POLYMODE NEWS

No. 33 August 19, 1977

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KNORR 66 CRUISE REPORT
by Keith Bradley

Cruise 66 of the R/V Knorr (10 May to 13 July, 1977) consisted of three legs with Bermuda as the port of call. The ship's tracks for the three legs, with their dates, are shown in Figure 1. The second and third legs of the cruise were devoted almost exclusively to POLYMODE work.

Leg I was a deployment cruise for the Western Boundary Undercurrent (WBUC) Experiment (Peter Rhines, WHOI), and the Benthic Boundary Layer (BBL) Experiment (Larry Armi, WHOI). Tests of POLYMODE mooring releases and CTD lowerings at the mooring sites were conducted. The five WBUC moorings were deployed in the vicinity of the Blake-Bahama Outer Ridge in water depths ranging from 3000 to 5200 m. The two BBL moorings were placed on the nearby Hatteras Abyssal Plain along with an acoustic beacon for CTD near-bottom navigation. Table 1 lists the mooring locations and instrument placements. Extensive near-bottom CTD surveying will be conducted from the R/V Oceanus in August, 1977 when the BBL moorings will be recovered. The WBUC moorings will remain in place until the spring of 1978.

After a port stop in Bermuda from 22-26 May, a new science crew boarded the Knorr and the POLYMODE work of Leg II began with the recovery of 4 array II moorings along 36°N.

(continued page 5)

SETTING OF ARRAY III CLUSTERS A AND B
by Carl Wunsch

POLYMODE array III clusters A and B were set on Leg II of R/V Knorr cruise 66 as described in the accompanying article by Keith Bradley. Overall purposes of the clusters have been described in the POLYMODE Program and Plan and in POLYMODE News No. 18. Cluster A is on the western flank of the Mid-Atlantic Ridge; cluster B on the eastern flank. As expected, the final configuration of the clusters does differ from the nominal plan, and is shown in Figure 5.

This region is one of exceedingly rough topography and the only charts available for the area seem based upon some form of artistic license. Cluster B was set first after a preliminary topographic survey of the region showed that there would be problems. The upper current meter on each mooring was scheduled for a depth of 200 m; consequently there was little room for error in finding the appropriate bottom depth. Each mooring of the cluster was set in a sediment pond -- locally flat regions which were sometimes found with difficulty. The mean depth in the cluster B area was roughly what was expected; in seeking appropriate positions for individual moorings we tried to preserve both a small and a large scale normal to and parallel to the gross trend of the Mid-Atlantic Ridge (roughly north-northeast). The result is

(continued page 7, lower half)

NOTES from the Editor

In this issue of POLYMODE News we present an account of and preliminary results from R/V Knorr cruise 66. This long cruise was an important element in the American part of POLYMODE field work. Note also in POLYMODE Office Notes that the Soviet field work is now in full swing.

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A few articles submitted to POLYMODE News are taking longer to appear than we normally expect. This is because we have been receiving an increased flow of contributions lately, and because we have been holding some articles so that they will appear in the same issue with related contributions. To relieve the increased flow, the POLYMODE News has recently been coming out every two weeks instead of every three weeks. We generally like to average less than a month between receipt of an article and the appearance of it in print. However, special issues on timely subjects (such as this one) seem to be worth putting ahead of more general scientific contributions. We apologize to those contributors who have waited several weeks to see their articles in print. Thanks for being patient with us.

--F. W.

POLYMODE OFFICE NOTES

On 4-6 August, Allan Robinson and Bob Heinmiller visited the Akademik Kurchatov in Curacao for discussions with Professor V. Kort and Dr. K. Federov.

The Soviet scientists outlined the preliminary results of the first CTD surveys of the region centered around the Soviet moored array at 29°N and laid out tentative plans for future work. The Soviet moored array was fully deployed by the end of July. Nineteen moorings had been set in the main, long-term array. In addition, two short-term small-scale moorings had been set approximately 10 miles from the central mooring. The main array will be recovered and reset between 20 and 30 August. The small-scale moorings were due to be recovered around 10 August. The first XBT and CTD surveys covered the area of the moored array approximately 300 km in diameter. Future surveys will be expanded to the full 500 km square area. All XBT data is being radioed-in to IGOSS and the U.S. National Weather Service, and the ships are receiving daily radio-facsimile maps based on the data.

The U.S. visitors laid out the recently developed plans for the U.S. Intensive-Balance-of-Terms (Local Dynamics) Experiment in May and June of 1978. This experiment is scheduled to be centered at 32°N, 70°W. The long-term float program will begin in the summer of 1978 in the vicinity of 29°N. The meeting discussed the coordination of these experimental elements with the large-scale Soviet density surveys, the USSR mooring array, and the joint XBT surveys. A number of logistical problems were discussed. The talks were valuable, and will be continued when the Akademik Kurchatov visits Philadelphia early in September.

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Kirk Bryan (Geophysical Fluid Dynamics Lab, Princeton University) and Peter Rhines (Woods Hole Oceanographic Institution) have agreed to co-chair the POLYMODE Theoretical Panel. Since the organization of POLYMODE, Allan Robinson (Harvard University) has served as the chairman of this panel -- he has resigned in order to free more time for other activities.

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Proposals to the IDOE Office of the National Science Foundation for 1 January funding will be reviewed at a mid-November panel meeting. Proposals should be submitted to NSF by 15 September; proposals that require prior POLYMODE Organizing Committee review should therefore be submitted as soon as possible.

FOUR SHORT XBT SECTIONS ACROSS THE MID-ATLANTIC RIDGE

by Gordon Volkmann

During R/V Knorr cruise 66, Leg II, four short XBT sections were made across the Mid-Atlantic Ridge between 38°N-26°N. The northernmost section (Figure 6), taken by Terry Joyce primarily to study the Mediterranean water, showed a large eddy centered on the Ridge. The eddy has a vertical extent of more than 300 m, and with CTD's should prove an interesting feature. The return section westward (Figure 7) also showed eddy structure; most of it east of the Ridge possibly because the section only extended a few kilometers beyond. Similarly, the section south to cluster B (Figure 8) was confined to the area east of the Ridge and showed a well-developed eddy at 31°N with a vertical excursion of at least 150 m.

The section taken between clusters A and B (Figure 9) shows almost no dynamic topography, but this is misleading. The XBT's and CTD's taken during the deployment of cluster B east of the Ridge show a modest variability of about 80 m, contourable in the shallower water with a horizontal scale of about 100 km but more diffuse in water deeper than about 400 m. The observations at cluster A show it to be relatively featureless, although the area is not as well sampled.

CTD OBSERVATIONS DURING KNORR 66, LEG II

by Terry Joyce

During the second leg of R/V Knorr cruise 66, a total of 48 conductivity-temperature-depth (CTD) stations were occupied. Two Neil Brown underwater units (nos. 4 and 5) were used, each with its own General Oceanics rosette system. The standard 12-bottle (1.7 liter) system on CTD no. 5 was backed up by a newly acquired 24-bottle (1.2)liter) system on CTD no. 4. The latter system was mostly used because it provided a greater number of water samples for calibration of Beckmann dissolved oxygen probes, new Brown "survey" conductivity cells, and Tritium/Helium^3 and silicate analyses.

The distribution of stations shown in Table 4 and Bradley's Figure 1 (see accompanying article) shows the large geographical area covered on the 30-day leg. CTD work was associated with the POLYMODE mooring array II, array-III clusters A and B, and a special study of the Mediterranean Water (MW) at the Mid-Atlantic Ridge near 35°N, 35°W. The latter two regions represent new areas for our CTD coverage and some results will be briefly presented in this note.

A total of 24 stations (nos. 21-44) were taken southwest of the Azores to study the interaction of the MW and general circulation with the Ridge. Nineteen of these comprise a section normal to and across the large-scale trend of the Ridge. The remaining 5 stations were near two neutrally buoyant vertical current meters (VCM's) which were deployed, tracked, and recovered after one day. Figure 2 presents a composite T/S diagram from selected stations on the hydrographic section. Going from northwest to southeast, stations 22, 31 and 39 show a continuous transition in the deep water from western basin, Mid-Atlantic Ridge, eastern basin. Changes in the MW are not gradual. An abrupt shift occurs between stations 21 and 22 ($\Delta X \sim 40$ n.m.) with little change thereafter. The VCM work and stations 40-43 took place on the "fresh" side of this MW transition anticipated by Eli Katz (1970) and dubbed by Val Worthington (personal communication) the "Katz Gap". On the section, T5 (1800 m) XBT's were taken at 10 n.m. intervals with the ship slowing to 6 knots. Only at such speeds was the acoustic noise low enough to enable a depth-sounder measurement to be made. Tritium/Helium^3 samples by Wolfgang Weiss (University of Heidelberg) and silicate samples were drawn during the section. These latter were frozen for later determination on Leg III.

The strategy and tactics for deployment of the POLYMODE array III clusters A and B are discussed by Bradley and Wunsch (see accompanying articles). The CTD data obtained in these regions will be supplemented by similar measurements upon recovery of the moorings.

CTD OBSERVATIONS DURING KNORR 66
LEG II (continued)

A CTD station was occupied at each mooring site in the current meter arrays with two additional stations on either side of the Ridge between the clusters. Water-mass variability observed near cluster A (west of the Ridge)(Figures 3 and 4) is less than near cluster B, which seems to be located near the boundary between Mediterranean Water and Antarctic Intermediate Water. This transition from MW to "south Atlantic water" is consistent with Worthington's (1976) Figure 19, but is more rapid. Moored temperature measurements at depths of 100-1500 m will need to be interpreted with these lateral gradients in mind. In contrast to the section to the north described above, the deep water on both sides of the Ridge is uniform in its T/S characteristics.

The data presented here are preliminary and await final calibration, the plots having been produced at sea. I wish to acknowledge the contributions of D. Moore (CTD, salinometer), G. Volkmann (O_2 titration), J. Dean (VCM's), T. Crook (computer technician), M. Raymer (CTD plotting) and the captain, crew and scientific party of the R/V Knorr for their many efforts on this cruise.

References

Katz, E. J. (1970) Diffusion of the core of Mediterranean water above the Mid-Atlantic Ridge crest. Deep-Sea Res., *17*, 611-625.

Worthington, L. V. (1976) On the North Atlantic circulation. The Johns Hopkins Oceanographic Studies, No. *6*. The Johns Hopkins University Press, Baltimore, MD, 110 pp.

CTD Number	Position	CTD Number	Position
16	35°54.7'N 58°56.4'W	40	34°00.0'N 38°30.0'W
17	35°53.5'N 58°54.8'W	41	33°56.6'N 38°24.3'W
18	35°57.4'N 55°27.5'W	42	33°56.2'N 38°24.2'W
19	35°55.5'N 54°45.1'W	43	33°50.3'N 37°55.1'W
20	35°56.8'N 53°45.7'W	44	33°56.5'N 38°21.6'W
21	38°02.0'N 37°53.2'W	45	27°26.8'N 41°07.2'W
22	37°33.5'N 37°27.2'W	46	27°17.5'N 40°46.0'W
23	37°02.8'N 36°54.5'W	47	27°15.8'N 40°20.1'W
24	36°48.0'N 36°41.0'W	48	26°53.0'N 41°13.0'W
25	36°31.8'N 36°25.0'W	49	26°09.4'N 41°40.1'W
26	36°20.0'N 37°07.8'W	50	26°39.0'N 43°37.0'W
27	36°06.0'N 35°52.2'W	51	27°09.8'N 45°30.0'W
28	35°51.6'N 35°36.8'W	52	27°26.3'N 47°49.2'W
29	35°37.0'N 35°19.5'W	53	28°00.7'N 48°02.9'W
30	35°22.5'N 35°04.4'W	54	27°52.1'N 48°39.8'W
31	35°08.0'N 34°47.5'W	55	27°54.5'N 48°51.2'W
32	34°53.0'N 34°31.5'W	56	26°52.2'N 49°14.2'W
33	34°38.7'N 34°15.4'W	57	30°30.0'N 55°00.0'W
34	34 25.8'N 33°59.9'W	58	31°34.8'N 54°25.2'W
35	34°10.6'N 33°43.0'W	59	32°29.6'N 55°00.1'W
36	33°54.9'N 33°28.0'W	60	32°05.0'N 55°00.0'W
37	33°41.3'N 33°09.4'W	61	31°34.8'N 54°58.0'W
38	33°11.0'N 32°37.5'W	62	31°36.7'N 54°54.6'W
39	32°38.9'N 32°05.0'W	63	31°35.0'N 55°35.0'W

Positions of CTD stations taken during R/V Knorr cruise 66, Leg II.
Table 4 (Joyce)

KNORR 66 CRUISE REPORT (continued)

Table 2 shows the entire station history of array II. As in all such work, CTD's were routinely taken at each mooring site. After steaming east to the Mid-Atlantic Ridge, a CTD survey of 21 lowerings was conducted by Terry Joyce (WHOI) for his Mediterranean Water Front Experiment (see accompanying article). For Phil Richardson (WHOI), two satellite-tracked drifter buoys with window-shade drogues at 200 m were deployed before and during the CTD section.

After the Knorr steamed south to the cluster B area of array III, Carl Wunsch (MIT) directed the placement of these moorings on extremely rough terrain. A transducer mounted on a tow-fish allowed a bottom survey to be conducted at Knorr's top speed. Clusters A and B were successfully deployed in roughly cross-shaped arrays. Because of the topography, perfect layout was not possible due to considerations of instrument-placement depths. Table 3 summarizes the

(continued page 6)

Station Number	Position	Water Depth (Meters)	Instrument	Instrument Depth (Meters)
616	30°54.9'N	3000	VACM-P	2000
(WBUC #1)	76°39.0'W		T/P	2000
			VACM	2800
617	30°32.1'N	3800	VACM-P	600
(WBUC #2)	75°06.0'W		VACM	2000
			VACM	3600
618	30°43.2'N	4000	VACM-P	2000
(WBUC #3)	74°11.0'W		VACM	3000
			VACM	3800
619	30°48.3'N	4600	VACM	600
(WBUC #4)	74°00.5'W		VACM-P	2000
			T/P	2000
			VACM	3000
620	31°03.5'N	5200	VACM-P	2000
(WBUC #5)	73°28.8'W		VACM	3000
			VACM	5000
621	28°31.0'N	5453	VACM	5368
(BBL #1)	70°28.5'W		VACM-DT	5388
			VACM-DT	5398
			VACM-DT	5408
			VACM-DT	5418
			VACM-DT	5428
			VACM-DT	5438
622	28°31.0'N	5453	VACM	5418
(BBL #2)	70°24.8'W			

*Key to instruments:
VACM = Vector-averaging current meter
VACM-P = Vector-averaging current meter with pressure
VACM-DT = Vector-averaging current meter with differential temperature
T/P = Temperature pressure recorders

Western Boundary Undercurrent and Benthic Boundary Layer moorings.
Table 1 (Bradley)

KNORR 66 CRUISE REPORT (continued)

array III positions. On the return to Bermuda, the southernmost POLYMODE array II-mooring was recovered along with an engineering Kevlar rope test mooring and an Internal Wave mooring (Briscoe, WHOI). An array of CTD stations in a diamond-shaped pattern was taken around this site.

The Knorr left Bermuda 28 June on Leg III to recover the ten remaining array II moorings. Val Worthington (WHOI) was aboard to take a hydrographic section along 55°W. The section work started as far south as projected timing would allow with the first station at 32°25'N. Deep and shallow hydrographic stations were taken at the identical spacings of the Knorr's cruise last October. A newly developed nephelometer was used for the first time with CTD stations at the mooring sites. As the cruise progressed, a "super station" plan was used on three separate occasions along the hydrographic section. This "super station" consisted of a Nansen bottle shallow cast combined with a deep CTD cast using a 24-bottle sampling rosette. Current meter mooring work was routine and the recovered moored inverted echo sounder appeared to function well. With some time remaining, the ship headed southwest and deployed 4 satellite-track buoys with 200-m deep drogues across the

(continued page 7, upper half)

Mooring Number	Station Number	Position	Deployed	Recovered	Days on Station	Total Station Days
1	557	55°03.8'W 35°53.0'N	3-V-75	18-XII-75	230	
	583	*55°02.5'W 35°52.5'N*	*18-XII-75*	*14-X-76*	*302*	793
	608	55°04.6'W 35°52.8'N	15-X-76	3-VII-77	261	
2	558	54°40.5'W 35°56.8'N	4-V-75	12-XII-75	223	
	579	*54°41.8'W 35°55.7'N*	*12-XII-75*	*4-X-76*	*298*	759
	600	54°44.4'W 35°55.3'N	4-X-76	29-V-77	238	
3	565	55°05.0'W 35°36.0'N	8-V-75	18-XII-75	225	
	55°05.0'W 35°36.0'N		*18-XII-75*	*15-X-76*	*303*	789
	609	55°04.8'W 35°35.8'N	15-X-76	3-VII-77	261	
4	559	53°45.8'W 35°58.2'N	4-V-75	11-XII-75	222	
	578	*53°45.5'W 35°58.3'N*	*11-XII-75*	*3-X-76*	*300*	760
	601	53°46.9'W 35°57.5'N	5-X-76	30-V-77	238	
5	566	55°01.7'W 34°53.5'N	9-V-75	17-XII-75	223	
	581	*55°04.7'W 34°55.6'N*	*17-XII-75*	*17-X-76*	*306*	787
	611	55°04.8'W 34°55.5'N	19-X-76	2-VII-77	258	
6	568	59°01.7'W 35°55.8'N	15-V-75	19-XII-75	219	
	584	*59°01.5'W 35°56.9'N*	*20-XII-75*	*2-X-76*	*288*	715
	598	59°02.3'W 35°55.3'N	2-X-76	28-V-77	208	
7	567	55°05.0'W 31°35.9'N	14-V-75	15-XII-75	216	
	580	*54°56.0'W 31°35.2'N*	*15-XII-75*	*19-X-76*	*310*	772
	612	54°56.0'W 31°35.2'N	19-X-76	21-VI-77	246	
8	564	55°00.0'W 37°29.5'N	7-V-75	10-XII-75	218	
	577	*55°01.0'W 37°28.7'N*	*10-XII-75*	*12-X-76*	*308*	792
	606	54°59.6'W 37°29.3'N	12-X-76	5-VII-77	266	
9	563	54°58.0'W 38°29.8'N	7-V-75	9-XII-75	217	
	576	*54°55.4'W 38°29.6'N*	*9-XII-75*	*10-X-76*	*307*	791
	605	54°56.1'W 38°28.8'N	11-X-76	5-VII-77	267	
10	562	54°59.2'W 39°29.0'N	7-V-75	8-XII-75	216	
	575	*54°59.9'W 39°30.2'N*	*8-XII-75*	*10-X-76*	*308*	794
	604	55°00.8'W 39°29.2'N	10-X-76	7-VII-77	270	
11	561	55°00.0'W 40°28.0'N	6-V-75	8-XII-75	217	
	574	*55°03.0'W 40°27.1'N*	*8-XII-75*	*9-X-76*	*307*	796
	603	55°03.0'W 40°27.1'N	9-X-76	8-VII-77	272	
12	560	54°59.8'W 41°29.2'N	6-V-75	6-XII-75	215	
	573	*54°58.6'W 41°29.3'N*	*7-XII-75*	*7-X-76*	*306*	795
	602	54°58.0'W 41°29.4'N	8-X-76	4-VII-77	274	
13	607	55°00.0'W 36°30.0'N	13-X-76	4-VII-77	264	264
14	610	55°00.0'W 35°14.5'N	16-X-76	3-VII-77	260	260
15	599	55°27.8'W 35°57.4'N	3-X-76	29-V-77	239	239
						10,106

Array II mooring positions and events
Table 2 (Bradley)

KNORR 66 CRUISE REPORT (continued)

Gulf Stream. On the return to Woods Hole two "super stations" were taken on either side of the Gulf Stream.

A statement of statistics for this cruise, which is the largest and longest cruise by the WHOI Buoy Group to date, includes: a) 65 days on the R/V Knorr; b) 8000 miles steaming; c) 17 moorings and 1 acoustic beacon set, 17 mooring recoveries; d) 113 current meters and 54 other scientific instruments set or recovered from the moorings; e) 506 XBT's; f) 82 CTD station; g) 24 hydrostations; h) 6 satellite buoys launched; i) over 2000 water samples analyzed; and j) 44 participants as science/crew members.

Mooring Number	Station Number	Position	Deployed	Recovered
		CLUSTER A		
central	630	48°39.4'W 27°51.7'N	17-VI-77	Spring 1978
2	628	47°50.0'W 27°25.6'N	16-VI-77	Spring 1978
3	629	48°03.3'W 28°01.0'N	17-VI-77	Spring 1978
4	631	48°52.1'W 27°55.8'N	18-VI-77	Spring 1978
5	632	49°13.5'W 26°51.8'N	18-VI-77	Spring 1978
		CLUSTER B		
central	623	41°07.7'W 27°24.8'N	11-VI-77	Spring 1978
2	624	40°45.5'W 27°17.5'N	12-VI-77	Spring 1978
3	625	40°21.1'W 27°14.5'N	12-VI-77	Spring 1978
4	626	41°12.8'W 26°52.7'N	13-VI-77	Spring 1978
5	627	41°40.7'W 26°09.8'N	14-VI-77	Spring 1978

Array III mooring positions and dates.
Table 3 (Bradley)

SETTING OF ARRAY III CLUSTERS A AND B (continued)

shown in Figure 5. Because of the extreme roughness, the 4000 m current meter on mooring 632 was raised to 3500 m.

Cluster A was then set with the experience of cluster B behind us. But here, the mean depth was quite different from that shown on the chart, and the entire 4500 m level of current meters was raised to 4000 m after the preliminary topographic survey. All instruments were finally placed within a few meters of that intended depth.

Special thanks are due George Tupper, Chief Scientist, and David Simoneau, in charge of the WHOI Buoy Group deck crew, for a successful outcome under trying circumstances.

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The POLYMODE* News is produced at the Woods Hole Oceanographic Institution. It is edited by Ferris Webster and Catherine Herrity.

Material of interest for this newsletter may be sent to either of the above at the Woods Hole Oceanographic Institution, Woods Hole, MA, 02543, Telephone (617) 548-1400, Telex 710-346-6601.

*POLYMODE is derived from the names of the U.S.S.R. POLYGON experiments and the Mid-Ocean Dynamics Experiment (MODE).

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Section	Contact	Vessel	Date	Description
A	G. Volkmann	R/V Knorr	May-Jun 77	38°00'N 38°08'W 32°42'N 32°22'W
B	G. Volkmann	R/V Knorr	May-Jun 77	34°00'N 38°00'W 32°42'N 32°22'W
C	G. Volkmann	R/V Knorr	May-Jun 77	34°00'N 38°00'W 26°12'N 41°32'W
D	G. Volkmann	R/V Knorr	May-Jun 77	28°18'N 48°37'W 26°12'N 41°32'W

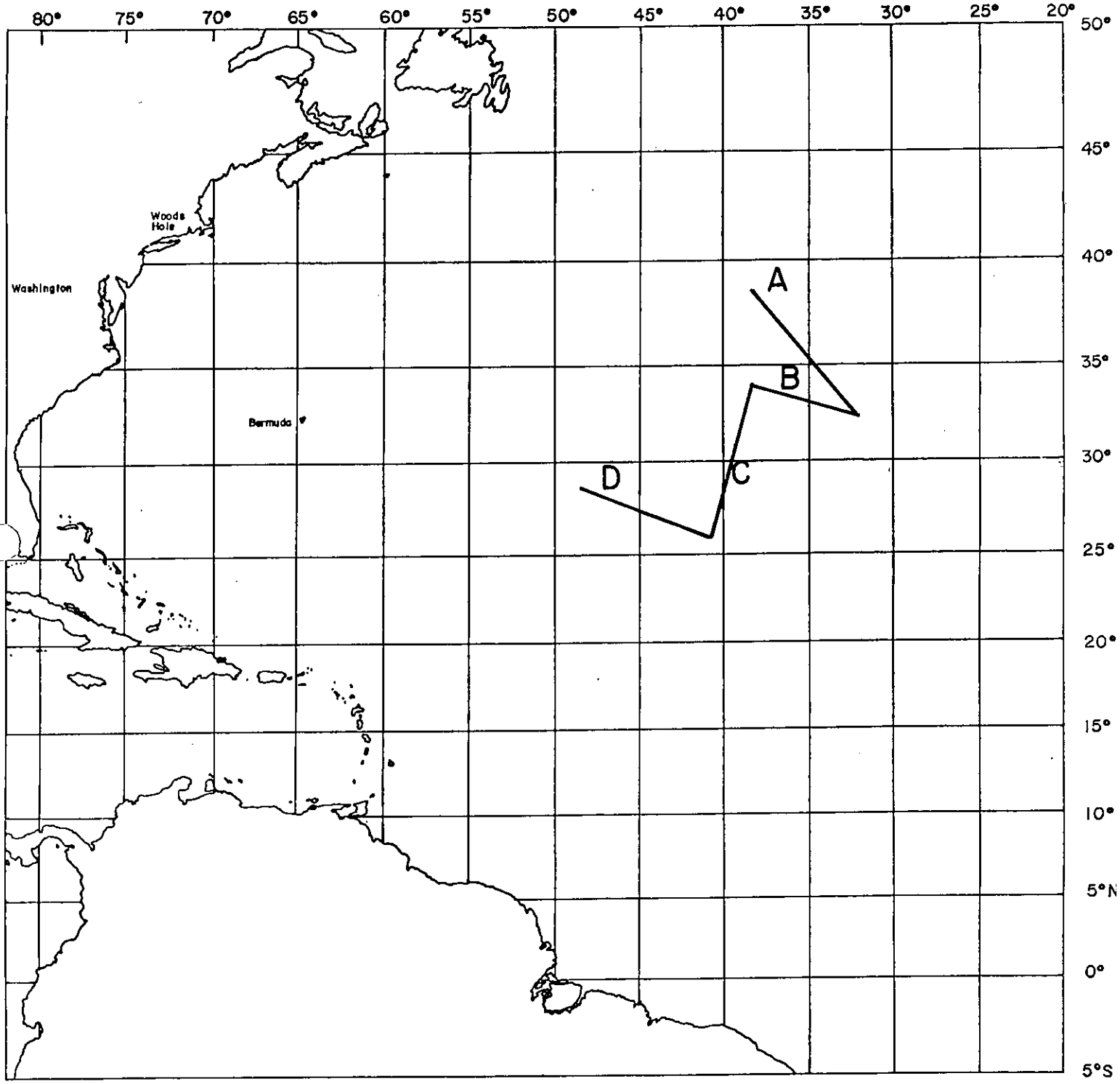
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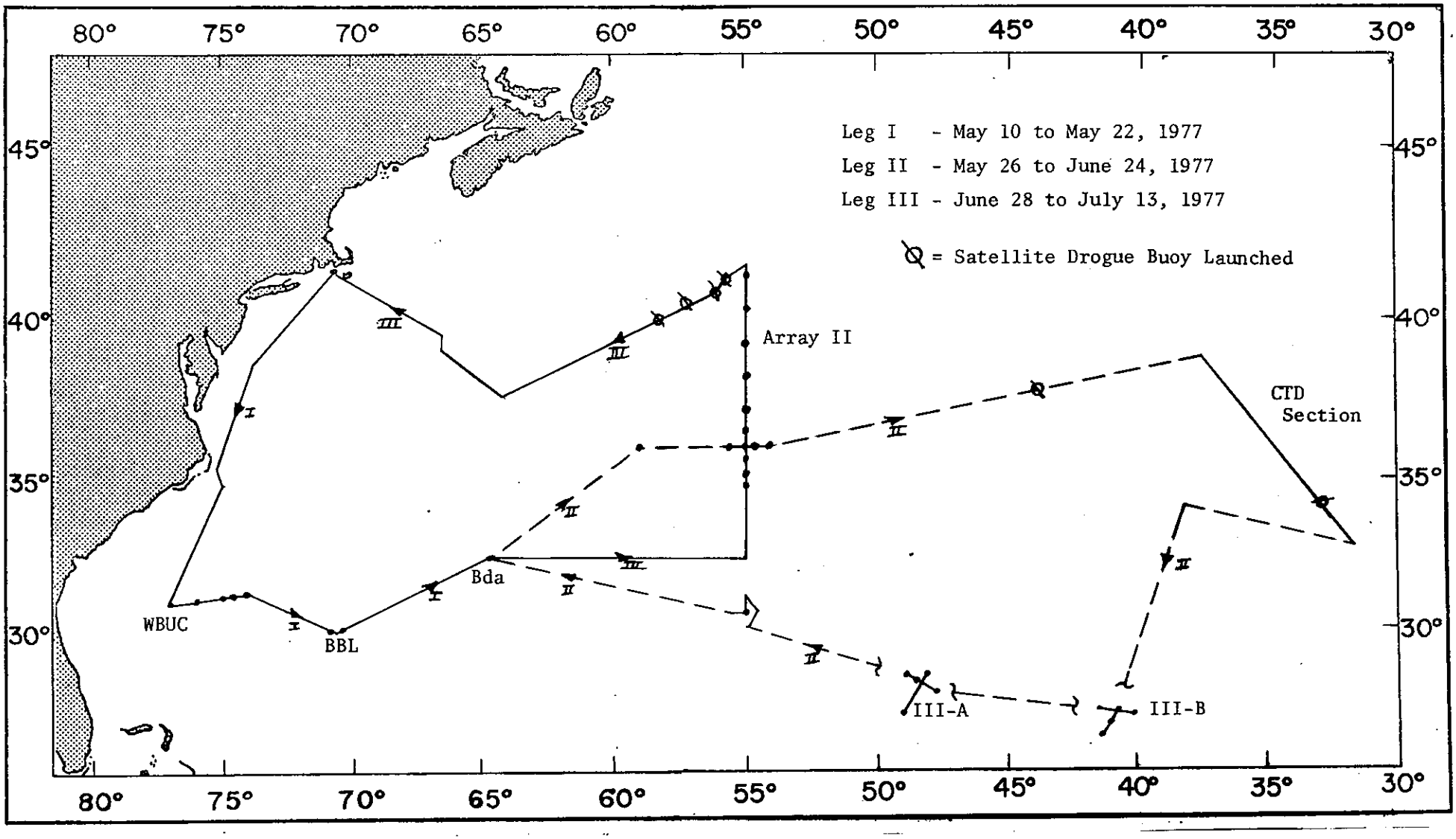
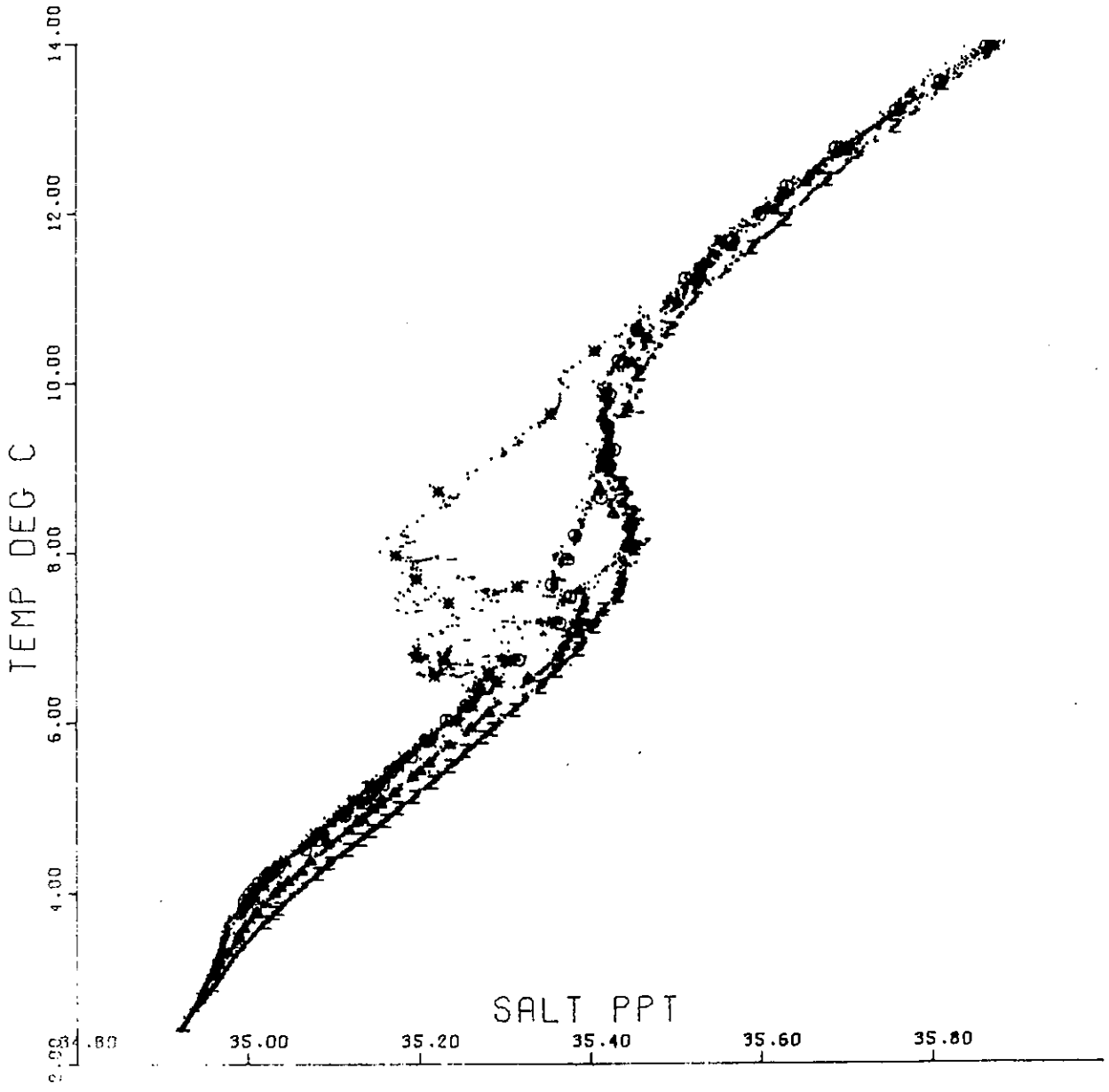
CHART I



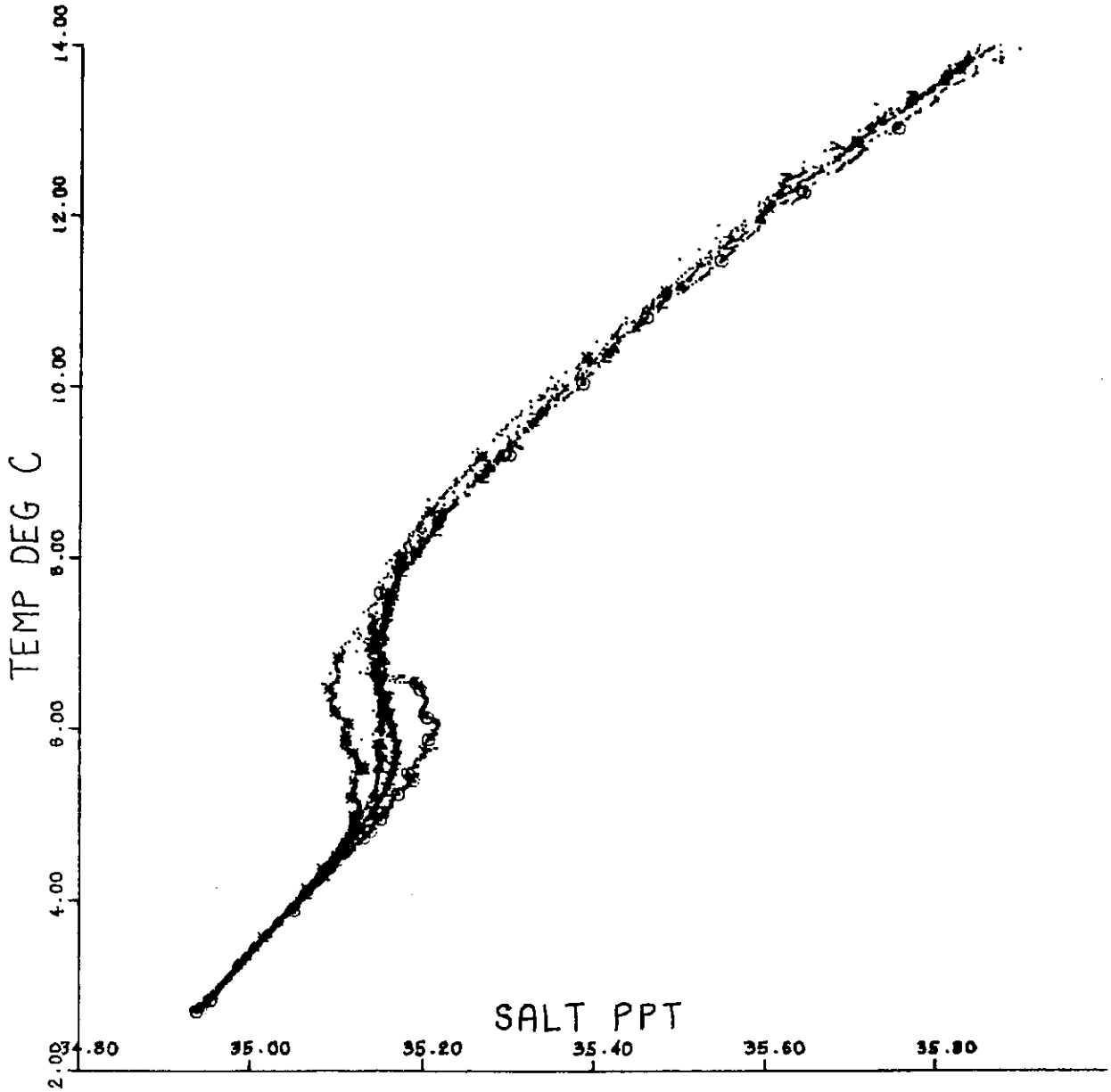
The ship's track for R/V Knorr cruise 66: Leg I, set Western Boundary Undercurrent and Bottom Boundary Layer moorings; Leg II, recovered 5 array II moorings, Internal Wave and engineering moorings, set POLYMODE array III clusters and conducted Mediterranean Water CTD section; Leg III, recovered 10 array II moorings and conducted 55°W and Gulf Stream hydrographic sections.

Figure 1 (Bradley)



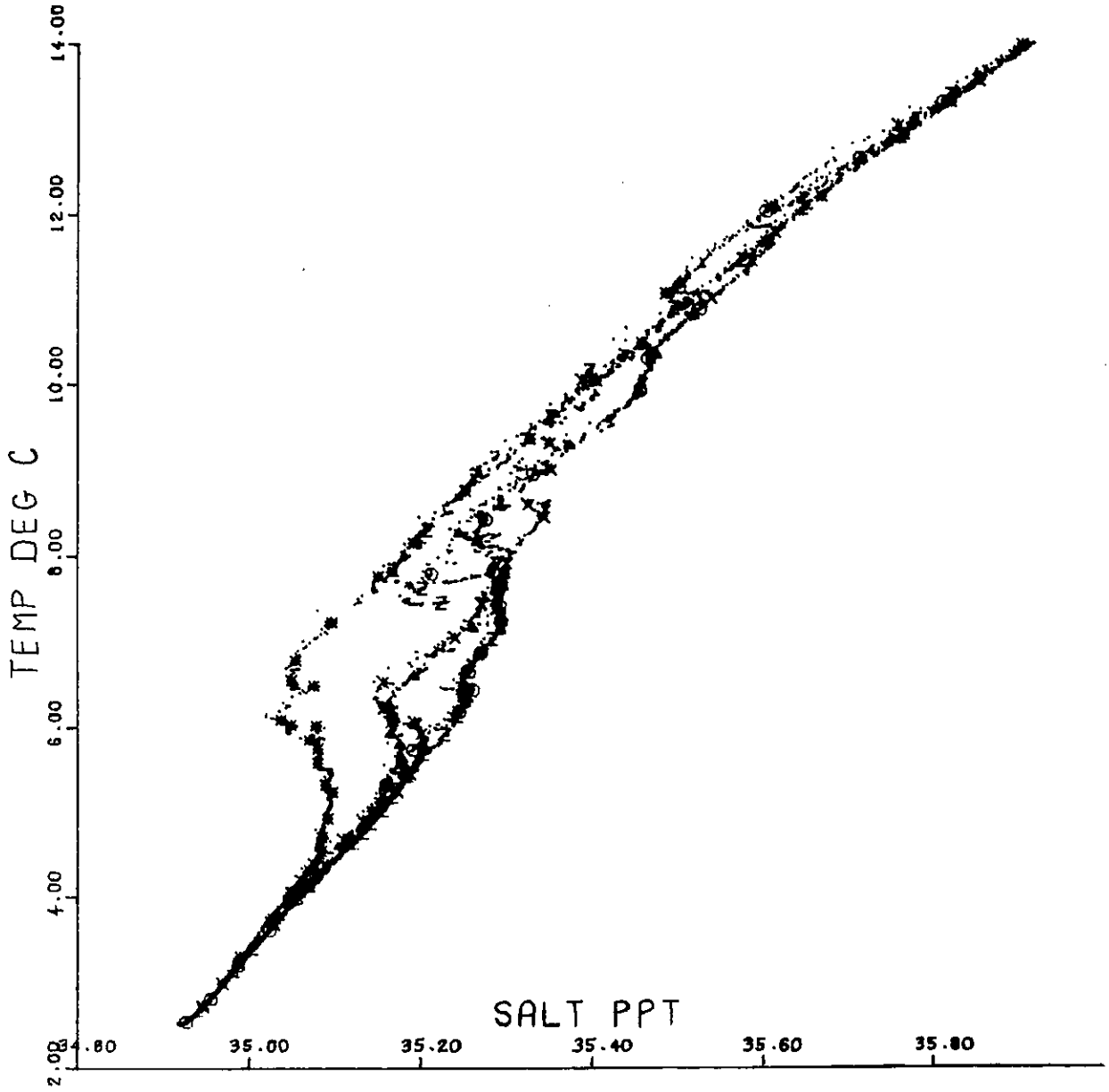
Temperature/salinity diagram for selected stations from MW section. Coding is: CTD 21 (*), 22 (o), 31 (Δ), 39 (z). See Table 4 for station locations.

Figure 2 (Joyce)



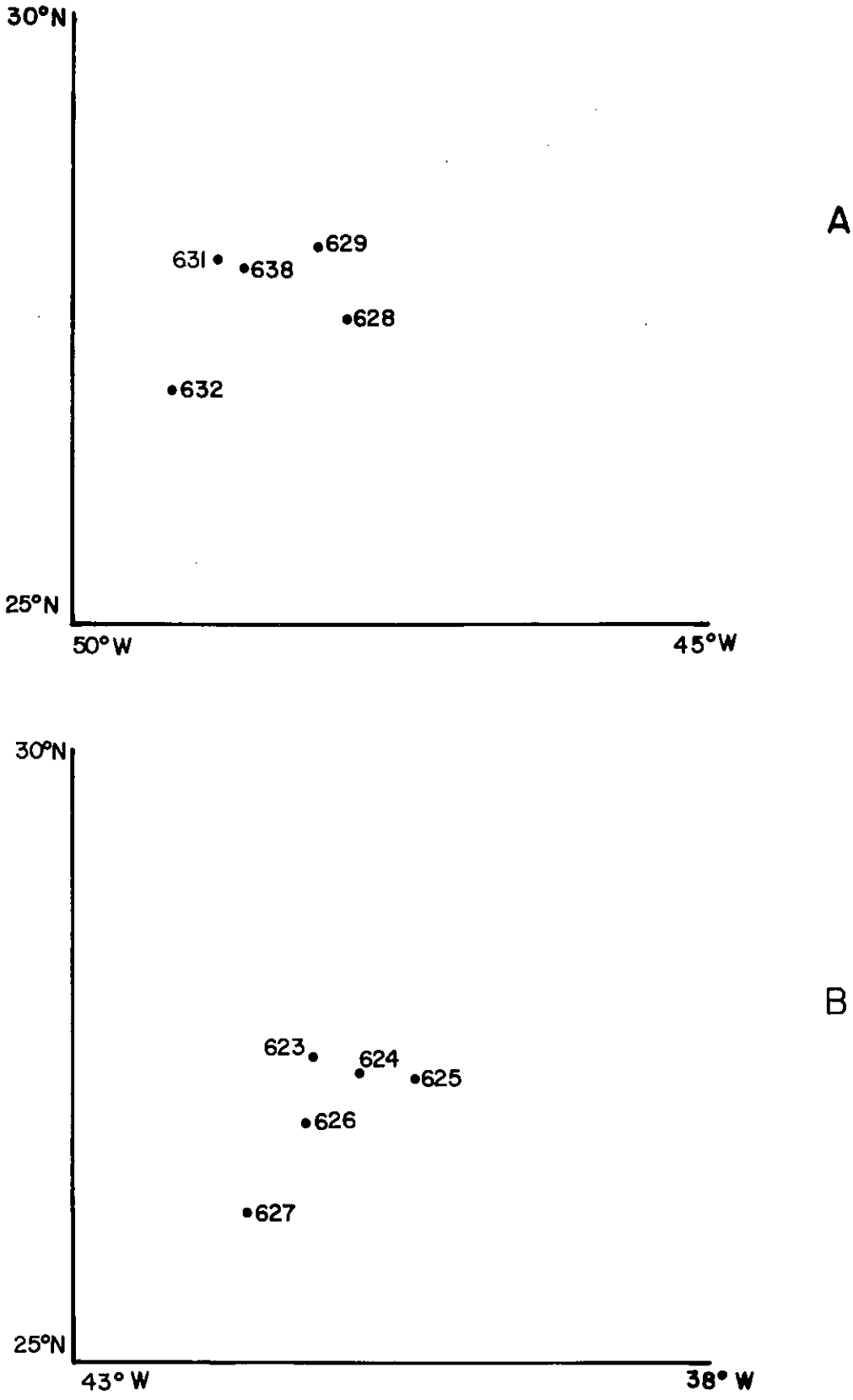
Temperature/salinity diagram for selected stations from array III cluster A. Coding is: CTD 50 (o), 52 (Δ), 54 (z), 56 (*).

Figure 3 (Joyce)



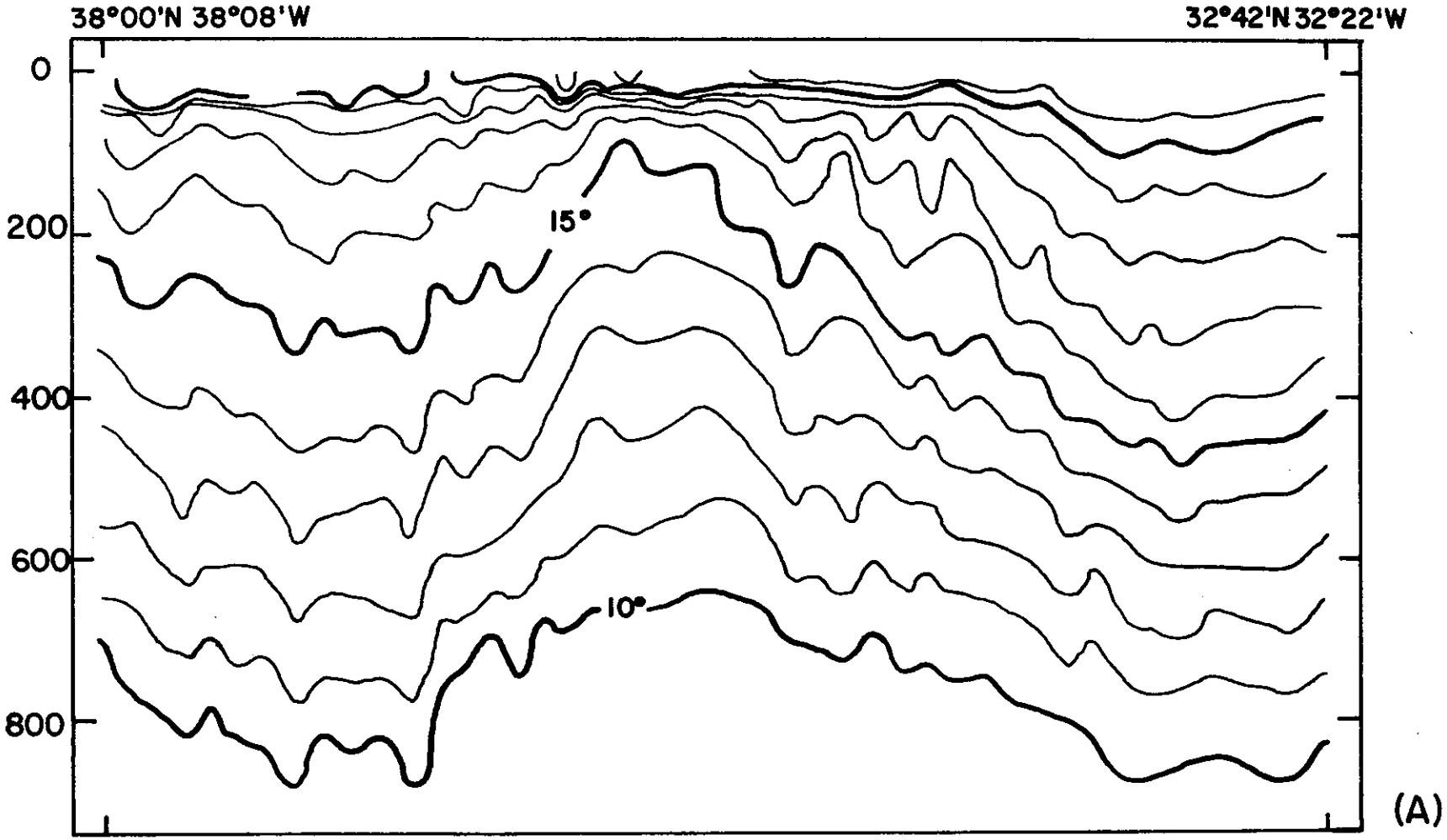
Temperature/salinity diagram for selected stations from array III cluster B. Coding is: CTD 45 (o), 46 (Δ), 47 (x), 48 (z), 49 (*).

Figure 4 (Joyce)

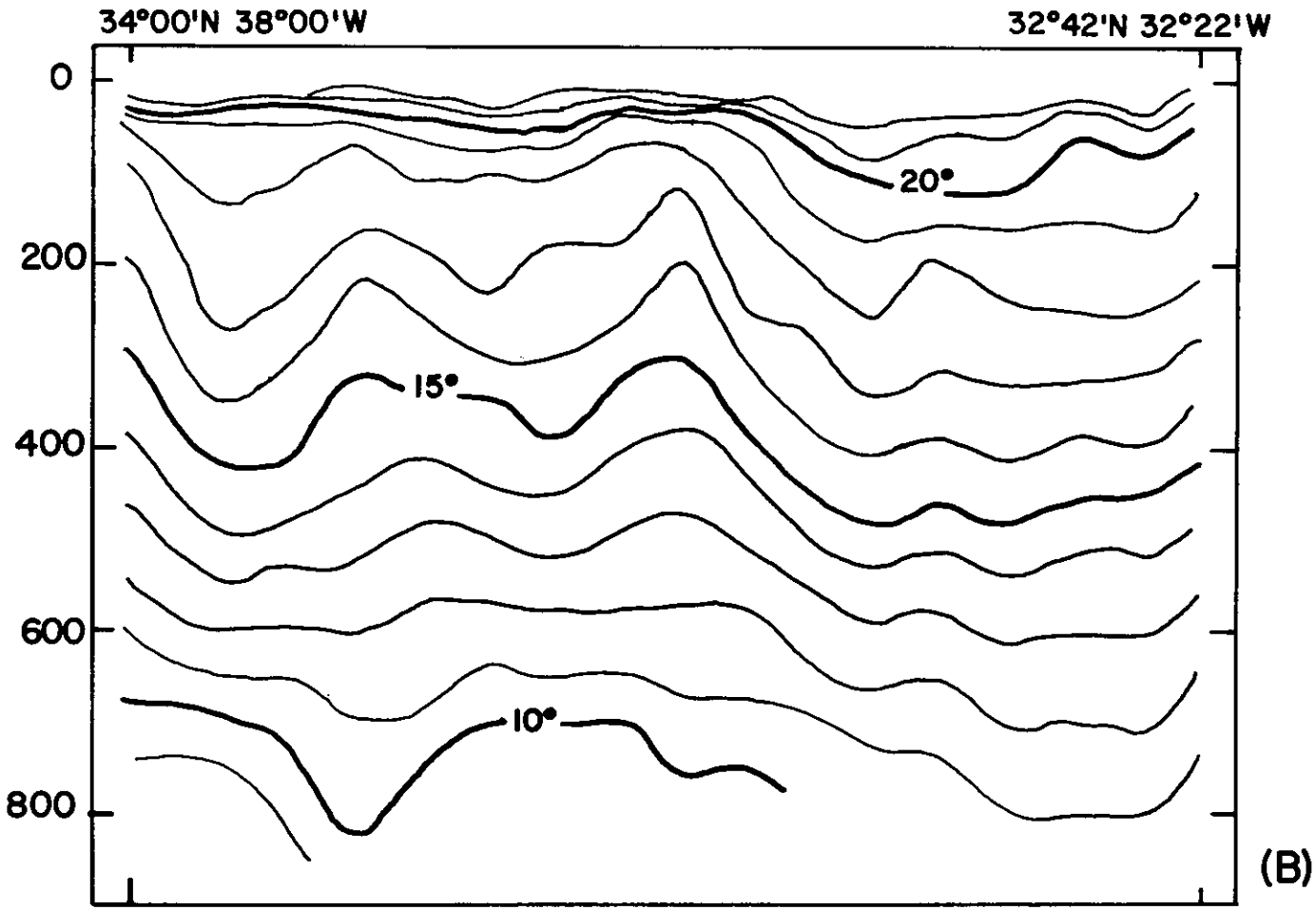


Clusters A and B of POLYMODE array III: A) cluster A is on the western flank of the Mid-Atlantic Ridge; B) cluster B is on the eastern flank of the Ridge.

Figure 5 (Wunsch)

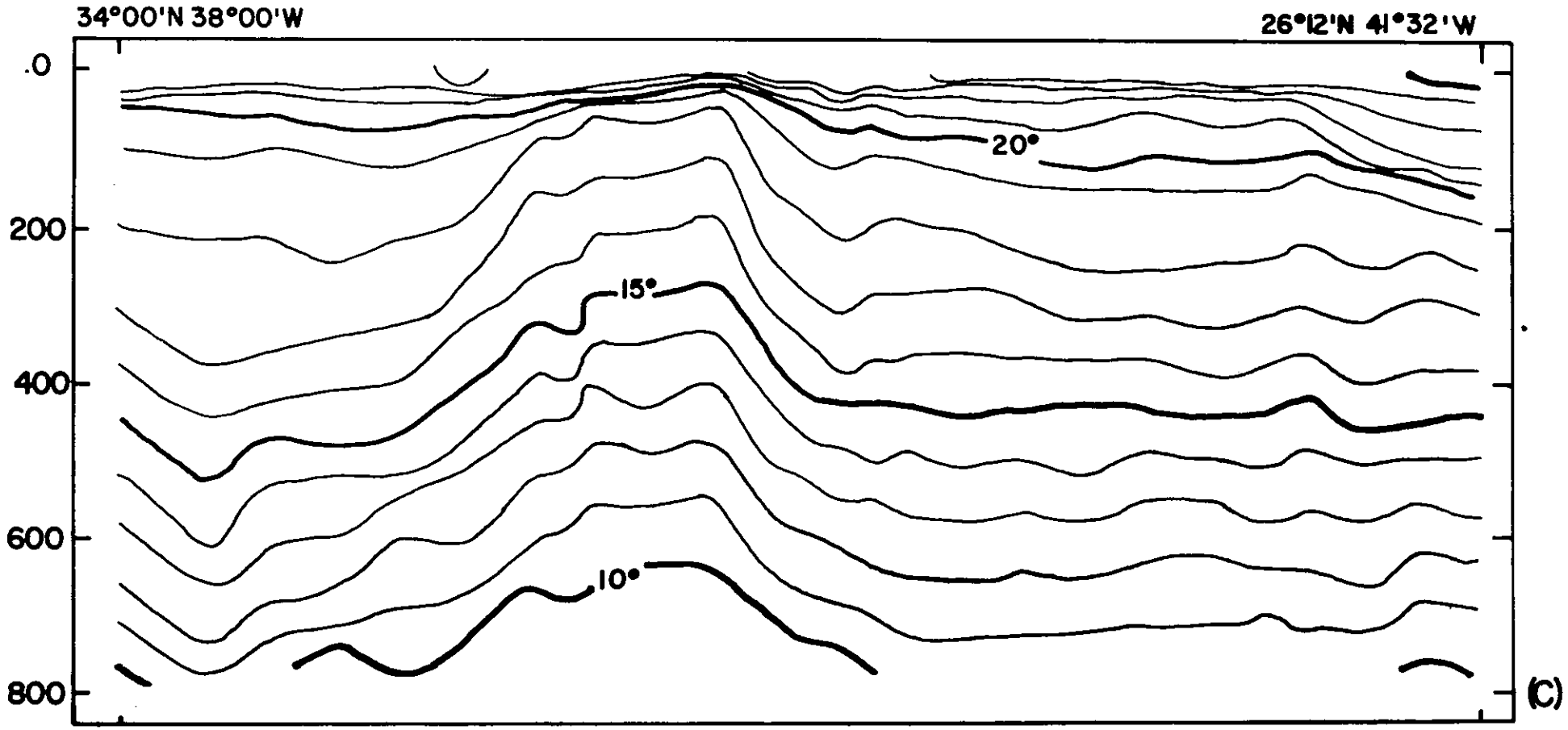


The northernmost XBT section taken aboard the R/V Knorr cruise 66, Leg II.
Figure 6 (Volkmann)



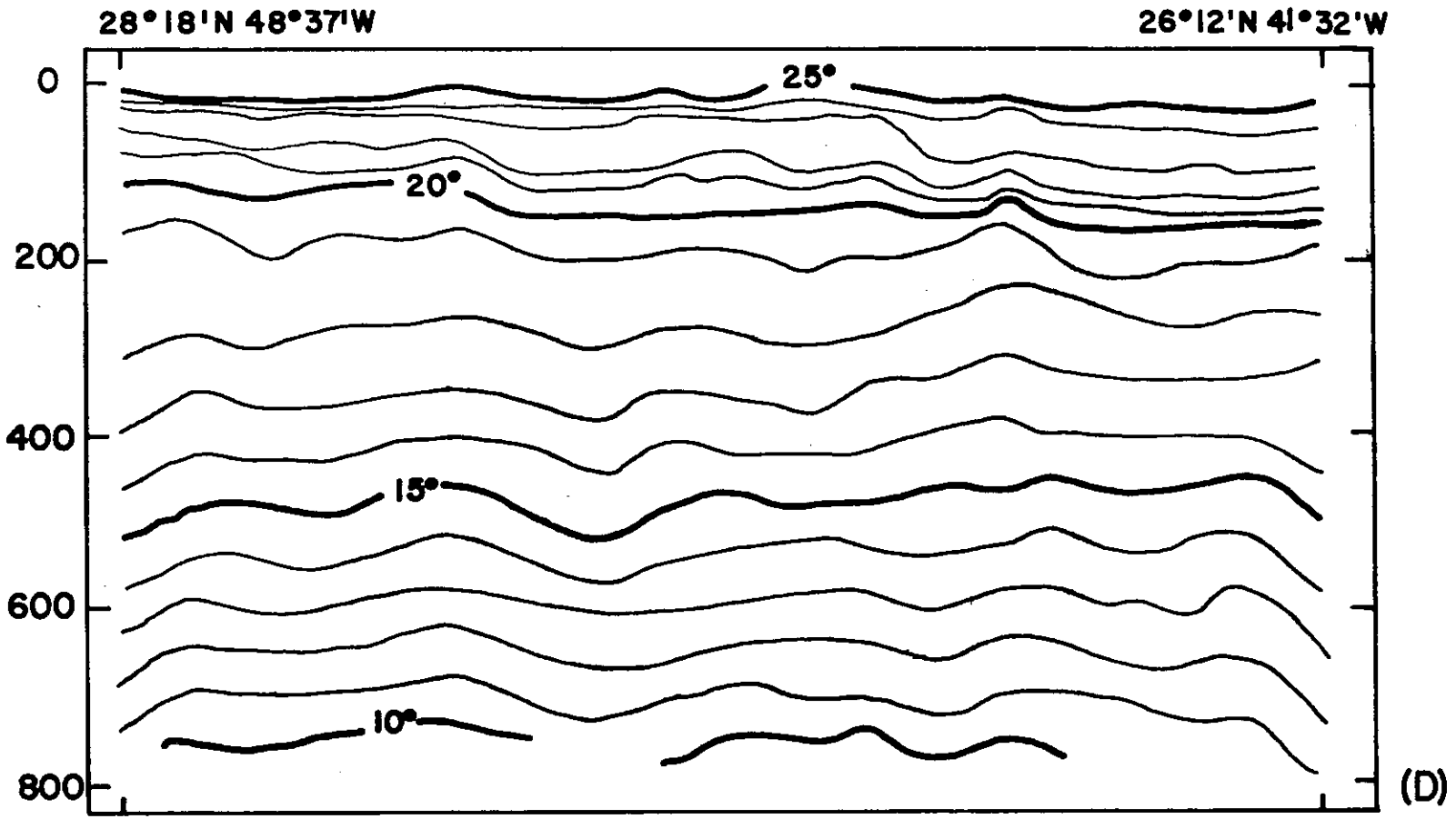
XBT section taken aboard the R/V Knorr cruise 66, Leg II.

Figure 7 (Volkmann)



XBT section taken south to cluster B (R/V Knorr cruise 66, Leg II).

Figure 8 (Volkmann)



XBT section taken between clusters A and B, R/V Knorr cruise 66, Leg II.
Figure 9 (Volkmann)