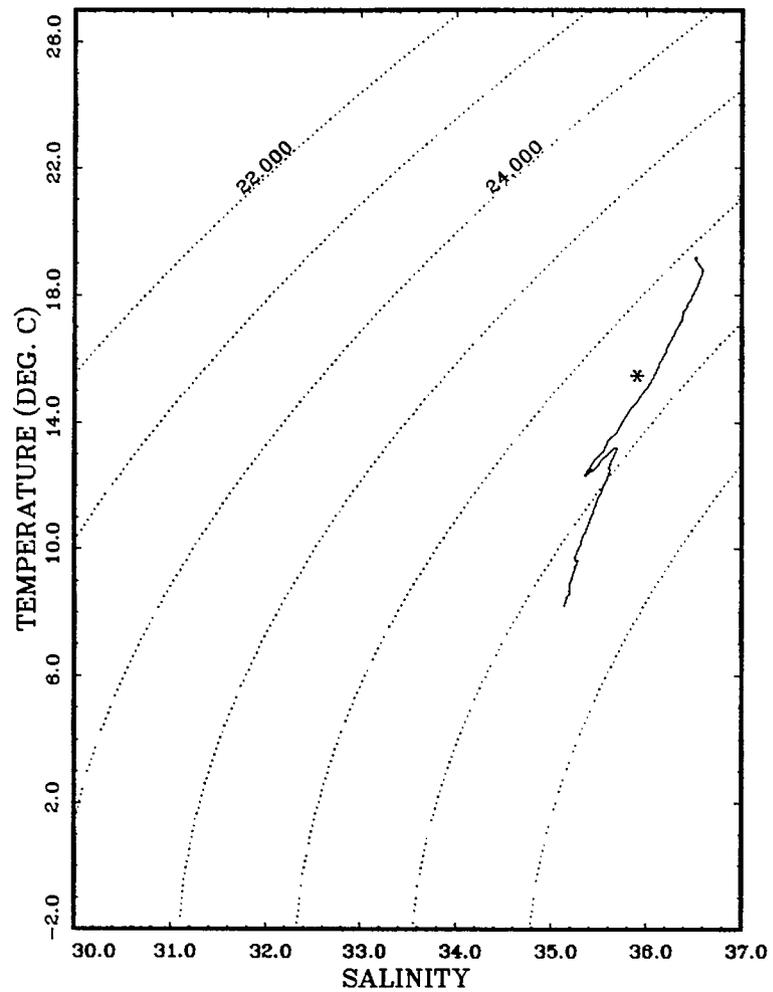
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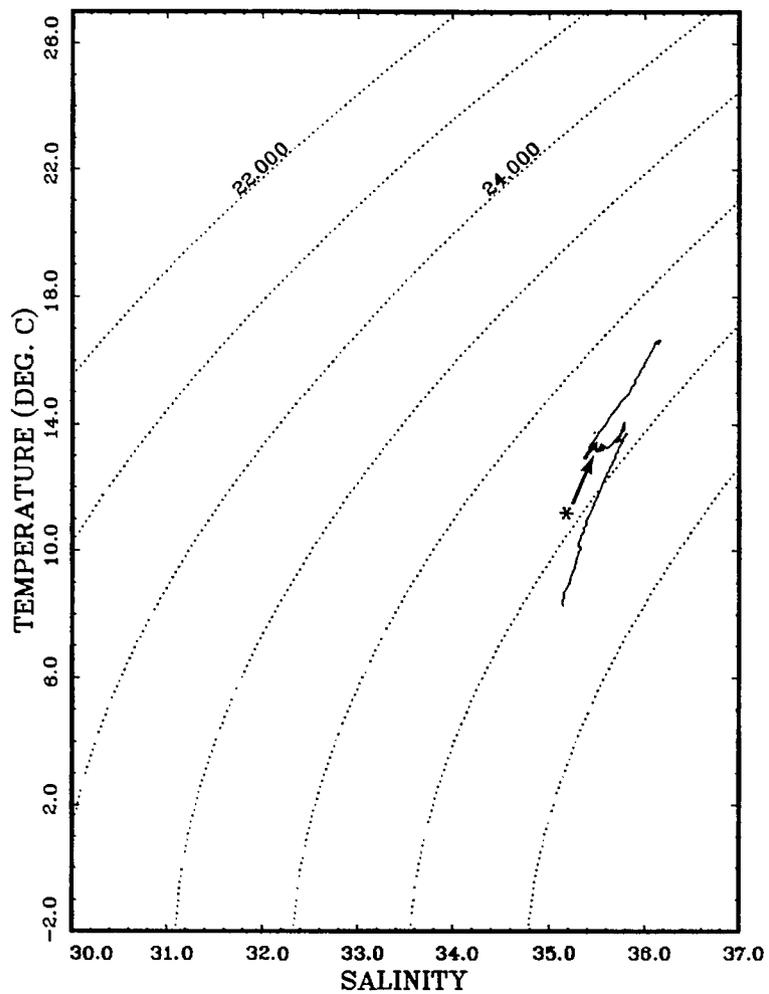
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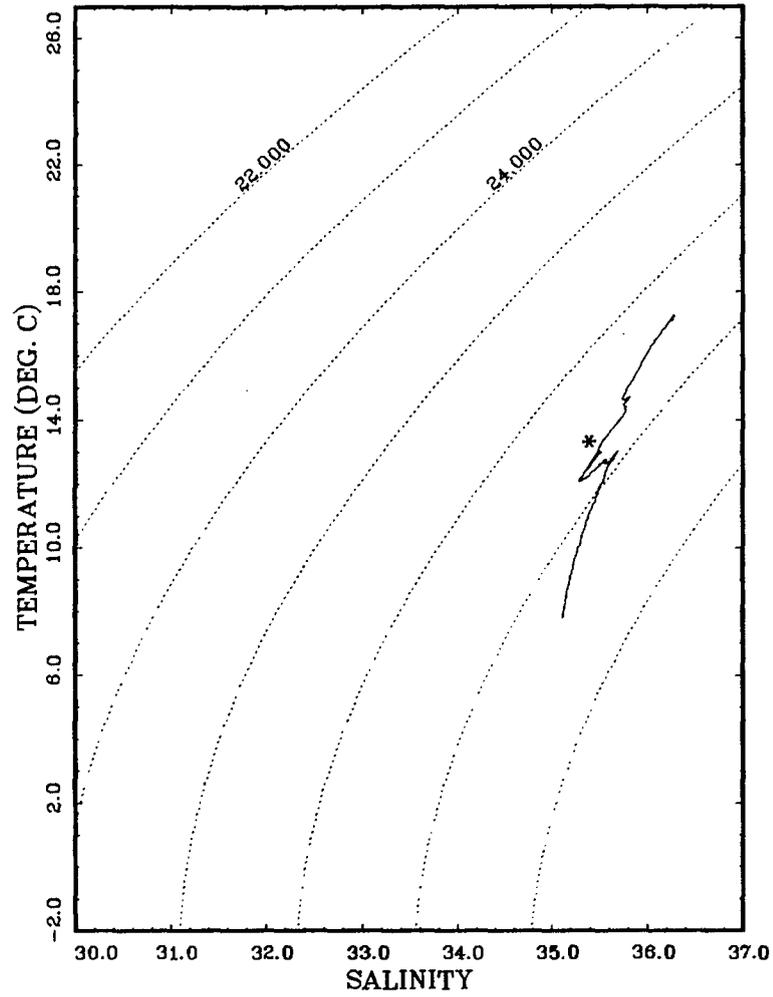
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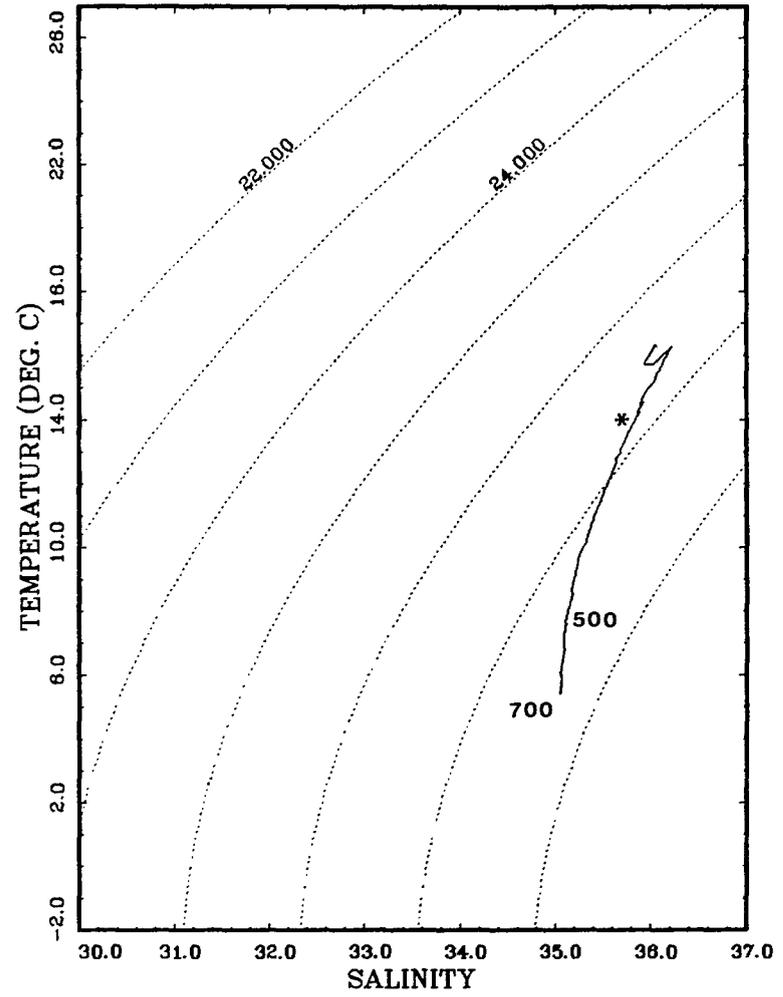
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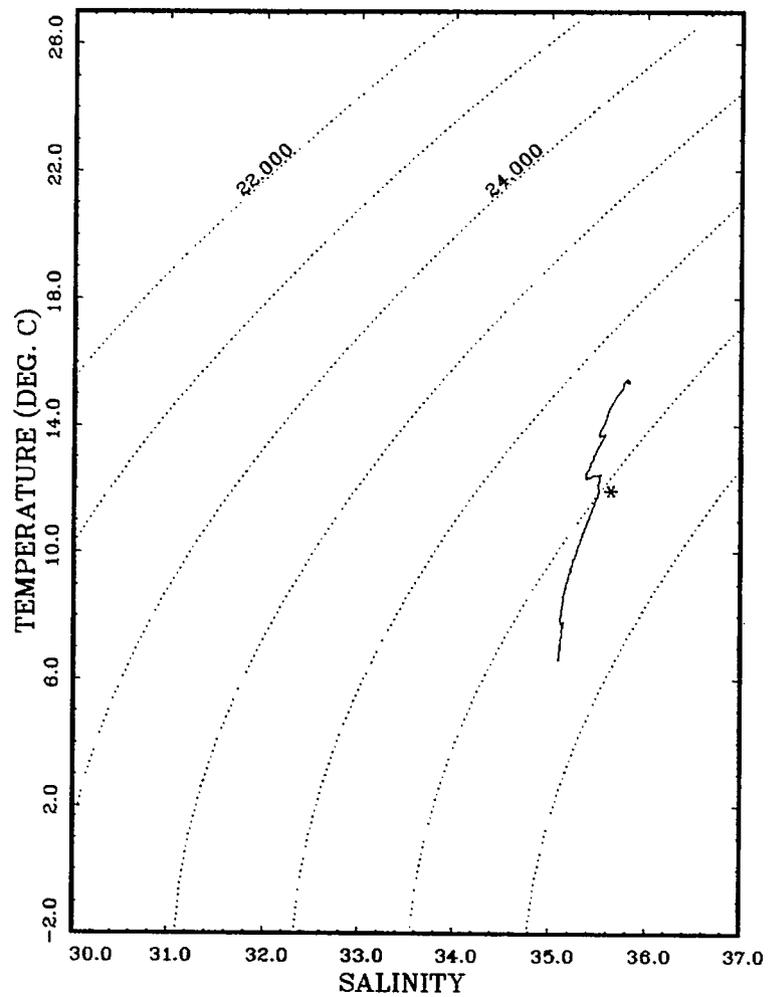
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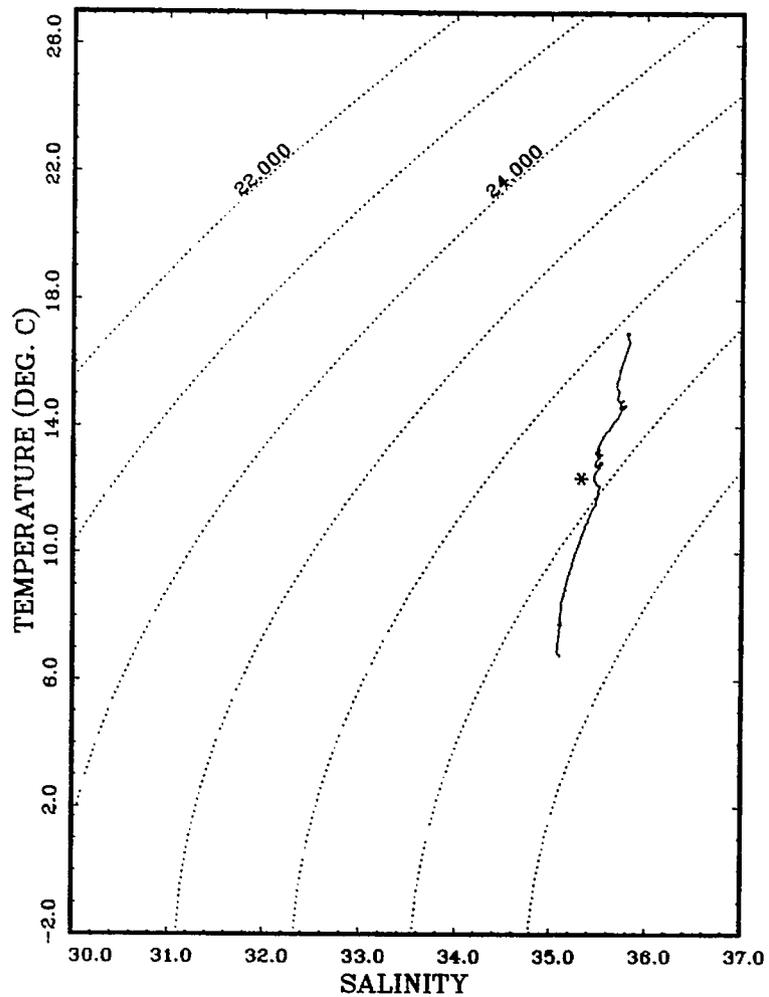
NEEDLER 119 - CTD 8



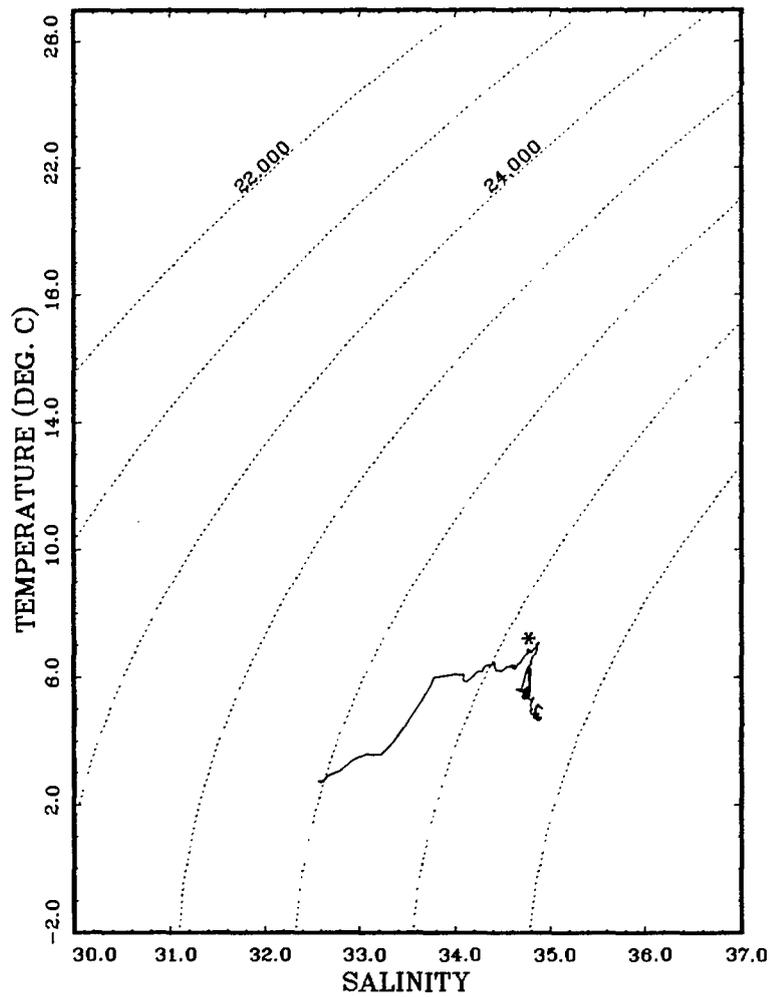
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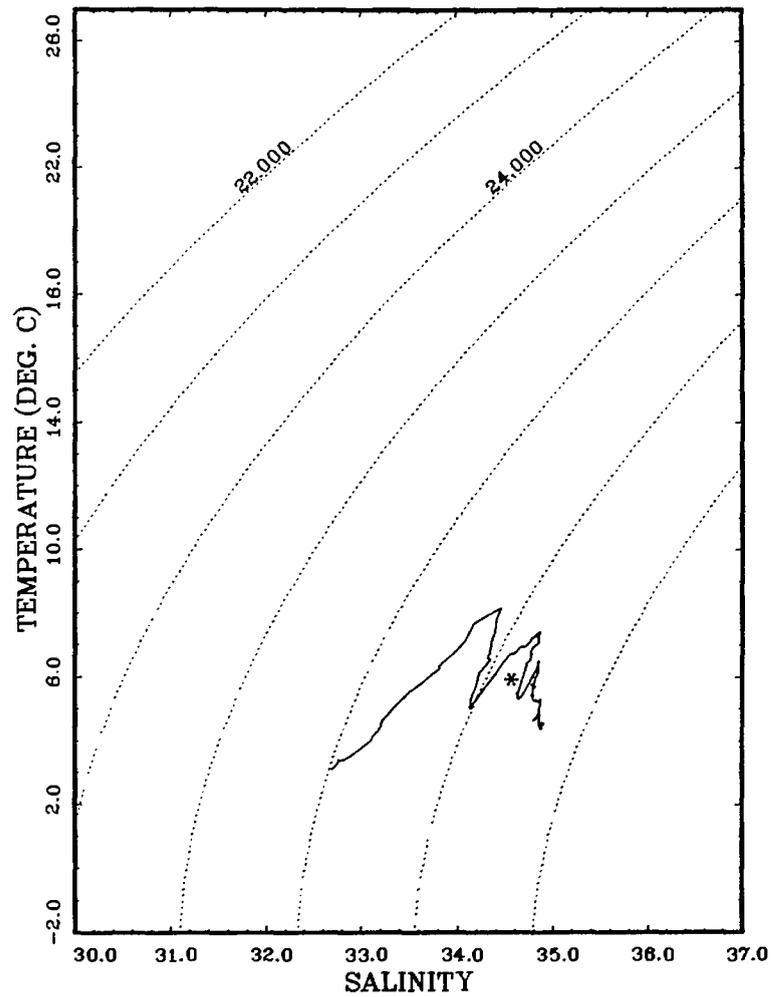
NEEDLER 119 - CTD 10



NEEDLER 119 - CTD 11

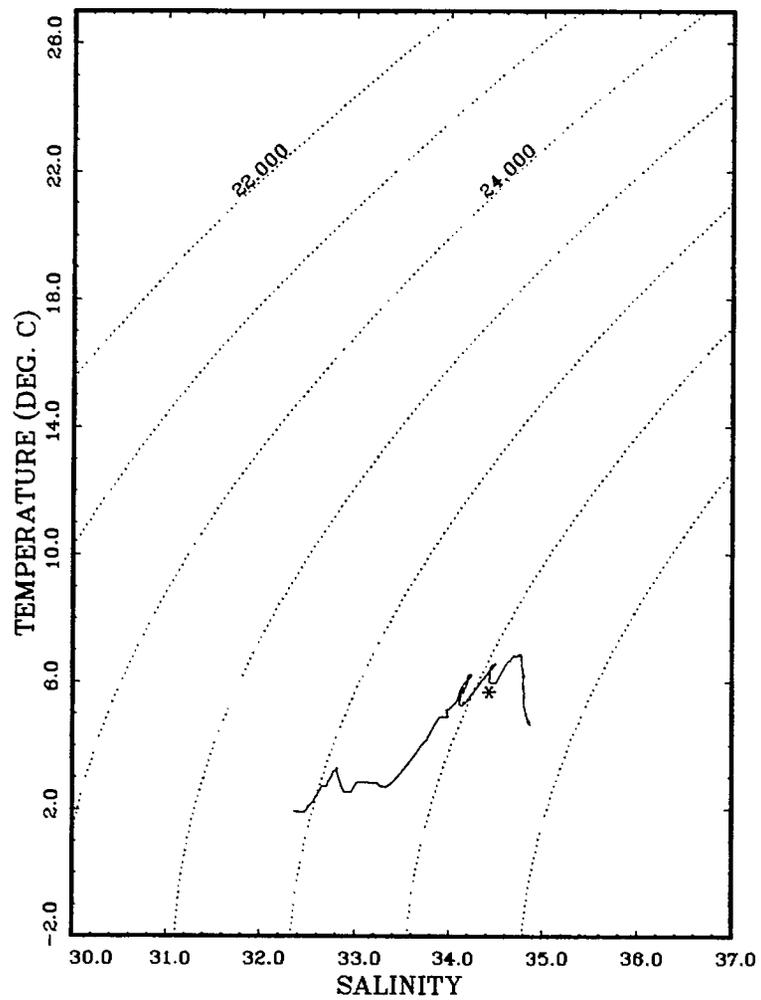


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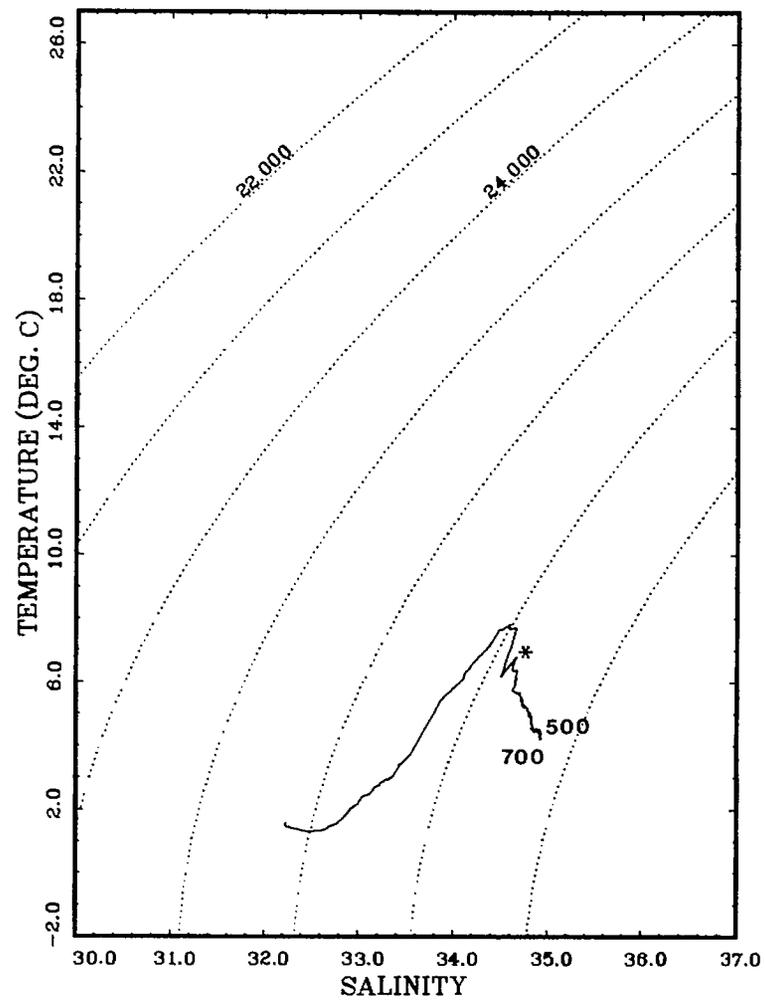


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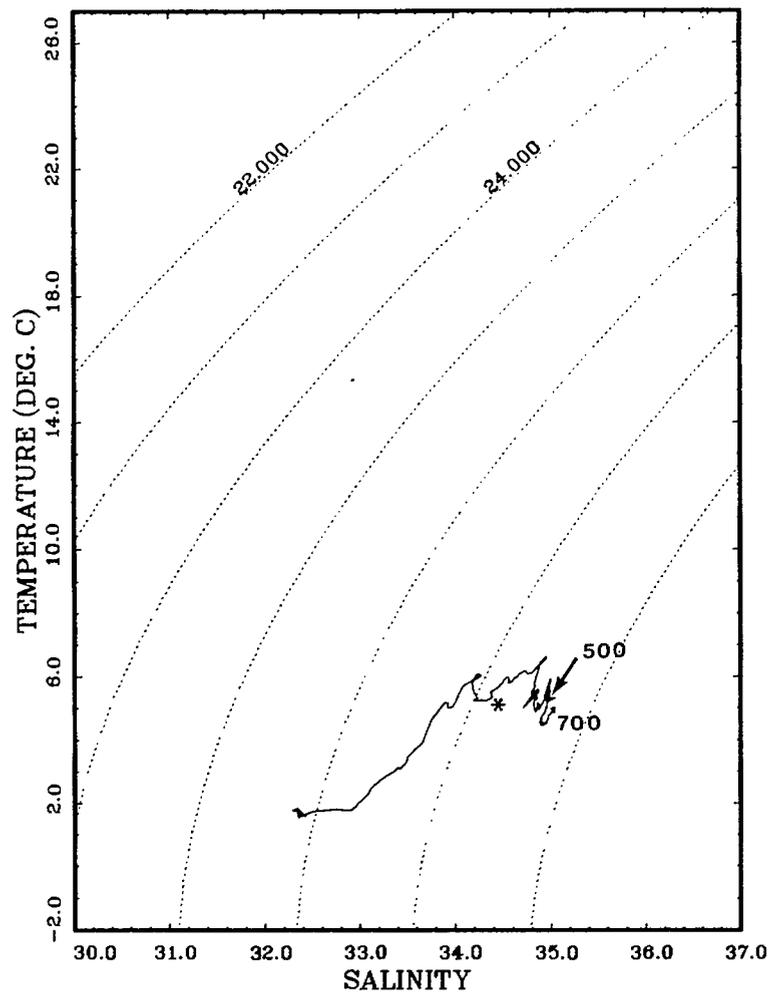
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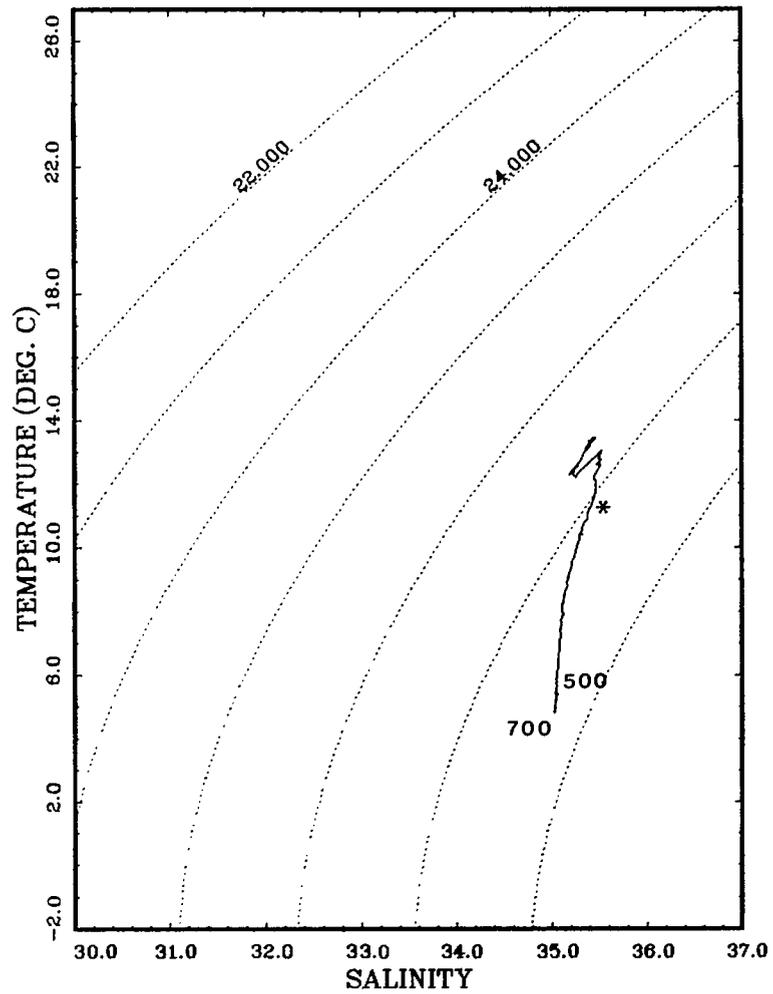
NEEDLER 119 - CTD 14



NEEDLER 119 - CTD 15

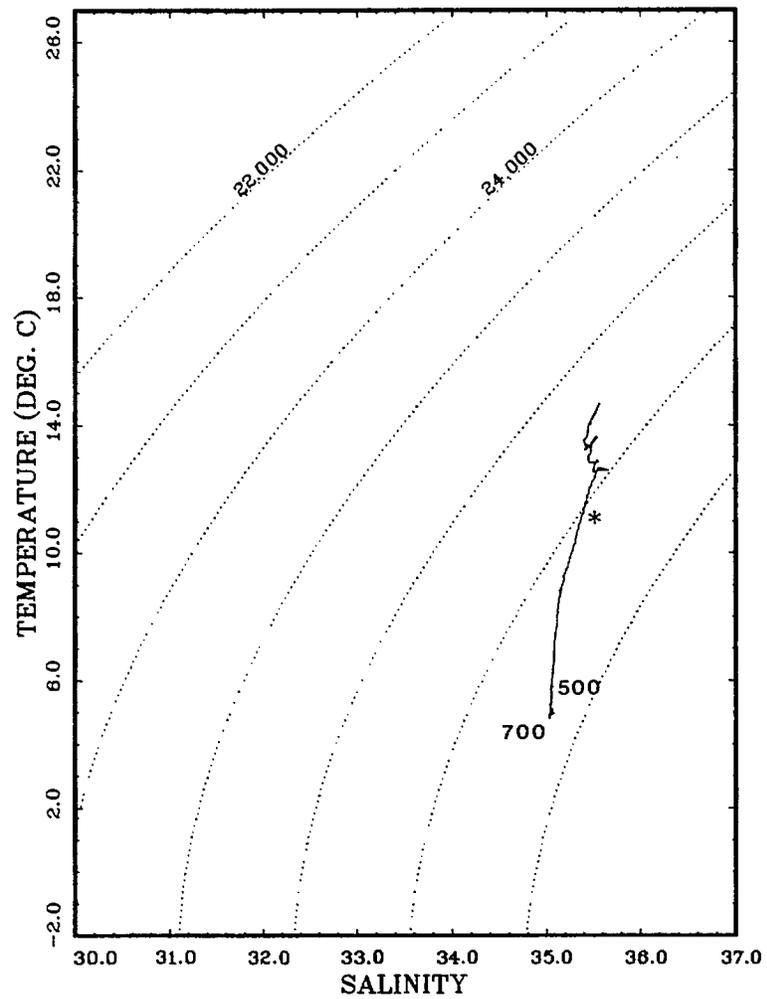


NEEDLER 119 - CTD 16

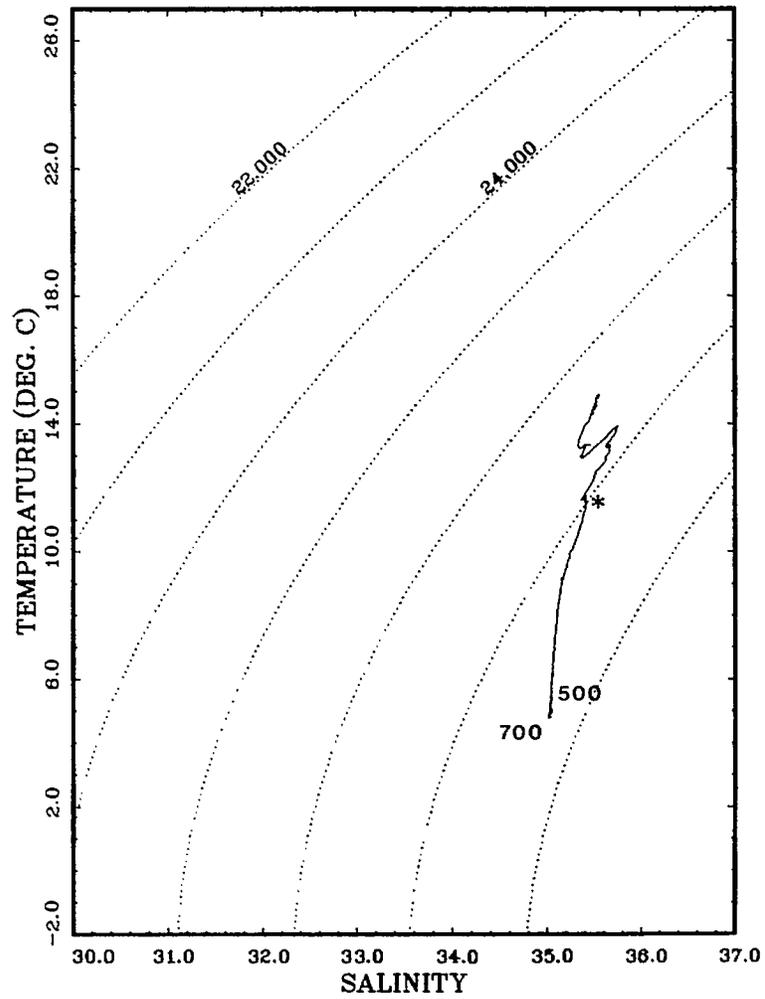


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NEEDLER 119 - CTD 17

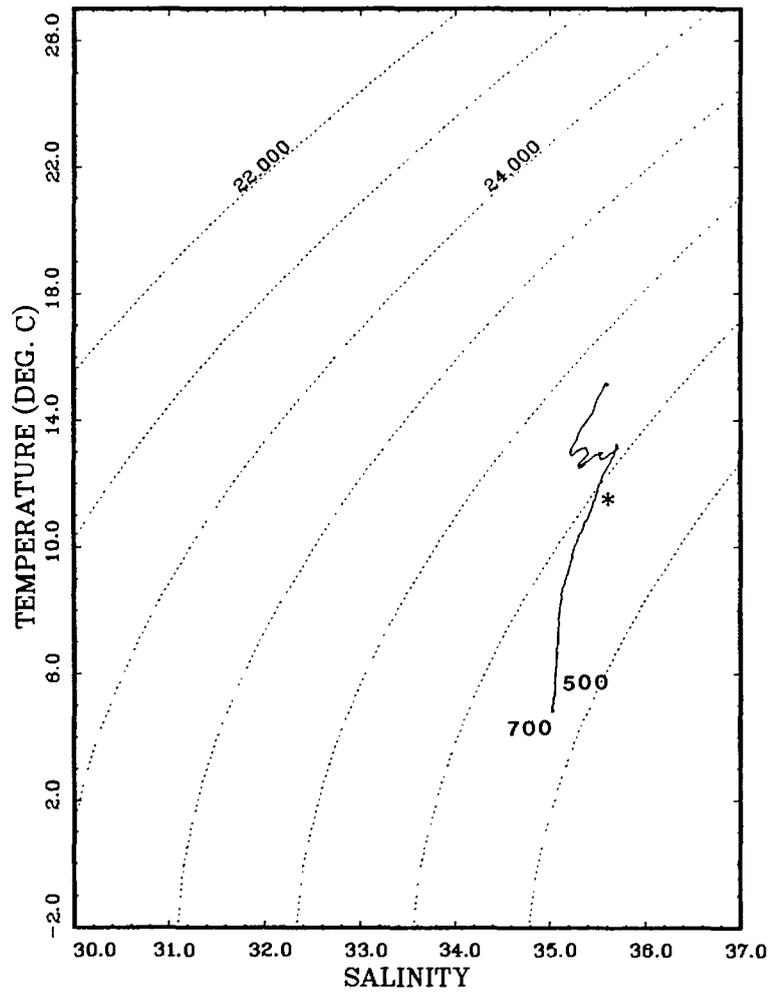


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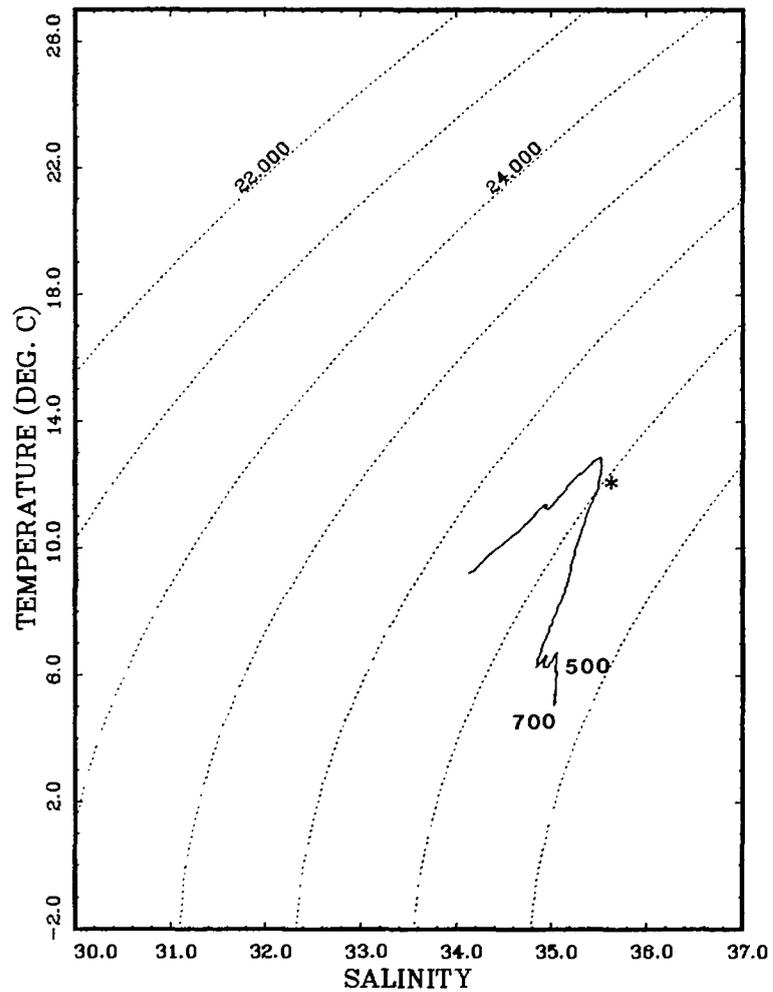


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NEEDLER 119 - CTD 19

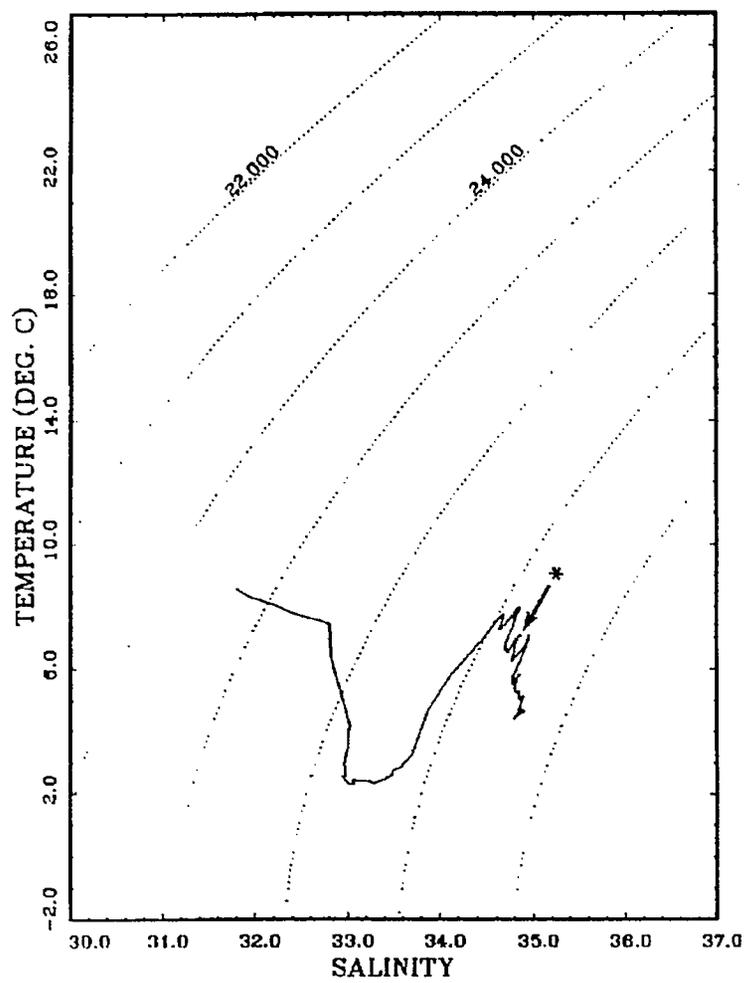


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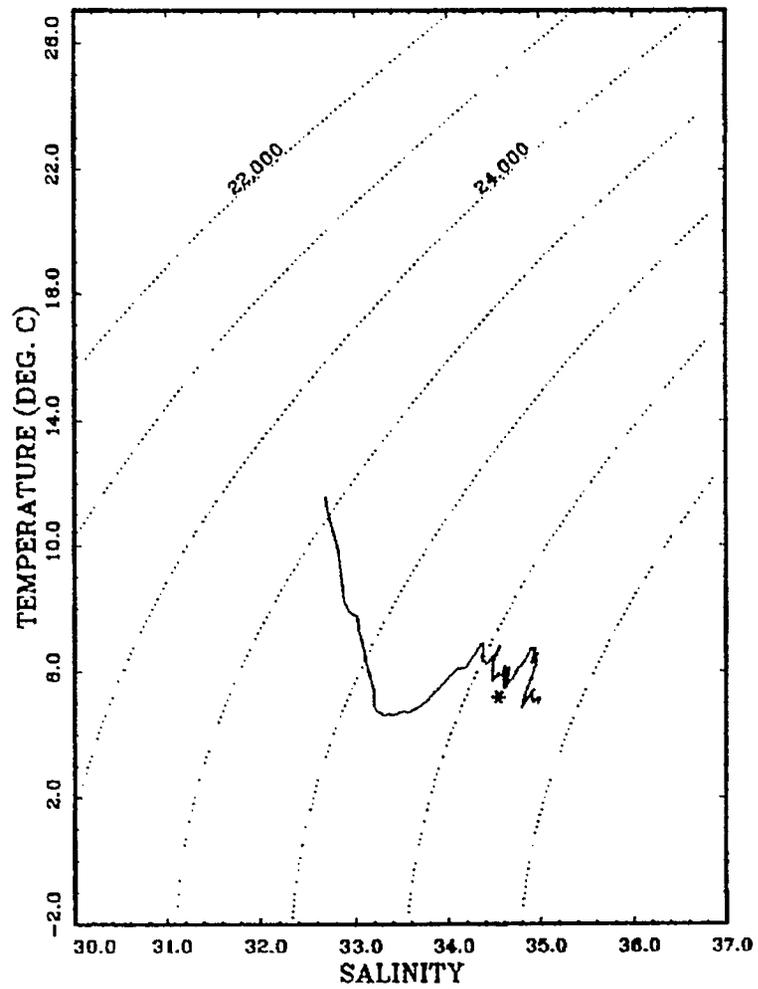


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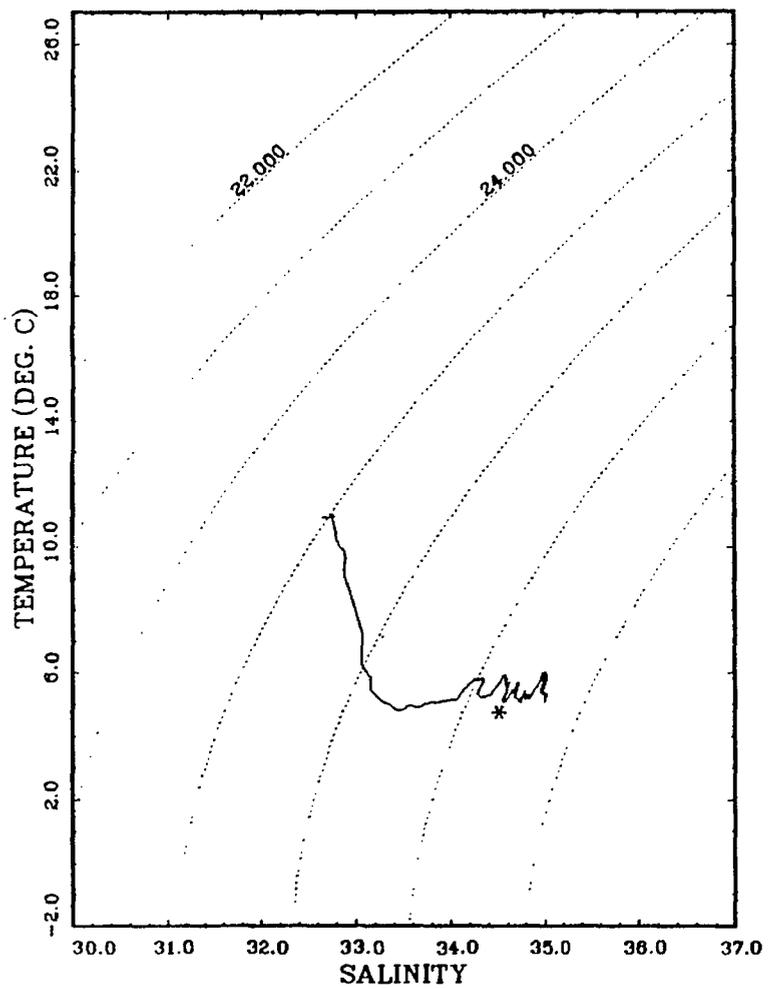
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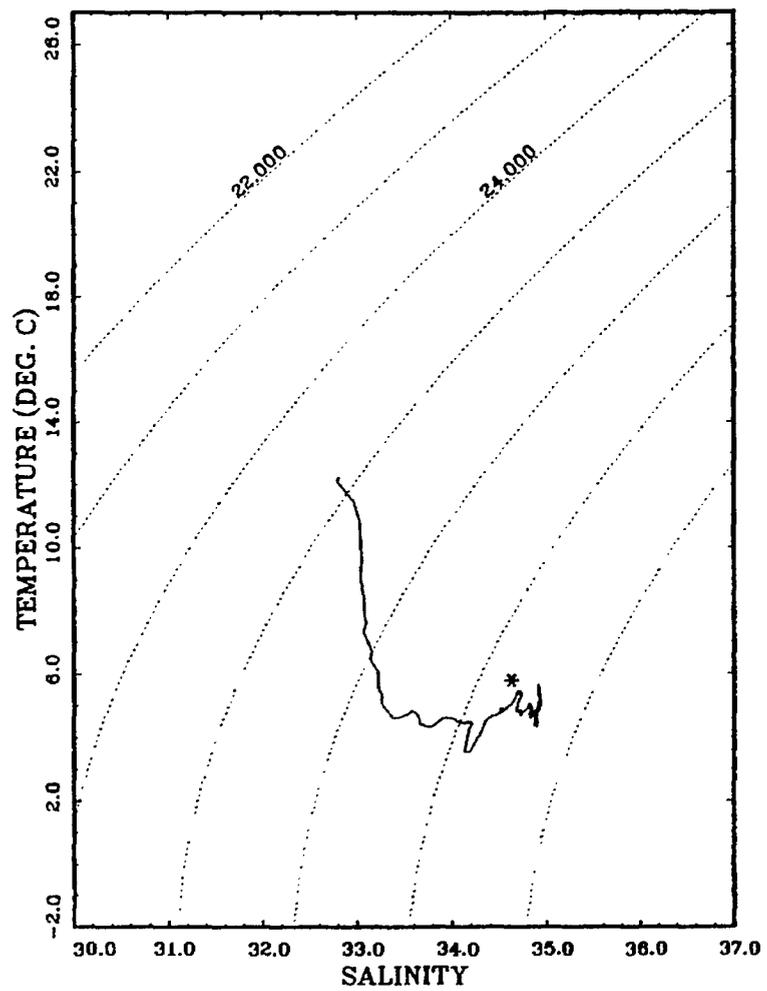
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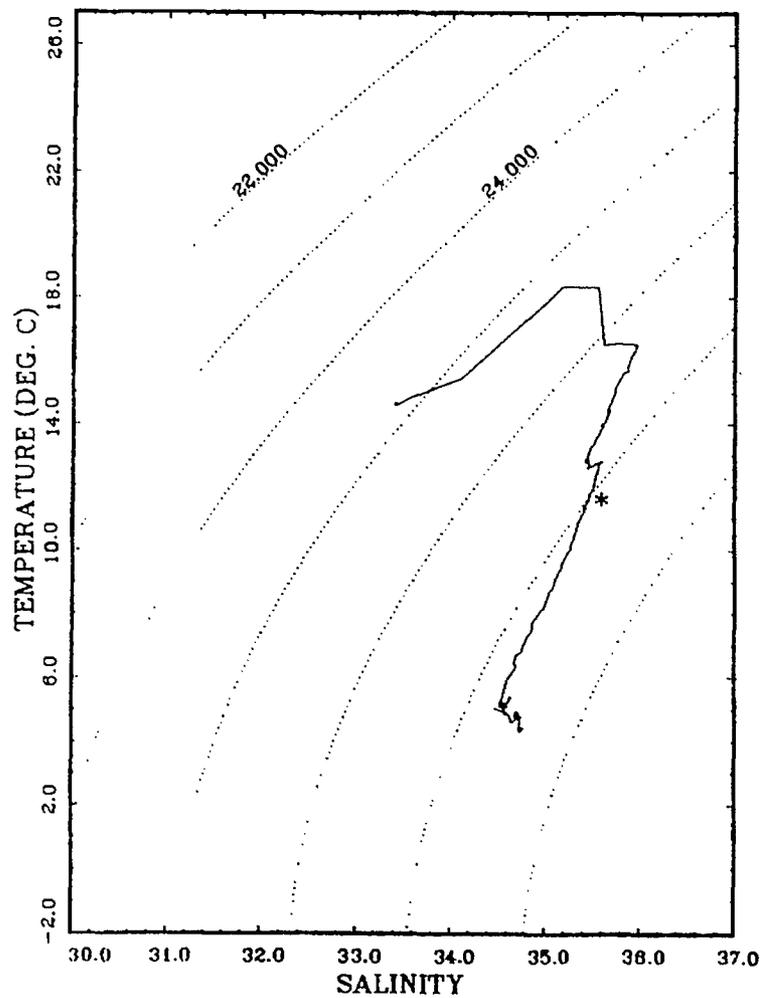
NEEDLER 122 - CTD 3



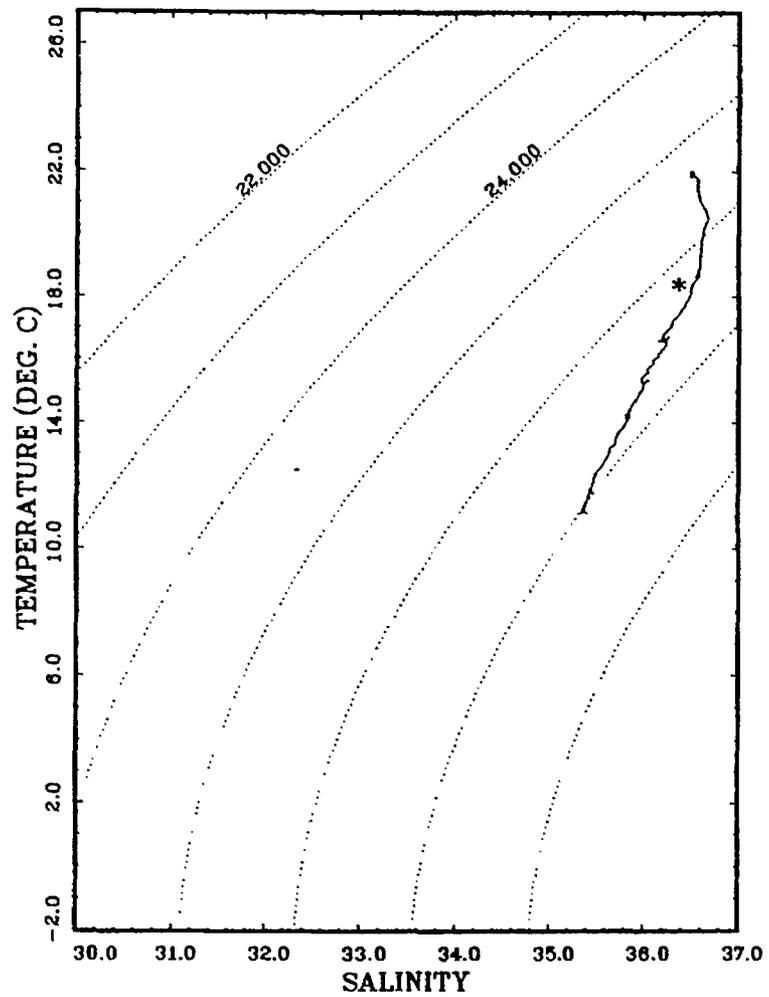
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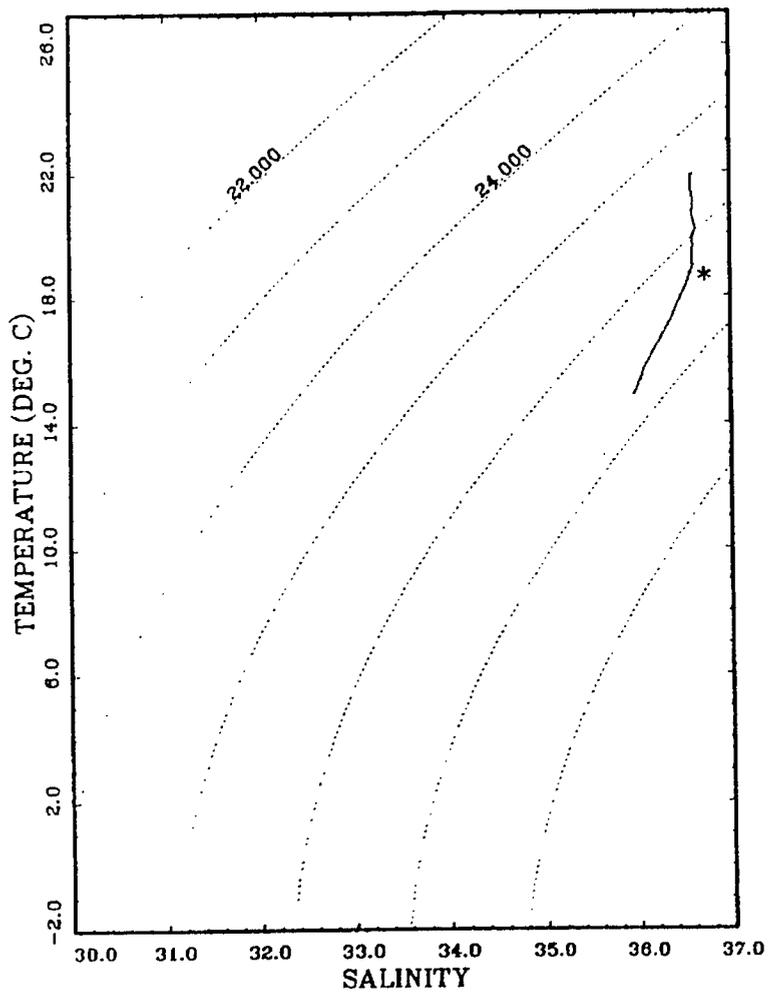
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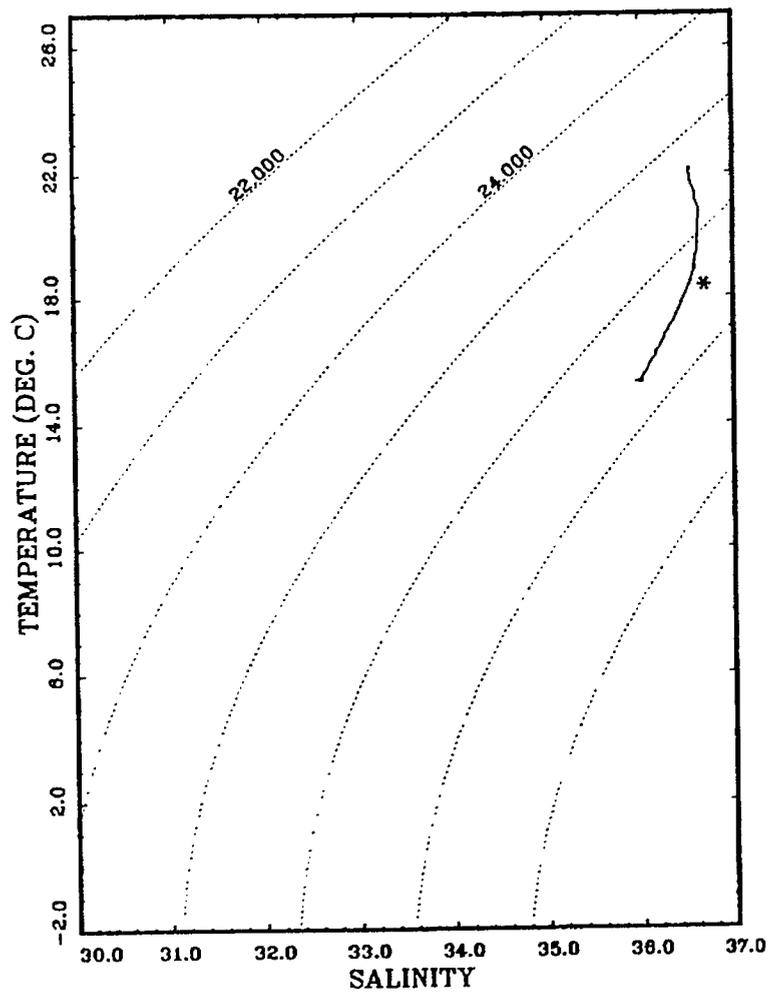
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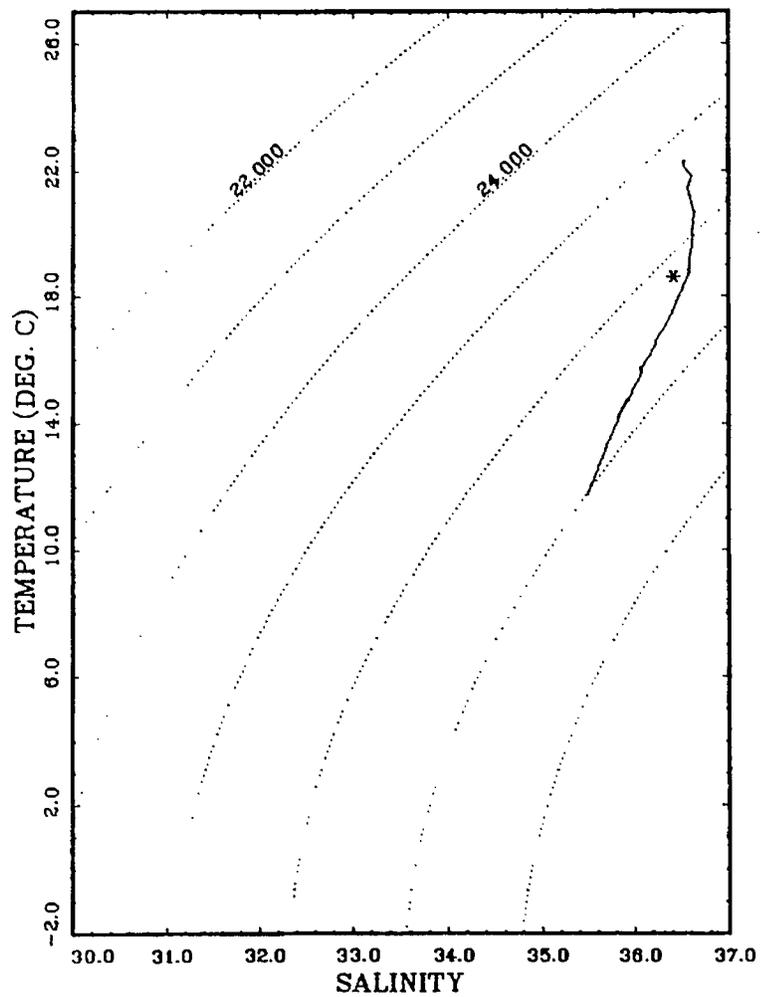
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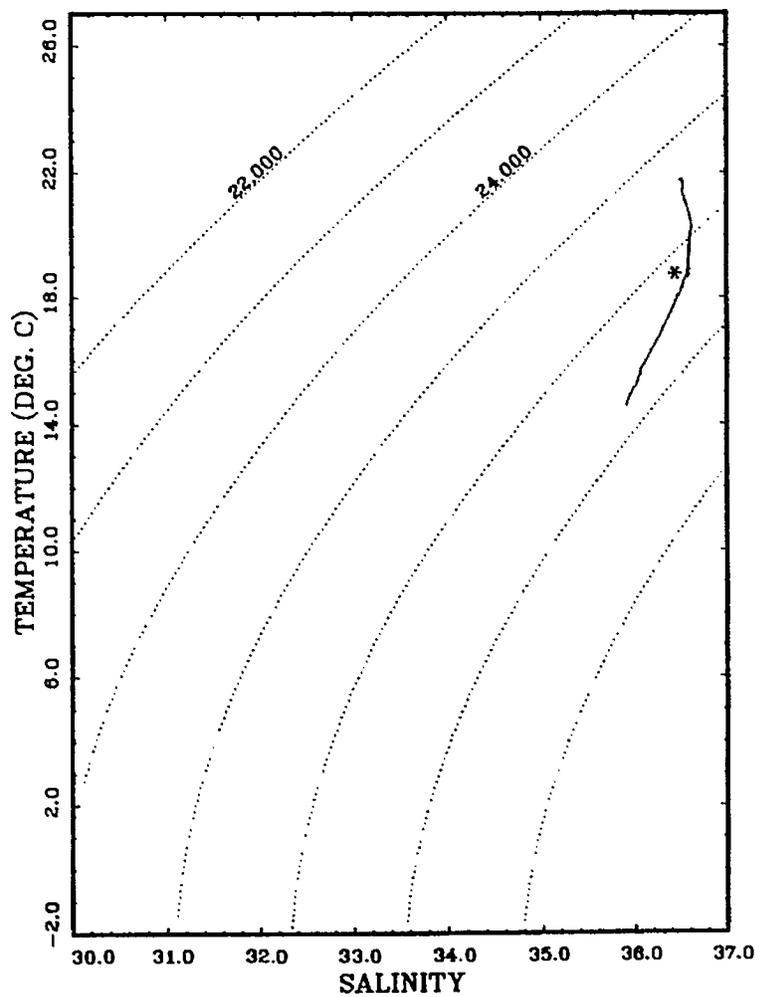
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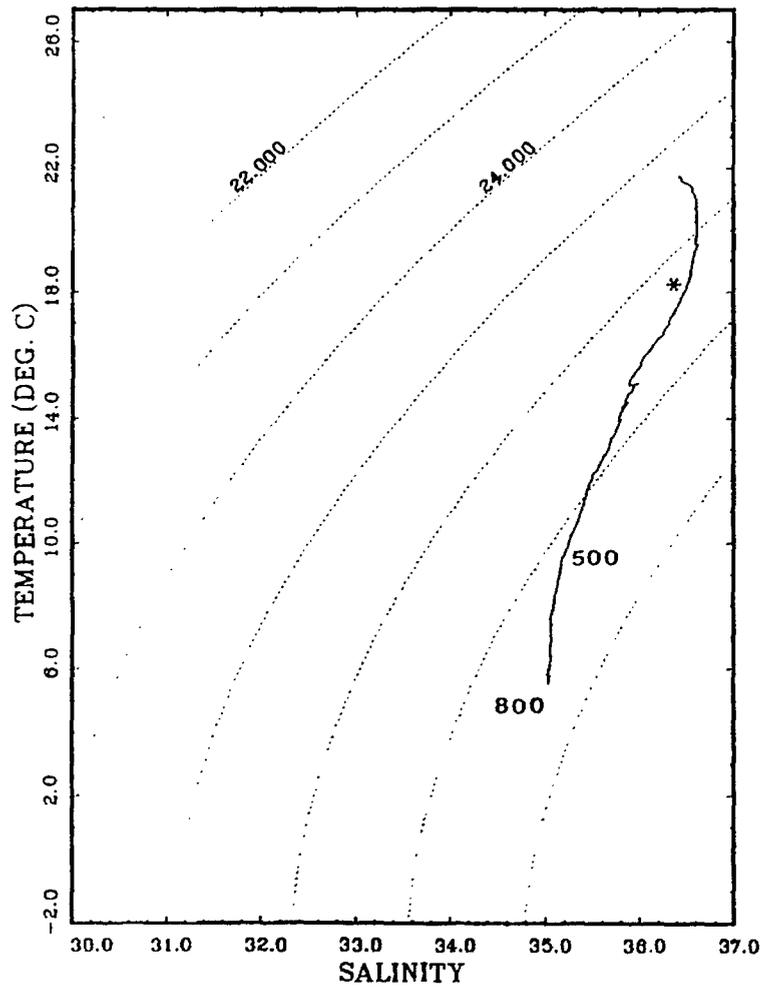
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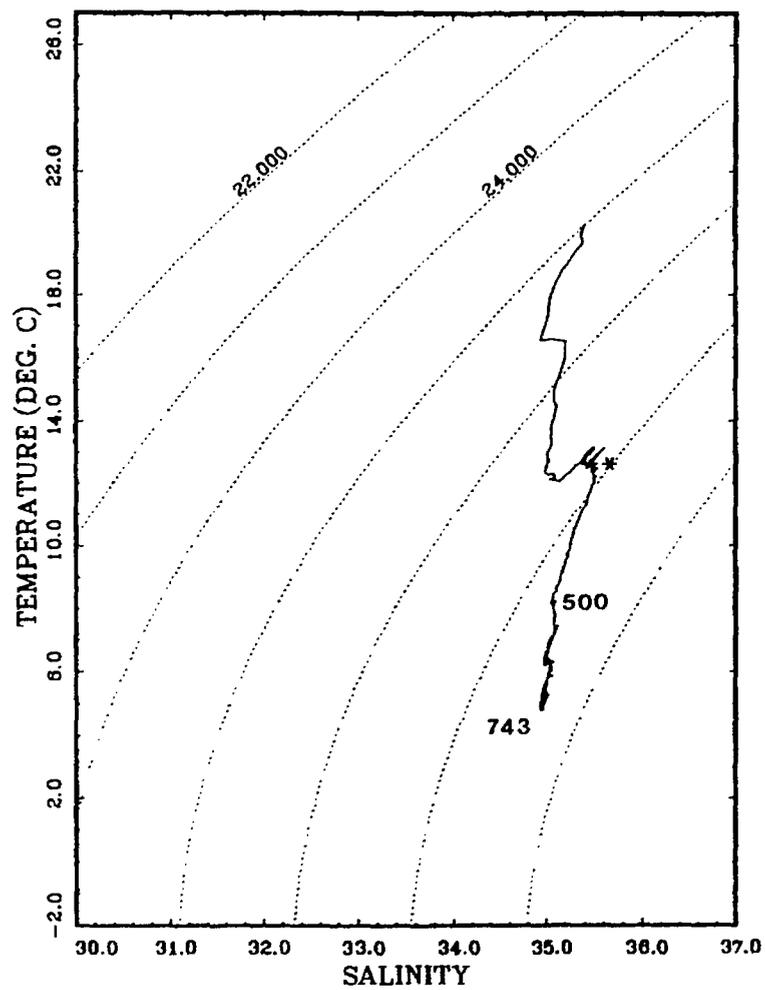
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NEEDLER 122 - CTD 11

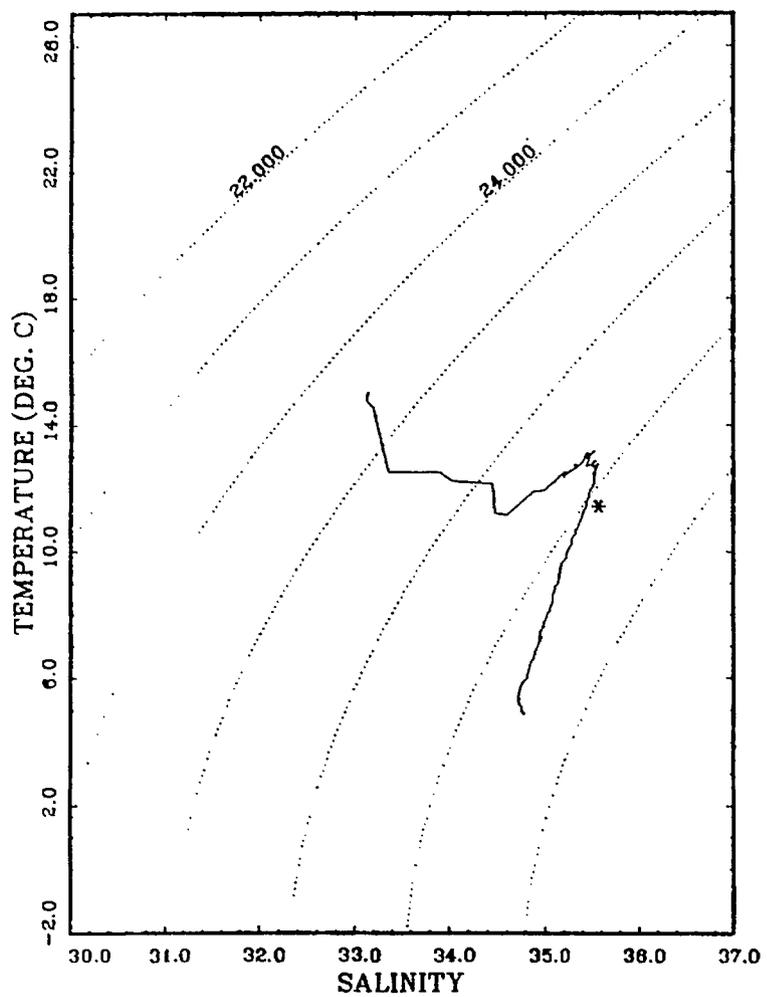


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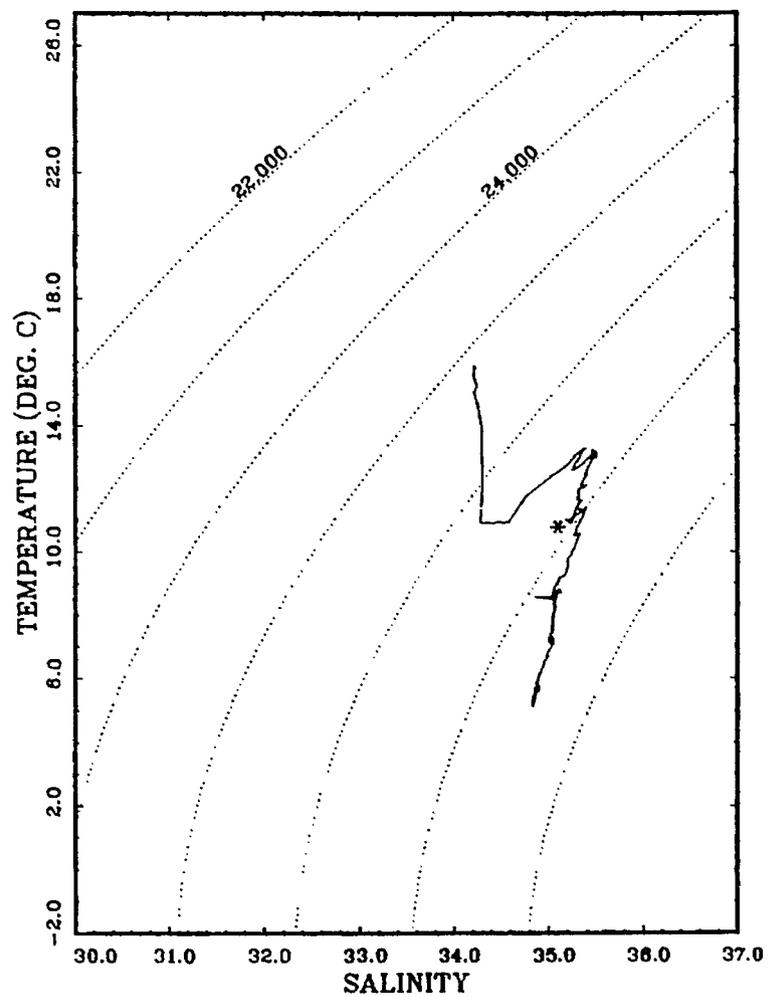


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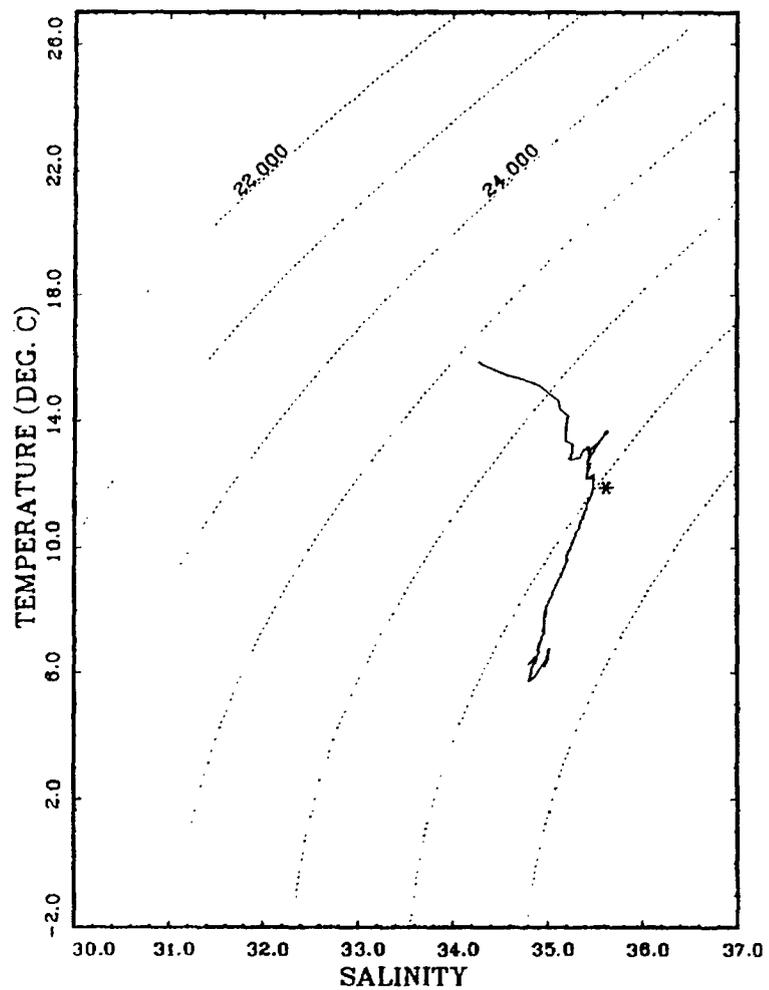
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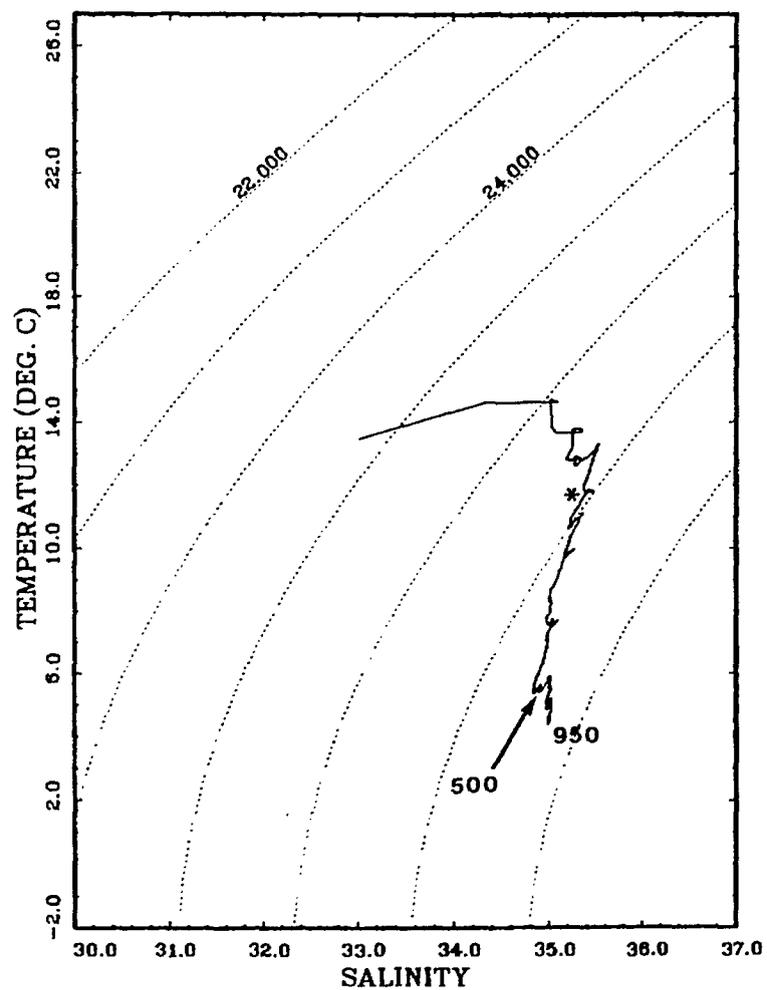
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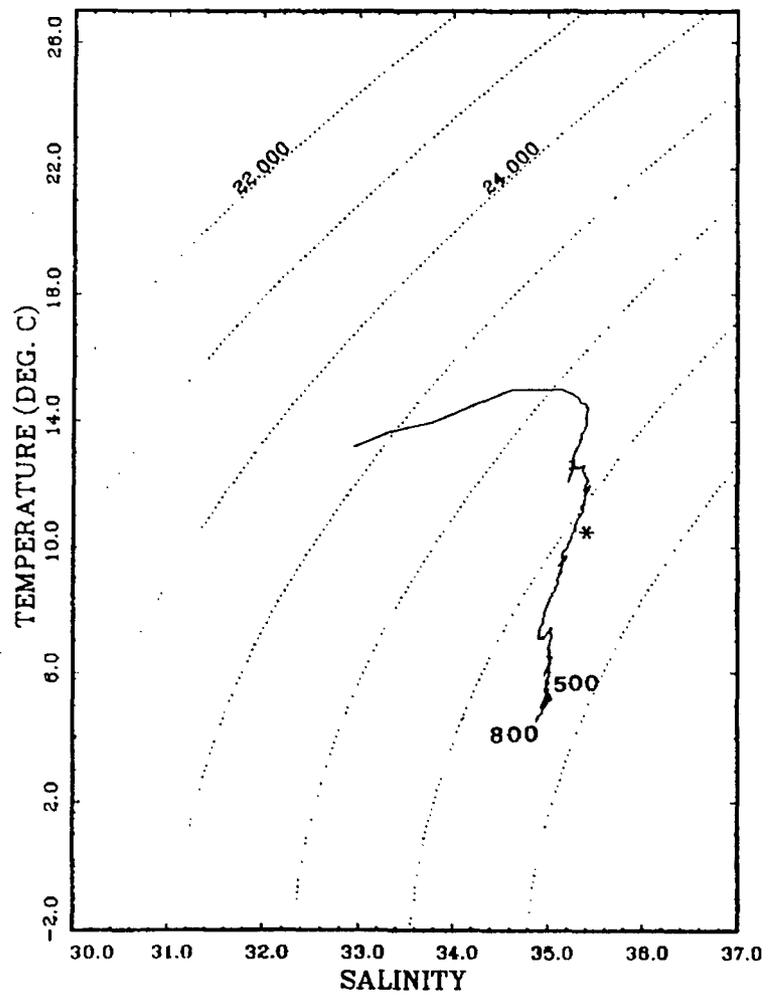
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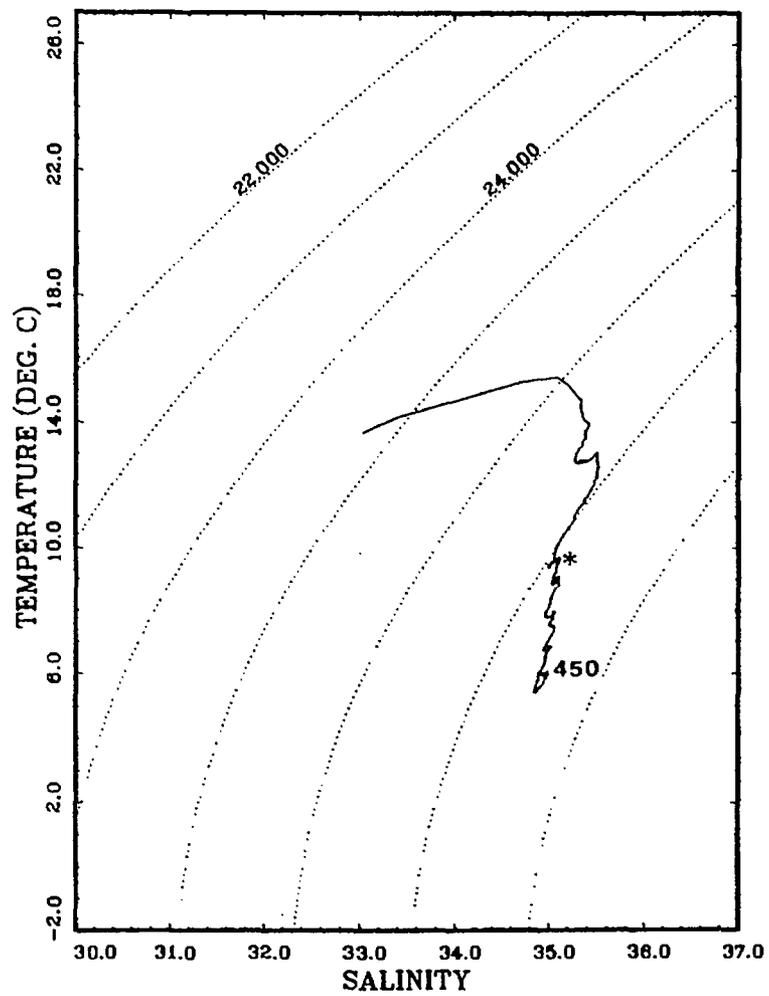
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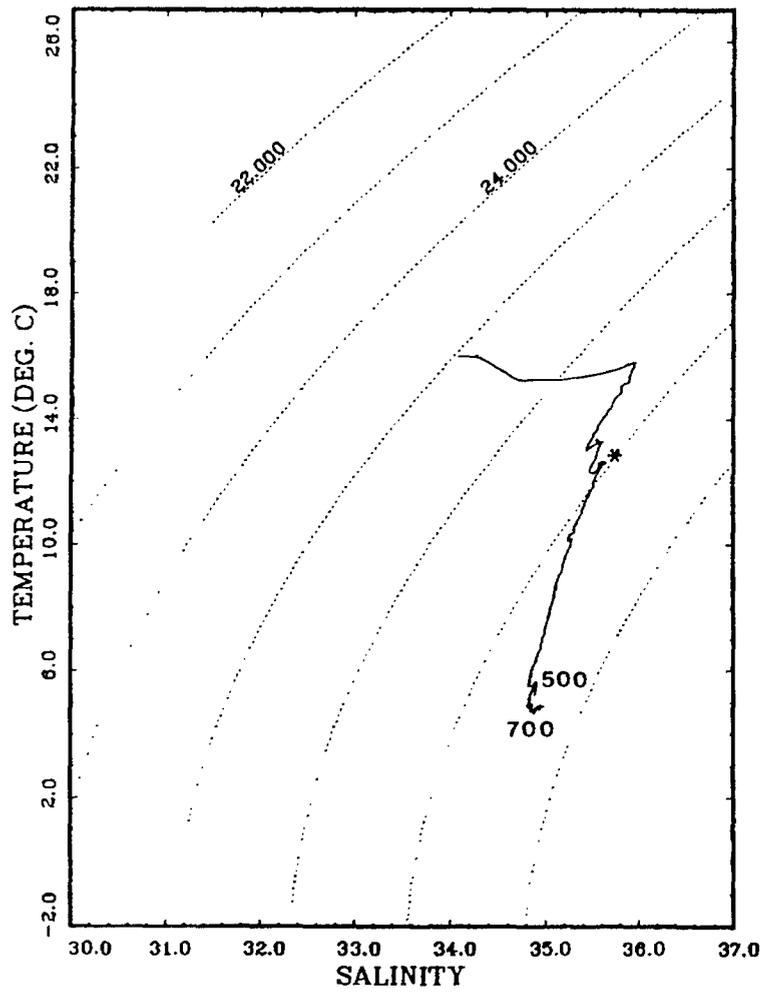
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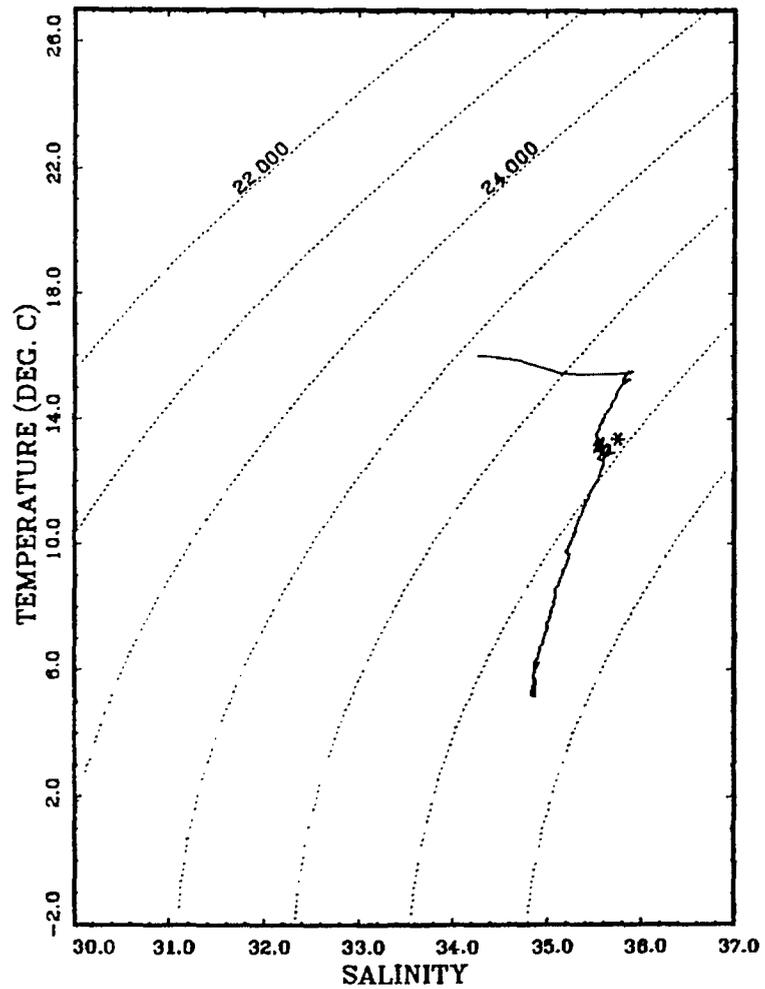
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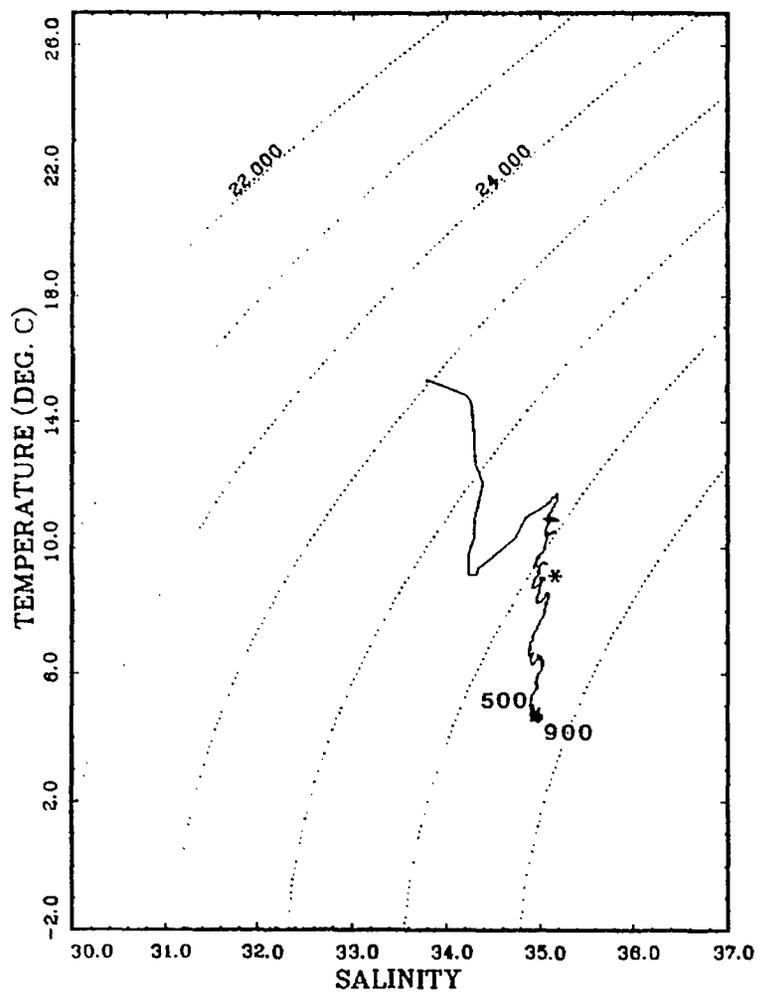
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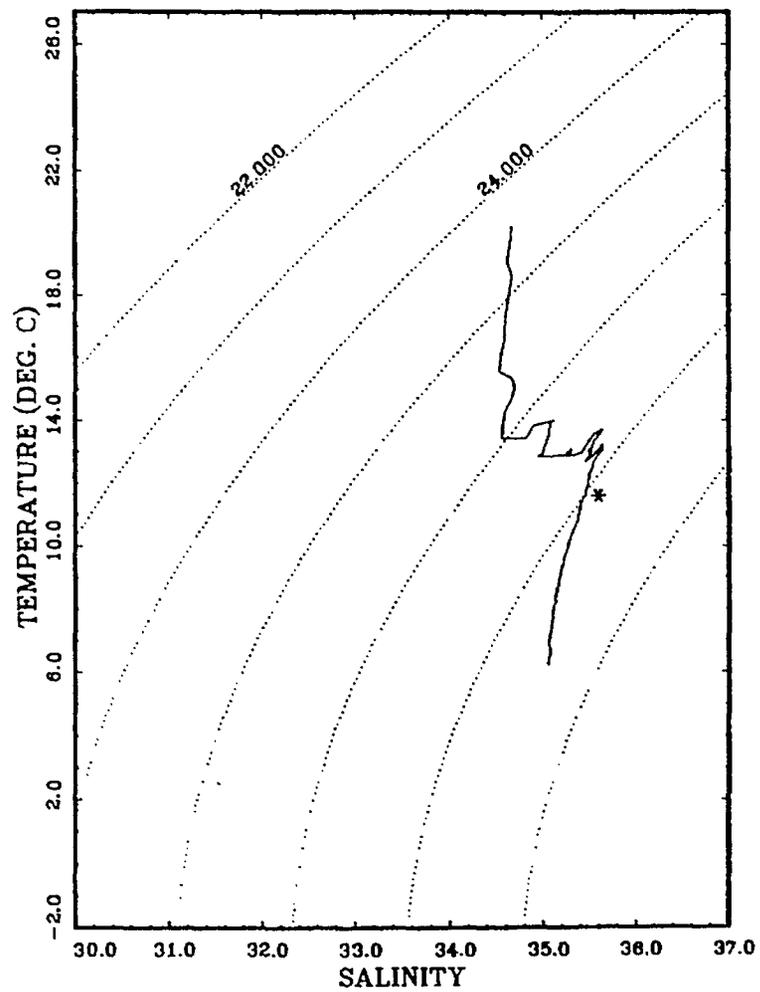
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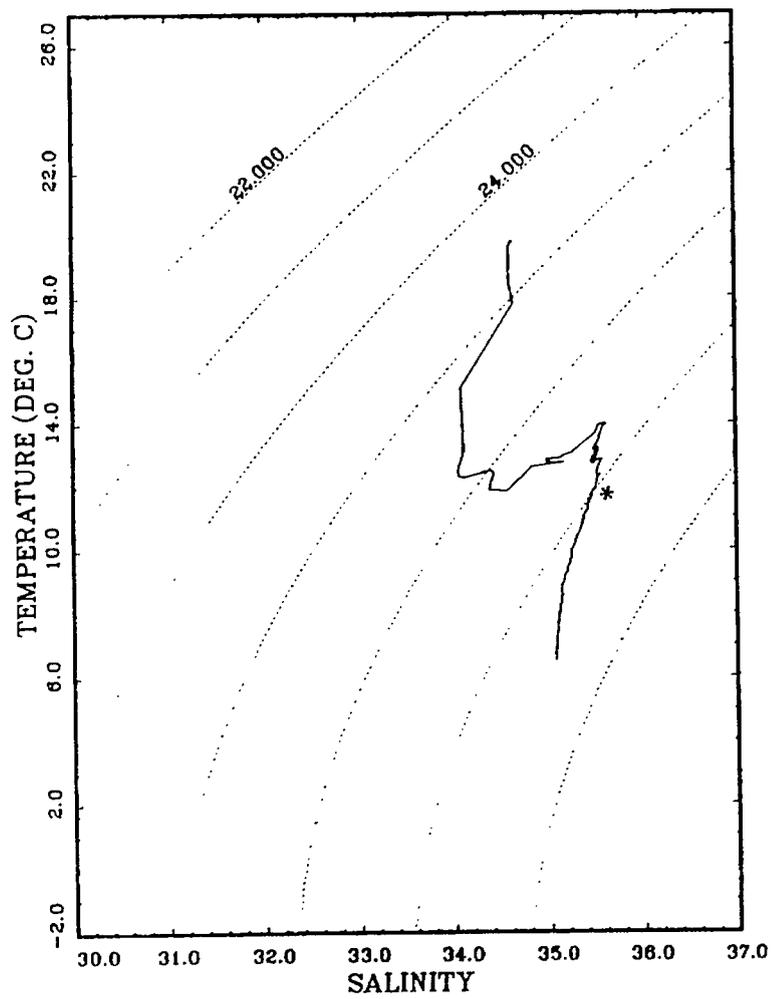
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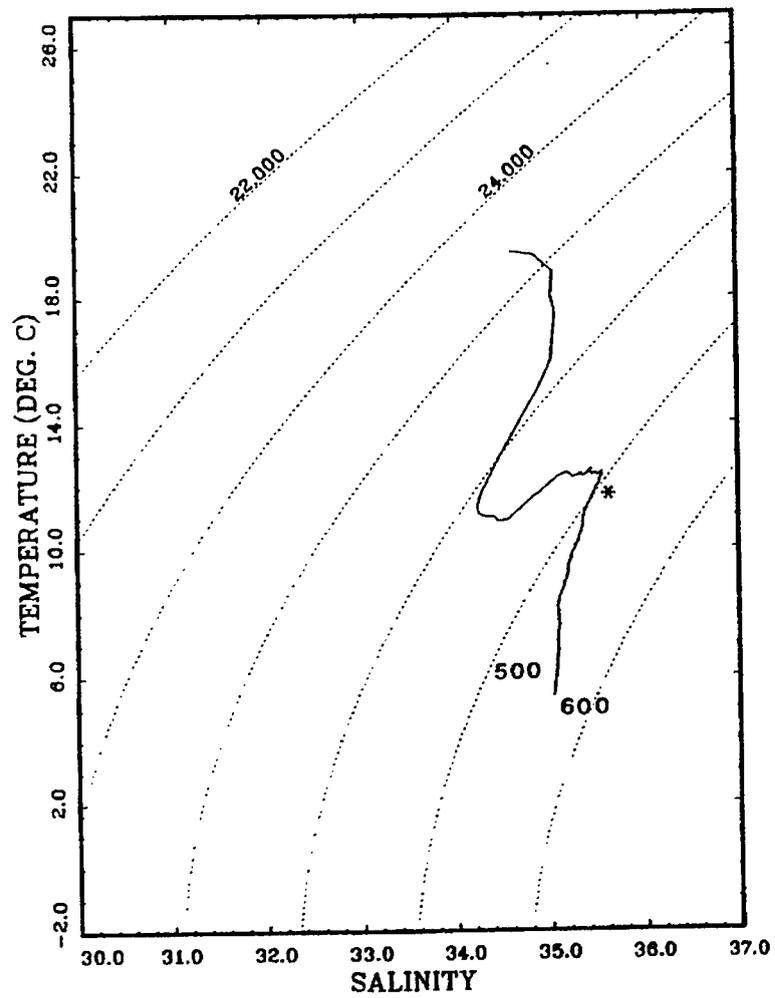
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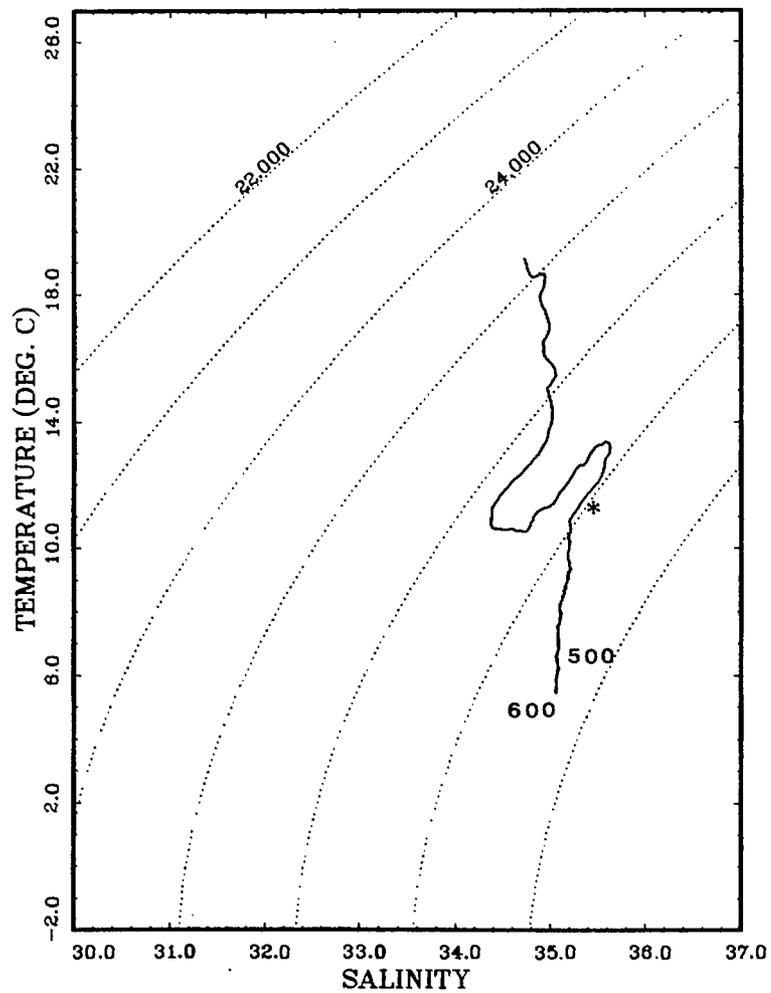
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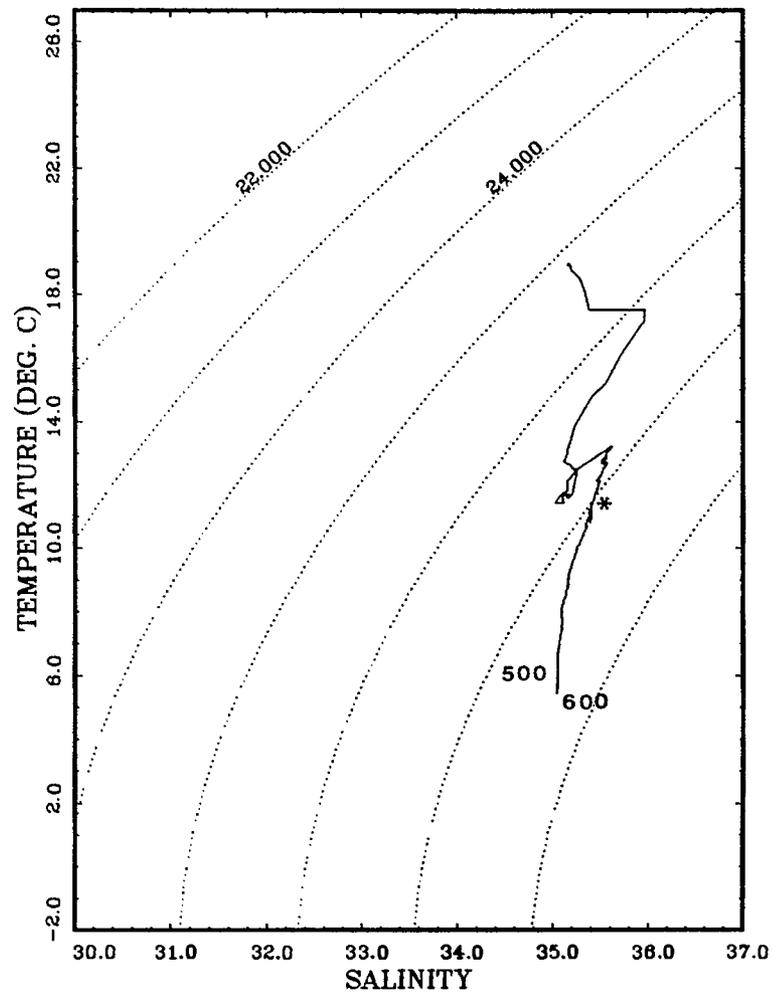
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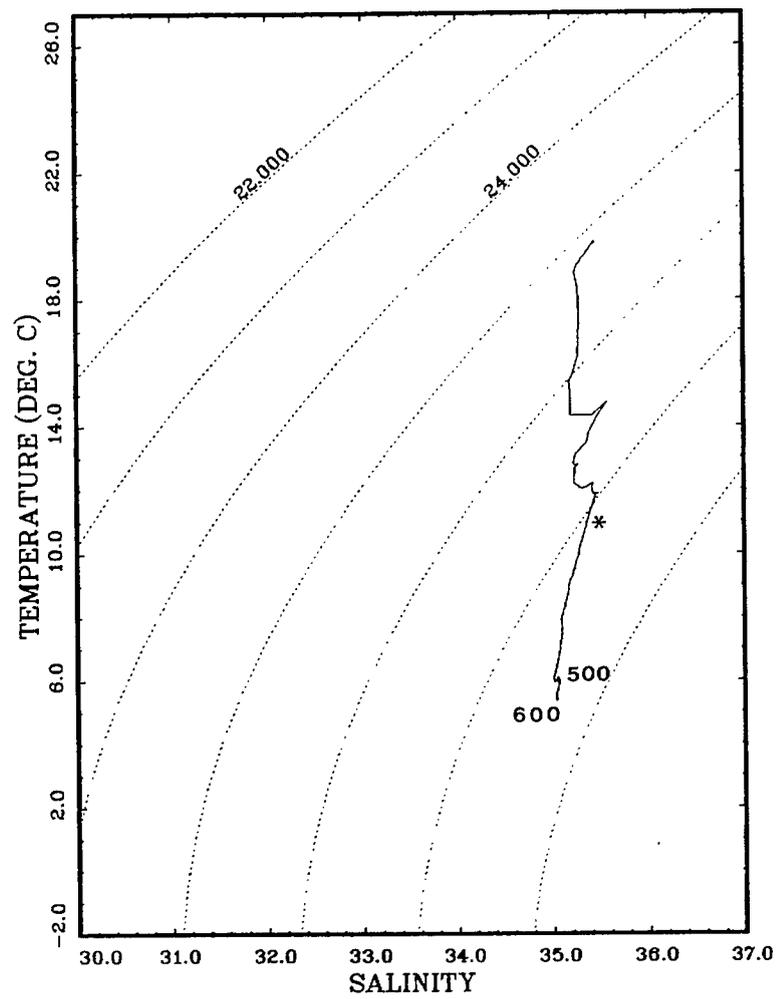
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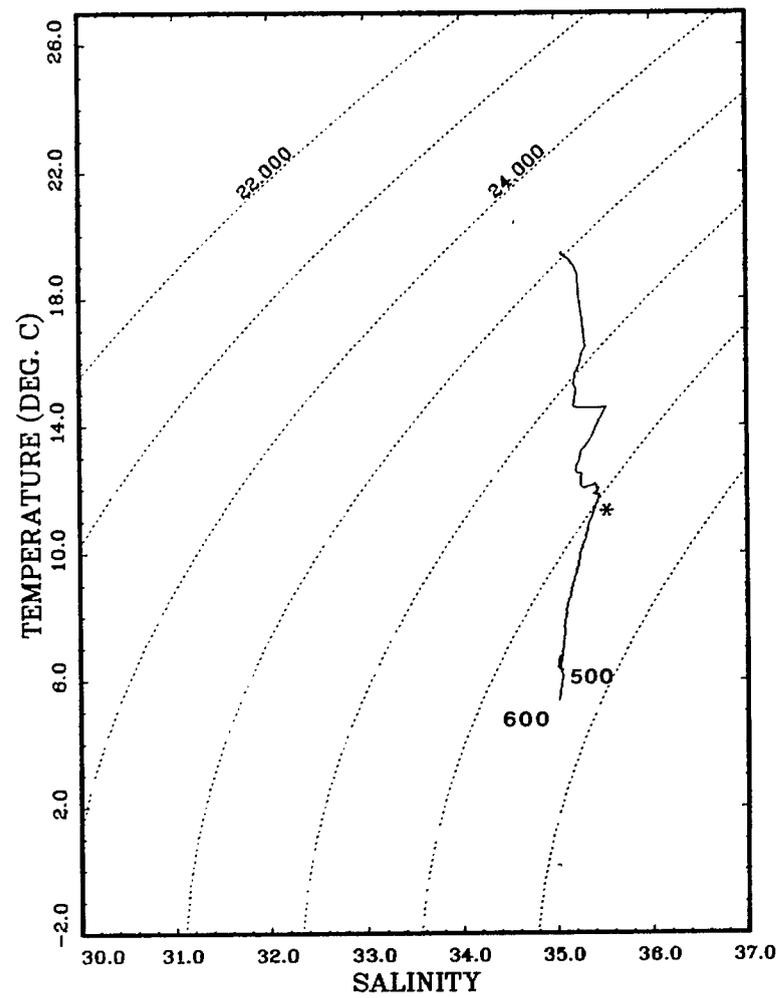
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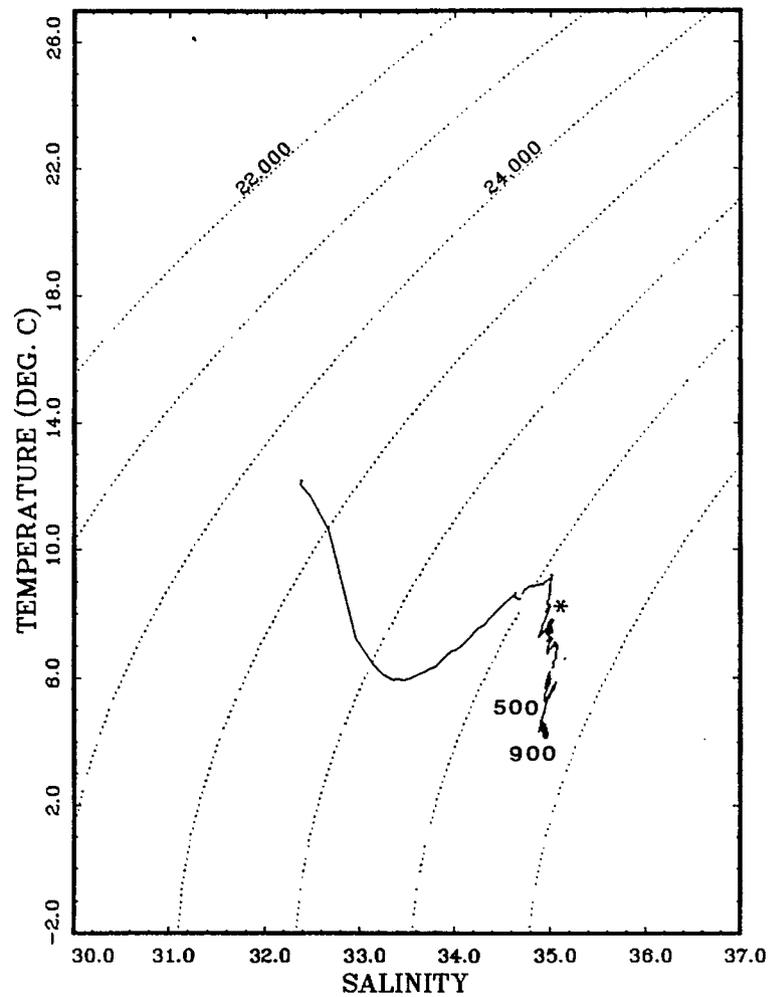
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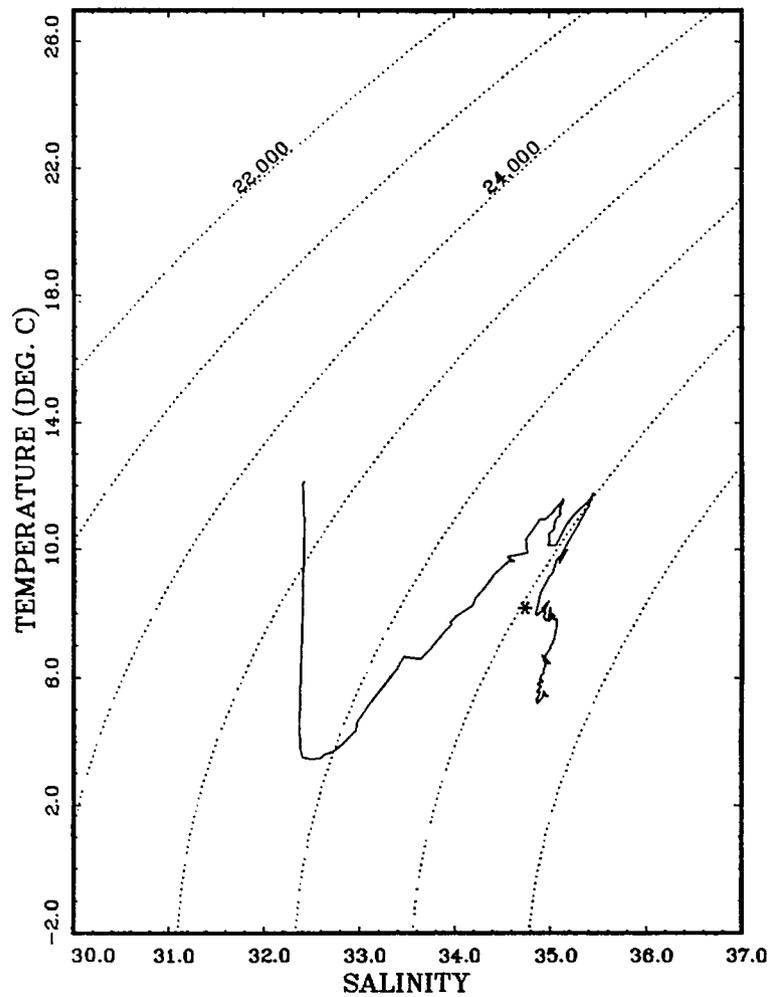
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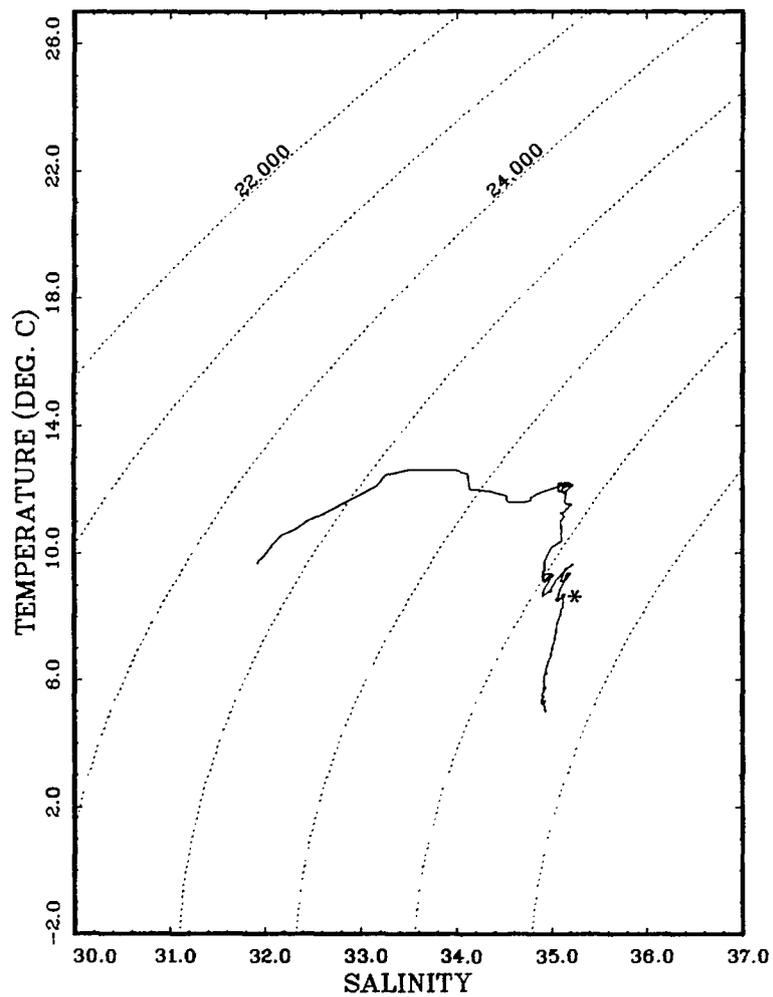
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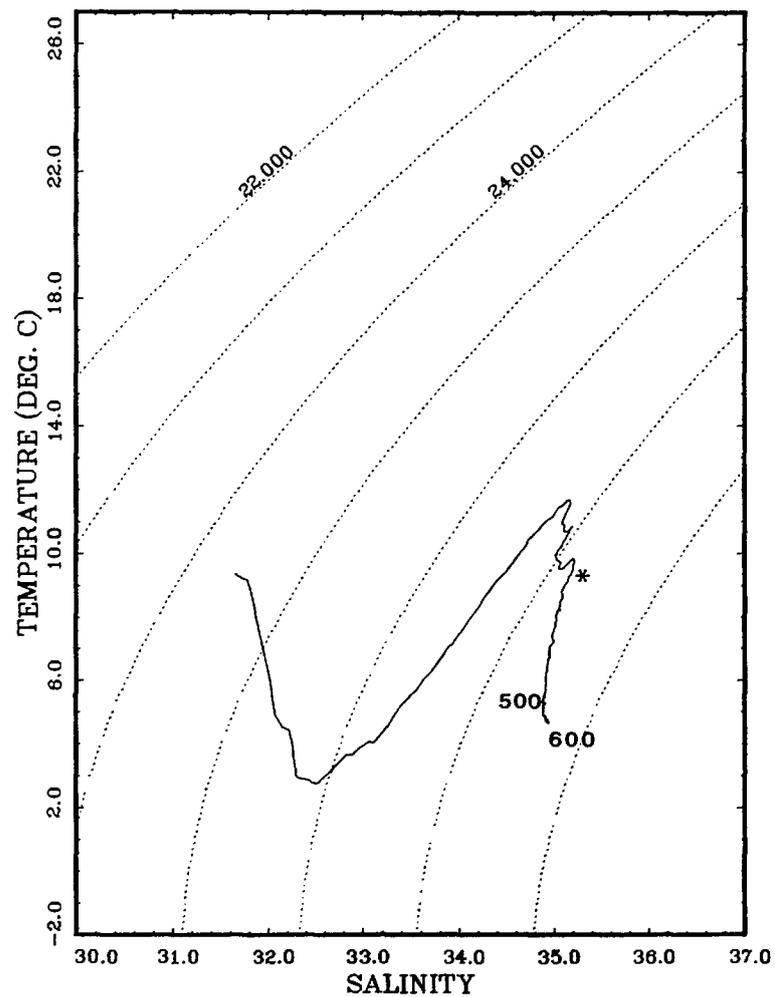
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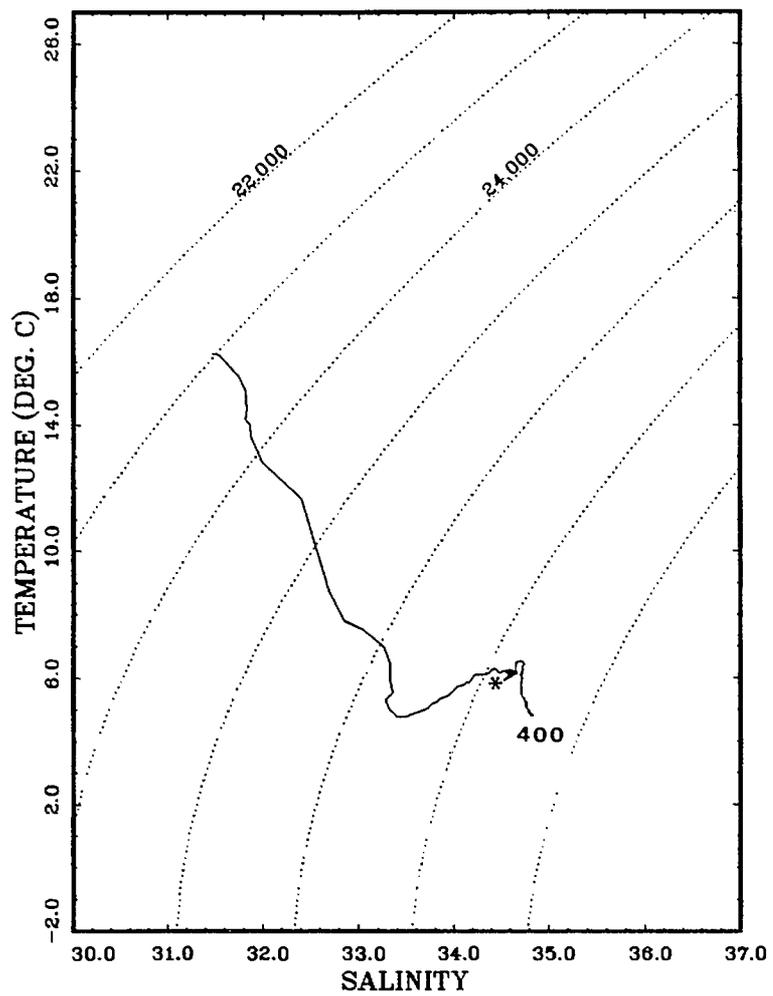
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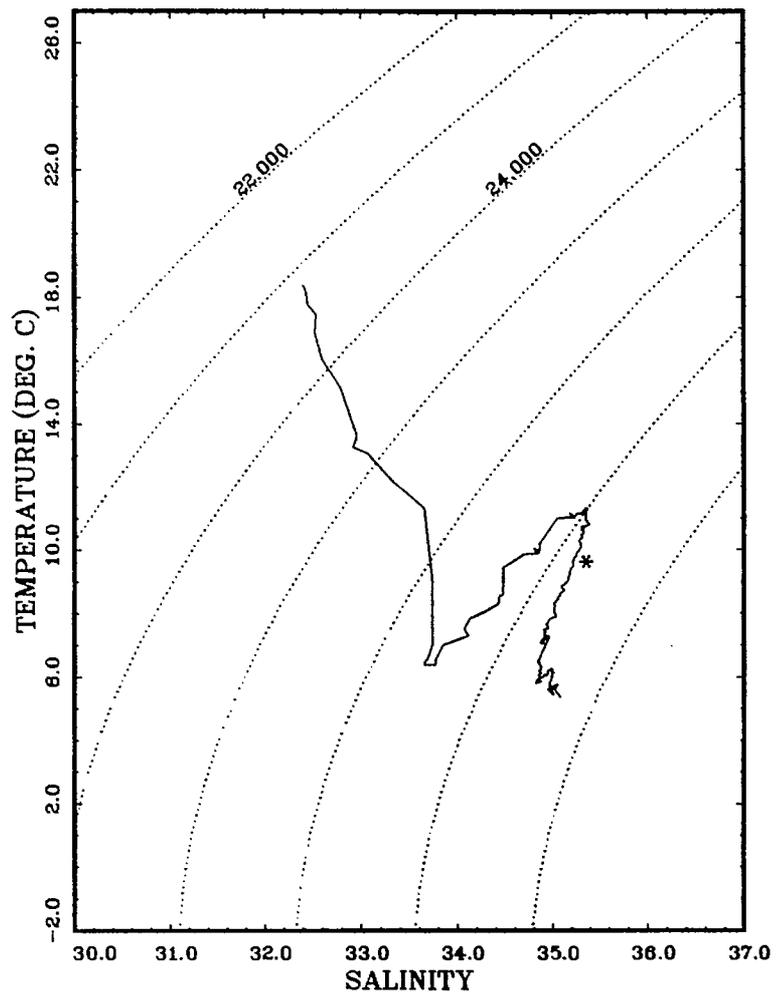
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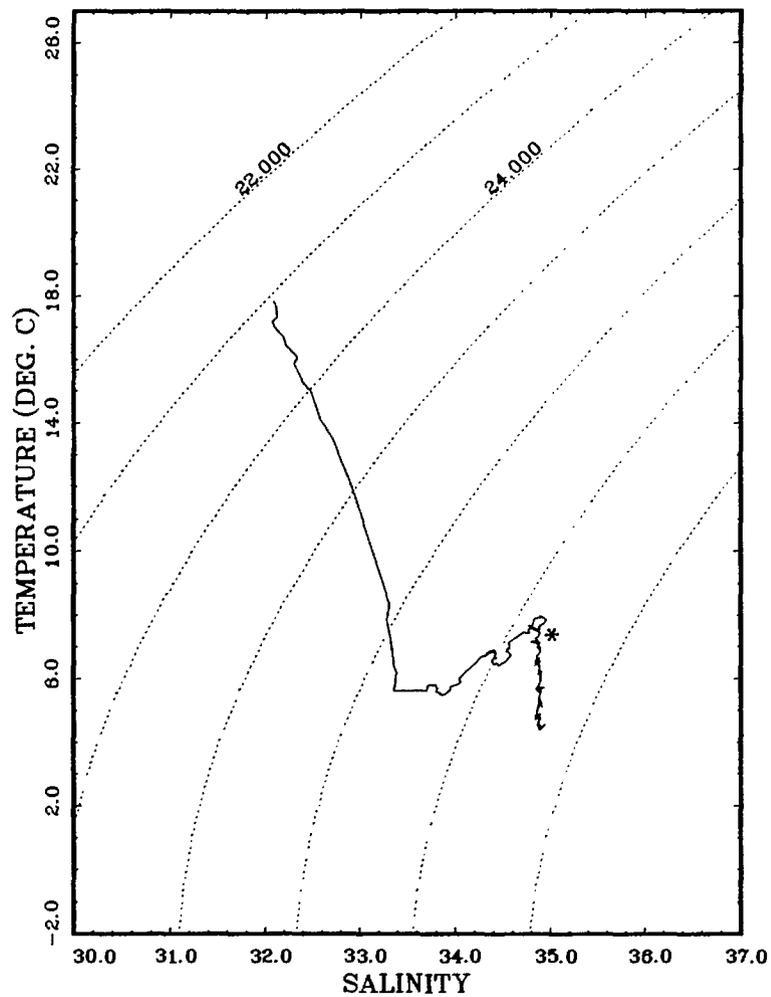
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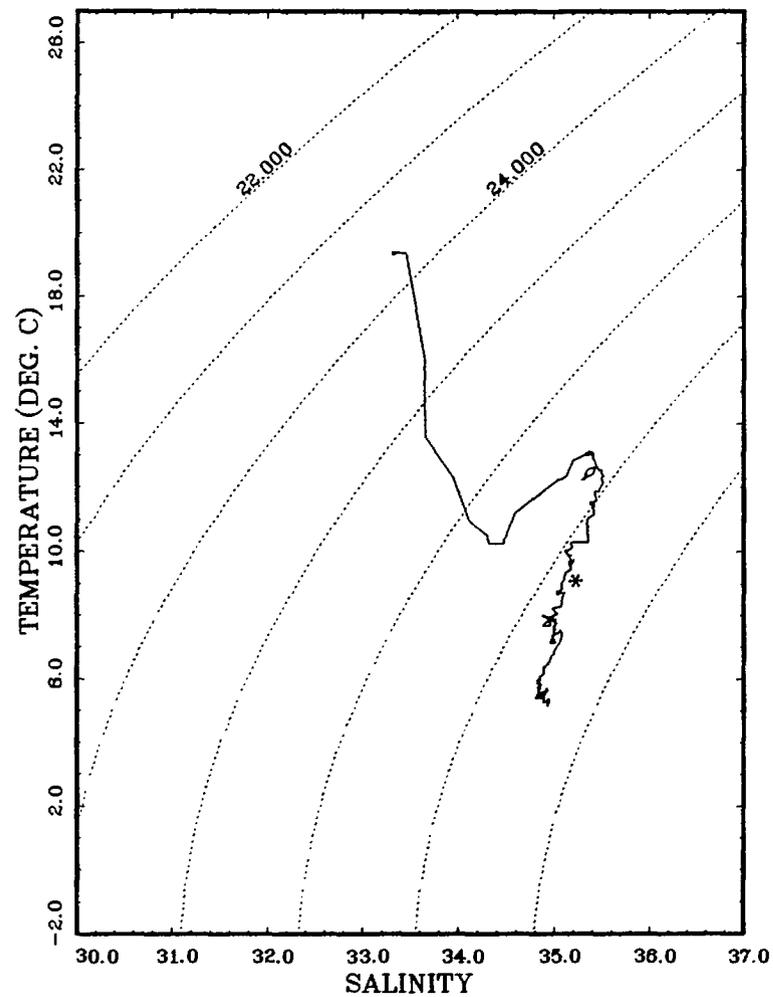
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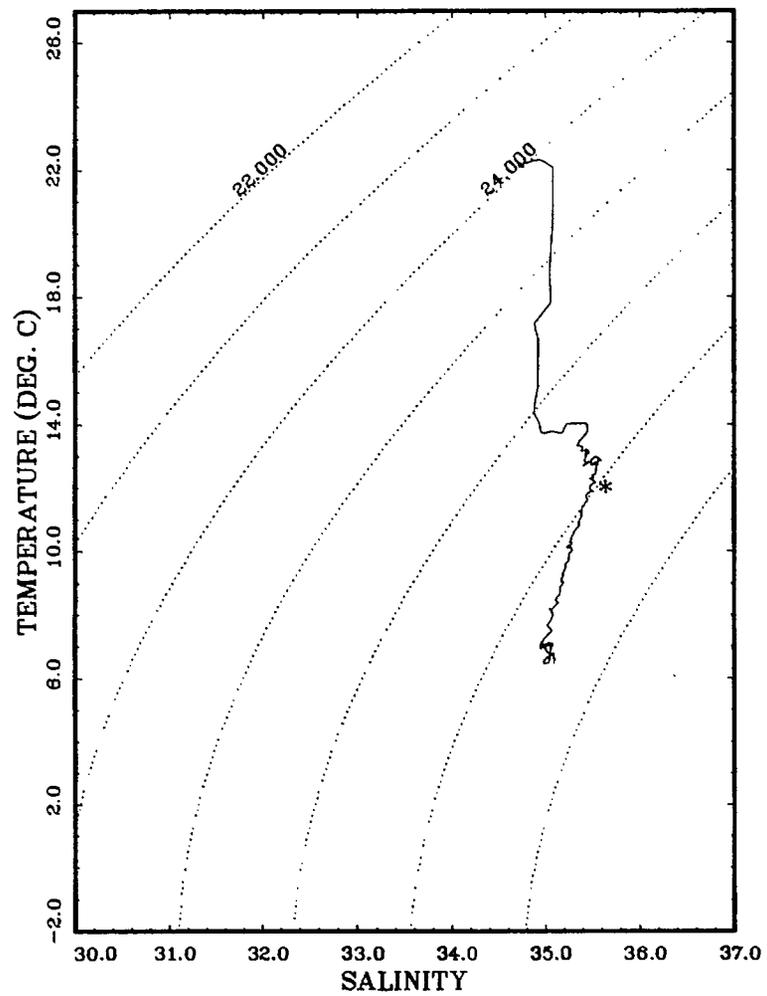
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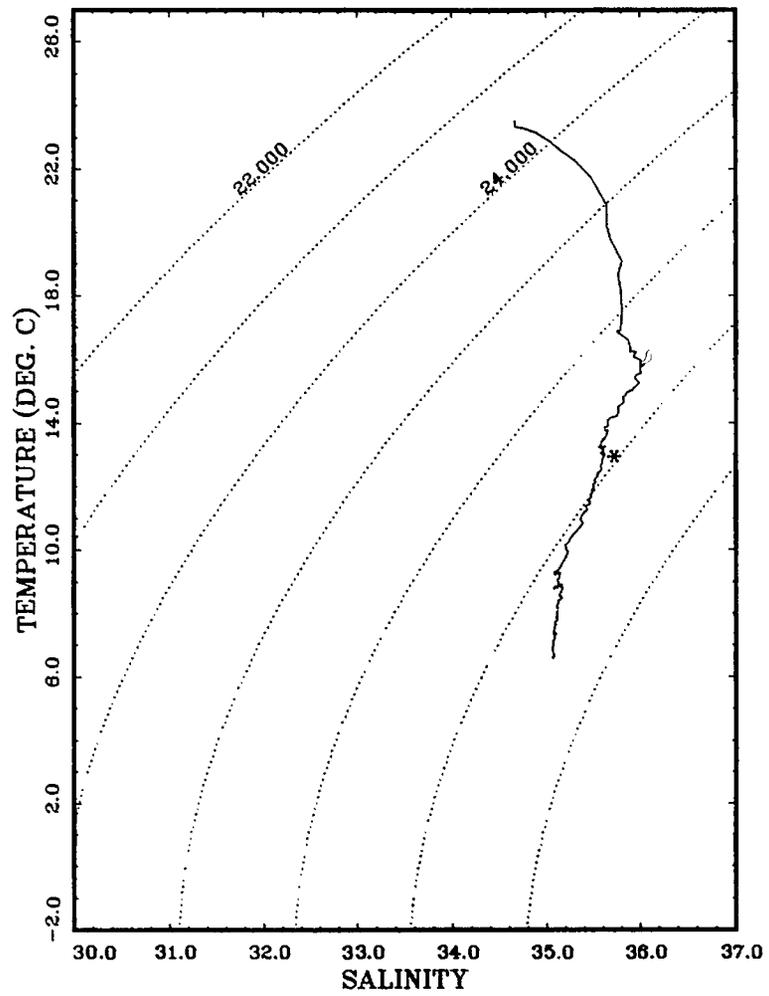
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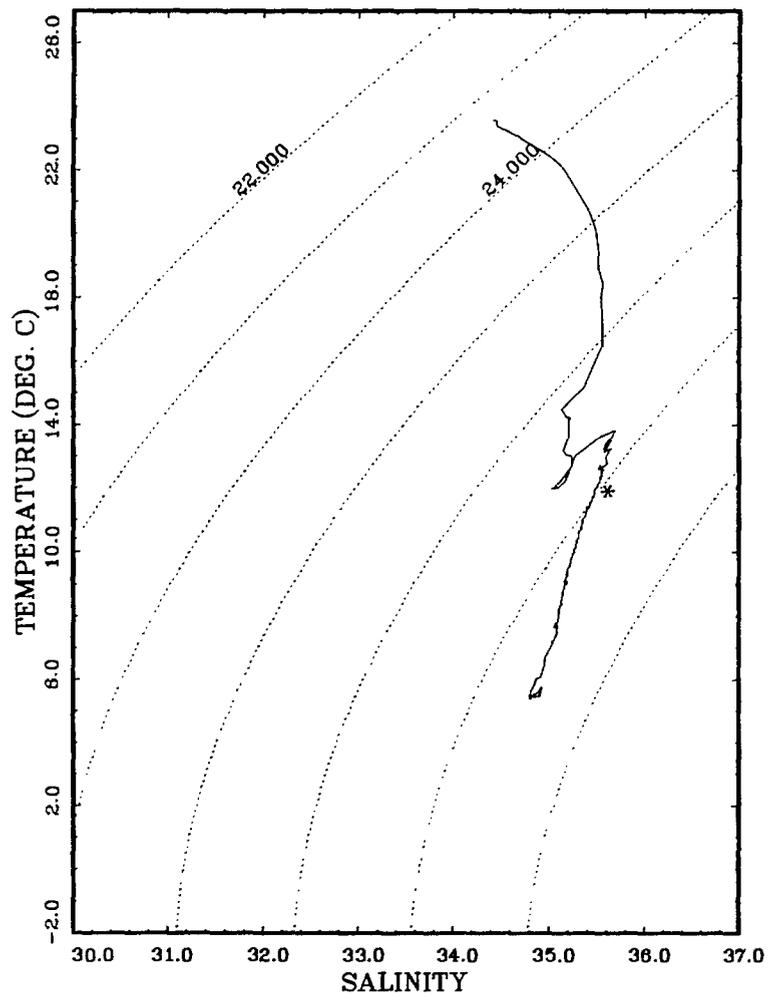
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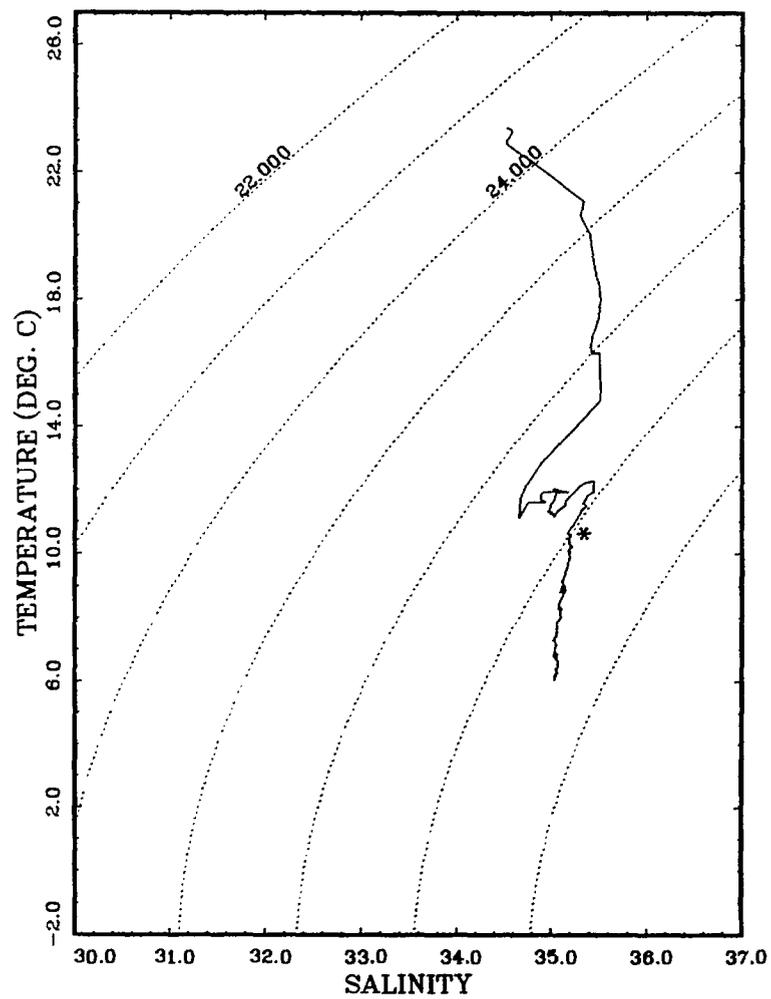
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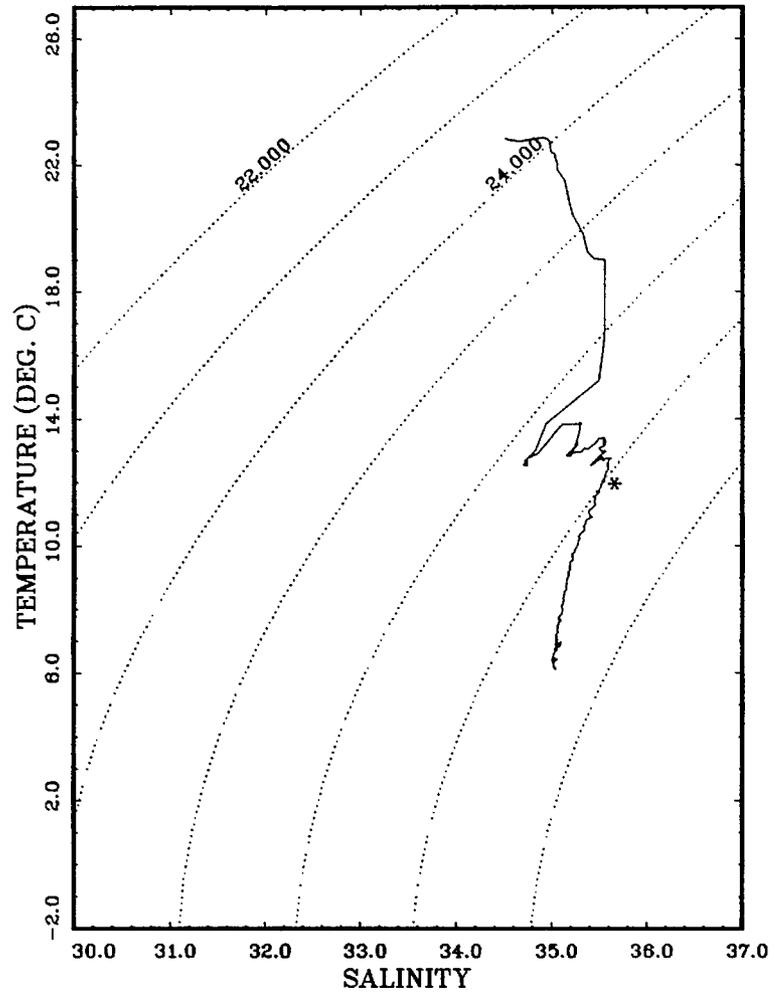
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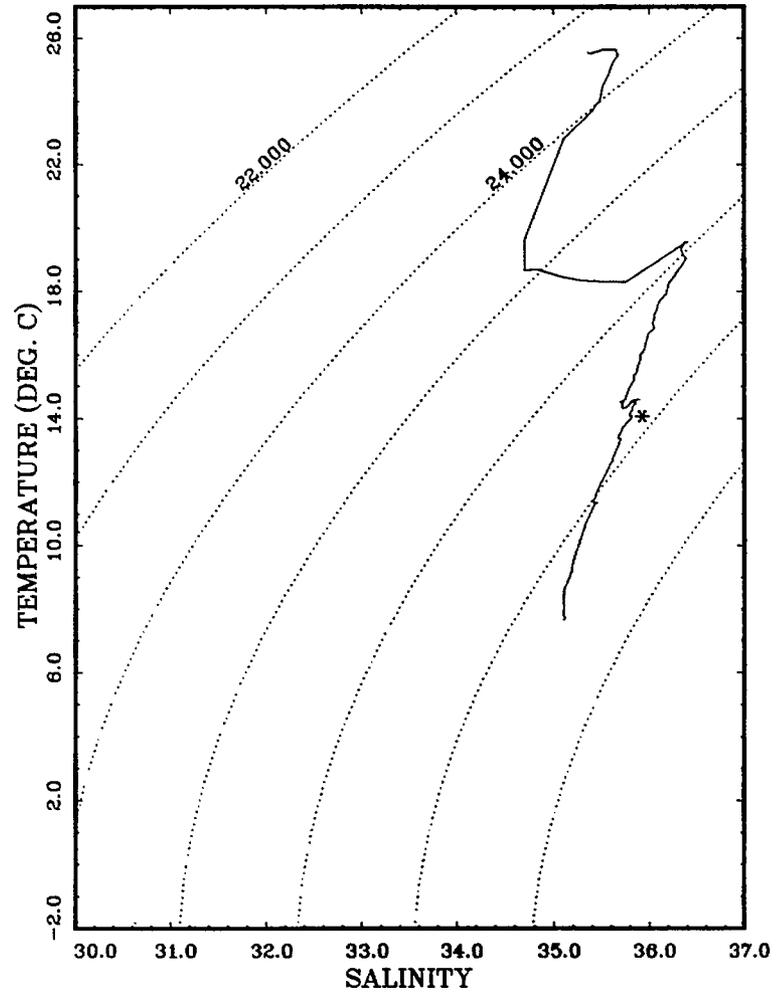
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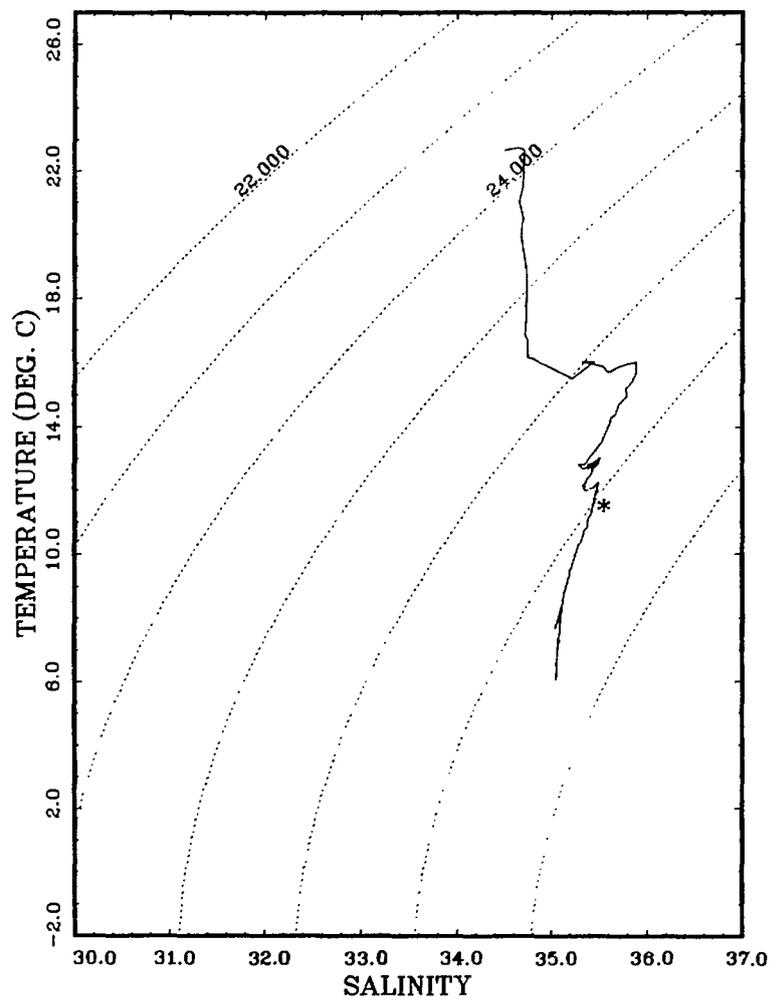
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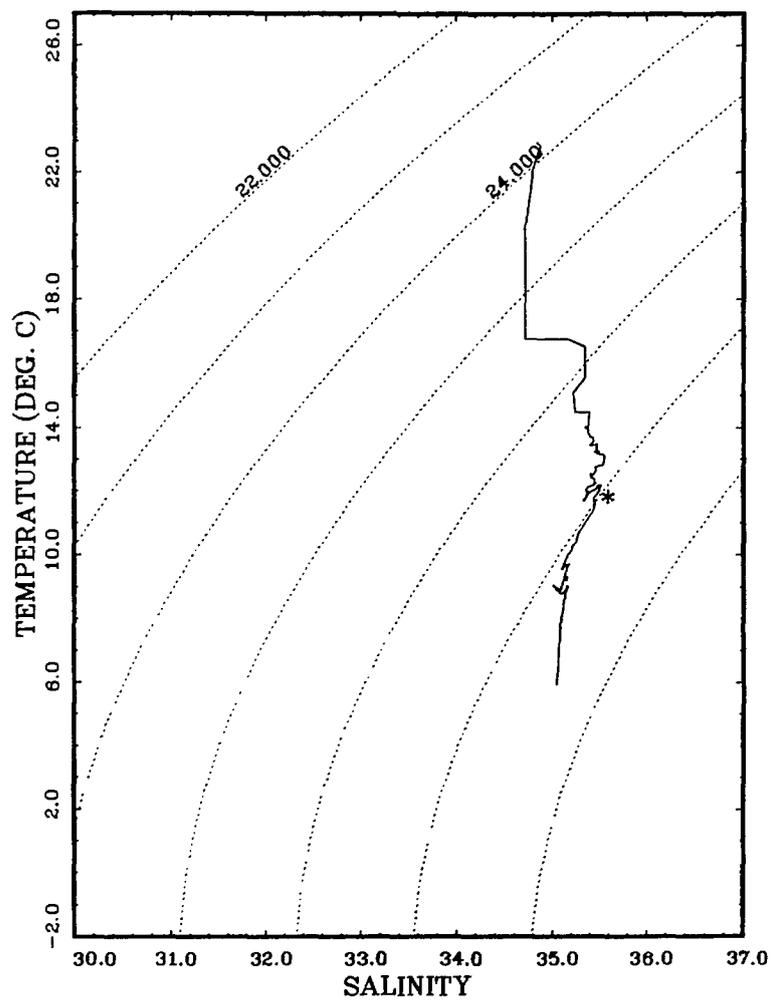
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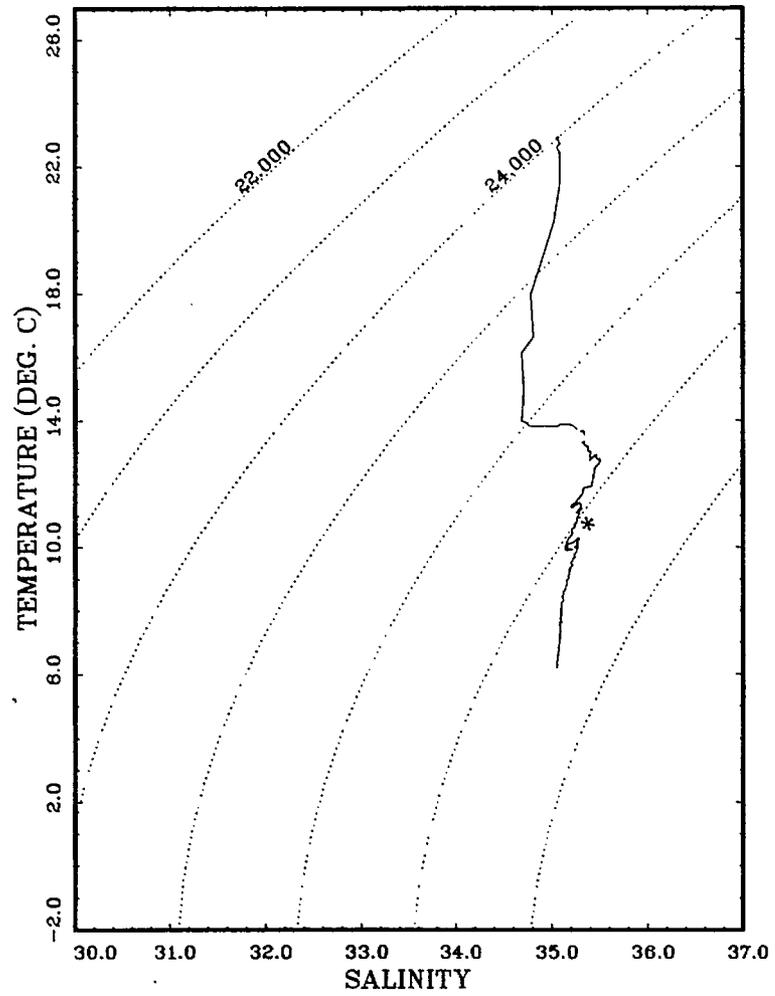
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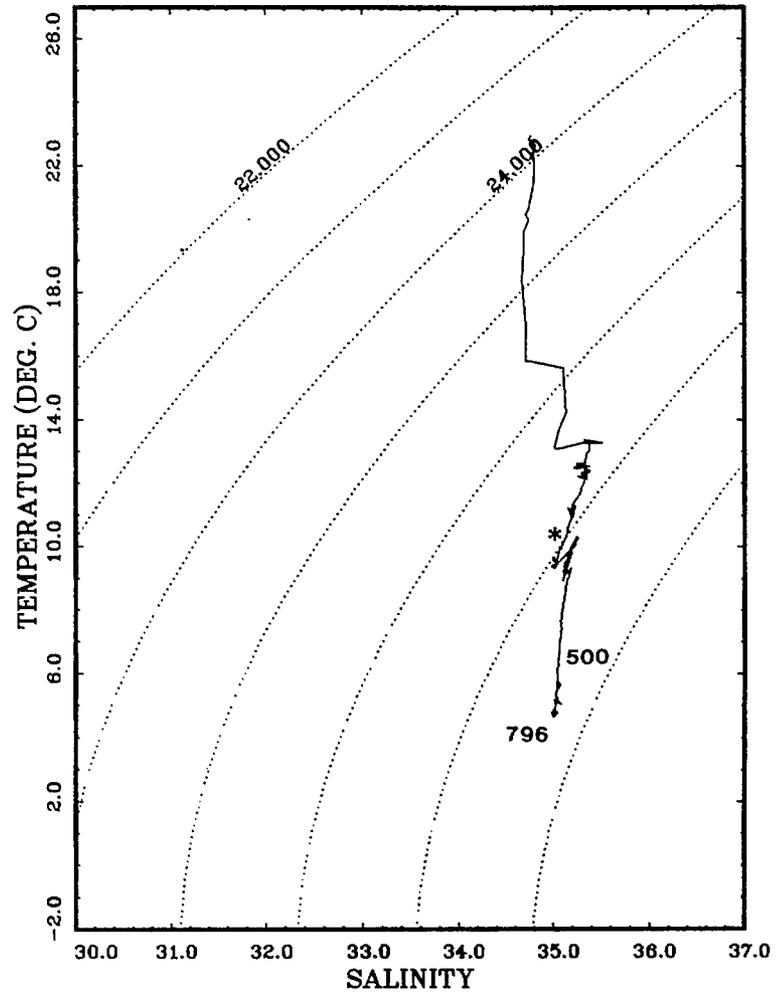
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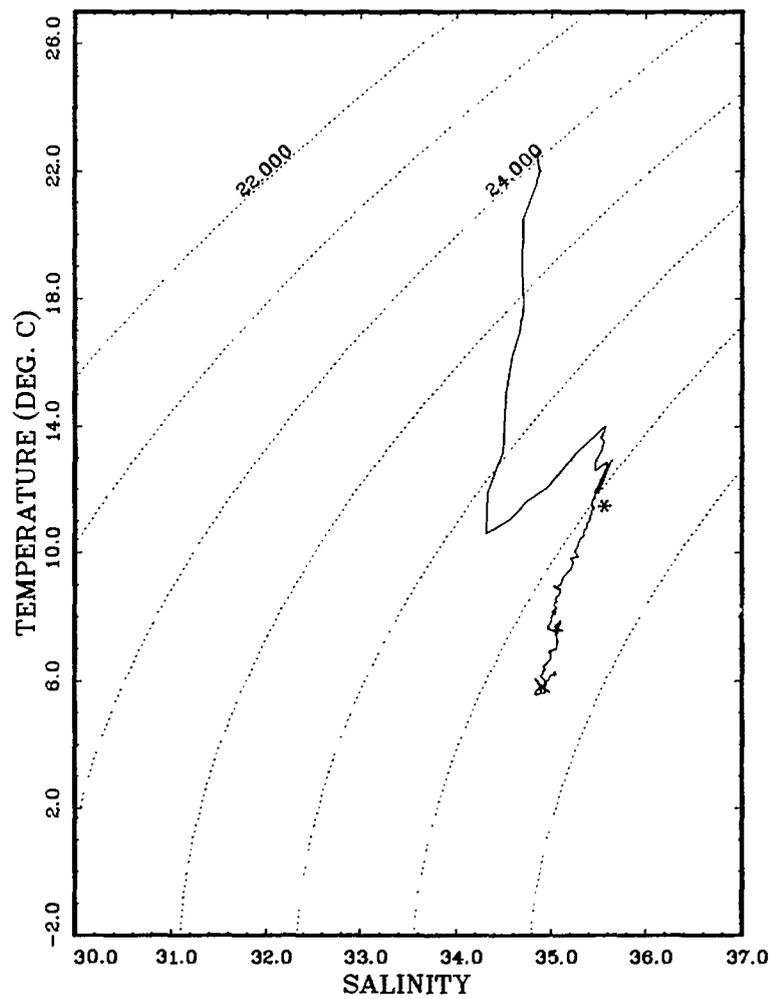
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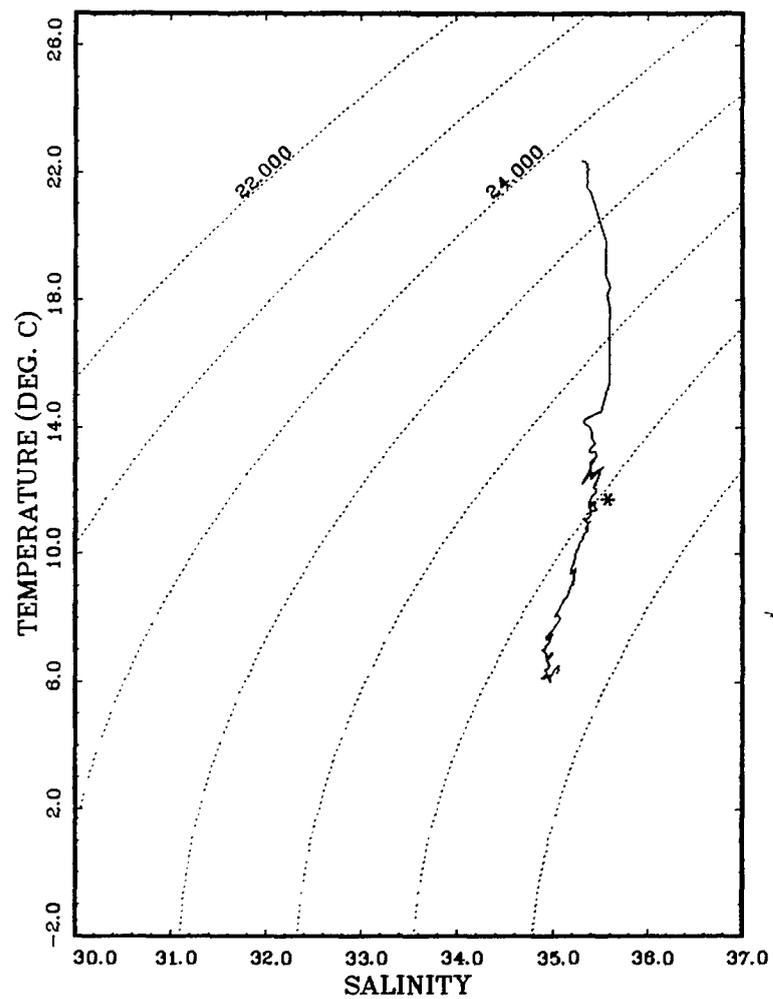
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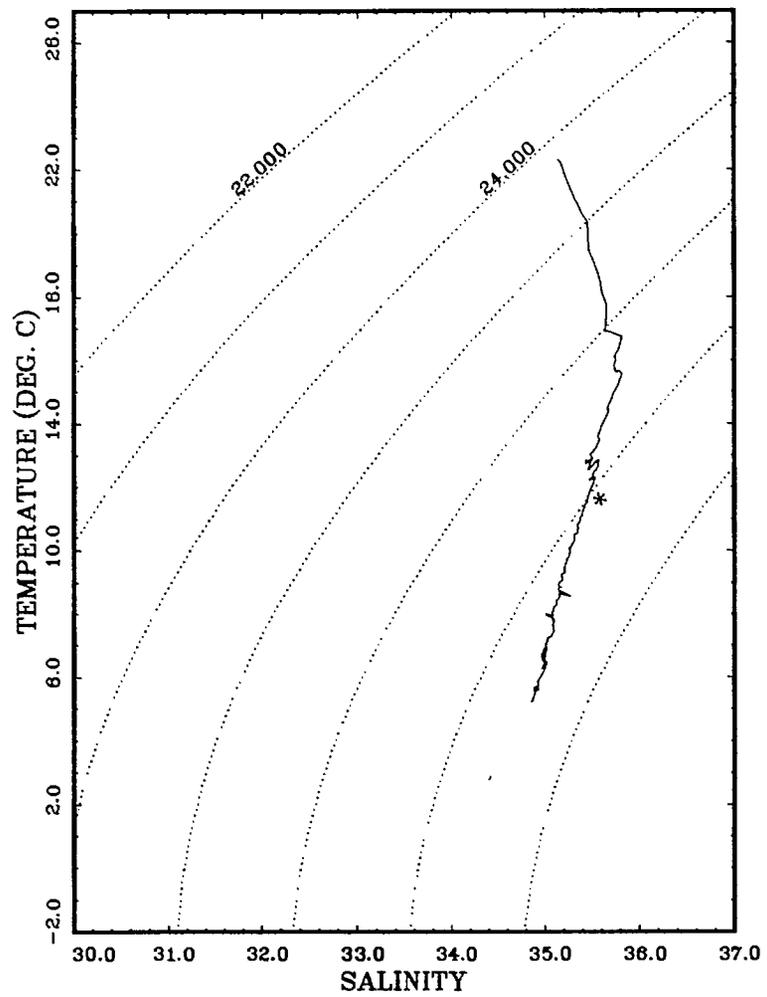
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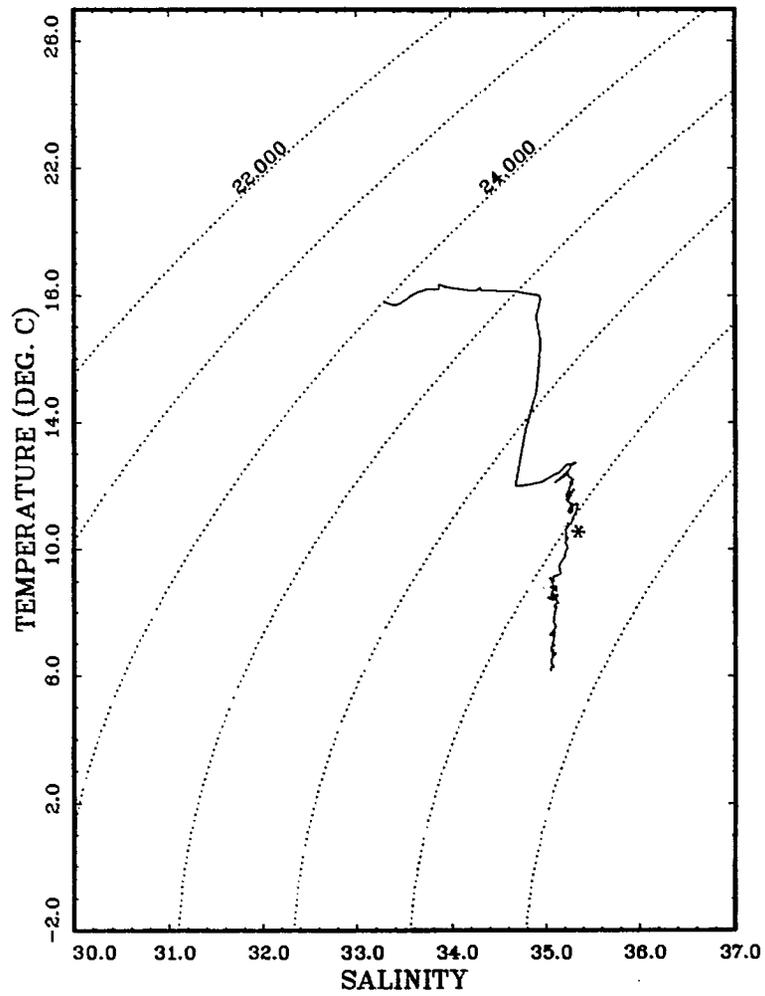
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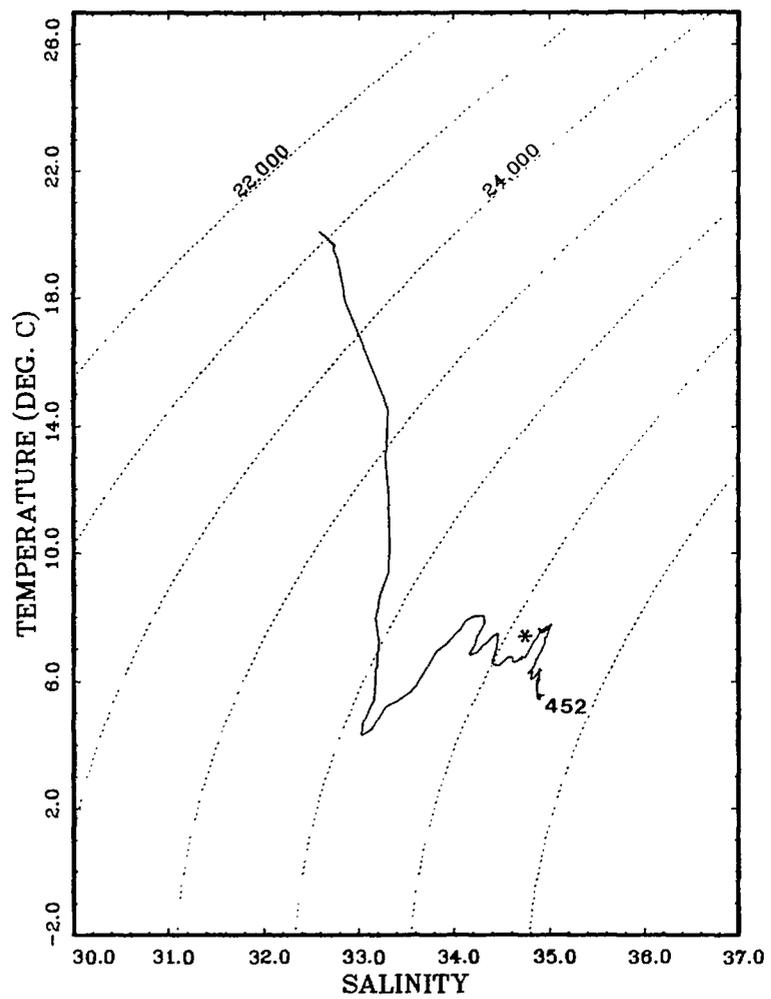
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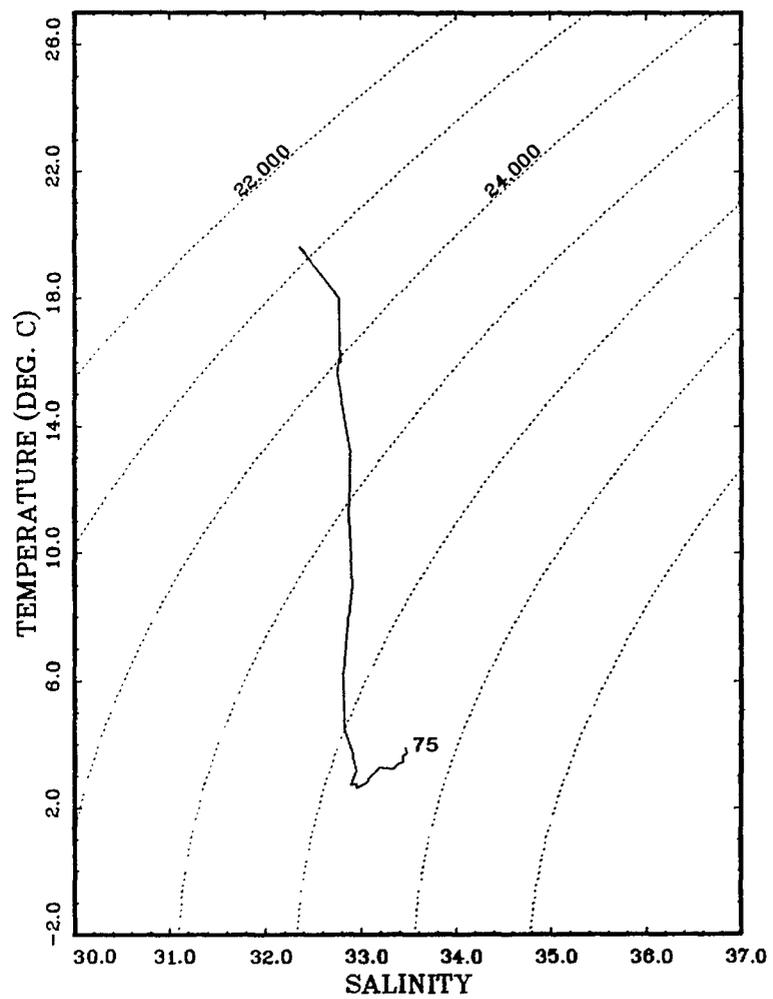
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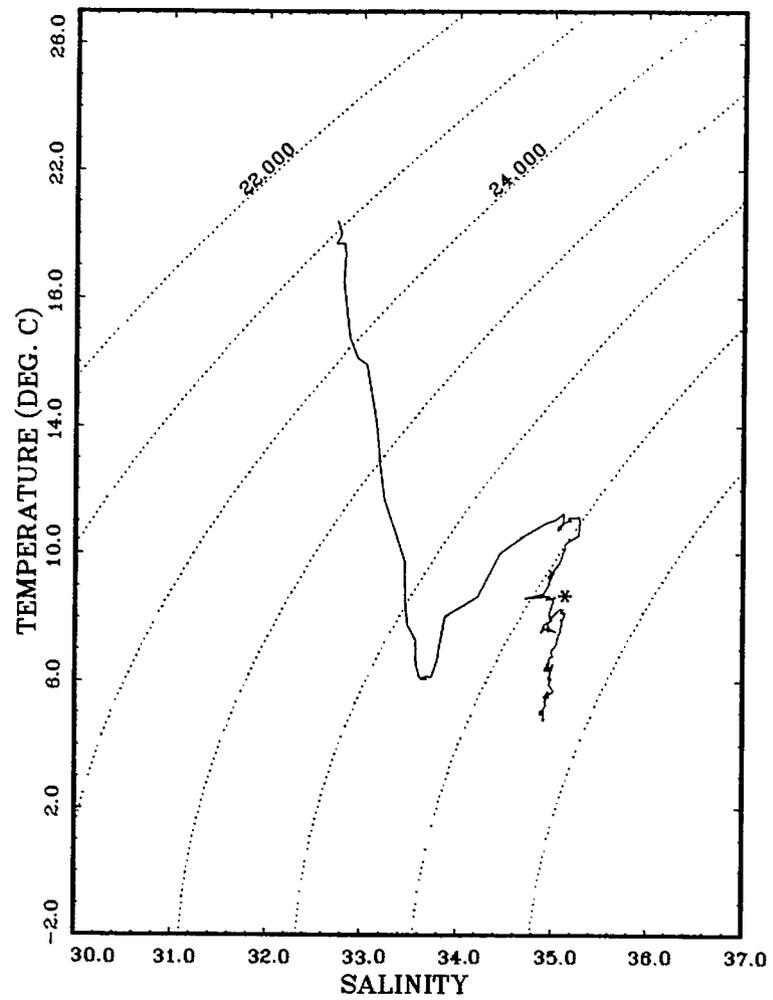
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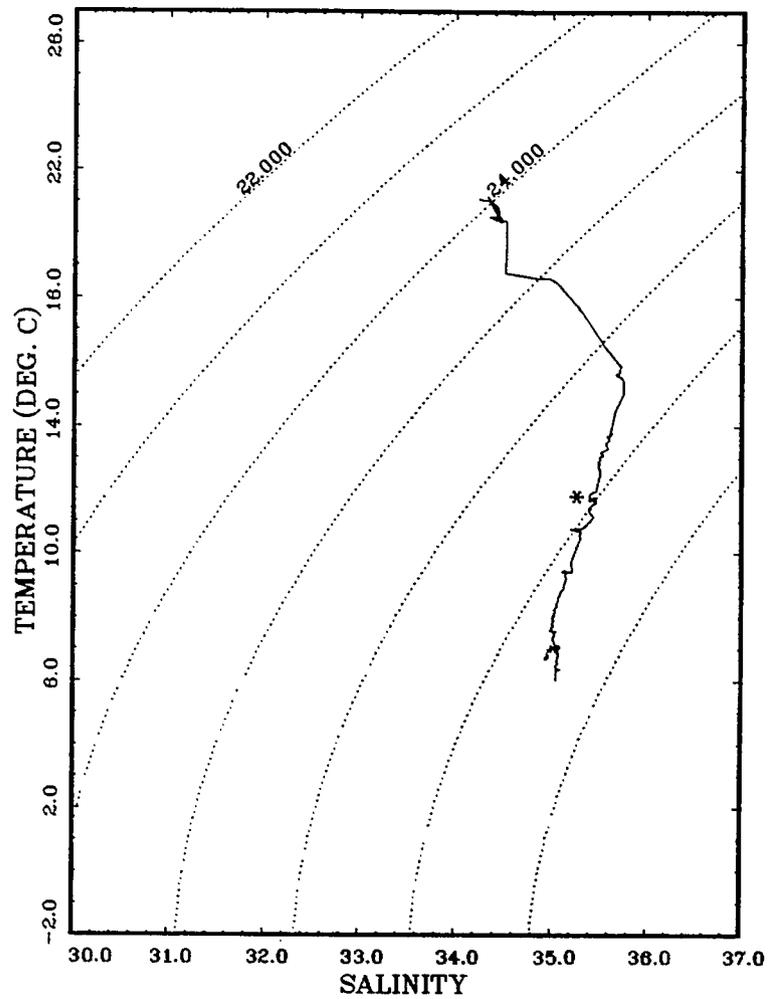
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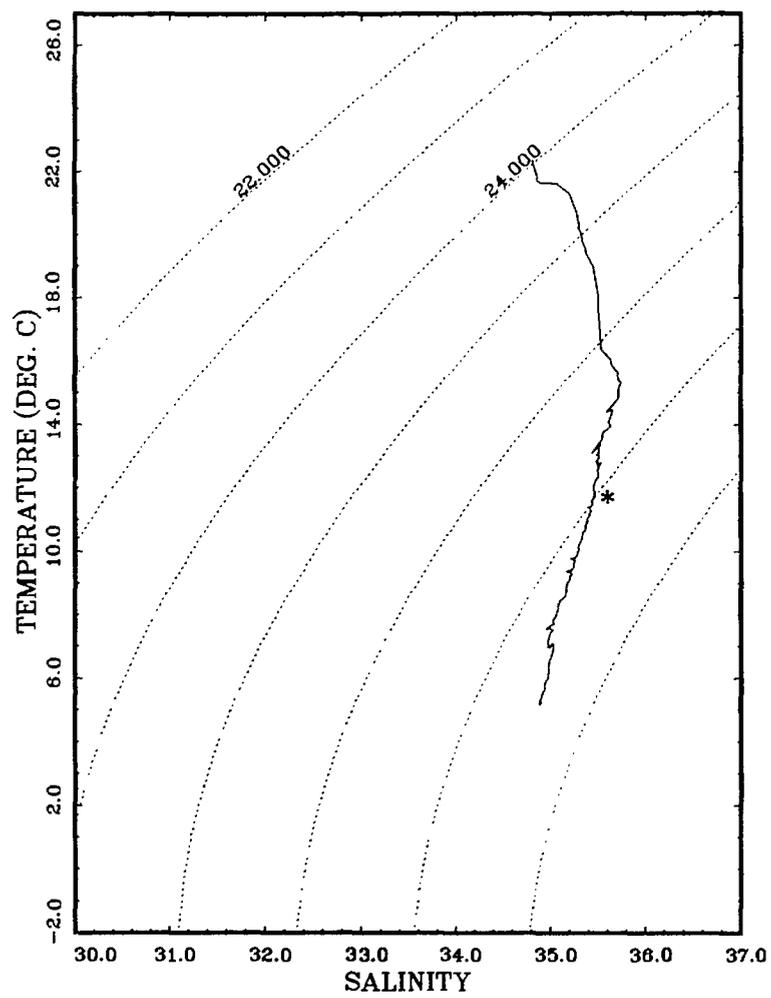
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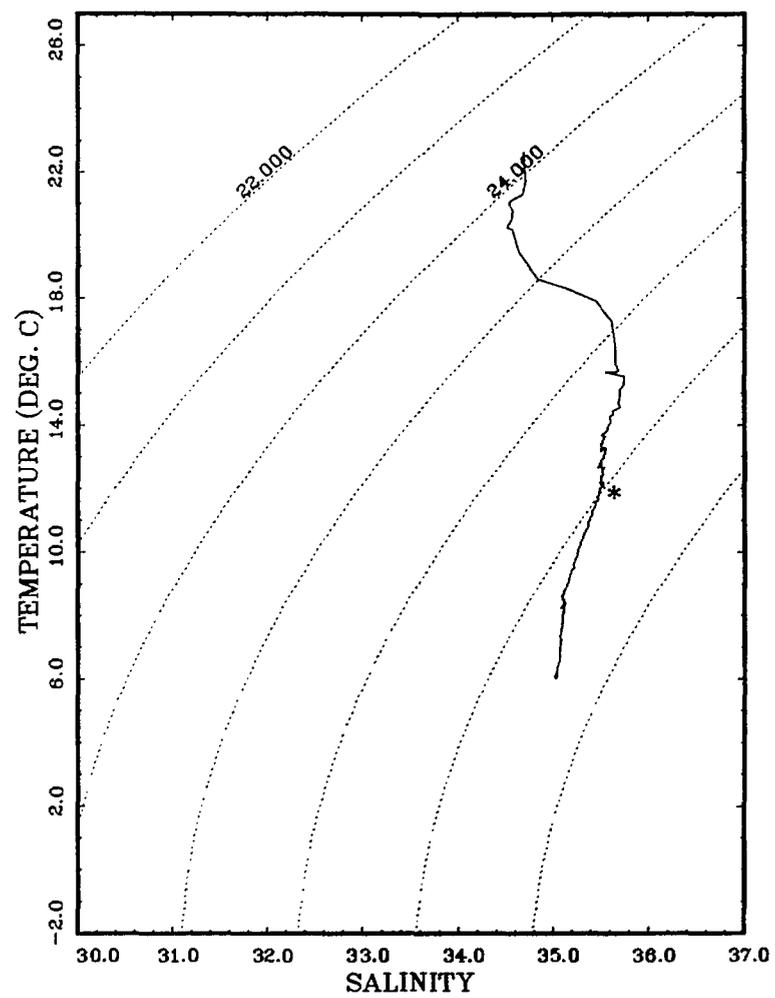
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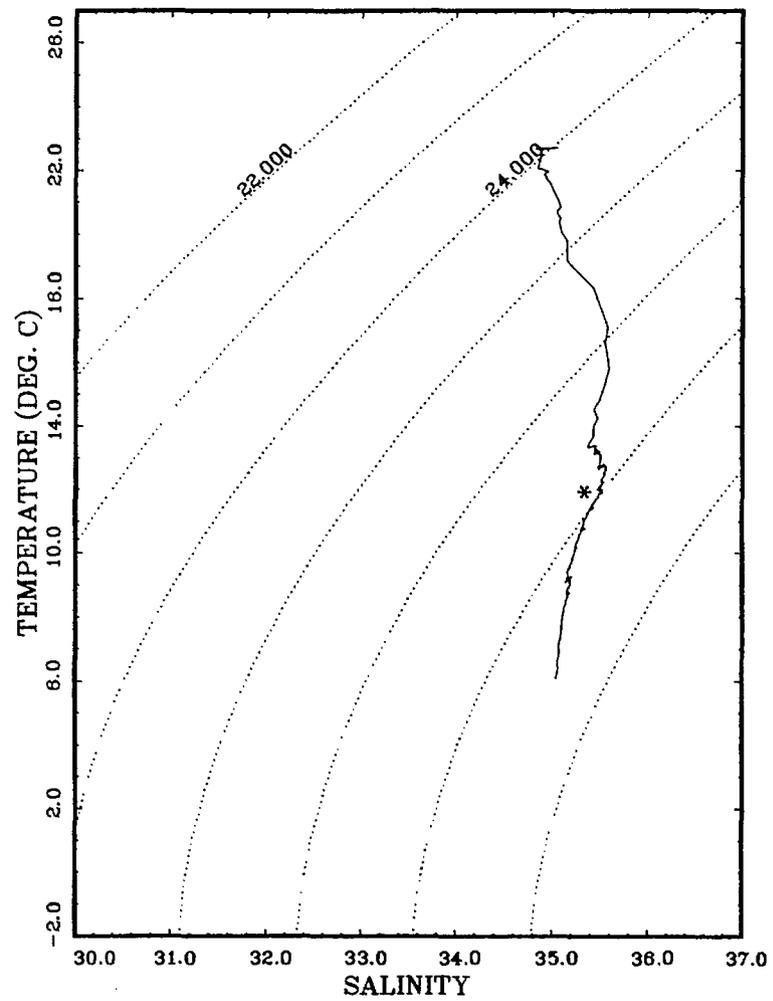
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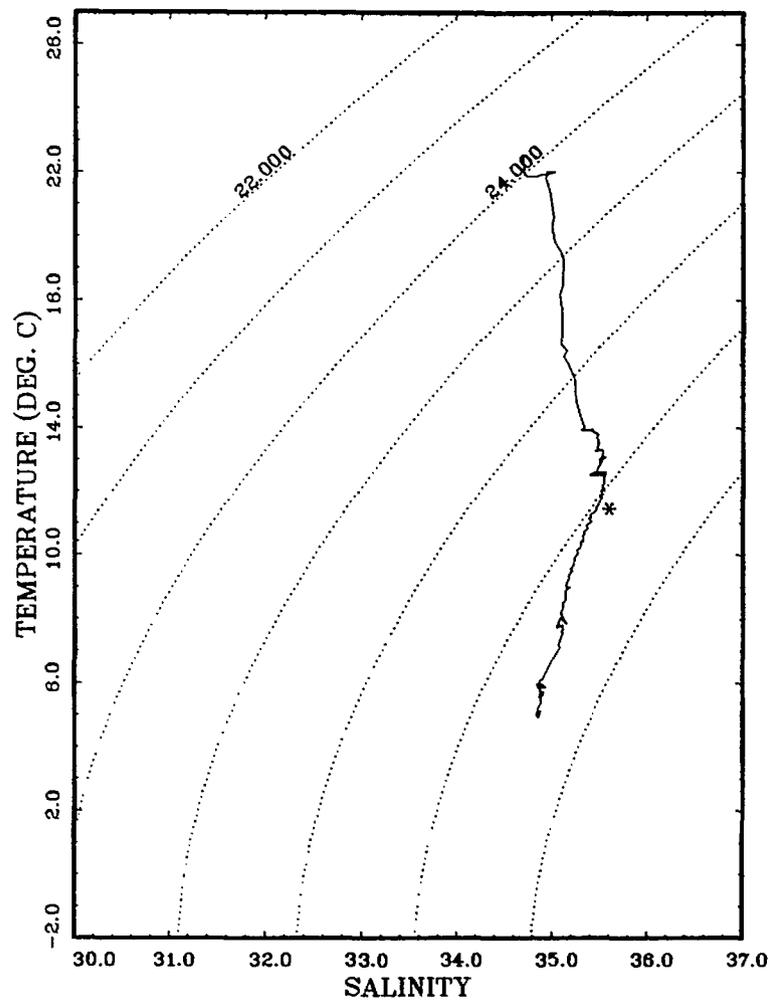
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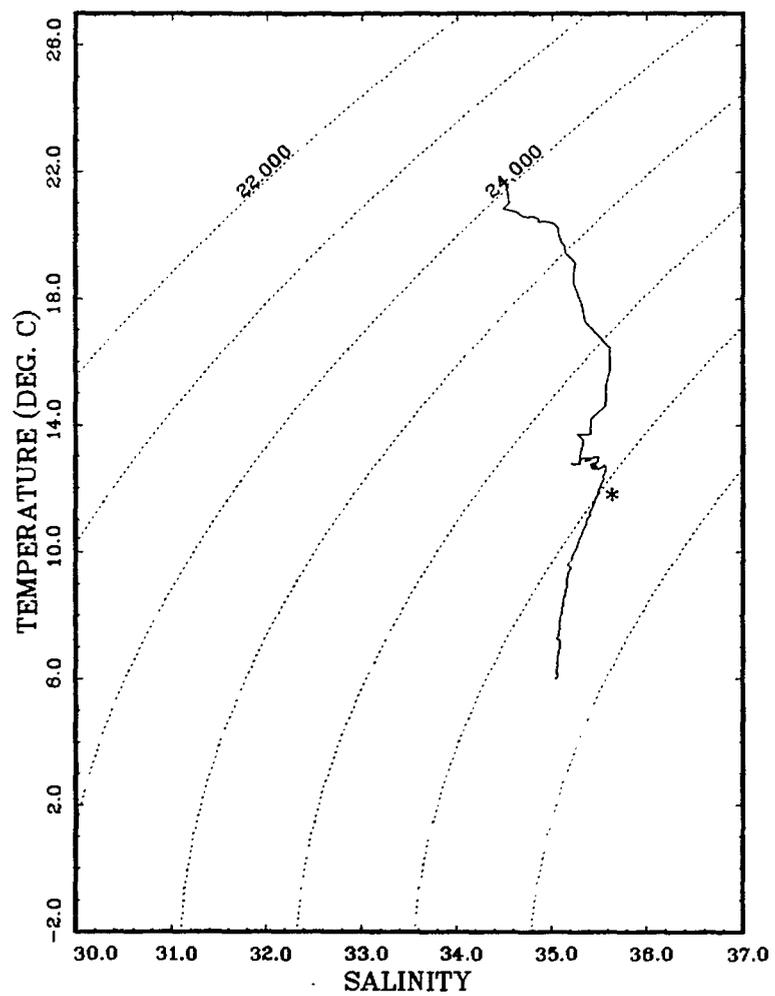
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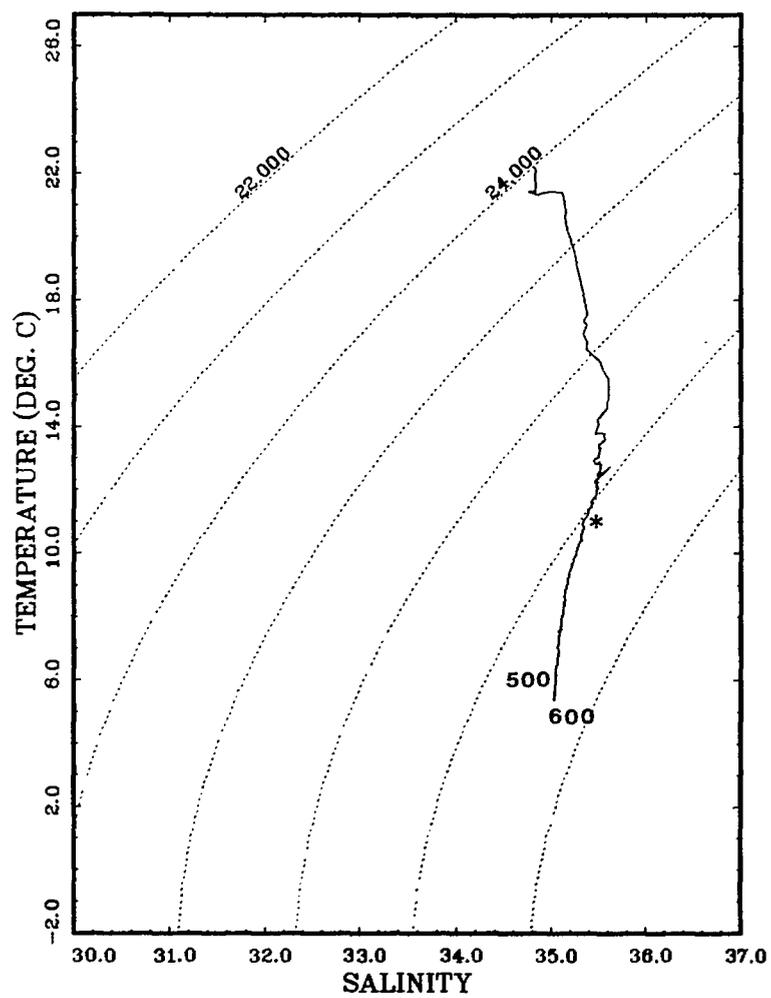
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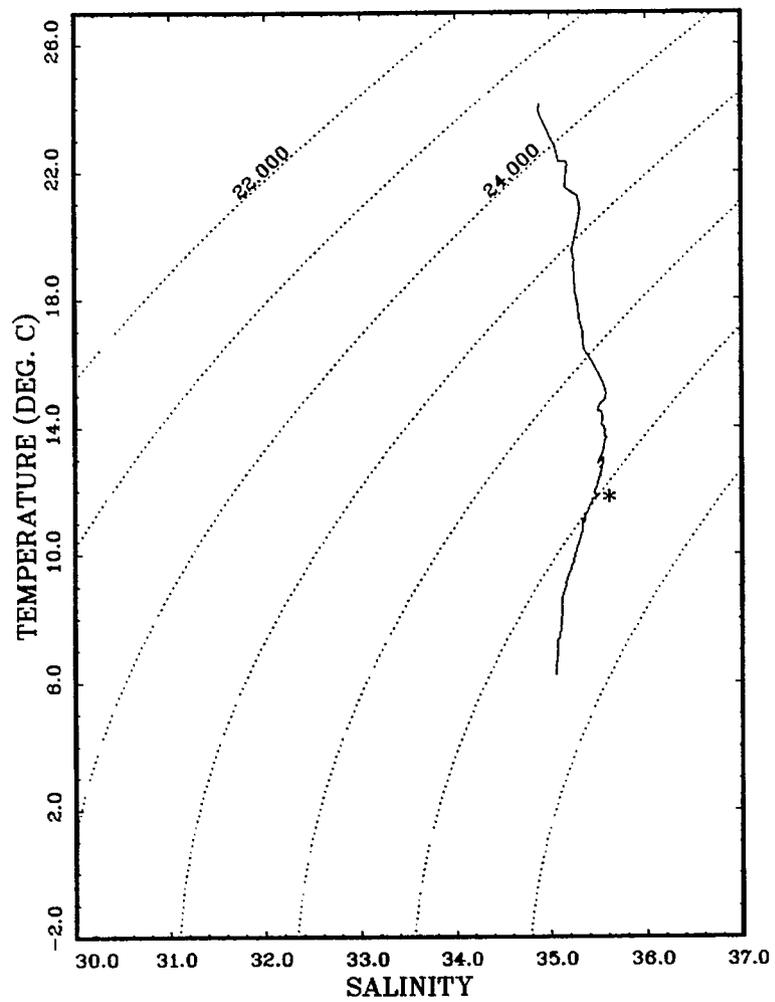
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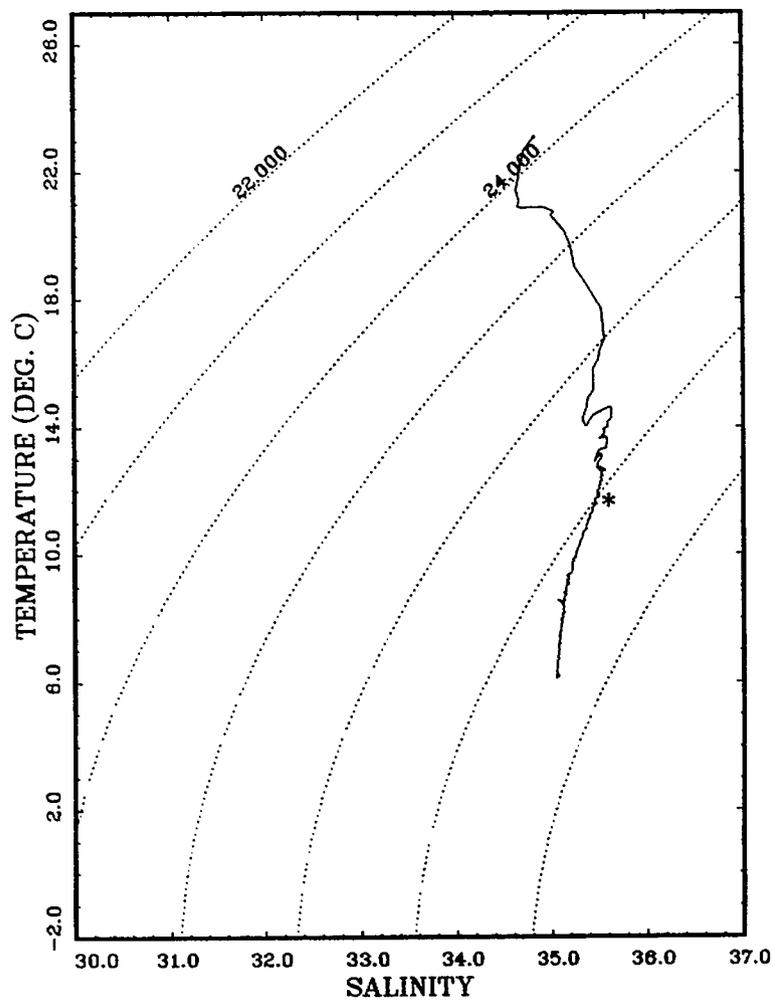
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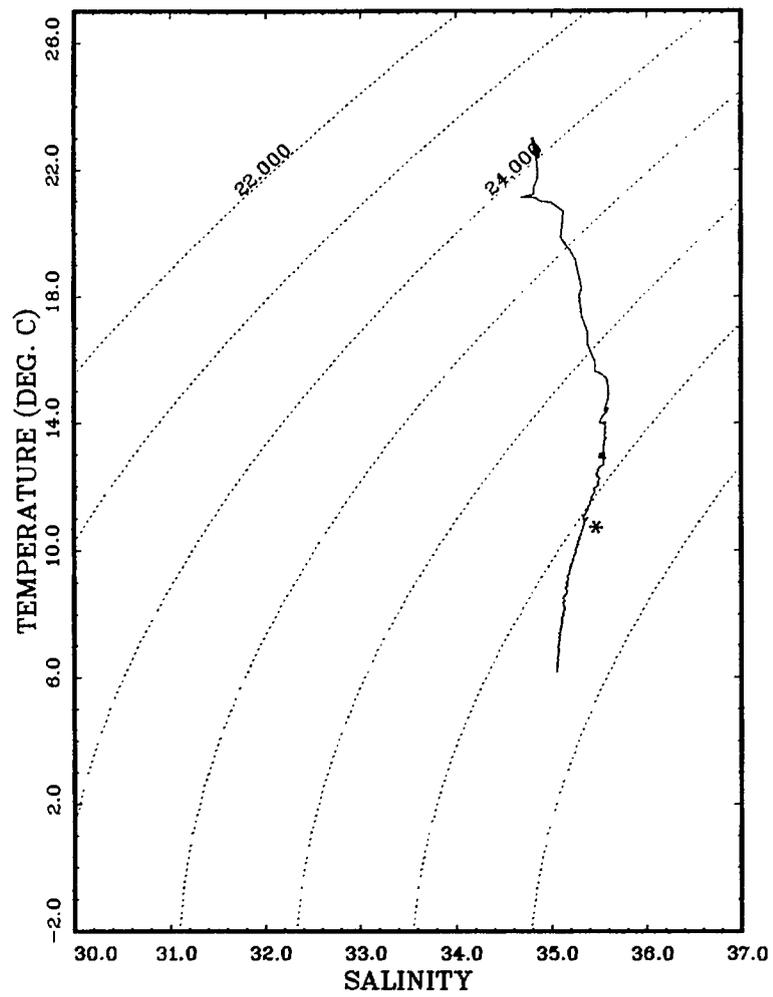
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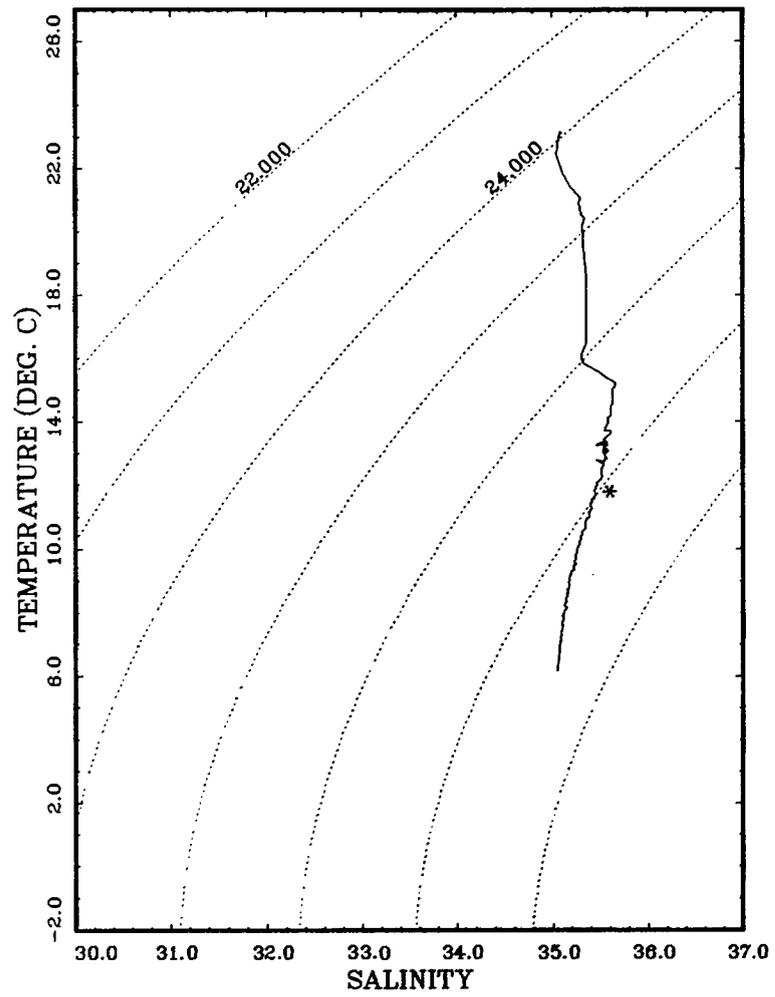
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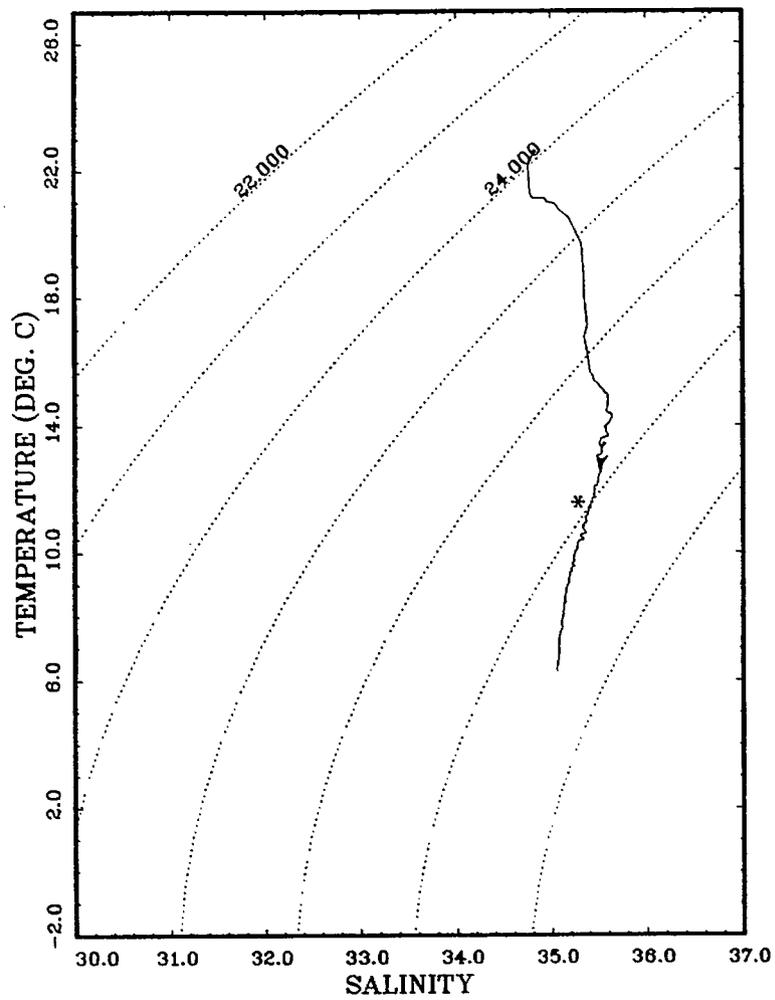
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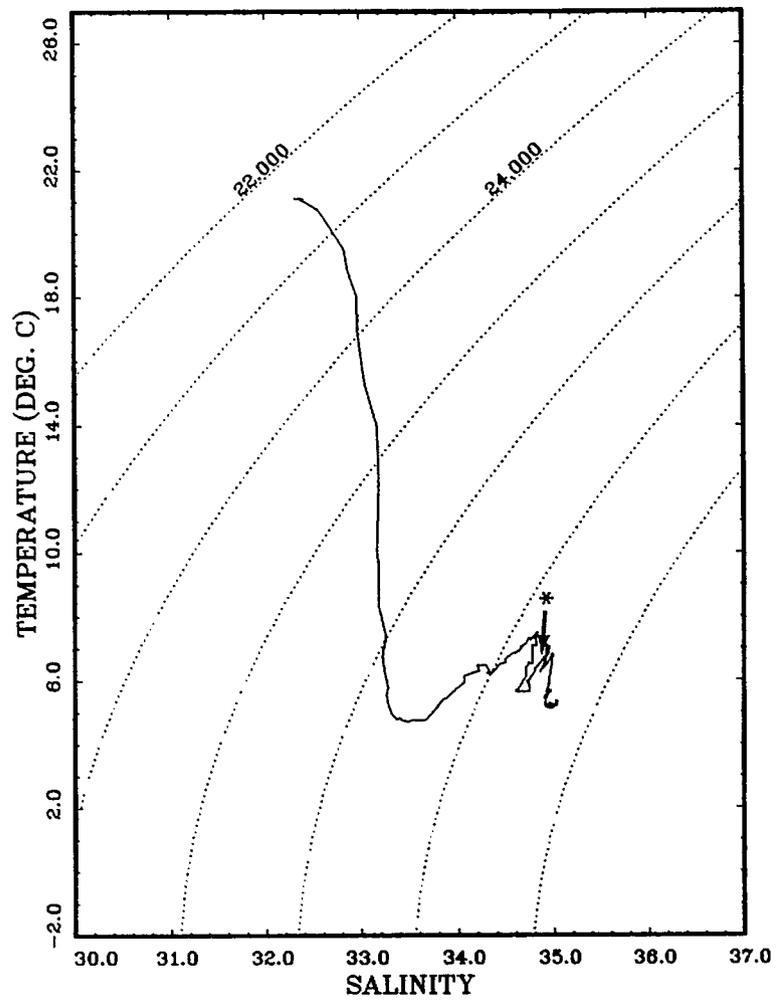
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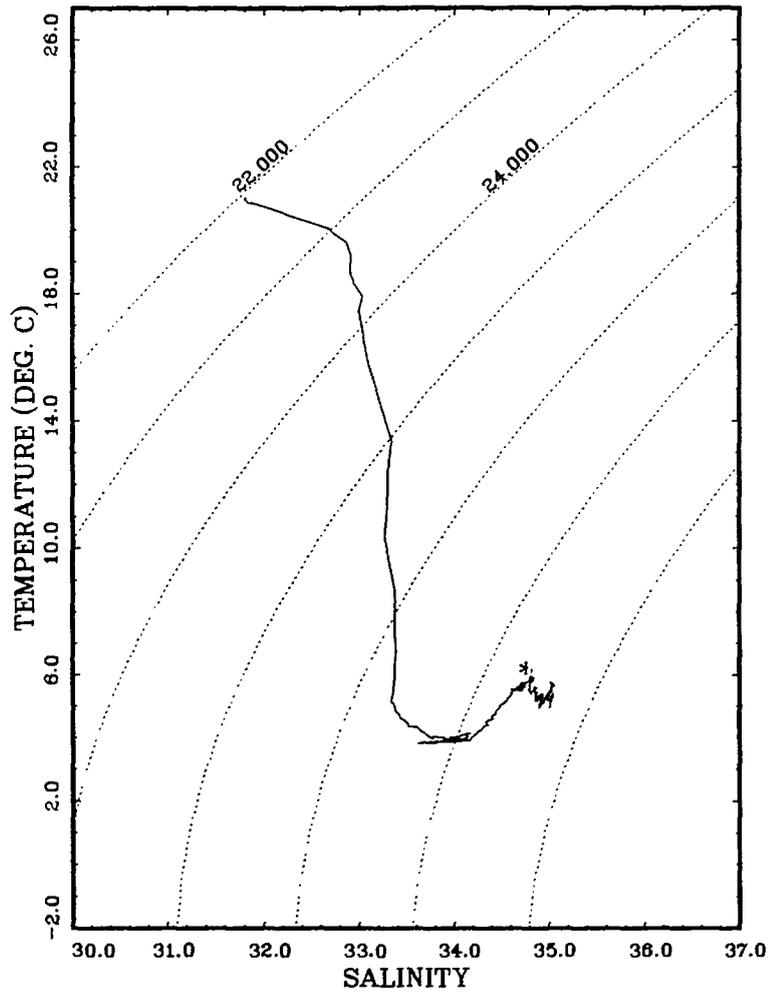
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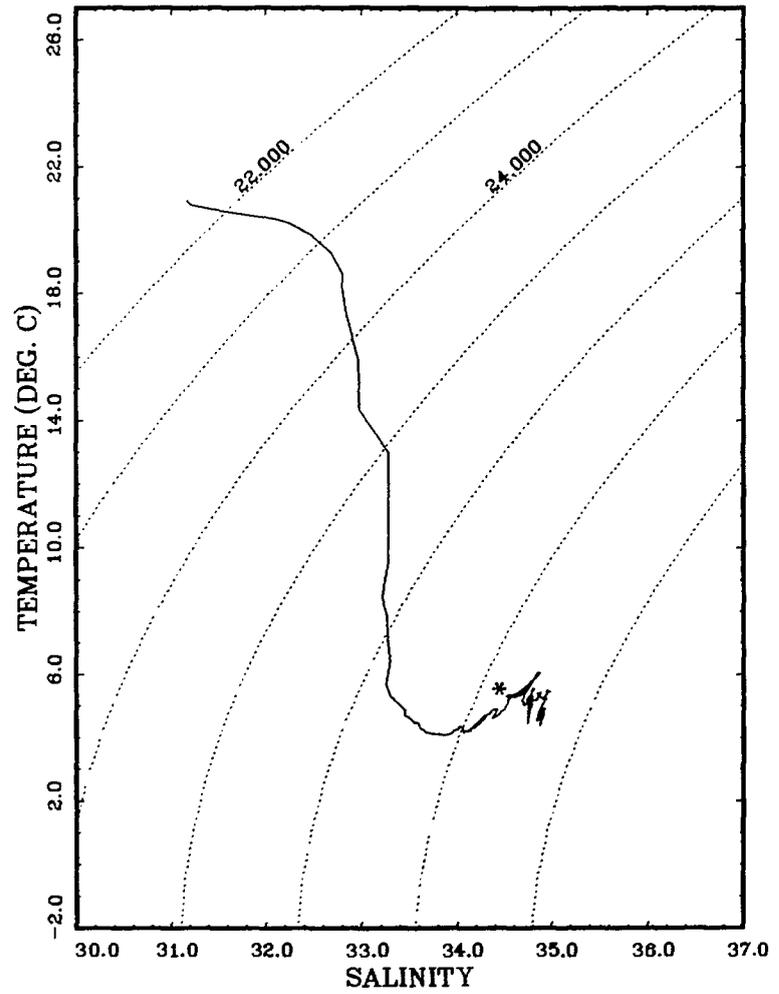
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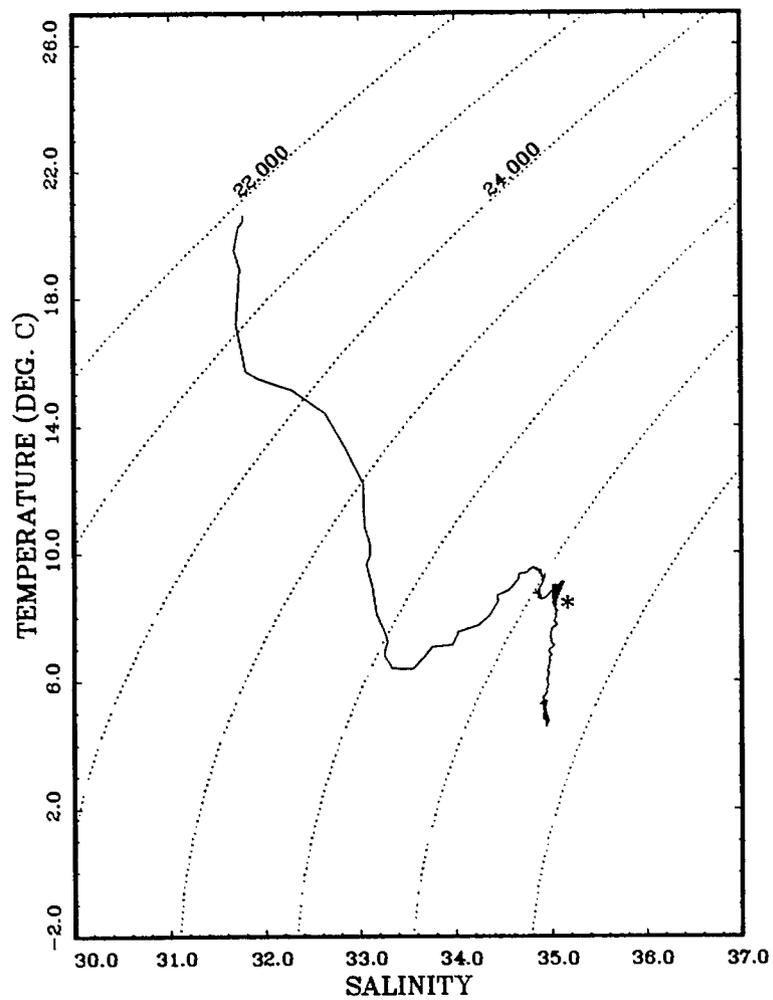
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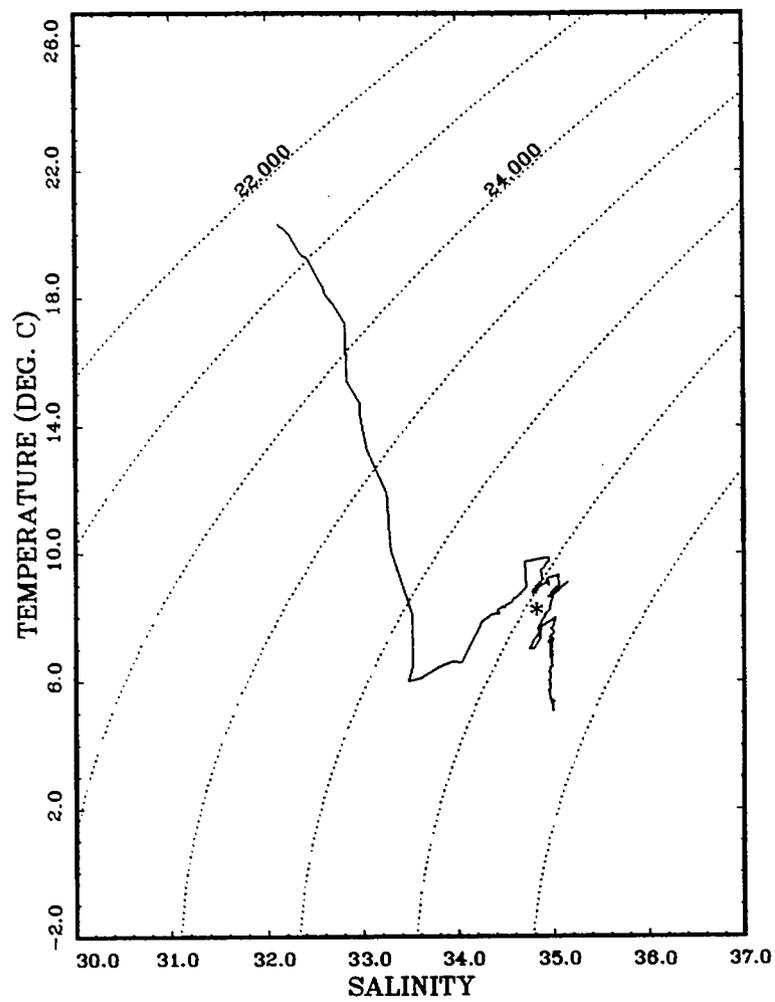
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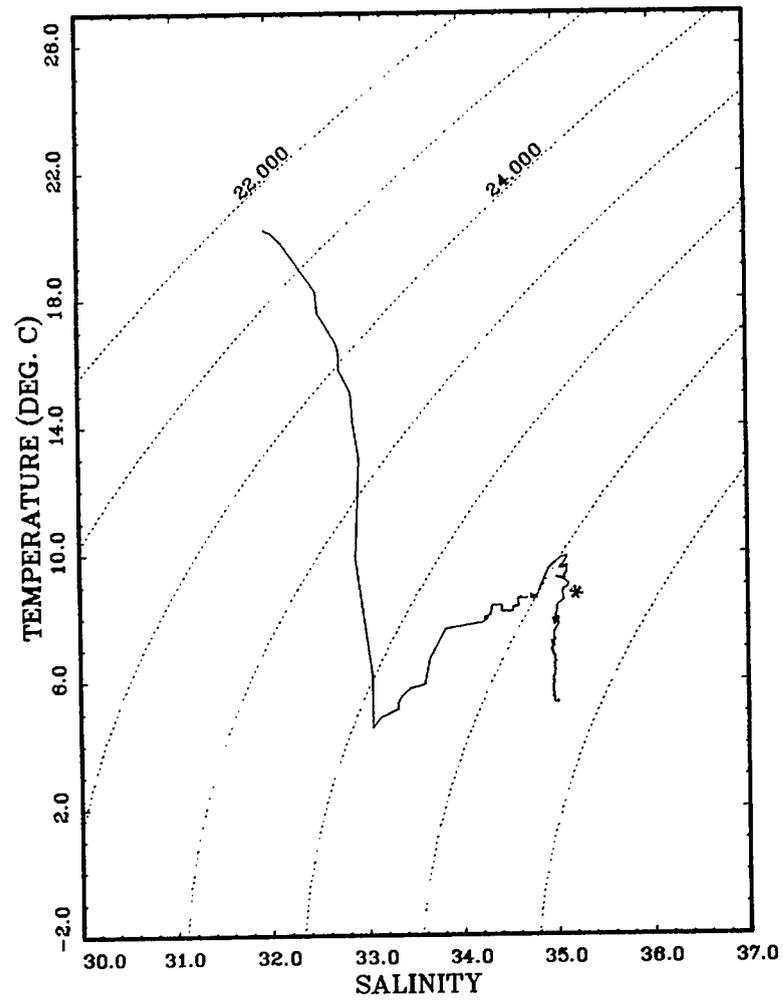
NEEDLER 126 - CTD 37



NEEDLER 126 - CTD 38



NEEDLER 126 - CTD 39



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