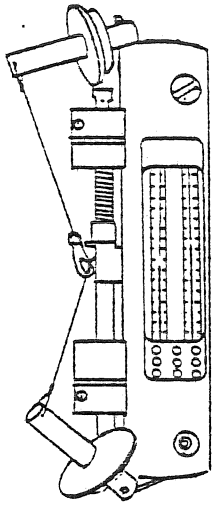
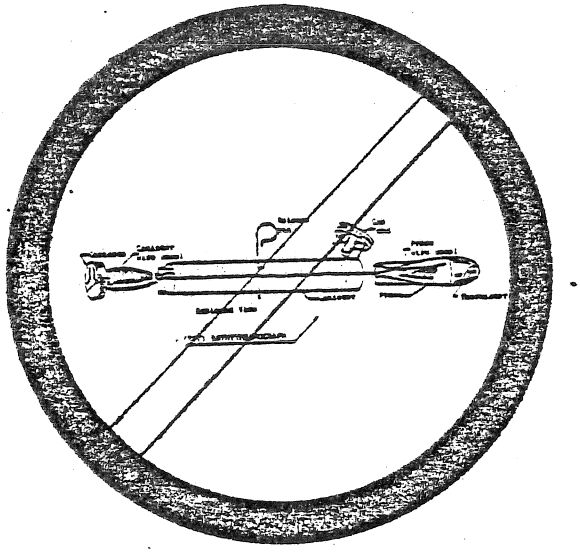
LABORATORY REFERENCE NUMBER 80-27

ARE XBTs EXPENDABLE ?





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ABSTRACT

Approximately 25 Marine Monitoring Assessment and Prediction (MARMAP) cruises were made from 1977 to 1980. A collection of temperatures from reversing thermometers and expendable bathythermograph (XBT) data obtained on three MARMAP cruises is presented in graphic form. The comparison of bottle cast versus XBT cast suggests that XBTs are redundant for present MARMAP purposes and should be used only when bottle data are not available.

INTRODUCTION

Since the beginning of MARMAP in 1977, XBTs have been used on selected stations (see Figure 1) making continuous profiles of the water column temperature to supplement the bottle cast's thermometer readings. In 1977 MARMAP cruises were usually conducted without personnel from the Fishery Oceanography group, although the Oceanographic group processed and stored the data once the cruise was completed. In 1978 the Fishery Oceanography group was requested to take part in the sea-going operations after which the collection of water, temperature, salinity, oxygen and nutrient data and associated record-keeping became an important and full-time job with the group. In the middle of 1979, the Fishery Oceanography group hired two retired oceanographers to coordinate work on MARMAP cruises. Cruises in 1980 have been very successful as far as oceanographic data quality and quantity are concerned. The purpose of this study was to examine the need for expendable bathythermographs (XBT) on future MARMAP cruises. Reviewing the experience acquired from past MARMAP cruises, we ask these questions: 1) have we learned what was planned, 2) can operations be improved, 3) can time and/or money be saved?

Data and Methods

Data presented in this report is from three MARMAP cruises from different years. The first cruise, DELAWARE II 78-02, was conducted from February 14 - March 13, 1978. The second, ALBATROSS IV 79-11, from October 1-19, 1979; and third, EVRIKA 80-01, April 14-May 15, 1980. XBTs were taken on all transect stations along with bottle casts. The transects presented here are the MARMAP transects "A", "B", "C", "D" (See Figure 1), which are normal to the coast.

Niskin bottles, with rotating thermometer frames, were lowered on a 3/8-in. hydro wire with an electronic meter block & readout. Reversing thermometers were the deep sea reversing type from various manufacturers. When the depth was 150 meters or greater, at least one unprotected thermometer was used.

The procedures for MARMAP XBT, and bottle cast was as follows[1]: upon arrival on station an XBT was cast. If the station depth was more than 75 meters, a regular bottle was placed one meter above the lead ball. If the station depth was 75 meters or less a "bottom trip"[2] bottle, without thermometers, was placed one meter above the lead ball and the deepest regular Niskin bottle was placed one-half meter higher. The remaining bottles were hung according to trip at 0, 5, 10, 15, 20, 25, 30, 35, 50, 75, 100, 150, 200, 250 and 300 meters, depending on bottom depth. A timer was set for 5 minutes after which the messen-

ger was dropped and wire angle and time were recorded. At stations less than 75 meters, the hydro wire was lowered until the "bottom trip" bottle tripped and the depth was recorded. Bottles were removed and placed on the rack and the water samples were drawn. Any malfunctions, leaks or other problems were recorded. The thermometers should have been read twice (no sooner than 15 minutes[3] after they were removed from the water). The hydrographer and assistant each read the thermometers once then entered the temperature on the master hydro log. At sometime during the cruise the temperatures were corrected using the proper "thermometer correction" graphs.

The XBT models[4] used were T6s (vertical temperature profile to 460 meters) and T10s (vertical temperature profile to 200 meters). XBTs were cast on an average of 18 minutes before the hydro cast (with a range from 6 to 49 minutes); figured from the messenger time on the hydro log and the cast time on the XBT graph sheet.

Contouring of bottle sections was done independently of XBT sections by not permitting the same person to contour both sections. This was to avoid the subjective "fitting" of the second section to the first.

RESULTS

Duplicate sections by XBT and bottle cast for DELAWARE II 78-02 are shown in Figures 2-5, with station information in Tables 1-4. In Transects A and B (Figures 2 and 3) The sections are almost identical in the upper 50 m where the bottles were closely spaced. Even small features such as the surface lens of water warmer than 17°C in Transect A are duplicated. Transect B is a close match except at station 28, where the XBT (taken 28 minutes earlier) shows some fine structure missed by the bottle cast. This close similarity is missing in the deeper water in all four transects, and also at lesser depths in the offshore stations on Transects C and D (Figures 4 and 5). There are three explanations for the discrepancy: 1) inadequate bottle spacing (there's no bottle between 50 and 200 m at Station 68, Figure 4a, for example); 2) time delays between XBT launch and bottle cast; and 3) variations in contouring, which becomes more subjective with fewer data points.

By late 1979, when ALBATROSS IV cruise 79-11 was made (Figures 6-9, Tables 5-8), equipment deficiencies had been corrected and much tighter bottle spacing was achieved. The four sets of sections show quite good agreement at all depths. However, time delays between XBT drop and messenger ranged from 5 to 40 minutes. Such delays tend to increase when the weather is bad, so that the ship is drifting not only longer between observations, but faster. The edge of the shelf, in particular, is a very complex area and substantial changes occur even in very short distances. Some features, such as the tight gradients at stations

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[1]Hydrographic work on MARMAP cruises, manual prepared by Ron Kirschner, NEFC Lab. Ref. 80-25.

[2]Bottom trip designed by Jay O'Reily, NMFS Sandy Hook.

[3]Naval Oceanographic Handbook of Oceanography.

[4]See Sippican XBT Handbook.

59 and 60 (Figure 8b) are inevitably more sharply defined by XBT.

Sections in 1980 (Figures 10-13) show continued improvement, with only small differences between the two sets of contours.

CONCLUSIONS AND RECOMMENDATIONS

It is clear that in the early cruises the XBTs were a valuable addition to the thermometer data, filling in gaps in the bottle spacing and providing a check on the quality of thermometer performance. From 1979 on, however, it appears that the XBTs are redundant, as both sets of sections show the same essential features. Where fine-scale structure is revealed by XBT it is of no value because (a) the spacing between drops is greater than the horizontal scale such features, and (b) no other variables are sampled continuously with depth.

Furthermore, data reduction and archiving are already a problem, and anything that can be done to reduce duplication will help. Finally, the cost of XBTs goes up annually. In 1978 about $13 000 worth of XBTs were used to cover all stations in MARMAP cruises. In 1981 to provide the same coverage will cost approximately $20 000, and doing transects only would cost about $8000.

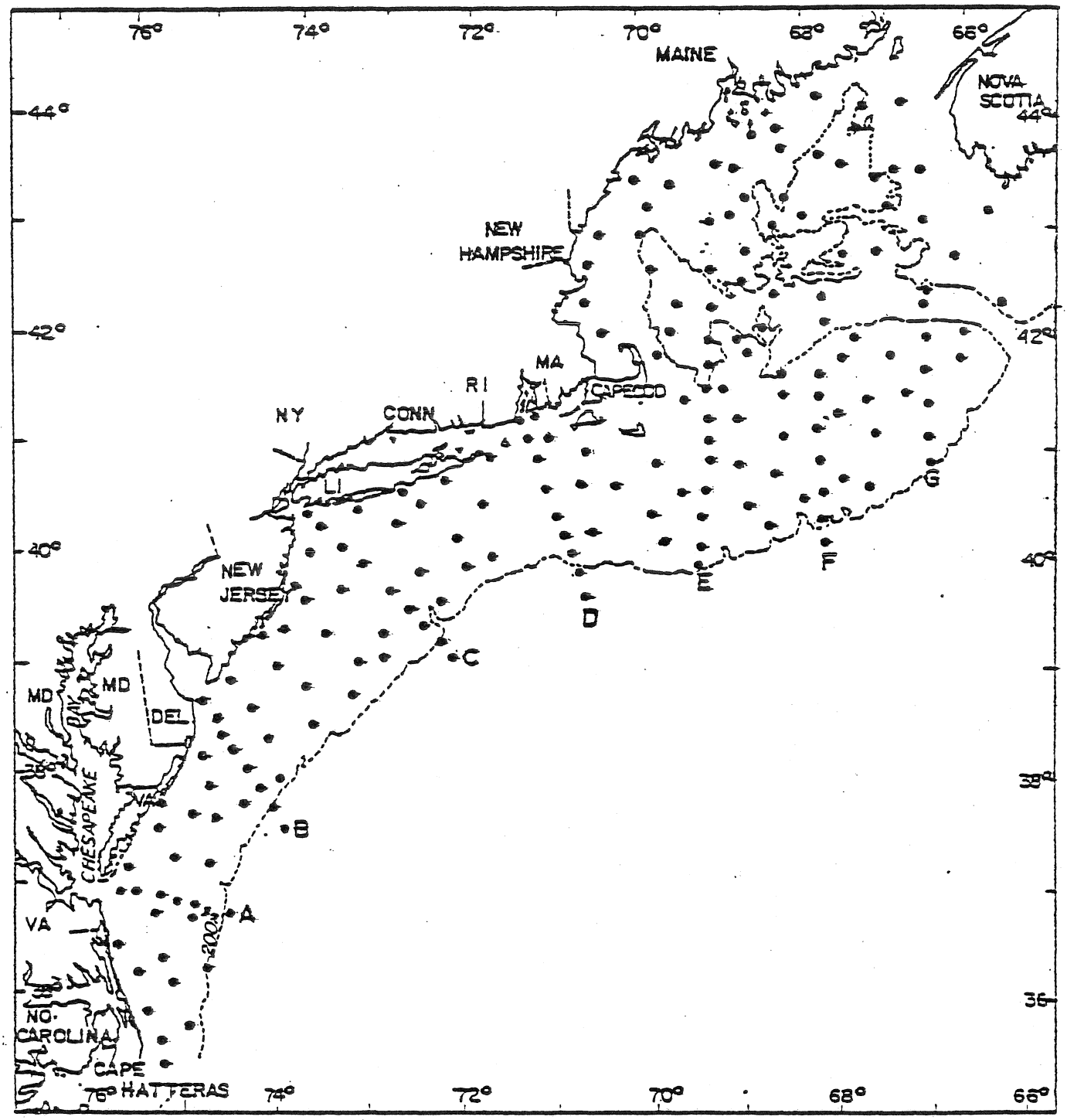
It is recommended therefore that

1. XBTs be used on MARMAP cruises, as presently conducted, only for backup in the event of loss or breaking of thermometers.

2. If an XBT is to be made at a MARMAP station, for any reason, it should be dropped at the same time as the messenger, to eliminate one major source of difference between the two techniques.

ACKNOWLEDGEMENTS

I wish to thank the following personnel from the Northeast Fisheries Center: Bruce Davis for collecting the data and drawning the bottle transects. Arthur Allen for helpful suggestions with the text and data analyses and Dr. Redwood Wright for reviewing the manuscript.



MARMAP Figure 1

1977 - XBT were taken on all stations.

1978 1979, 1980 - XBT were taken on only transect stations.

Duplicate sections based on XBT and reversing thermometer data are shown side by side on the following pages. In each case the thermometer section is on the left, with dots representing the depths of observations. The tables give data on observation times and bucket temperatures for the stations shown above. This information was not available for EVRIKA 80-01.

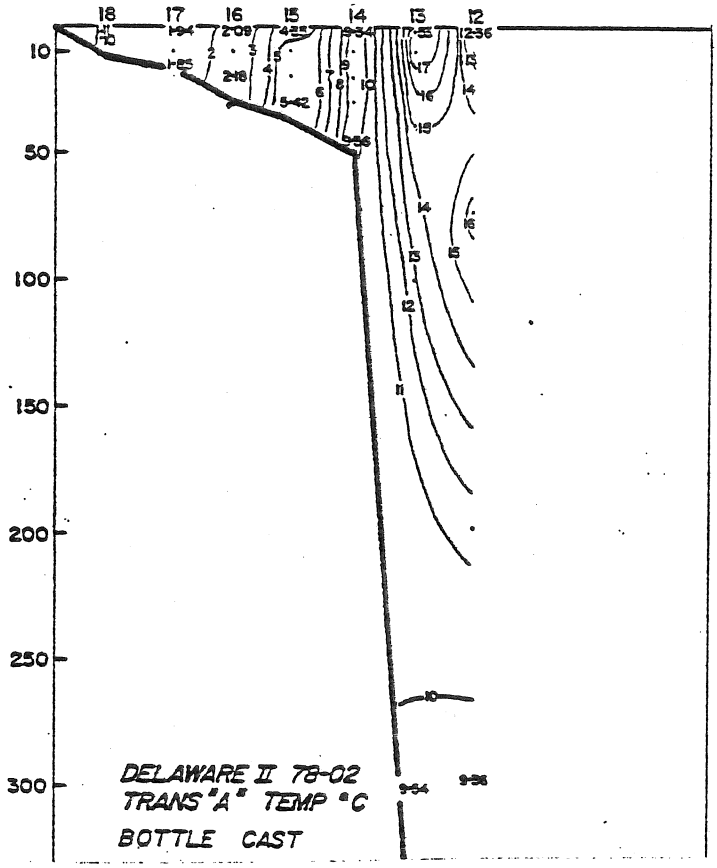


FIG.2a

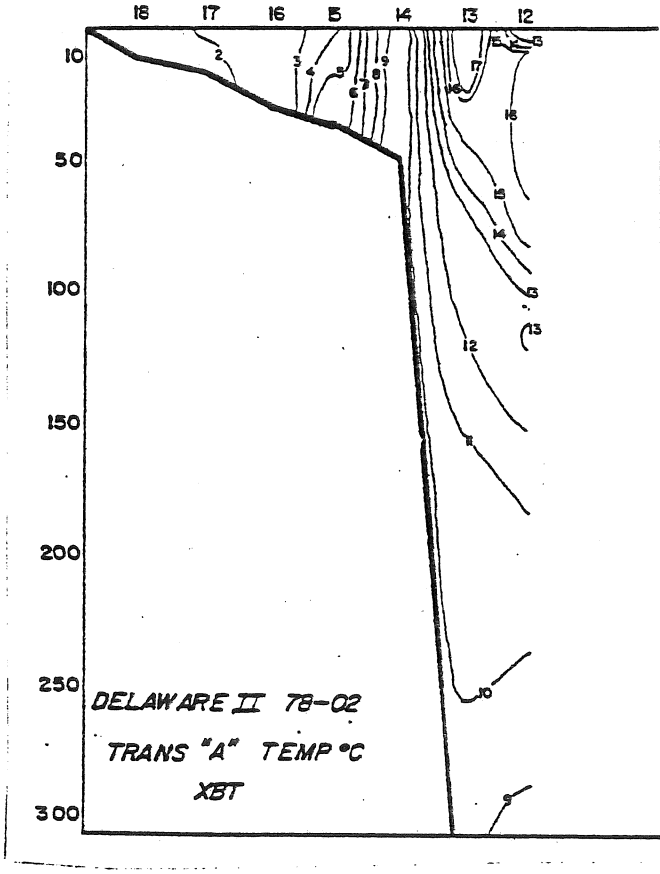


FIG. 2b

TABLE 1.

VESSEL	CRUISE	STN	TRANS	TIME OF XBT DROP	TIME OF BOTTLE CAST	TOTAL TIME DIFFERENCE	REMARKS: BUCKET TEMP
DELAWARE II	78-02	13	A	0525(GMT)	0540	15 MIN	1.2 °C
DELAWARE II	78-02	17	A	0347(GMT)	0402	15 MIN	2.0 °C
DELAWARE II	78-02	15	A	0215(GMT)	0230	15 MIN	2.5 °C
DELAWARE II	78-02	15	A	0020(GMT)	0037	17 MIN.	[illegible]
DELAWARE II	78-02	18	A	2229(GMT)	2255	26 MIN	[illegible]
DELAWARE II	78-02	19	A	1920(GMT)	1955	35 MIN	17.7 °C
DELAWARE II	78-02	12	A	1630(GMT)	1702	32 MIN.	12.8 °C

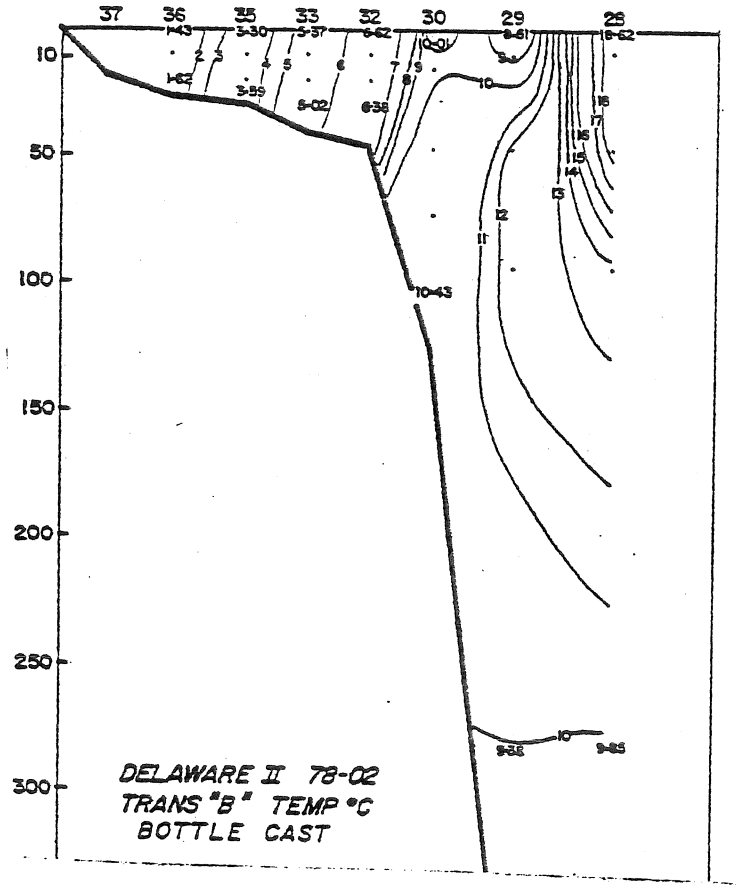


FIG. 3a

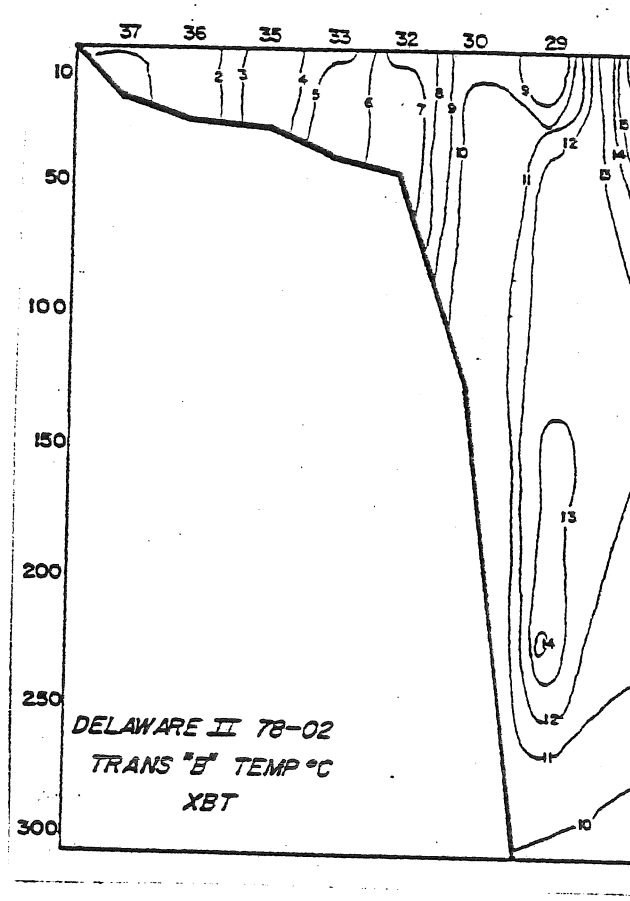


FIG. 3b

TABLE 2.

VESSEL	CRUISE	VESSEL	CRUISE	VESSEL	CRUISE	VESSEL	CRUISE
DELAWARE II	78-02	DELAWARE II	78-02	DELAWARE II	78-02	DELAWARE II	78-02
STN 37	TRANS B	STN 36	TRANS B	STN 30	TRANS B	STN 29	TRANS B
TIME OF XBT DROP 0940(GMT)		TIME OF XBT DROP 0783(GMT)		TIME OF XBT DROP 1607(GMT)		TIME OF XBT DROP 1304(GMT)	
TIME OF BOTTLE CAST 1001		TIME OF BOTTLE CAST 0792		TIME OF BOTTLE CAST 1634		TIME OF BOTTLE CAST 1334	
TOTAL TIME DIFFERENCE 21 MIN.		TOTAL TIME DIFFERENCE 9 MIN.		TOTAL TIME DIFFERENCE 27 MIN.		TOTAL TIME DIFFERENCE 30 MIN.	
REMARKS: BUCKET TEMP +0.8 °C		REMARKS: BUCKET TEMP 1.5 °C		REMARKS: BUCKET TEMP +0.8 °C		REMARKS: BUCKET TEMP +0.5 °C*	

VESSEL	CRUISE	VESSEL	CRUISE	VESSEL	CRUISE
DELAWARE II	78-02	DELAWARE II	78-02	DELAWARE II	78-02
STN 26	TRANS B	STN 22	TRANS B	STN 32	TRANS B
TIME OF XBT DROP 0512(GMT)		TIME OF XBT DROP 0132(GMT)		TIME OF XBT DROP 2230 (GMT)	
TIME OF BOTTLE CAST 0940		TIME OF BOTTLE CAST 0043		TIME OF BOTTLE CAST 2247	
TOTAL TIME DIFFERENCE 28 MIN.		TOTAL TIME DIFFERENCE 11 MIN.		TOTAL TIME DIFFERENCE 17 MIN.	
REMARKS: BUCKET TEMP +3.5 °C*		REMARKS: BUCKET TEMP +1.5 °C		REMARKS: BUCKET TEMP 0 °C NO BUCKET TAKEN	

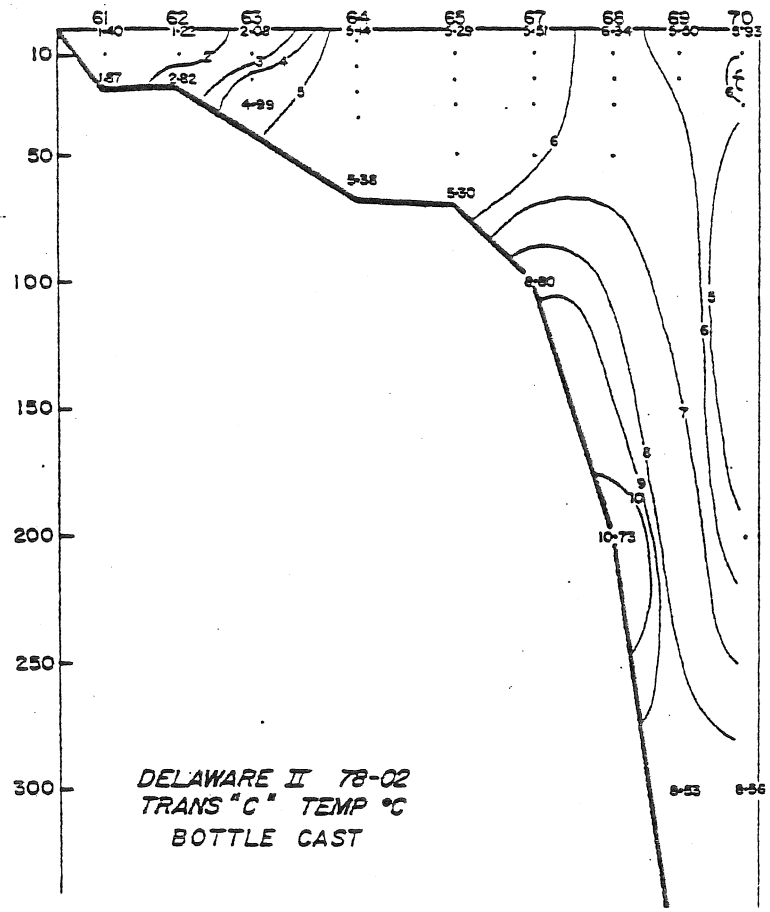


FIG.4a

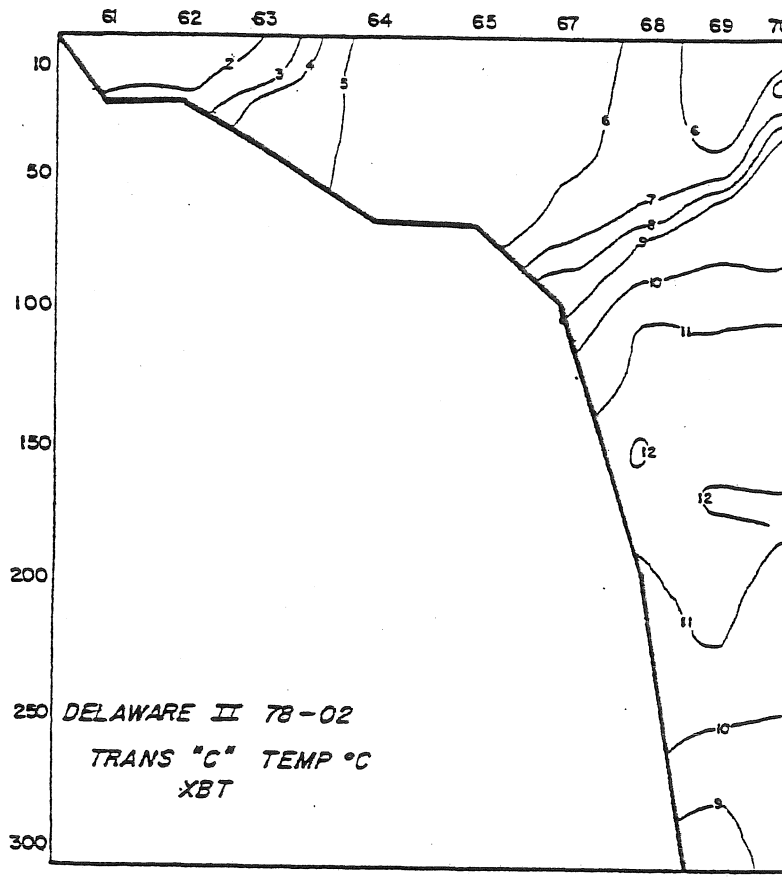


FIG.4b

TABLE 3

VESSEL	CRUISE	VESSEL	CRUISE	VESSEL	CRUISE
DELAWARE II	78-02	DELAWARE II	78-02	DELAWARE II	78-02
STN 61	TRANS C	STN 62	TRANS C	STN 63	TRANS C
TIME OF XBT DROP 1919(GMT)		TIME OF XBT DROP 2130(GMT)		TIME OF XBT DROP 2318(GMT)	
TIME OF BOTTLE CAST		TIME OF BOTTLE CAST		TIME OF BOTTLE CAST	
TOTAL TIME DIFFERENCE		TOTAL TIME DIFFERENCE		TOTAL TIME DIFFERENCE	
REMARKS: BUCKET TEMP +1.5 °C		REMARKS: BUCKET TEMP +1.2 °C		REMARKS: BUCKET TEMP +2.0 °C	

VESSEL	CRUISE	VESSEL	CRUISE	VESSEL	CRUISE
DELAWARE II	78-02	DELAWARE II	78-02	DELAWARE II	78-02
STN 64	TRANS C	STN 65	TRANS C	STN 67	TRANS C
TIME OF XBT DROP 0203(GMT)		TIME OF XBT DROP 0431(GMT)		TIME OF XBT DROP 2217(GMT)	
TIME OF BOTTLE CAST		TIME OF BOTTLE CAST		TIME OF BOTTLE CAST	
TOTAL TIME DIFFERENCE		TOTAL TIME DIFFERENCE		TOTAL TIME DIFFERENCE	
REMARKS: BUCKET TEMP °C		REMARKS: BUCKET TEMP +5.5 °C		REMARKS: BUCKET TEMP +5.5 °C	
NO BUCKET TAKEN					

VESSEL	CRUISE	VESSEL	CRUISE	VESSEL	CRUISE
DELAWARE II	78-02	DELAWARE II	78-02	DELAWARE II	78-02
STN 68	TRANS C	STN 69	TRANS C	STN 70	TRANS C
TIME OF XBT DROP 1251(GMT)		TIME OF XBT DROP 1500(GMT)		TIME OF XBT DROP 1719(GMT)	
TIME OF BOTTLE CAST		TIME OF BOTTLE CAST		TIME OF BOTTLE CAST	
TOTAL TIME DIFFERENCE		TOTAL TIME DIFFERENCE		TOTAL TIME DIFFERENCE	
REMARKS: BUCKET TEMP °C		REMARKS: BUCKET TEMP +5.7 °C		REMARKS: BUCKET TEMP +5.3 °C	
NO BUCKET TAKEN					

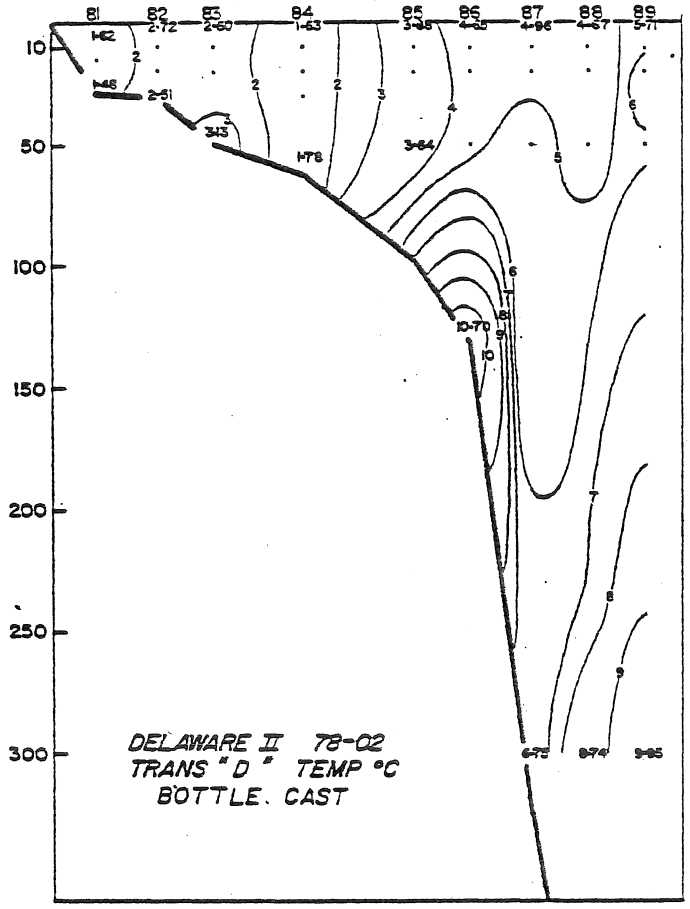


FIG. 5a

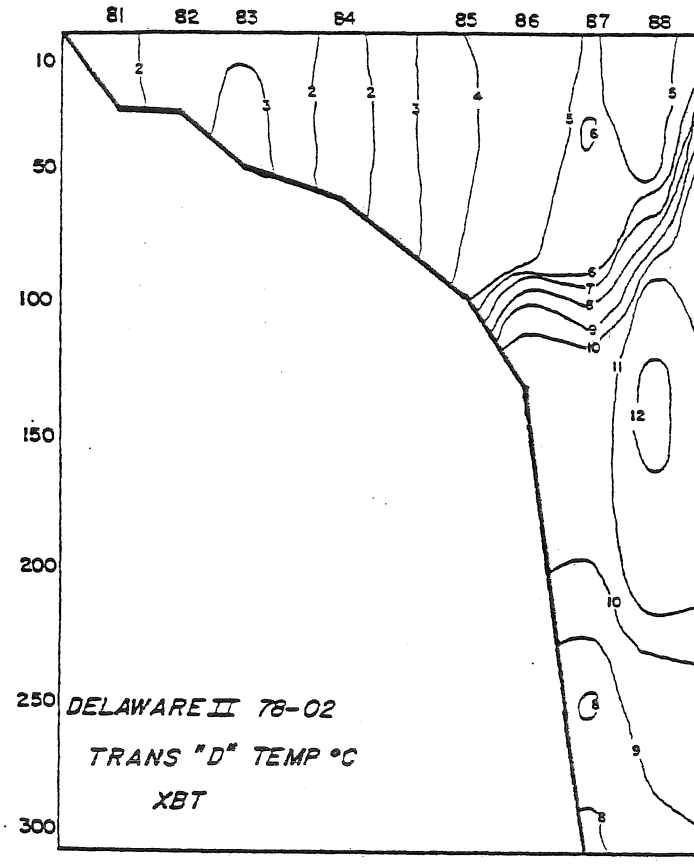


FIG. 5b

TABLE 4.

VESSEL	CRUISE	STN	TRANS	TIME OF XBT DROP	TIME OF BOTTLE CAST	TOTAL TIME DIFFERENCE	REMARKS
DELAWARE II	78-02	81	D	2223(GMT)	2232	10 MIN.	BUCKET TEMP +1.6 °C
DELAWARE II	78-02	82	D	0024 (GMT)	0044	20 MIN.	BUCKET TEMP +3.0 °C
DELAWARE II	78-02	83	D	0204(GMT)	0229	25 MIN.	BUCKET TEMP °C NO BUCKET
DELAWARE II	78-02	84	D	0432(GMT)	0447	25 MIN.	BUCKET TEMP +1.8 °C
DELAWARE II	78-02	85	D	1923 (GMT)	0749		BUCKET TEMP [illegible] °C
DELAWARE II	78-02	86	D	0923(GMT)	0948	25 MIN.	BUCKET TEMP [illegible] °C
DELAWARE II	78-02	87	D	1137(GMT)	1210	33 MIN.	BUCKET TEMP °C NO BUCKET
DELAWARE II	78-02	88	D	1404(GMT)	1438	34 MIN.	BUCKET TEMP °C NO BUCKET
DELAWARE II	78-02	89	D	1614(GMT)	1650	36 MIN.	BUCKET TEMP °C NO BUCKET

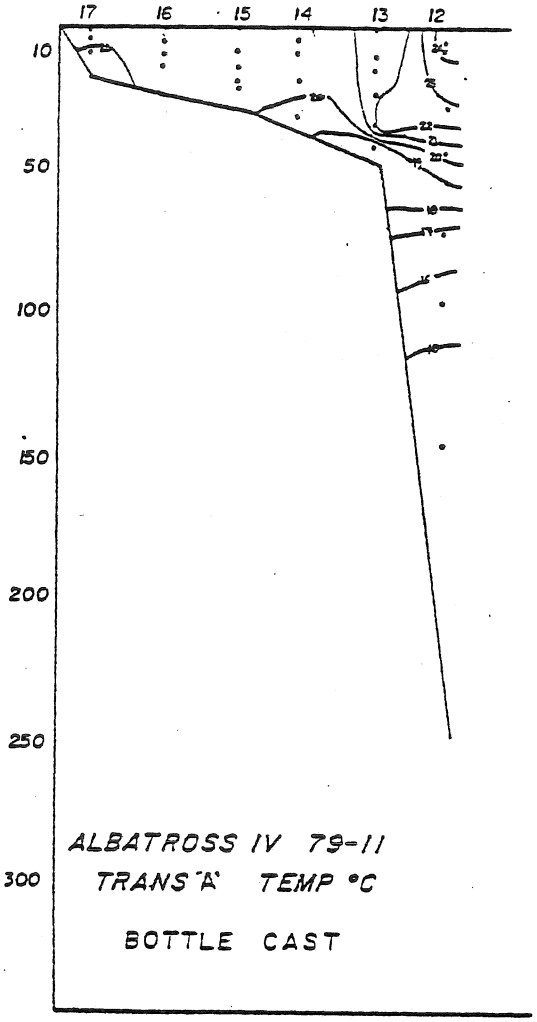


FIG. 6a

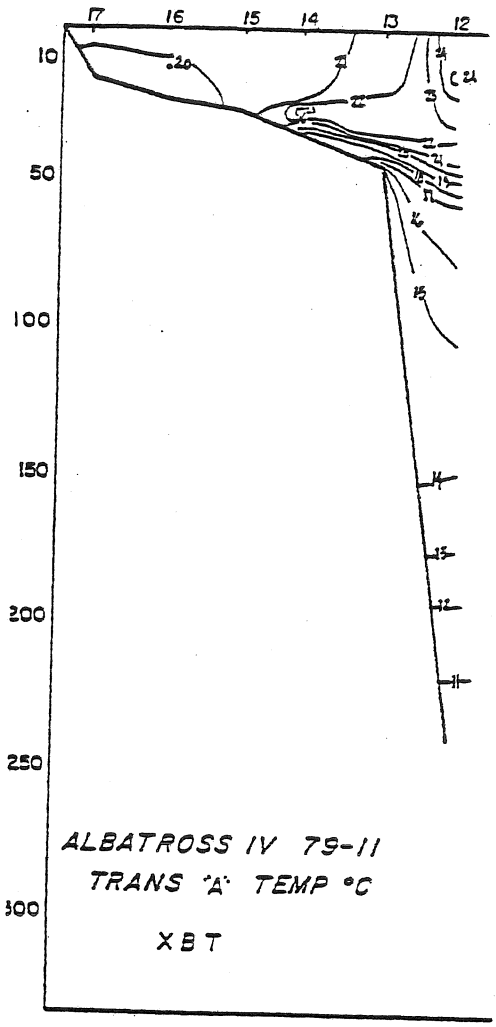


FIG. 6b

TABLE 5.

VESSEL: ALBATROSS IV	CRUISE: 79-11	VESSEL: ALBATROSS IV	CRUISE: 79-11	VESSEL: ALBATROSS IV	CRUISE: 79-11
STN: 17	TRANS: A	STN: 16	TRANS: A	STN: 15	TRANS: A
TIME OF XBT DROP: 0722(GMT)		TIME OF XBT DROP: 0439(GMT)		TIME OF XBT DROP: 0114(GMT)	
TIME OF BOTTLE CAST: 0735		TIME OF BOTTLE CAST: 0450		TIME OF BOTTLE CAST: 0134	
TOTAL TIME DIFFERENCE: 13 MIN.		TOTAL TIME DIFFERENCE: 11 MIN.		TOTAL TIME DIFFERENCE: 20 MIN.	
REMARKS: BUCKET TEMP +20.2°C		REMARKS: BUCKET TEMP +20.4°C		REMARKS: BUCKET TEMP +20.2°C	

VESSEL: ALBATROSS IV	CRUISE: 79-11	VESSEL: ALBATROSS IV	CRUISE: 79-11	VESSEL: ALBATROSS IV	CRUISE: 79-11
STN: 14	TRANS: A	STN: 13	TRANS: A	STN: 12	TRANS: A
TIME OF XBT DROP: 2001(GMT)		TIME OF XBT DROP: 1810(GMT)		TIME OF XBT DROP: 1509(GMT)	
TIME OF BOTTLE CAST: 2027		TIME OF BOTTLE CAST: 1825		TIME OF BOTTLE CAST: 1536	
TOTAL TIME DIFFERENCE: 26 MIN.		TOTAL TIME DIFFERENCE: 15 MIN.		TOTAL TIME DIFFERENCE: 27 MIN.	
REMARKS: BUCKET TEMP +20.5°C		REMARKS: BUCKET TEMP +21.2°C		REMARKS: BUCKET TEMP +24.1°C	

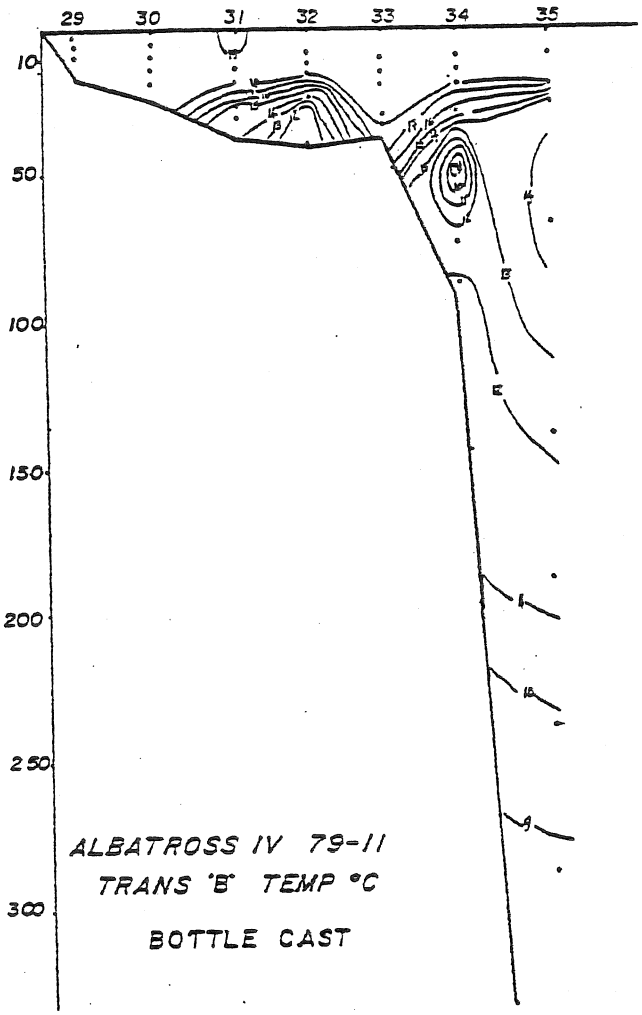


FIG. 7a

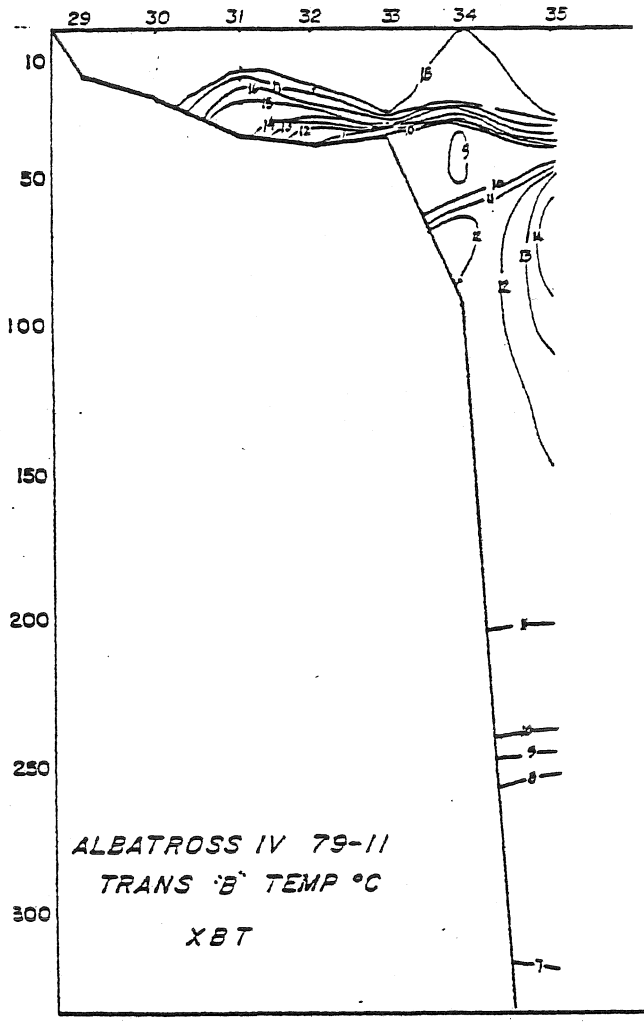


FIG. 7b

VESSEL	CRUISE	VESSEL	CRUISE	VESSEL	CRUISE
ALBATROSS IV	79-11	ALBATROSS IV	79-11	ALBATROSS IV	79-11
STN 29	TRANS B	STN 30	TRANS B	STN 31	TRANS B
TIME OF XBT DROP 1627(GMT)		TIME OF XBT DROP 1825(GMT)		TIME OF XBT DROP 2017(GMT)	
TIME OF BOTTLE CAST 1655		TIME OF BOTTLE CAST 1836		TIME OF BOTTLE CAST 2032	
TOTAL TIME DIFFERENCE 28 MIN.		TOTAL TIME DIFFERENCE 11 MIN.		TOTAL TIME DIFFERENCE 15 MIN.	
REMARKS: BUCKET TEMP +18.6°C		REMARKS: BUCKET TEMP +15.5°C		REMARKS: BUCKET TEMP +18.8 °C	

TABLE 6.

VESSEL	CRUISE	VESSEL	CRUISE	VESSEL	CRUISE	VESSEL	CRUISE
ALBATROSS IV	79-11	ALBATROSS IV	79-11	ALBATROSS IV	79-11	ALBATROSS IV	79-11
STN 32	TRANS B	STN 33	TRANS B	STN 34	TRANS B	STN 35	TRANS B
TIME OF XBT DROP 0613(GMT)		TIME OF XBT DROP 1745(GMT)		TIME OF XBT DROP 1950(GMT)		TIME OF XBT DROP 2201(GMT)	
TIME OF BOTTLE CAST 0632		TIME OF BOTTLE CAST 1803		TIME OF BOTTLE CAST 2006		TIME OF BOTTLE CAST 2241	
TOTAL TIME DIFFERENCE 19 MIN.		TOTAL TIME DIFFERENCE 18 MIN.		TOTAL TIME DIFFERENCE 16 MIN.		TOTAL TIME DIFFERENCE 40 MIN.	
REMARKS: BUCKET TEMP +18.7 °C		REMARKS: BUCKET TEMP +18.7 °C		REMARKS: BUCKET TEMP +18.0 °C		REMARKS: BUCKET TEMP +18.8 °C	

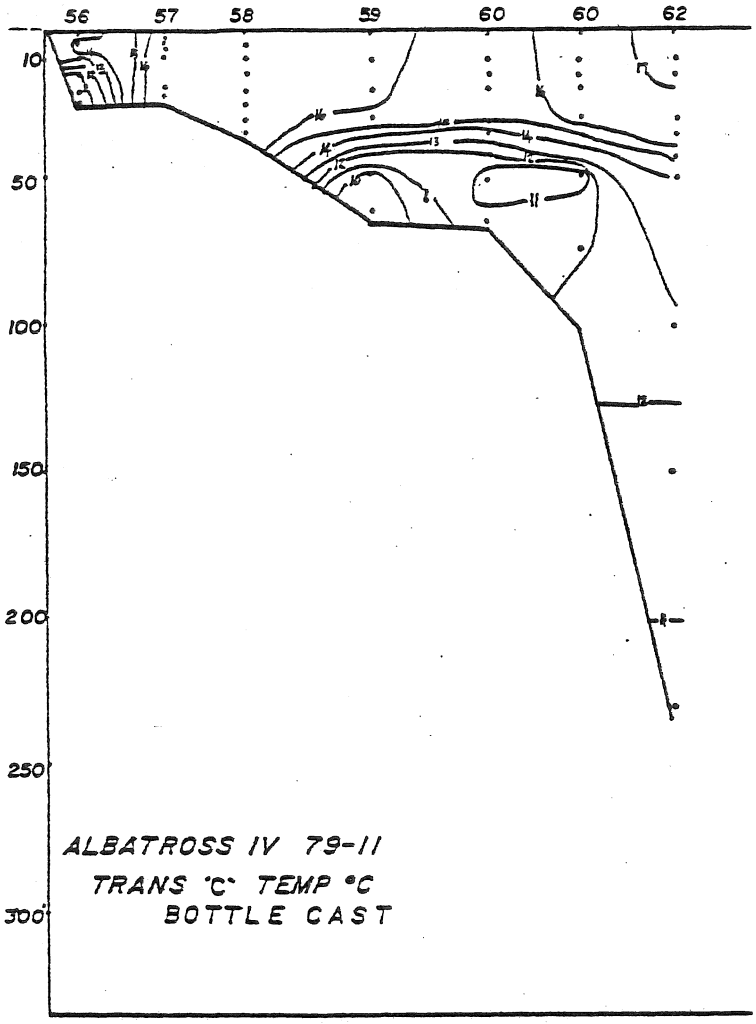


FIG. 8a

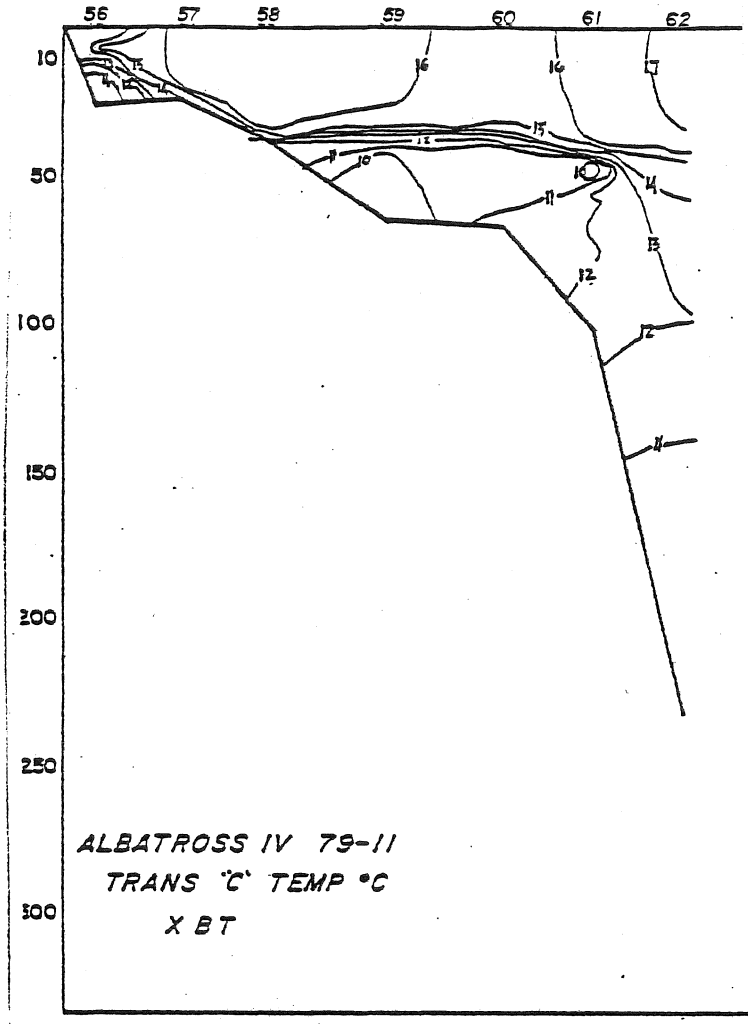


FIG. 8b

TABLE 7

VESSEL	ALBATROSS IV	CRUISE	79-11	VESSEL	ALBATROSS IV	CRUISE	79-11	VESSEL	ALBATROSS IV
STN	56	TRANS	C	STN	57	TRANS	C	STN	58
TIME OF XBT DROP	1416(GMT)			TIME OF XBT DROP	1611(GMT)			TIME OF XBT DROP	1820(GMT)
TIME OF BOTTLE CAST	1425			TIME OF BOTTLE CAST	1628			TIME OF BOTTLE CAST	1836
TOTAL TIME DIFFERENCE	11 MIN.			TOTAL TIME DIFFERENCE	17 MIN.			TOTAL TIME DIFFERENCE	16 MIN.
REMARKS:	BUCKET TEMP 13.2 °C			REMARKS:	BUCKET TEMP 16.2 °C			REMARKS:	BUCKET TEMP 16.0 °C

VESSEL	ALBATROSS IV	CRUISE	79-11	VESSEL	ALBATROSS IV	CRUISE	79-11	VESSEL	ALBATROSS IV
STN	59	TRANS	C	STN	60	TRANS	C	STN	61
TIME OF XBT DROP	2052(GMT)			TIME OF XBT DROP	2330(GMT)			TIME OF XBT DROP	0122(GMT)
TIME OF BOTTLE CAST	2105			TIME OF BOTTLE CAST	2341			TIME OF BOTTLE CAST	0139
TOTAL TIME DIFFERENCE	13 MIN.			TOTAL TIME DIFFERENCE	11 MIN.			TOTAL TIME DIFFERENCE	17 MIN.
REMARKS:	BUCKET TEMP 15.9 °C			REMARKS:	BUCKET TEMP 15.5 °C			REMARKS:	BUCKET TEMP 16.5 °C

VESSEL	ALBATROSS IV	CRUISE	79-11	VESSEL	ALBATROSS IV
STN	62	TRANS	C		
TIME OF XBT DROP	0358(GMT)				
TIME OF BOTTLE CAST	0422				
TOTAL TIME DIFFERENCE	24 MIN.				
REMARKS:	BUCKET TEMP 17.2 °C				

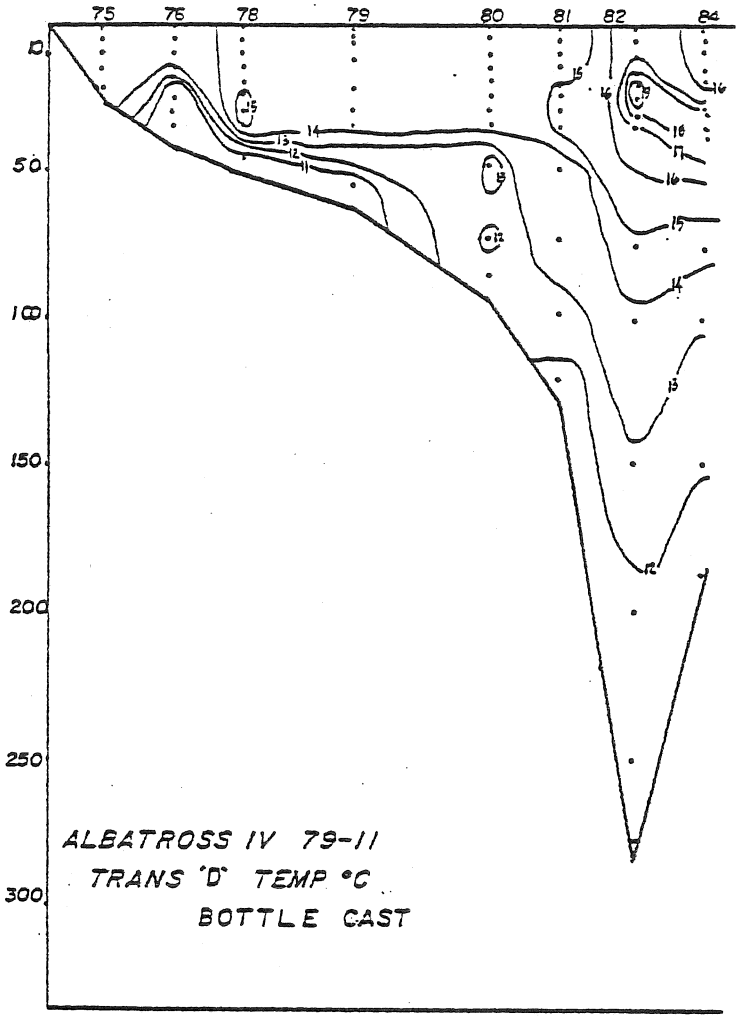


FIG. 9a

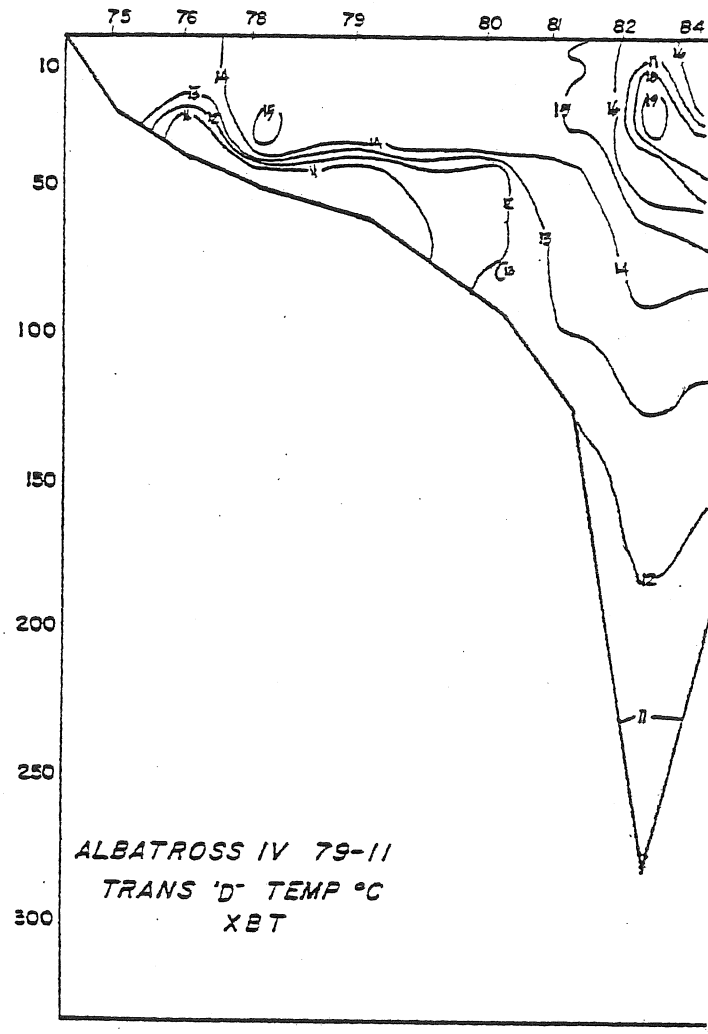


FIG. 9b

TABLE 8

VESSEL: ALBATROSS IV	CRUISE: 79-11
STN: 75	TRANS: D
TIME OF XBT DROP	0728(GMT)
TIME OF BOTTLE CAST	0789
TOTAL TIME DIFFERENCE	21 MIN.
REMARKS: BUCKET TEMP	13.8 °C

VESSEL: ALBATROSS IV	CRUISE: 79-11
STN: 76	TRANS: D
TIME OF XBT DROP	0940(GMT)
TIME OF BOTTLE CAST	1008
TOTAL TIME DIFFERENCE	28 MIN.
REMARKS: BUCKET TEMP	13.8 °C

VESSEL: ALBATROSS IV	CRUISE: 79-11
STN: 78	TRANS: D
TIME OF XBT DROP	1326(GMT)
TIME OF BOTTLE CAST	1332
TOTAL TIME DIFFERENCE	6 MIN.
REMARKS: BUCKET TEMP	18.2 °C

VESSEL: ALBATROSS IV	CRUISE: 79-11
STN: 79	TRANS: D
TIME OF XBT DROP	1550(GMT)
TIME OF BOTTLE CAST	1639
TOTAL TIME DIFFERENCE	40 MIN.
REMARKS: BUCKET TEMP	14.6 °C

VESSEL: ALBATROSS IV	CRUISE: 79-11
STN: 80	TRANS: D
TIME OF XBT DROP	1938(GMT)
TIME OF BOTTLE CAST	1957
TOTAL TIME DIFFERENCE	19 MIN.
REMARKS: BUCKET TEMP	14.5 °C

VESSEL: ALBATROSS IV	CRUISE: 79-11
STN: 81	TRANS: D
TIME OF XBT DROP	2145(GMT)
TIME OF BOTTLE CAST	2205
TOTAL TIME DIFFERENCE	20 MIN.
REMARKS: BUCKET TEMP	14.8 °C

VESSEL: ALBATROSS IV	CRUISE: 79-11
STN: 82	TRANS: D
TIME OF XBT DROP	2340(GMT)
TIME OF BOTTLE CAST	0003
TOTAL TIME DIFFERENCE	23 MIN.
REMARKS: BUCKET TEMP	15.2 °C

VESSEL: ALBATROSS IV	CRUISE: 79-11
STN: 84	TRANS: D
TIME OF XBT DROP	0440(GMT)
TIME OF BOTTLE CAST	0506
TOTAL TIME DIFFERENCE	26 MIN.
REMARKS: BUCKET TEMP	15.8 °C

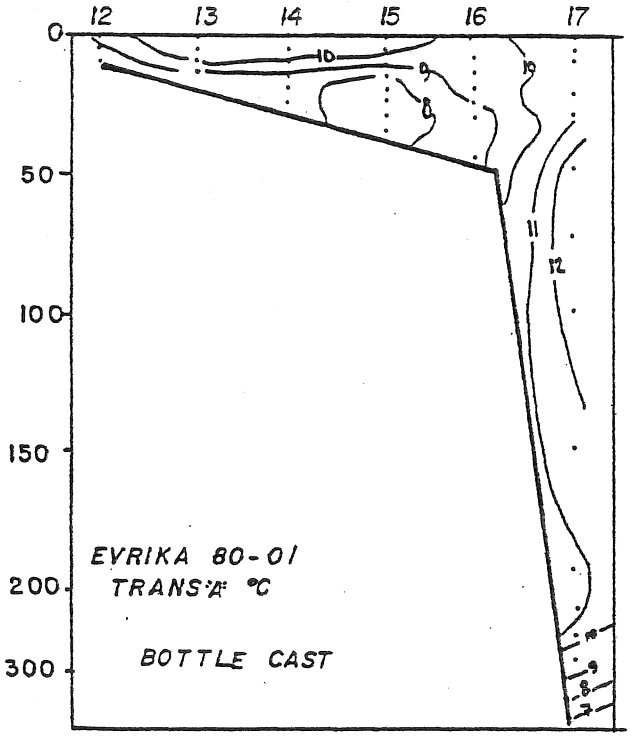


FIG. 10a

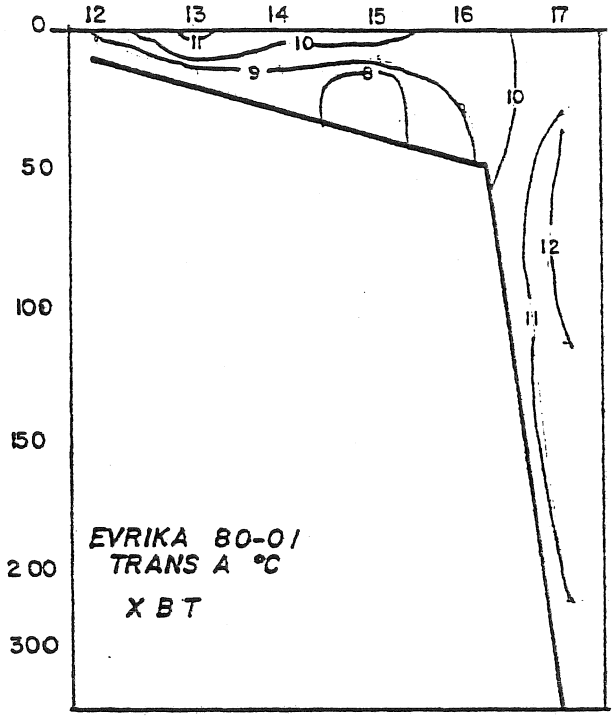


FIG. 10b

FIG. 11a

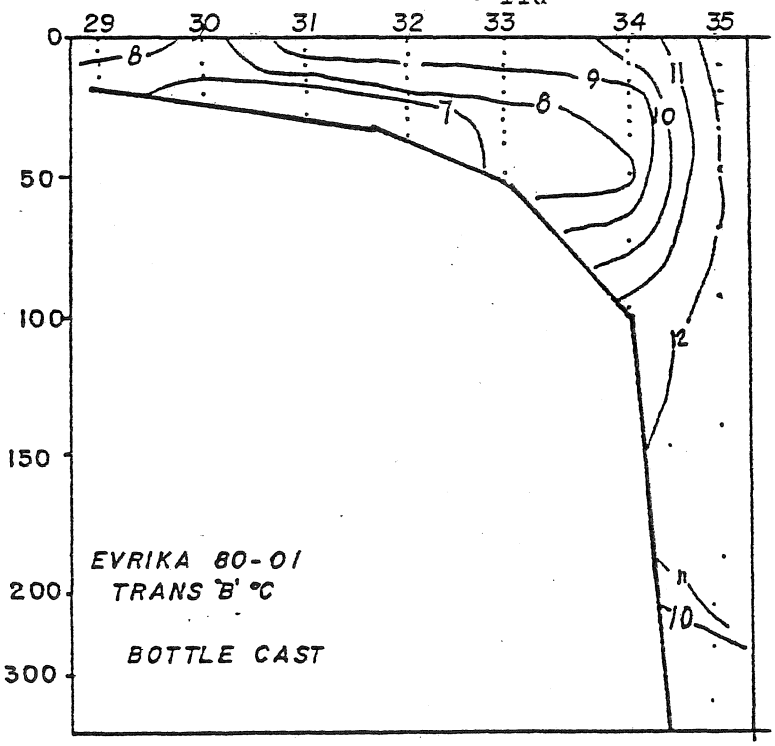
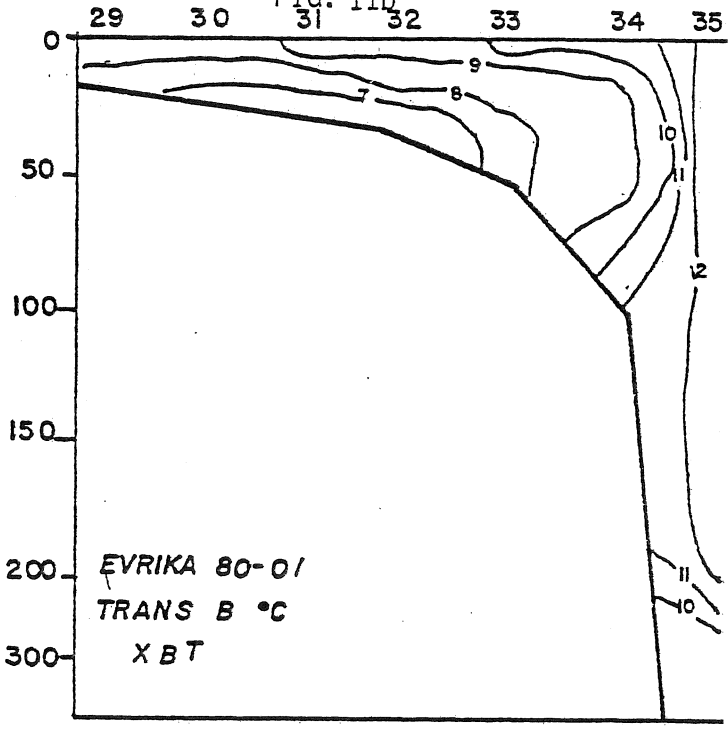


FIG. 11b



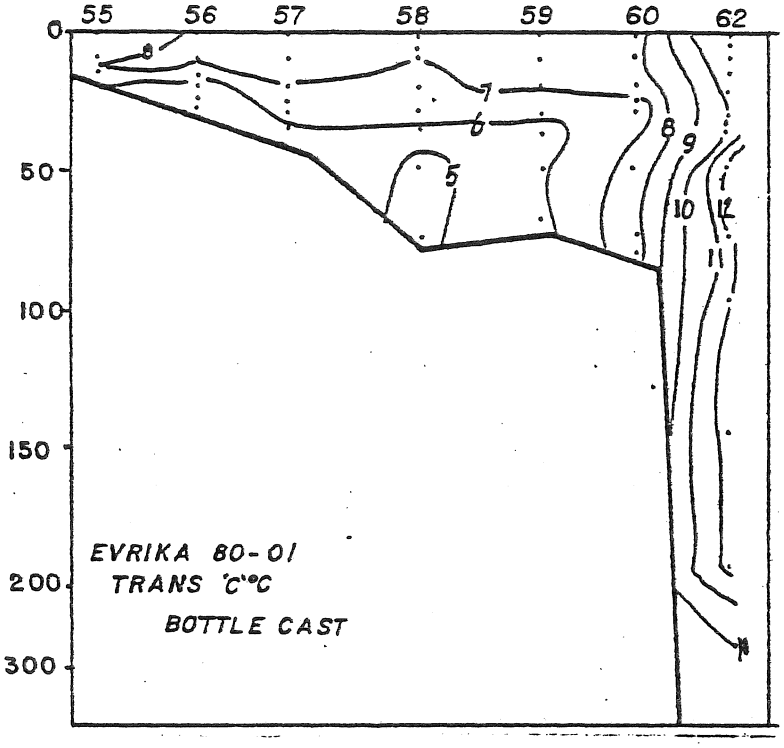


FIG. 12a

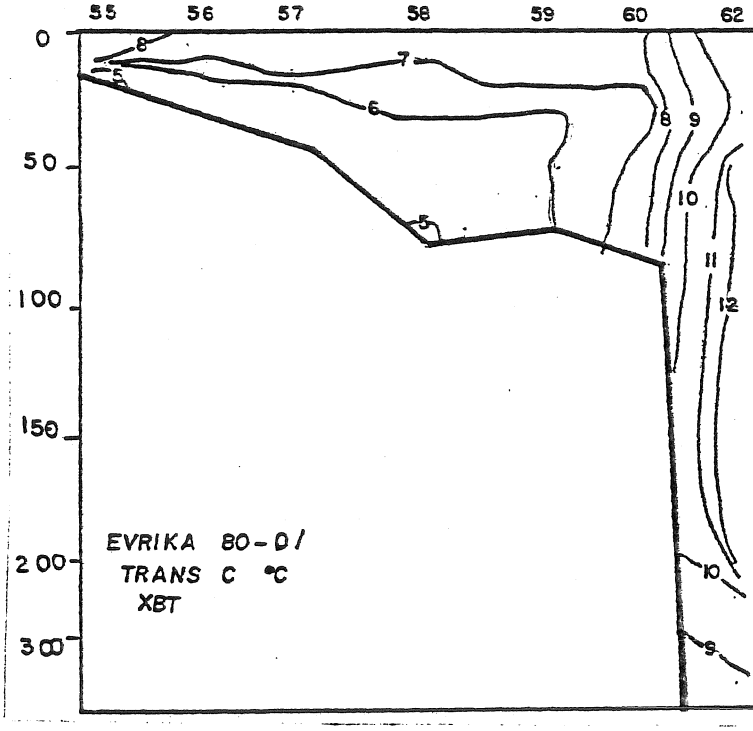


FIG. 12b

FIG. 13a

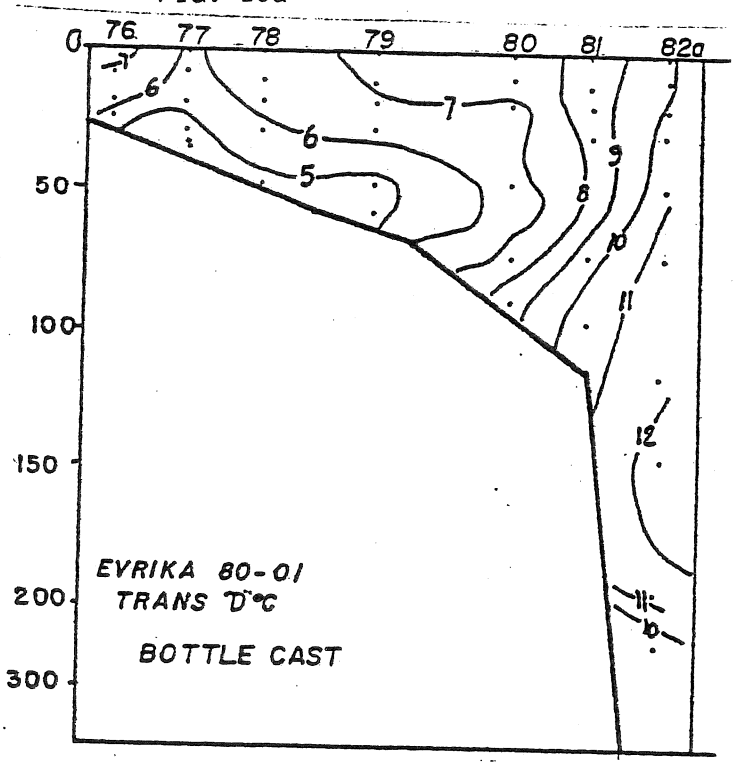
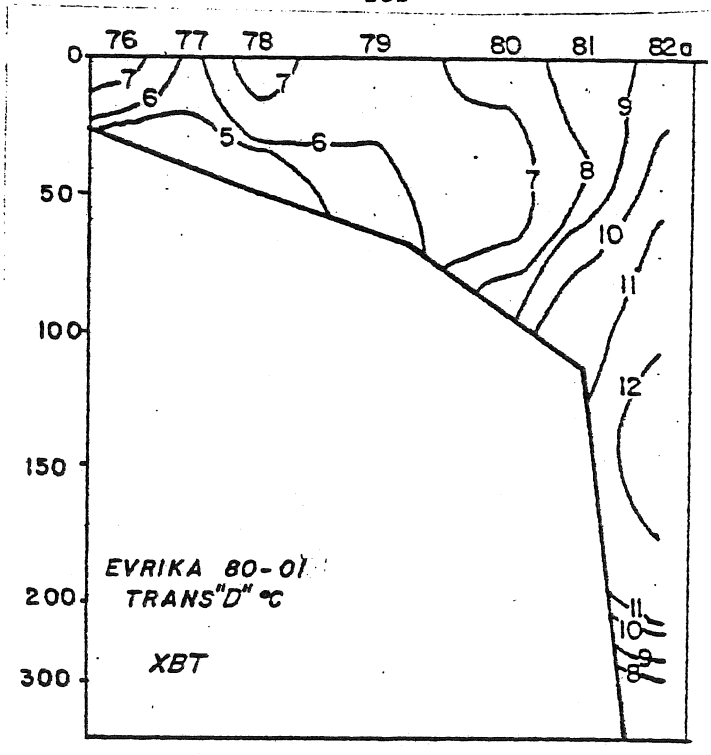



FIG. 13b