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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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Southwest Fisheries Center

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ABSTRACT

Temperature and salinity observations were made from the surface down to 1500 m, in the central northwestern Weddell Sea, during March 1986. These observations sampled the three water masses characterizing the region. The uppermost, Surface Water, layer extended down to 30-50m, had temperatures from near freezing (-1.8C) up to about 0C and salinities of 33-34 ppt. A layer of Weddell Winter Water underlay the Surface Water, extending down to about 100m, and had temperatures of -1.5 to -1.7C and a salinity of about 34.46 ppt. The Weddell Warm Deep Water extended from the bottom of the Winter Water down to more than 1500m, displaying temperature increasing with depth to a maximum of about 0.5C near 500m then decreasing down to 1500m. Salinity increased with depth in this layer to about 34.67 ppt near 500m, then decreased slightly at greater depths. A warm core having temperatures greater than 0.5C was present near 500m depth in the westernmost part of the study region. The temperature maximum region within the Warm Deep Water decreased in depth eastward, toward the center of the gyre, within this core. The baroclinic circulation, expressed as dynamic topography of the surface relative to the 1500 db level, was insignificant throughout the region.

INTRODUCTION

Temperature and salinity observations were carried out in the northwestern Weddell Sea marginal ice zone (MIZ) during March 1986 as part of the Antarctic Marine Ecosystem Research at the Ice Edge Zone (AMERIEZ) program. The purpose of these observations was to define the oceanic temperature, salinity and density fields associated with the MIZ. Particular emphasis was placed on features, such as vertical stratification in the upper oceanic layers, which were expected to impact local biological processes. The observation region encompassed a zonal band extending from the northwestern Weddell Sea continental rise out to the deep basin (Figure 1). The western portion of the region lay under the late summer ice cover, which consisted primarily of multi-year pack ice remaining from previous winters. The eastern portion of the study region encompassed open water.

The program took place during the late summer-early autumn season, prior to the start of the winter ice advance. The conditions sampled were therefore representative of an MIZ just as early season cooling has commenced but prior to significant ice formation. While air temperatures were usually below freezing, water temperatures were in most instances too far above freezing for ice formation to occur. Advection of existing ice by off-ice winds into water warmer than the melting point (about 1C) resulted, in several instances, in ice melting along the edge and contributing to upper layer meltwater accumulation which will be evident in the following discussion. Only during the westernmost penetration into the ice and during a few particularly cold days within the ice was active ice formation observed. Hence, the cruise timing occupied the transitional period between summer net ice melting and winter freezing.

The observations were carried out from two vessels. One, the icebreaker Glacier, operated within the sea ice out to the vicinity of the ice edge. The second vessel, R/V Melville, operated in the open water seaward of the ice edge. Temperature and salinity (as conductivity) observations were made from both vessels using Neil Brown Mark IV CTD (conductivity/temperature/depth) profiling systems. Sixty-six CTD casts were made from the Glacier and 49 from the Melville. Geographical locations for these casts are indicated on Figure 2, and exact coordinates and other information are provided in Appendix 1. Most of the casts extended to depths greater than 500 m, and more than half extended to 1500 m.

CTD data quality was of primary concern. The data were printed out and plotted during the field program, allowing a near real-time check on instrument performance and data quality. The data were also recorded digitally for later processing. The CTD used on the Glacier was calibrated prior to and following the cruise at the Northwest Regional Calibration Center in Bellevue, Washington. The CTD's on both vessels were calibrated regularly (typically every third or fourth cast) during the field program against temperature and salinity values obtained using rosette of Nansen sample bottles and deep-sea reversing thermometers. The calibration data revealed a slight conductivity drift problem with the Glacier CTD system, and allowed development of an algorithm which was successfully used to correct the problem. The final data are accurate to within 0.01C in temperature and 0.01 o/oo in salinity. Resolution was better than 0.005C and 0.005 o/oo in these variables.

This report presents the CTD data as a series of vertical transects which show the distribution of T,S and density (as sigma-t). Secondly, the horizontal distributions are shown for parameters such as T,S, and dynamic height of the sea surface relative to fixed reference levels. Finally, the data are discussed briefly within the context of past research in the region.

VERTICAL DISTRIBUTION OF PROPERTIES

To describe the vertical distribution of the water masses in the survey area we present vertical cross sections of T,S and sigma-t along four sections across the MIZ and one parallelling the edge just inside the ice (Table 1). Section 1 and 4 are rapid (less than 40 hr. for 1 and 4) transects across the ice edge along the southern and northern transects, respectively. These two transects were separated by about 48 km (Figure 1). Sections 2,3 and 5 are slower transects (3-5 days). We will first describe the distribution of properties in the upper 300 m of the water column where the most significant stratification occurred (Figures 3-6). Then we will discuss the water masses in the very uniform region below 300 m (Figures 7-11). The near-surface distribution is not presented for section 5, because conditions near the surface did not vary appreciably along this section. The heavy black line at the surface of each vertical section denotes the approximate extent of the pack ice.

Upper Layer Properties (Figures 3-6)

Section 1:

During the first rapid transect (Figure 3) on the southern line the upper 20-30m beneath the ice-covered area was near the freezing point (-1.7 to -1.8C) . The upper layer stratification was primarily controlled by the salinity field. The 20-30m surface layer with relatively low salinity Weddell Sea Surface Water (33.6-33.8 o/oo) was underlain by a sharp halocline (and associated pycnocline). Only seaward of the MIZ was there a temperature and salinity structure reflecting the upper layer salinity and density structure. Mixed layer temperatures increased away from the ice edge zone to a maximum of about -0.2C at a distance of 200 km from the ice edge. The lense of low salinity water (S < 33.6 o/oo) beneath the ice edge represents meltwater from some recent ice melting episodes.

Below the halocline/pycnocline at approximately 50-100m there was a temperature minimum layer (-1.5 to -1.7C) with a relatively constant salinity of 34.46 o/oo which was a remnant of the previous winter's thermohaline convection and is identified as Weddell Winter Water (Carmack,1977). Below the Winter Water the temperature and salinity increased gradually with depth with the temperature increasing more rapidly to T>0C deeper than 200 m.

The density (sigma-t) distribution reveals the controlling influence of the salinity stratification with the low density contours in the surface layer corresponding to the lenses of low salinity water. The strong pycnocline between 20-30m was determined by the halocline. The trend of the 27.8 isopycnal suggests the existence of higher density water below 100m in the region covered by ice, in contrast to the open water region.

Table 1.
Vertical cross sections occupied during AMERIEZ 1986

Section	type	dates	Glacier sta.#	Melville sta.#
1	rapid	3/8-3/9	1-7	2-10
2	slow	3/13-3/16	12-14	17-24
3	slow	3/18-3/23	21-23	28-38
4	rapid	3/25-3/27	24-28	43-53
5	slow	3/27-3/31	55-66	

Section 2:

The southern line was re-occupied 4 days later in the slow transect mode. There was virtually no change in the distribution of properties in the upper 300m (Figure 4) since the occupation of Section 1. The upper layer was slightly colder and more saline in the region distant from the ice edge zone. This section did not penetrate as far into the ice edge zone as Section 1.

Section 3:

This section was the first occupation of the northern transect and the data cover a period of nearly 5 days. The ice cover was advancing and the Melville station nearest the ice edge was actually occupied in pancake ice. The surface layer with temperatures less than -1.5C was seen to be extending 50 km beyond the nominal ice edge (Figure 5). Near the edge of the marginal ice edge zone a lense of low salinity ($S < 33.2$ o/oo) reached a depth of about 25m. The mixed layer beneath the ice cover had temperatures near the freezing point (about -1.8C) in a layer 20-30m thick. Weddell Winter Water was also present in the 40-100m depth interval beneath the mixed layer. There was an indication of some mesoscale features in the region of strong temperature and salinity gradients between 100 and 200 m, but the lack of synopticity in this section precludes any speculation as to the nature of of these features.

Section 4:

This rapid transect along the northern section reveals that the principal change in the upper layer was a slight deepening of the upper mixed layer in the open water region to depths of 40-50 meters (Figure 6). This may reflect the onset of seasonal cooling combined with wind mixing. The upwarping of the isopleths of all properties at the first station seaward of the ice edge is of uncertain origin.

Deep Water Properties (Figures 7-11):

Below 200 m the water properties varied far less than near the surface. Temperatures increased from near 0C at 200 m to a maximum of 0.4-0.5C at about 500 m, then decreased to values near 0C at 1500 m. Beneath this temperature maximum a broad salinity maximum (34.68-34.71 o/oo) was found in the 500-1000 m depth range, with the core of the salinity maximum beneath the temperature maximum (T > 0.5C). The Warm Deep Water of the Weddell Sea is identified by T > 0C and S > 34.65 o/oo and is found over the oceanic domain of the Weddell Sea centered at about 500 m (Carmack and Foster,1975). The principal feature evident in these deep sections was the the increase in depth of the core of the Warm Deep Water from near 300 m in the distant open water stations to near 500 m beneath the marginal ice zone. The vertical stability was very weak throughout the Warm Deep Water, and the major density gradient was in the horizontal, between the denser deep water beneath the marginal ice zone and the less dense deep water in the central Weddell Sea.

A final CTD transect (Section 5, Table 1) was occupied, inside the ice edge, just prior to termination of the field work (Figure 2). The upper layer characteristics were effectively the same as those shown for the regions beneath the ice on Figures 3-6. The water characteristics below this upper layer are shown on figure 11. The warm (>0.5C), saline (34.70 o/oo) Warm Water layer at about 500-600 m depths is apparent on the north-south portion of the the transect. A feature which resembles a weak meander or anticyclonic eddy having a diameter of about 100 km was roughly centered in this north-south portion. A cold (<0.2C) lens lay at the center of this feature at about 250m depth, and a warm (>0.48C), saline (>34.69 o/oo) band appeared to circulate around the feature at about 500-600 m. The east-west portion of the transect shows lower core temperatures (0.4C) in the warm layer, and both the 0C isotherm and the 34.60 o/oo isohaline were somewhat deeper than along the north-south portion because of a downward sloping of the isolines toward the west in the region just west of the right-angle bend in the transect. This downward slope reflected a north-northeastward flow of water from the western limb of the Weddell Gyre, and was located over the continental rise and outer continental slope region. Father west, a region of litle apparent structure was situated off the end of the ridge extending east from the Antarctic Peninsula. At the western end of the transect, a deeper (700-800 m) core of slightly more saline water (> 34.71 o/oo) than was observed farther east was found over the continental rise. The continental slope at the eastern end of Bransfield Strait was overlain by a mass of cold (<-0.2C) water having slightly lower salinities than observed farther east at the same depths (34.67 o/oo as compared to 34.71 o/oo). The slopes of the isopycnals in this cold water suggest that it was flowing very weakly northward.

The principal water masses observed in the marginal ice edge zone in the northwestern Weddell Sea are displayed in Figure 12 which is a T/S diagram for the USCGC Glacier stations 20-55. The highly variable Weddell Surace

Water, characterized by low salinities, lies above the Winter Water identified by the temperature minimum at a salinity of 34.45-34.50 o/oo. The Warm Deep Water is identified by the temperature maximum at 0.5C with a salinity of 34.65-34.68 o/oo and is seen as the inflection point in the T/S curves just below the 27.8 isopycnal.

HORIZONTAL DISTRIBUTIONS OF VARIABLES

Horizontal distributions of T and S for the upper mixed layer are shown in Figures 13 and 14. Since this layer was generally uniform in the vertical, it has been assumed that the 10 m deep distributions represent the entire layer.

Upper layer lenses of low salinity water (as low as 33.1 o/oo) underlay the ice in the vicinity of the ice edge, and represent meltwater remaining from recent ice melting episodes (Figure 13). In contrast, salinities higher than 33.8 o/oo were present beneath the ice and in the open water seaward of the ice edge. Upper layer tempeatures were horizontally quite uniform in the region underlying the ice, and in the region well to seaward of the ice edge (Figure 14). A temperature front coincided approximately with, or lay somewhat seaward of, the ice edge. Temperatures increased from beneath the ice to seaward across this front. The highest observed upper layer temperatures were above 0C and occurred more than 200 km seaward from the ice edge.

The primary mid-depth T feature was the maximum located within the Weddell Warm Deep Water (Figure 15). Temperatures at the maximum were highest (>0.5C) in the region nearly coincident with the ice edge, and values decreased seaward to less than 0.3C at the eastern extremes of the study region. The temperature maximum was at its greatest depth (>500m) in the area within 100 km seaward of the ice edge, then shoaled to depths of less than 300m farther east (Figure 16). This warm core also shoaled slightly (to less than 500m) beneath the ice edge, and there is some indication in the data that it may have again deepened toward the west farther under the ice. The warm core was deeper than 600m in Bransfield Strait. Station density east of the Antarctic Peninsula was, in general, inadequate to define the depth variation there.

Finally, dynamic heights of the sea surface relative to the 500 db and 1500 db pressure levels are shown (Figures 17 and 18). These dynamic topographies, relative to either depth, suggest a very weak northward baroclinic surface flow along the ice edge. The variations were, however, on the order of 1-2 dynamic centimeters, or barely above the resolution of the data. It is concluded that the baroclinic upper layer currents are negligible.

DISCUSSION

Conditions observed during the March 1986 AMERIEZ program were consistent with previous observations in the same region, notably those of Foster and Middleton (1980) who sampled temperature and salinity during February 1976 along a transect oriented similarly to that shown here in Figure 11. The Surface Water, Winter Water and Weddell Warm Deep Water have been documented, if not exhaustively so, in the region (see,e.g., Carmack,1977). The extremely weak baroclinic circulation relative to both 500 and the 1500 db pressure levels is typical of the Weddell Gyre in general, as evidenced in the dynamic topography relative to 1000 db presented by Gordon, et al. (1978). The westward deepening of the temperature maximum in the Warm Deep Water has been noted previously (e.g., Deacon, 1979), and our data provide a better definition of this deepening than has been heretofore possible. In particular, this maximum attained its greatest depths (>500m) in the vicinity of the observed late summer ice edge in 1986, shoaling toward the west as well as eastward.

Oceanic conditions were approximately steady-state during the near 30-day duration of the March 1986 field program. This is evident on inspection of the vertical distributions of temperature, salinity and density obtained from the same area throughout this time interval (Figures 3-10). While air temperatures measured from the USCGC Glacier at or near the ice edge were below 0C for all except 4 days out of this period, the upper layer water temperatures seaward of the ice edge were still sufficiently high to prevent significant ice formation. A comparison between the initial and final zonal sections (Figures 3 and 6) indicates, in fact, that substantial cooling of the upper layer did not occur during March. At the onset of freezing along an ice edge, combined brine introduced to the water column and wind mixing deepen the upper mixed layer. No substantive new ice formation occurred during March 1986, as clearly shown on the ice distribution/ice edge charts (Figure 19). In the absence of ice formation no brine was introduced into the water column.

Between the Winter Water and Warm Deep Water layers, at 100-500m depths, there was a region of vertical step-like structures in temperature, salinity and density (Figure 20). In the upper portion of this zone, from about 100 to 180m, the steps were small (of order 1 meter) in vertical extent. At about 180m there was a sudden transition to much larger vertical steps, with vertical scales frequently exceeding 100m. A similar pattern of steps was observed near the center of the Weddell Gyre by Foster and Carmack (1976). The entire region of steps had the proper gradients of temperature and salinity to undergo double-diffusive convection of the sort that would lead to steps. The small steps between 100 and 180m resembled those which have been observed in other regions where active double diffusion was occurring. The much larger, deeper steps are, however, of uncertain origin. They probably represent a combination of the results of double diffusion and vertical overturning made possible by the extremely small vertical density gradients. Their horizontal distribution shows that they were most prevalent in the areas underlain by the highest maximum temperatures (generally >0.5C) in the Warm Deep Water layer (Figure 21). This is consistent with physical reasoning, which dictates that temperature increasing with depth will destabilize the water column, leading to such mechanisms as (in the case of sufficiently small stabilizing salinity gradient) double diffusion and vertical overturning. The interrelationships between vertical mixing and distributions of temperature and salinity are discussed in detail by Turner (1973). The practical significance of these mechanisms rests in their ability to transport heat upward from the Warm Deep Water layer. Given sufficient brine input through surface ice formation, the upper layer salinity might, under the proper circumstances, be increased sufficiently to destabilize the entire water column above the temperature maximum, allowing transport of heat upward and retarding further ice formation. A similar upward transfer of heat has been postulated by Martinson et al. (1981) to have been responsible for a large polynya which occurred repeatedly, if irregularly, in the eastern Weddell Sea during the winters of 1973-77.

SUMMARY

Our significant results can be summarized as follows:

1. The study region was effectively in a steady-state situation during the duration of March 1986 field program, with no significant change in the physical water column parameters or in the sea ice cover.

2. The region was characterized by cold Surface Water and Winter Water layers underlain by a warmer Weddell Warm Deep Water, consistent with past research. The temperature maximum layer reached its maximum depth of greater than 500 m near the ice edge, shoaling to the east and west.

3. Baroclinic surface circulation relative to the 500 and 1500 db pressure surfaces was negligibly small, consistent with past research.

4. A very weak, cold core, anticyclonic eddy or meander about 100 km in lateral scale and extending to depths greater than 1500m was observed along the ice edge in the northern part of the study region. This feature was of uncertain origin.

5. The upper portion of the Warm Deep Water layer exhibited vertical temperature, salinity and density steps ranging in vertical scale from less than a meter to more than 100m. The smaller steps probably originated through double diffusive processes, while the large steps probably reflect a combination of double diffusion and overturning. The processes responsible for these steps probably play an important role in upward transfer of heat from the Warm Deep Water layer. Under the proper conditions, this upward heat transfer might be adequate to delay or prevent ice formation.

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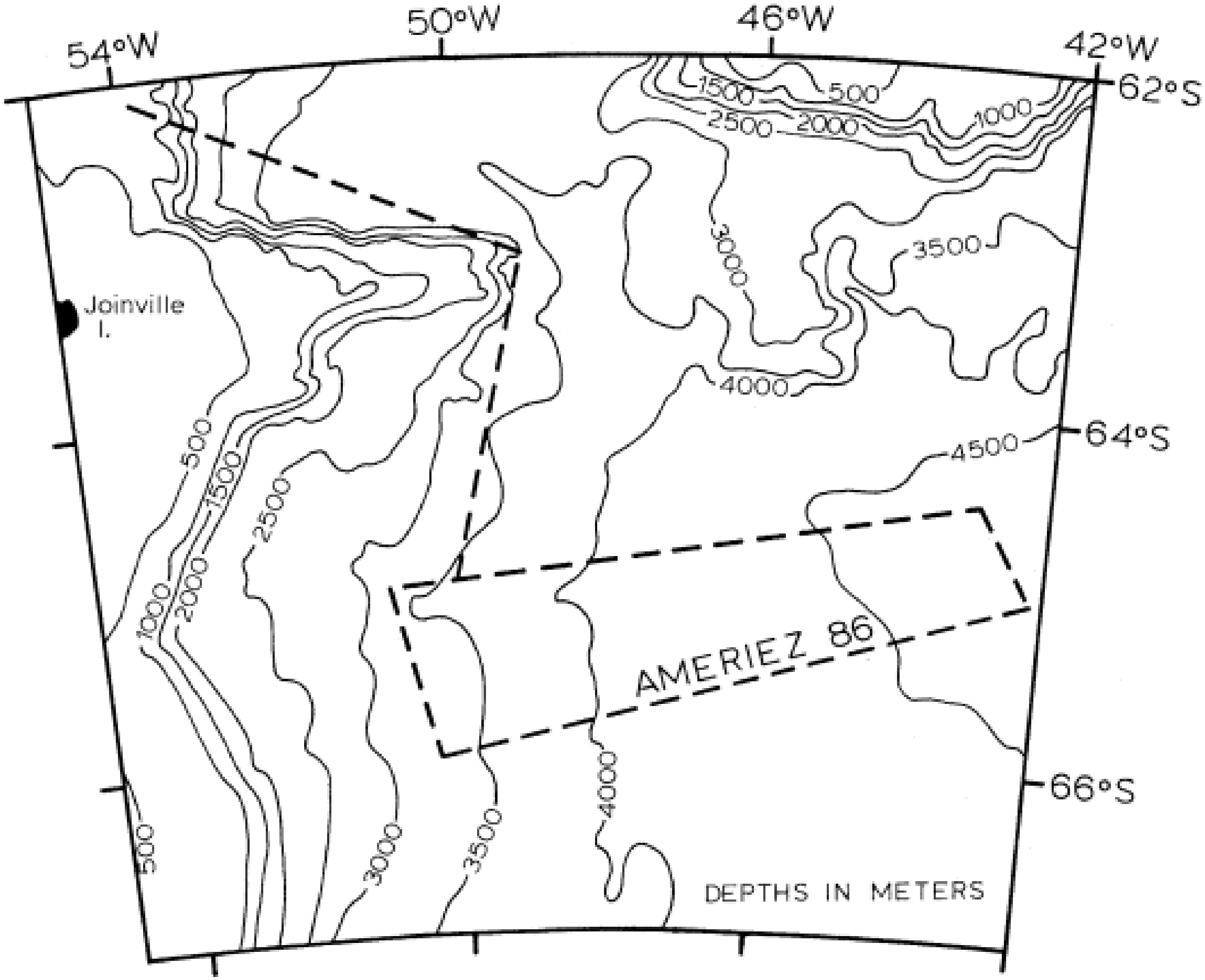

Figure 1. Geographical location of AMERIEZ 86 survey area in relation to the bathymetry of the northwestern Weddell Sea.

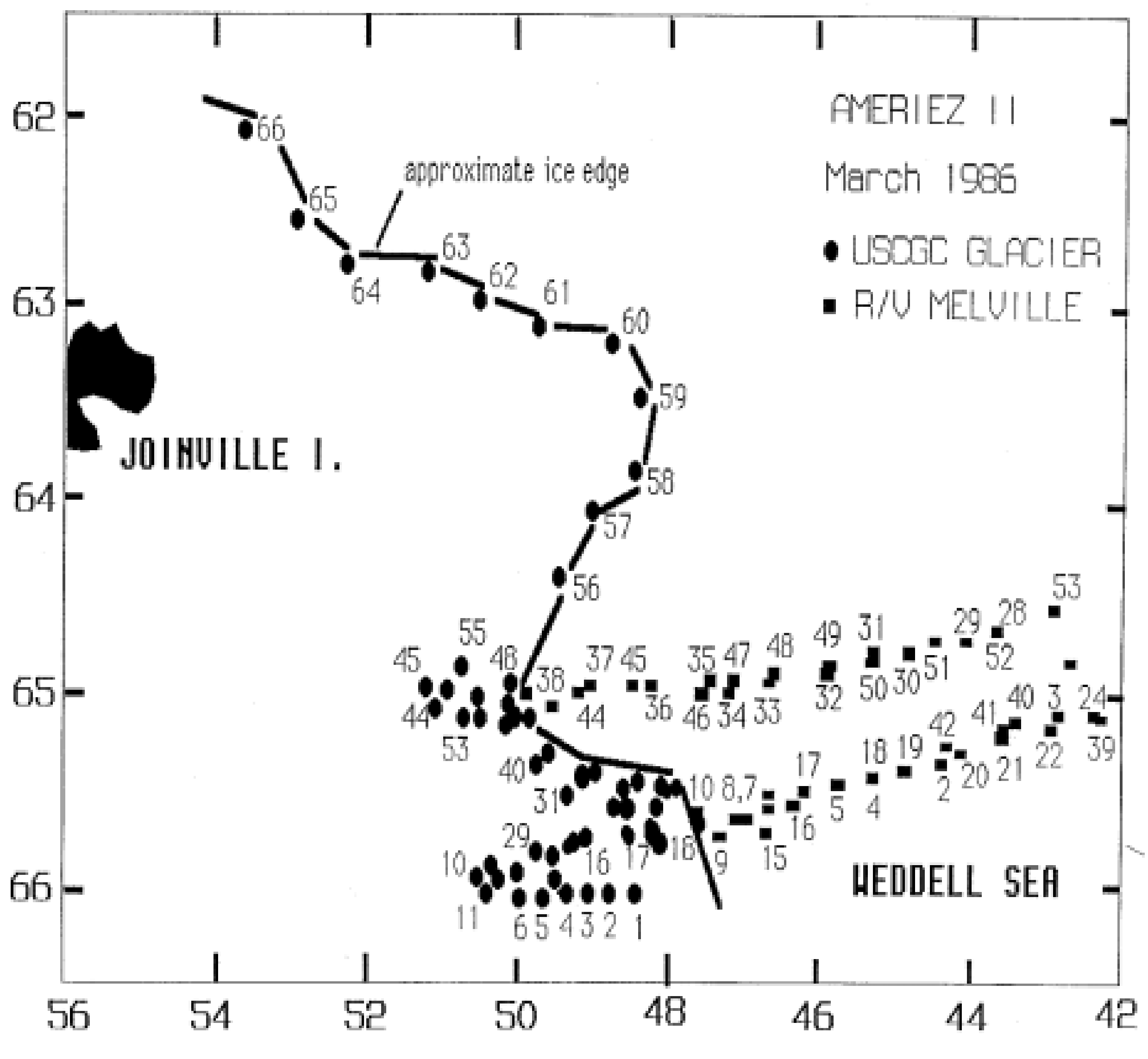

Figure 2. Locations of stations during AMERIEZ 86 and the approximate location of the ice edge.

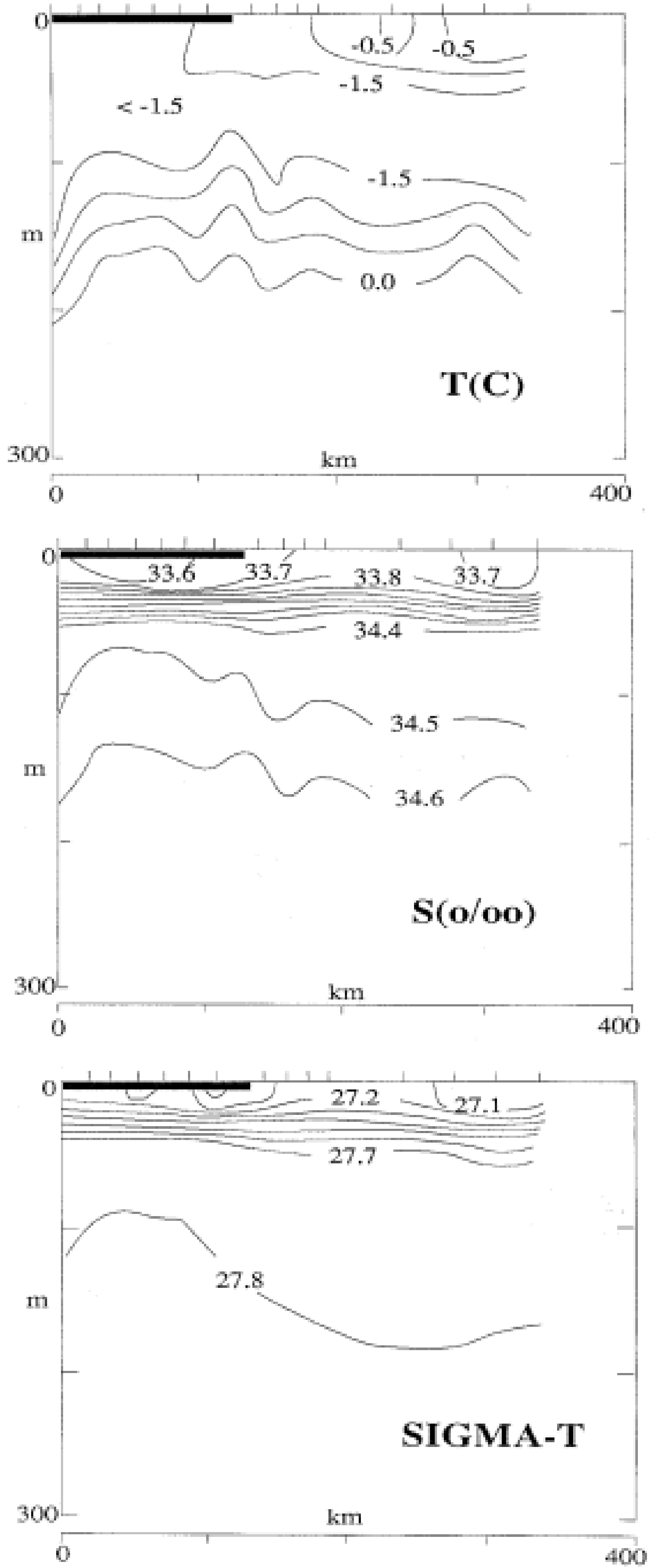

Figure 3. Vertical cross sections of properties along the southern section in the upper 300 m. during 8-9 March 1986. The heavy black line at the surface denotes the approximate extent of the ice cover.

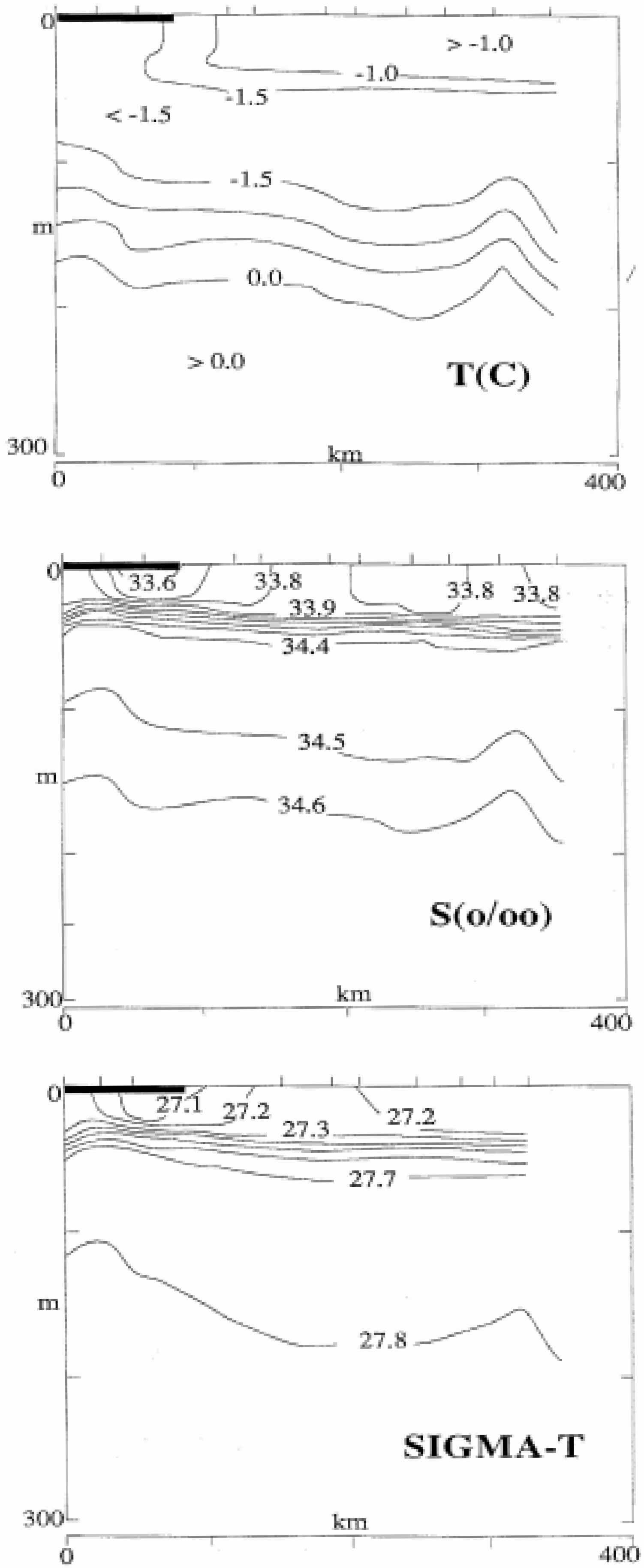

Figure 4. Vertical cross sections of properties along the southern section in the upper 300 m. during 13-16 March 1986. The heavy black line at the surface denotes the approximate extent of the ice cover.

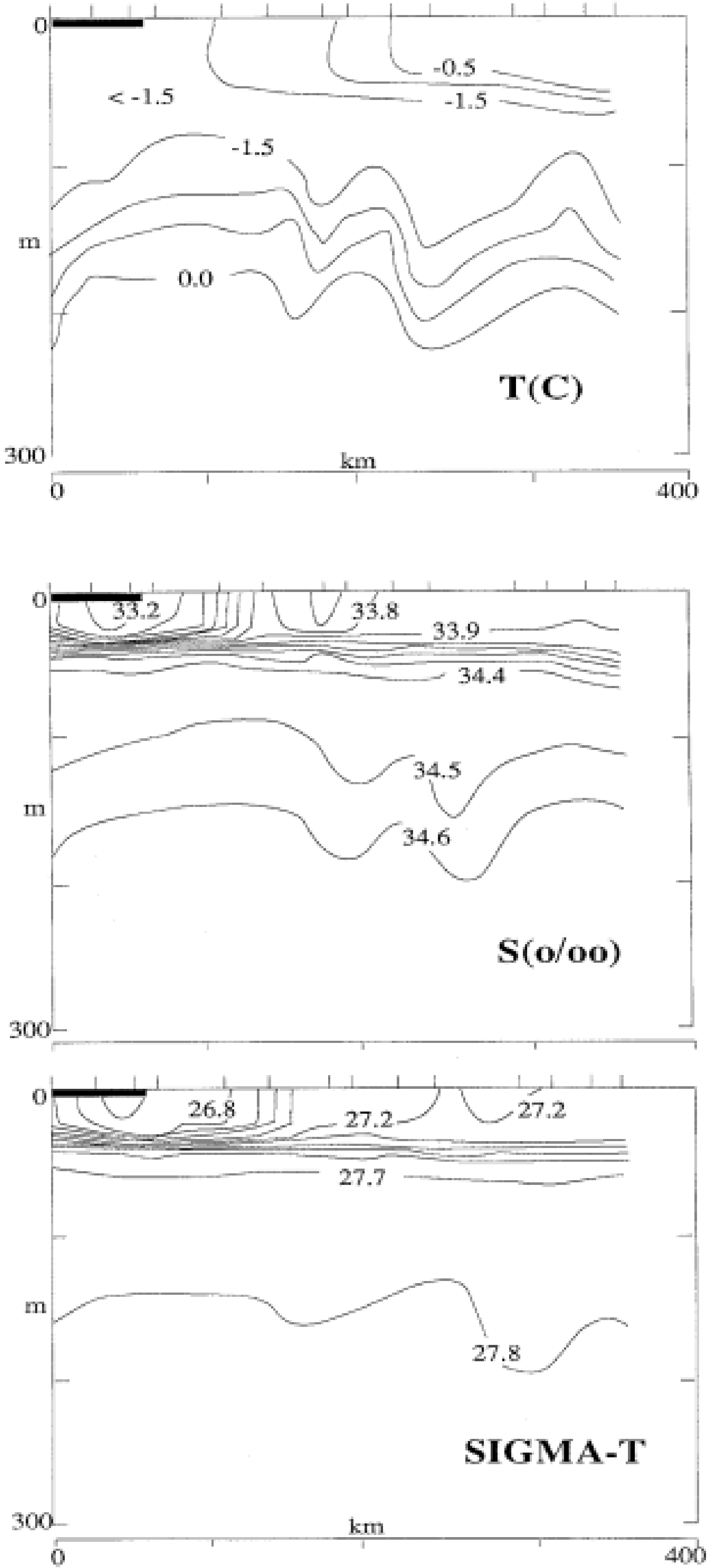

Figure 5. Vertical cross sections of properties along the northern section in the upper 300 m. during 18-23 March 1986. The heavy black line at the surface denotes the approximate extent of the ice cover.

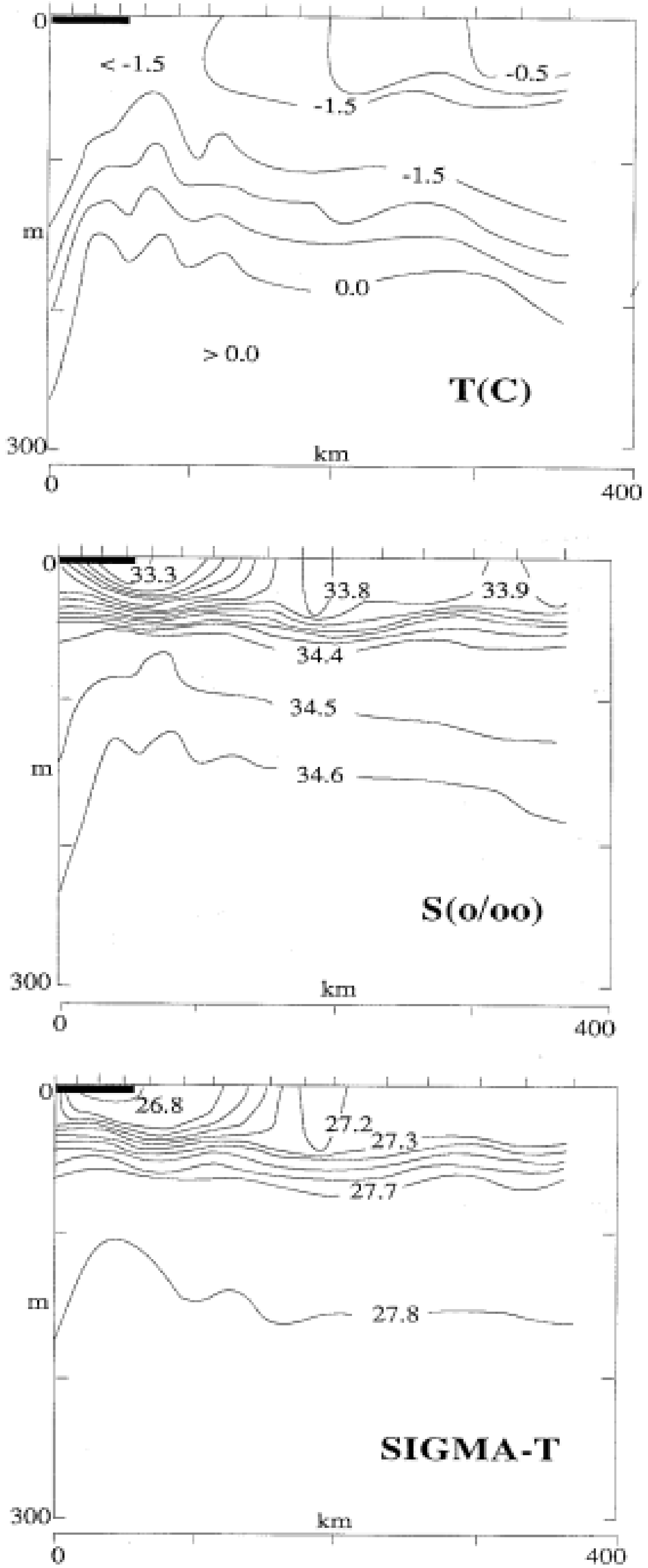

Figure 6. Vertical cross sections of properties along the northern section in the upper 300 m. during 25-27 March 1986. The heavy black line at the surface denotes the approximate extent of the ice cover.

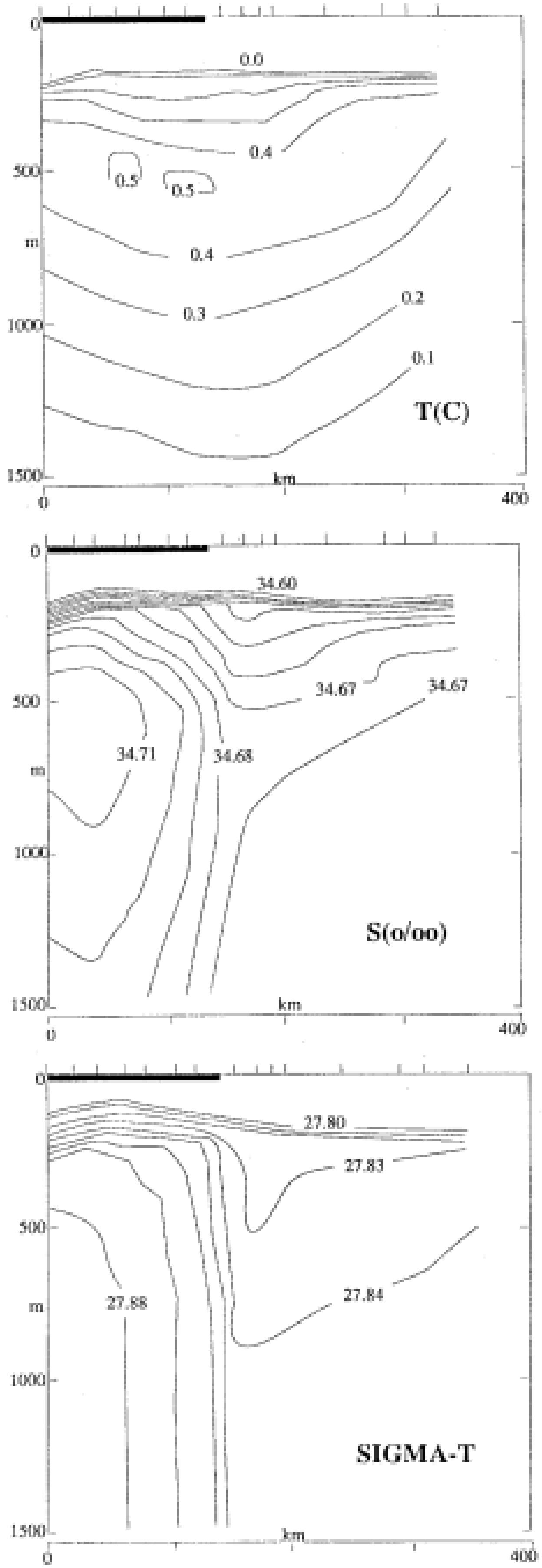

Figure 7. Vertical cross sections of properties along the southern section from near 200 m. to 1500 m. during 8-9 March 1986. The contour intervals for temperature, salinity and density are 0.01C, 0.01 ppt and 0.01 , respectively.

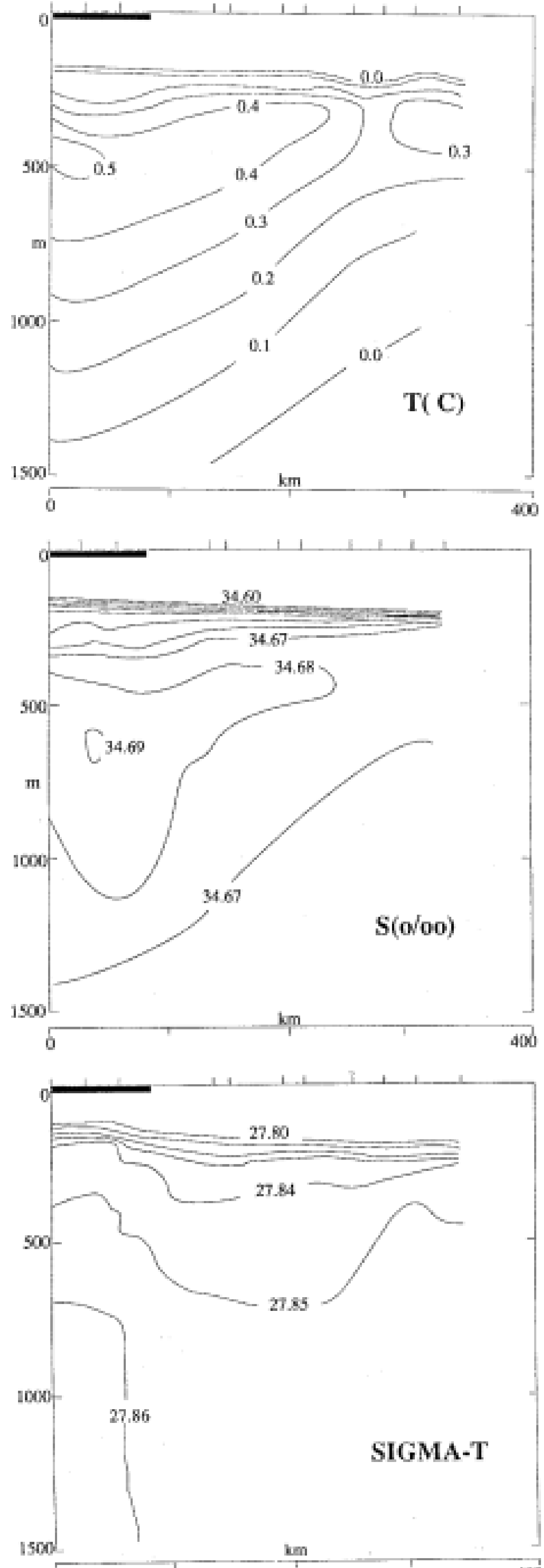

Figure 8. Vertical cross sections of properties along the southern section from near 200 m. to 1500 m. during 13-16 March 1986. The contour intervals for temperature, salinity and density are 0.01C, 0.01 ppt and 0.01 , respectively.

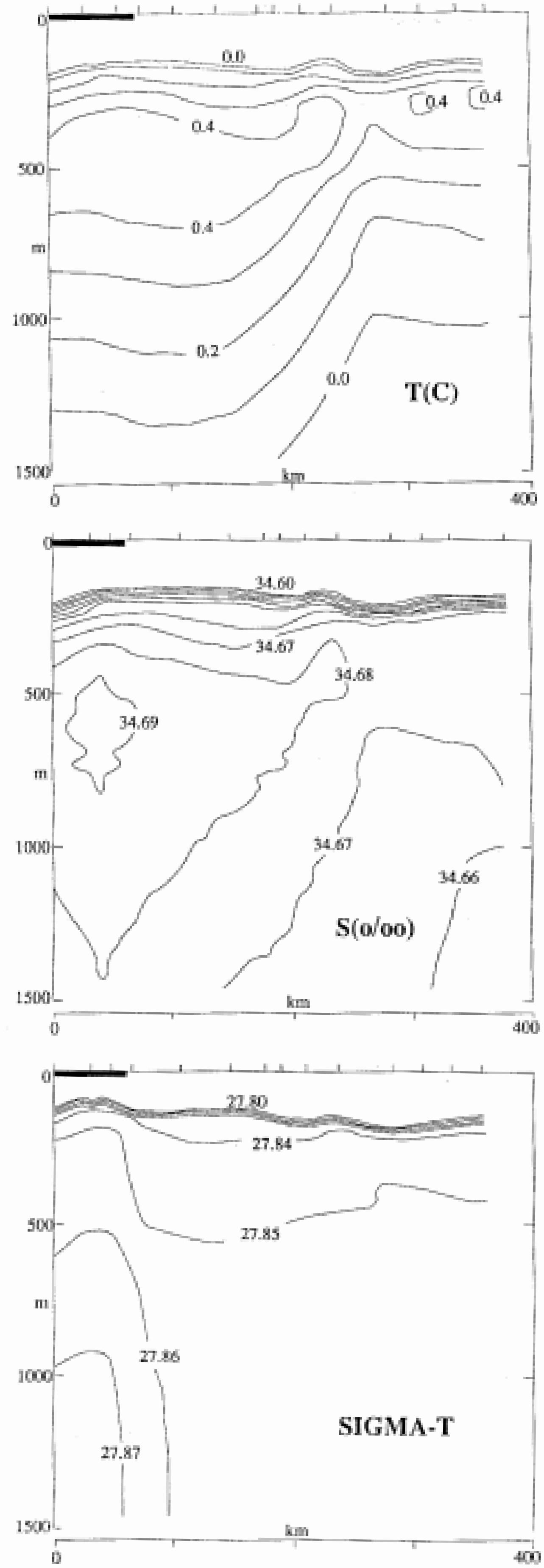

Figure 9. Vertical cross sections of properties along the northern section from near 200 m. to 1500 m. during 18-23 March 1986. The contour intervals for temperature, salinity and density are 0.01C, 0.01 ppt and 0.01 , respectively.

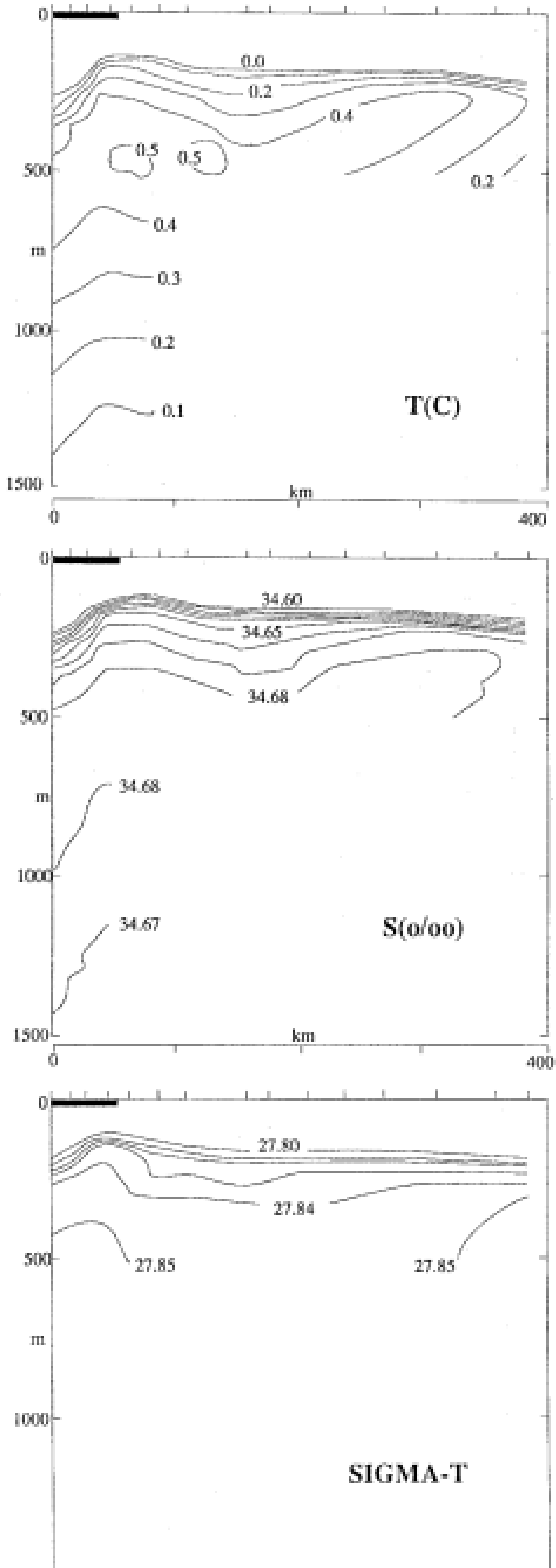

Figure 10. Vertical cross sections of properties along the northern section from near 200 m. to 1500 m. during 25-27 March 1986. The contour intervals for temperature, salinity and density are 0.01C, 0.01 ppt and 0.01 , respectively.

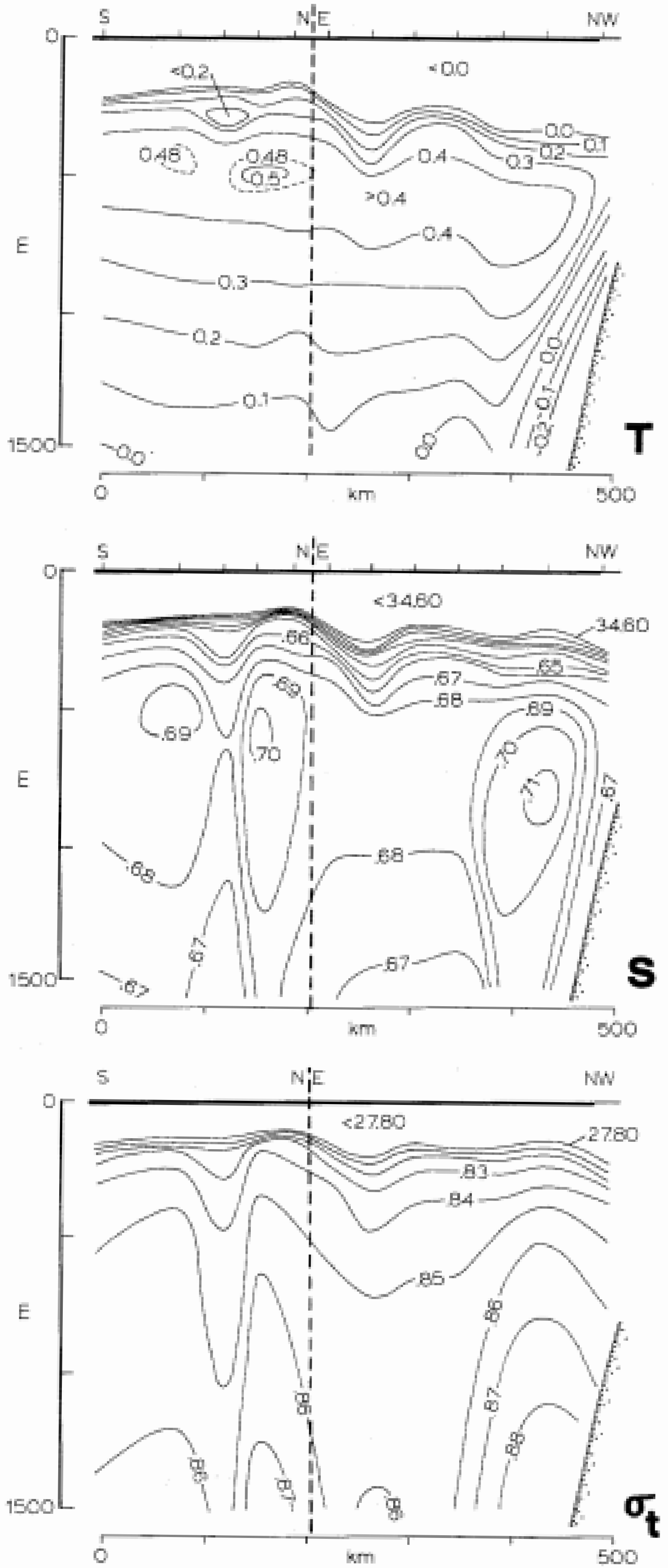

Figure 11. Vertical cross sections of properties along the south-north and east-west track shown in figure 1 during 27-31 March 1986.The dotted vertical line indicates the turning point from the south-north to the east-west

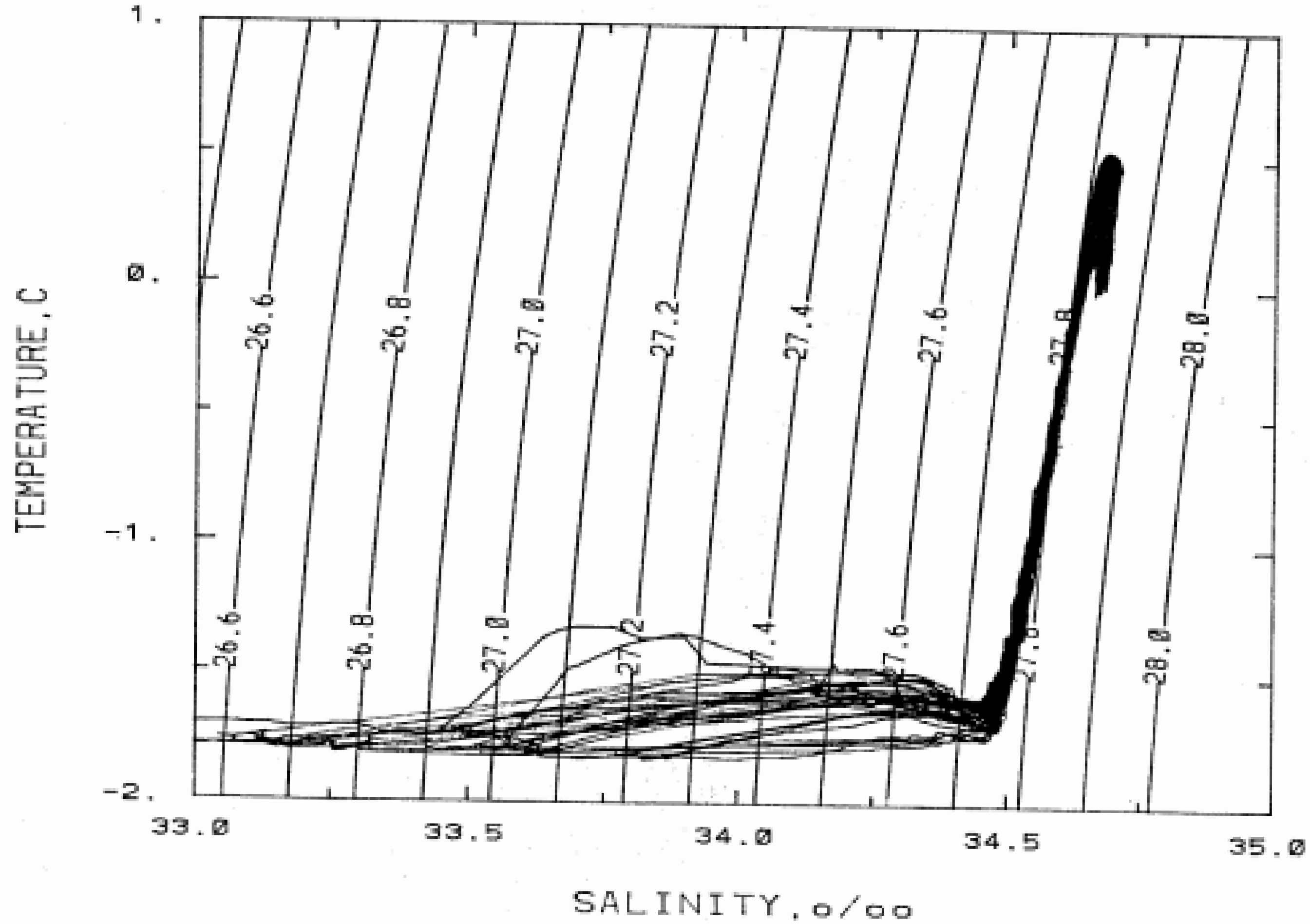

Figure 12. Temperature vs. salinity diagram for USCGC Glacier stations 20-55 during 11-27 March 1986.

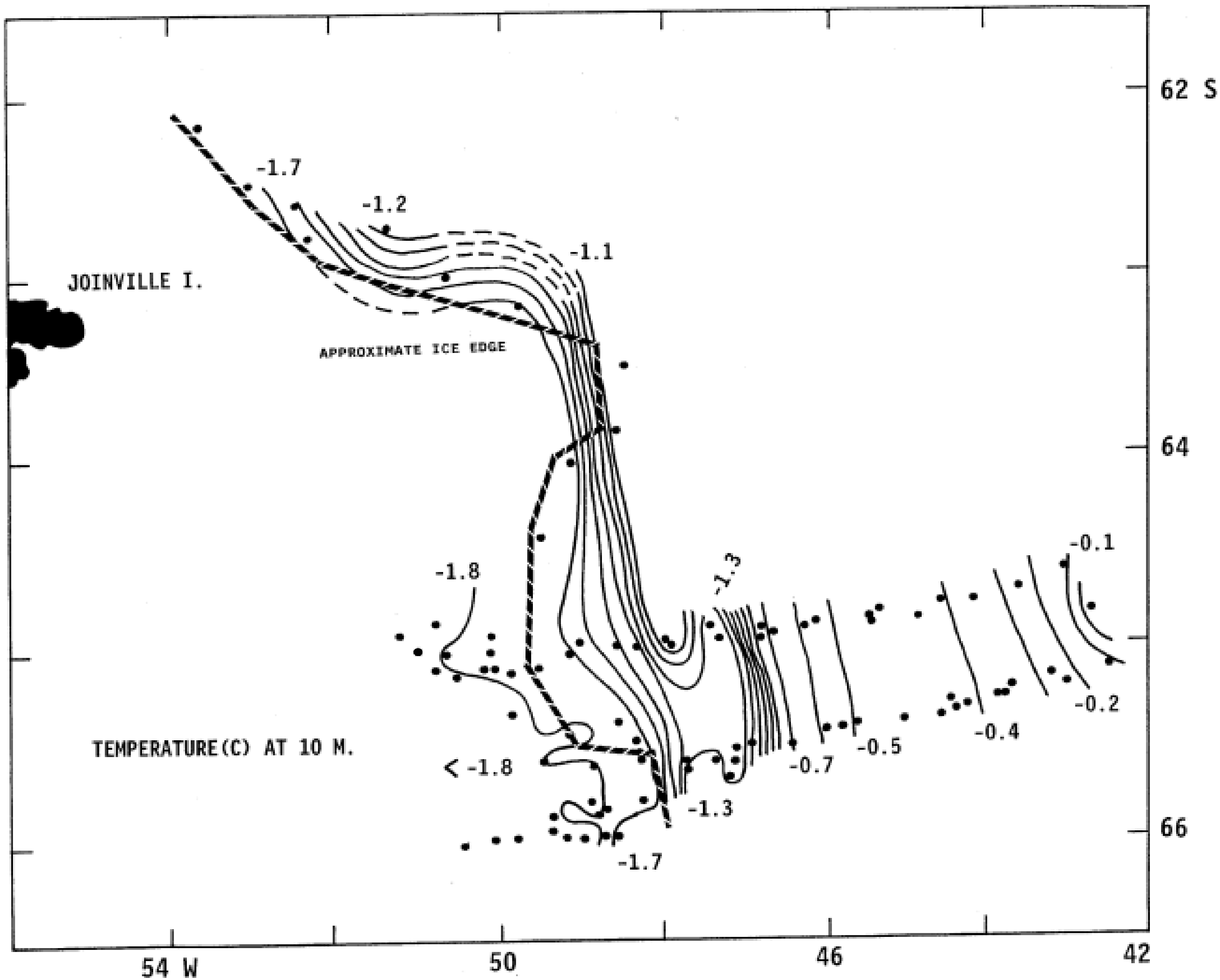

Figure 13. Horizontal distribution of temperature at a depth of 10 m. during AMERIEZ 1986. Contour interval is 0.1C .

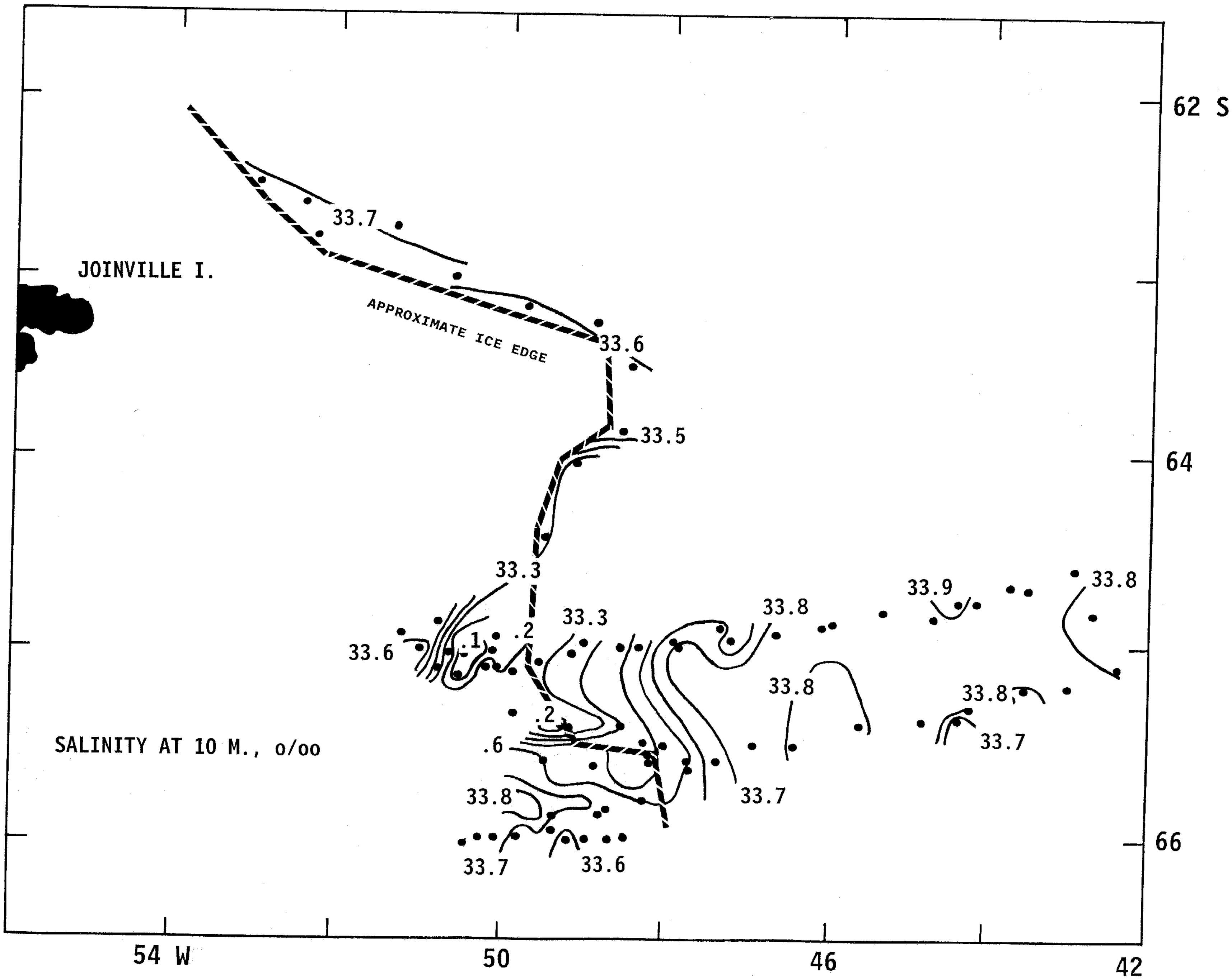

Figure 14. Horizontal distribution of salinity at a depth of 10 m. during AMERIEZ 1986. Contour interval is 0.01 ppt. The approximate location of the ice edge during the survey is indicated by the hatched line.

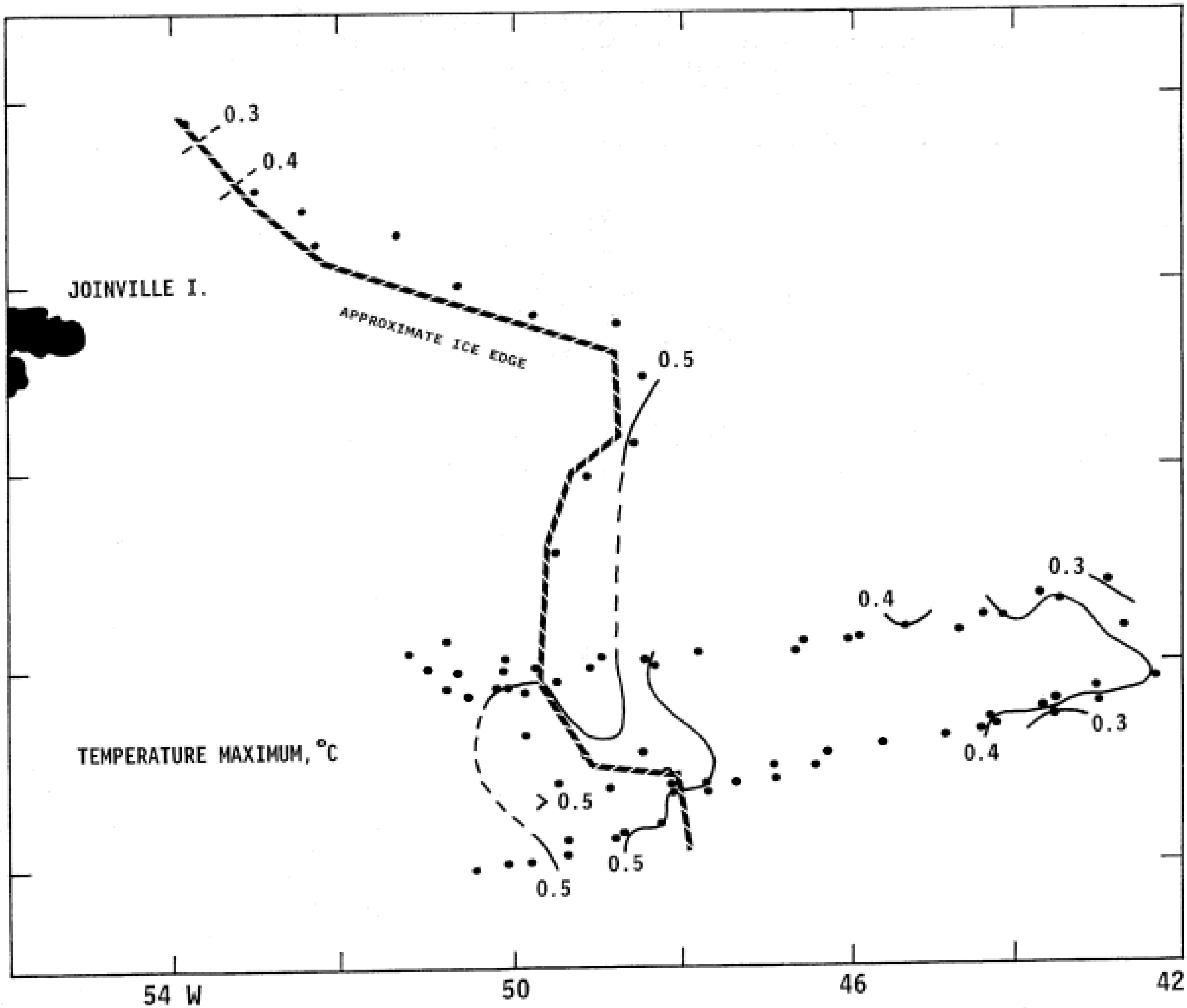

Figure 15. Horizontal distribution of the magnitude of the subsurface temperature maximum during AMERIEZ 1986. Contour interval is 0.1C. The approximate location of the ice edge during the survey is indicated by the hatched line.

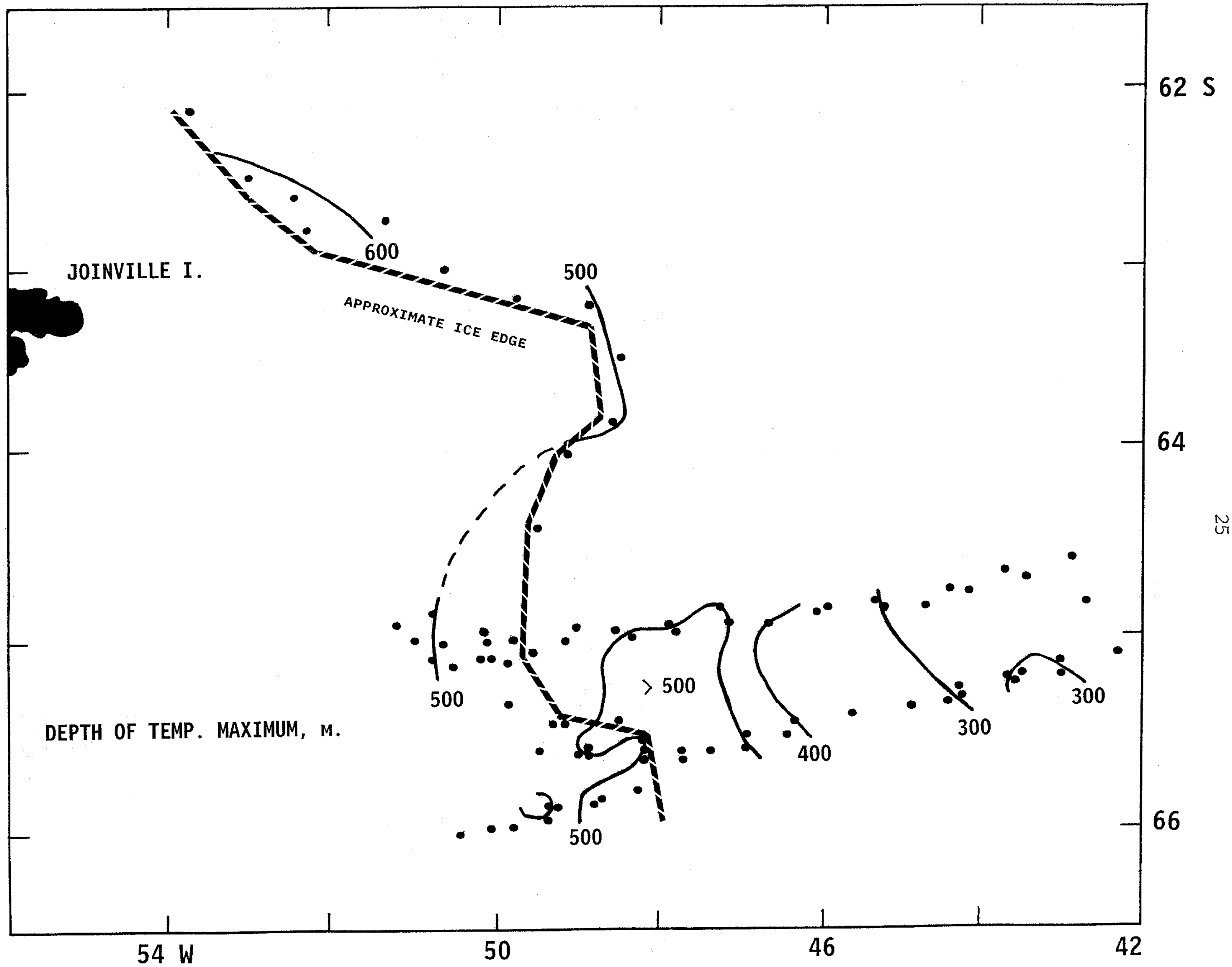

Figure 16. Horizontal distribution of the depth of the subsurface temperature maximum during AMERIEZ 1986. Contour interval is 100 m. The approximate location of the ice edge during the survey is indicated by the hatched line.

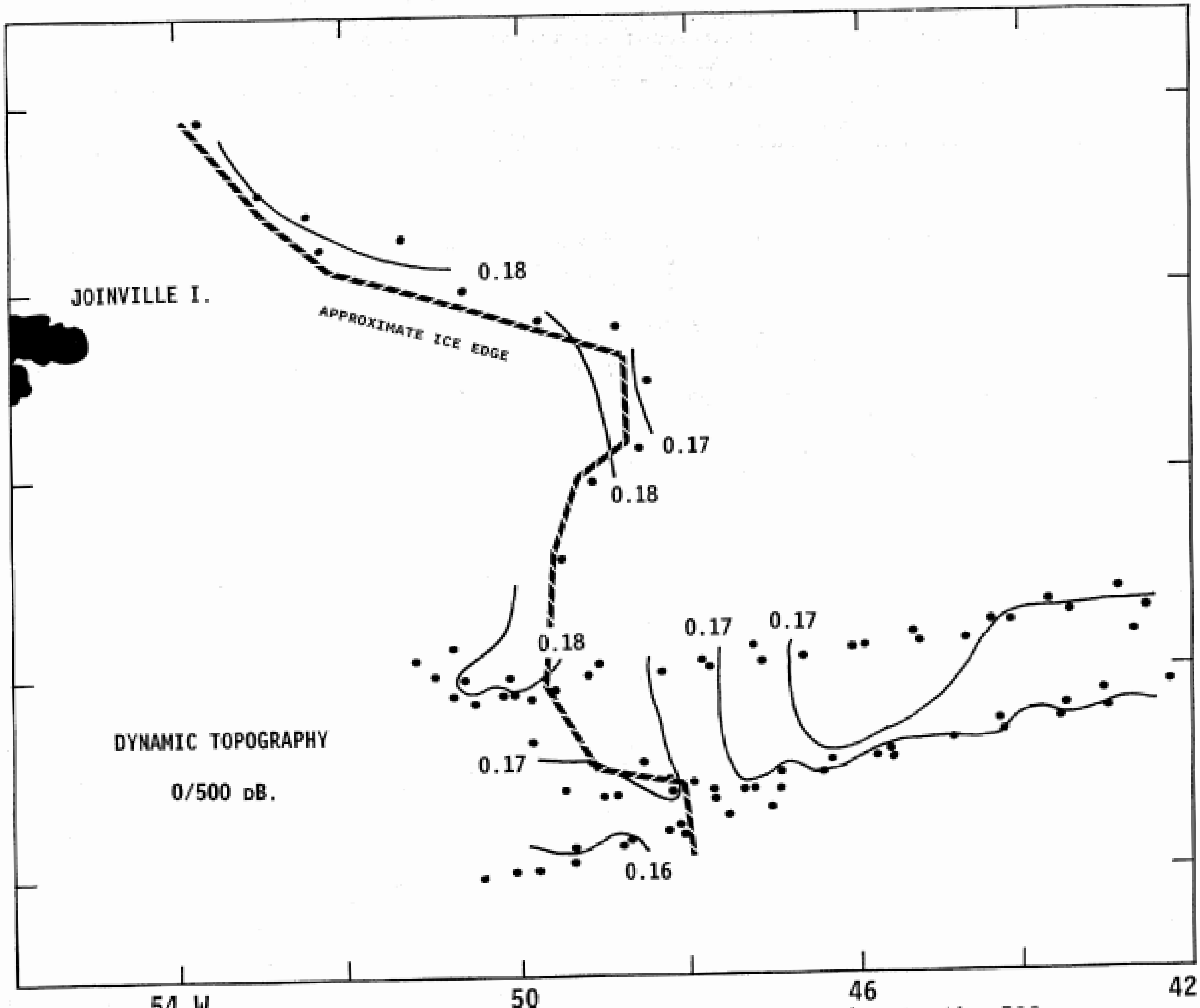

Figure 17. Dynamic topography of the sea surface relative to the 500 decibar pressure level during AMERIEZ 1986. Contour interval is 0.01 dynamic meters (1 dynamic centimeter). The approximate location of the ice edge during the survey is indicated by the hatched line.

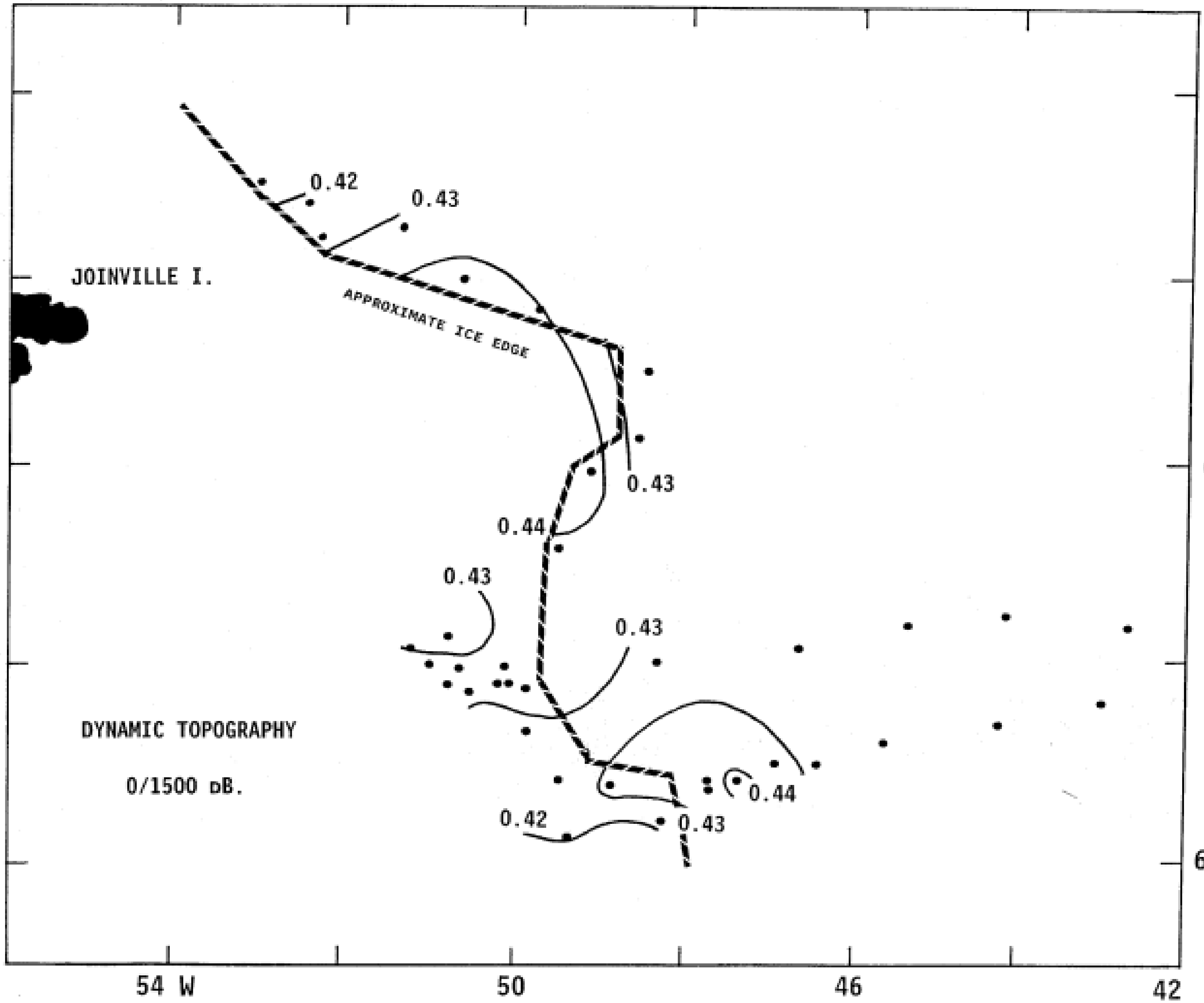

Figure 18. Dynamic topography of the sea surface relative to the 1500 decibar pressure level during AMERIEZ 1986. Contour interval is 0.01 dynamic meter (1 dynamic centimeter). The approximate location of the ice edge during the survey is indicated by the hatched line.

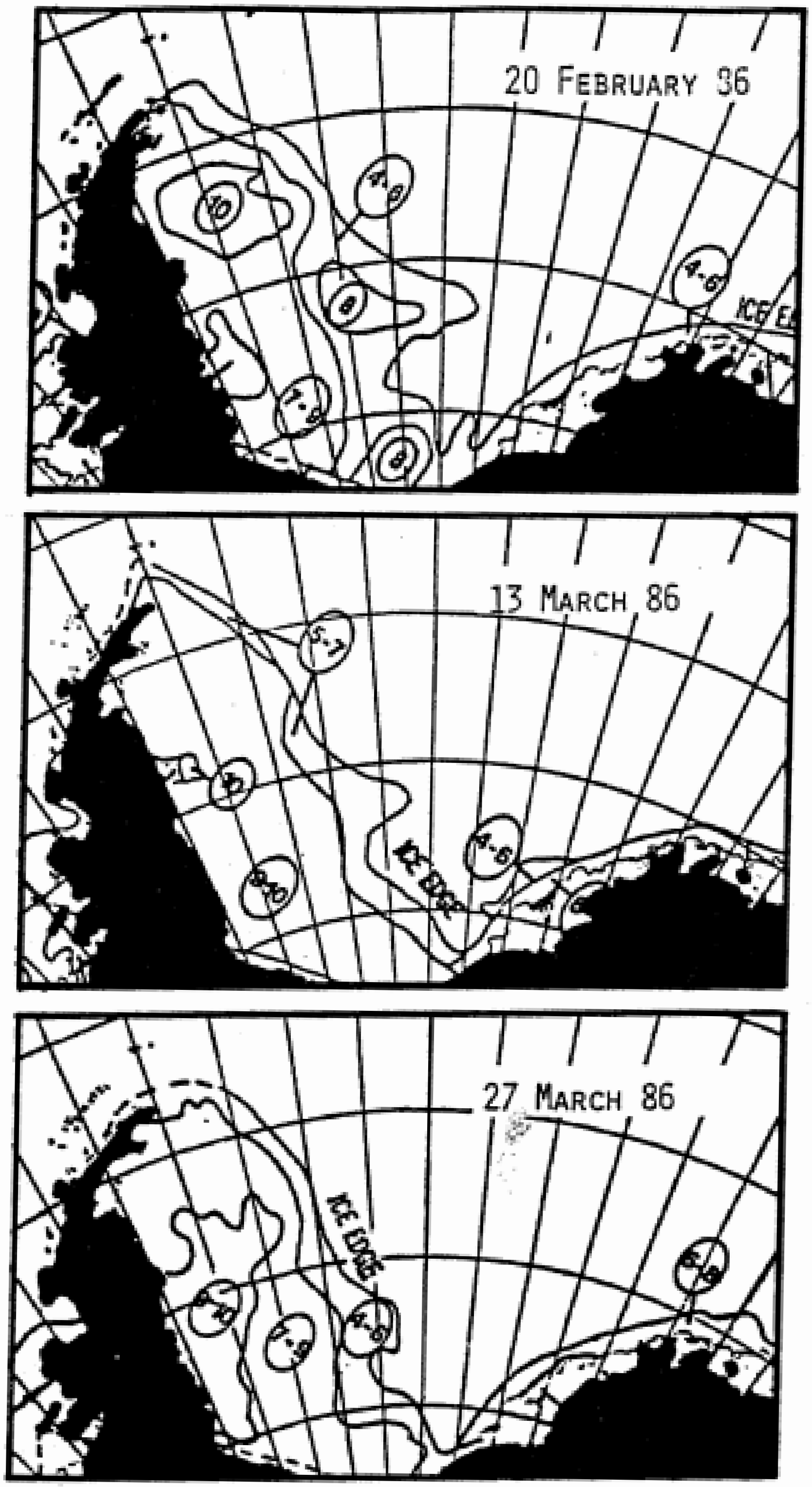

Figure 19. Ice limits and total ice concentrations (in tenths) in the Weddell Sea prior to and during the AMERIEZ 1986 survey. (Adapted from the weekly charts produced by the NAVY-NOAA Joint Ice Center, Naval Polar Oceanography Center, Suitland, Md.)

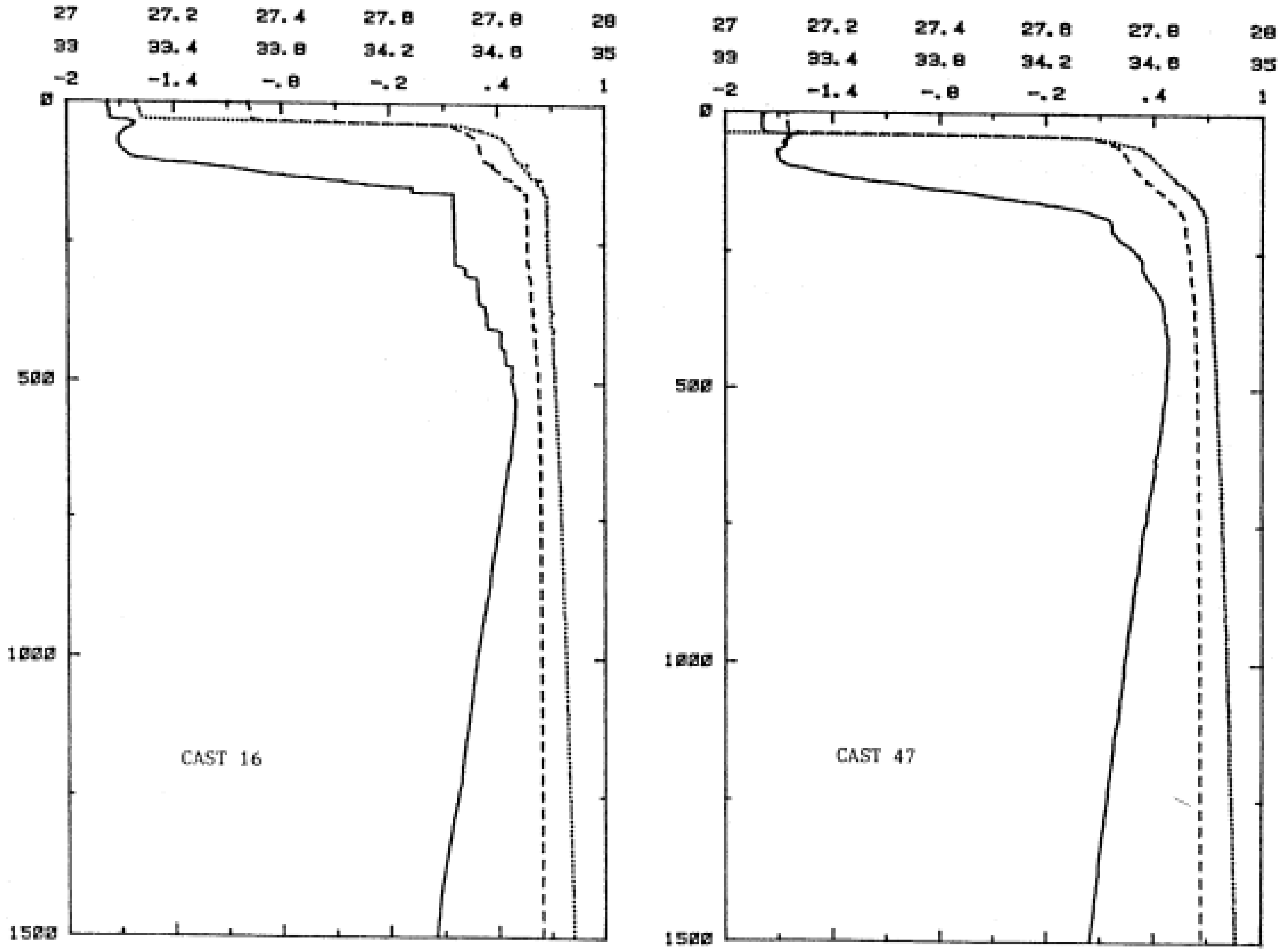

Figure 20. Vertical profiles of temperature (solid), salinity (dashed) and sigma-t (dotted) derived from two CTD casts obtained from the USGCG GLACIER during AMERIEZ 1986.

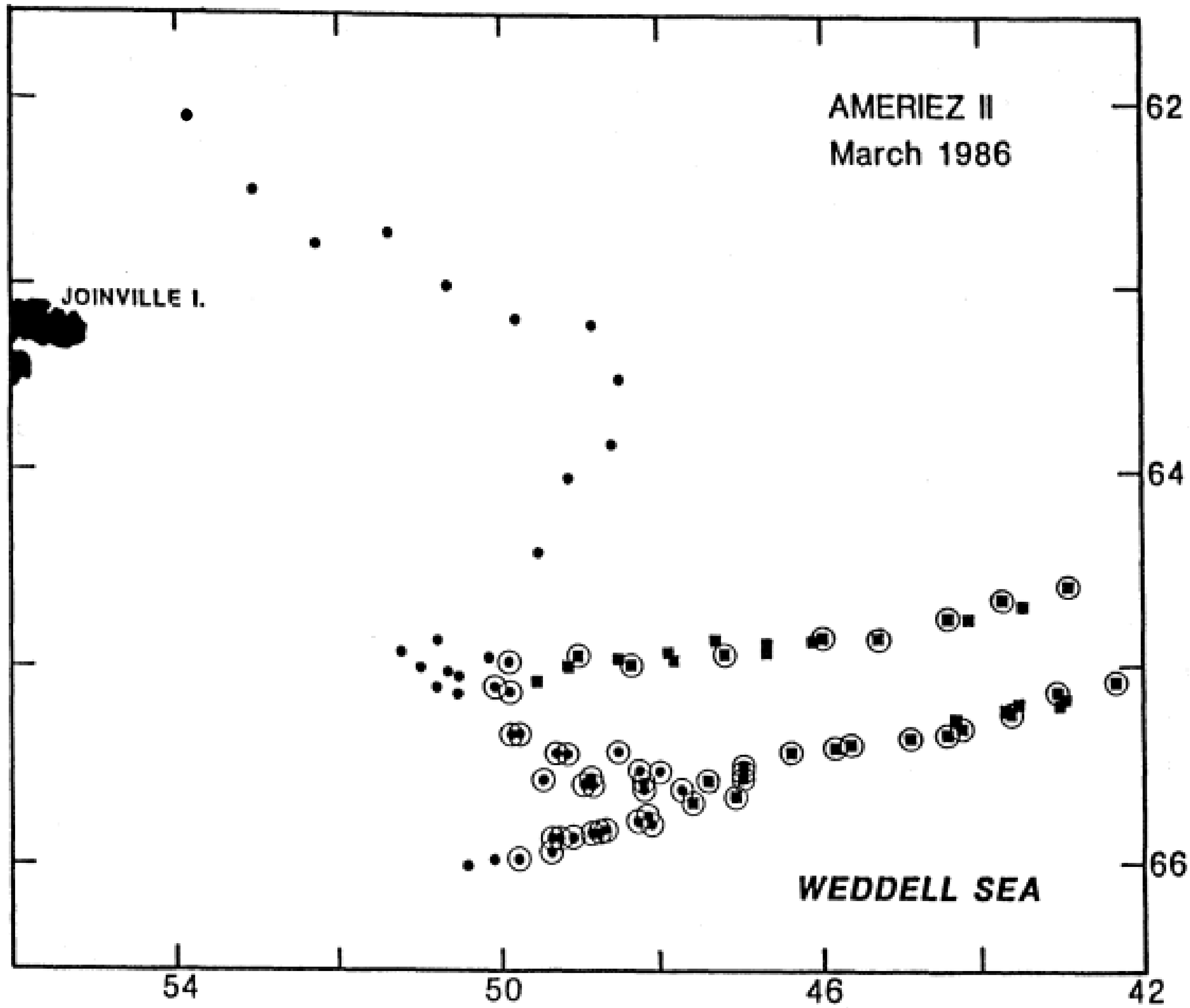

Figure 21. Locations of CTD casts during AMERIEZ 1986 which exhibited vertical step structures in temperature, salinity and density (circles).

APPENDIX 1

USCGC <u>GLACIER</u> 1986 Station Numbers and Positions

Station #	Latitude (deg S)	Longitude (deg W)	Date (Z)	Time (Z)	CTD #
-	66-06.0	48-29.6	3/4	1745	1
-	66-02.0	48-05.0	3/5	0445	2
-	66-04.0	48-57.4	3/5	0604	3
-	65-59.7	49-04.0	3/5	0743	4
-	65-59.7	49-28.4	3/5	1010	5
-	65-59.3	49-53.9	3/5	1354	6
-	65-57.6	50-09.8	3/5	1951	7
-	65-58.0	50-11.9	3/5	2326	8
0	65-57.8	50-12.9	3/6	1730	9
-	65-57.8	50-19.5	3/6	2233	10
1	65-59.2	50-21.0	3/7	2100	11
2	65-56.6	50-02.6	3/8	0350	12
3	65-57.2	49-43.6	3/8	0800	13
4	65-54.1	49-19.3	3/8	1450	14
5	65-50.0	49-03.6	3/8	2220	15
6	65-47.4	48-38.5	3/9	0430	16
7	65-45.2	48-10.4	3/9	1030	17
8	65-35.8	47-42.8	3/9	1350	18
9	65-30.7	47-59.7	3/10	1530	19
10	65-23.0	48-28.1	3/11	1109	20
-	65-26.0	48-29.0	3/11	1140	21
-	65-30.4	48-12.9	3/11	2126	22
11	65-36.8	48-11.9	3/12	1120	23
-	65-37.8	48-12.3	3/12	2311	24
12	65-44.9	48-07.8	3/13	1430	25
-	65-47.4	48-06.3	3/13	2222	26
13	65-49.0	48-44.3	3/14	1330	27
-	65-48.6	48-50.1	3/14	2213	28
14	65-51.5	49-16.9	3/15	1300	29
-	65-50.7	49-12.6	3/15	2115	30
15	65-32.6	49-25.3	3/16	1330	31
-	65-33.0	49-25.1	3/16	2031	32
16	65-34.5	48-50.6	3/17	1300	33
-	65-34.8	48-50.2	3/17	1433	34
-	65-34.7	48-56.3	3/17	1819	35
-	65-32.9	48-49.8	3/18	0136	36
17	65-33.4	48-15.1	3/18	1330	37
18	65-24.1	49-08.3	3/19	1400	38
-	65-24.5	49-16.4	3/19	1806	39
19	65-16.3	49-47.4	3/20	1330	40
-	65-17.6	49-44.0	3/20	2103	41
20	65-06.5	50-28.3	3/21	1330	42
-	65-02.0	50-30.9	3/22	0013	43
21	64-56.6	51-06.5	3/22	1630	44
-	64-53.9	51-07.6	3/22	2022	45
22	64-59.9	50-31.9	3/23	1600	46

23	64-59.0	50-04.9	3/24	1430	47
-	64-55.8	50-07.3	3/24	2032	48
-	65-44.0	50-03.4	3/25	1147	49
24	65-08.4	49-49.8	3/25	2330	50
25	65-04.6	50-09.2	3/26	0500	51
26	65-06.7	50-29.9	3/26	1100	52
27	65-05.4	50-44.2	3/26	1600	53
28	64-58.4	50-55.3	3/27	0200	54
29	64-51.3	50-41.8	3/27	1813	55
30	64-23.4	49-29.9	3/28	0626	56
31	64-02.5	49-08.1	3/28	1142	57
32	63-50.7	48-34.2	3/29	0527	58
33	63-28.9	48-28.0	3/29	1005	59
34	63-11.5	48-50.8	3/29	2232	60
35	63-09.1	49-44.8	3/30	0340	61
36	62-58.0	50-33.5	3/30	0845	62
37	62-43.1	51-17.1	3/30	1532	63
38	62-46.7	52-11.7	3/31	0100	64
39	62-31.1	52-56.1	3/31	0909	65
40	62-06.9	53-44.6	3/31	1923	66

R/V Melville 1986 Station Numbers and Positions

Station #	Latitude (deg S)	Longitude (deg W)	Date (Z)	Time (Z)	CTD #
2	65-20.9	44-26.7	3/7	0041	2
3	65-14.2	43-40.7	3/8	0714	3
4	65-22.2	44-53.0	3/8	1245	4
5	65-26.2	45-38.8	3/8	1840	5
6	65-28.9	46-08.2	3/8	2205	6
7	65-33.5	47-02.7	3/9	0230	7
8	65-36.1	47-19.2	3/9	0530	8
9	65-39.6	47-34.0	3/9	0824	9
10	64-34.6	47-46.1	3/9	1512	10
11	65-33.6	46-55.0	3/10	1745	11
12	65-31.2	46-54.7	3/10	2145	12
13	65-32.2	46-59.7	3/11	0110	13
15	65-39.8	46-49.1	3/12	1030	15
16	65-30.6	46-26.0	3/12	2245	16
17	65-26.0	46-17.6	3/13	1154	17
18	65-25.4	45-18.9	3/13	2249	18
19	65-22.0	44-53.7	3/14	1110	19
20	65-16.8	44-11.5	3/14	2203	20
21	65-12.0	43-39.1	3/15	1040	21
22	65-09.7	42-59.3	3/15	2142	22
24	65-06.8	42-20.3	3/16	1111	24
25	64-48.0	42-44.5	3/16	2315	25
28	64-38.9	43-37.3	3/18	1435	28
29	64-43.2	44-05.9	3/18	2304	29
30	64-49.3	44-41.8	3/19	1054	30
31	64-47.4	45-14.5	3/19	2249	31

32	64-52.8	46-08.1	3/20	1120	32
33	64-53.1	46-36.5	3/20	2234	33
34	64-56.2	47-14.3	3/21	1055	34
35	64-55.0	47-28.3	3/21	1711	35
36	64-57.9	48-12.1	3/22	1924	36
37	64-57.7	48-57.1	3/23	1115	37
38	64-59.9	49-52.0	3/23	1853	38
43	65-04.7	49-28.3	3/25	2218	43
44	65-00.2	49-03.5	3/26	0131	44
45	64-57.3	48-26.8	3/26	0449	45
46	64-57.7	47-34.3	3/26	0841	46
47	64-53.4	47-13.9	3/26	1135	47
48	64-53.2	46-37.4	3/26	1439	48
49	64-51.5	45-59.1	3/26	1808	49
50	64-50.4	45-17.7	3/26	2147	50
51	64-42.9	44-24.0	3/27	0421	51
52	64-37.8	43-29.3	3/27	0800	52
53	64-35.9	42-55.5	3/27	1112	53

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