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Description of the Oceanographic Conditions on the Northeast Continental Shelf: 1977-1985

by

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Abstract

Oceanographic observations from 42 surveys during 1977-1985 on the Northeast Continental Shelf are reported. Surface and bottom distributions and cross-shelf vertical distributions of both temperature and salinity are presented in the form of contour maps. Average values for specific regions of the shelf and layers of the water column are presented in the form of time series plots.

Introduction

In an attempt to monitor the seasonal and inter-annual variability of the physical environment on the Northeast Continental Shelf, the National Marine Fisheries Service occupied 184 standard stations from Cape Hatteras, North Carolina to Cape Sable, Nova Scotia as part of the Marine Resources Monitoring, Assessment , and Prediction (MARMAP) program (Sherman 1980).

Observations from July 1977 to December 1985, a total of 42 surveys, are reported graphically (see Table 1). Although portions of these data have been portrayed elsewhere (Patanjo 1980; Nickerson and Mountain 1983), they are included in this volume in order to make it a complete report. Observations from 1986 and 1987, the final two years of MARMAP cruises, are reported elsewhere in Manning and Lierheimer (1988) and Holzwarth and Manning (1989), respectively. Intrepretations and analyses of MARMAP data are given in Mountain and Jessen (1987) and Manning (unpublished).

The data portrayals are organized sequentially by cruise in atlas form. No attempt is made to analyze the data or even to discuss individual observations. Except for the case of surface and bottom temperature anomaly plots, actual observations (*i.e.* the raw data) are input to the contouring software.

Methods

Niskin bottles made of PVC with reversible thermometers were used to sample temperature and salinity at standard water depths (1, 5, 10, 15, 20, 25, 30, 35, 50, 75, 100, 150, 200, 250, 300 m) for each station occupied. Surface temperatures were checked with a concurrent bucket sample. Bottom observations were taken from the deepest bottle within 10 m of the bottom to a maximum of 300 m, except in water less than 75 m. There, a special bottom-tripped bottle was used to obtain a salinity sample from within 1 m of the bottom. Salinity samples were analyzed with a Guildline Autosal salinometer. Details of the procedures at sea may be found in Kirschner (1980) and Patanjo, Nickerson, and Steimle (1982).

Several other parameters such as nutrients, ichthyoplankton, zooplankton, oxygen, and chlorophyll were measured concurrently with the hydrographic work (see Sibunka and Silverman 1984; Morse, Fahay, and Smith 1987; Zetlin and O'Reilly, unpublished; Waldhauer, unpublished). Occasionally, in order to investigate a particular feature, extra stations were occupied in addition to the standard set. These extra stations, typically less than 10 per cruise, are indicated on the individual station plots by numbers greater than 199.

A set of cross-shelf transects, labeled A through G in Figure 2, are part of the standard grid. Each transect consists of closely spaced stations designed to sample the structure of the Shelf Water synoptically (one to three days per transect). The typical distance between these stations was 20 km. The seaward limit of the transects was typically near the shelf break, often far enough seaward to capture the features of the shelf/slope water interface.

Temperature anomalies were calculated

Table 1. MARMAP transect coverage, 1977-1985.

Cruise	Date	A	B	C	D	E	F	G
YU7702	31 JUL-3 SEP	*				*	*	
AR7701	15 OCT-11 NOV	–	–	*	*	*	*	
MT7711	12-19 NOV							–
KE7711	25 NOV-4 DEC				–	–	–	
DE7802	14 FEB-13 MAR	–	–	–	*	–		
AR7804	13 APR-24 MAY	*	–	–	*	–	*	
AL7807	22 JUN-1 JUL	–	–	–	–	–	*	
BE7801	9 AUG-5 SEP	–	–	–	–	–	–	–
BE7803	5 OCT-2 NOV				–	–	–	
BE7804	15-30 NOV				*	*	–	
DE7903	23 FEB-15 MAR	*	*	*	*	*		
DE7905	4-29 MAY	–	–	–	–	–	–	–
AL7906	12 JUN-14 JUL	–	–	–	–	–	–	
BE7901	9 AUG-3 SEP	–	–	–	–	–	–	
AL7911	1-29 OCT	–	–	–	–	–	–	–
AL7913	14 NOV-21 DEC				–		–	–
WI8002	18 FEB-11 MAR				*	–	*	
AL8002	27 FEB- 5 APR	–	–	*	–	–	–	–
EV8001	14 APR-15 MAY	–	–	–	–	–	–	
DE8003	21 MAY-13 JUN	–	–	–	–	–		
EV8004	24 JUN-30 JUN						–	
EV8006	18 JUL-11 AUG	–	*	–	–	–	*	
AL8010	24 SEP-30 OCT	–	–	–	–	–	–	–
AL8012	17 NOV-23 DEC	–	–	–	–	–	–	–
AL8101	17 FEB-26 MAR		*	–	–	–	–	–
KE8103	18 MAR- 9 APR	*	–	–	*	*	–	*
DE8103	20 MAY-18 JUN		–	–	*	–	–	*
AL8114	16 NOV-22 DEC				–	–	–	–
AL8202	16 FEB-25 MAR	–	–	–	–	–	–	–
DE8203	17 MAY-22 JUN			*	–	–	–	*
DE8209	15 NOV-22 DEC		–	*	*	–	–	*
DE8301	24 JAN-11 FEB					*	*	–
AL8304	23 MAY-22 JUN	–	–	–	–	–	–	–
DE8309	14 NOV-21 DEC	–	–	–	–	–	–	–
DE8401	9 JAN-10 FEB	–	–	–	–	–	–	–
AL8403	7 MAY- 3 JUN	–	–	–	–	–	–	–
DE8409	29 NOV- 7 DEC	–	–	–	*	*	*	
DE8501	7 JAN- 8 FEB	–	–	–	–	–	–	*
DE8503	1 APR- 2 MAY	–	–	–	–	–	–	*
AL8504	8 MAY- 6 JUN	–	–	–	*	*	–	*
DE8507	26 AUG-22 SEP	–	–	–	–	–	–	*
DE8510	5 NOV-12 DEC	–	–	–	–	–	–	–

– = complete transects
* = incomplete transects, at least one standard station missing

for the surface and bottom temperature observations at each standard MARMAP station on all of the surveys. An anomaly is the difference between the observed temperature and the expected temperature at the station for the day of the year the observation was made. The expected temperature was determined from a mean annual temperature curve derived from all of the MARMAP observations at the standard station (see Mountain and Holzwarth, in press). The anomaly value was normalized by dividing it by the standard deviation associated with the fitting of the annual curve. This normalized anomaly indicates the significance of the temperature anomaly, i.e., the number of standard deviations from the mean or expected value.

Data Portrayals

A series of figures which portray some of the more significant features of the physical oceanographic structure are appended. For each cruise, a station plot is followed by computer-generated contour plots of the temperature and salinity distribution for both the surface and the bottom. In the case of temperature, where the seasonal cycle is well defined (Mountain and Holzwarth, in press), standardized anomalies are contoured as well. Anomalies greater than two standard deviations from the mean are hachured. Horizontal and vertical hachuring represent cold and warm anomalies, respectively.

The contour plots were generated using the Interactive Concepts Incorporated Surface3 software package on a VAX 11/785 computer. Since the contouring is done by computer, there are inevitable inadequacies in the output. There may be, therefore, undetectable interpolation/extrapolation errors, especially near the survey boundaries. Hence, one should treat the contoured data as computerized estimates rather than actual observations.

Cross-shelf profiles of both temperature and salinity are included for all transects (A-G) whenever at least four stations were occupied. On some cruises, the transects were extended either onshore or offshore by a few extra stations; but, in order to be consistent and retain a synoptic (less than a few days) representation of the cross-shelf structure, only the standard stations were included in the cross-sectional contour plots. No more than seven stations were included in any contoured section. Axis labels, meters in the vertical and kilometers in the horizontal, were omitted to maximize plotting space on the page.

Finally, after data from each cruise are presented, a set of time- series plots are used to display average temperature and salinity for different layers of the water column and regions of the shelf. Various regions of the shelf are shown in Figure 3. In order to focus on shelf water and to eliminate the overwhelming influence of small slope water intrusions onto the shelf area, water greater than 34 PSU was omitted from these calculations. Each cruise, represented by a single point, is coded by year and plotted on a yearday axis (Figures 250-261). The seasonal cycle is represented by the solid lines along with its associated standard deviation (dashed lines). As explained in Mountain and Holzwarth (in press), this is a multiple linear regression of one, two, and three cycles per year. In their report, the regression is conducted on the surface and bottom values of each MARMAP station but, here, it is presented for large regions of the shelf and layers of the water column. In this way, one may distinguish both seasonal and inter-annual variability of broad scale features.

Acknowledgements

The authors would like to thank Lisa Lierheimer, Dan Patanjo, and all others who helped process the data. Thanks also to David Mountain for providing the seasonal temperature cycle, the associated graphics (Figures 250-261), and for overseeing our work in general.

References

Holzwarth, T.J. and J. Manning. 1989. Description of the 1986 oceanographic conditions of the northeast continental shelf. Woods Hole, MA: Northeast Fisheries Center. Reference Document 89-03. Available from: Northeast Fisheries Center; Woods Hole, MA; 02543.

Kirschner, R.A. 1980. Hydrographic work on MARMAP Cruises. Woods Hole, MA: Northeast Fisheries Center. Woods Hole Laboratory Reference Document 80-25. Available from: Northeast Fisheries Center; Woods Hole, MA; 02543.

Manning, J.P. (unpublished). Middle Atlantic Bight salinity and the influence of local meteorolgic processes. Manuscript available from the author: Northeast Fisheries Center; Woods Hole, MA; 02543.

Manning, J.P. and L.J. Lierheimer. 1988. Description of the 1987 oceanographic conditions of the northeast continental shelf. Woods Hole, MA: Northeast Fisheries Center. Woods Hole Reference Document 88-01. Available from: Northeast Fisheries Center, Woods Hole, MA; 02543.

Morse, W.W., M.P. Fahay, and W.G. Smith. 1987. MARMAP surveys of the Continental Shelf from Cape Hatteras, North Carolina, to Cape Sable, Nova Scotia (1977-1984): Atlas No. 2 Annual distribution patterns of fish larvae. Woods Hole, MA: Northeast Fisheries Center. NOAA Technical Memorandum NMFS-F/NEC-47. Available from: Northeast Fisheries Center; Woods Hole, MA; 02543.

Mountain, D.G. and P.F. Jessen. 1987. Bottom waters of the Gulf of Maine, 1978-1983. *J. Mar. Res.* 45:319-345

Mountain, D.G. and T.J. Holzwarth. (in press). The annual cycle of surface and bottom temperature on the Northeast Continental Shelf. Woods Hole, MA: Northeast Fisheries Center. NOAA Technical Memorandum NMFS-F/NEC. Available when published from: Northeast Fisheries Center; Woods Hole, MA; 02543.

Nickerson, S.R. and D.G. Mountain. 1983. Surface and bottom temperature and bottom salinity distributions on the continental shelf, Cape Hatteras to Cape Sable from MARMAP Cruises, 1977-1982. Woods Hole, MA: Northeast Fisheries Center. Woods Hole Laboratory Reference Document 83-09. Available from: Northeast Fisheries Center; Woods Hole, MA; 02543.

Patanjo, D., S.R. Nickerson, and F. Steimle. 1982. Report on temperature, salinity, and dissolved oxygen measurements made on MARMAP Surveys between October 1977 - December 1978. Woods Hole, MA: Northeast Fisheries Center. Woods Hole Laboratory Reference Document 82-03. MARMAP contribution MED/NEFC 82-11. Available from: Northeast Fisheries Center; Woods Hole, MA; 02543.

Sherman, K. 1980. MARMAP, a fisheries ecosystem study in the Northwest Atlantic: fluctuations in ichthyoplankton-zooplankton components and their potential for impact on the system. In *Advanced Concepts on Ocean Measurements for Marine Biology*, eds. F.P. Diemer, F.J. Vernberg, and D.Z. Mirkes, pp. 9-37. Columbia, SC: University of South Carolina Press.

Sibunka, J.D. and M.J.Silverman. 1984. MARMAP surveys of the continental shelf from Cape Hatteras, North Carolina, to Cape Sable, Nova Scotia (1977-1984): Atlas No. 1 Summary of operations. Woods Hole, MA: Northeast Fisheries Center. NOAA Technical Memorandum NMFS-F/NEC-33. Available from: Northeast Fisheries Center; Woods Hole, MA; 02543,

Waldhauer, R. (unpublished). Nutrient distributions on the northeast continental shelf: 1977-1985. Manuscript available from the author: Northeast Fisheries Center; Sandy Hook Laboratory; PO Box 428; Highlands, NJ; 07732.

Zetlin, C. and J. O'Reilly. (unpublished). Chlorophyll distributions on the Northeast Continental Shelf: 1977-1985. Manuscript available from the authors: Northeast Fisheries Center; Sandy Hook Laboratory; PO Box 428; Highlands, NJ; 07732.

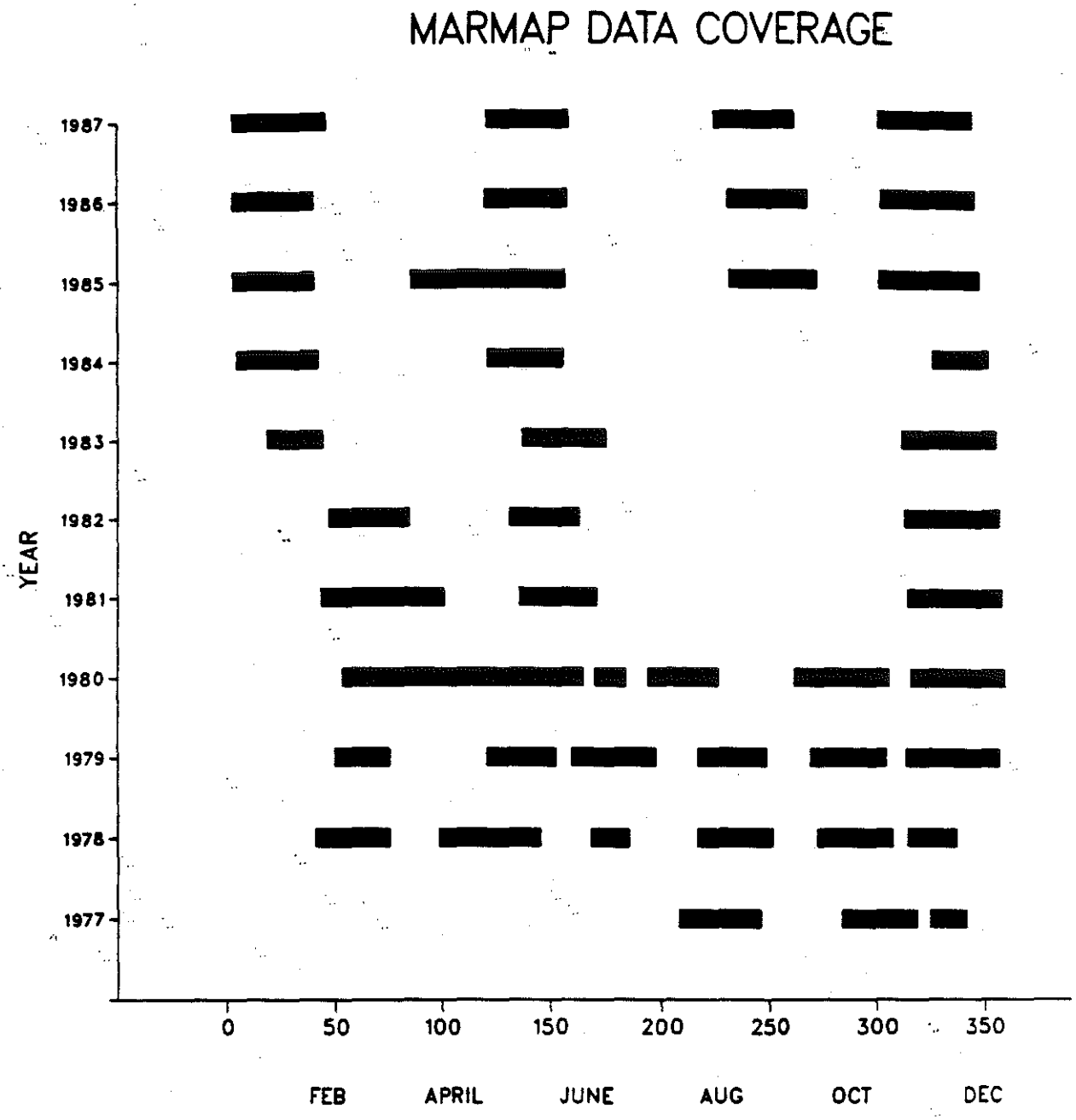


Figure 1. Timing of MARMAP sampling, 1977-1987.

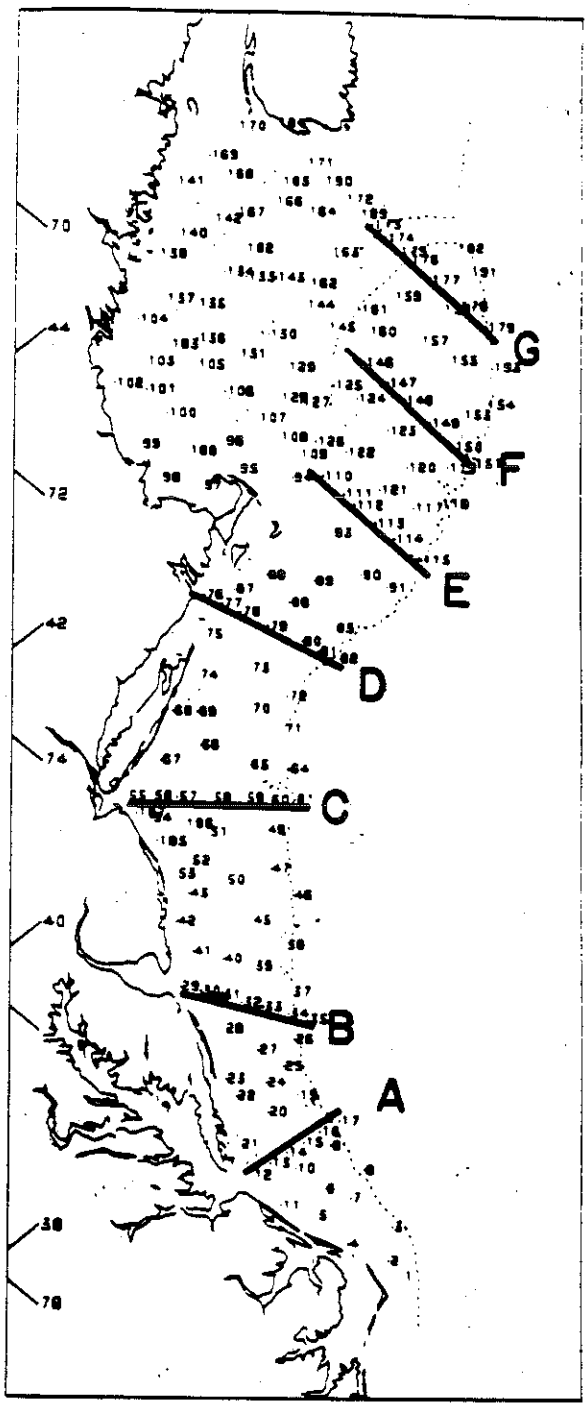


Figure 2. Standard MARMAP stations.

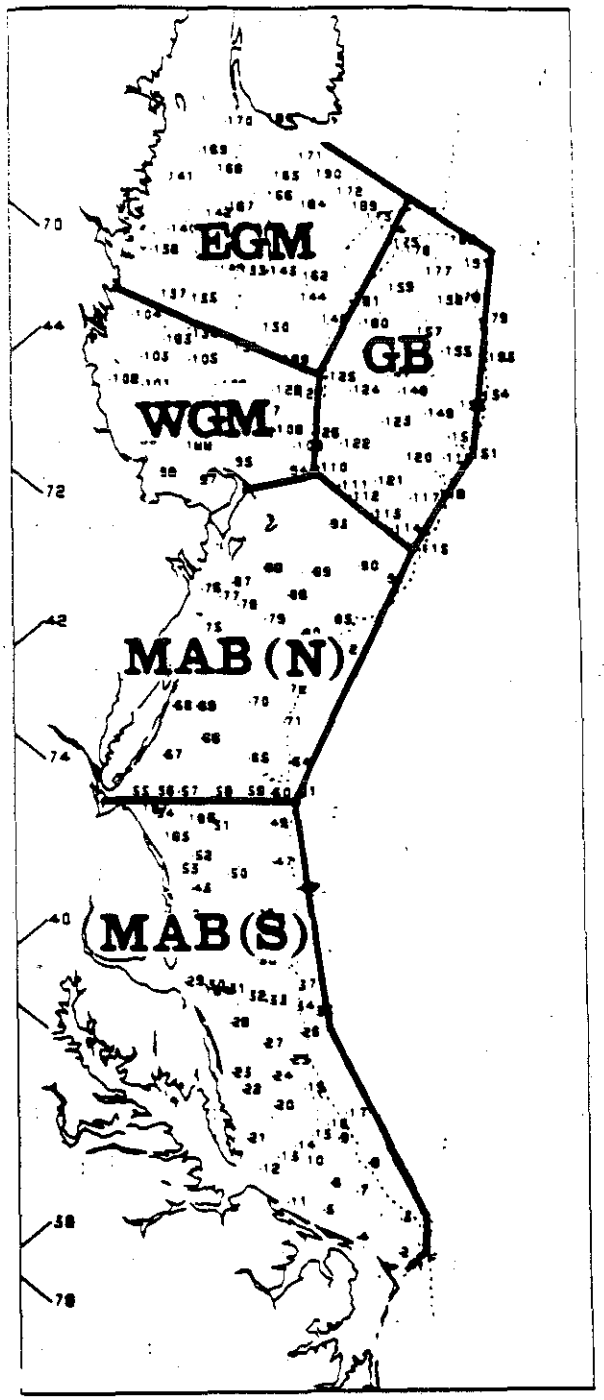


Figure 3. Five regions on the Northeast Continental Shelf: Eastern Gulf of Maine (EGM), Western Gulf of Maine (WGM), Georges Bank (GB), Northern Middle Atlantic Bight (MABN) and Southern Middle Atlantic Bight (MABS).

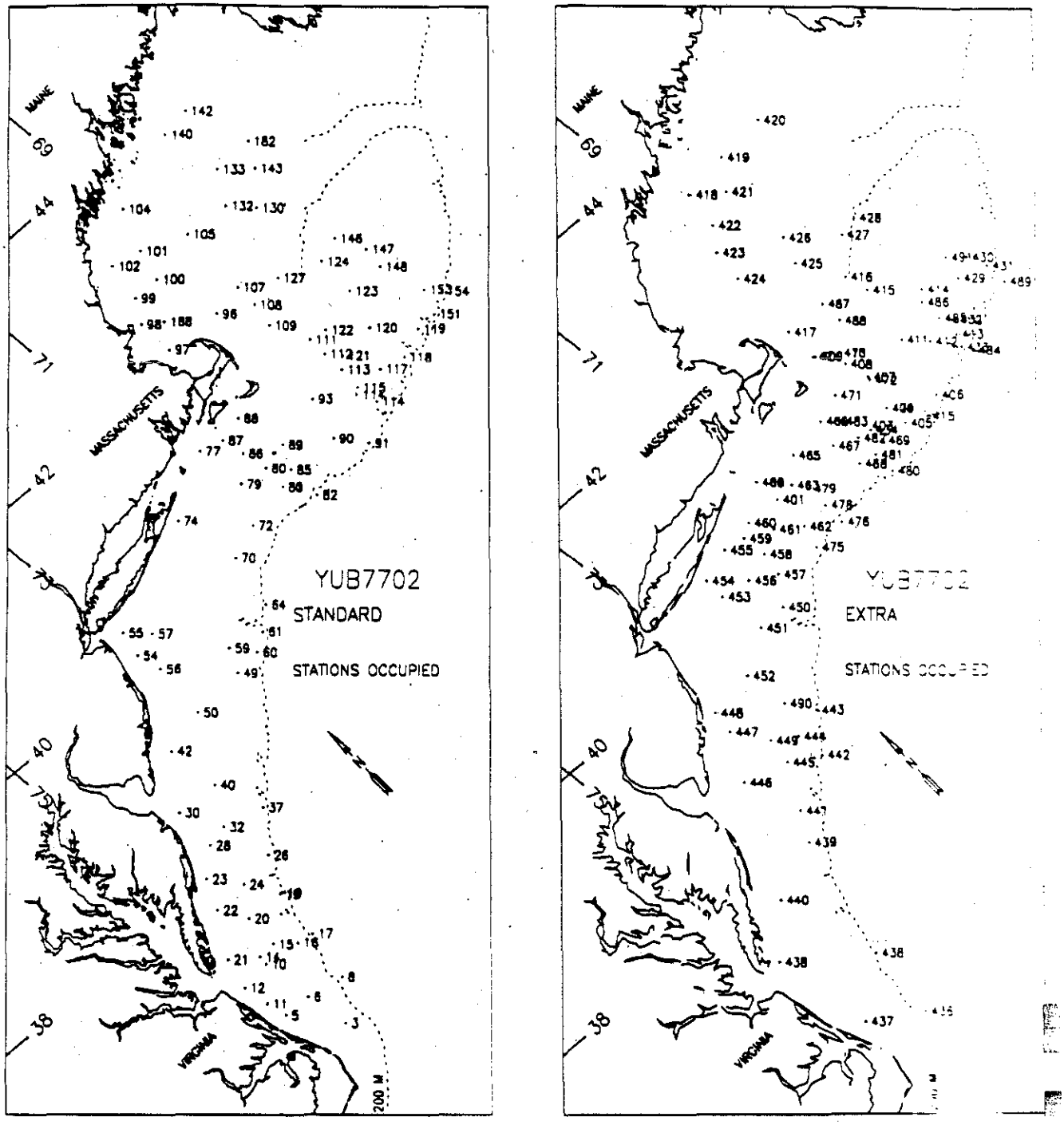


Figure 4. Station positions: YUB7702.

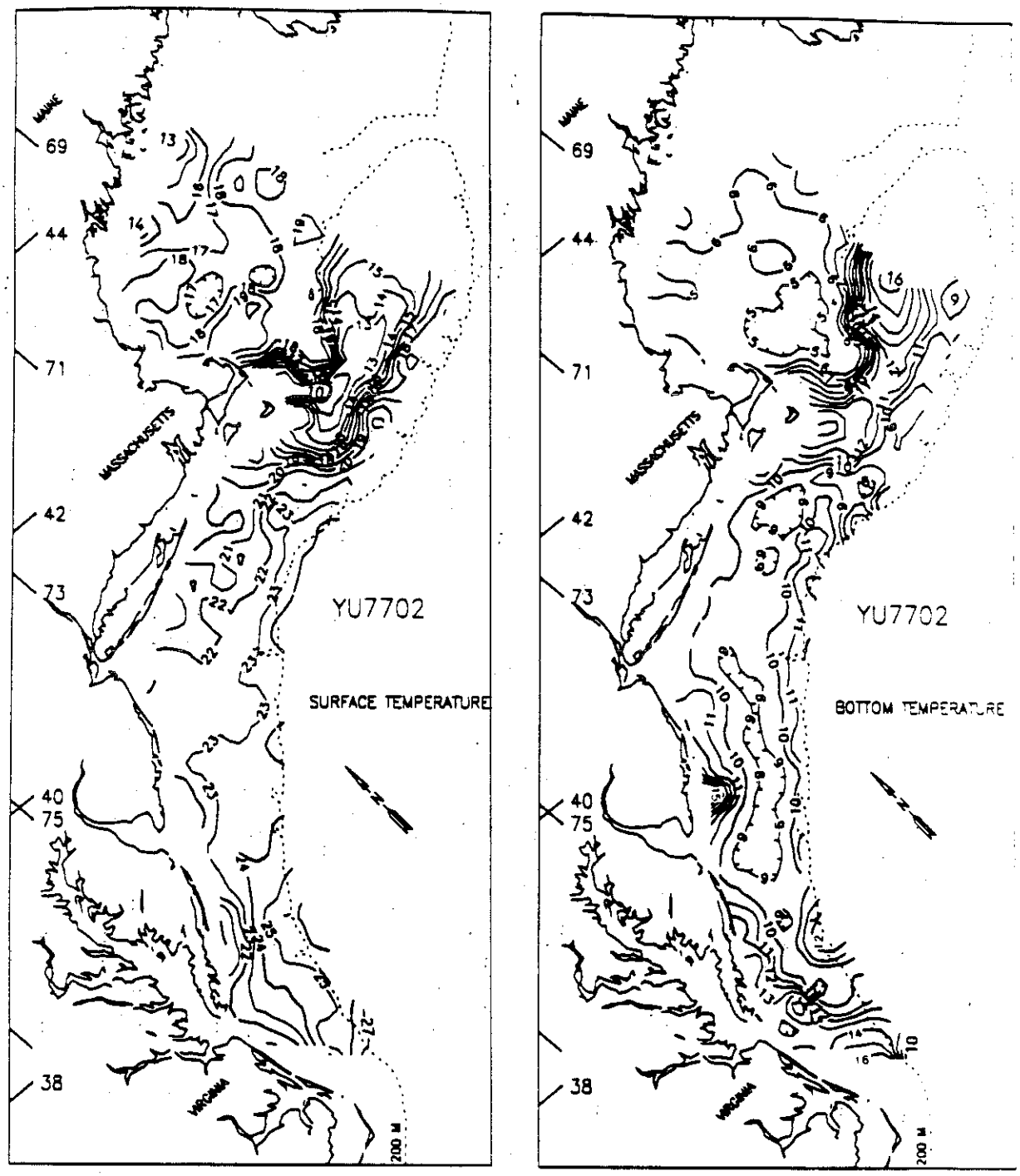


Figure 5. Surface and bottom temperature (°C) distribution: YUB7702.

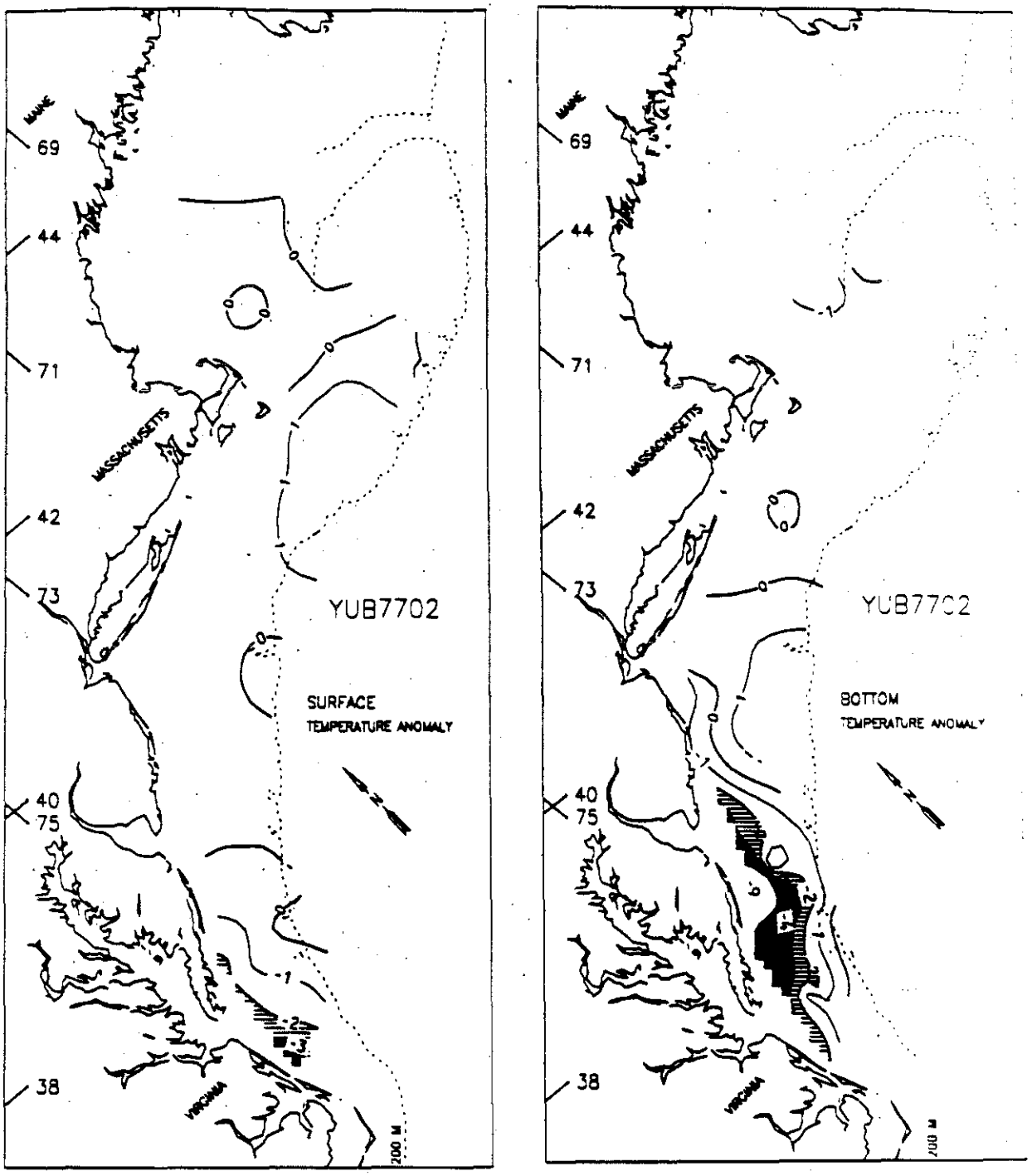


Figure 6. Normalized surface and bottom temperature anomaly: YUB7702. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

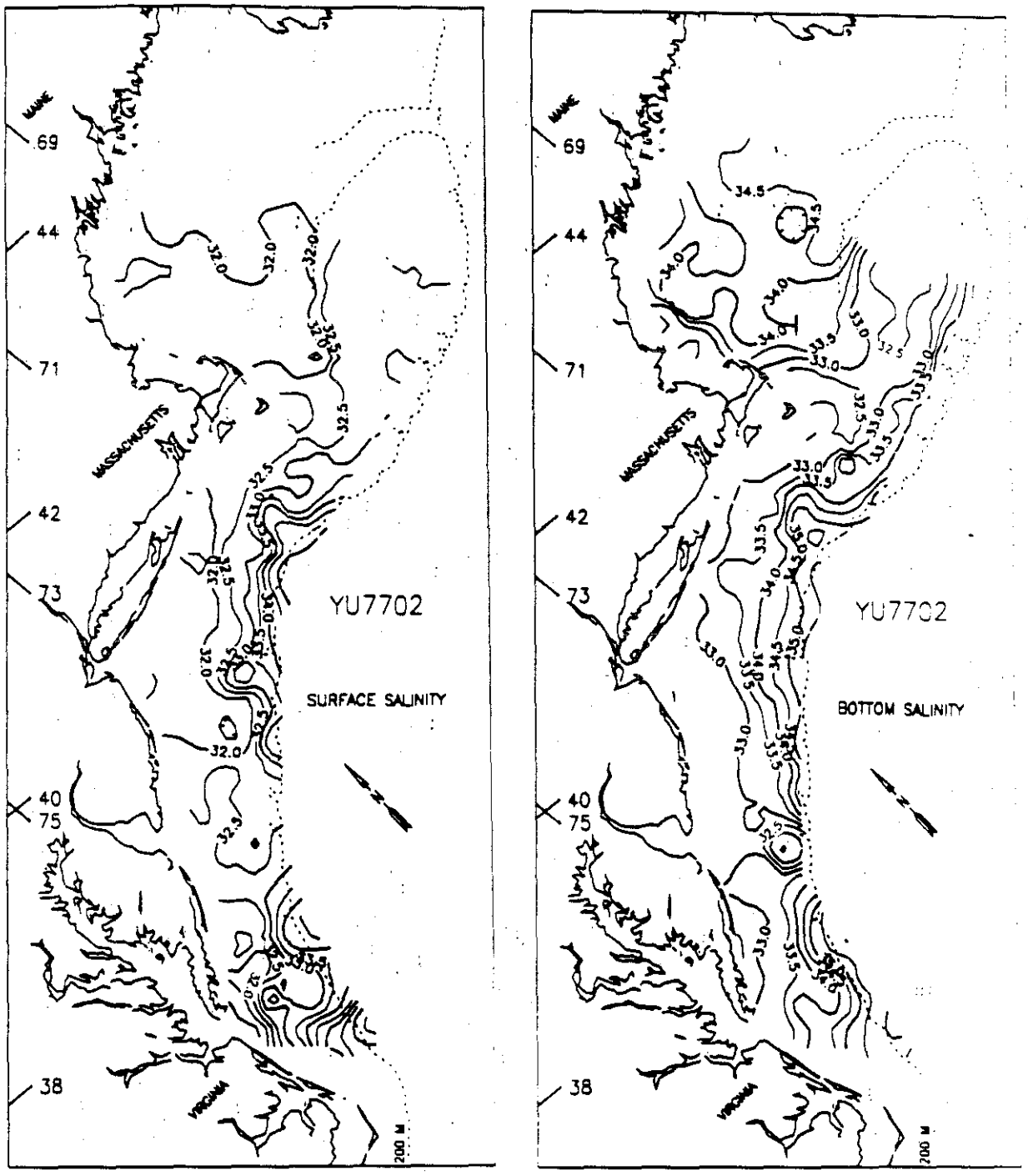
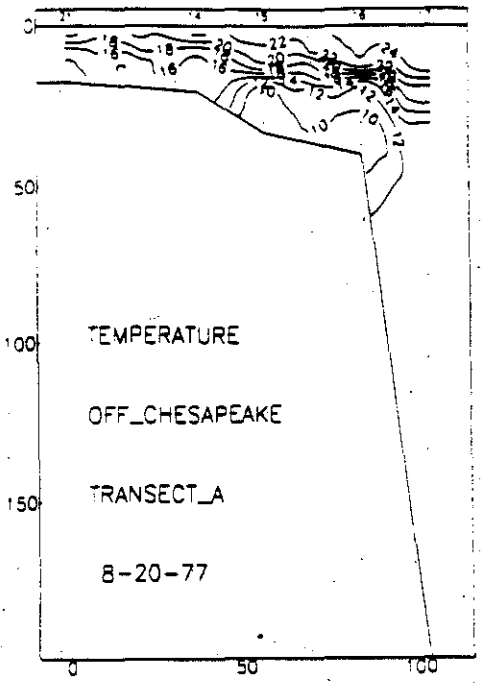
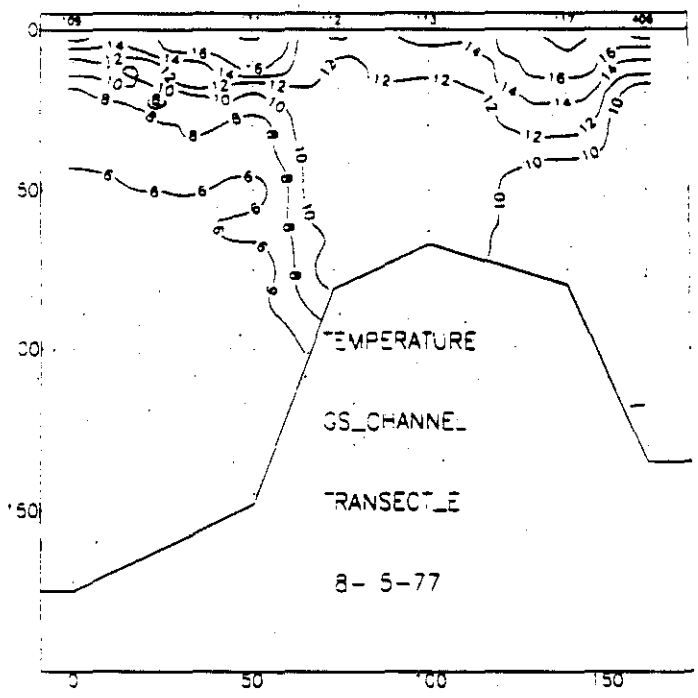


Figure 7. Surface and bottom salinity (PSU) distribution: YUB7702.





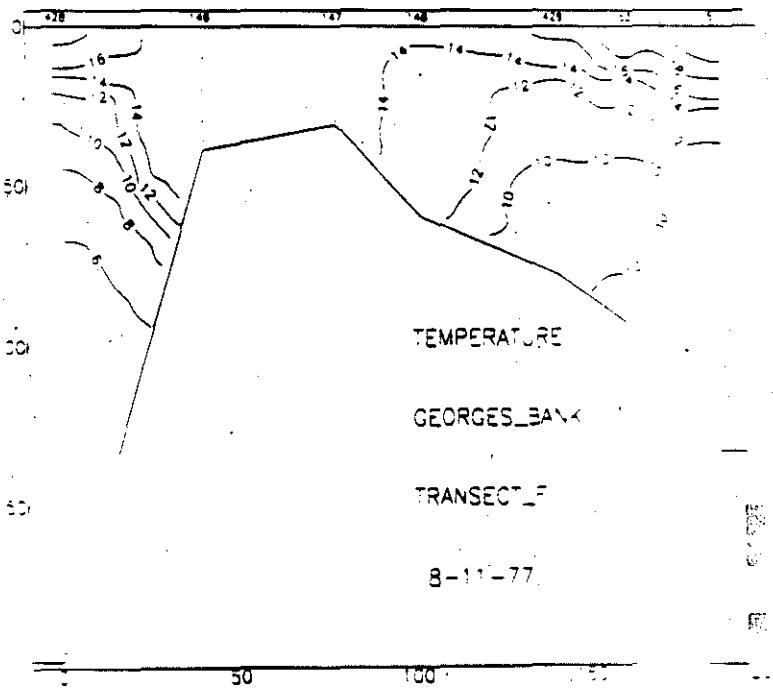
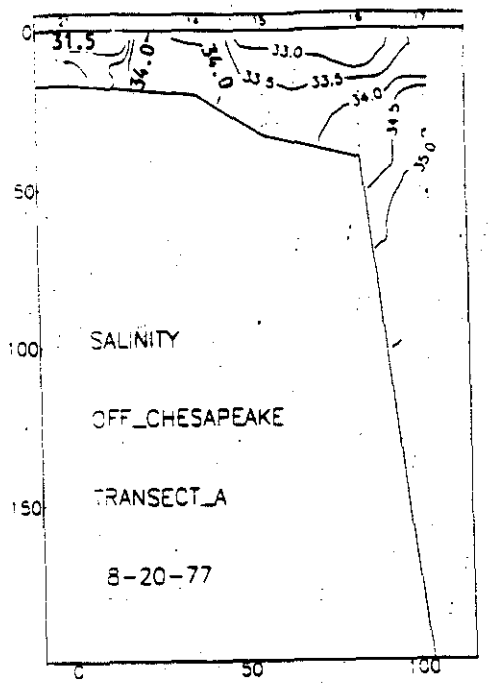
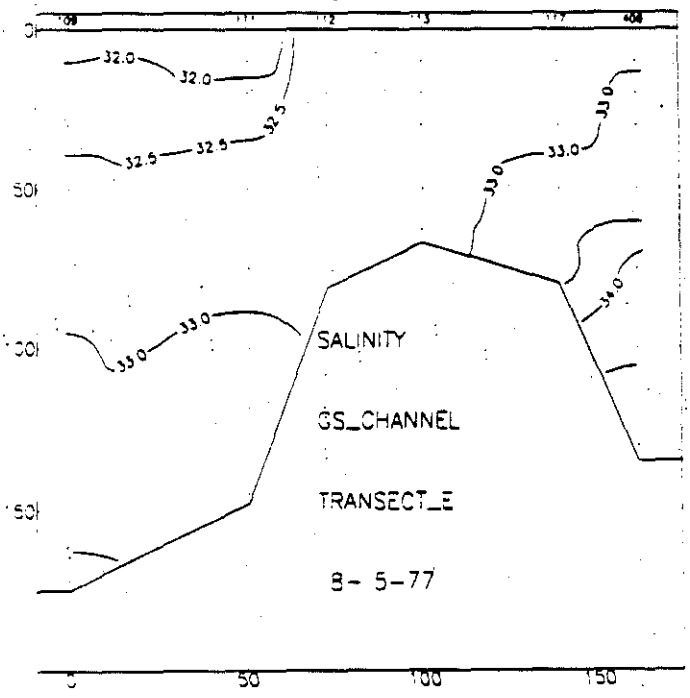


Figure 8. Temperature (°C) transects: YUB7702.





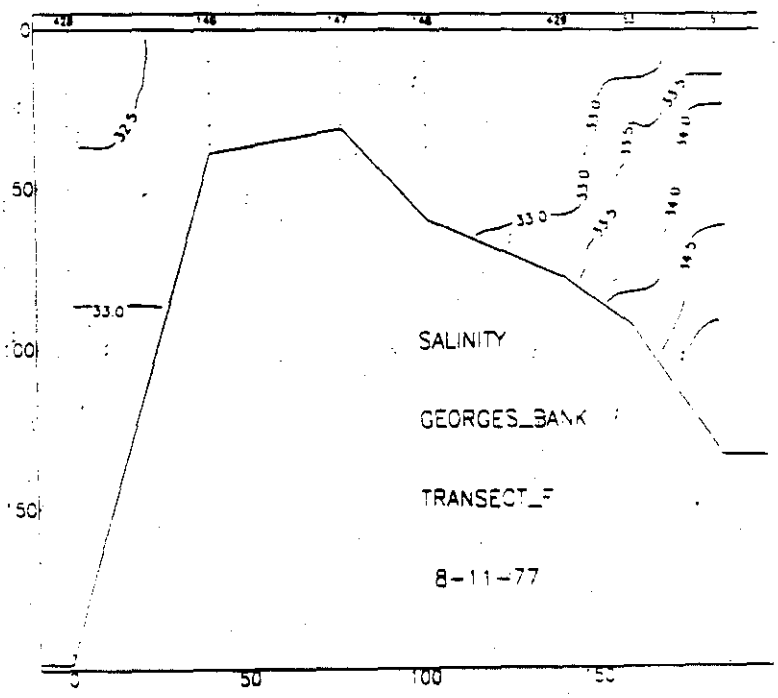


Figure 9. Salinity (PSU) transects: YUB7702.

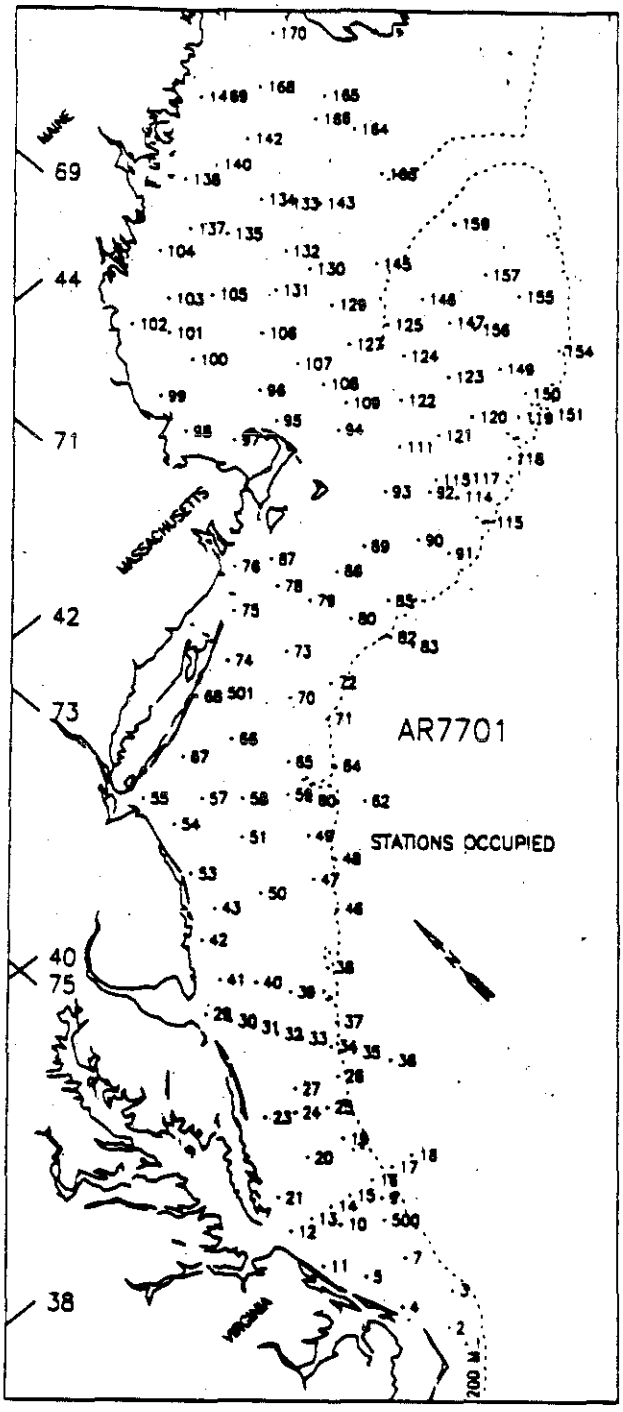


Figure 10. Station positions: ARG7701.

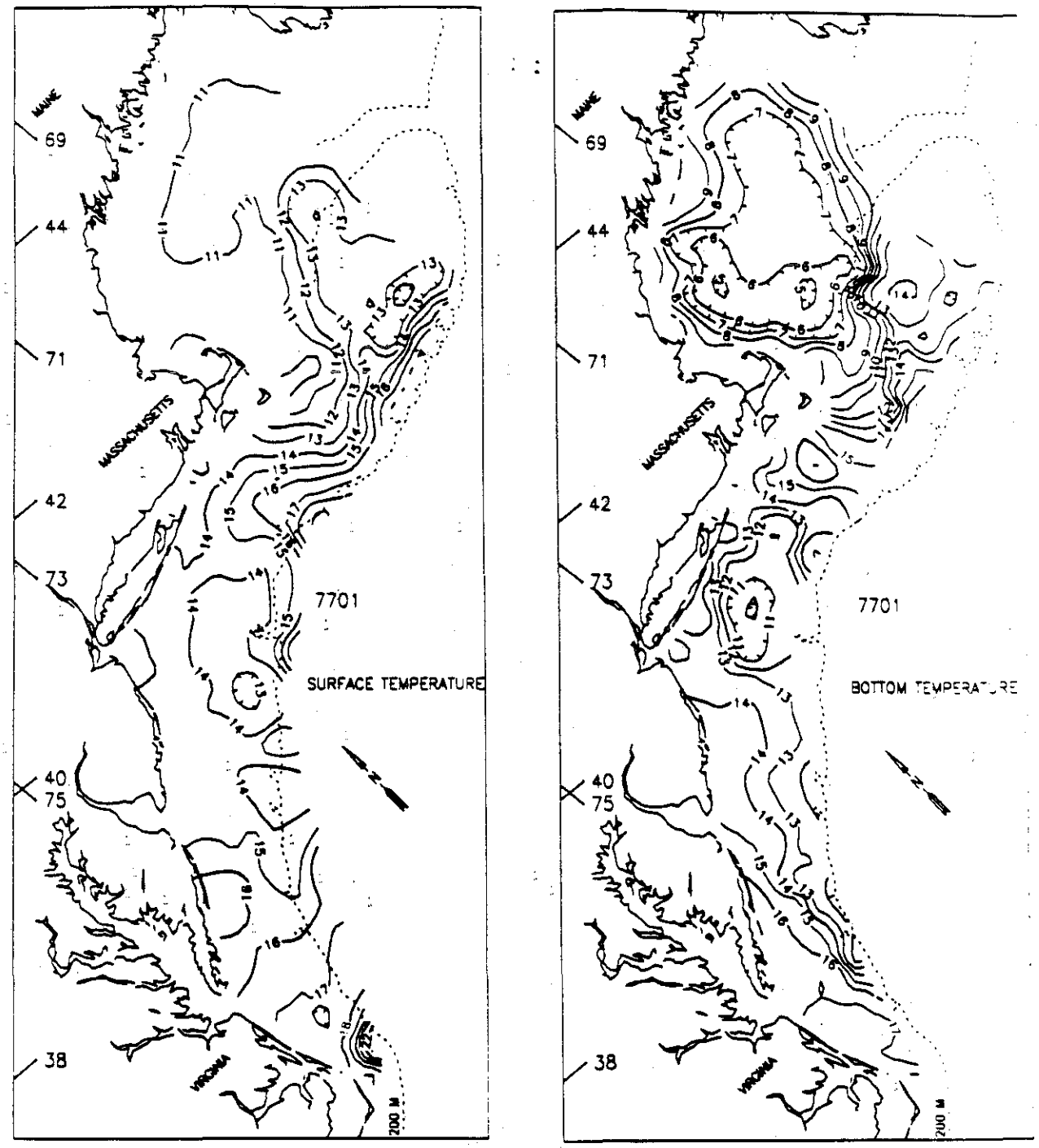


Figure 11. Surface and bottom temperature (°C) distribution: ARG7701.

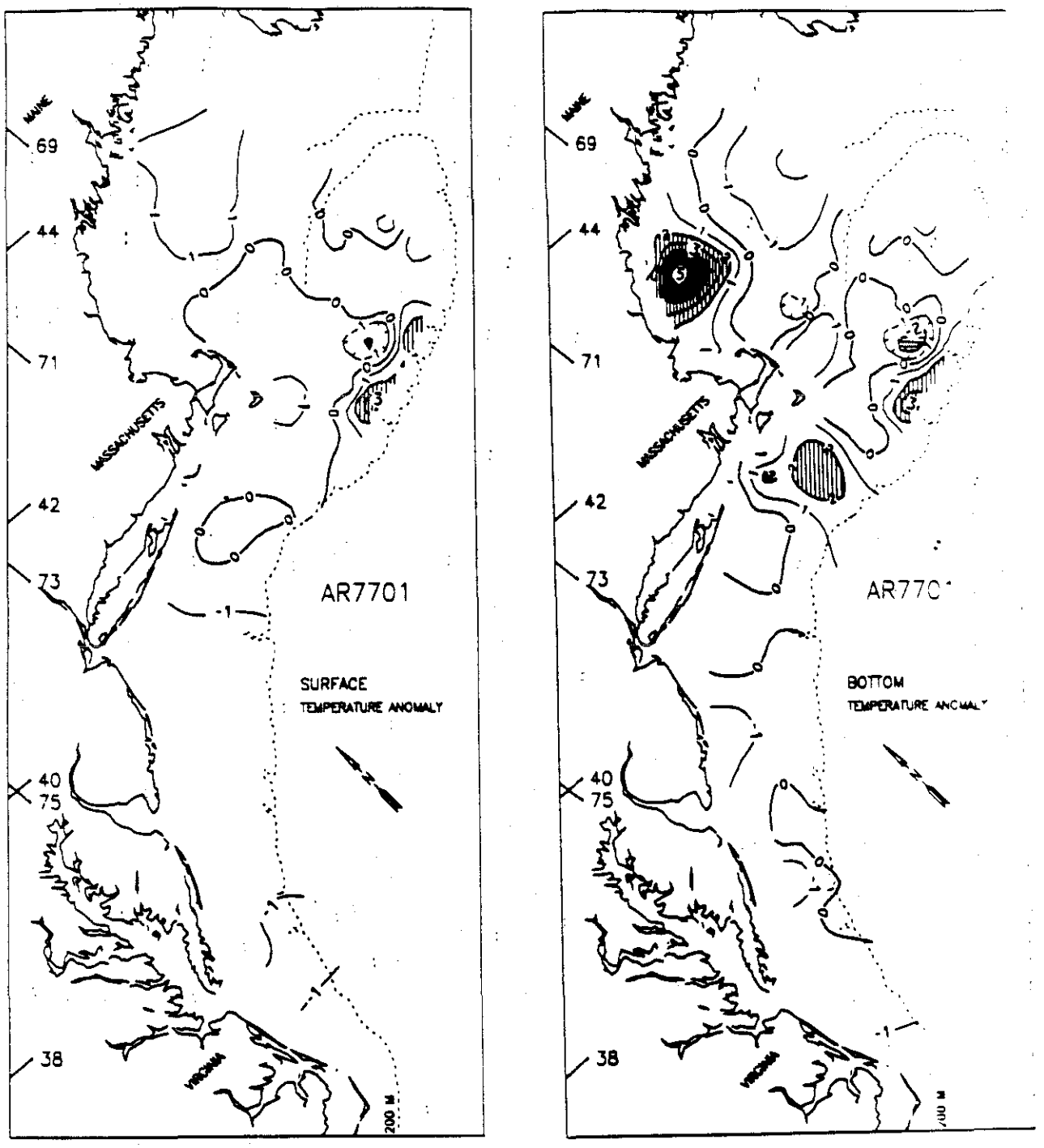


Figure 12. Normalized surface and bottom temperature anomaly: ARG7701. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

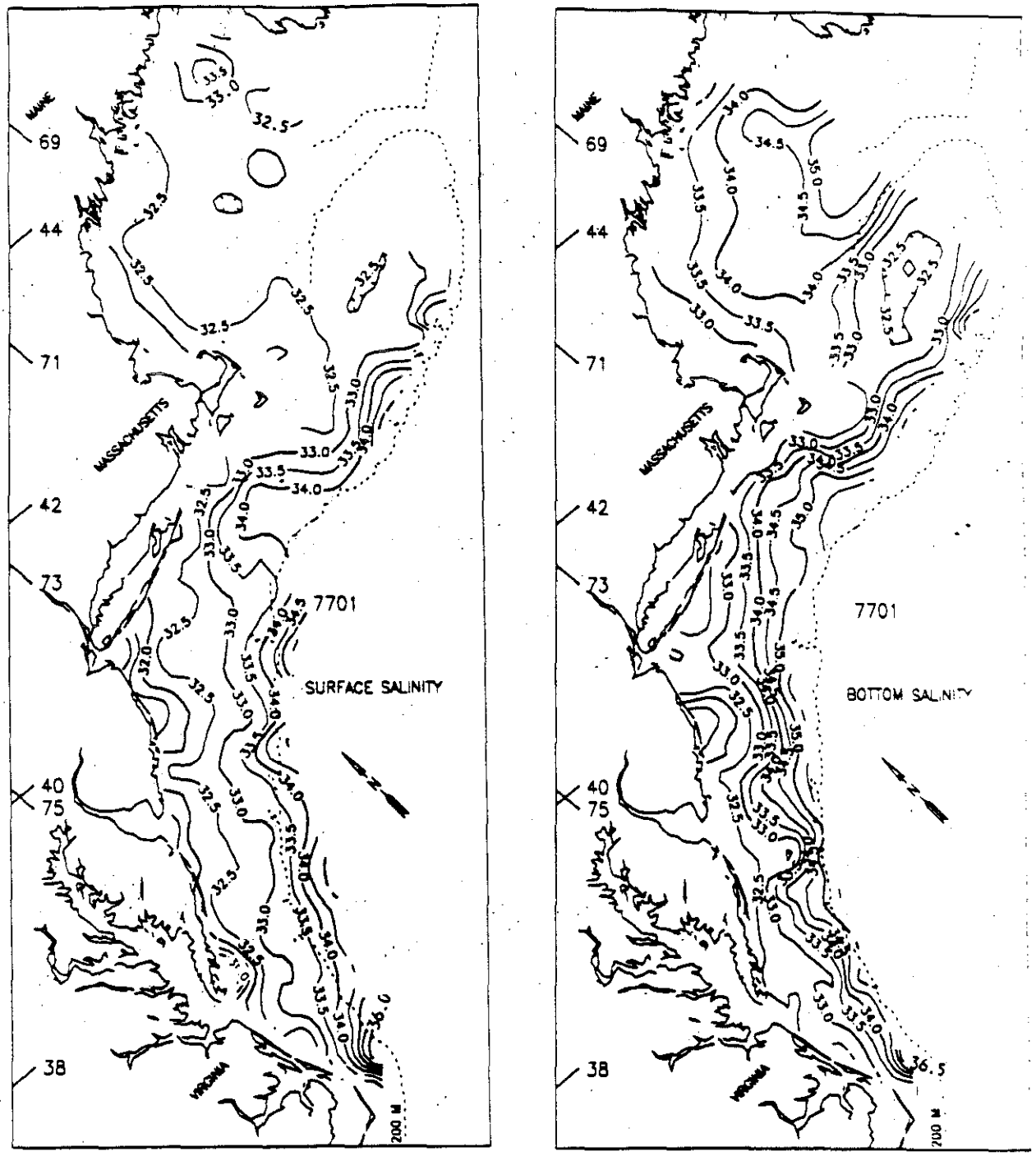
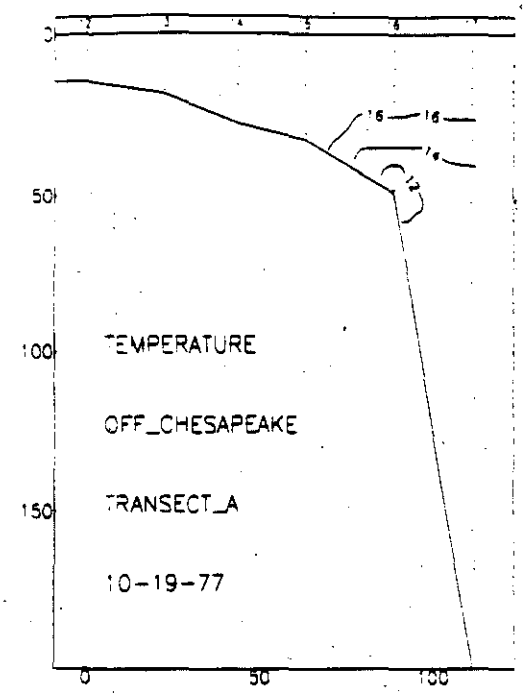
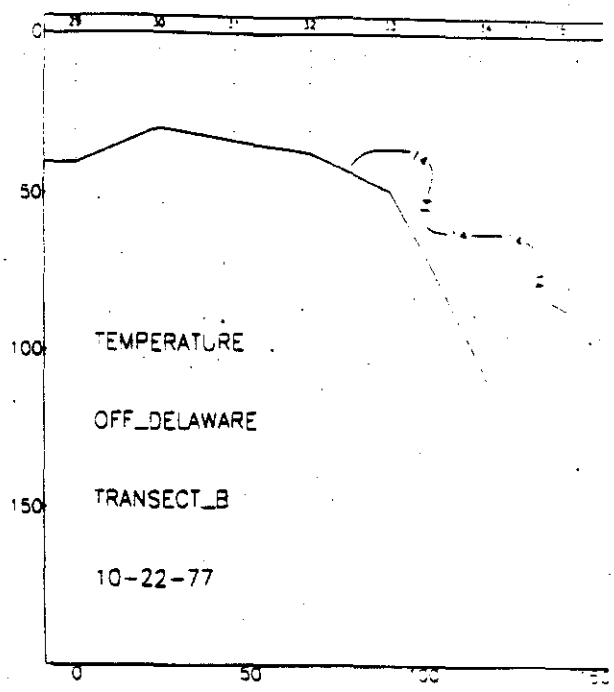
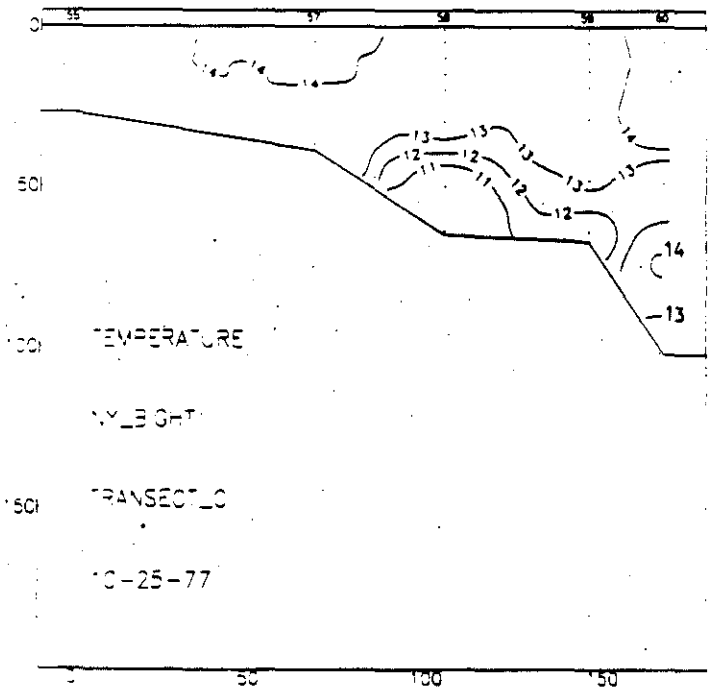


Figure 13. Surface and bottom salinity (PSU) distribution: ARG7701.







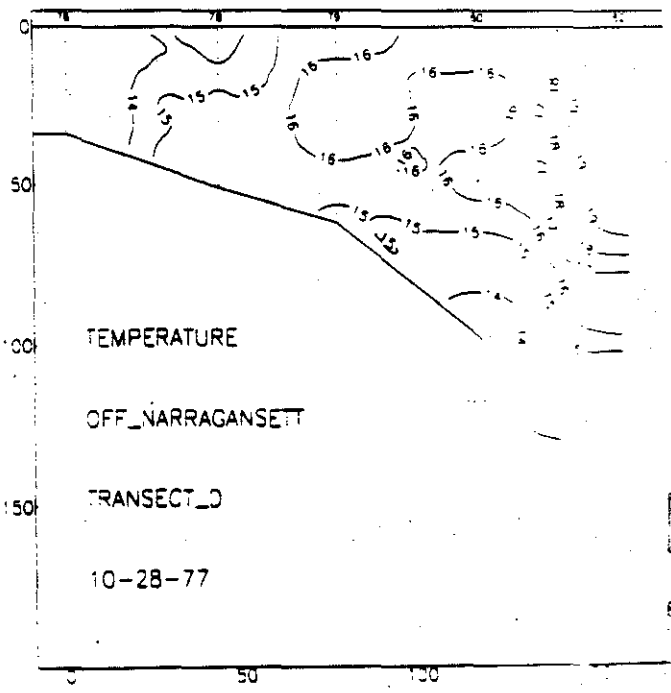
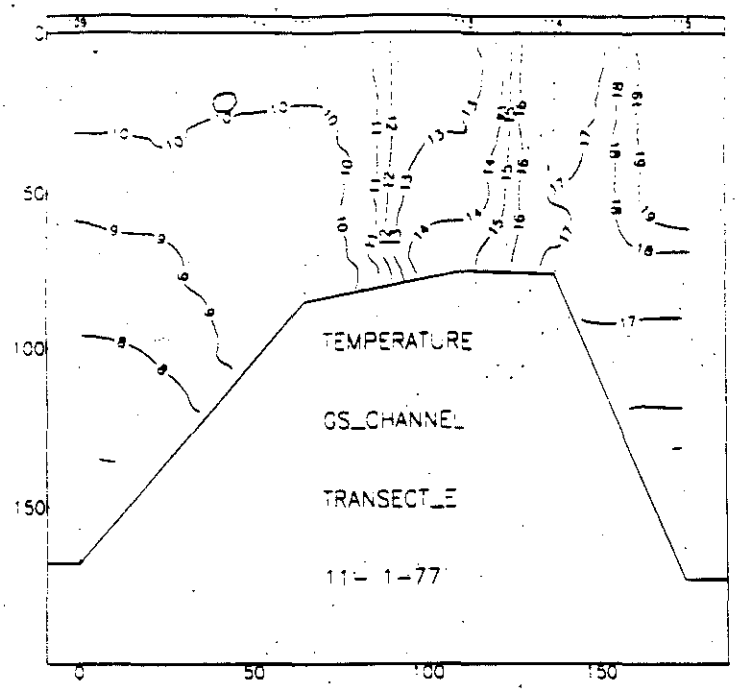
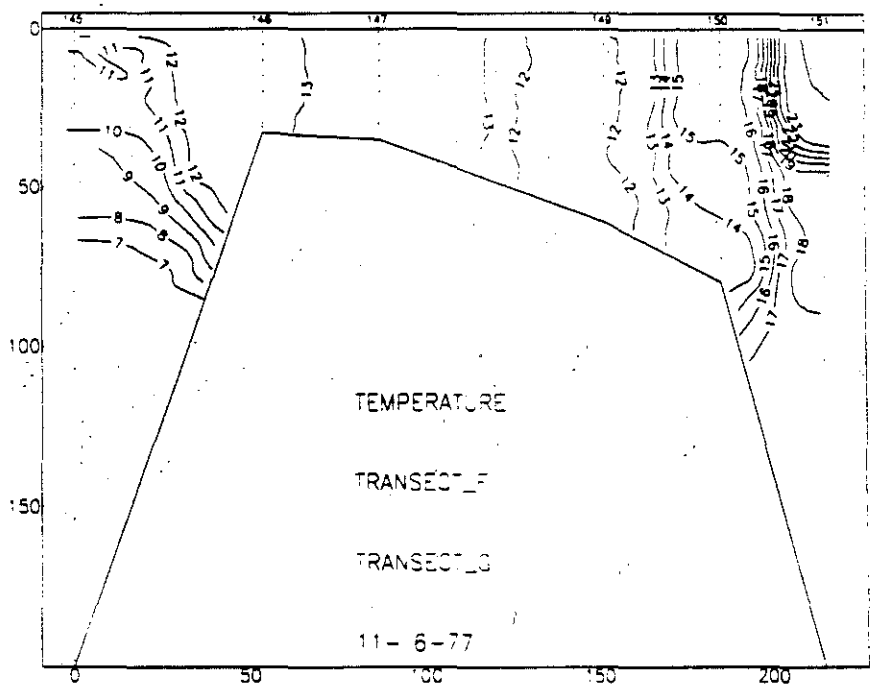


Figure 14. Temperature (°C) transects: ARG7701.





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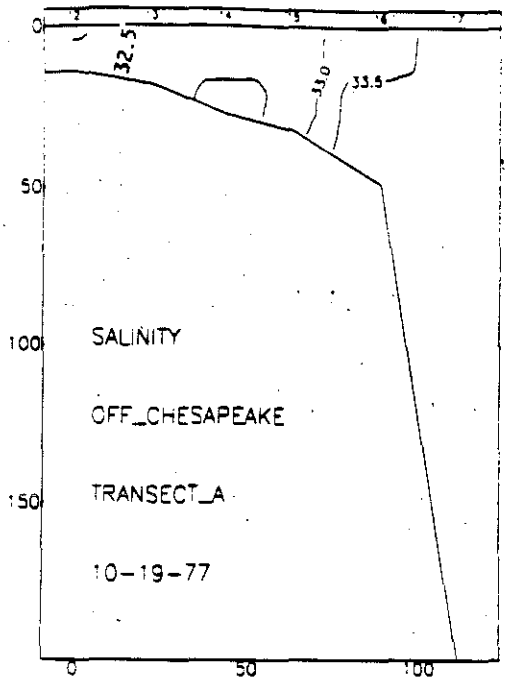
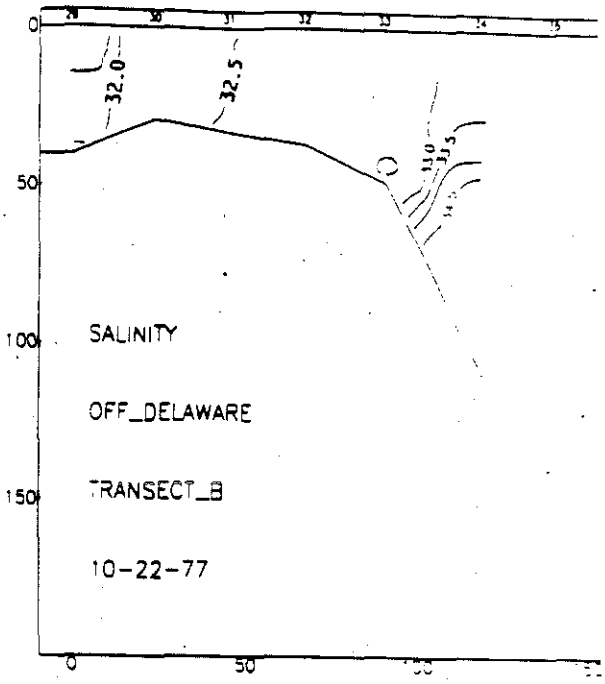
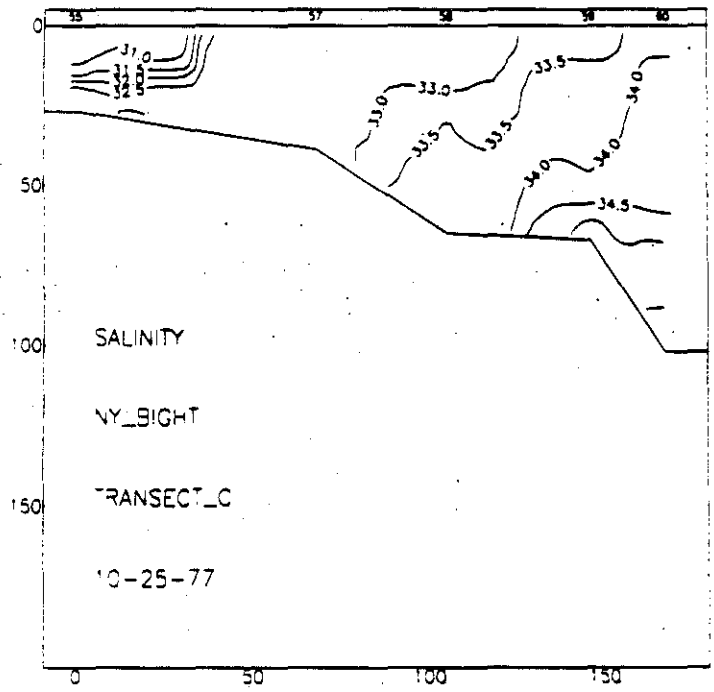






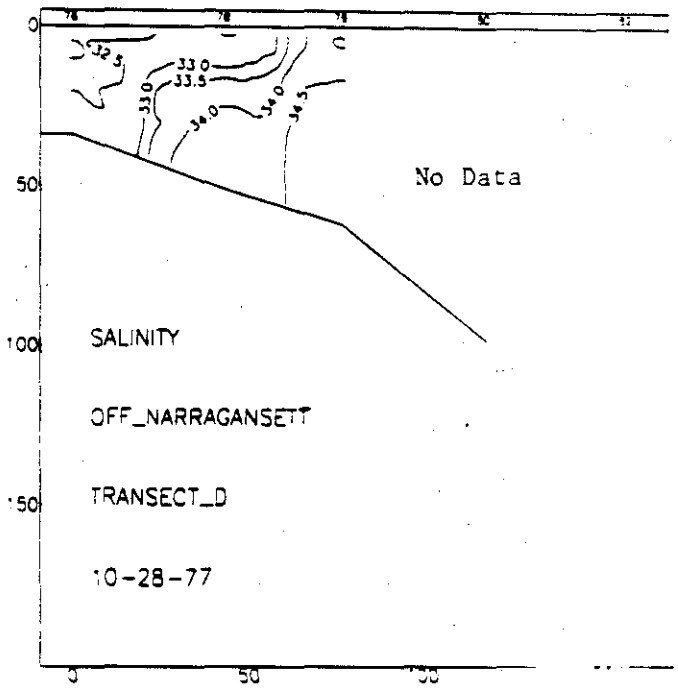
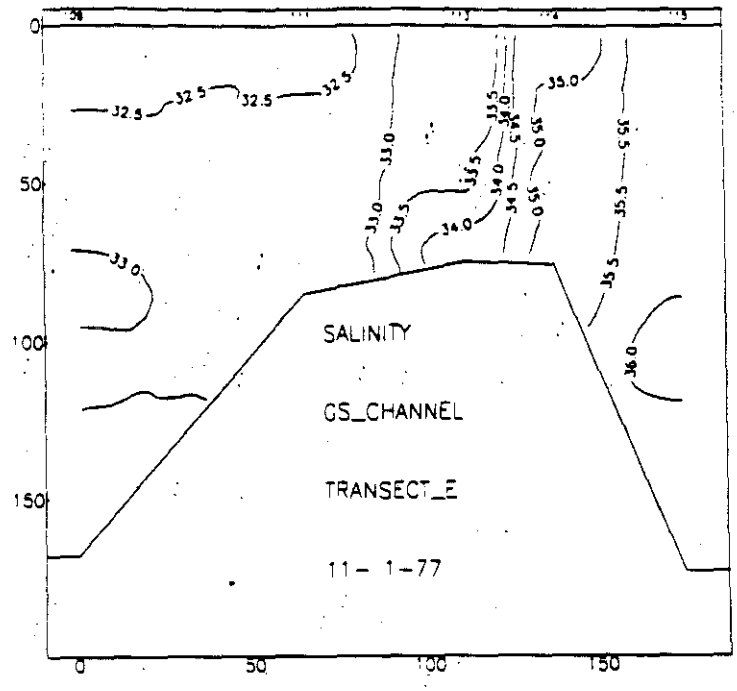


Figure 15. Salinity (PSU) transects: ARG7701.



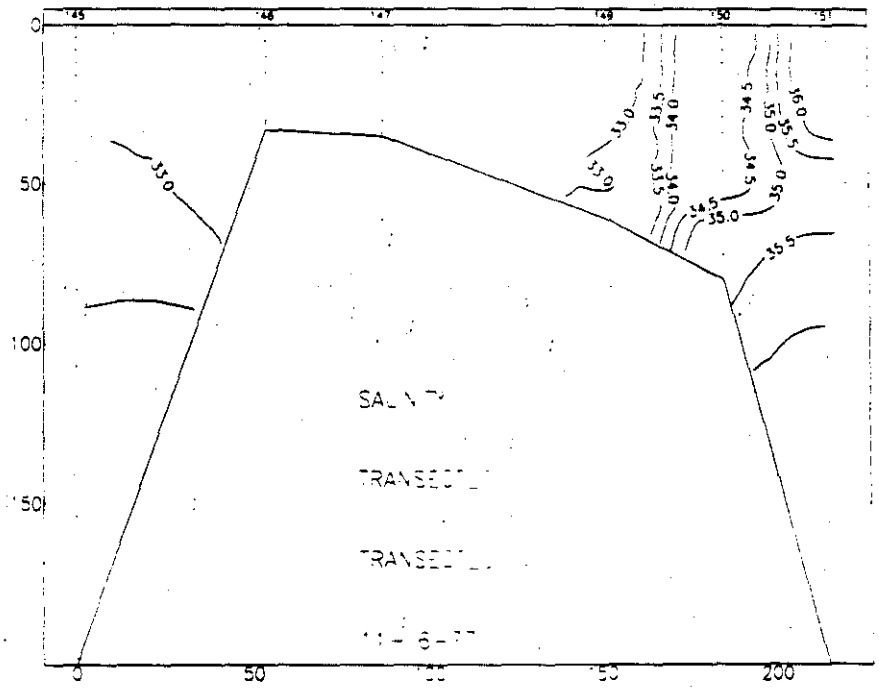


Figure 15. Continued.

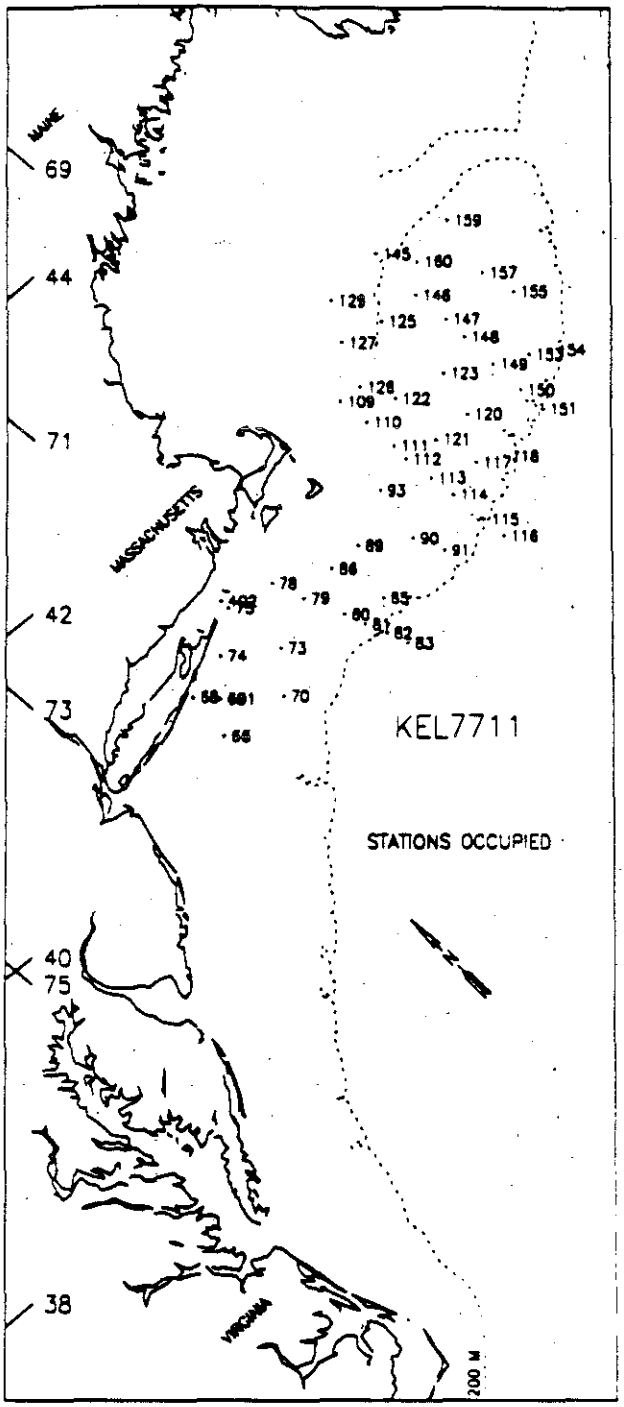


Figure 16a. Station positions: KEL7711.

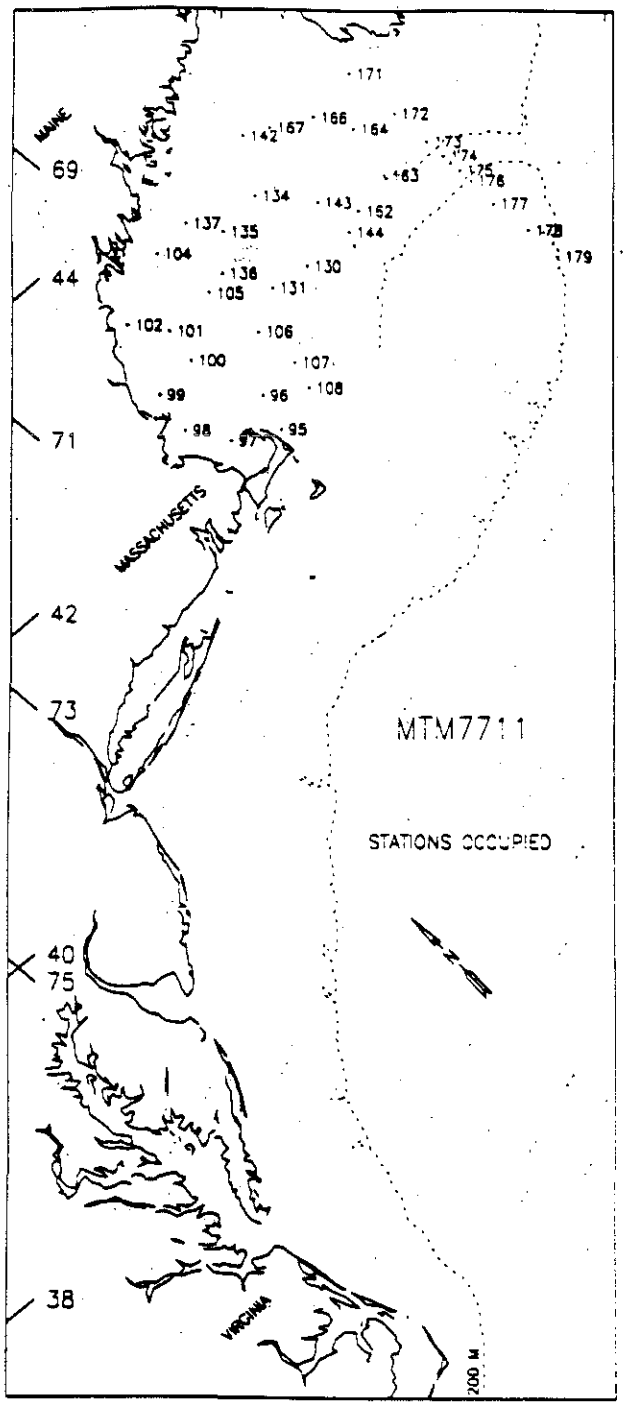


Figure 16b. Station positions: MTM7711.

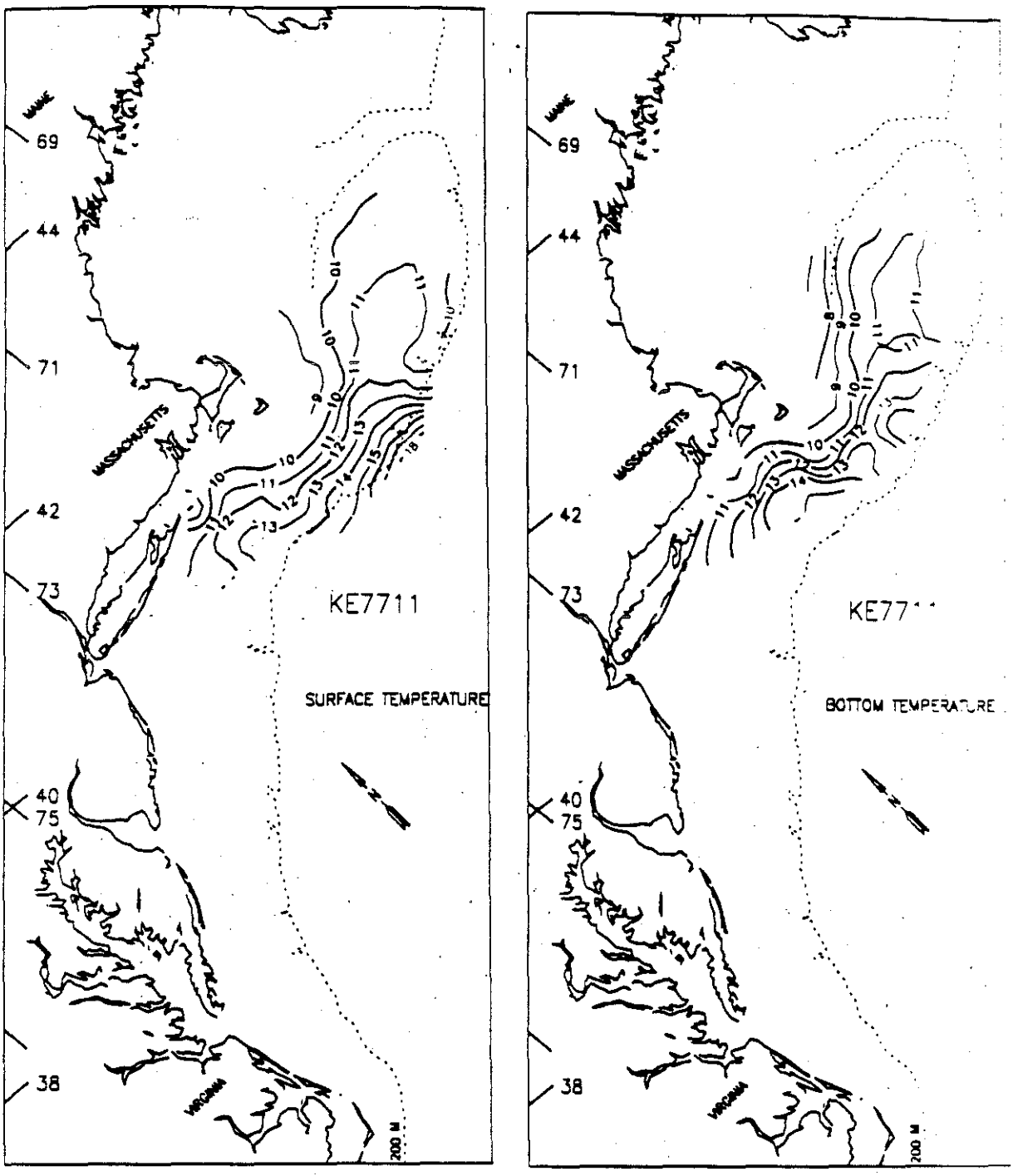


Figure 17a. Surface and bottom temperature (°C) distribution: KEL7711.

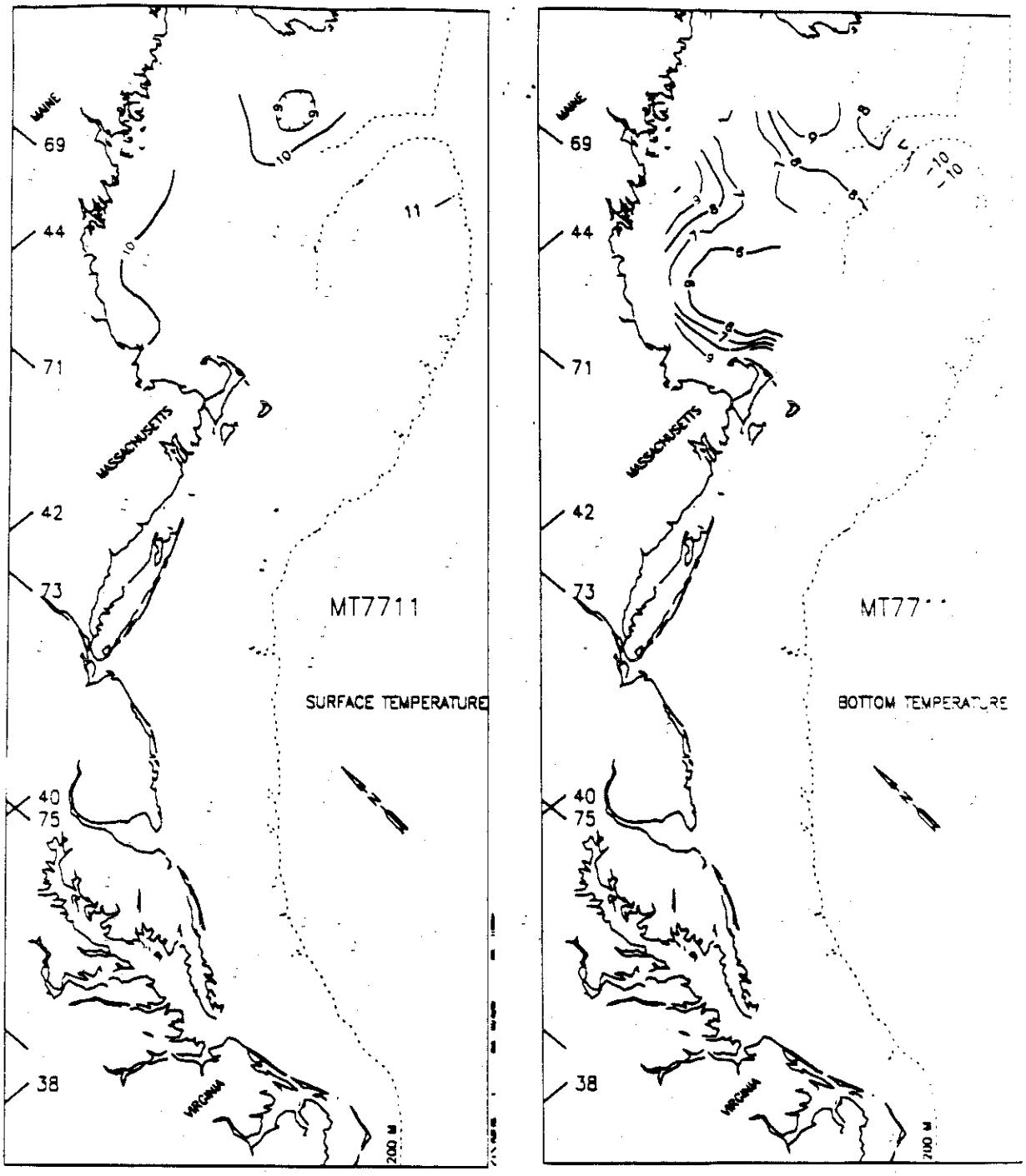


Figure 17b. Surface and bottom temperature(°C) distribution: MTM7711.

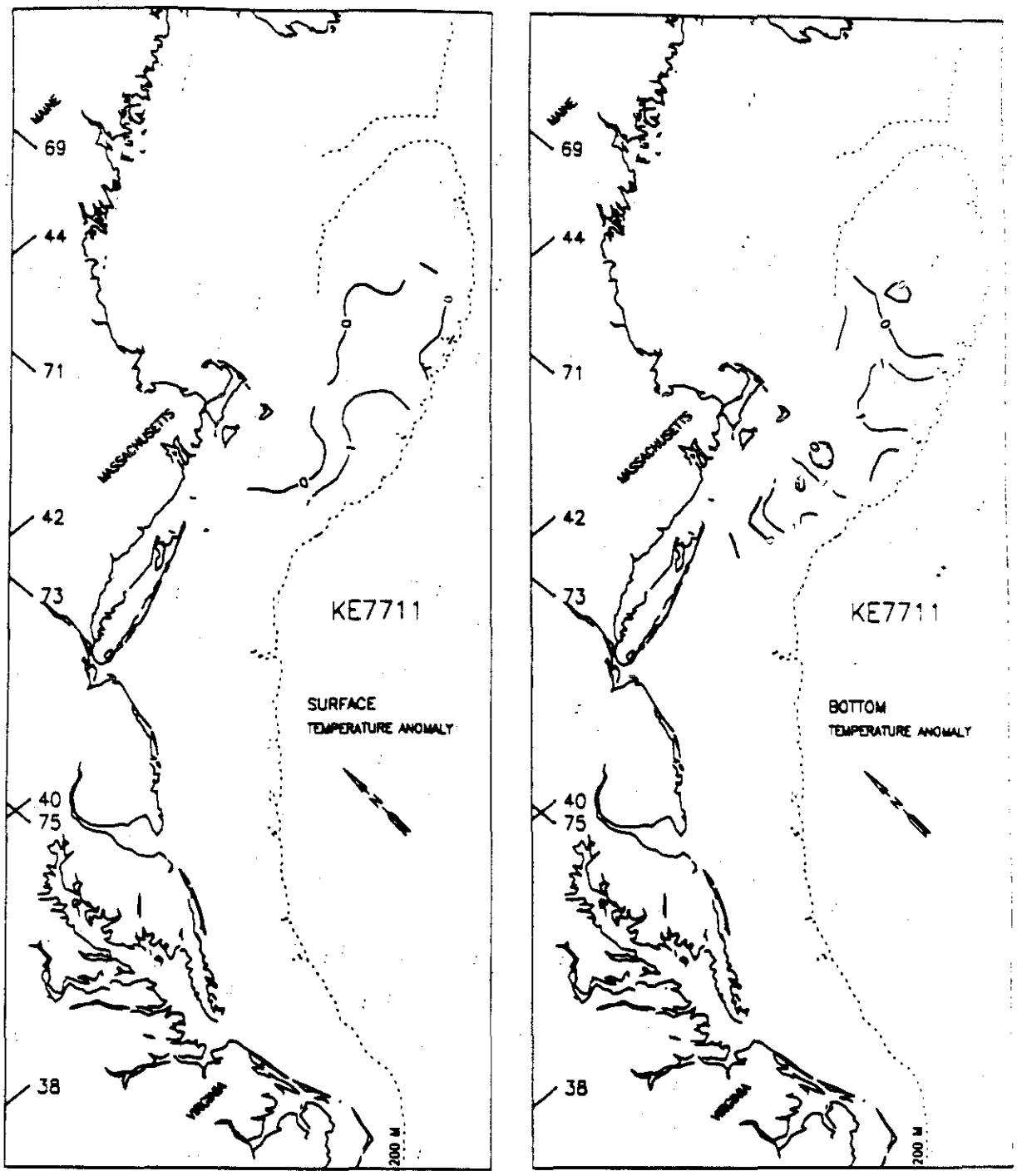


Figure 18a. Normalized surface and bottom temperature anomaly: KEL7711. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

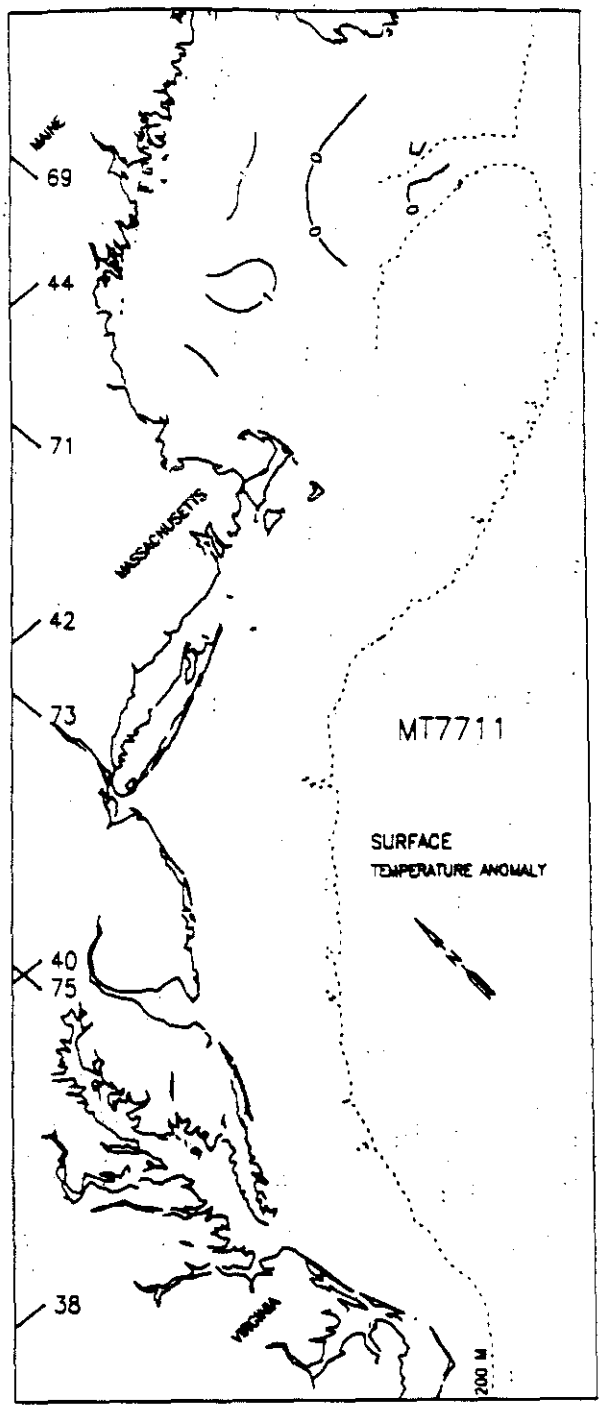


Figure 18b. Normalized surface and bottom temperature anomaly: MTM7711. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

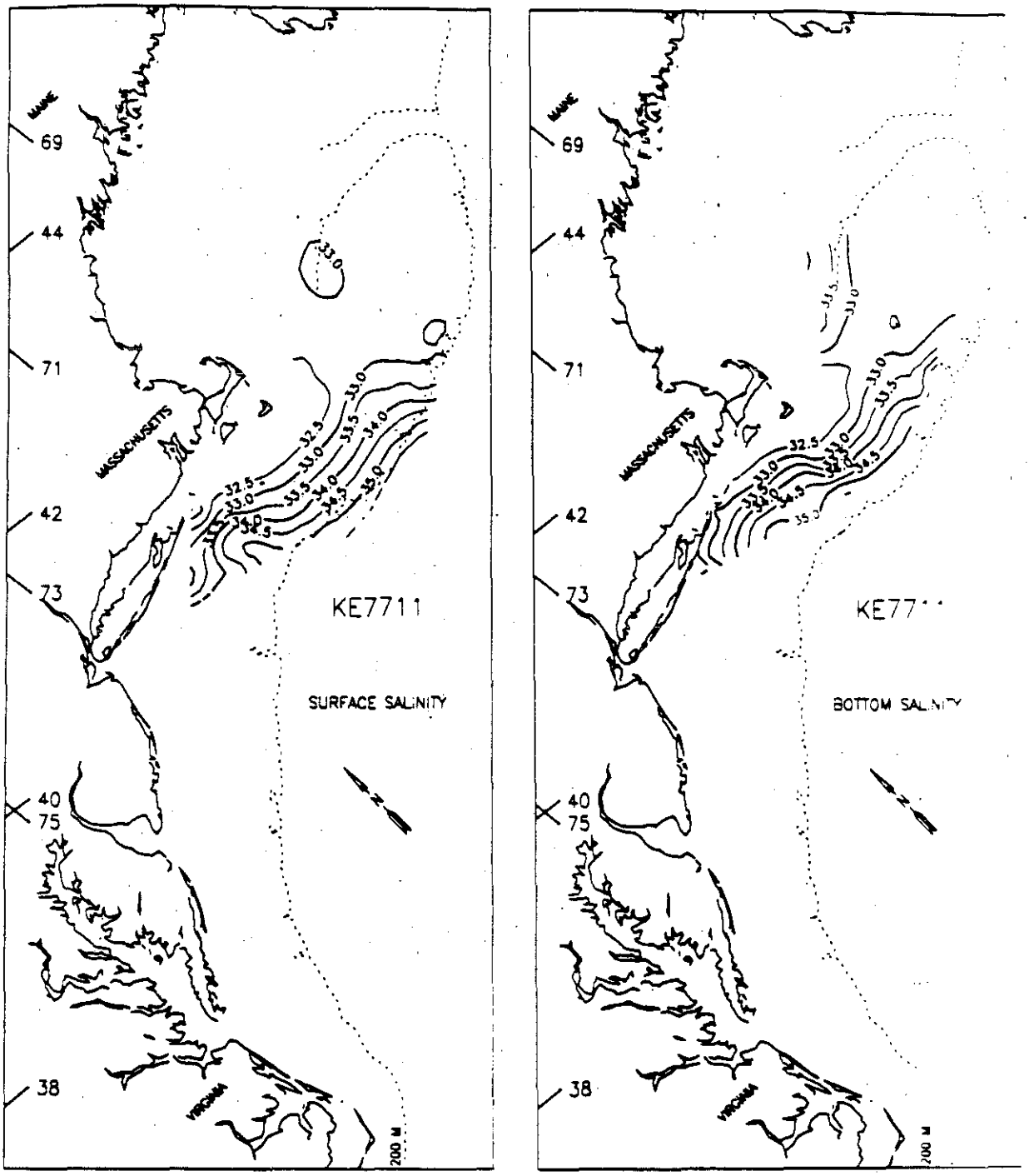


Figure 19a. Surface and bottom salinity (PSU) distribution: KEL7711.

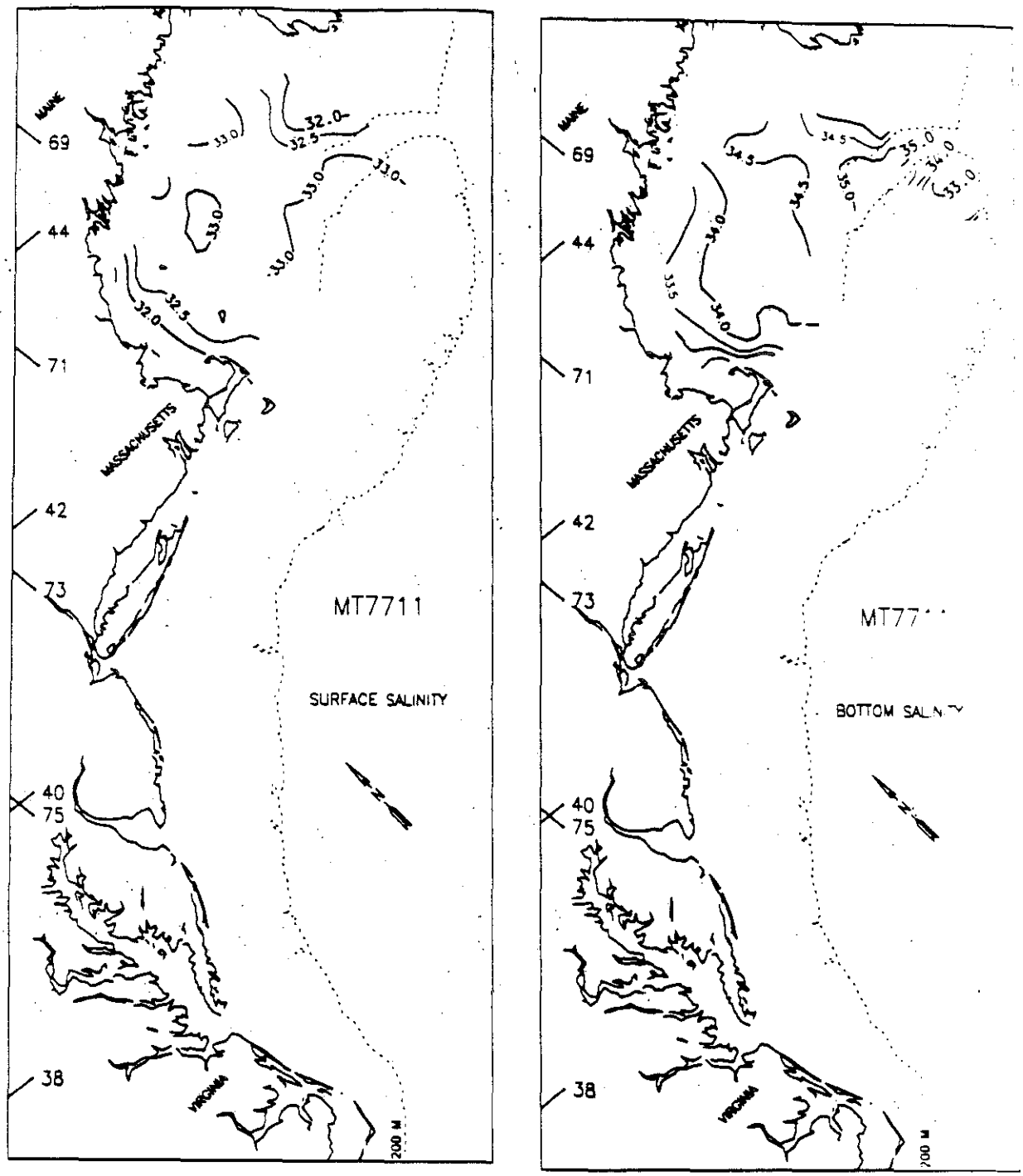
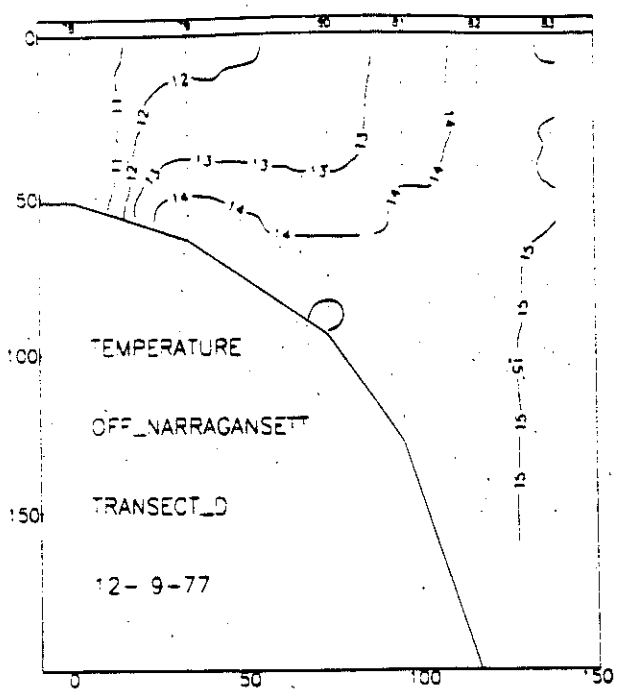
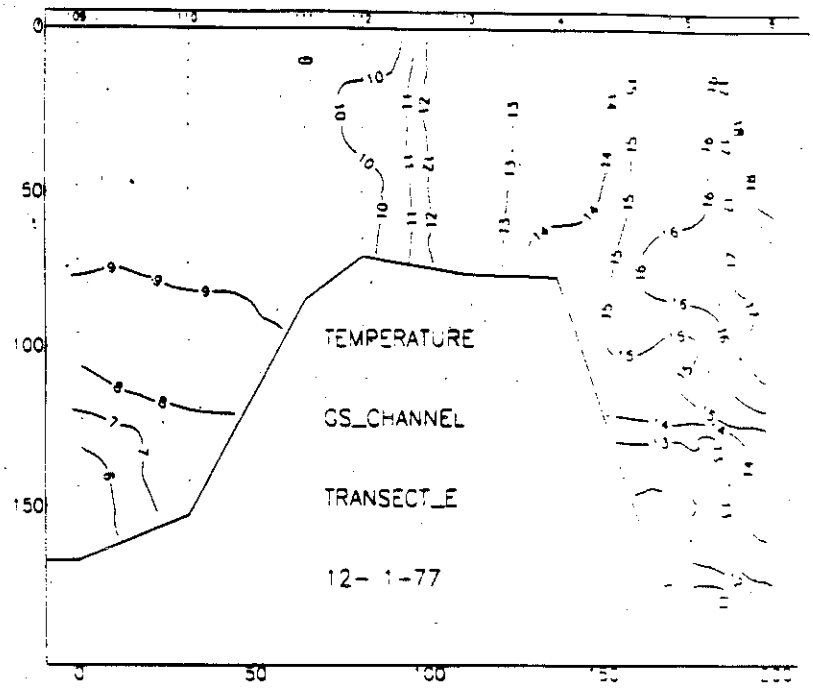


Figure 19b. Surface and bottom salinity (PSU) distribution: MTM7711.





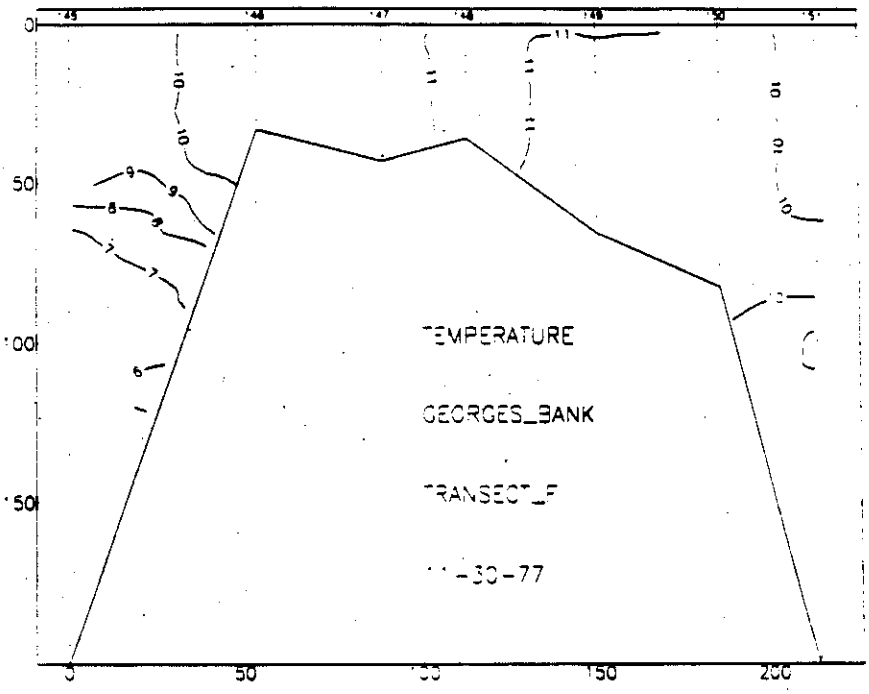


Figure 20a. Temperature (°C) transects: KEL7711.

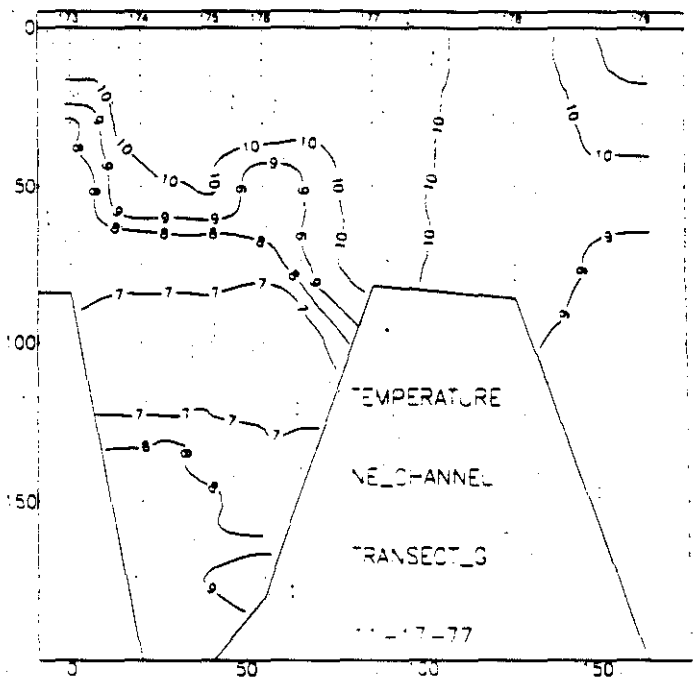


Figure 20b. Temperature (°C) transects: MTM7711.

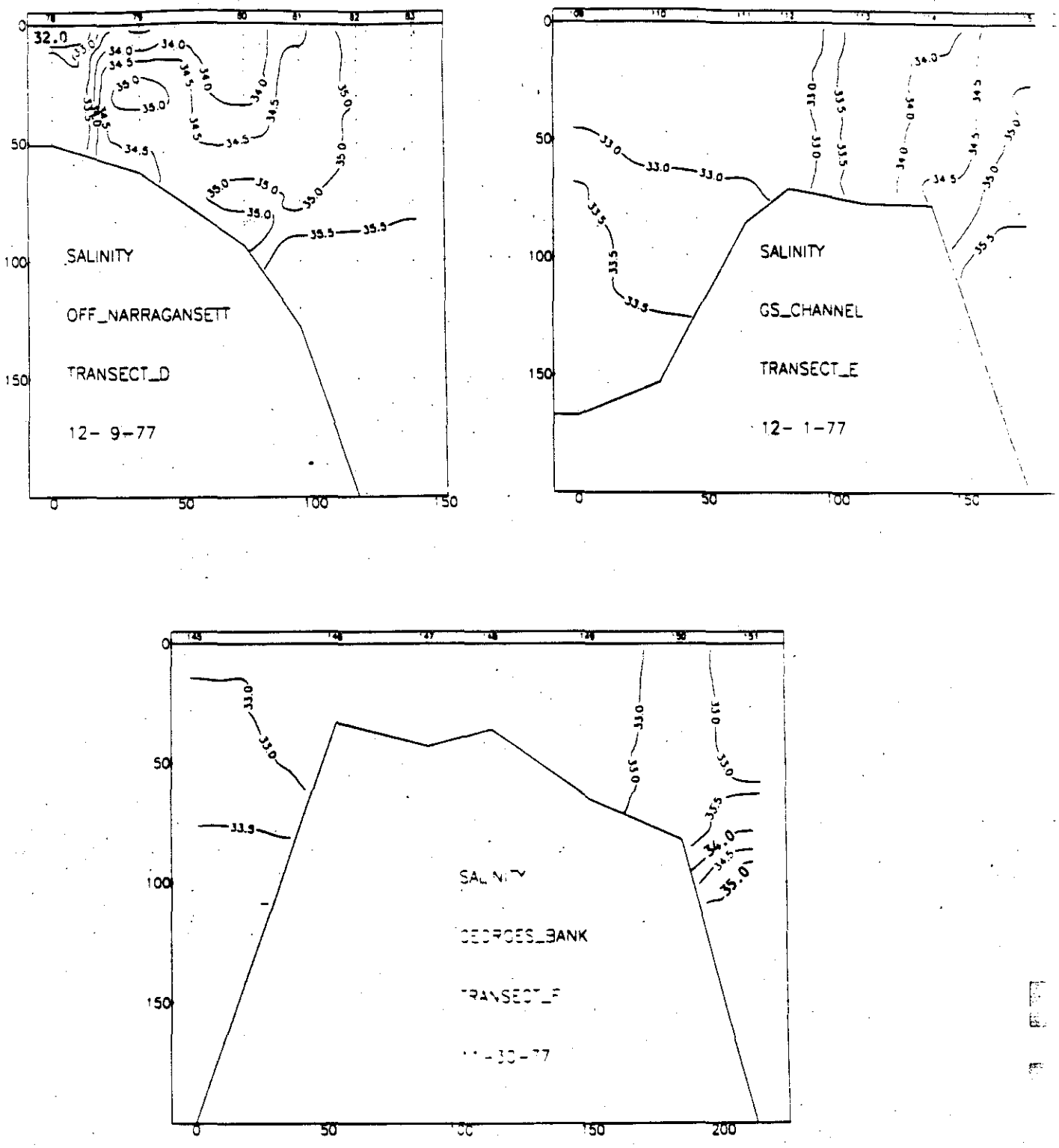


Figure 21a. Salinity (PSU) transects: KEL7711.

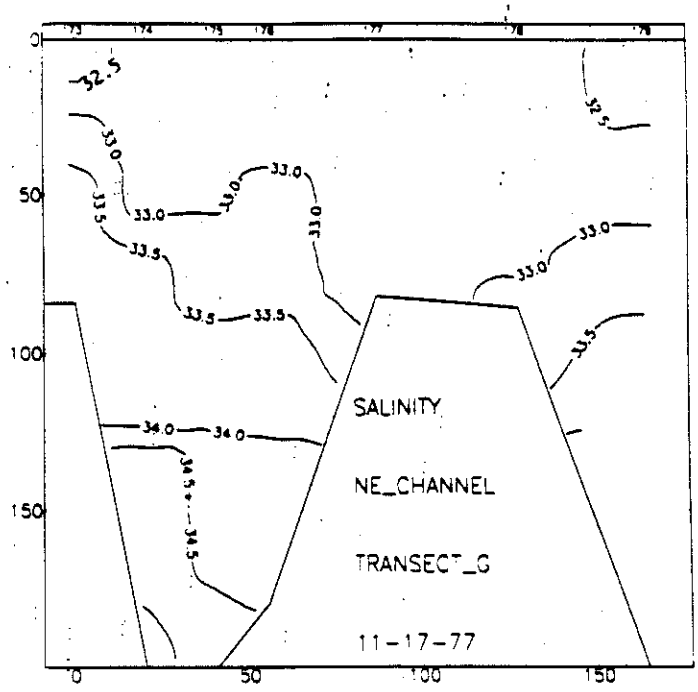


Figure 21b. Salinity (PSU) transects: MTM7711.

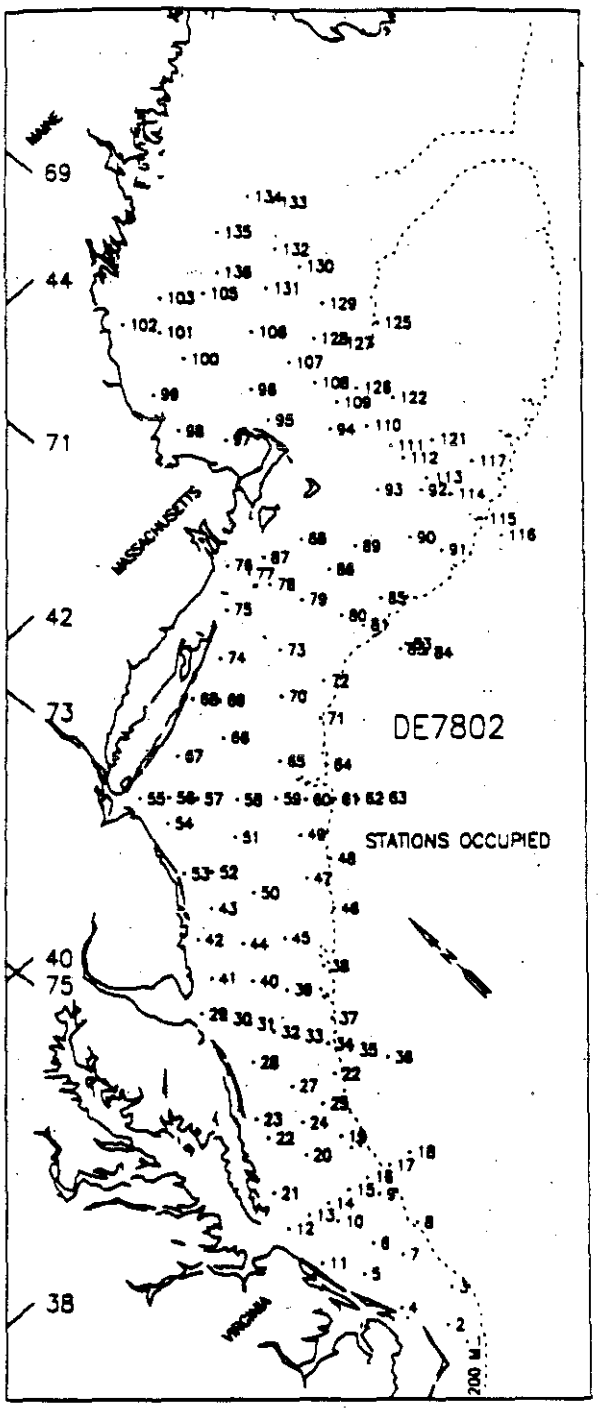


Figure 22. Station positions: DEL7802.

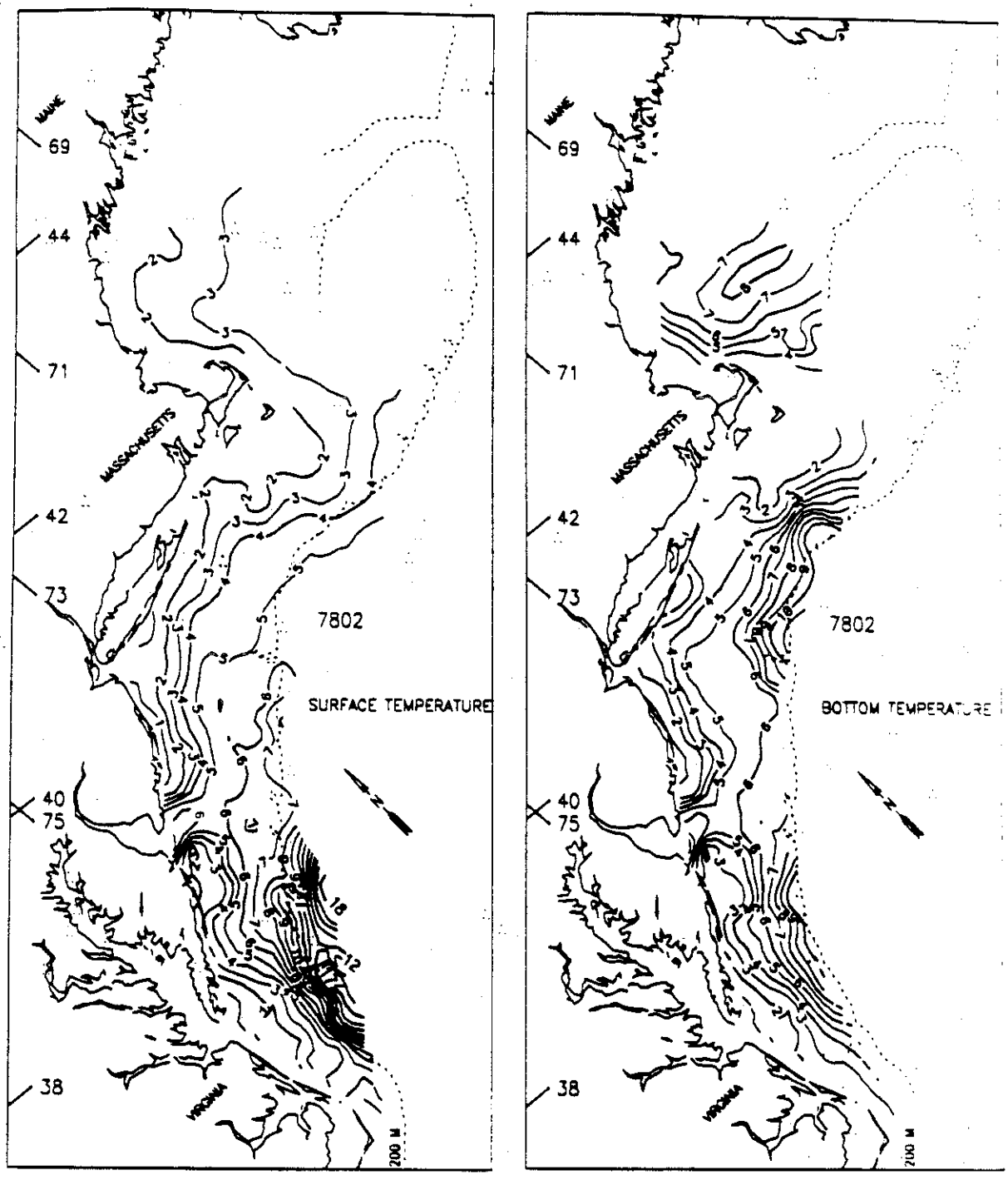


Figure 23. Surface and bottom temperature (°C) distribution: DEL7802.

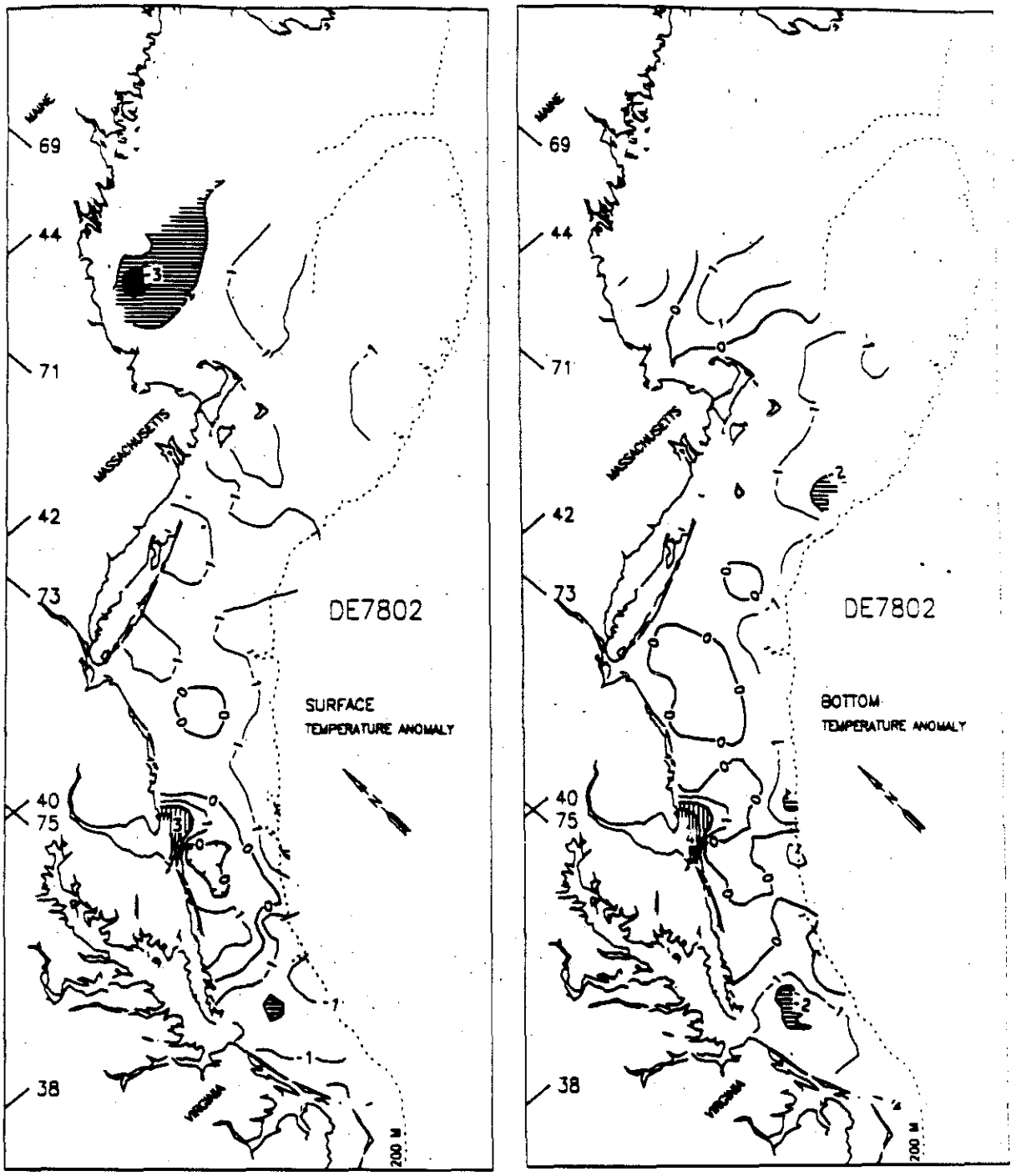


Figure 24. Normalized surface and bottom temperature anomaly: DEL7802. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

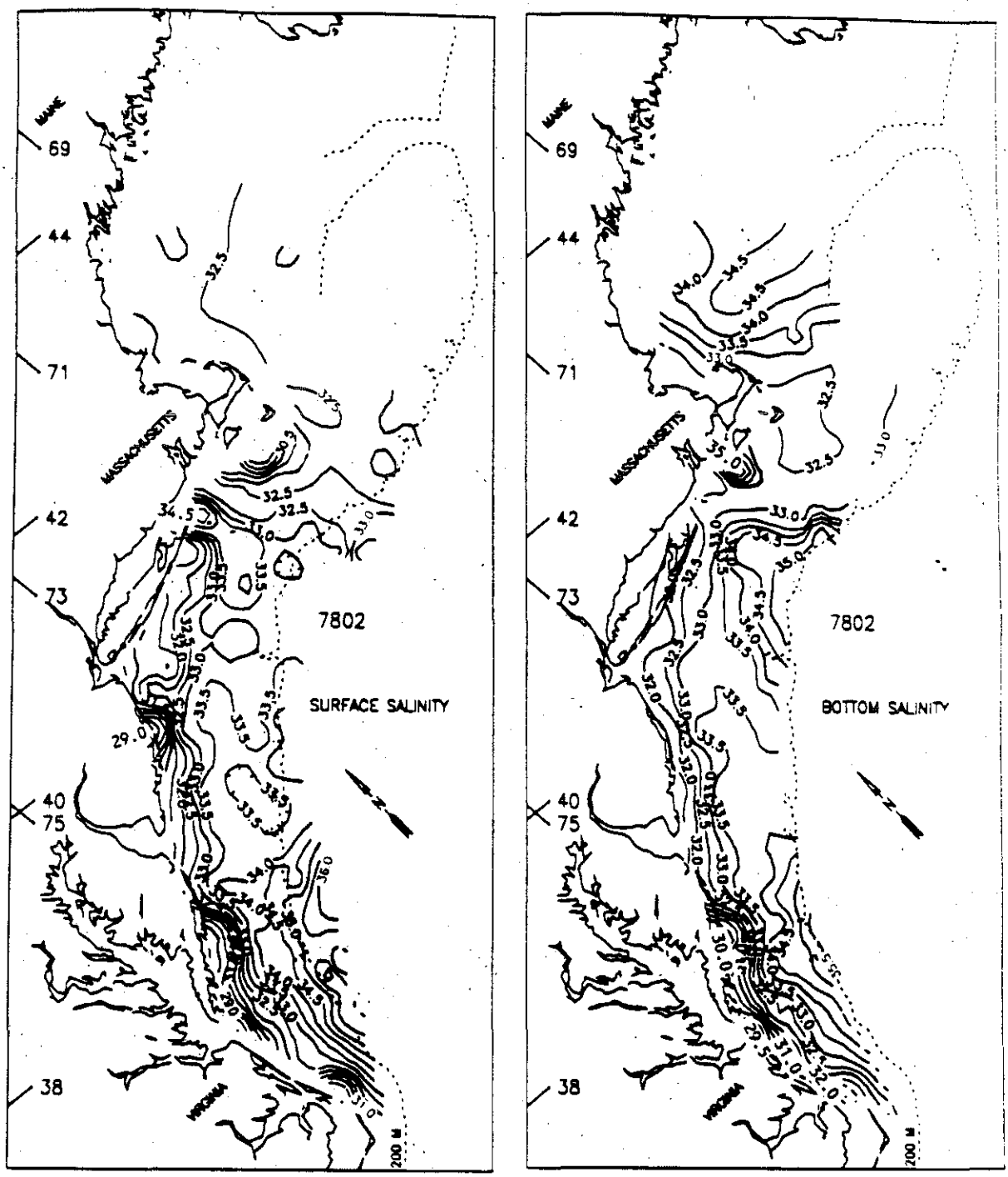
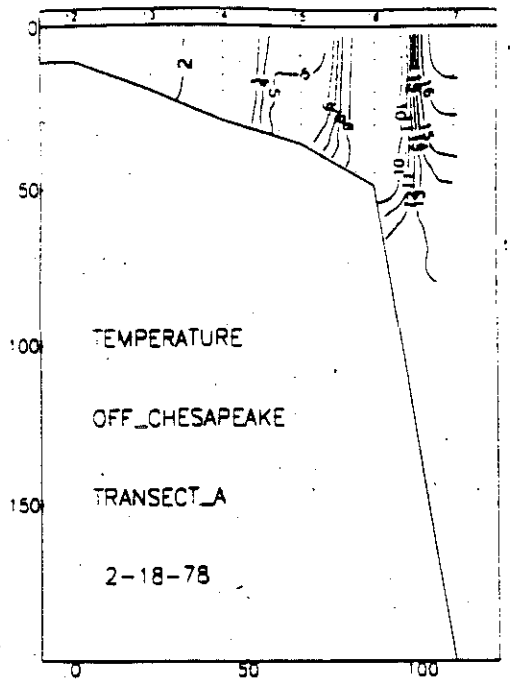
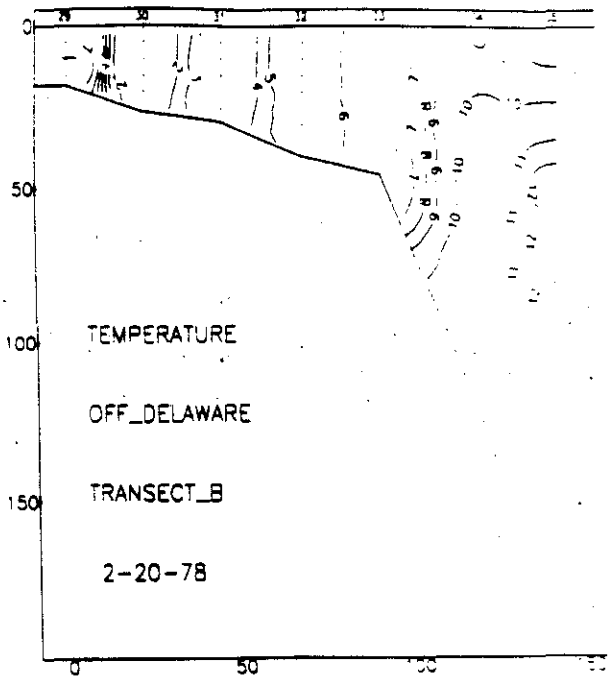
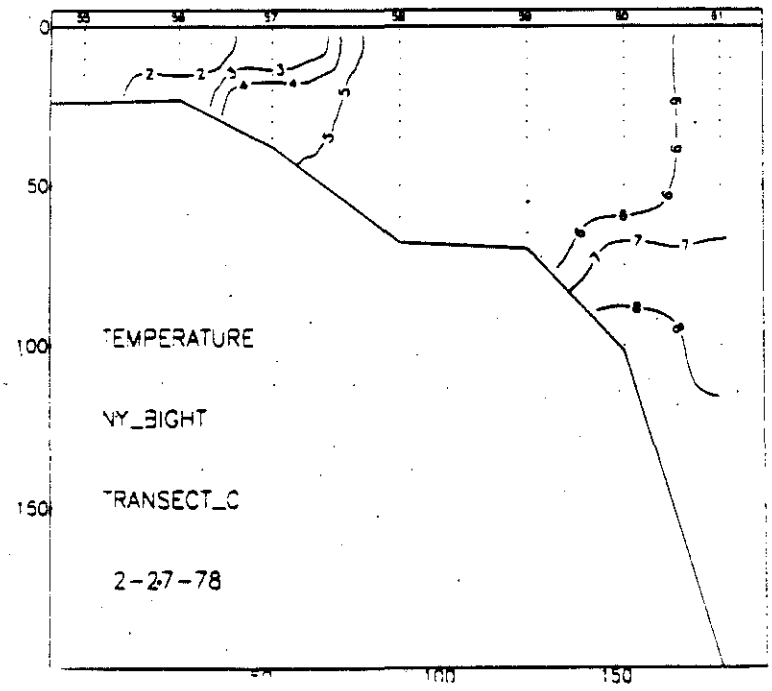


Figure 25. Surface and bottom salinity (PSU) distribution: DEL7802.







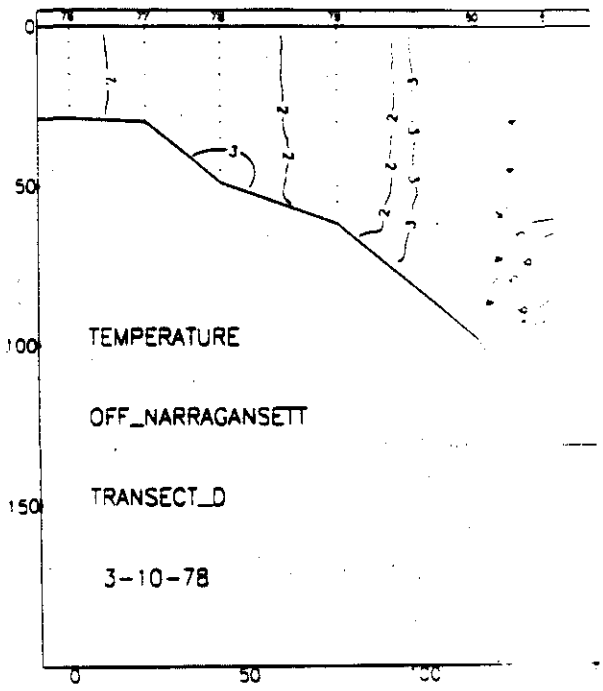


Figure 26. Temperature (°C) transects: DEL7802.

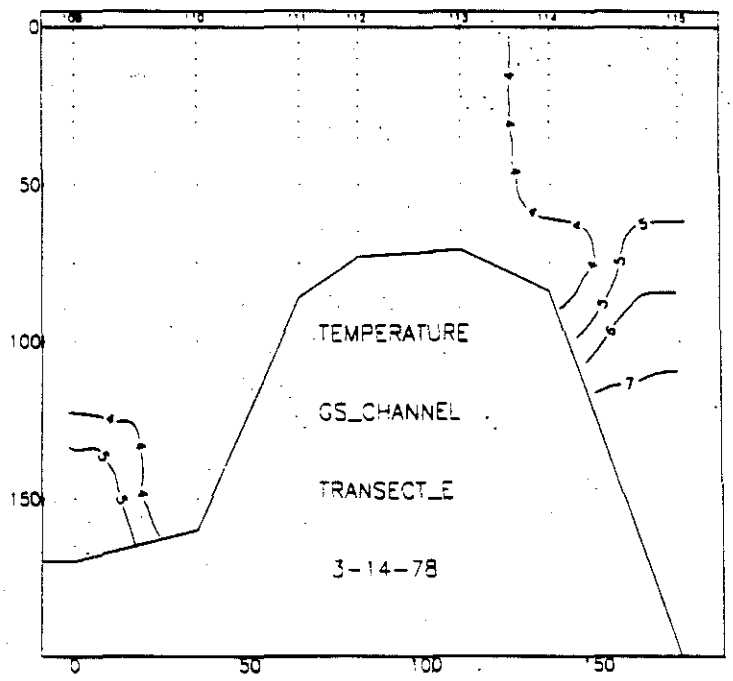
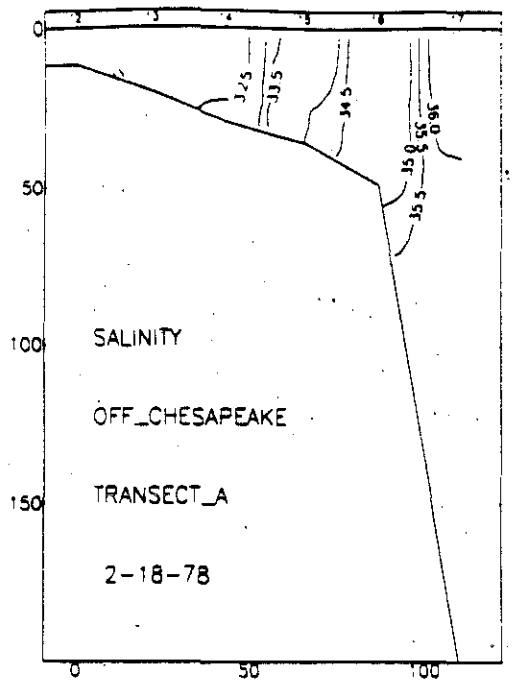
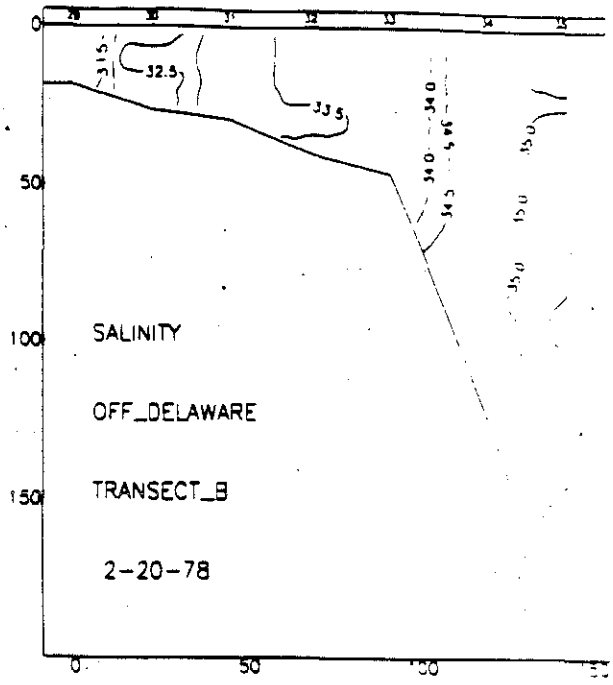
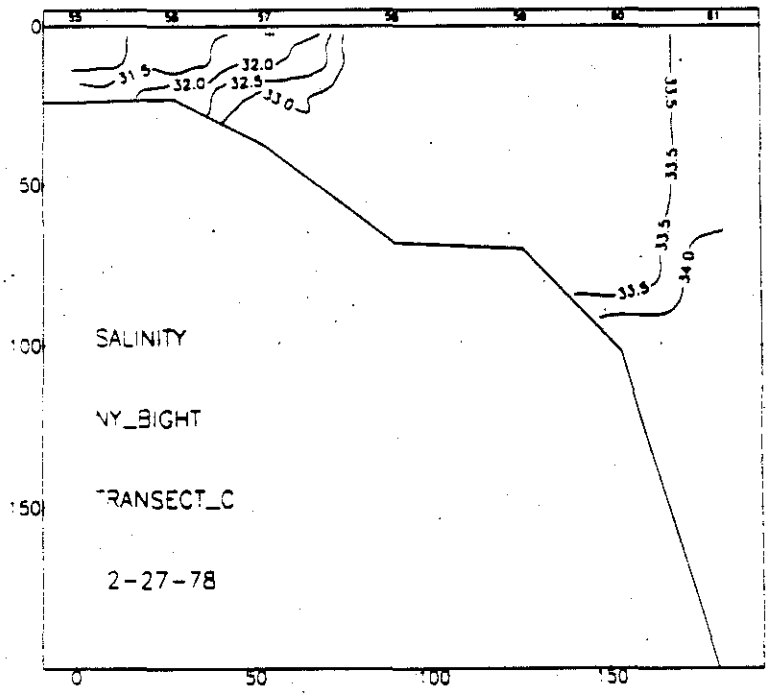


Figure 26. Continued.







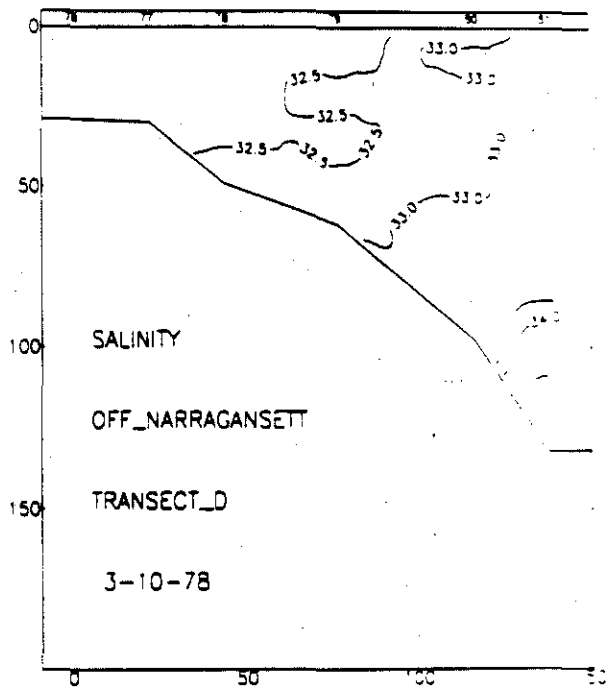


Figure 27. Salinity (PSU) transects: DEL7802.

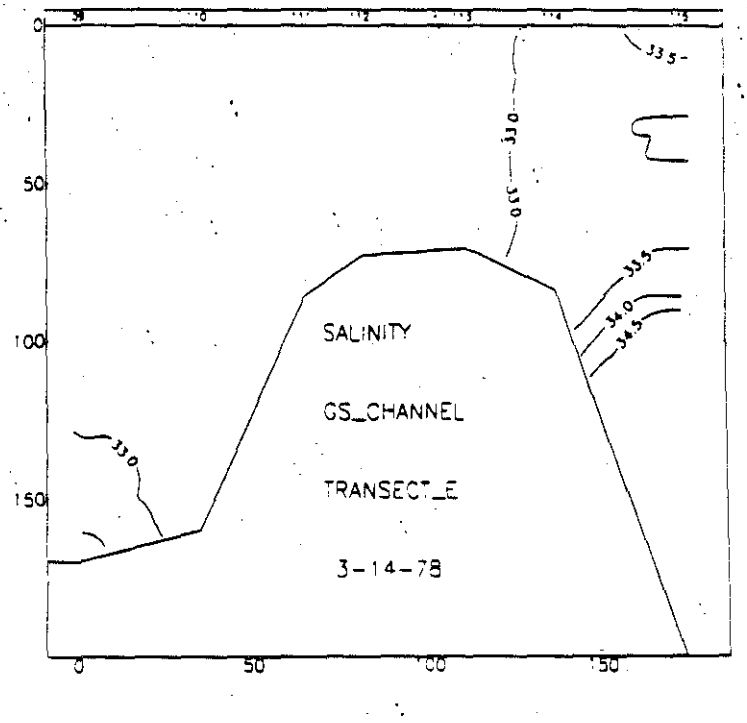


Figure 27. Continued.

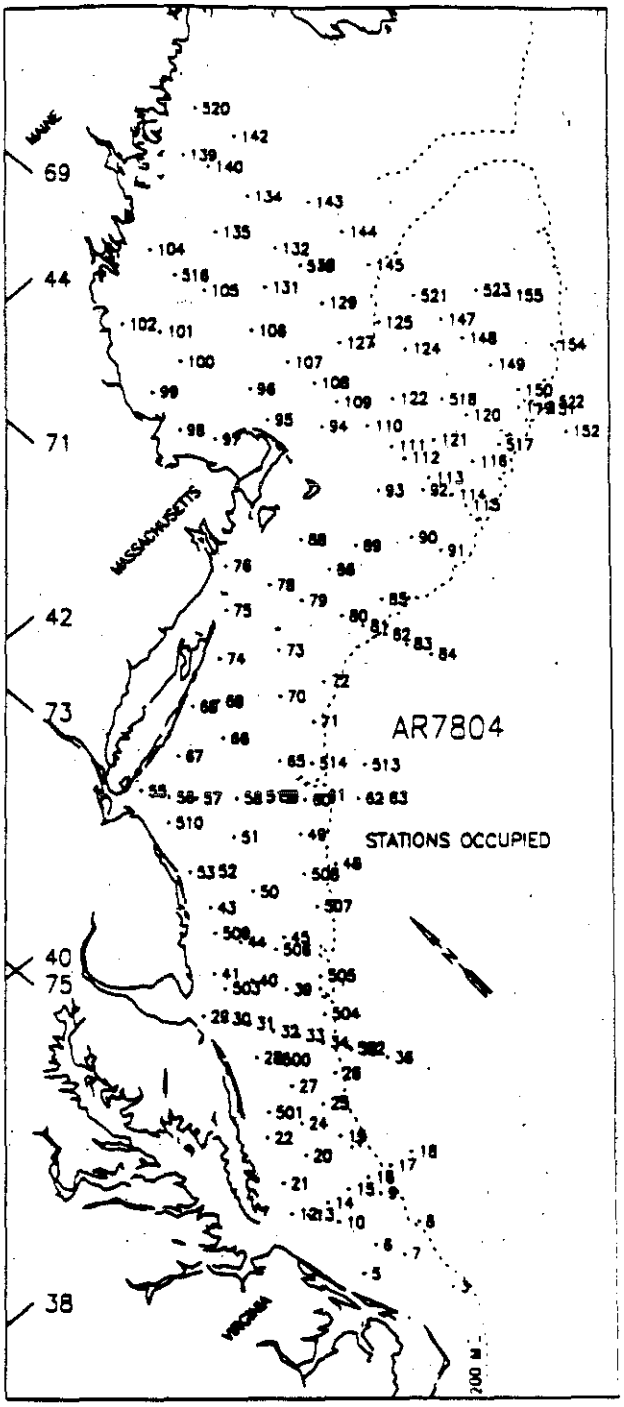


Figure 28. Station positions: ARG7804.

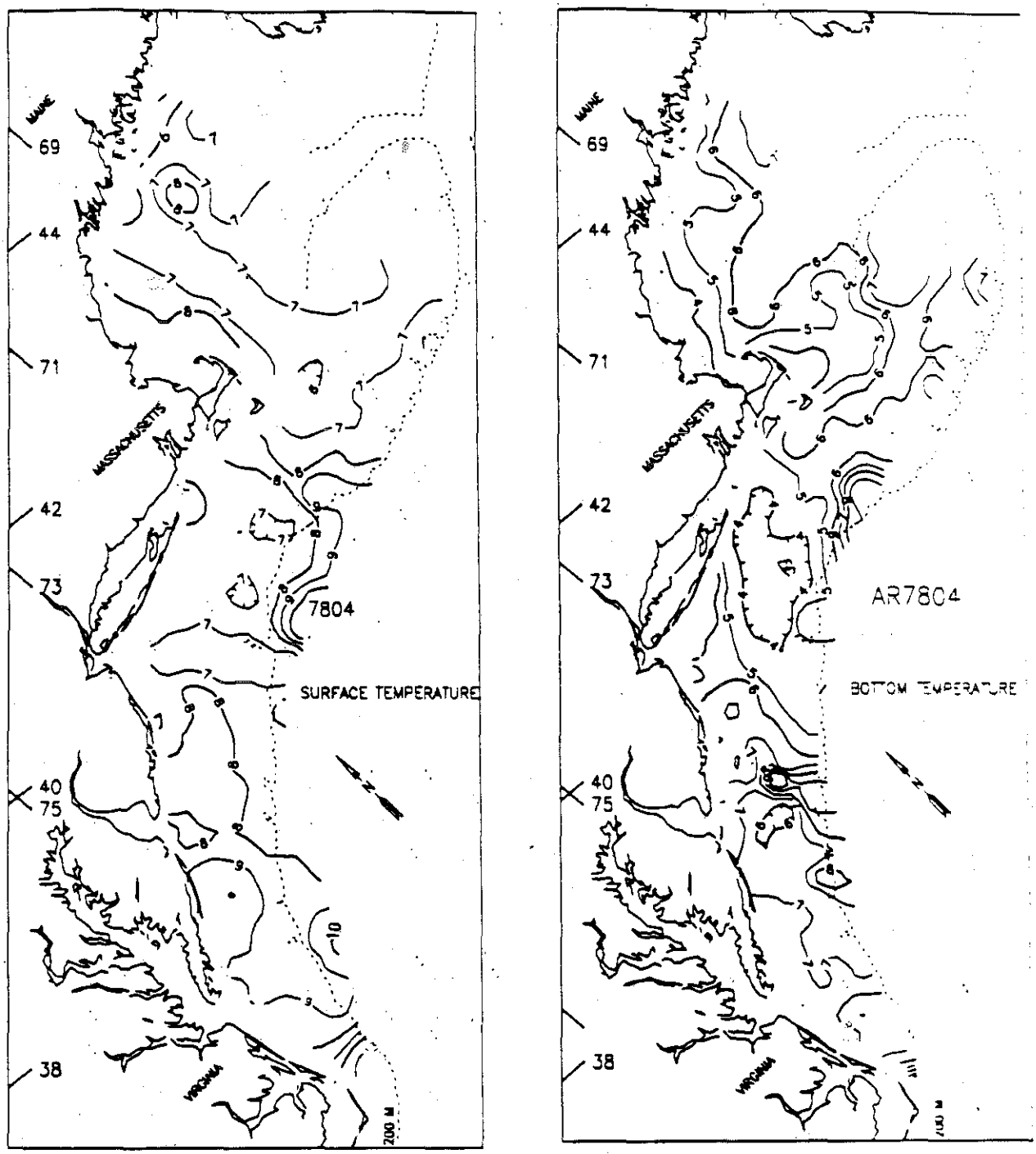


Figure 29. Surface and bottom temperature (°C) distribution: ARG7804.

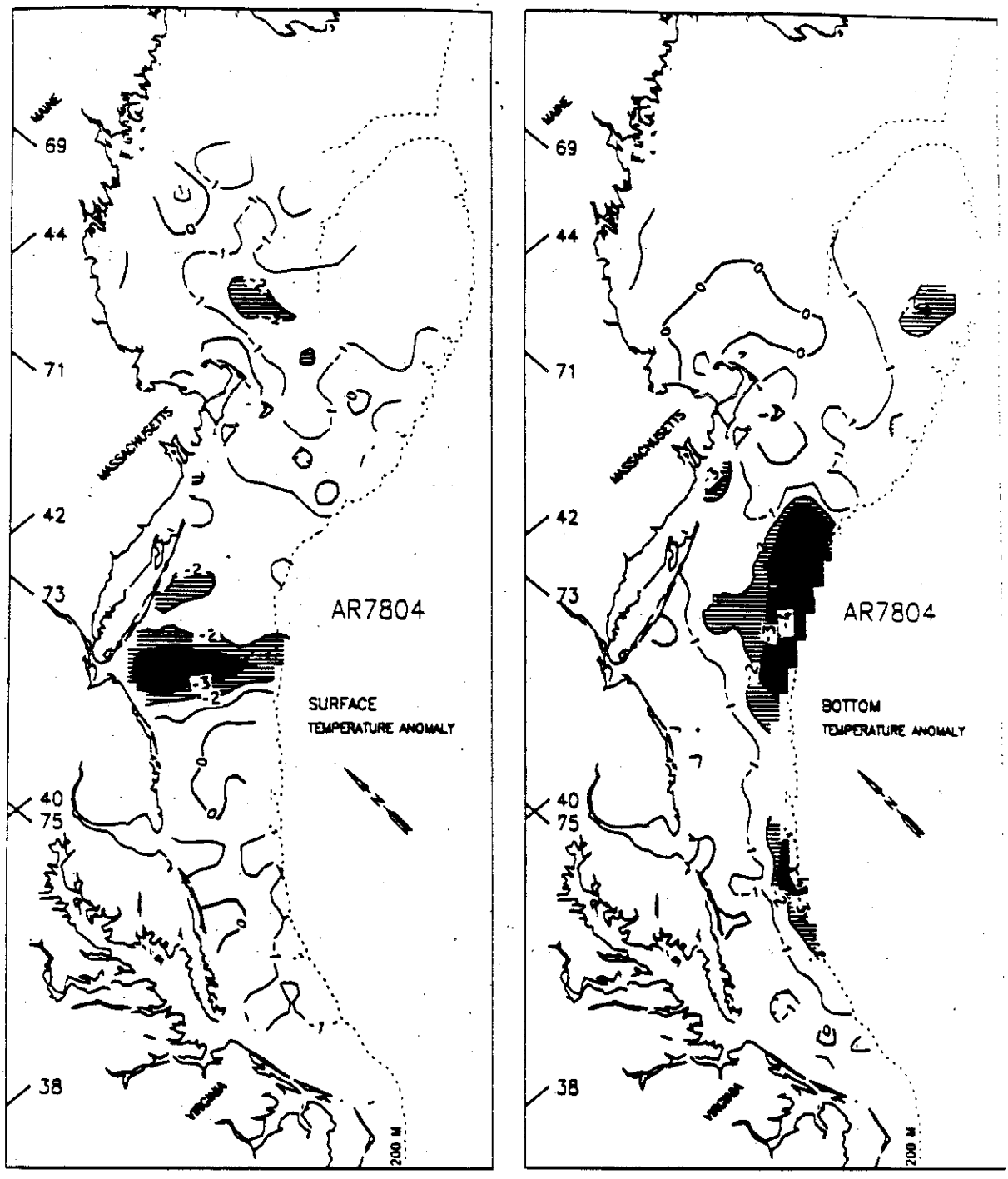


Figure 30. Normalized surface and bottom temperature anomaly: ARG7804. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

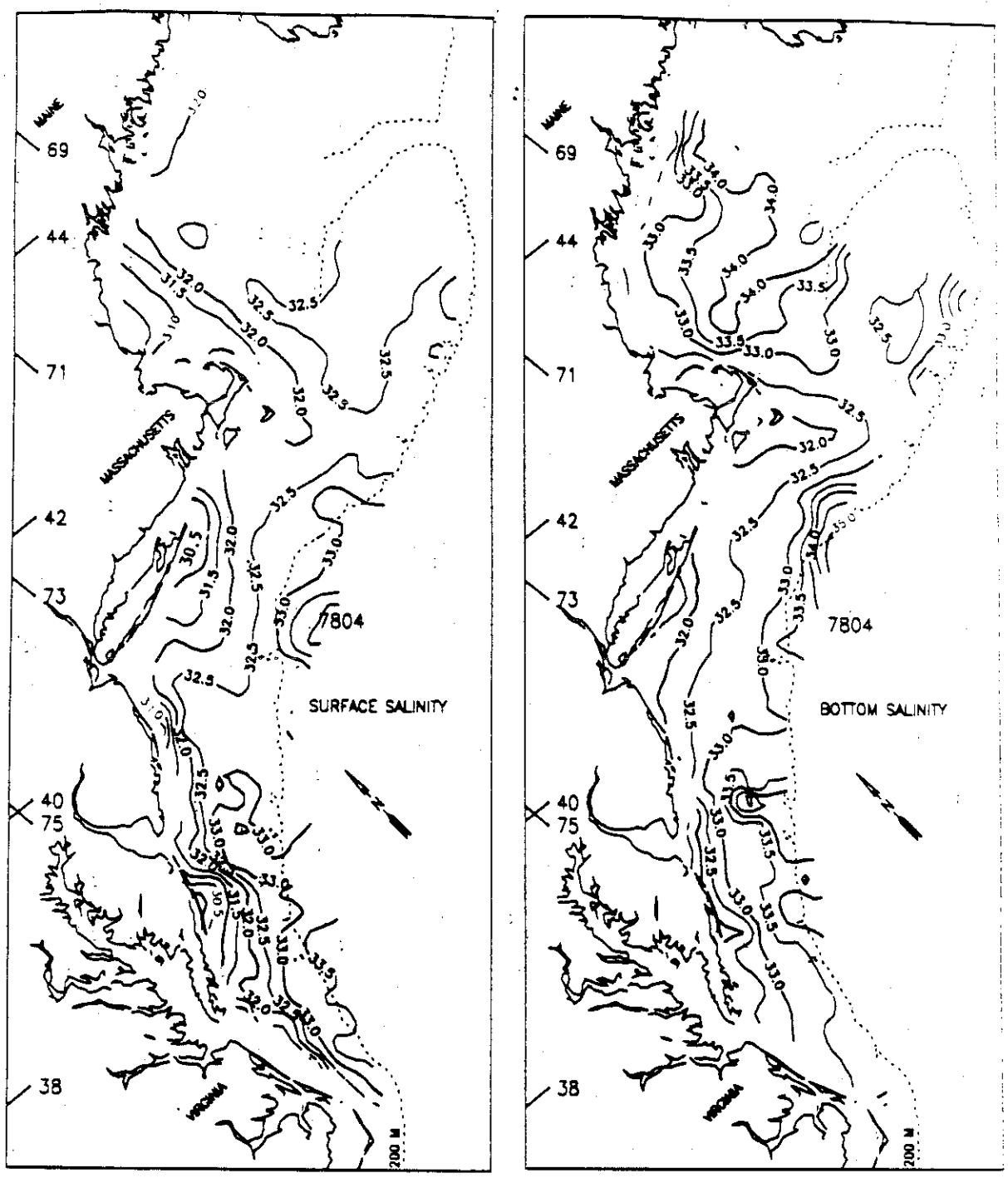
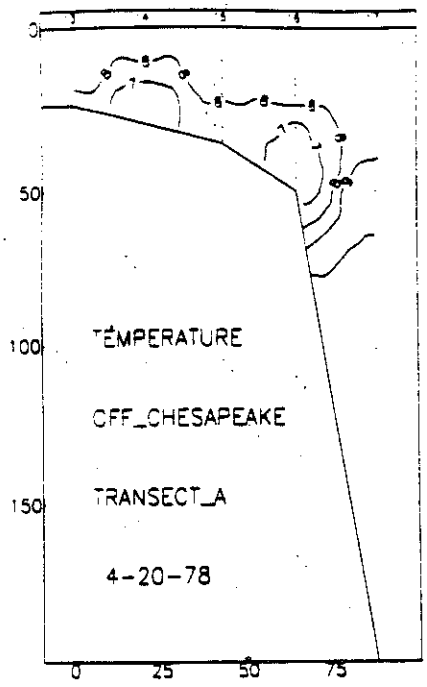
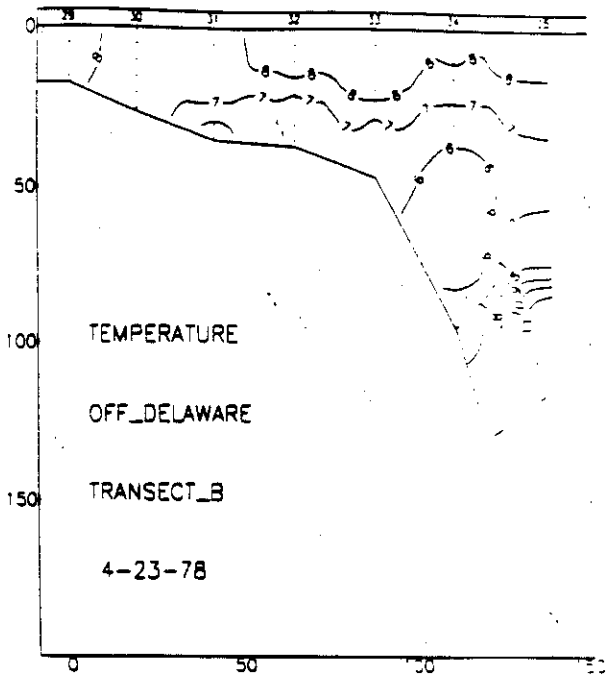
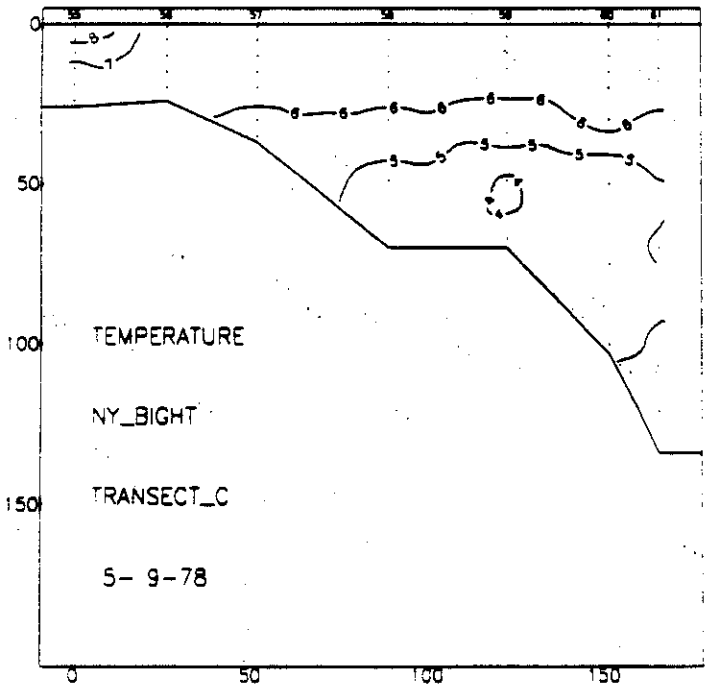


Figure 31. Surface and bottom salinity (PSU) distribution: ARG7804.







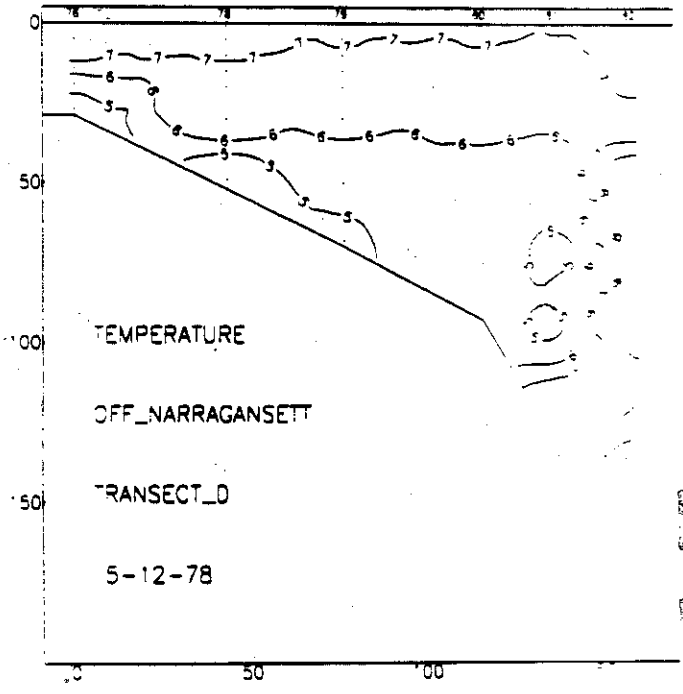


Figure 32. Temperature (°C) transects: ARG7804.

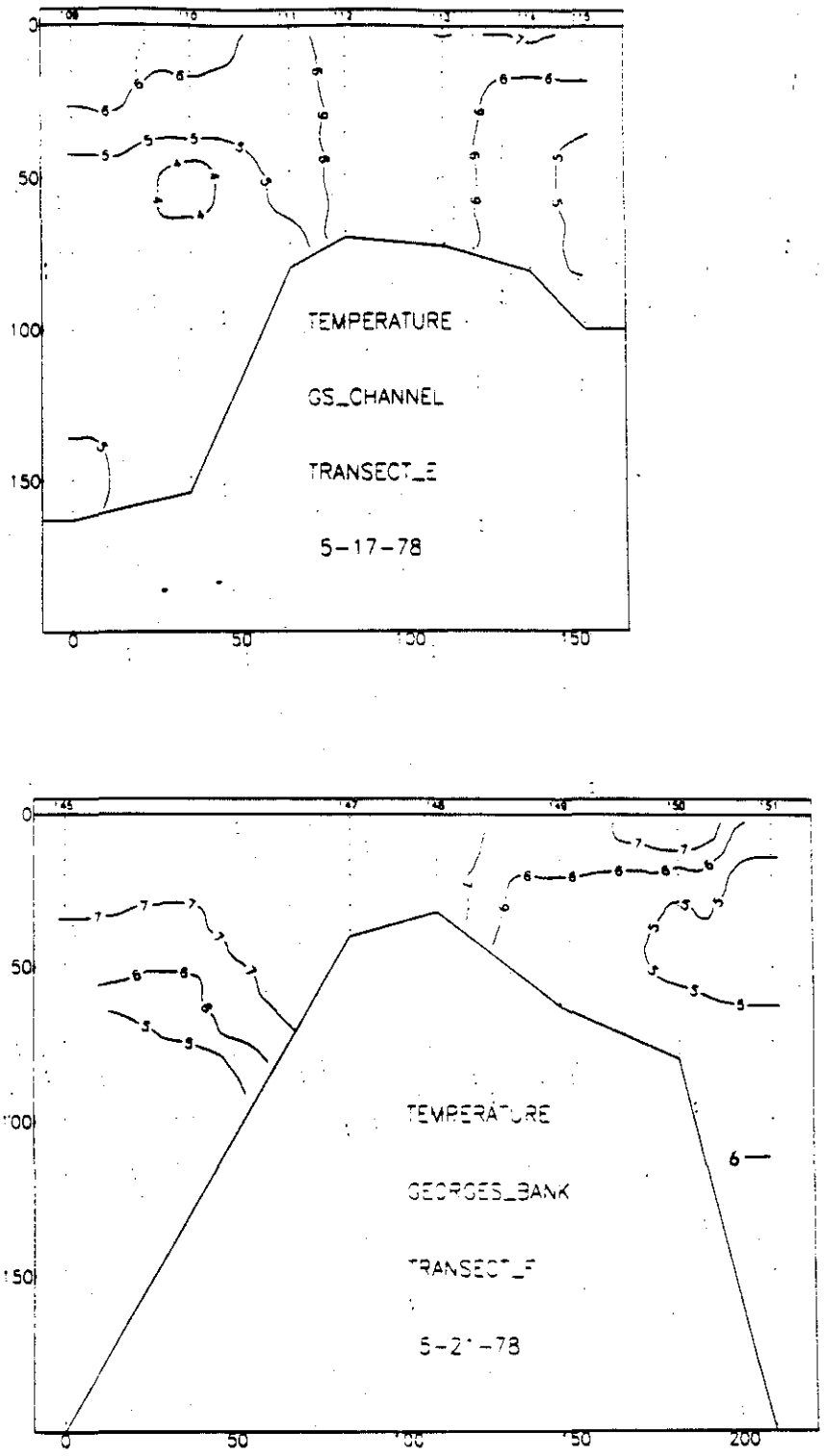
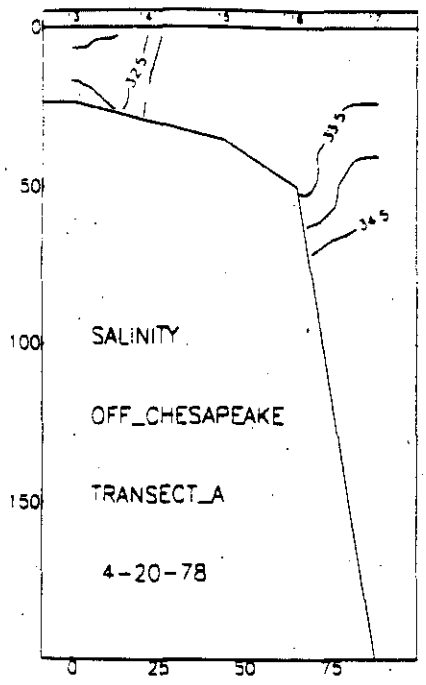
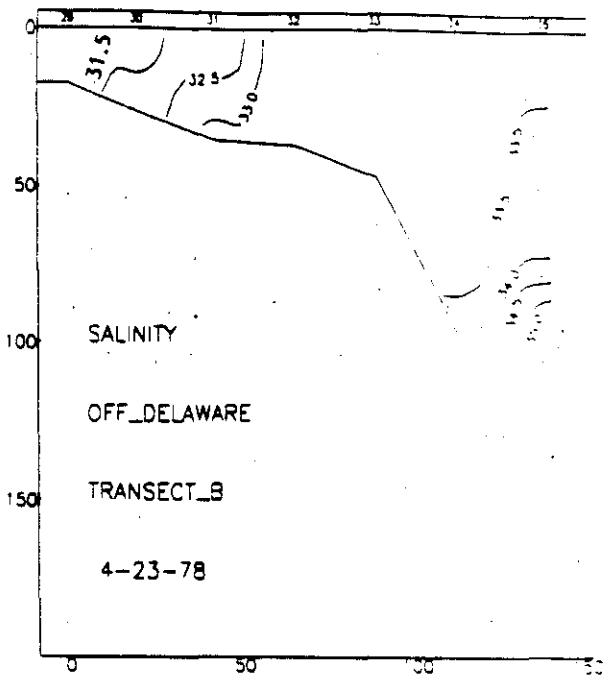
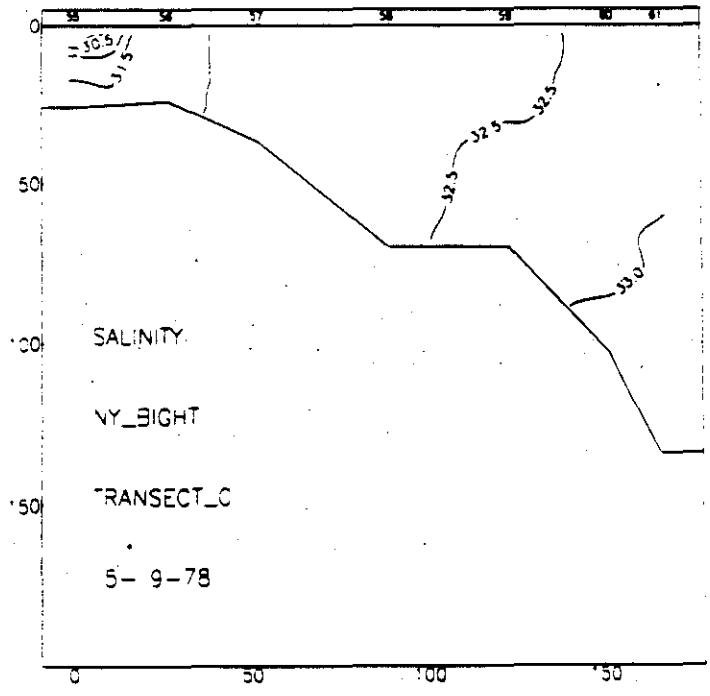


Figure 32. Continued.







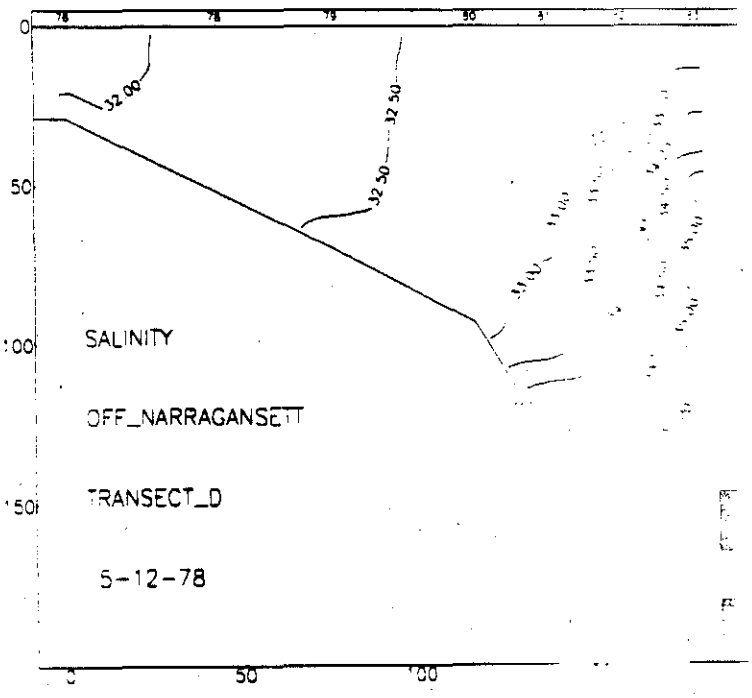
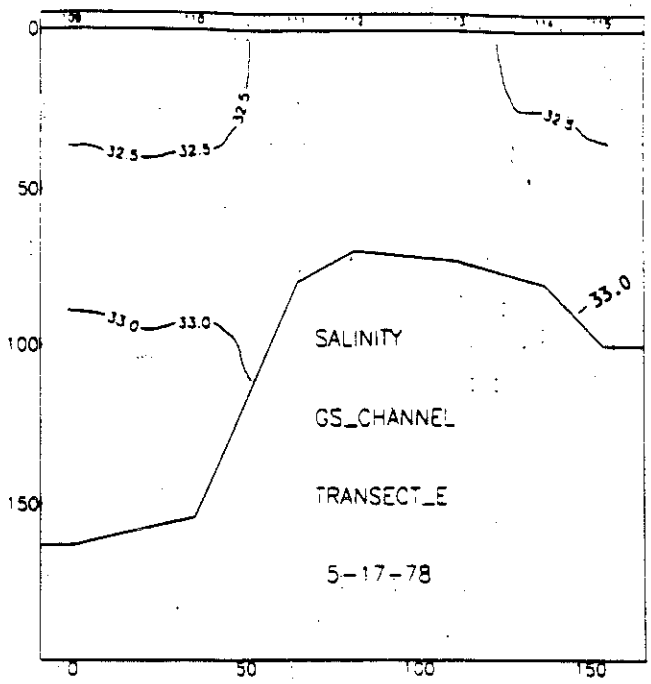


Figure 33. Salinity (PSU) transects: ARG7804.



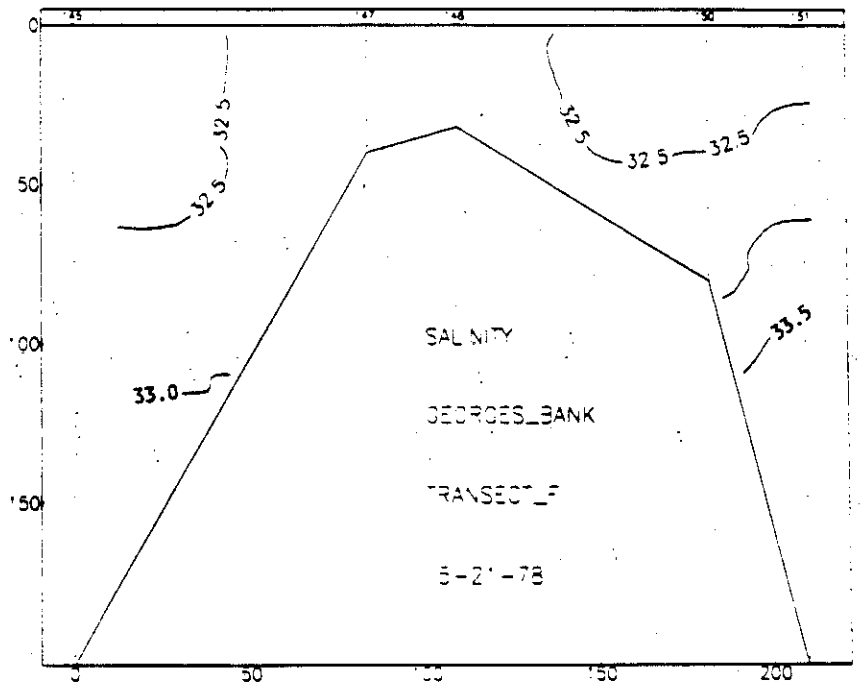


Figure 33. Continued.

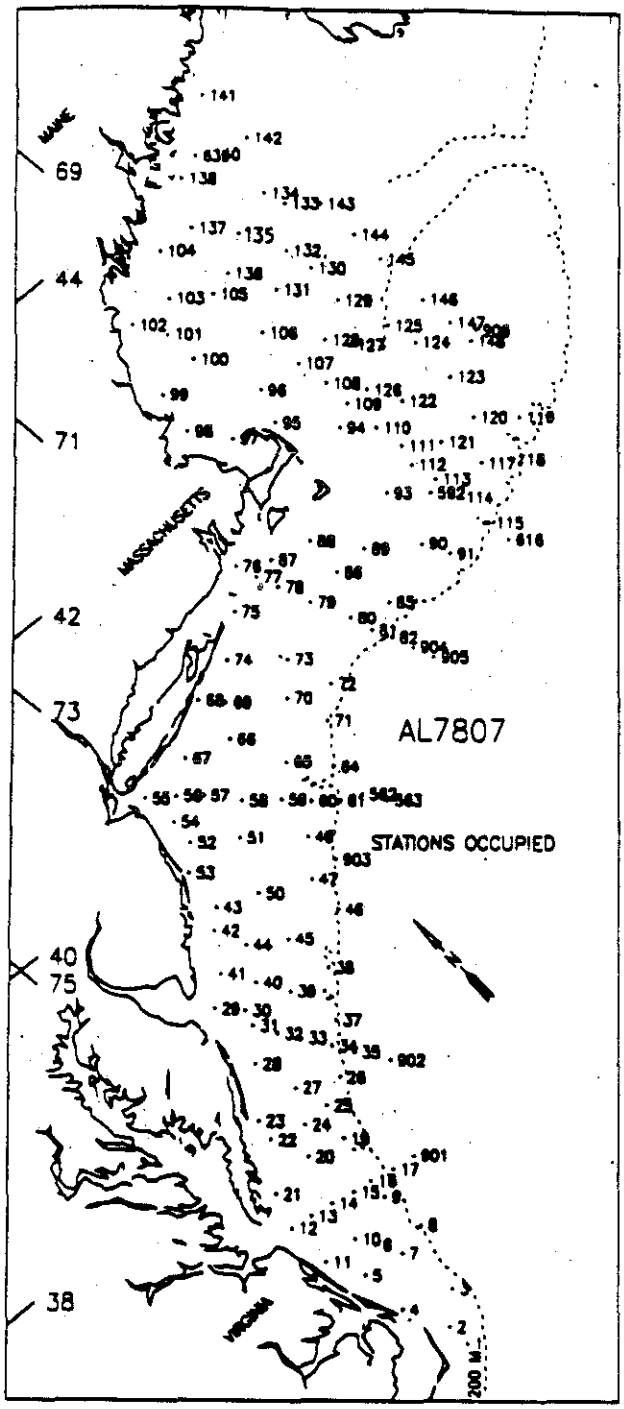


Figure 34. Station positions: ALB7807.

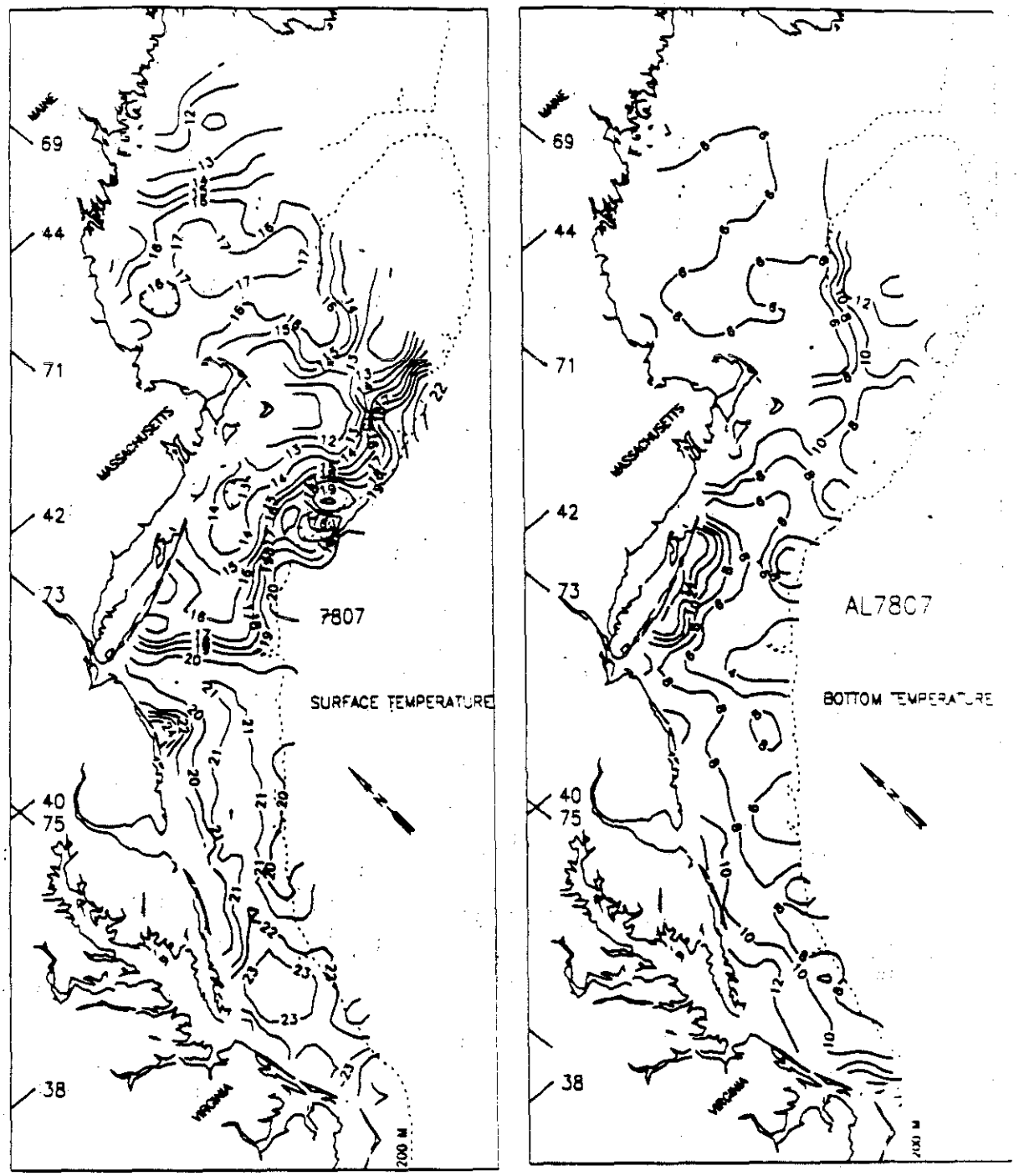


Figure 35. Surface and bottom temperature (°C) distribution: ALB7807.

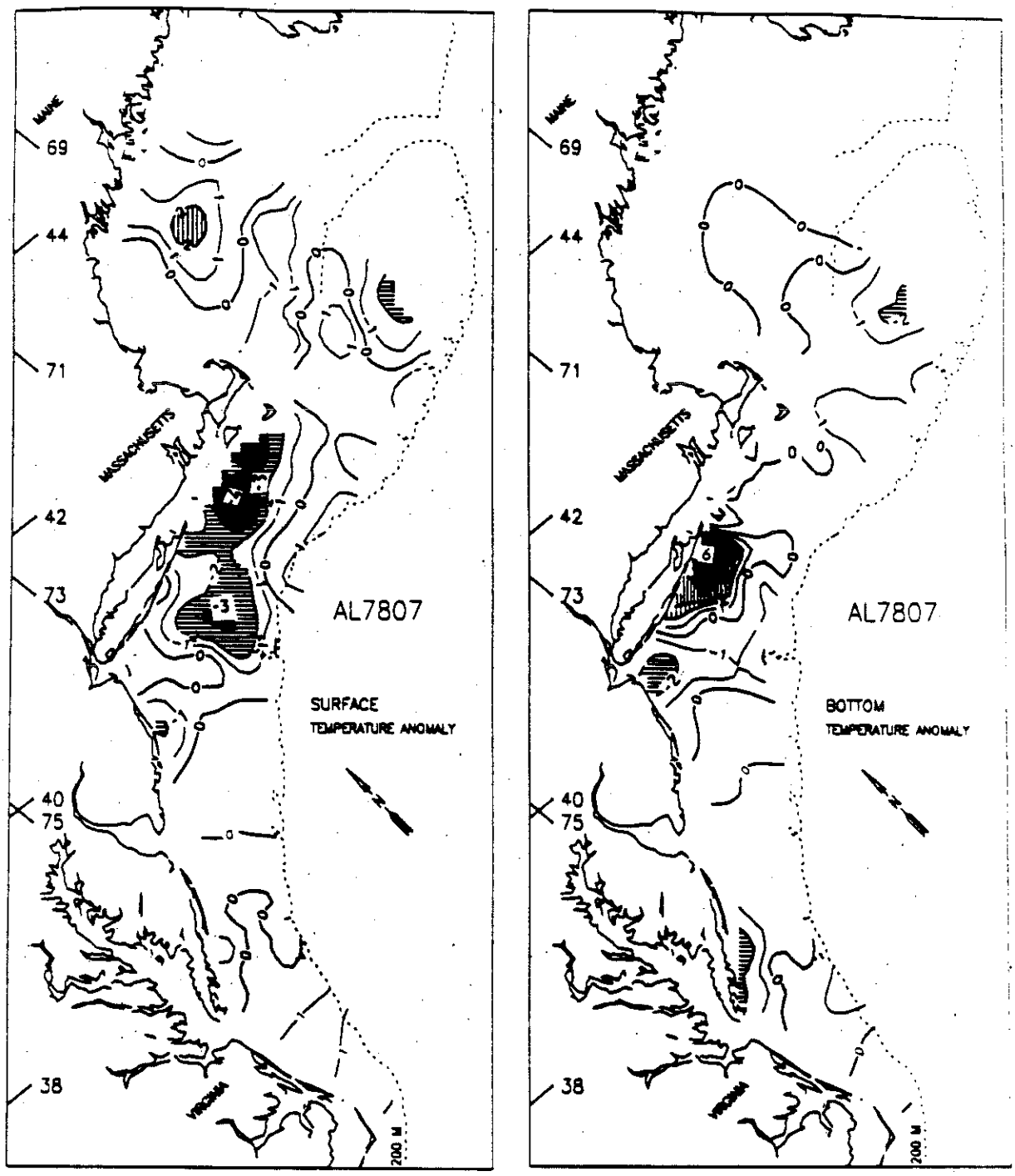


Figure 36. Normalized surface and bottom temperature anomaly: ALB7807. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

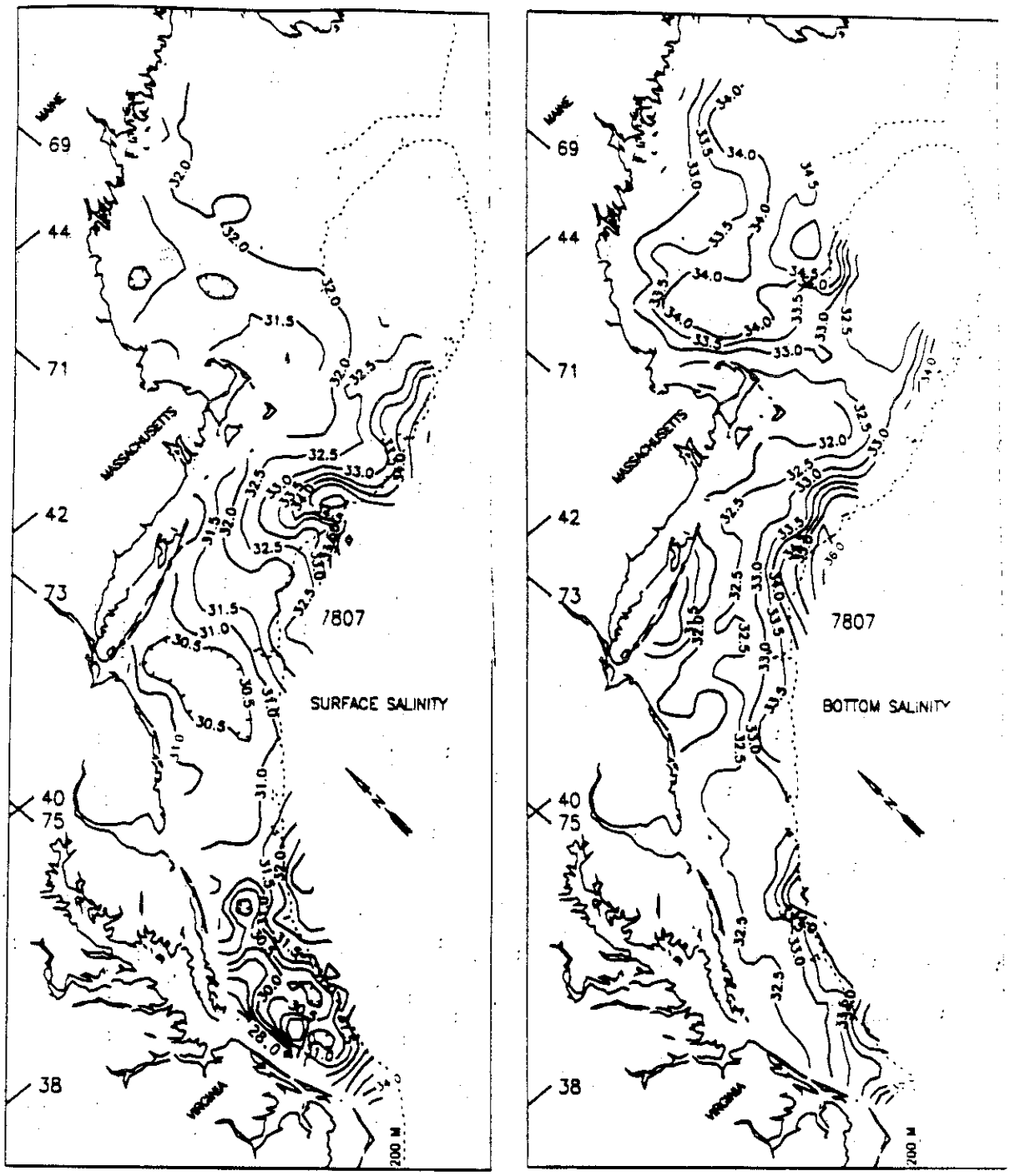
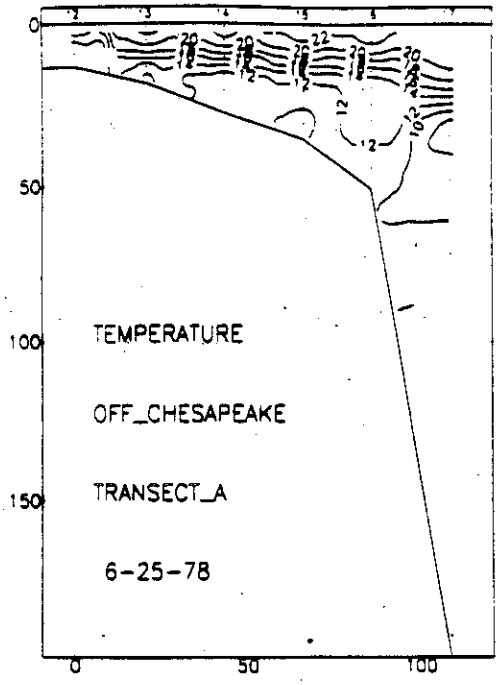
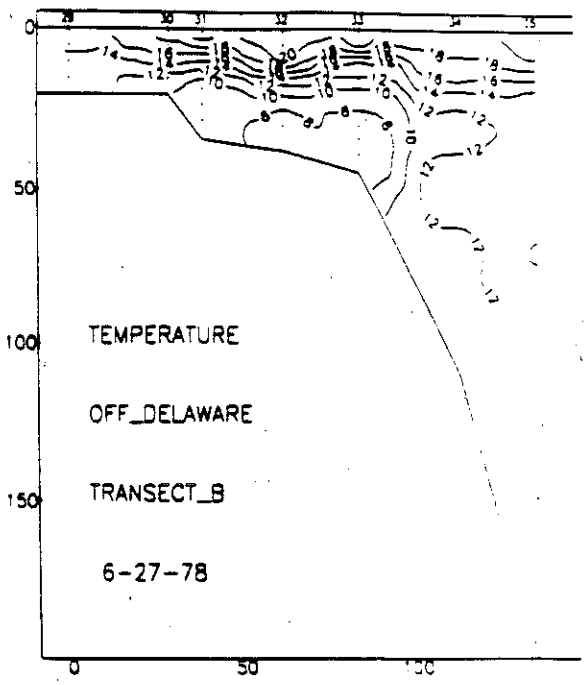
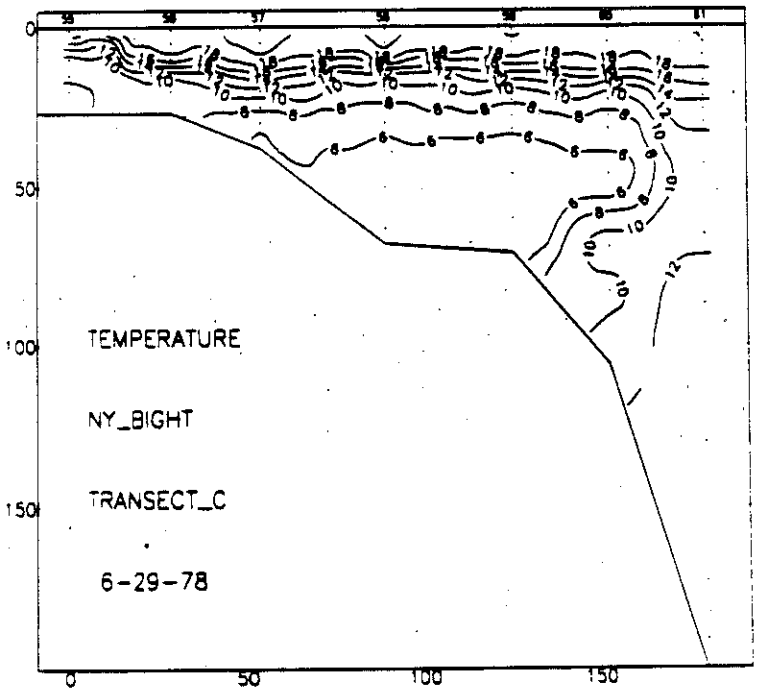


Figure 37. Surface and bottom salinity (PSU) distribution: ALB7807.







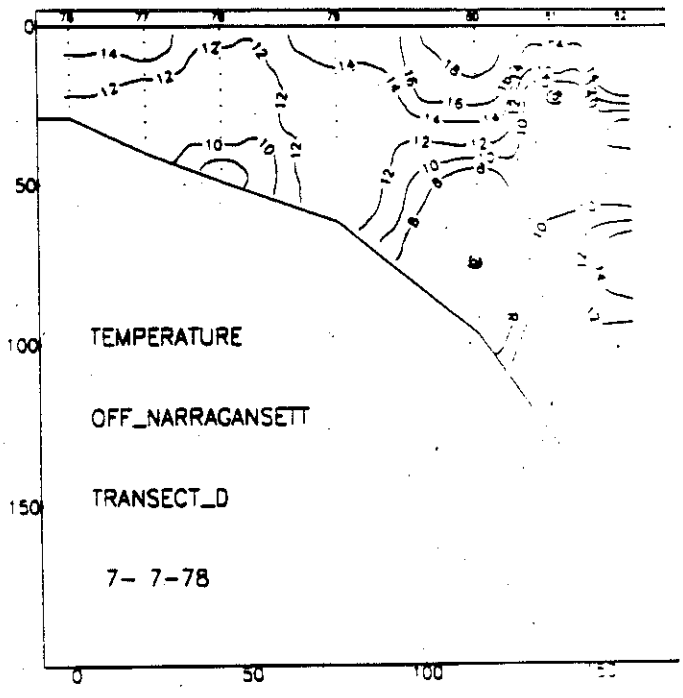
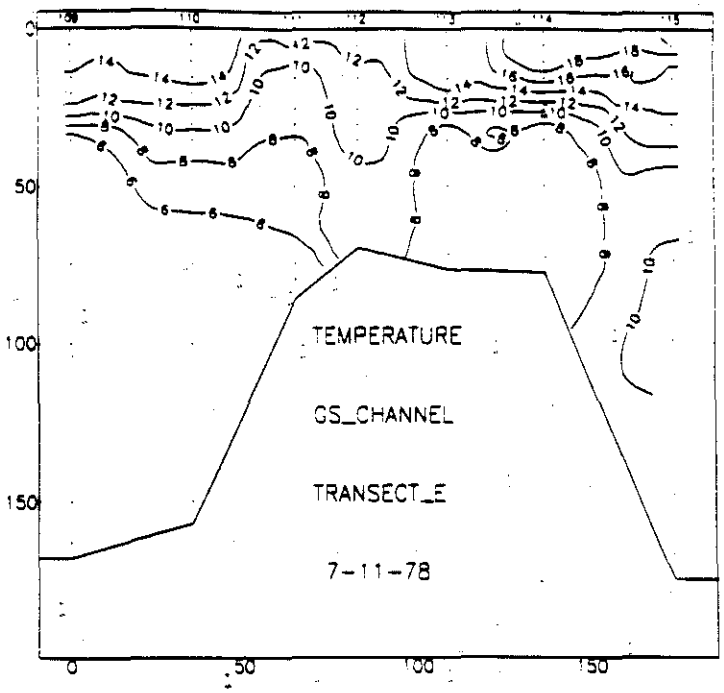


Figure 38. Temperature (°C) transects: ALB7807.



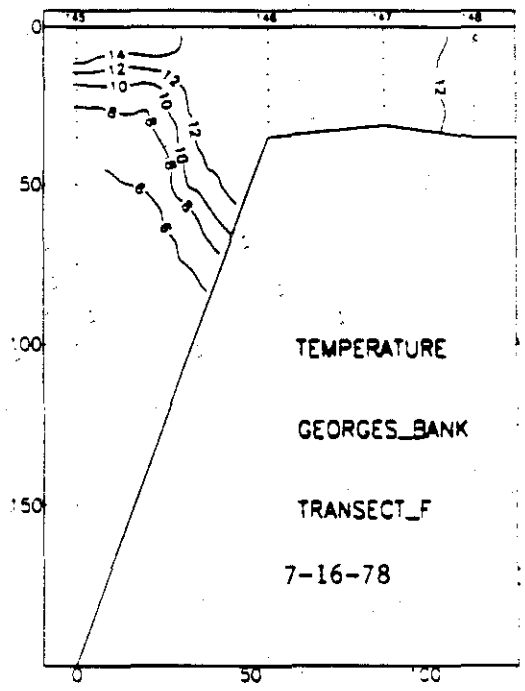
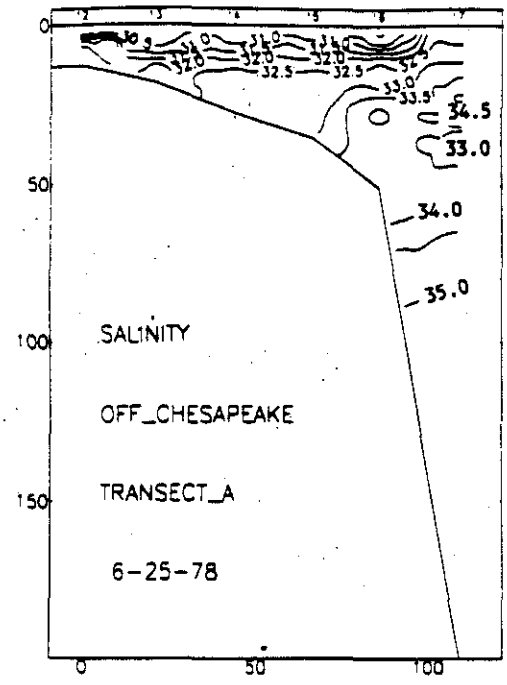
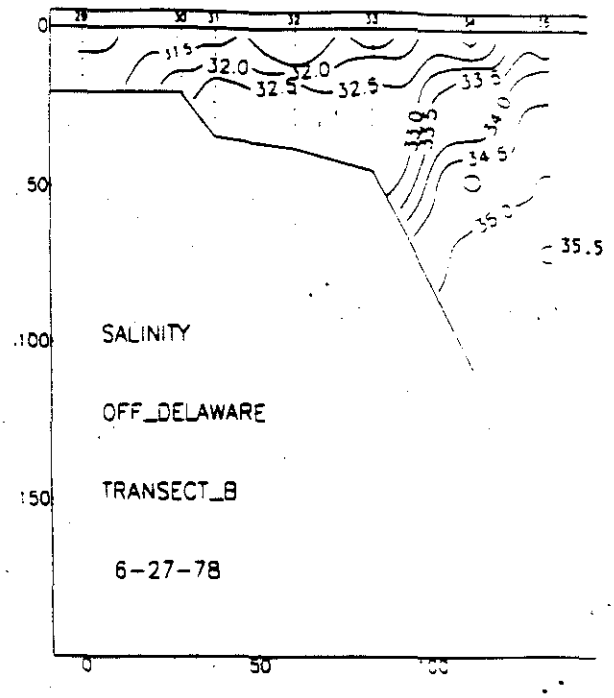
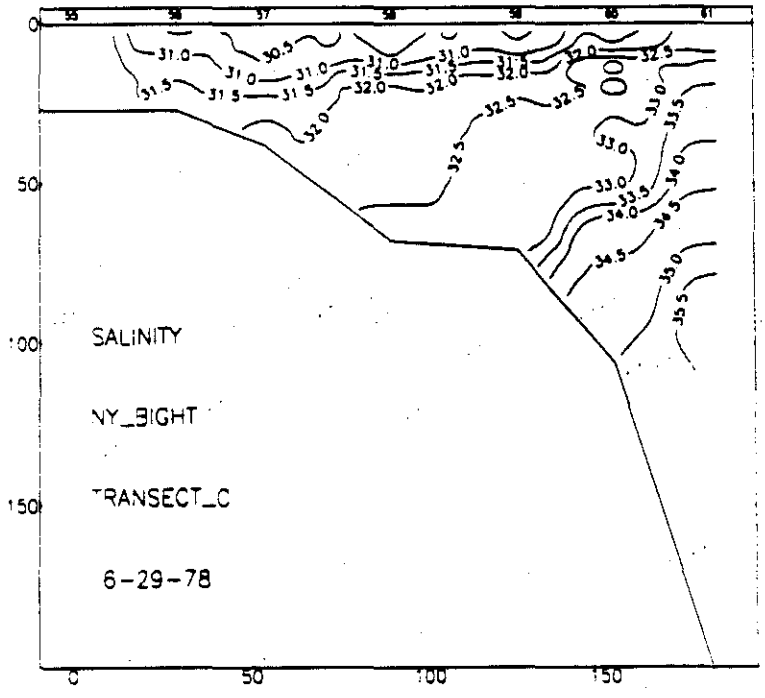


Figure 38. Continued.







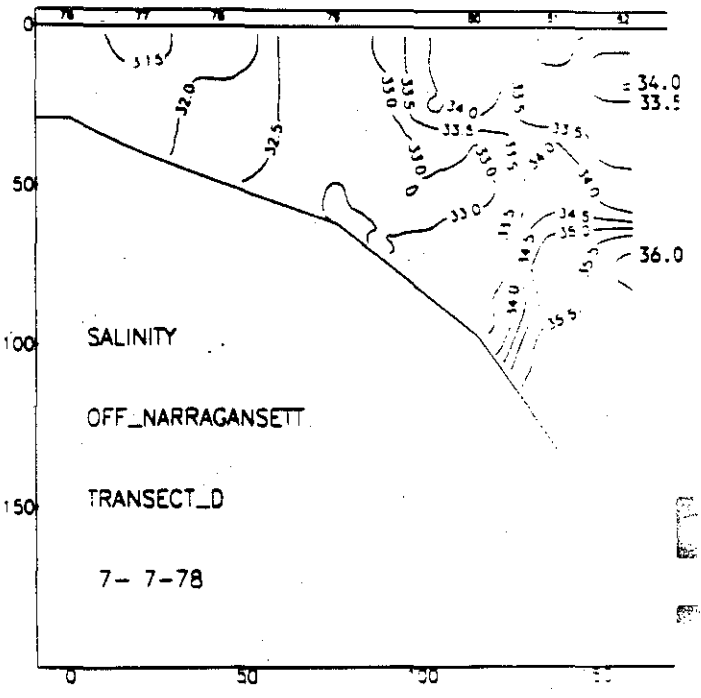
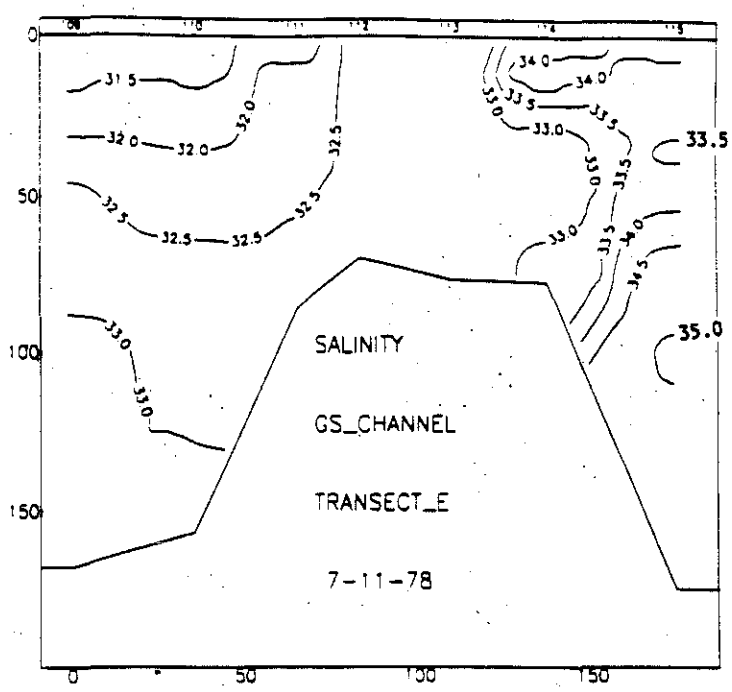


Figure 39. Salinity (PSU) transects: ALB7807.



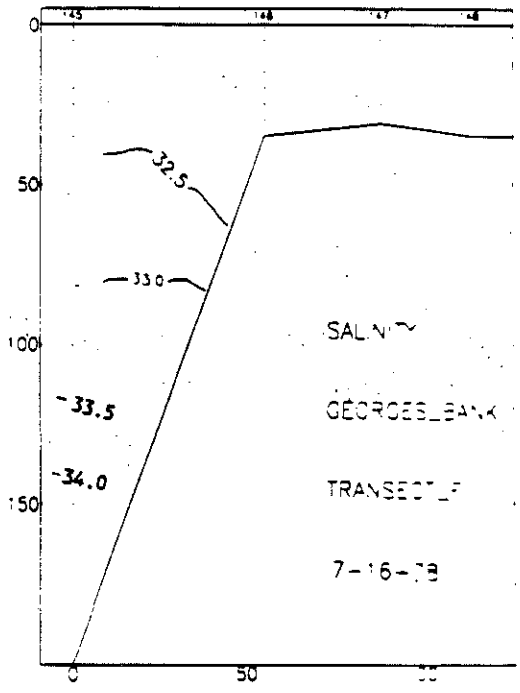


Figure 39. Continued.

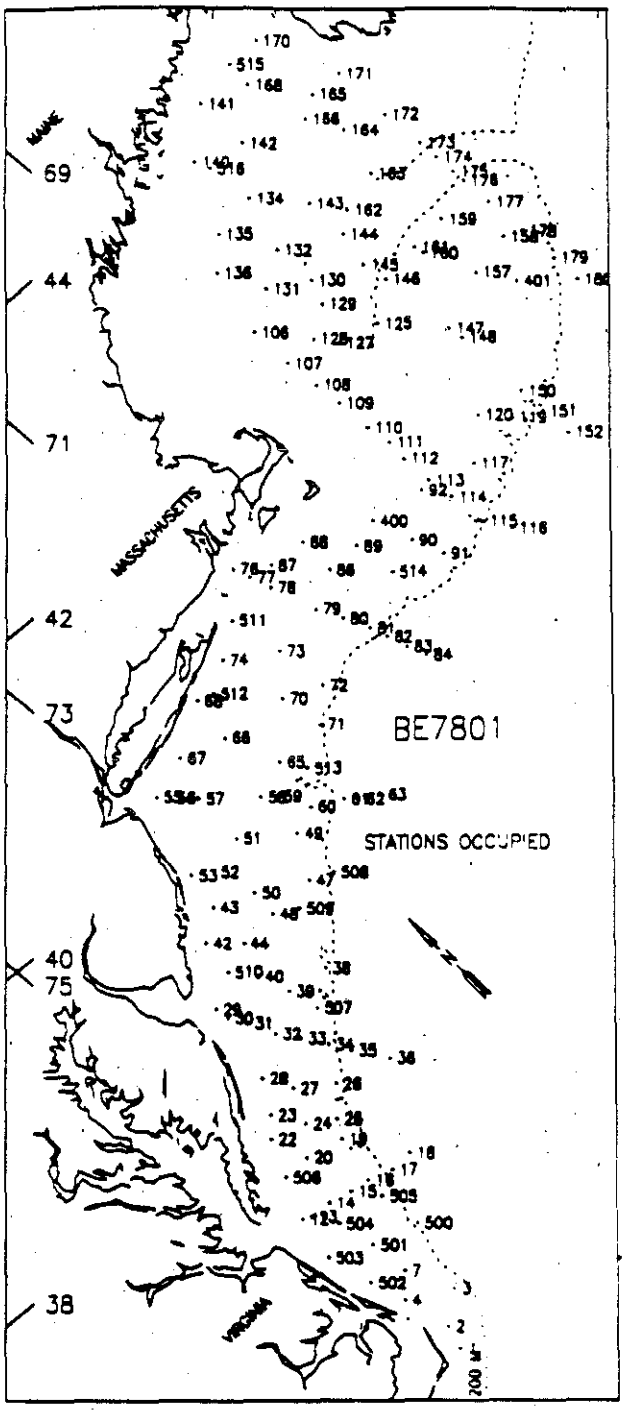


Figure 40. Station positions: BEL7801.

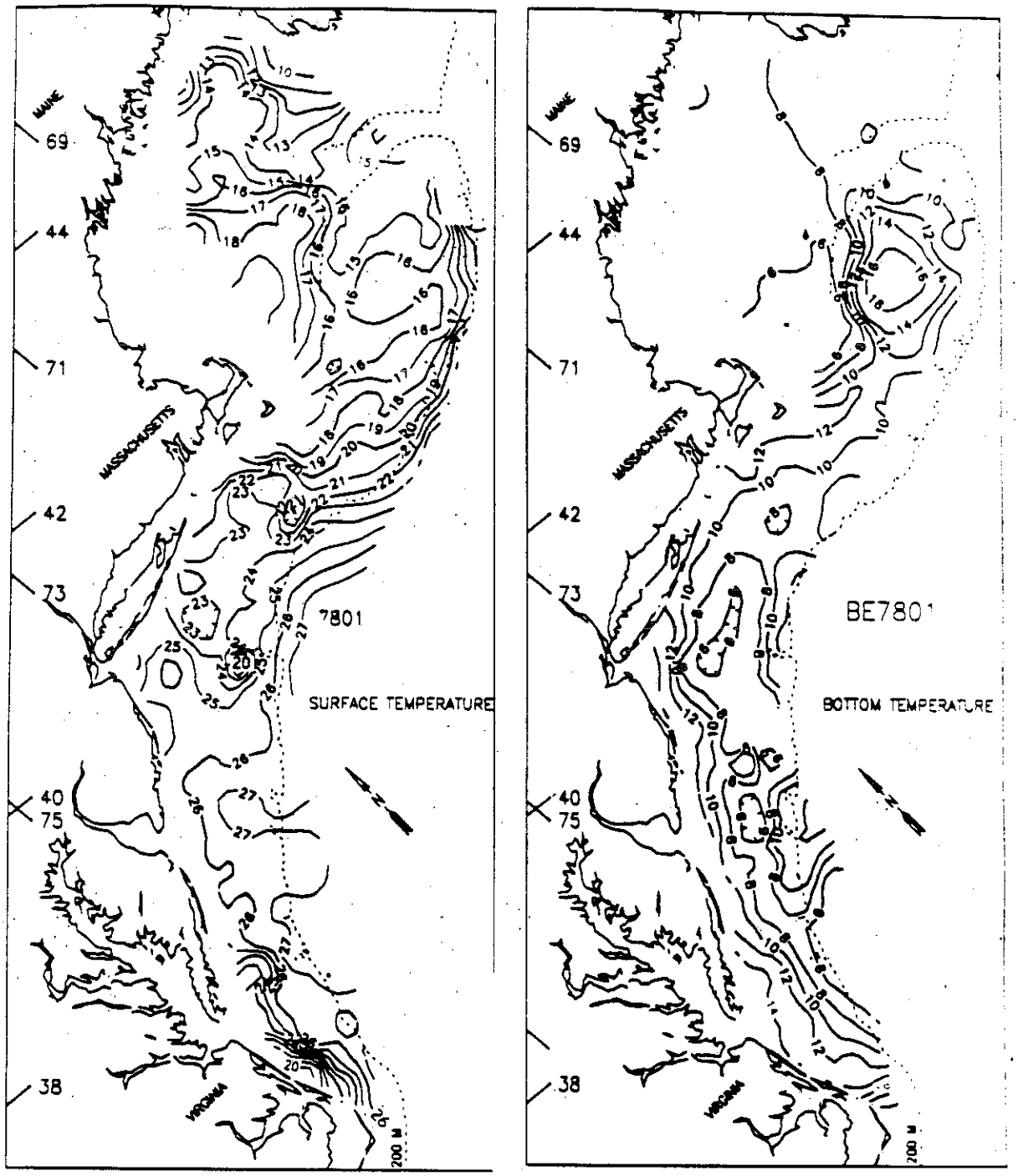


Figure 41. Surface and bottom temperature (°C) distribution: BEL7801.

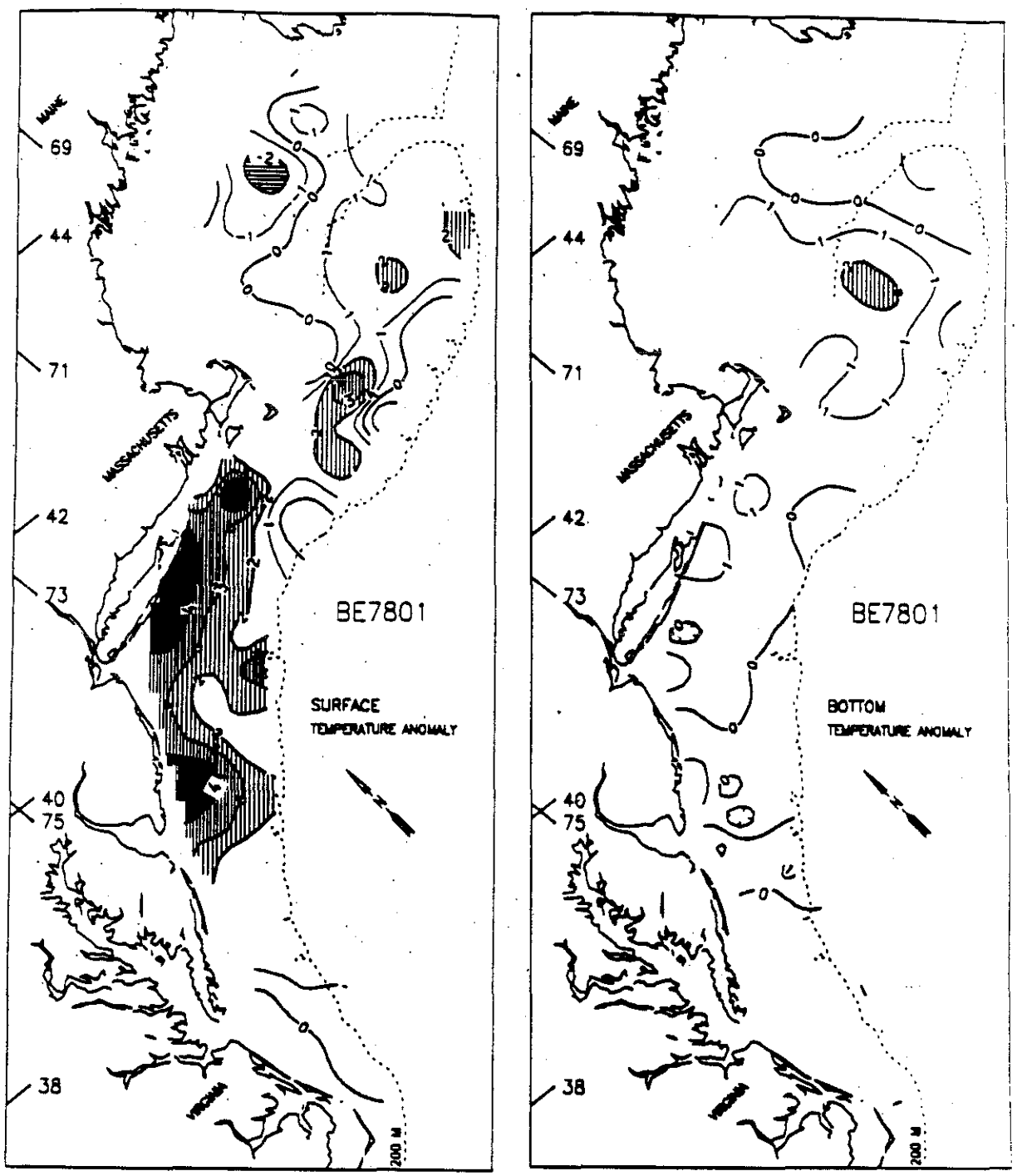


Figure 42. Normalized surface and bottom temperature anomaly: BEL7801. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

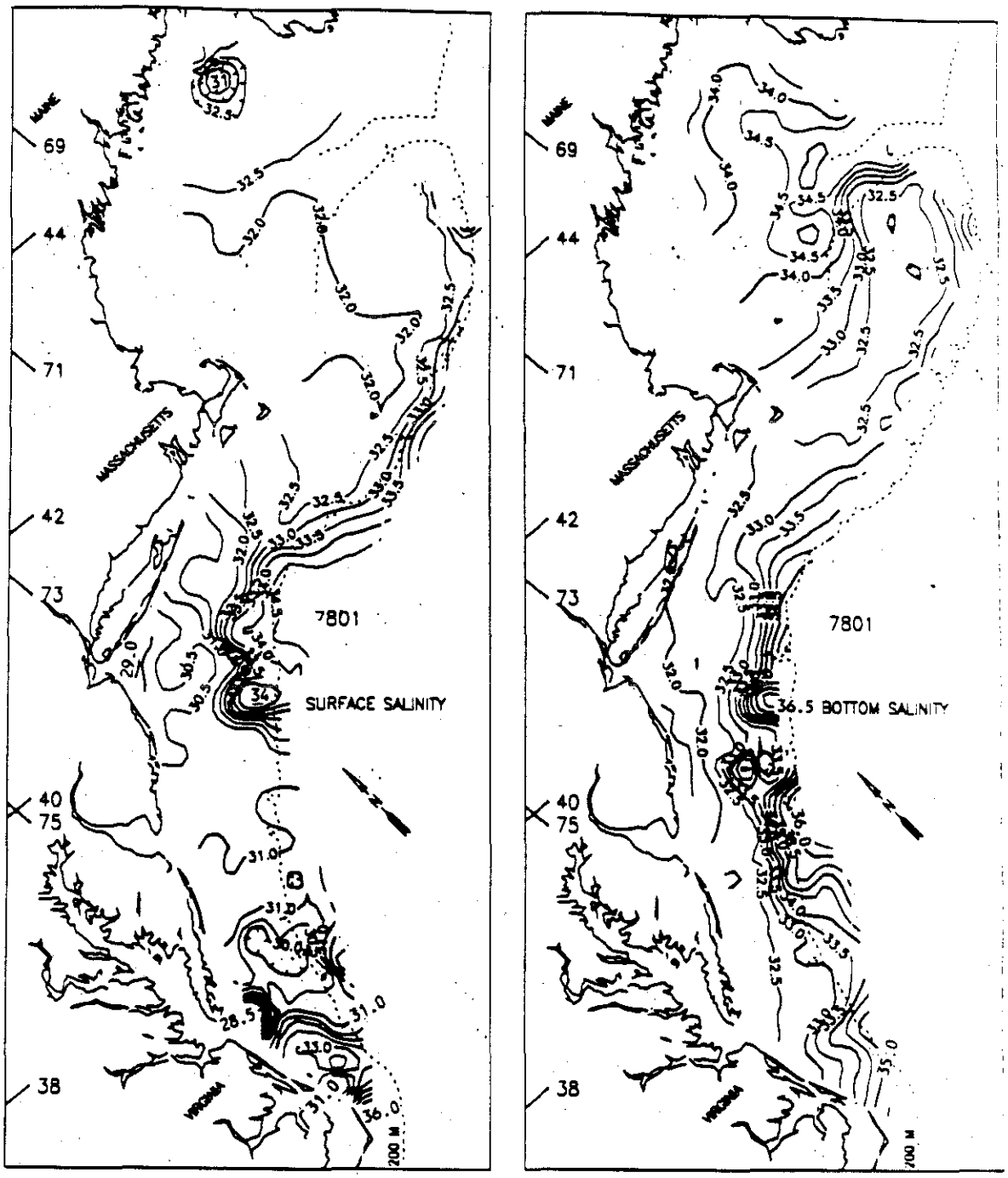


Figure 43. Surface and bottom salinity (PSU) distribution: BEL7801.

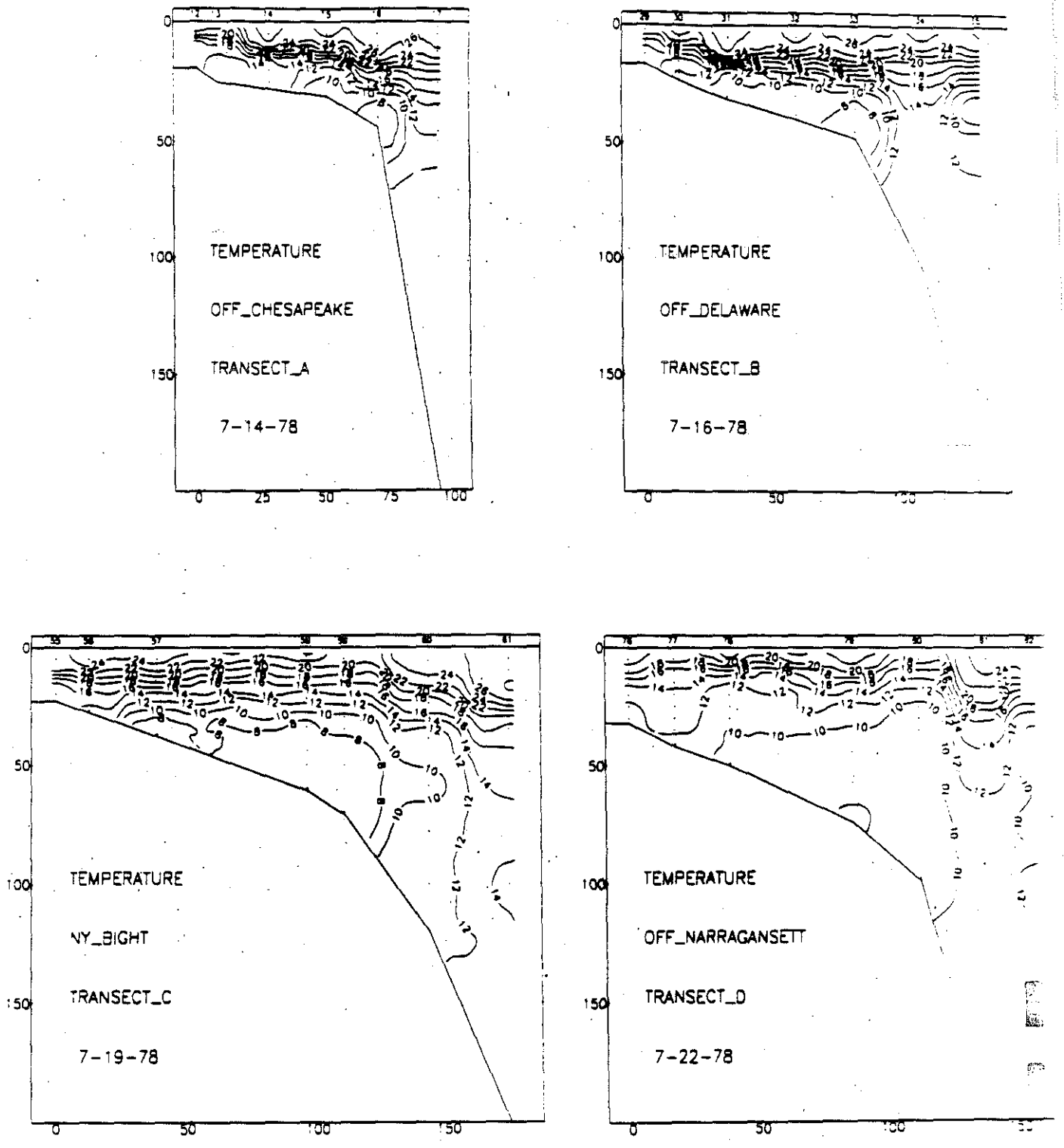
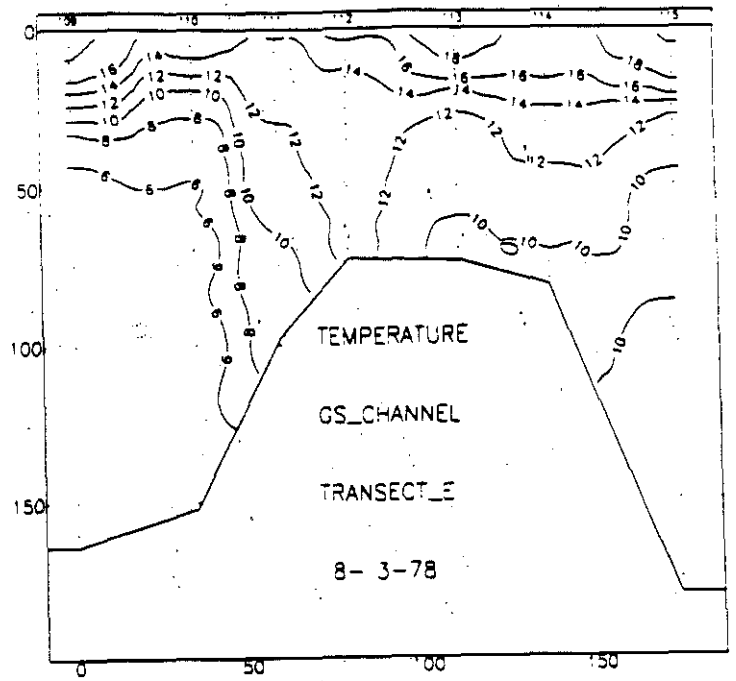


Figure 44. Temperature (°C) transects: BEL7801.



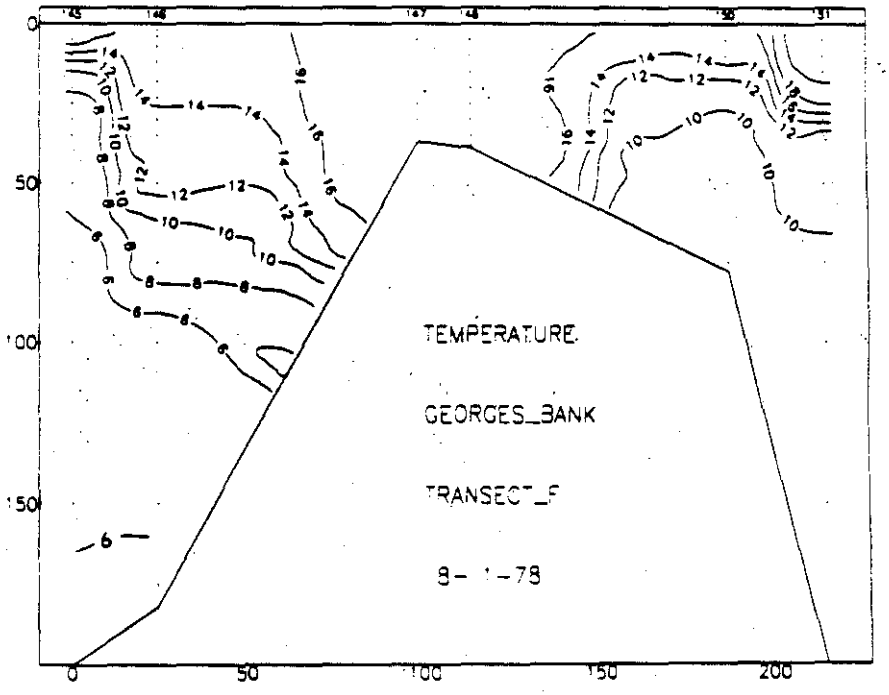


Figure 44. Continued.

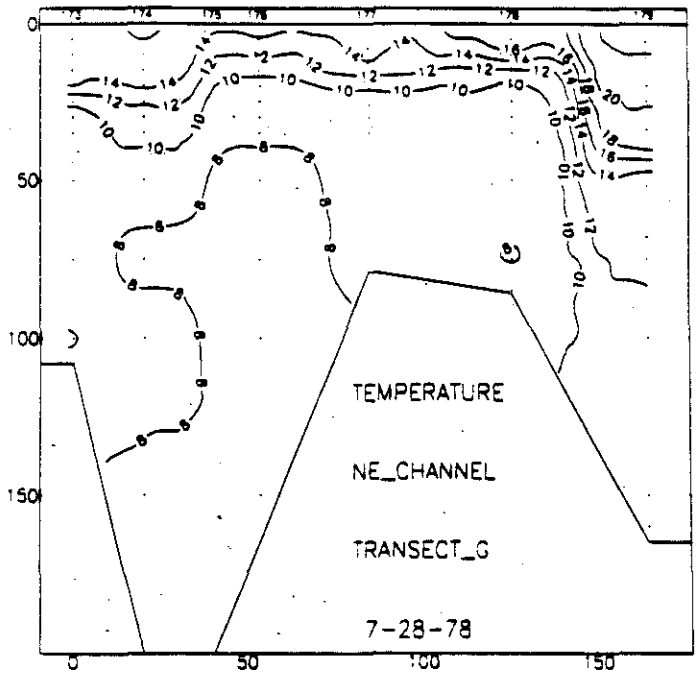


Figure 44. Continued.

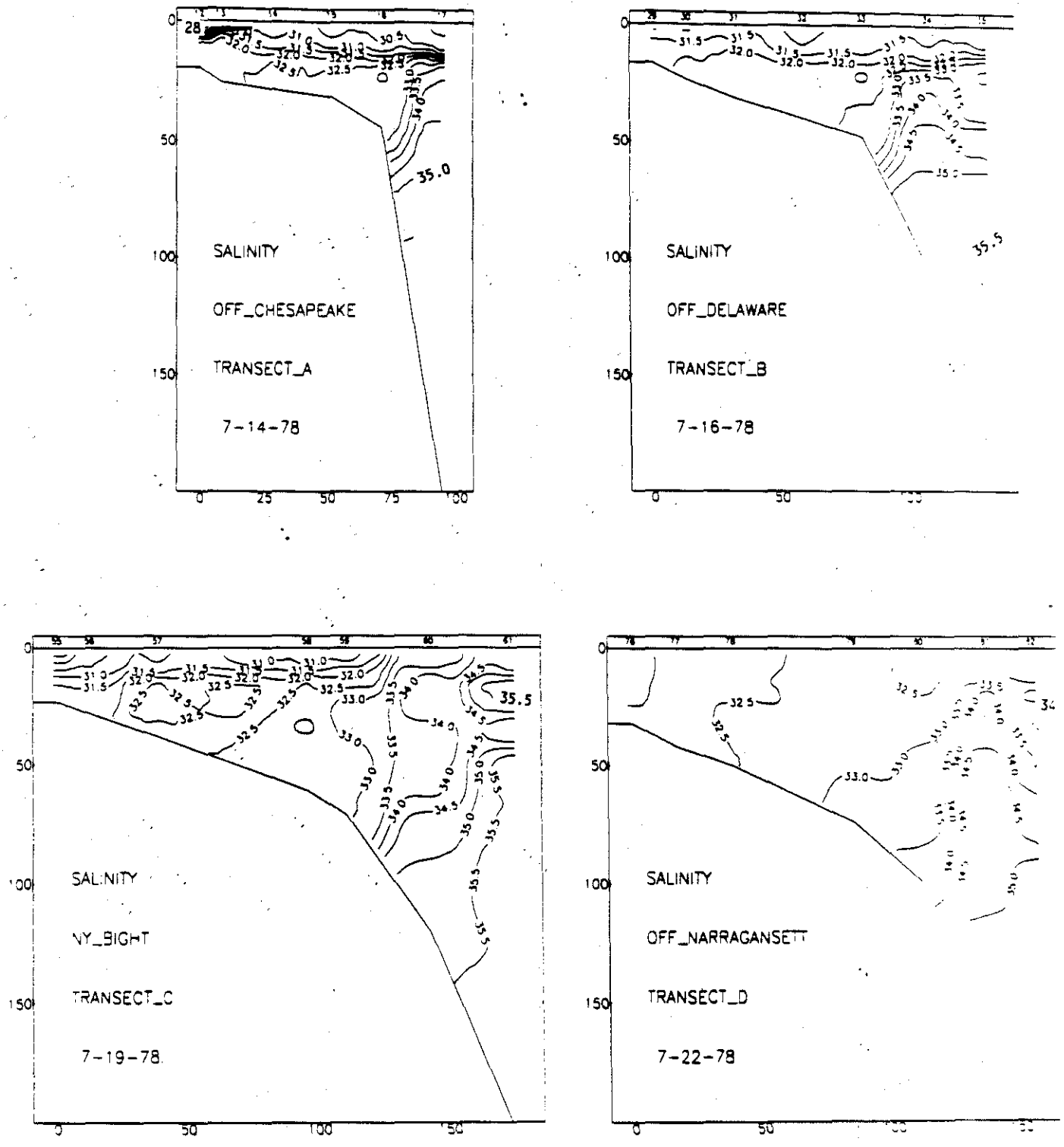
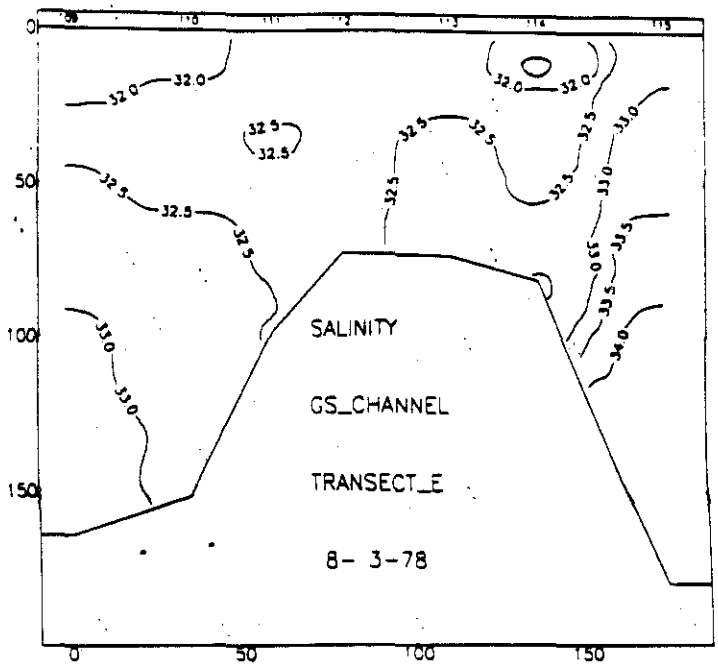
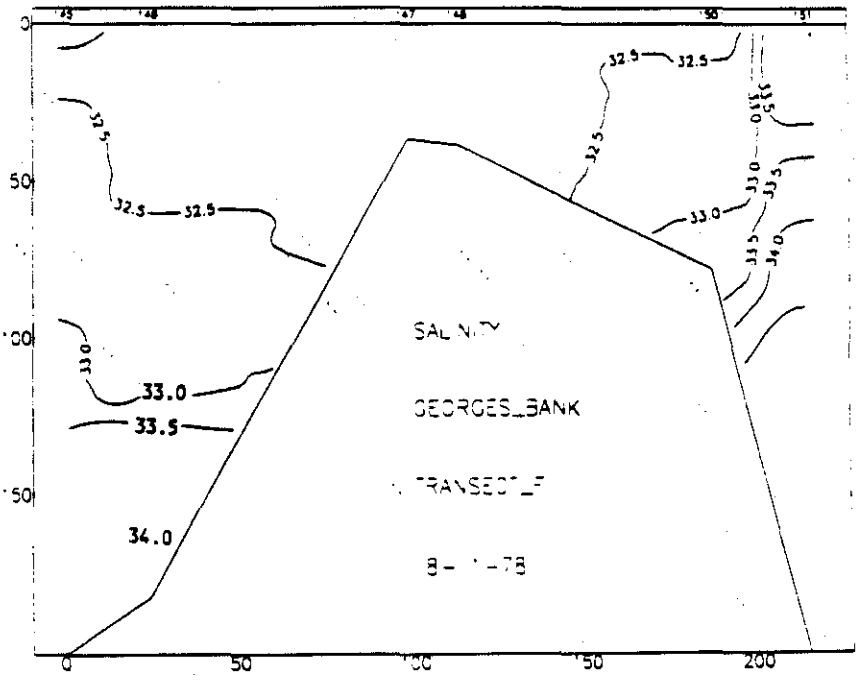


Figure 45. Salinity (PSU) transects: BEL7801.





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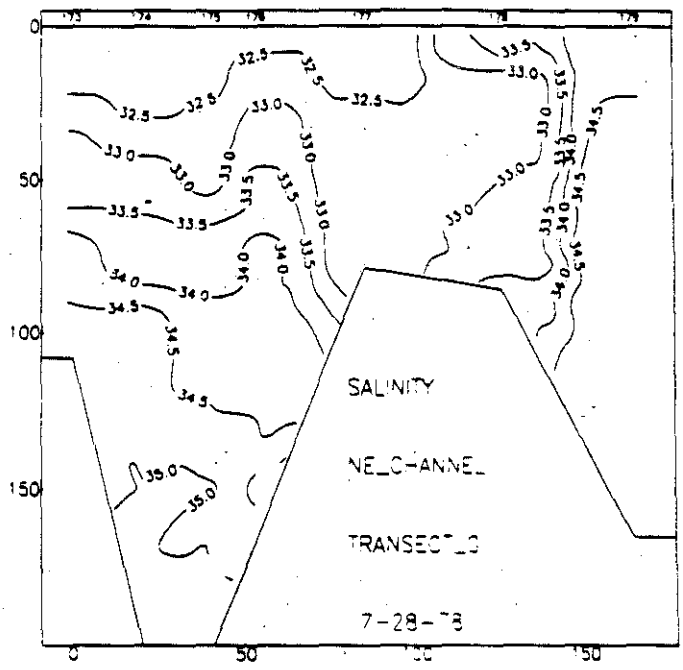

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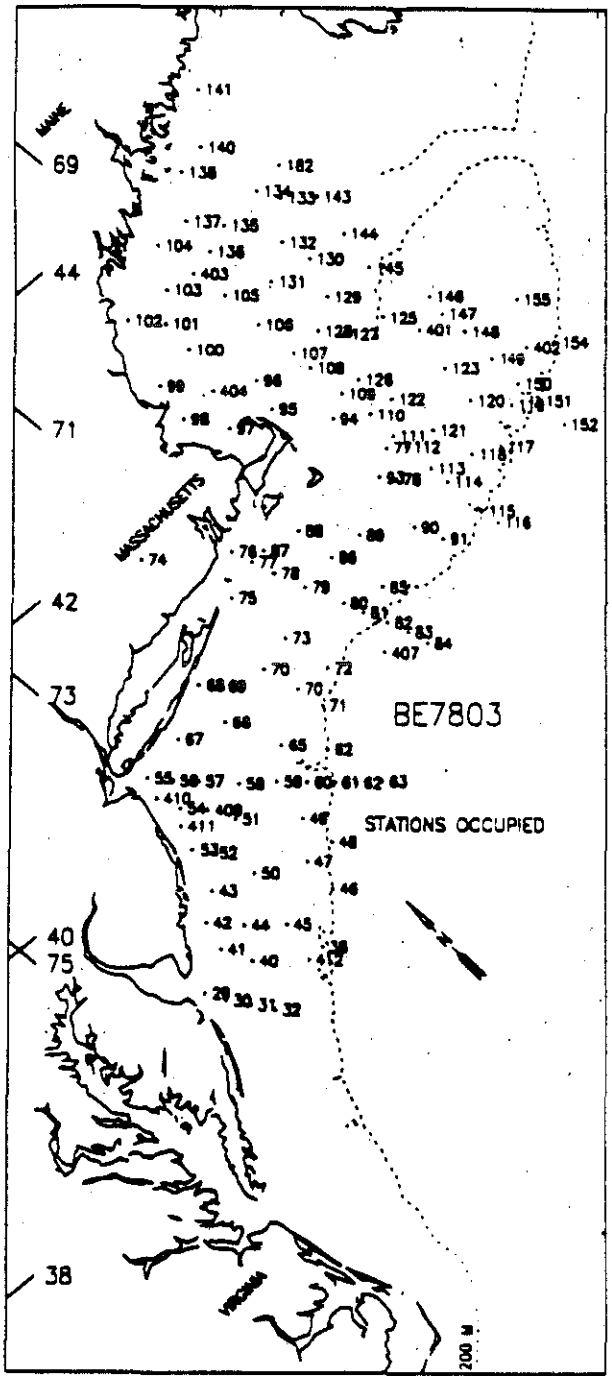


Figure 46. Station positions: BEL7803.

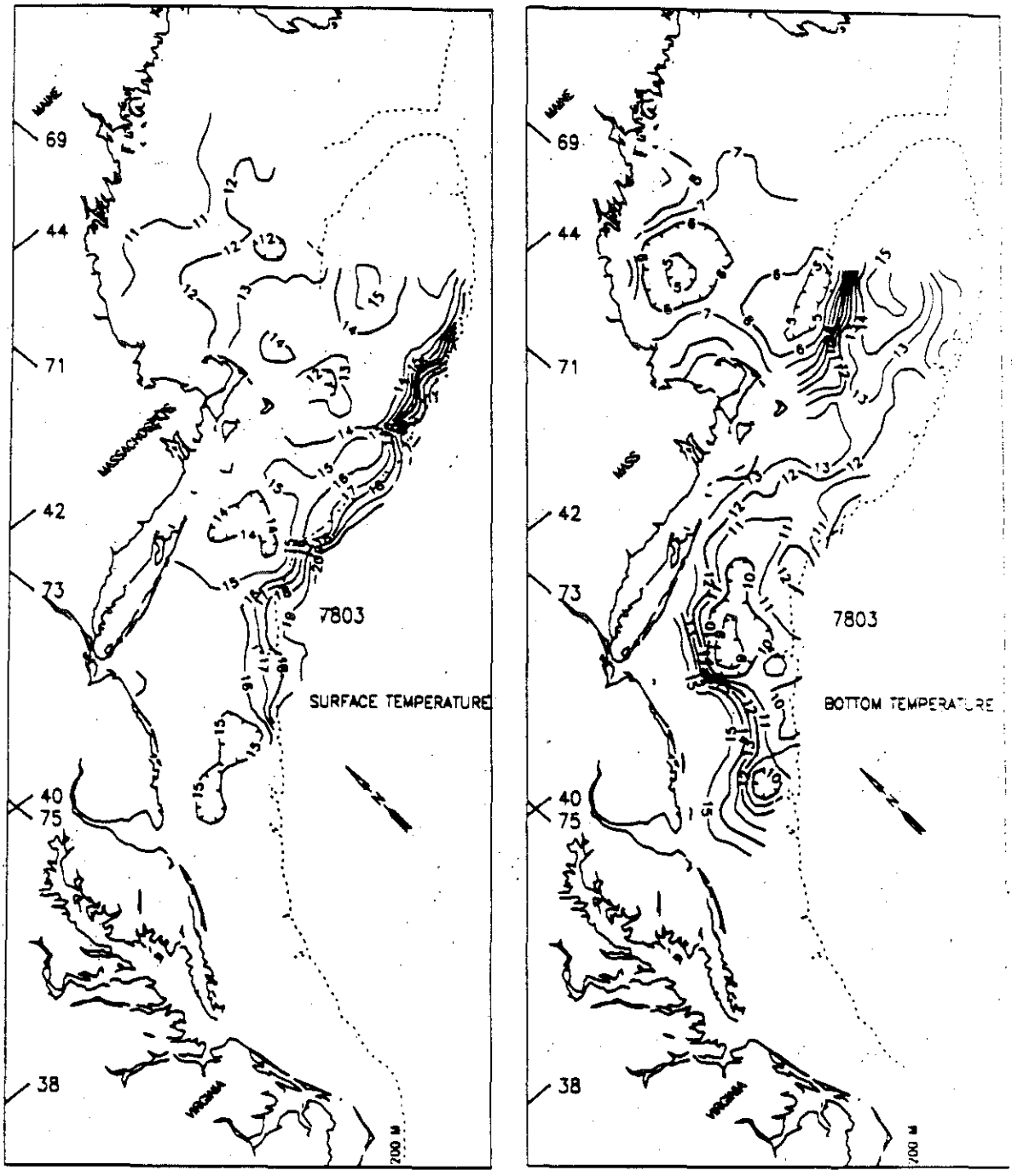


Figure 47. Surface and bottom temperature (°C) distribution: BEL7803.

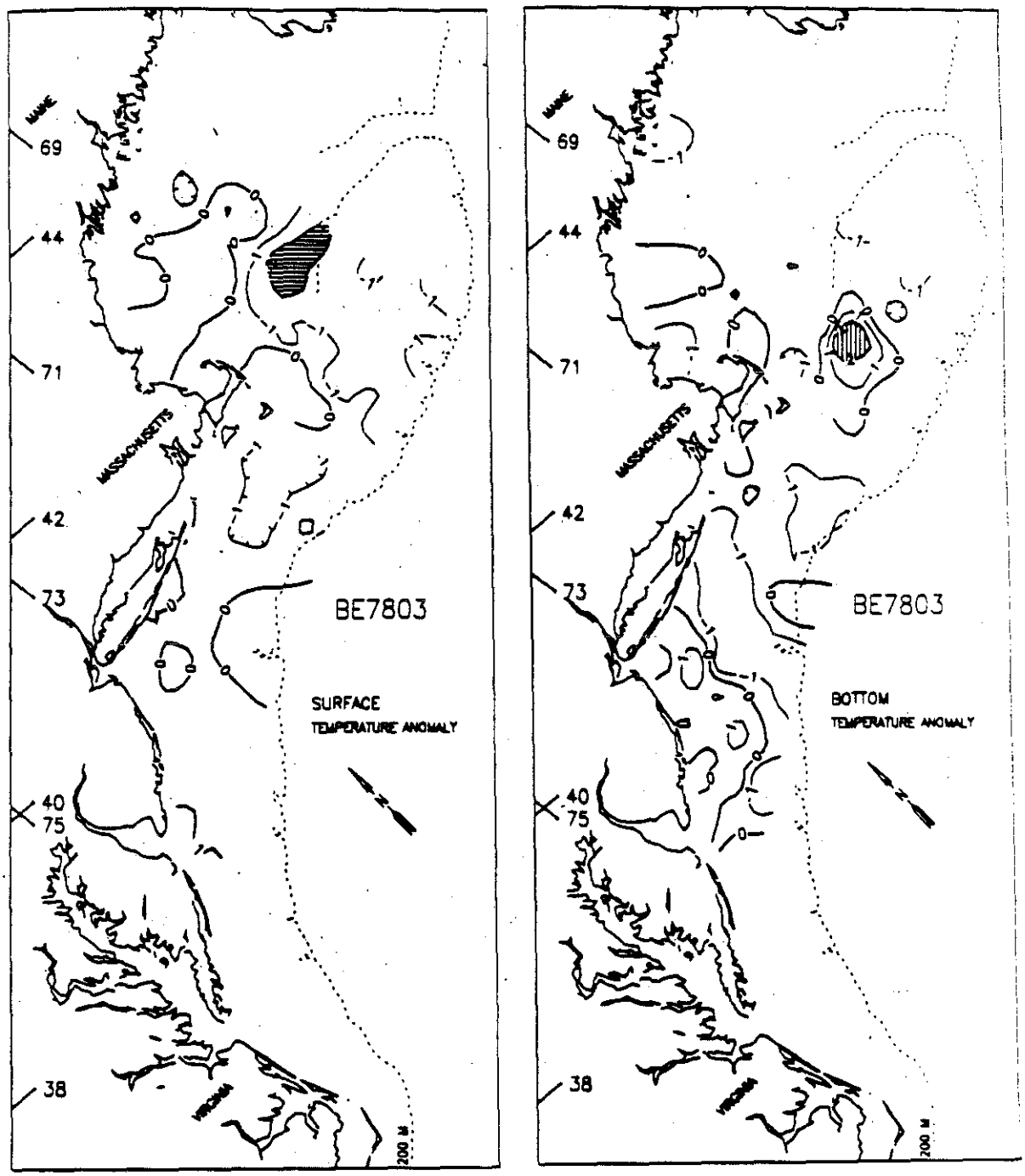


Figure 48. Normalized surface and bottom temperature anomaly: BEL7803. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

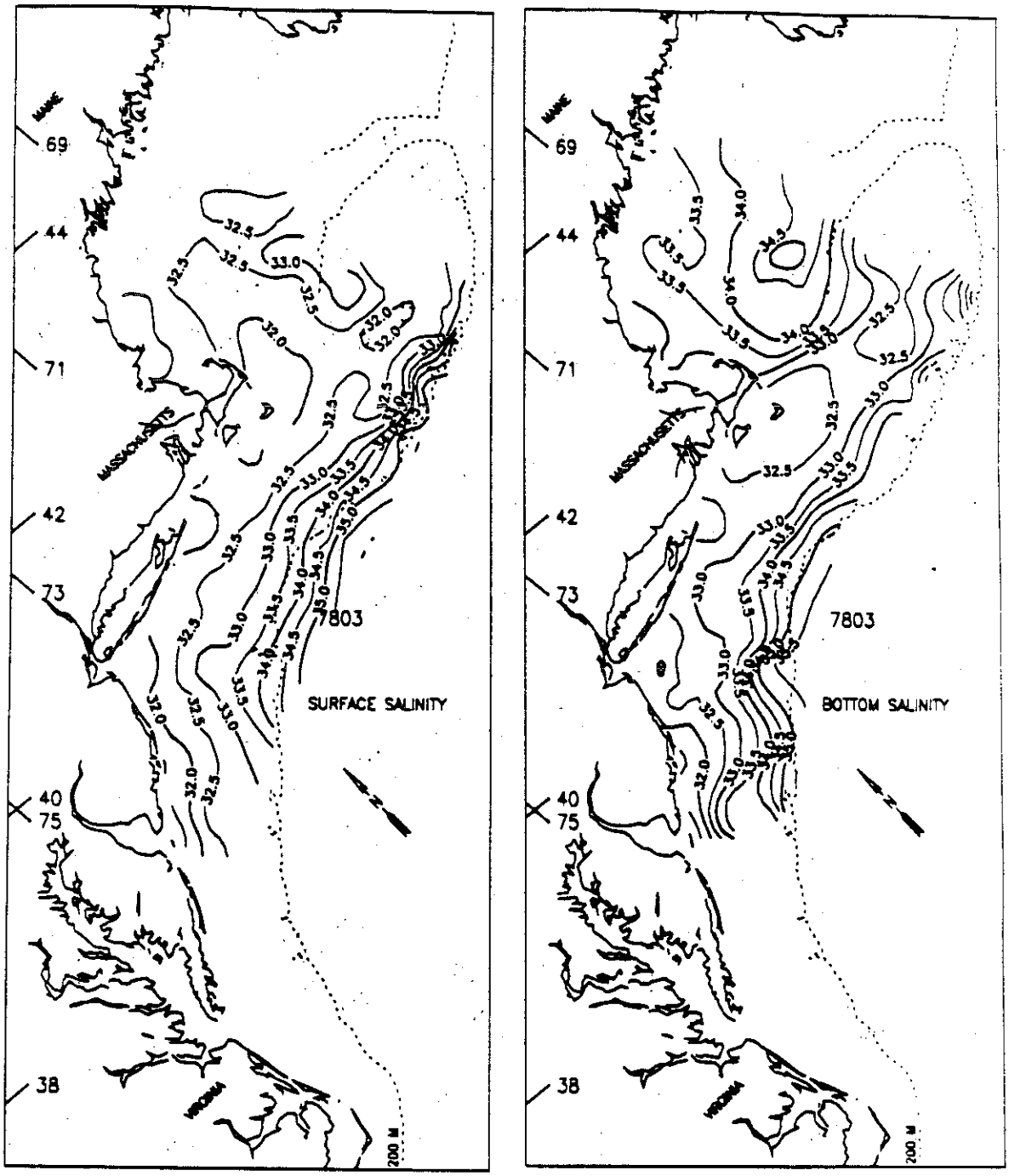


Figure 49. Surface and bottom salinity (PSU) distribution: BEL7803.

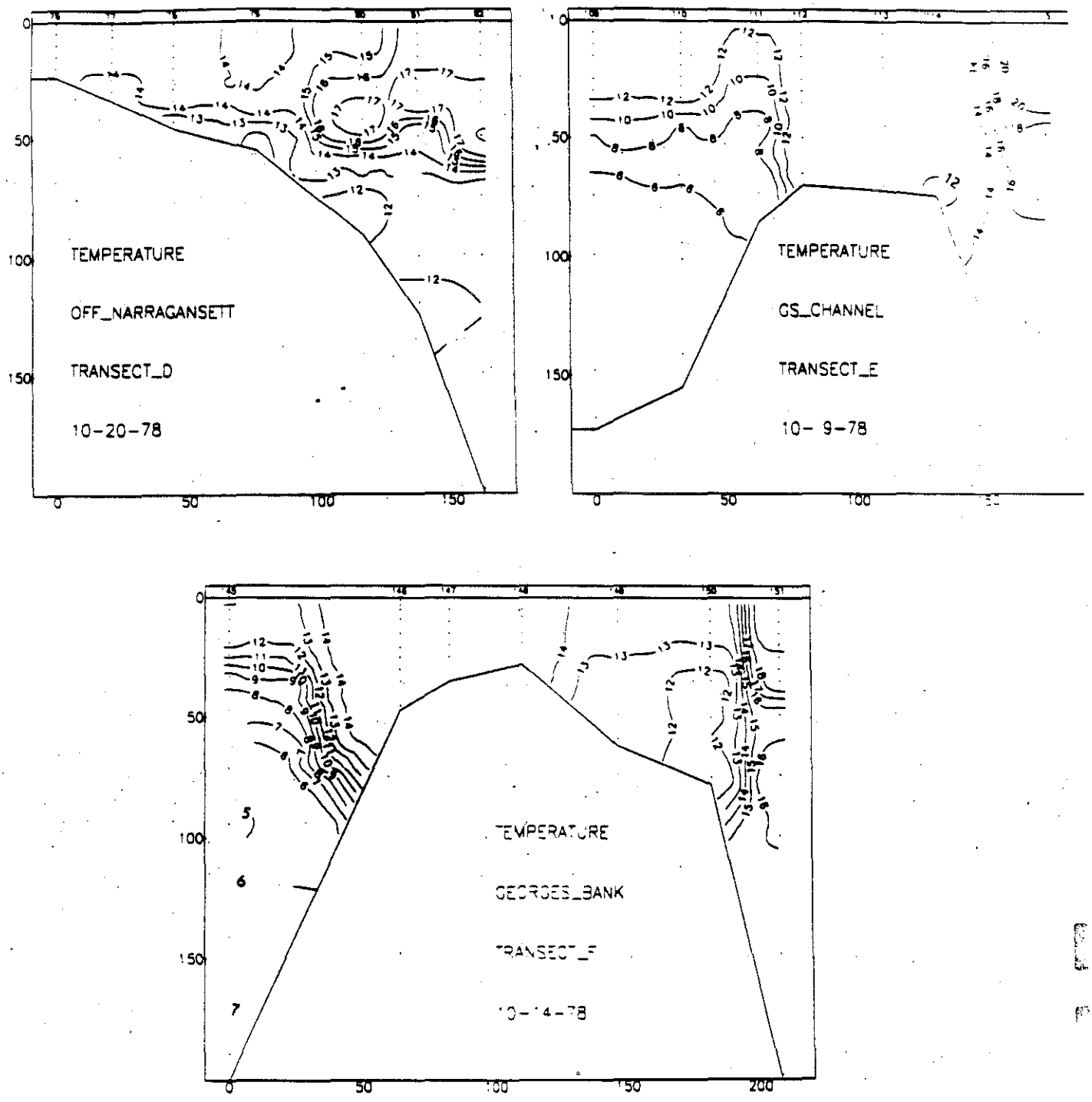


Figure 50. Temperature (°C) transects: BEL7803.

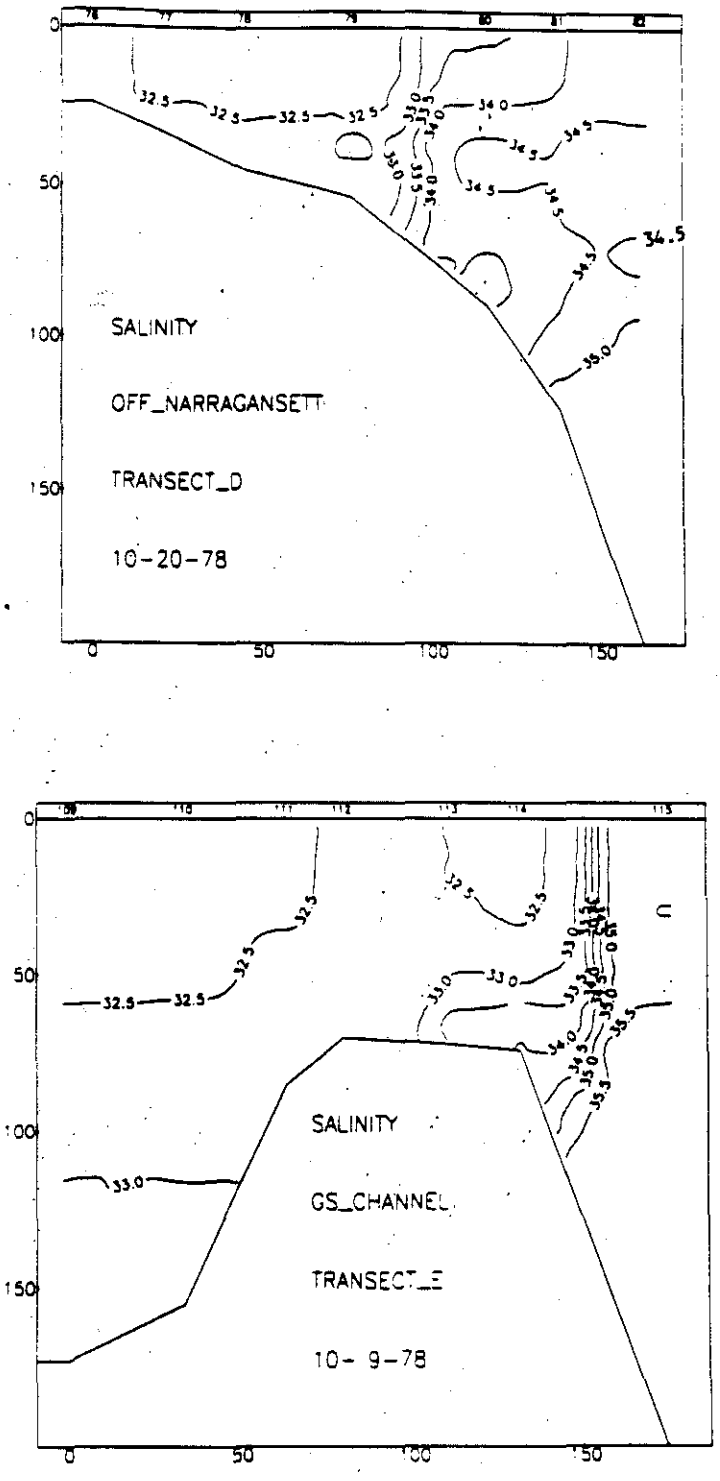


Figure 51. Salinity (PSU) transects: BEL7803.

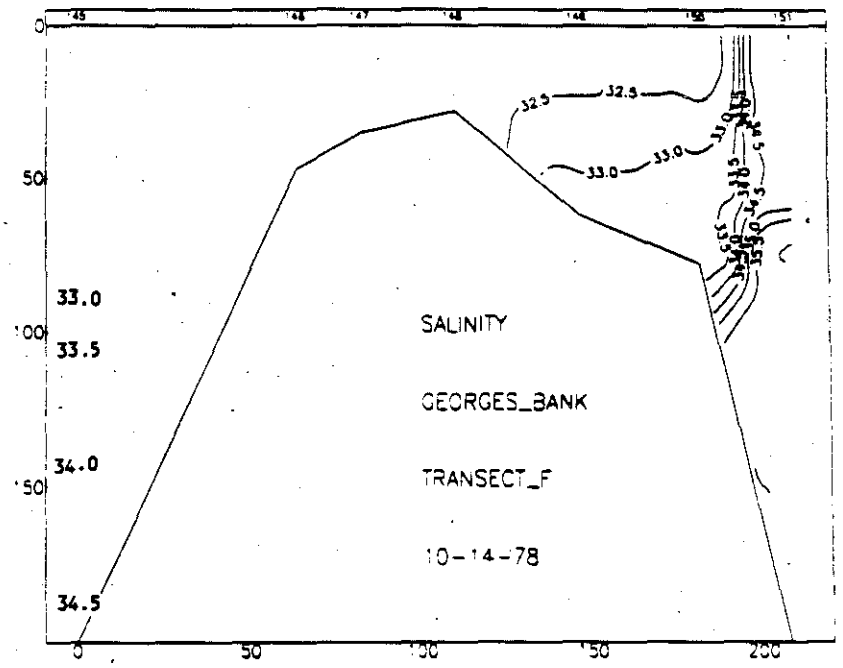


Figure 51. Continued.

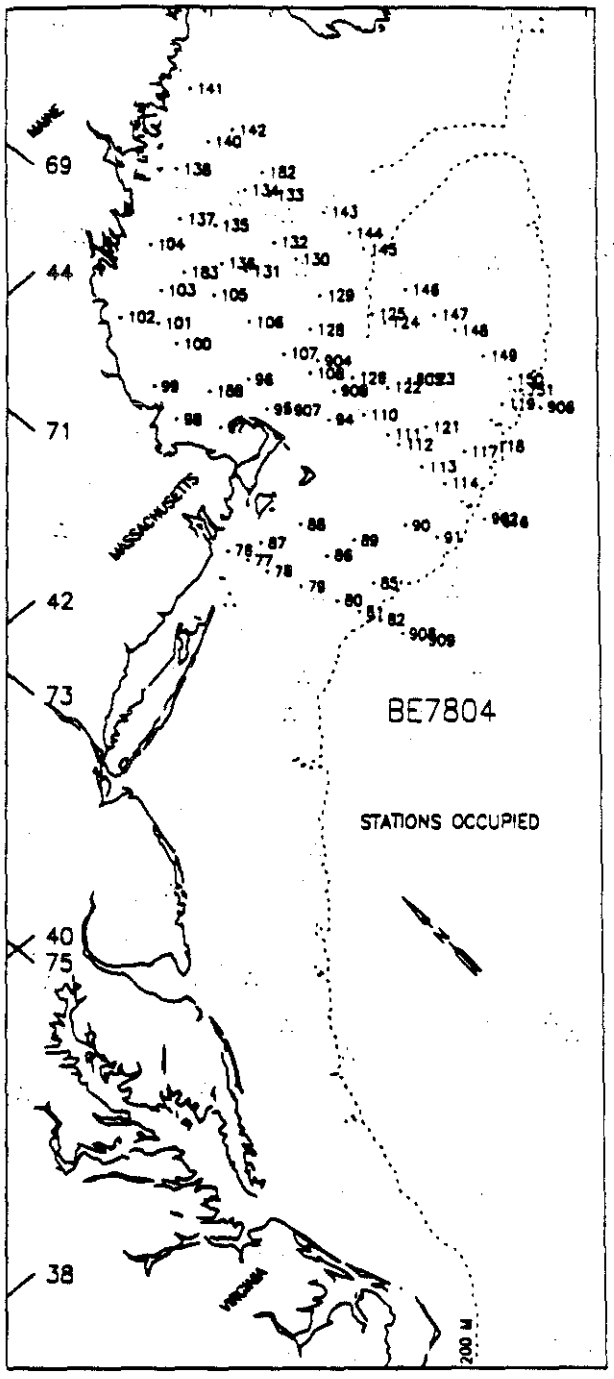


Figure 52. Station positions: BEL7804.

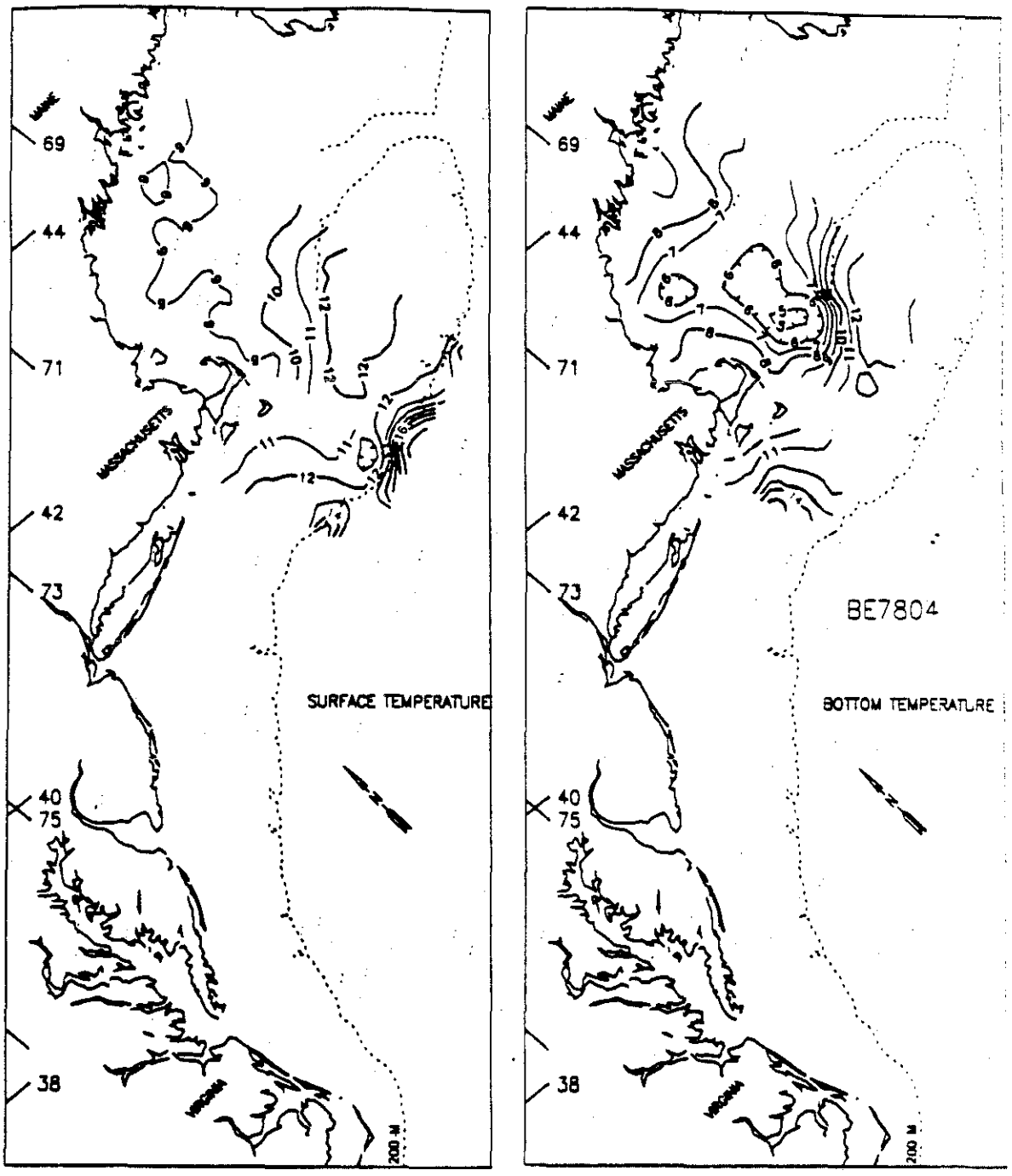


Figure 53. Surface and bottom temperature (°C) distribution: BEL7804.

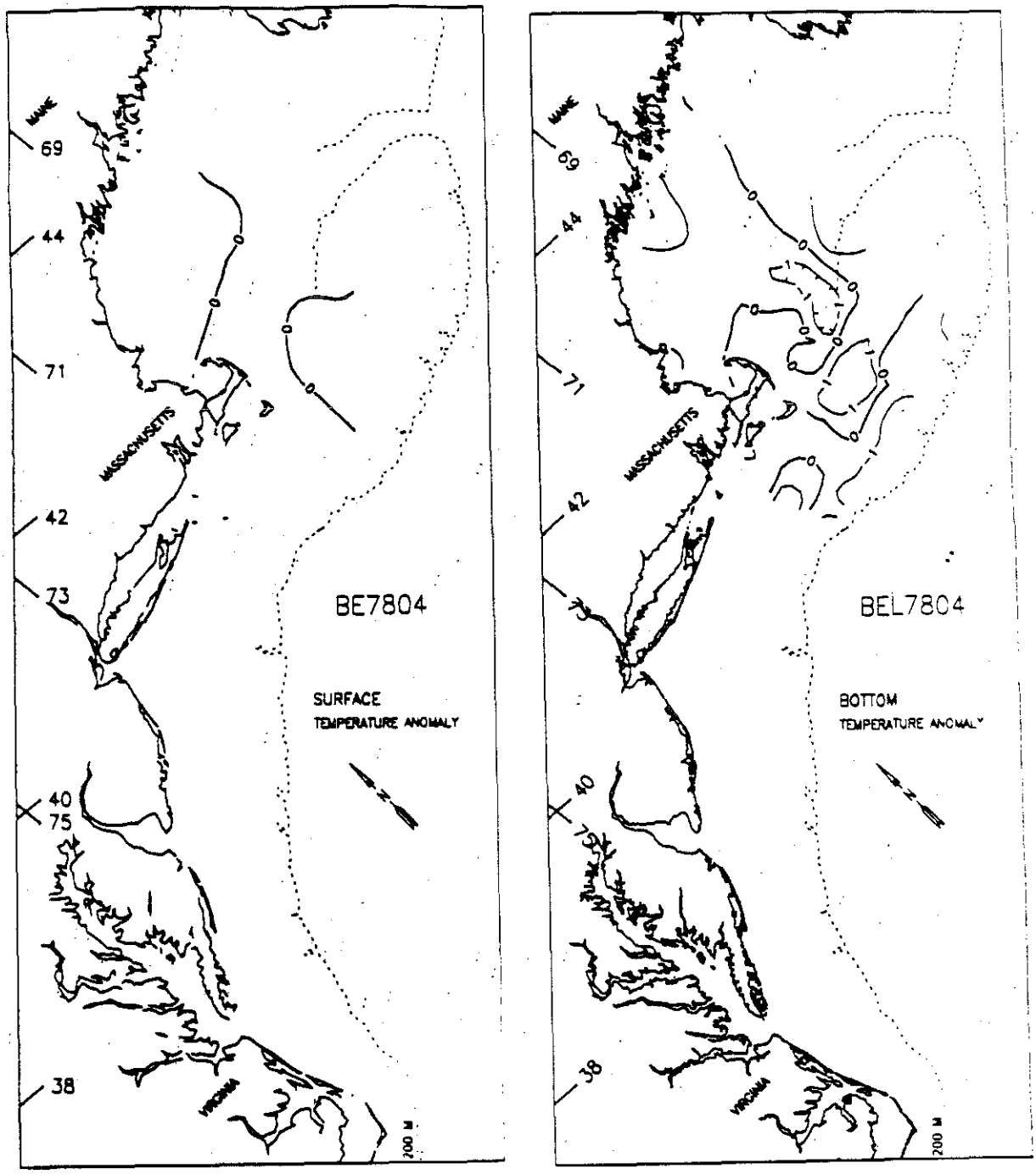


Figure 54. Normalized surface and bottom temperature anomaly: BEL7804. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

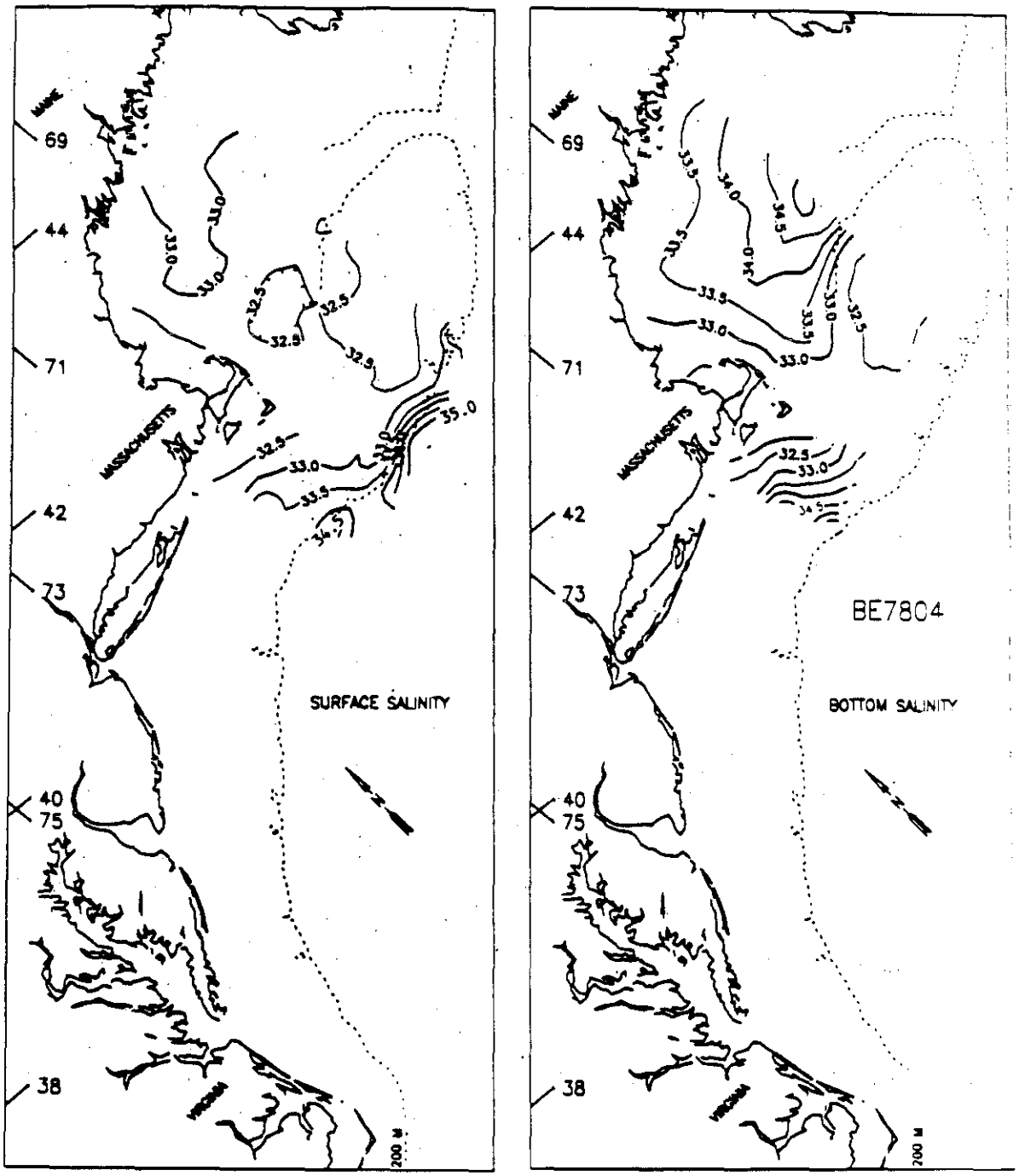


Figure 55. Surface and bottom salinity (PSU) distribution: BEL7804.

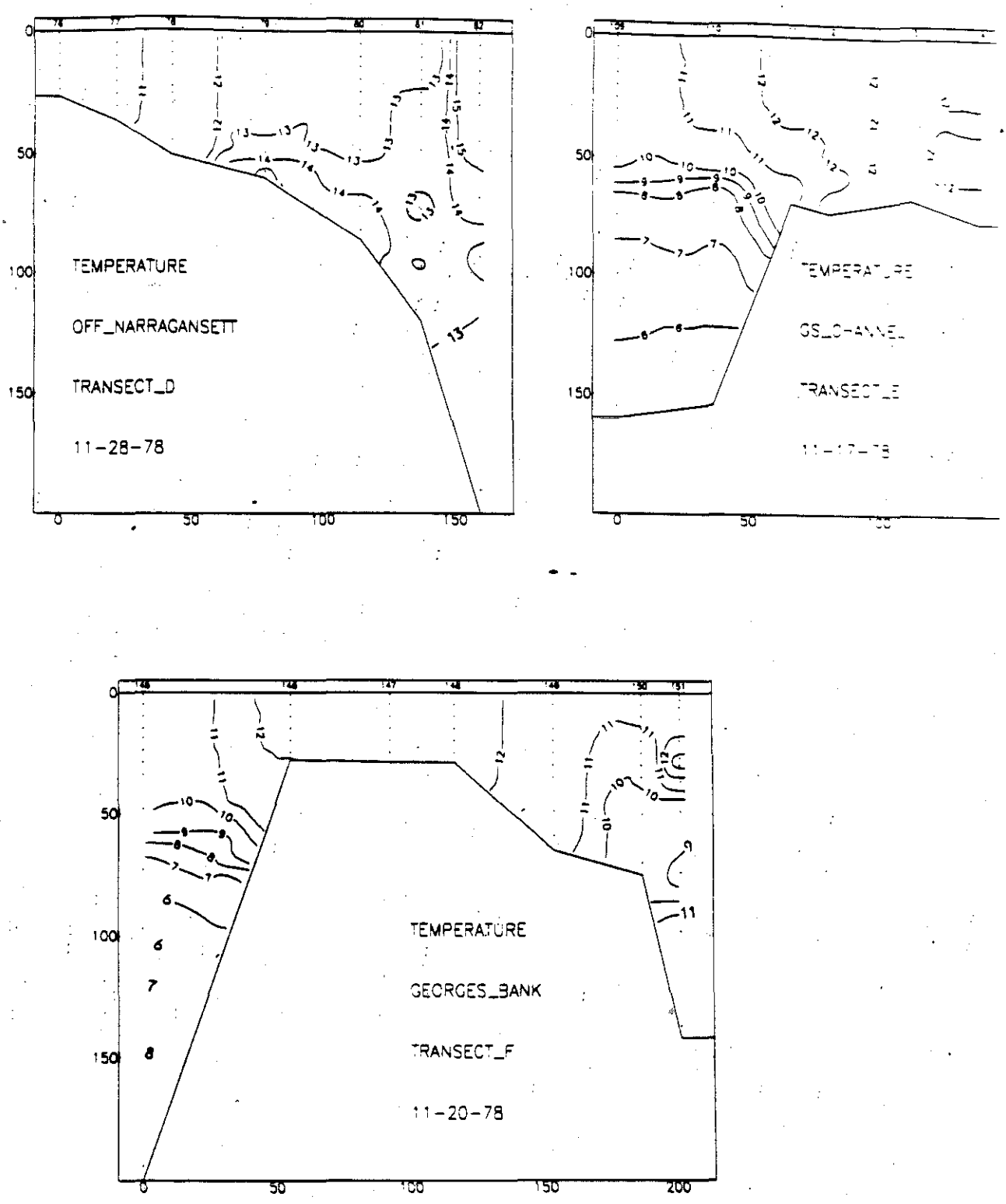


Figure 56. Temperature (°C) transects: BEL7804.

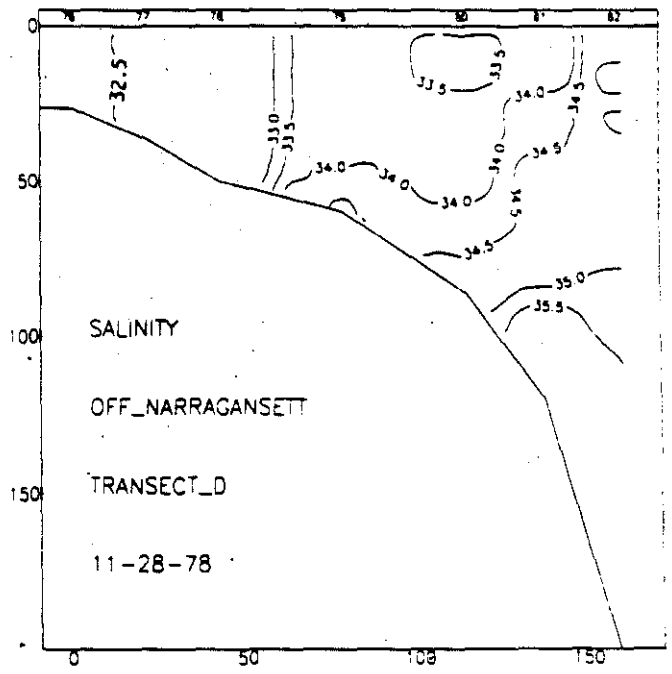
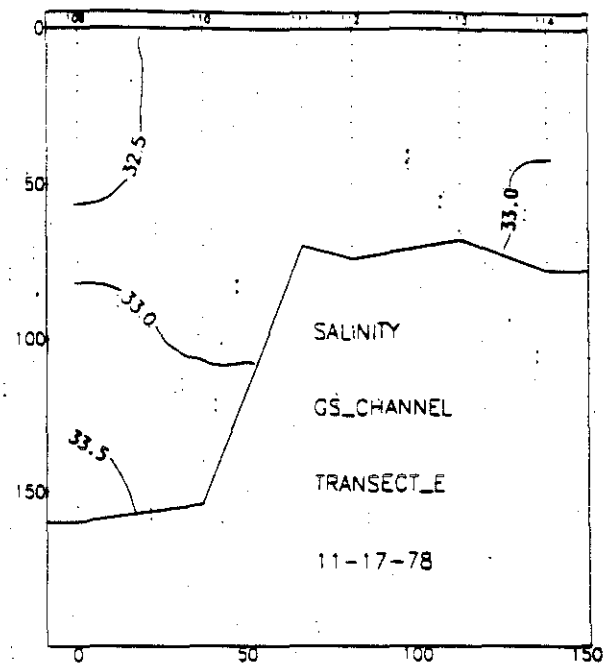


Figure 57. Salinity (PSU) transects: BEL7804.



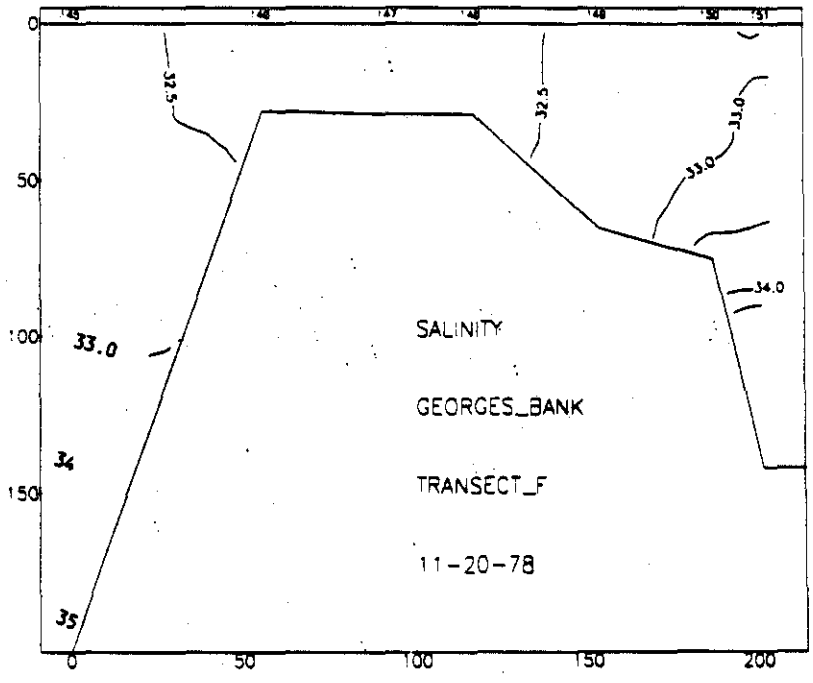


Figure 57. Continued.

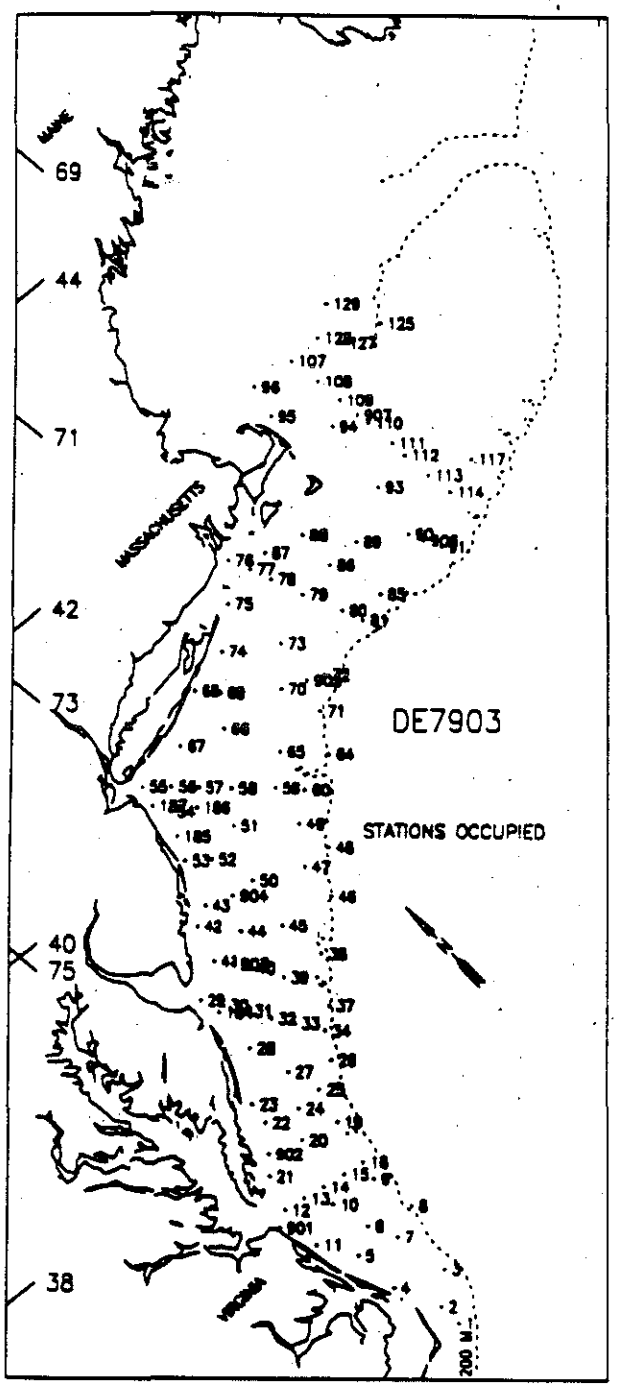


Figure 58. Station positions: DEL7903.

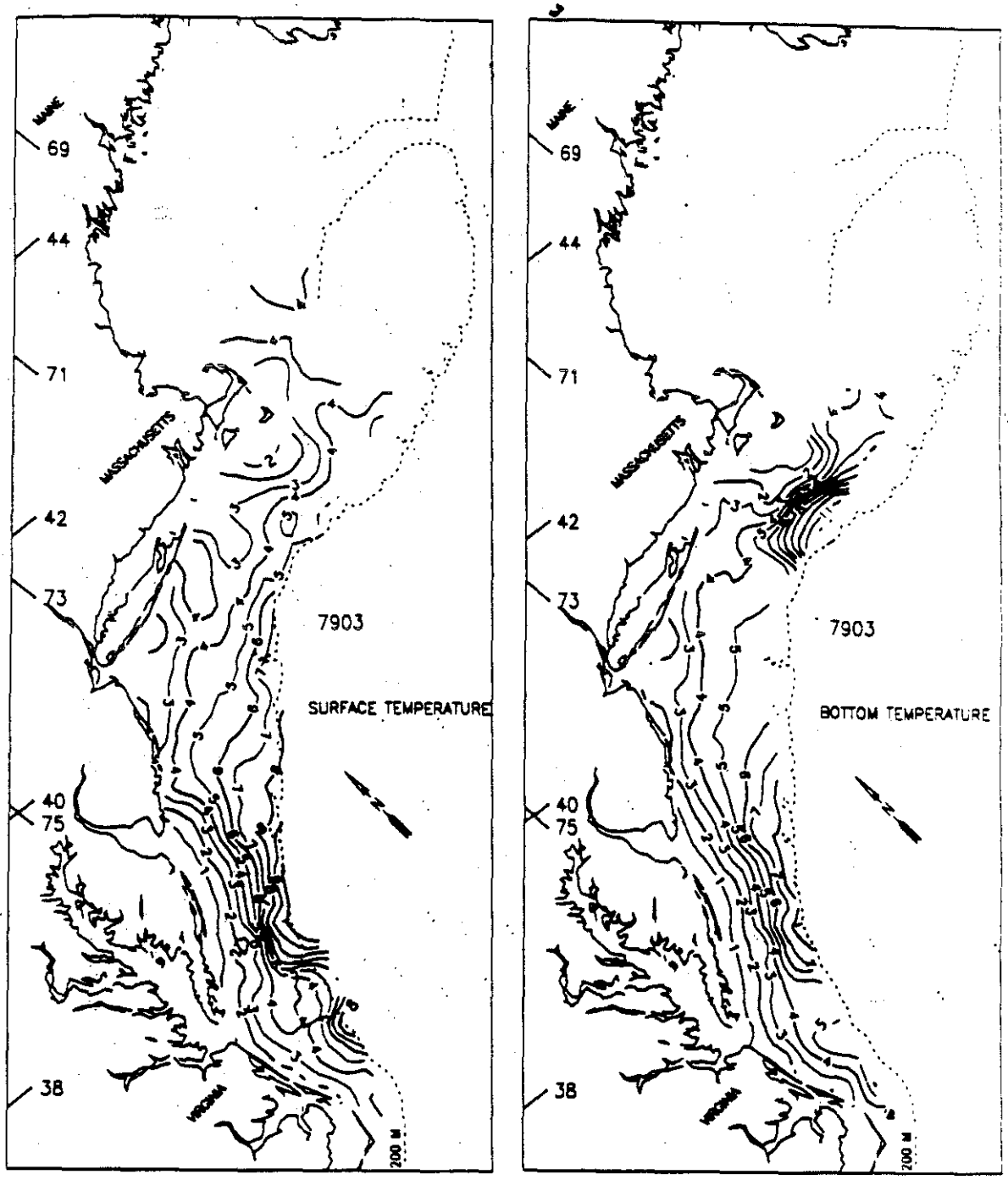


Figure 59. Surface and bottom temperature (°C) distribution: DEL7903.

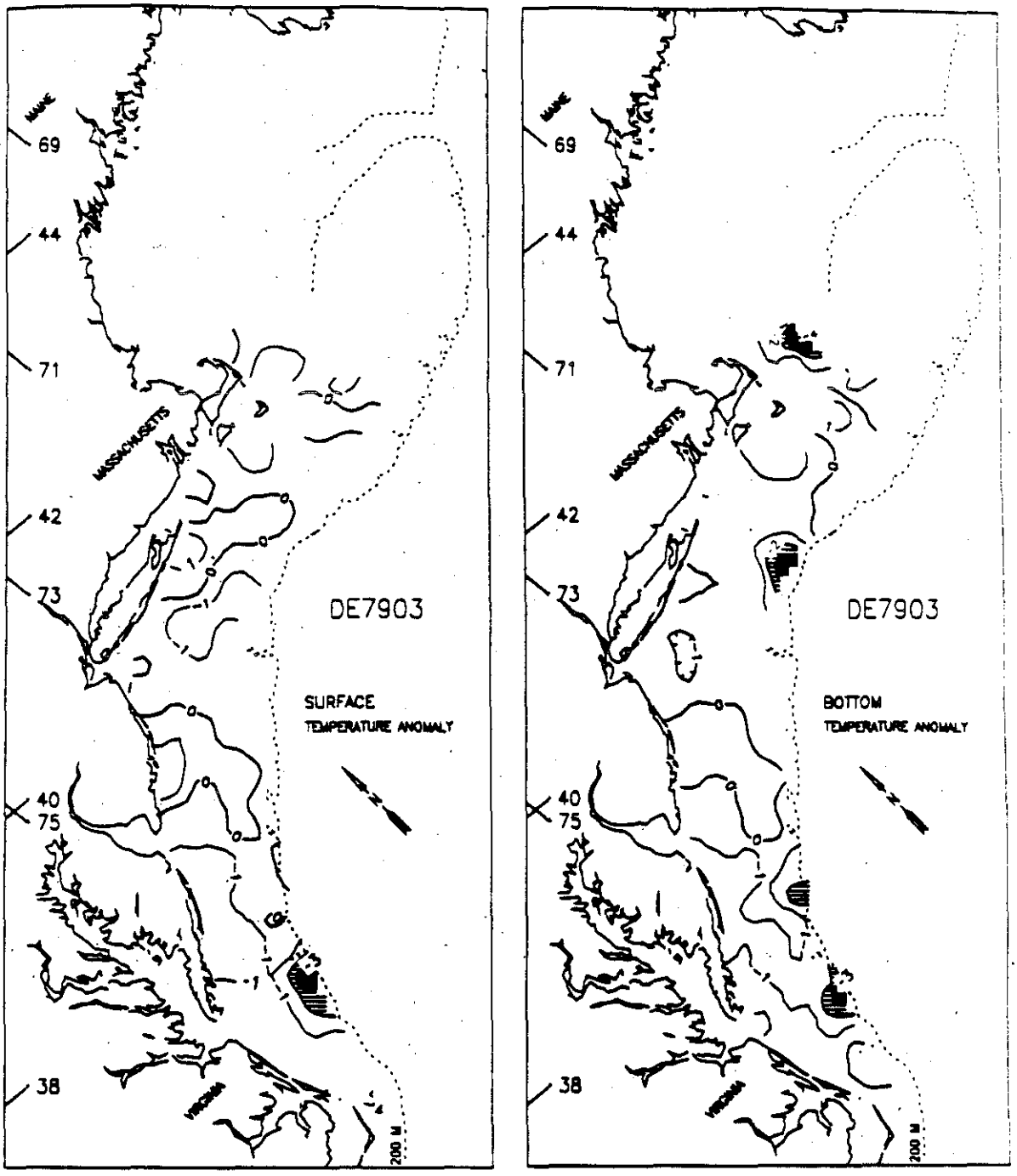


Figure 60. Normalized surface and bottom temperature anomaly: DEL7903. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

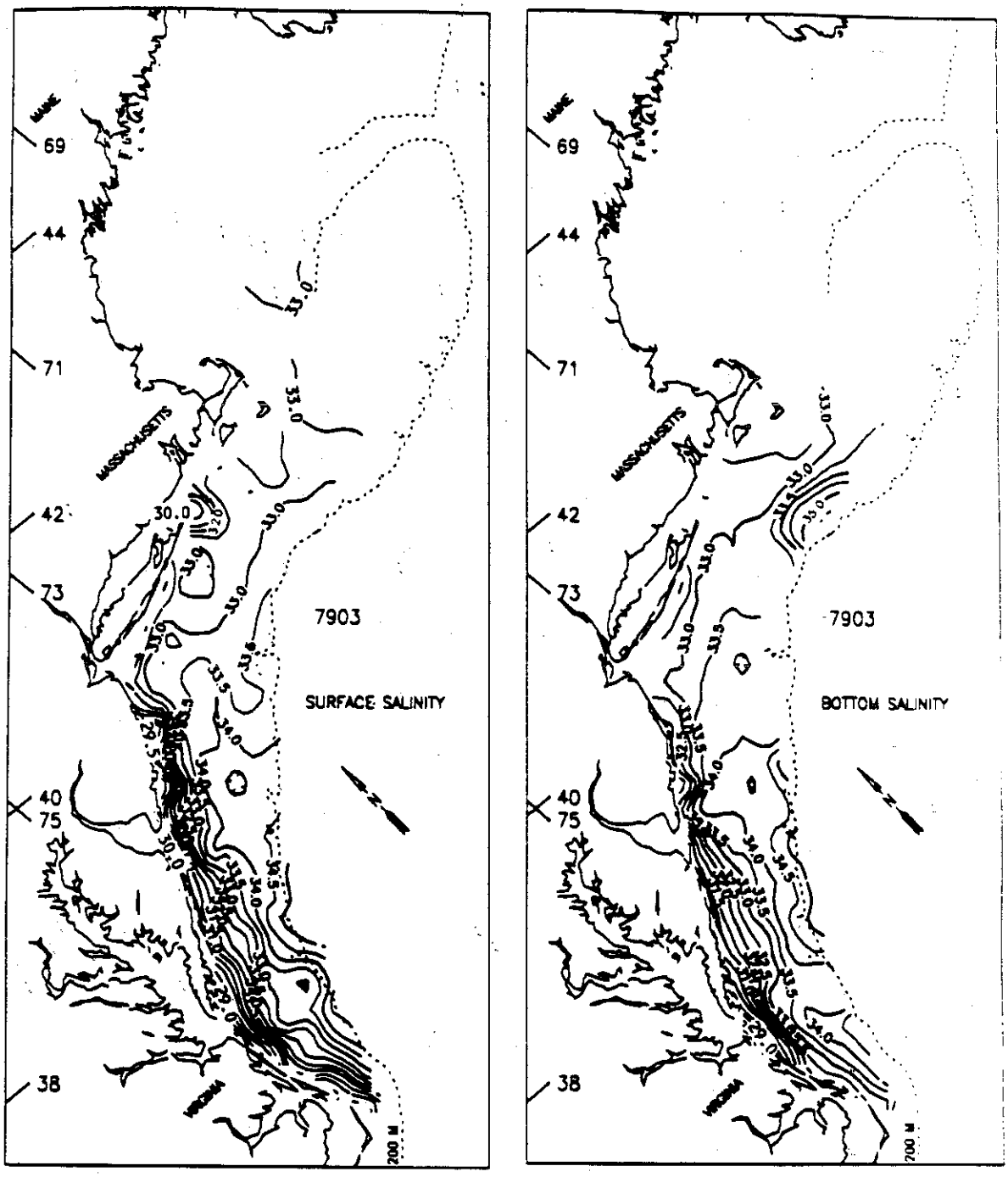


Figure 61. Surface and bottom salinity (PSU) distribution: DEL7903.

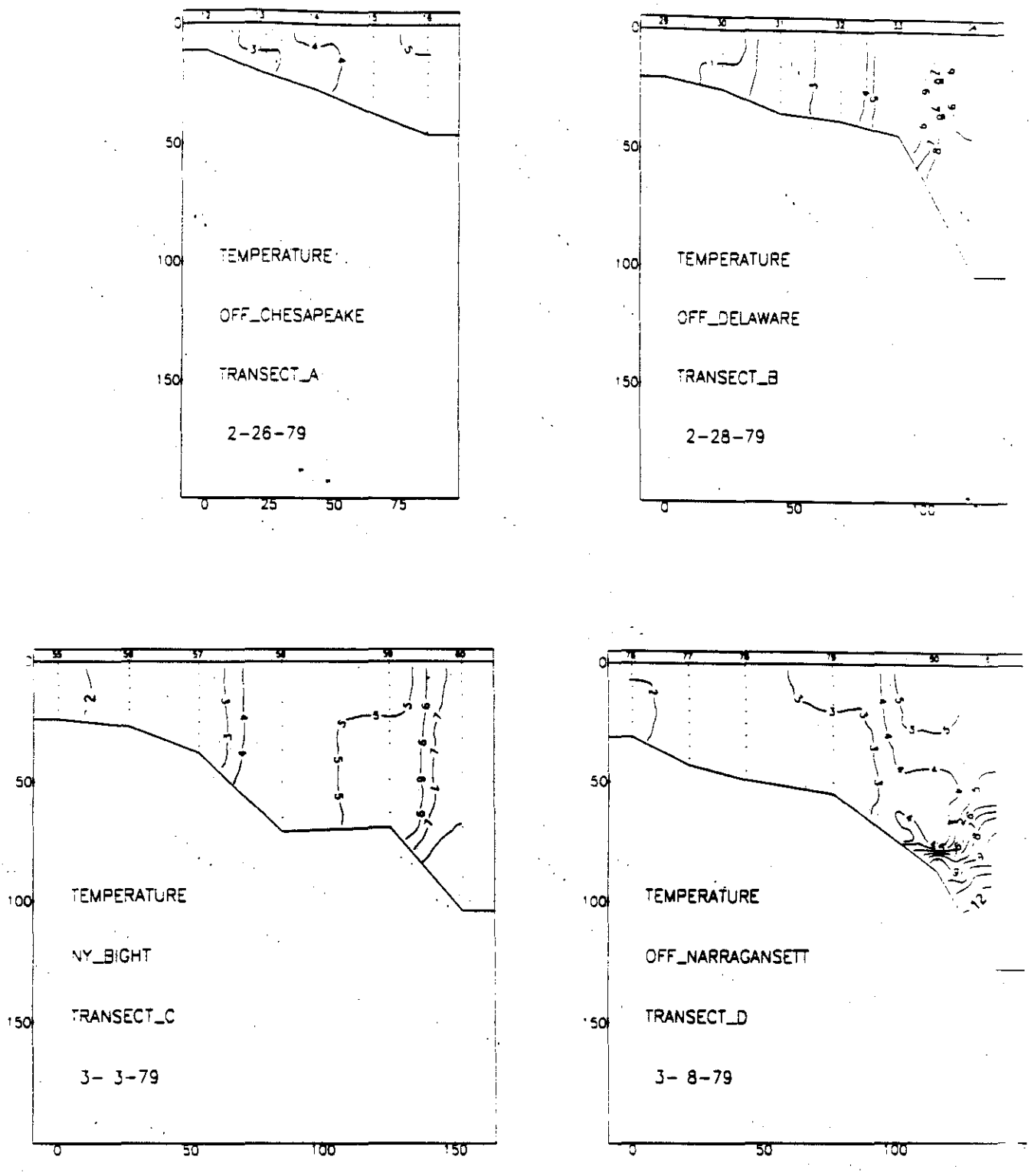


Figure 62. Temperature (°C) transects: DEL7903.

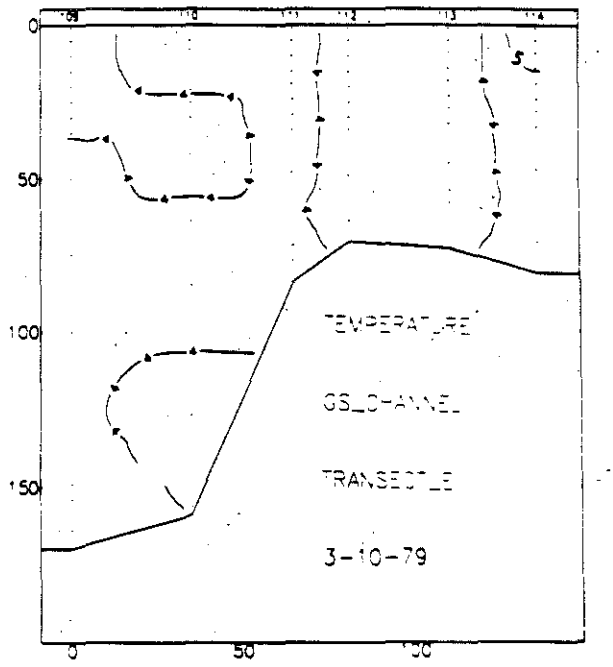


Figure 62. Continued.

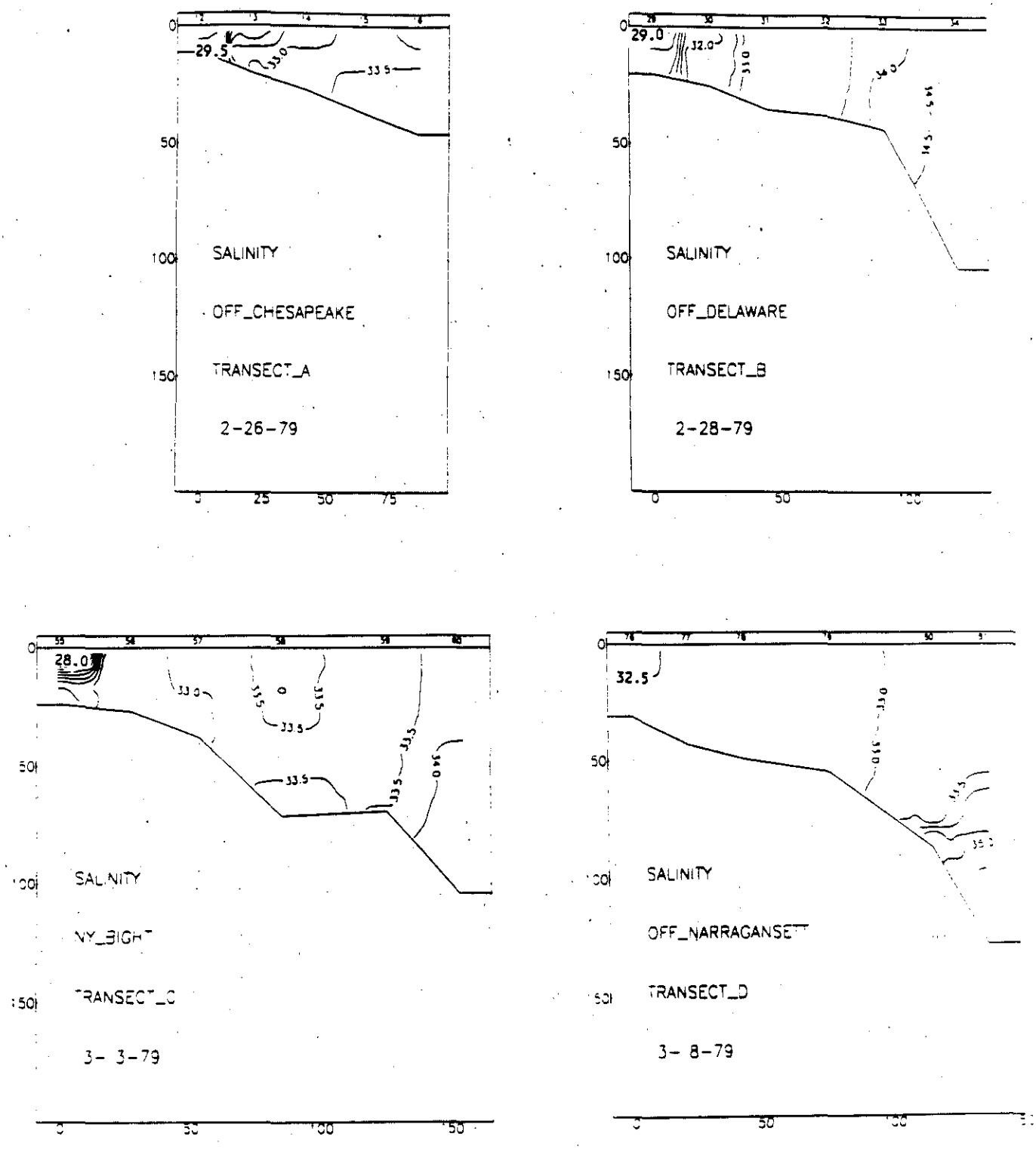


Figure 63. Salinity (PSU) transects: DEL7903.

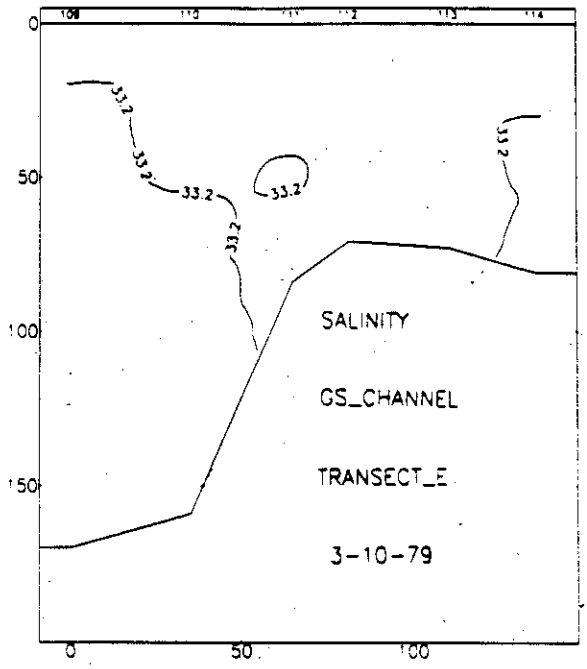


Figure 63. Continued.

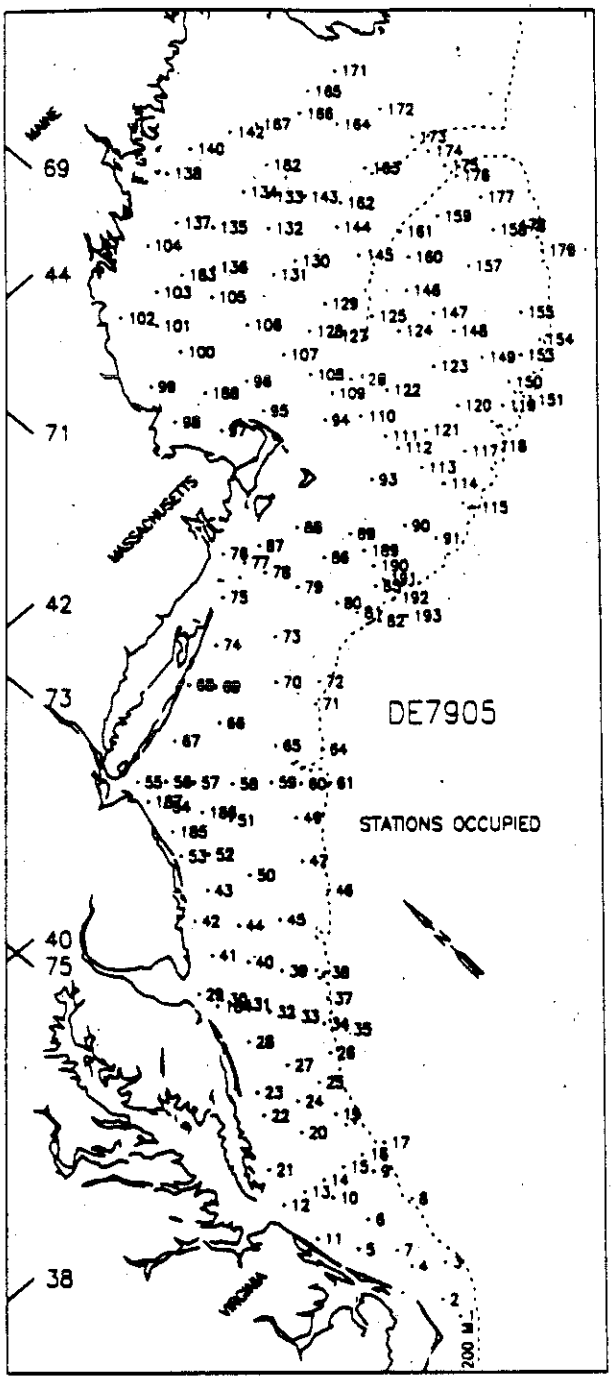


Figure 64. Station positions: DEL7905.

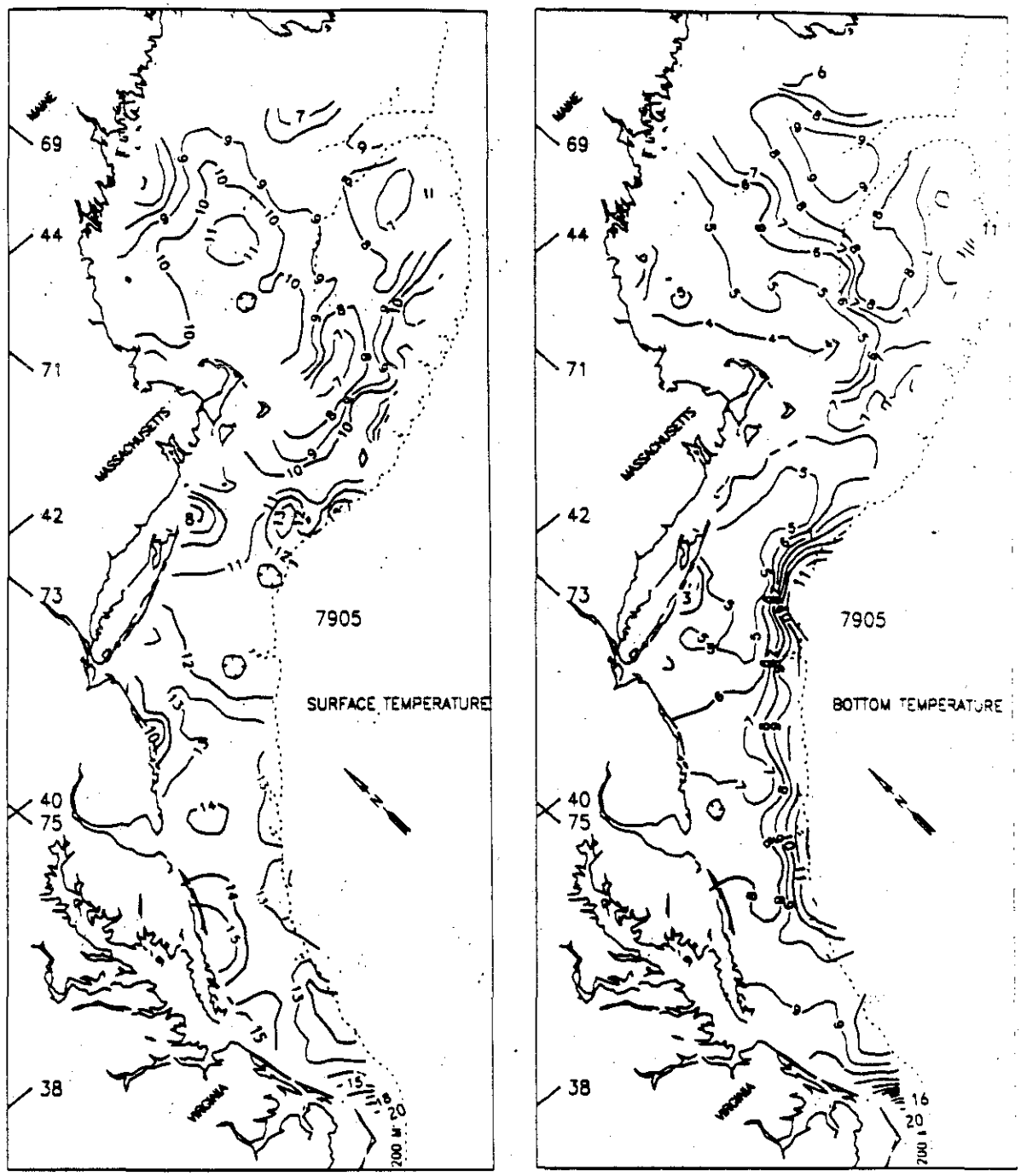


Figure 65. Surface and bottom temperature (°C) distribution: DEL7905.

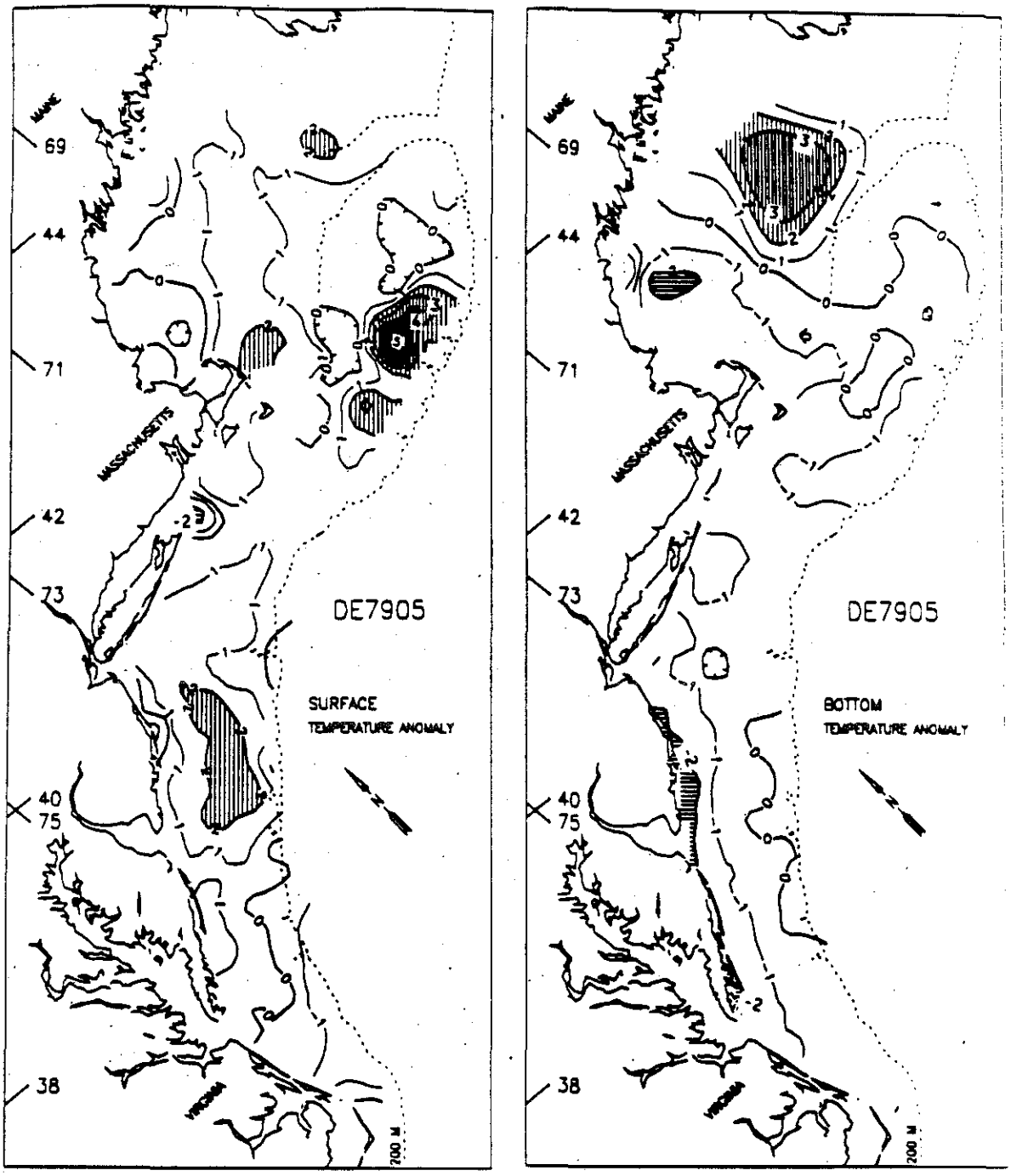


Figure 66. Normalized surface and bottom temperature anomaly: DEL7905. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

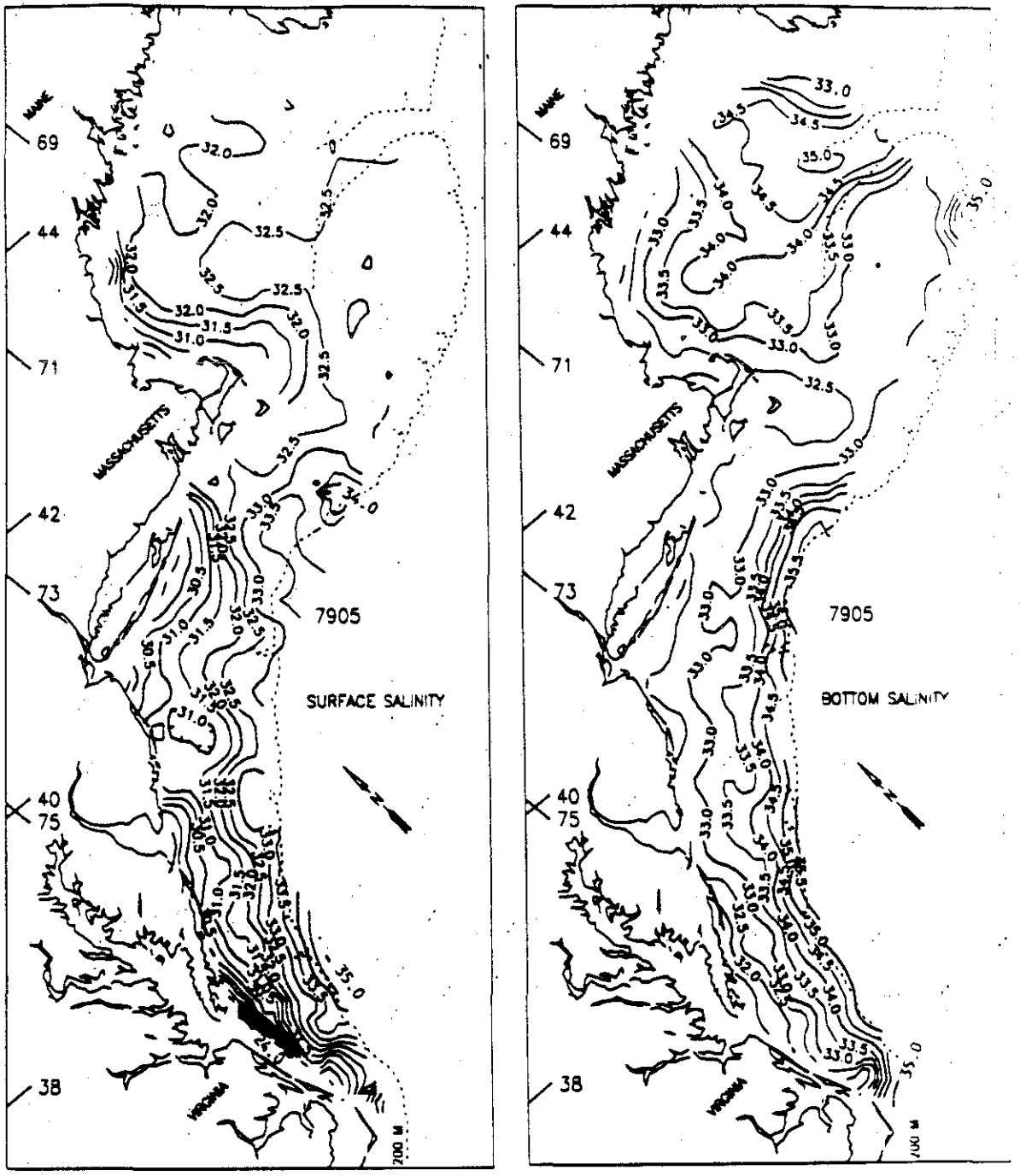


Figure 67. Surface and bottom salinity (PSU) distribution: DEL7905.

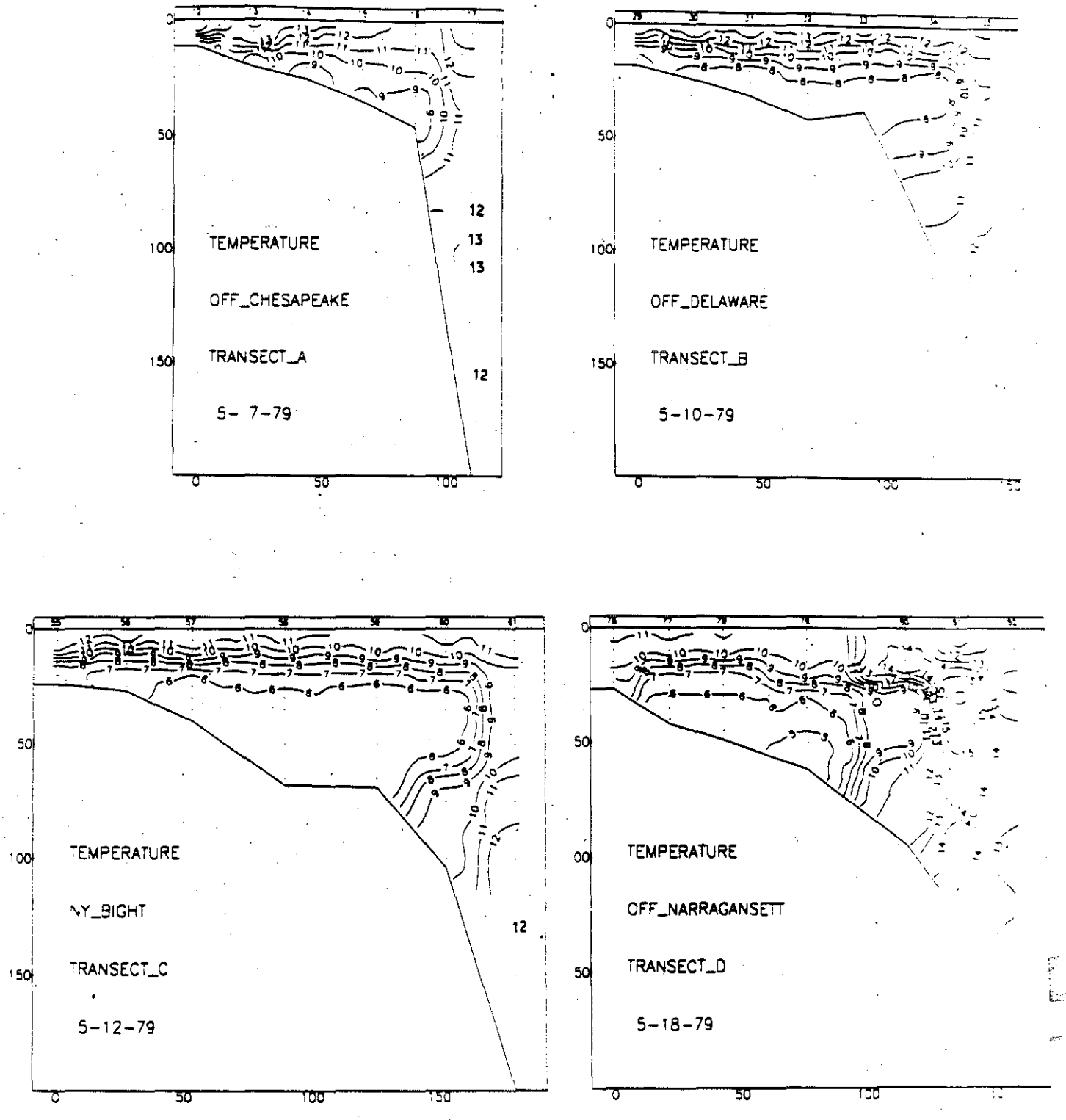


Figure 68. Temperature (°C) transects: DEL7905.

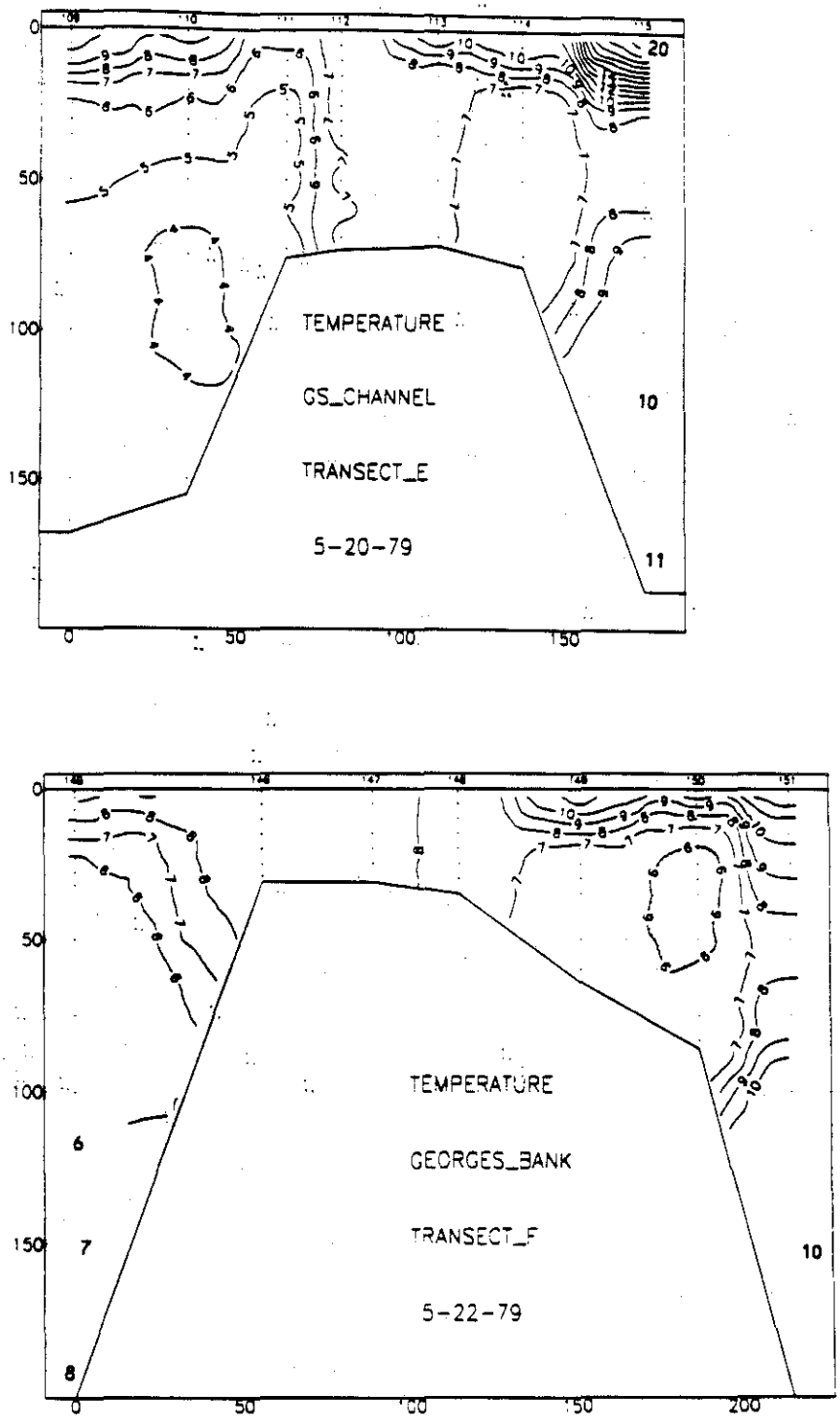


Figure 68. Continued.

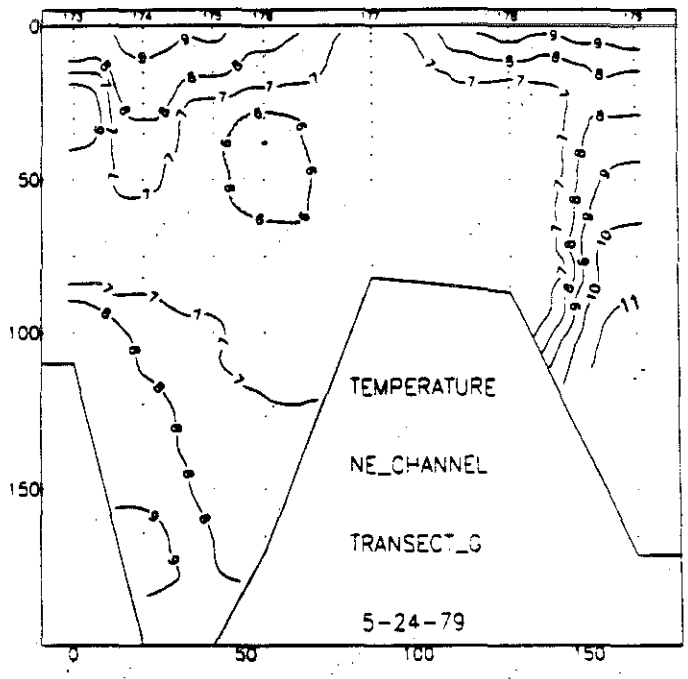


Figure 68. Continued.

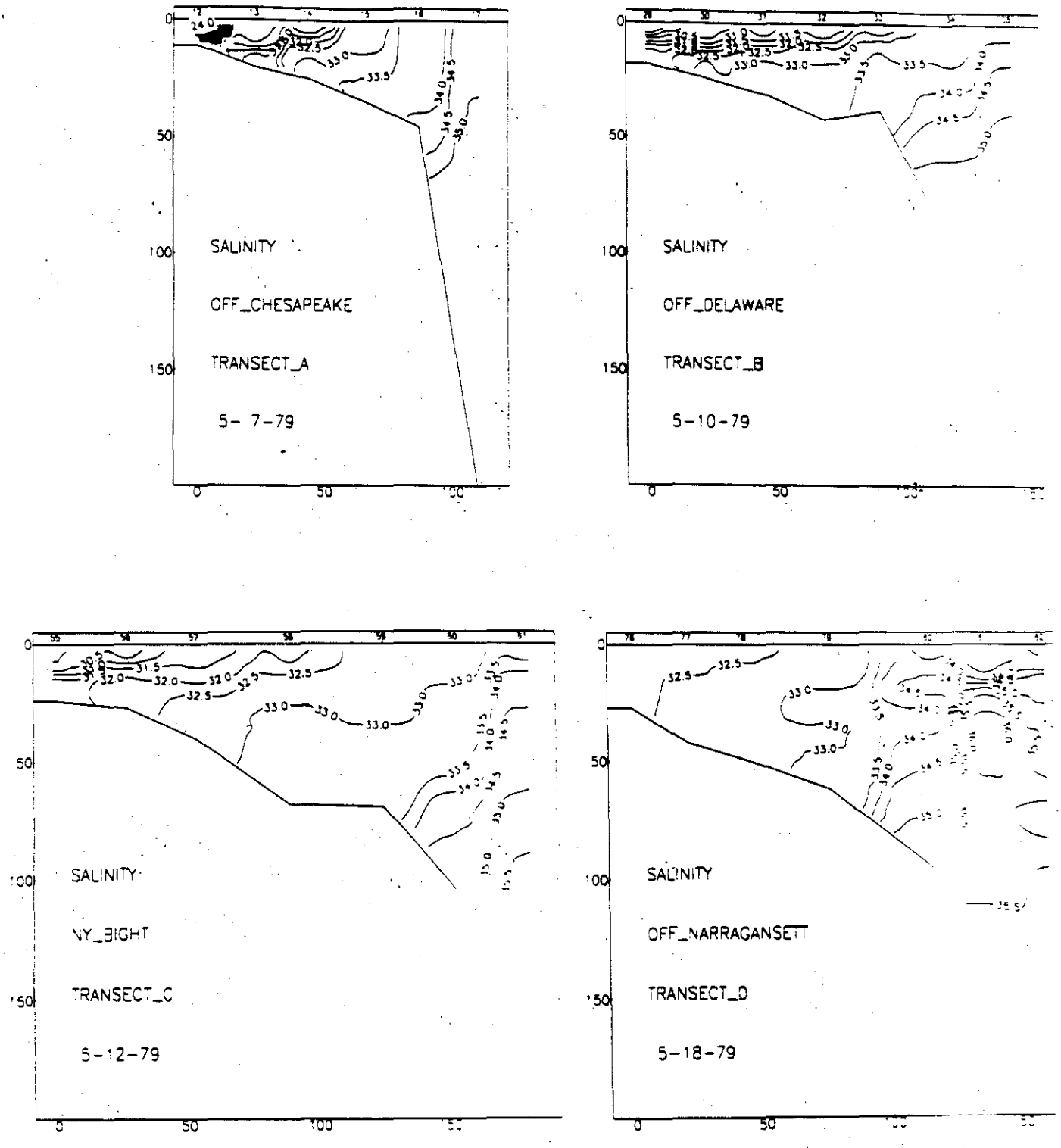
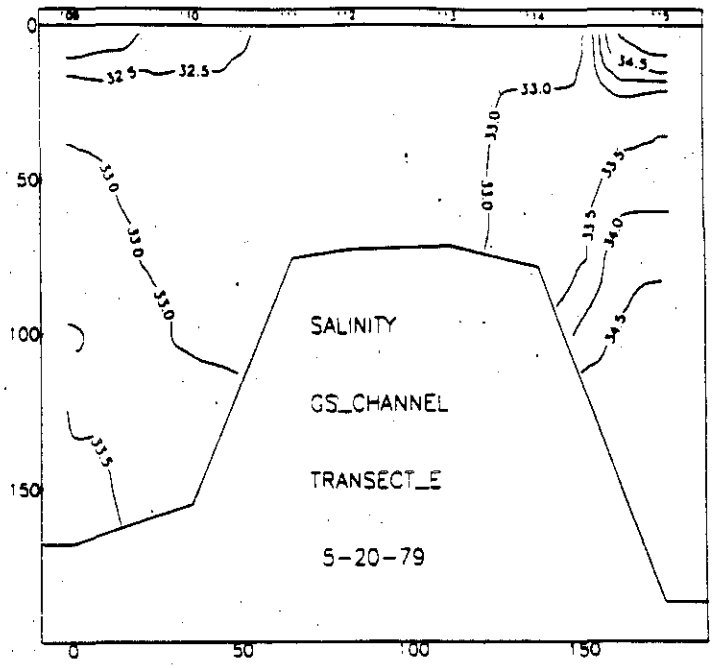


Figure 69. Salinity (PSU) transects: DEL7905.



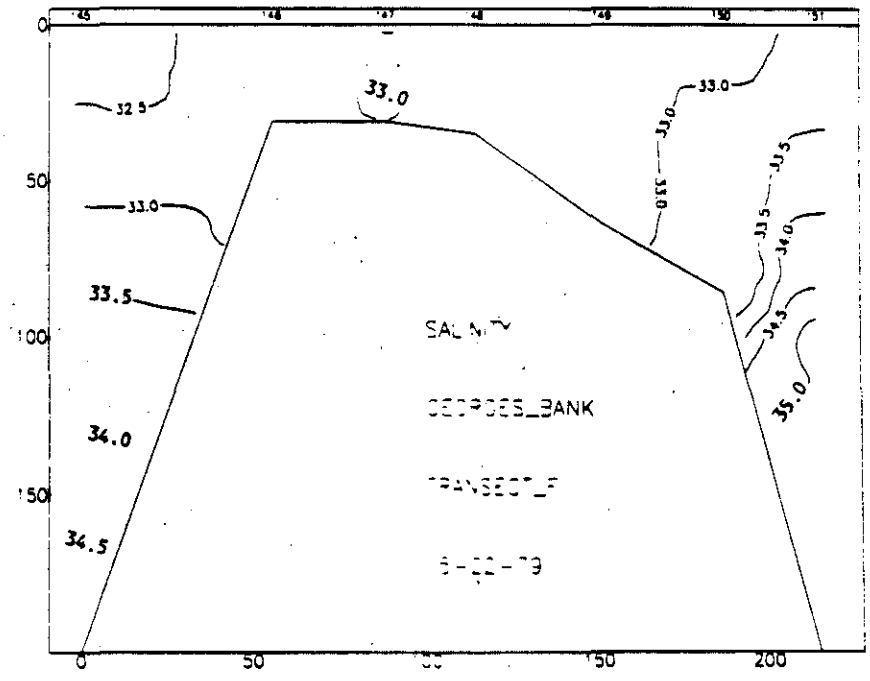


Figure 69. Continued.

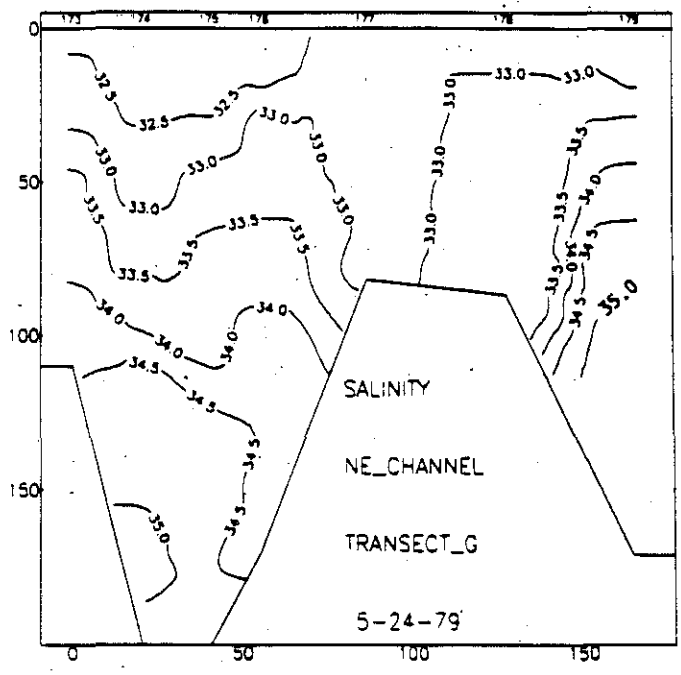


Figure 69. Continued.

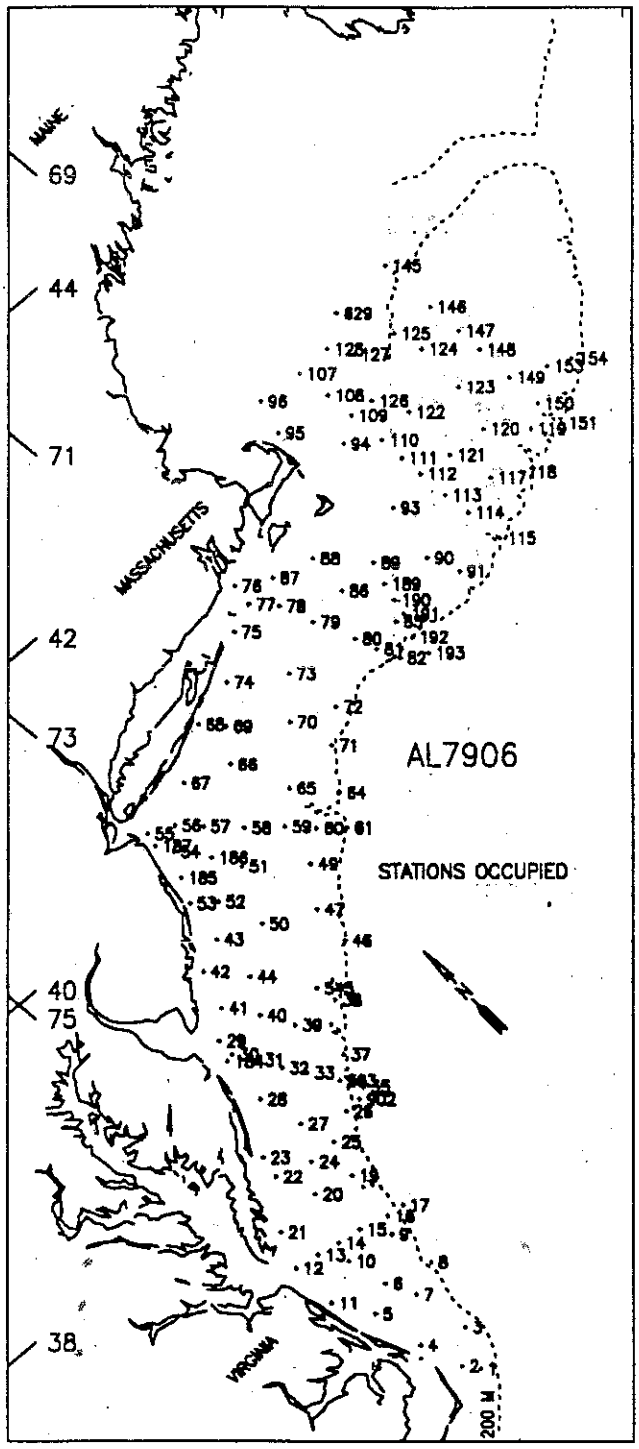


Figure 70. Station positions: ALB7906.

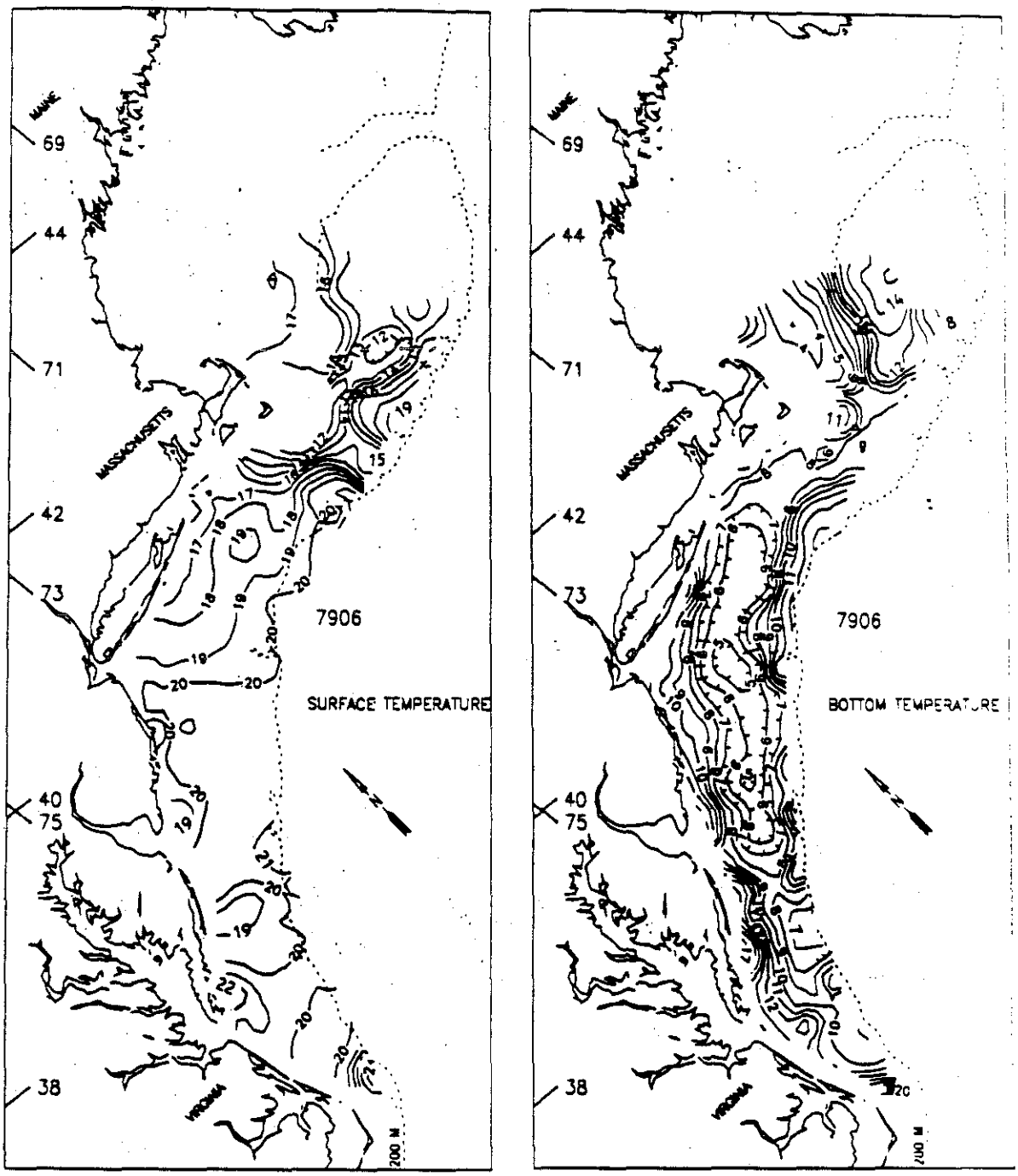


Figure 71. Surface and bottom temperature (°C) distribution: ALB7906.

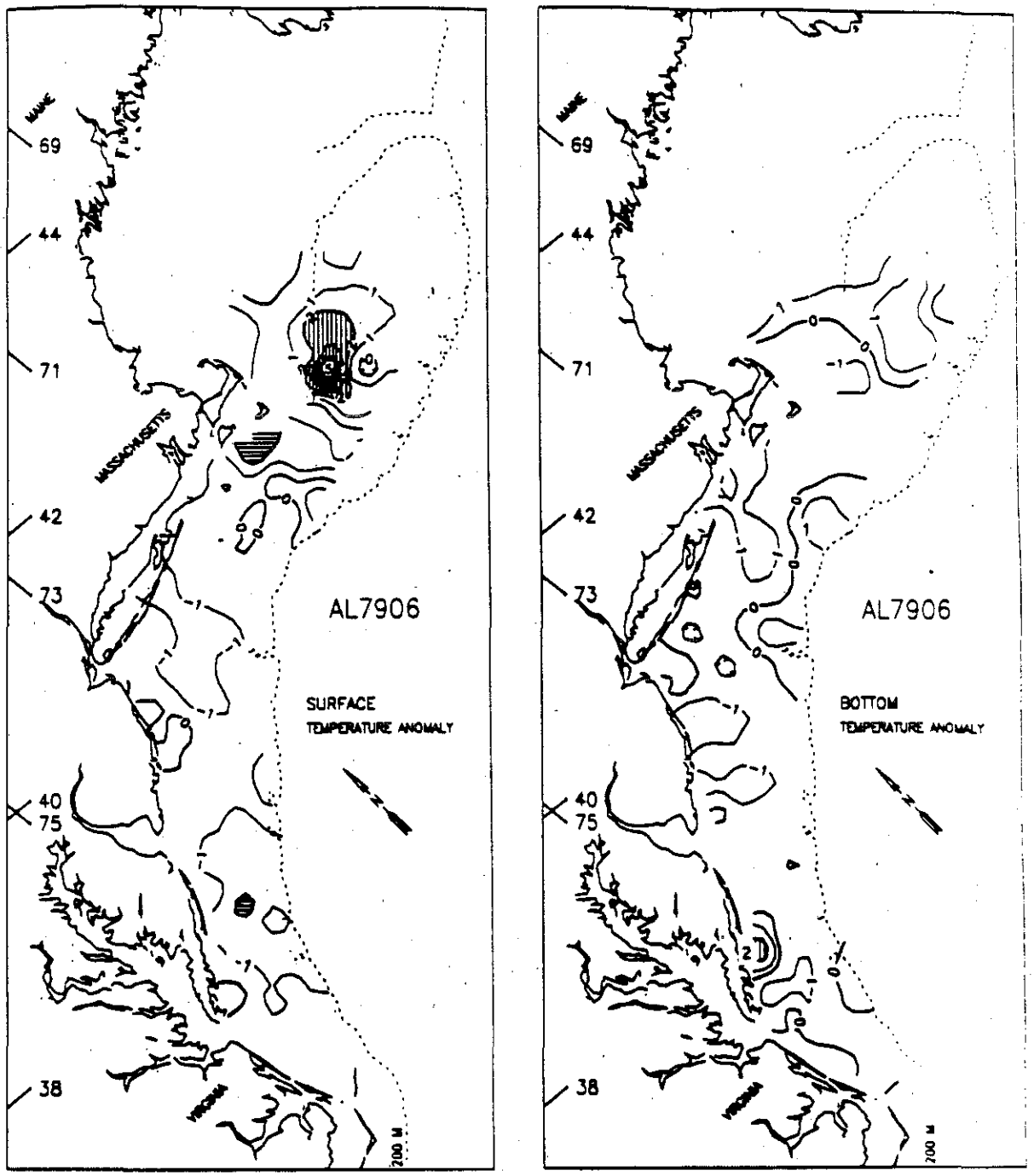


Figure 72. Normalized surface and bottom temperature anomaly: ALB7906. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the year mean.

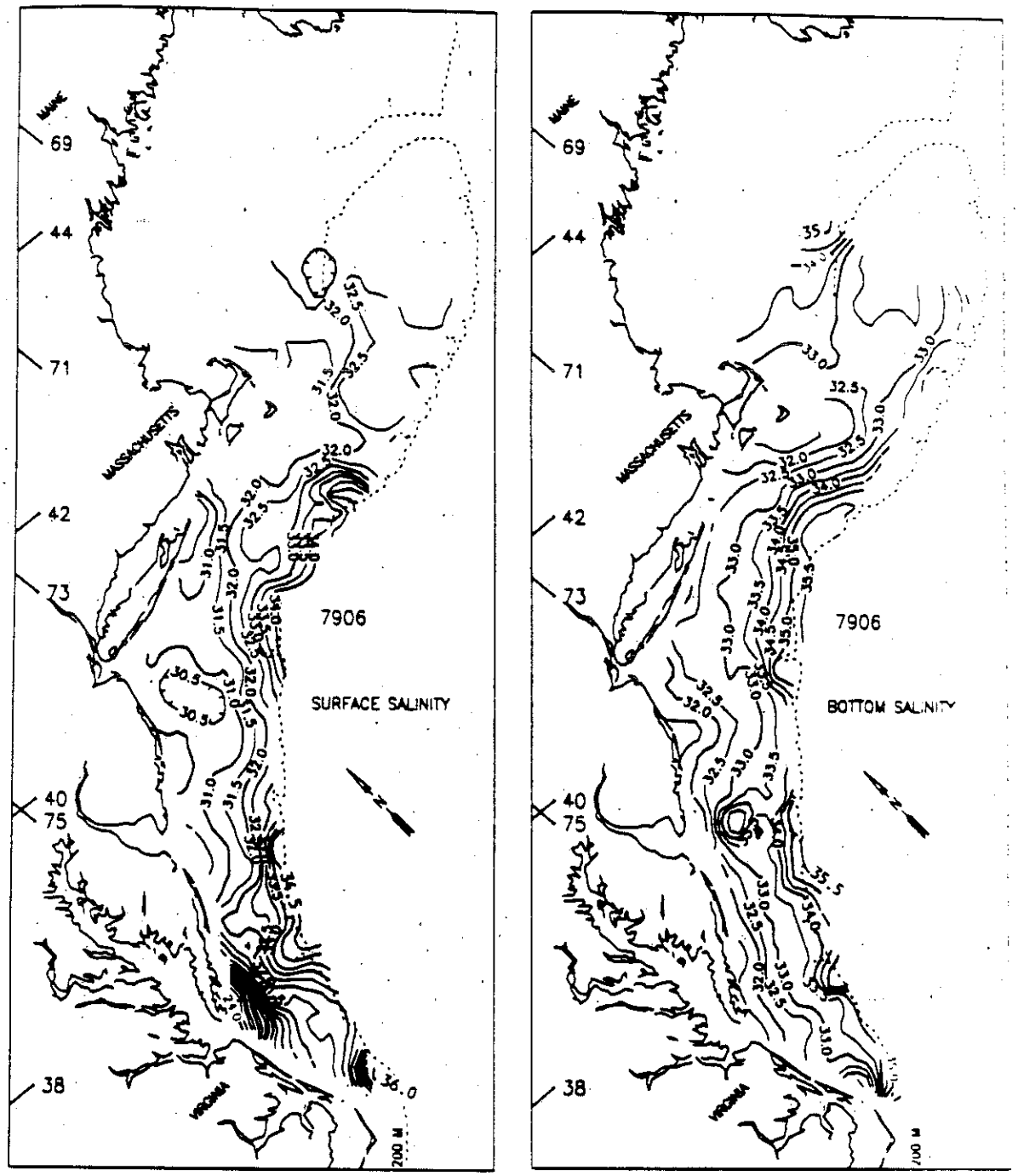


Figure 73. Surface and bottom salinity (PSU) distribution: ALB7906.

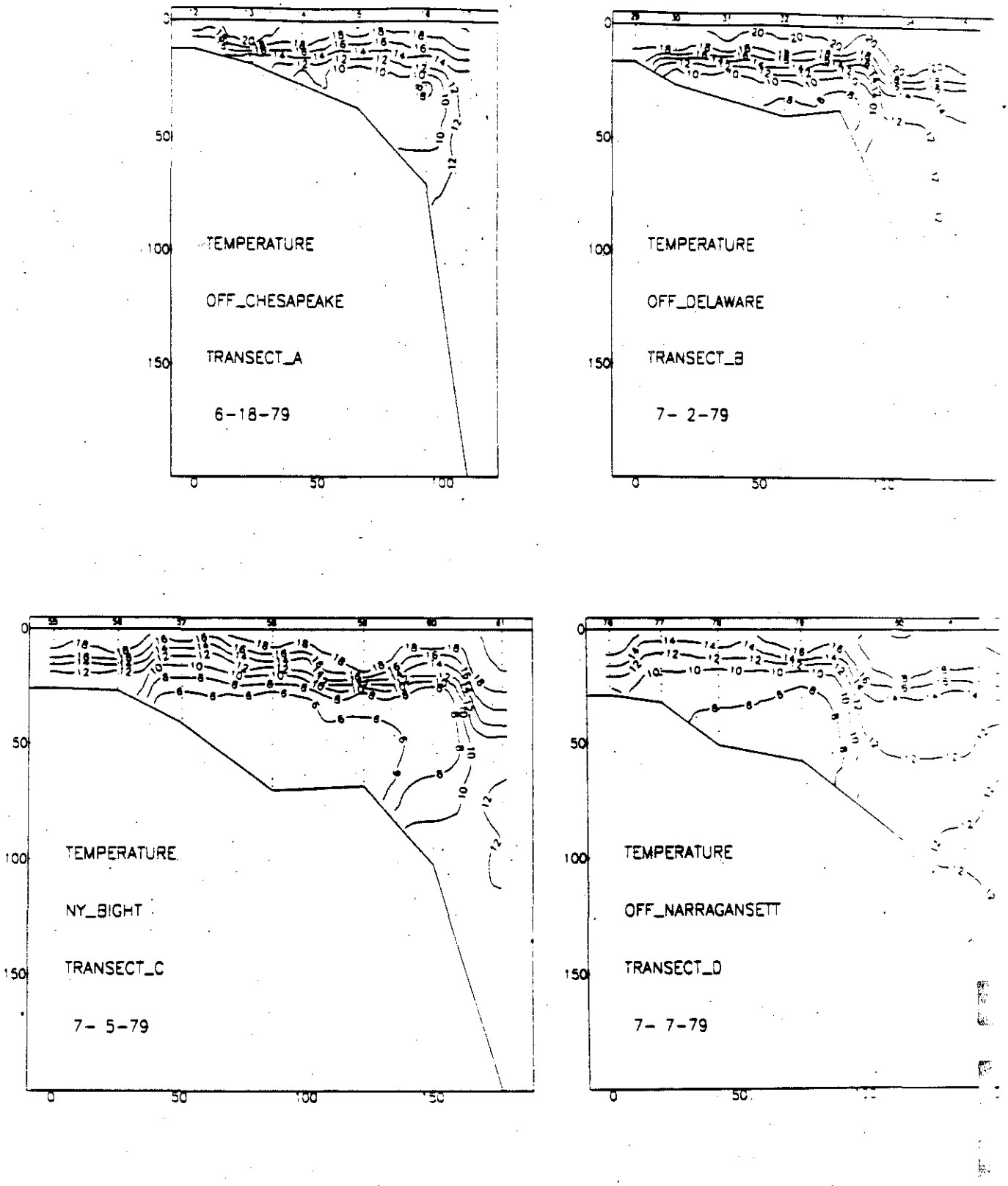
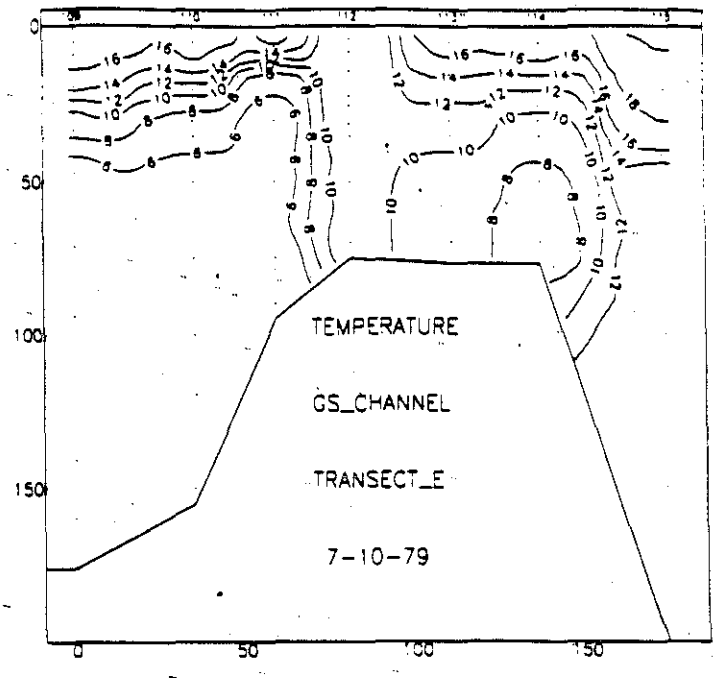


Figure 74. Temperature (°C) transects: ALB7906.



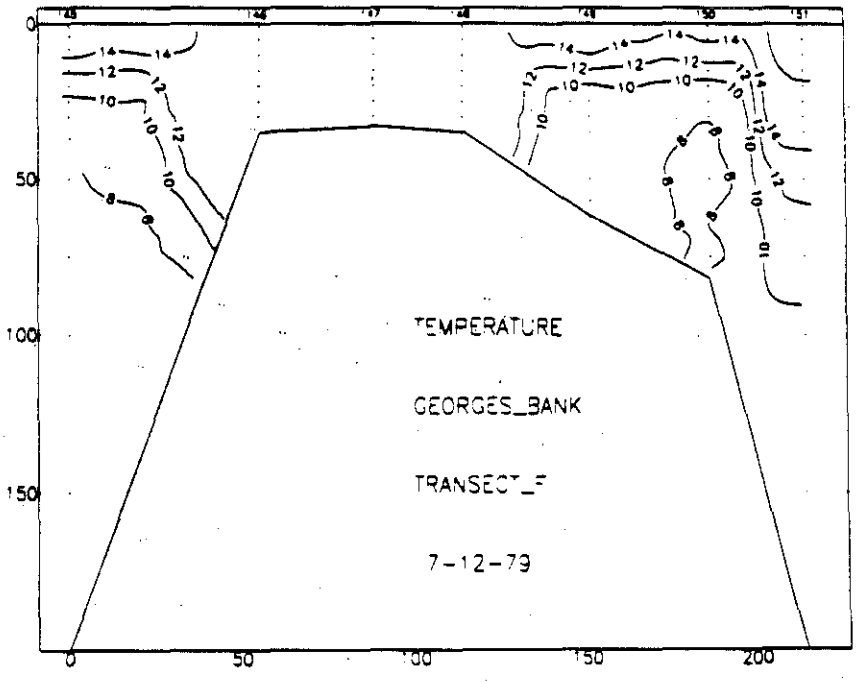
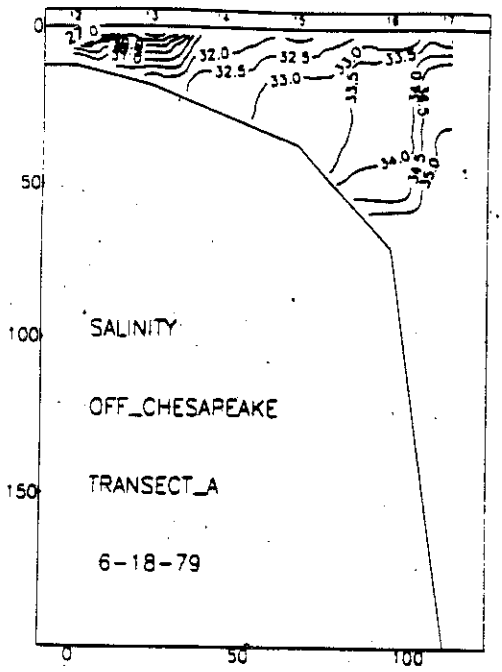
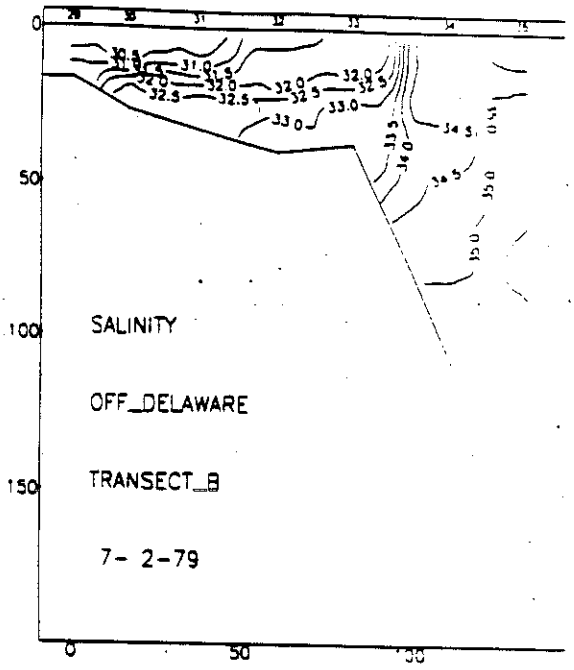
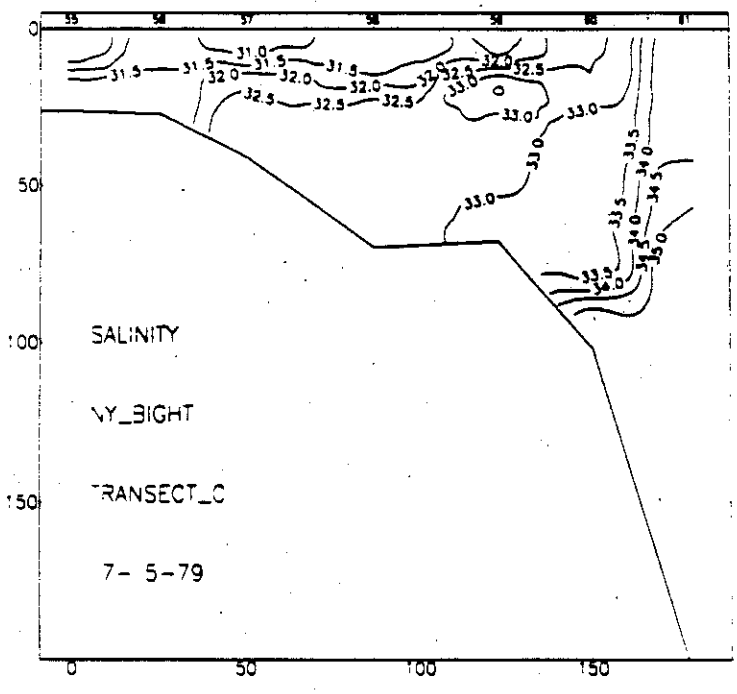


Figure 74. Continued.







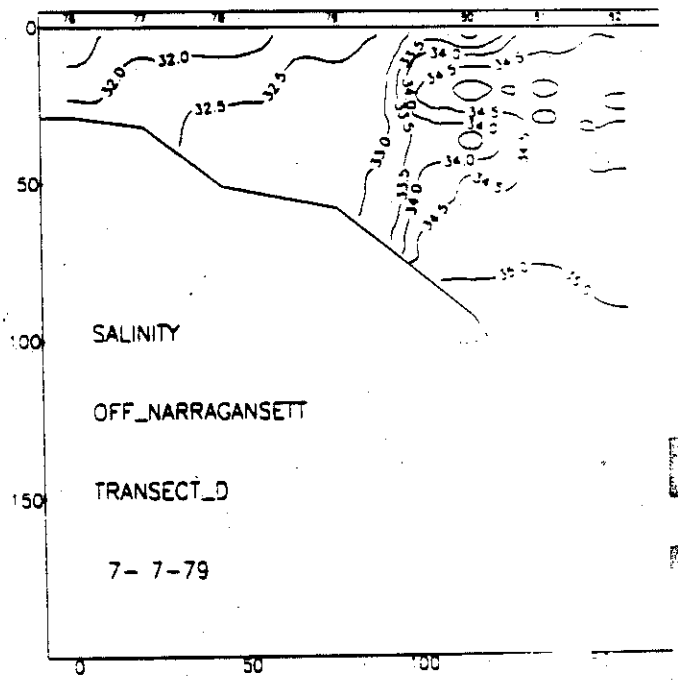
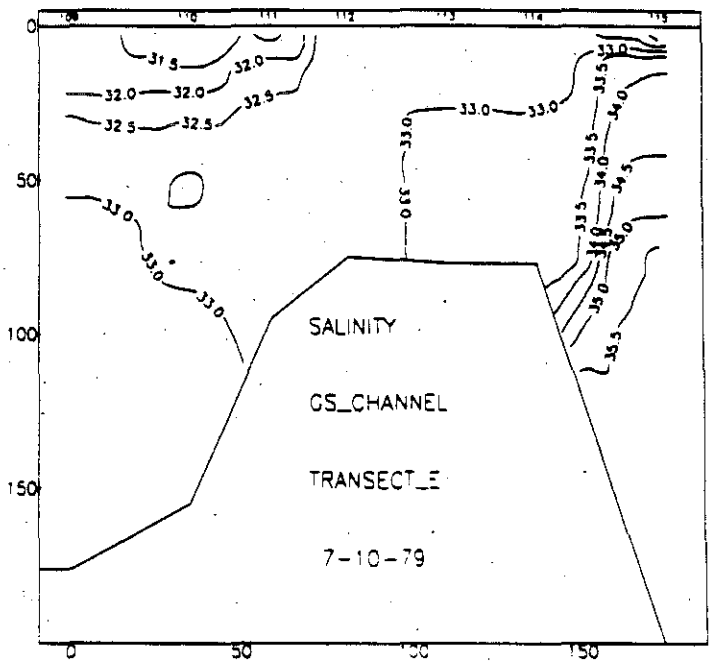


Figure 75. Salinity (PSU) transects: ALB7906.



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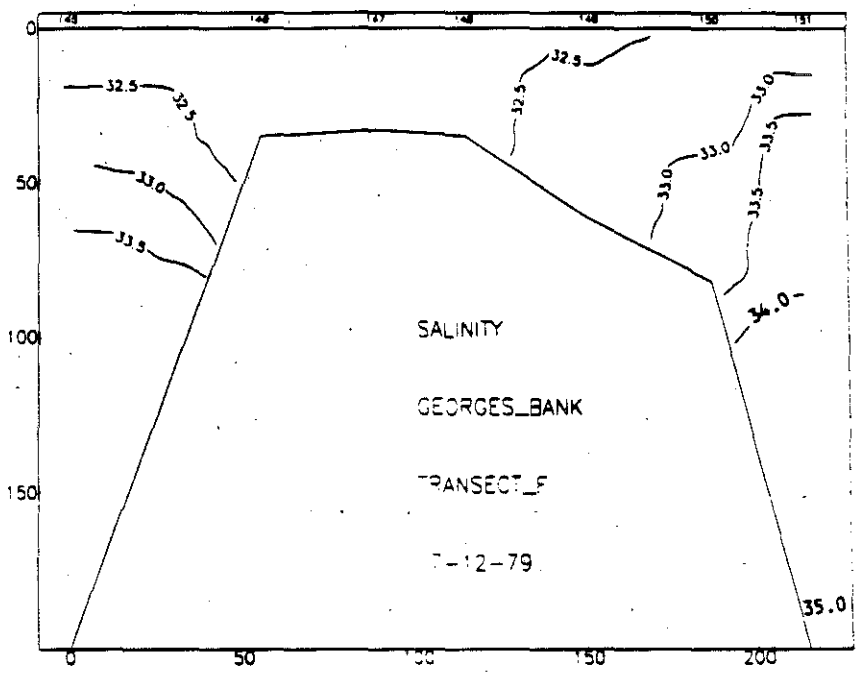


Figure 75. Continued.

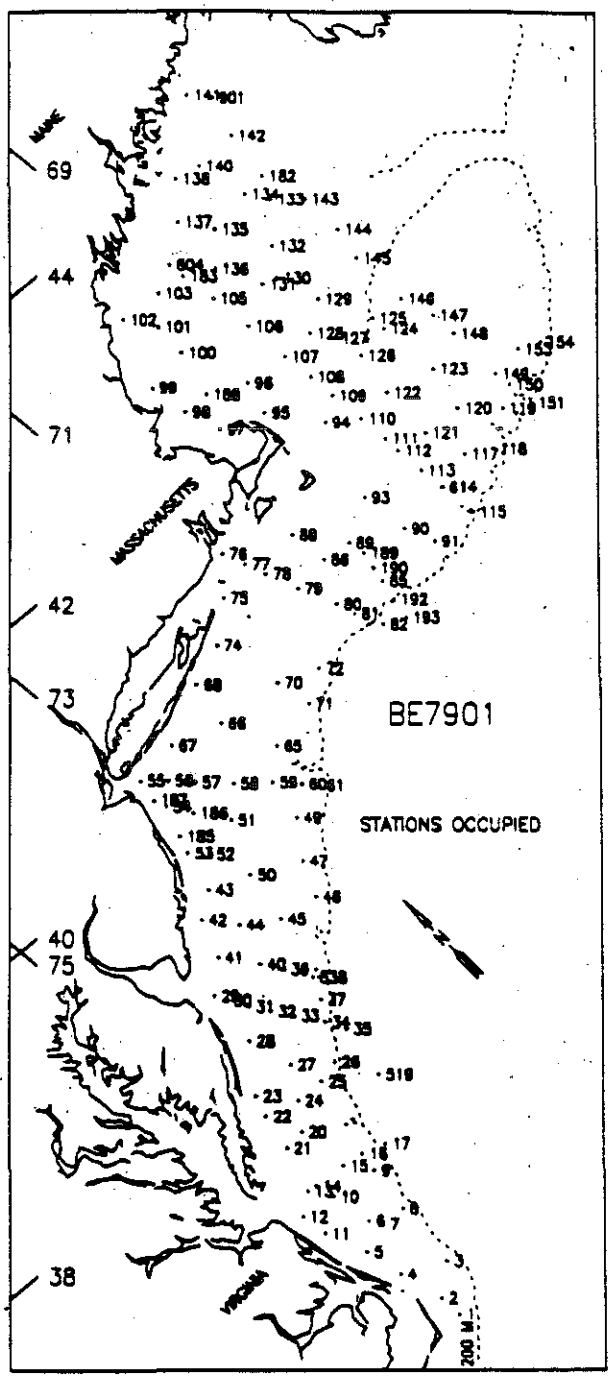


Figure 76. Station positions: BEL7901.

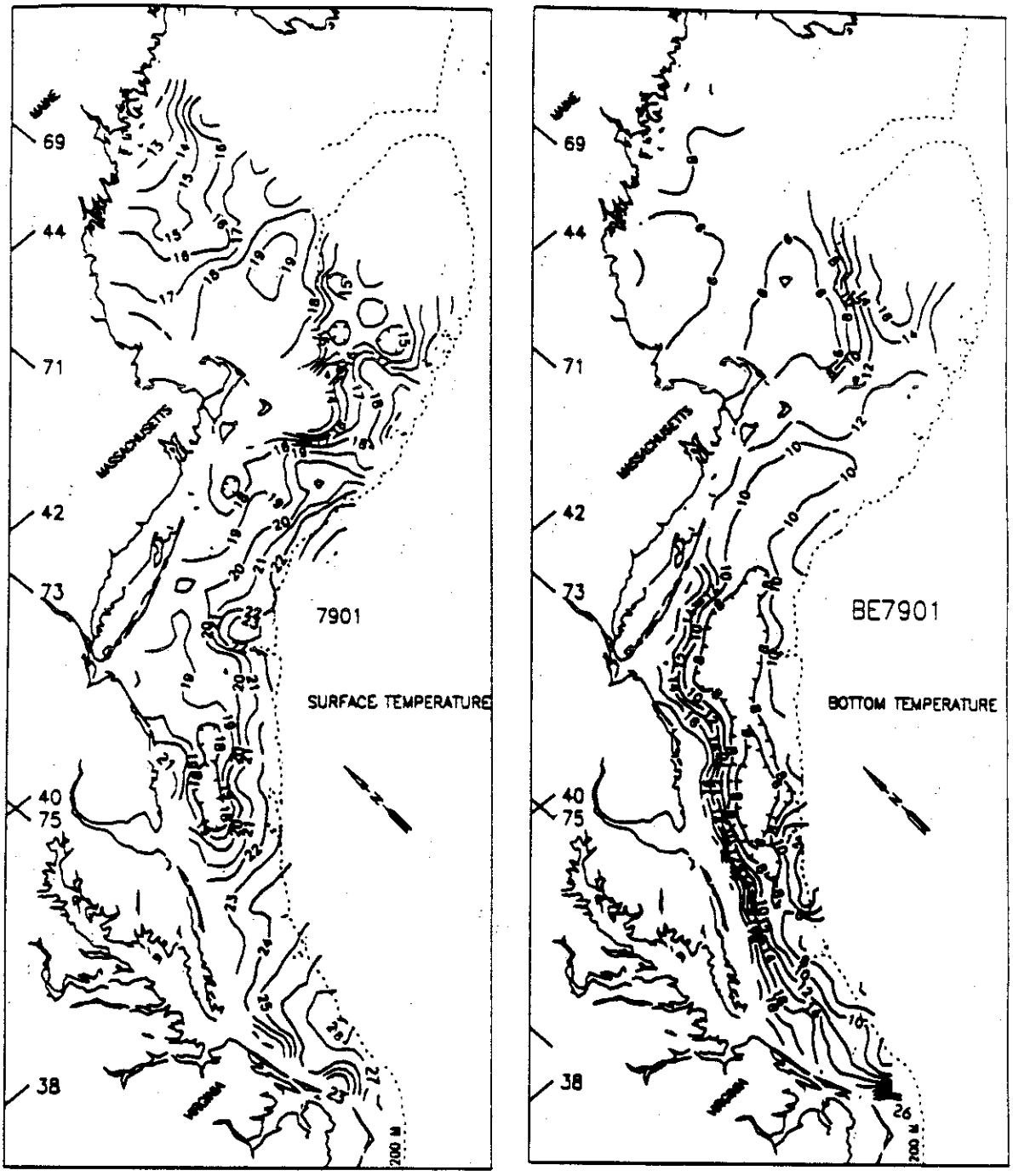


Figure 77. Surface and bottom temperature (°C) distribution: BEL7901.

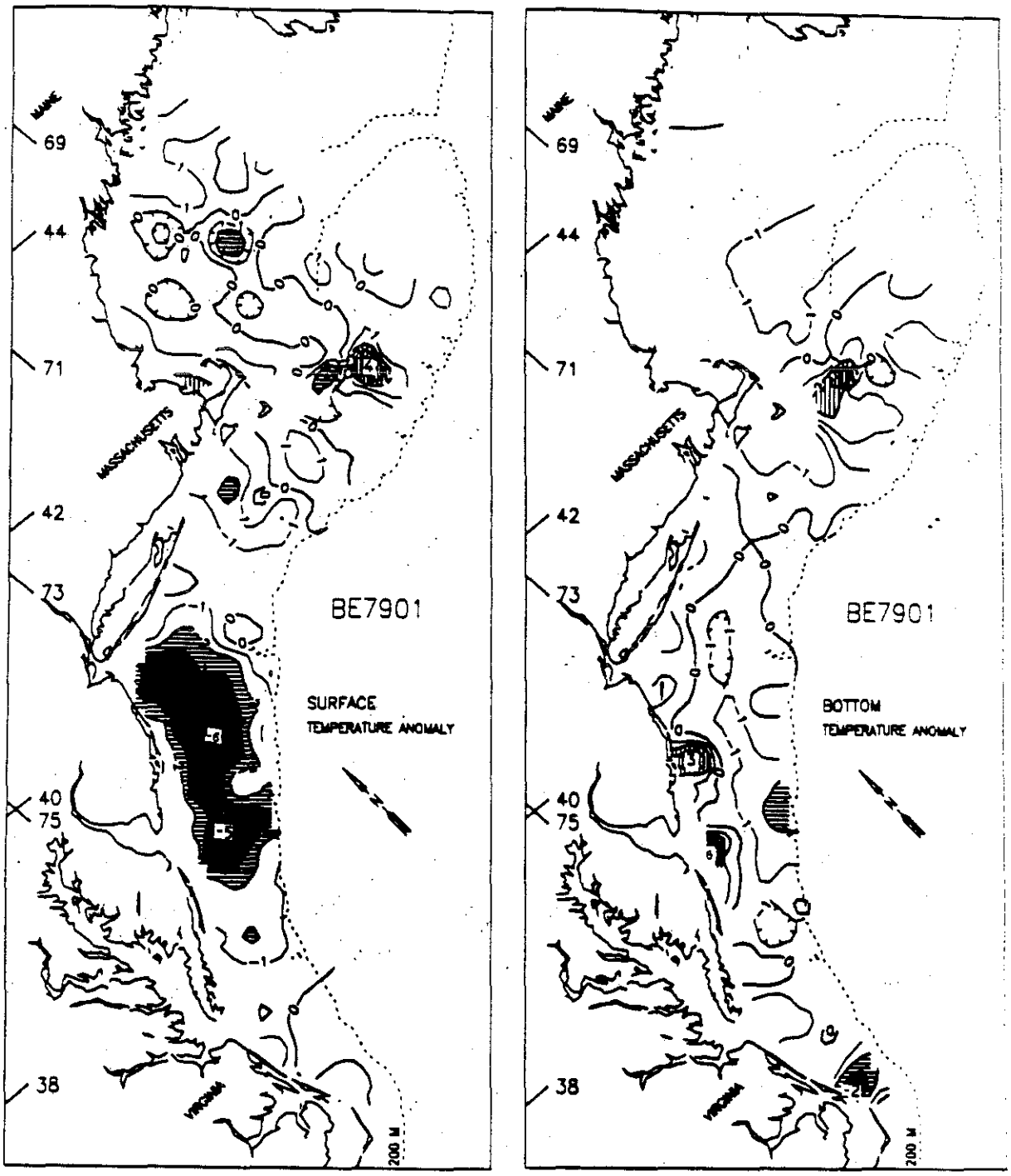


Figure 78. Normalized surface and bottom temperature anomaly: BEL7901. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

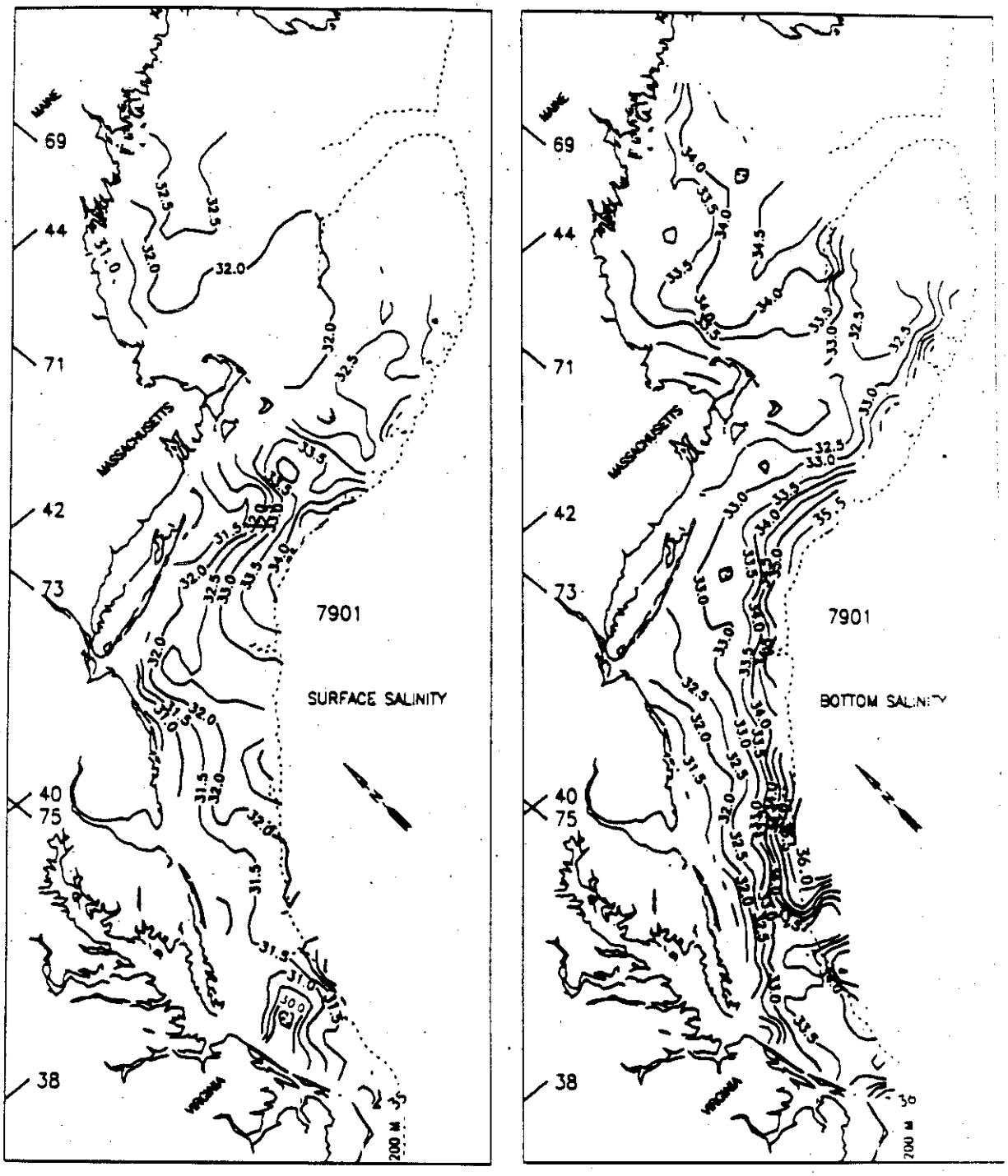


Figure 79. Surface and bottom salinity (PSU) distribution: BEL7901.

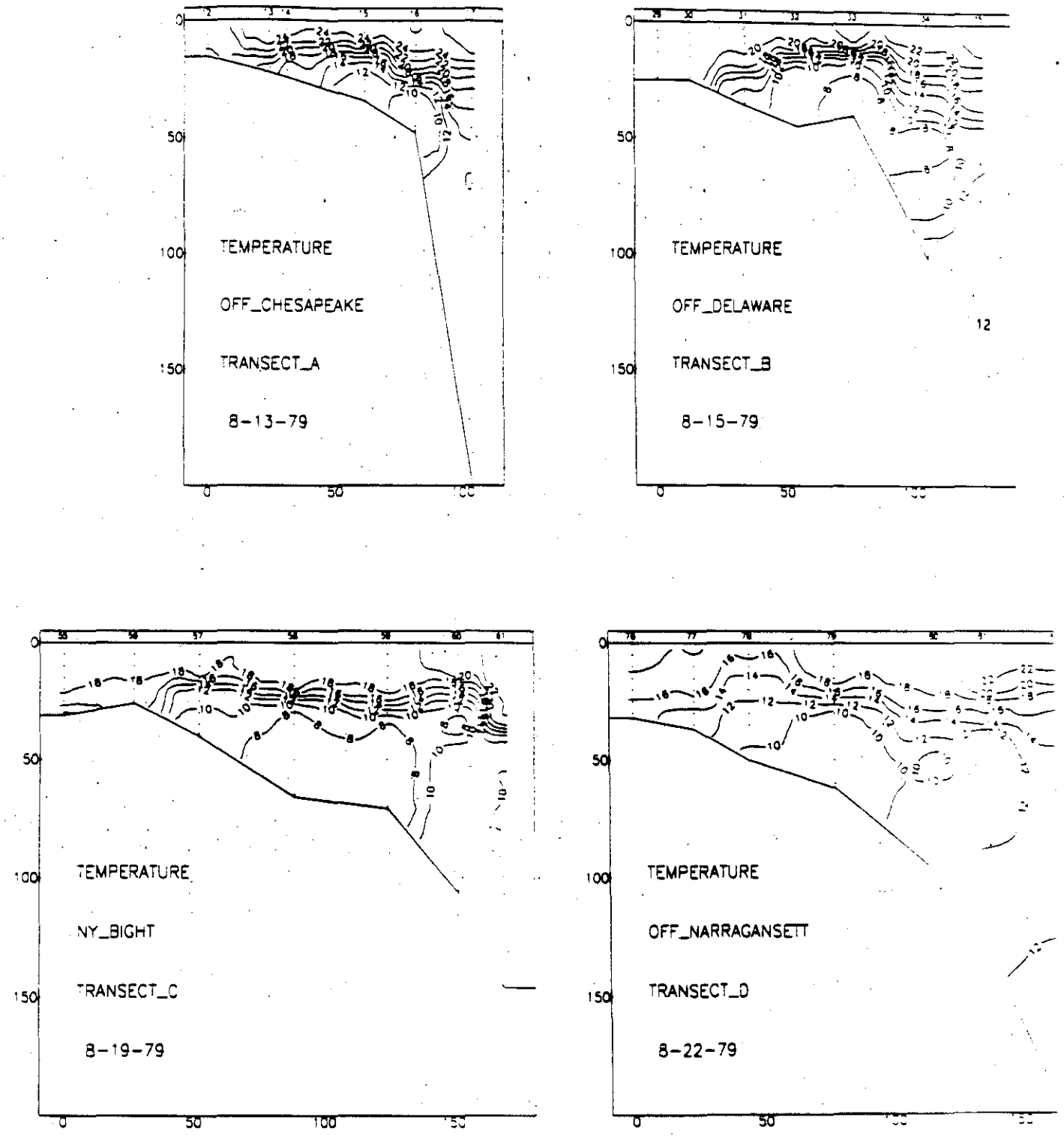
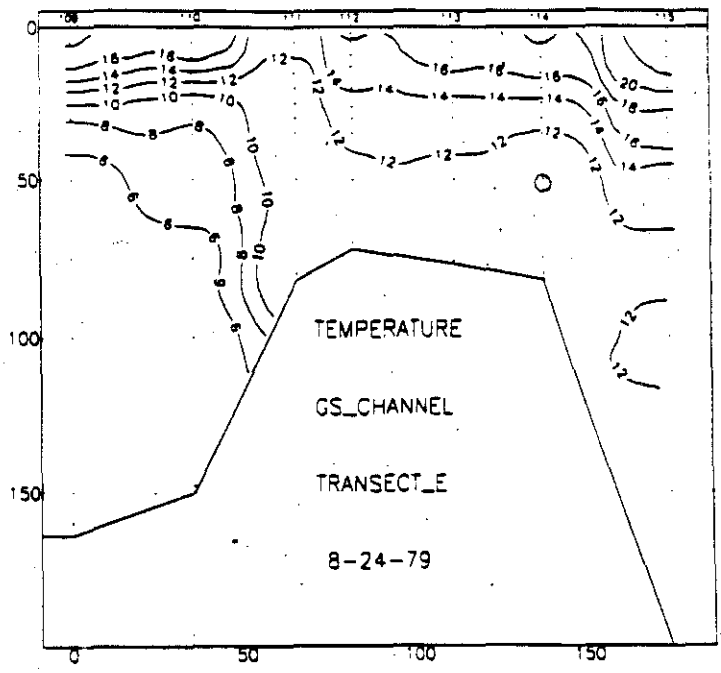


Figure 80. Temperature (°C) transects: BEL7901.



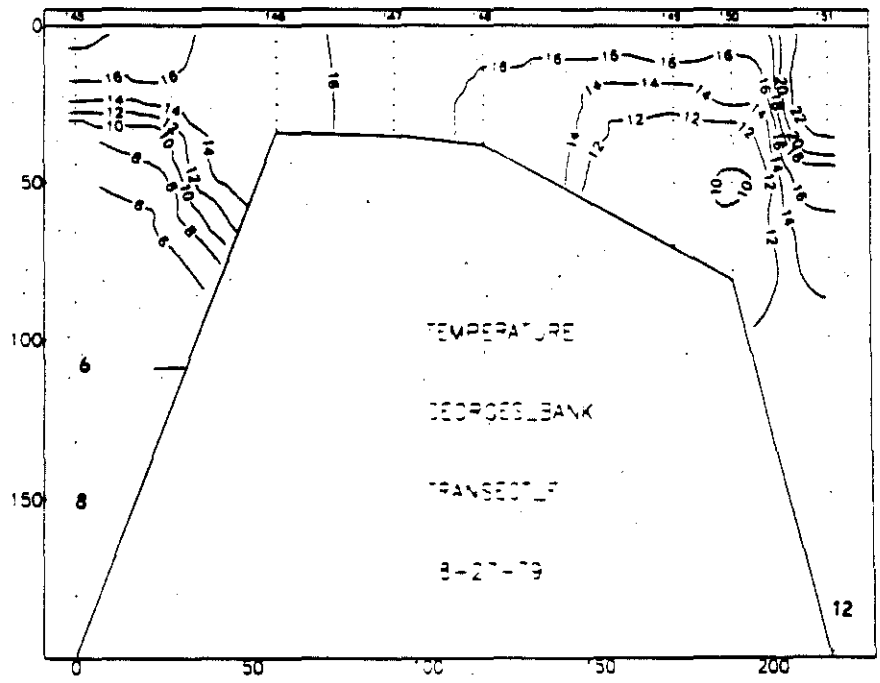


Figure 80. Continued.

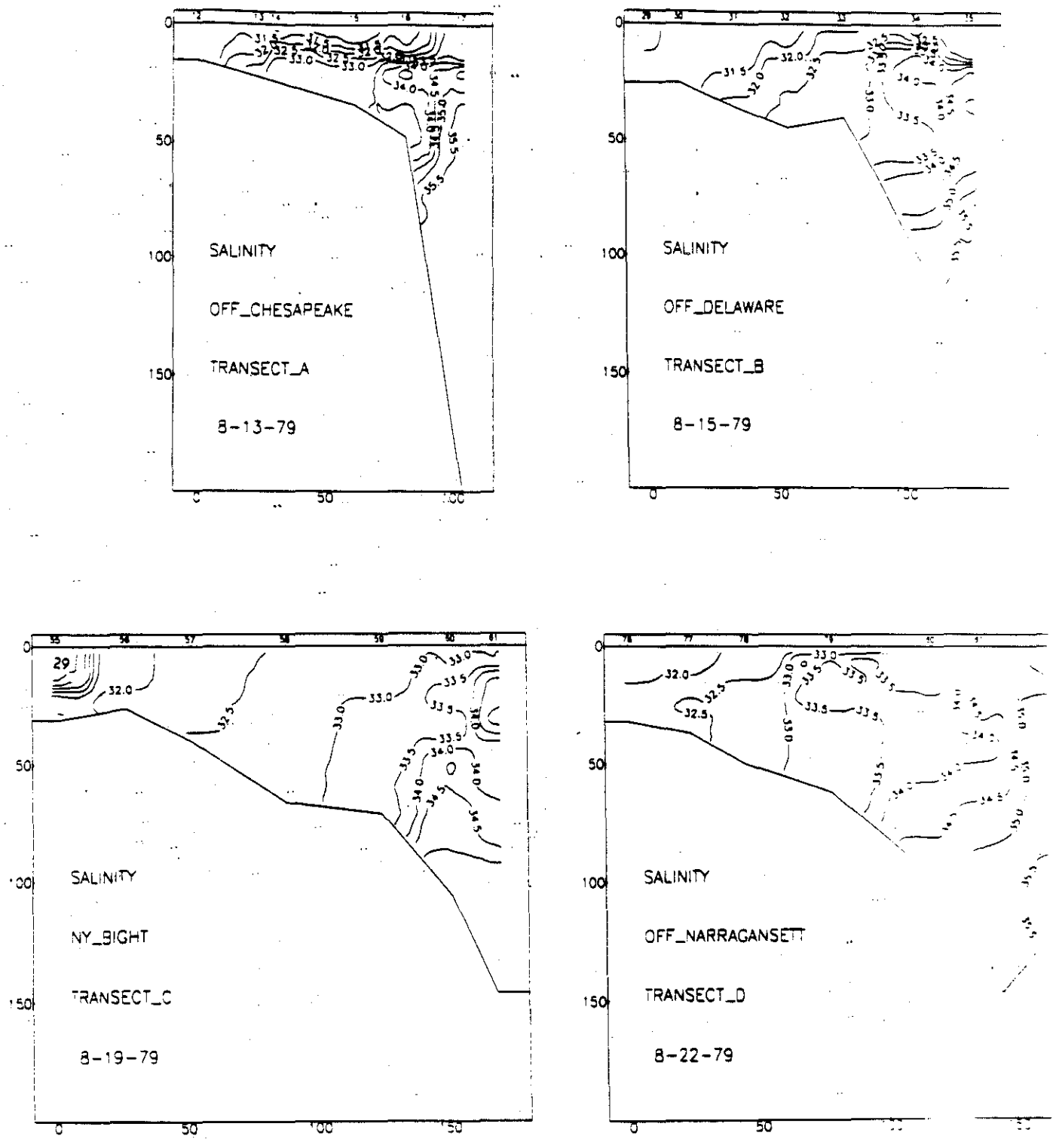
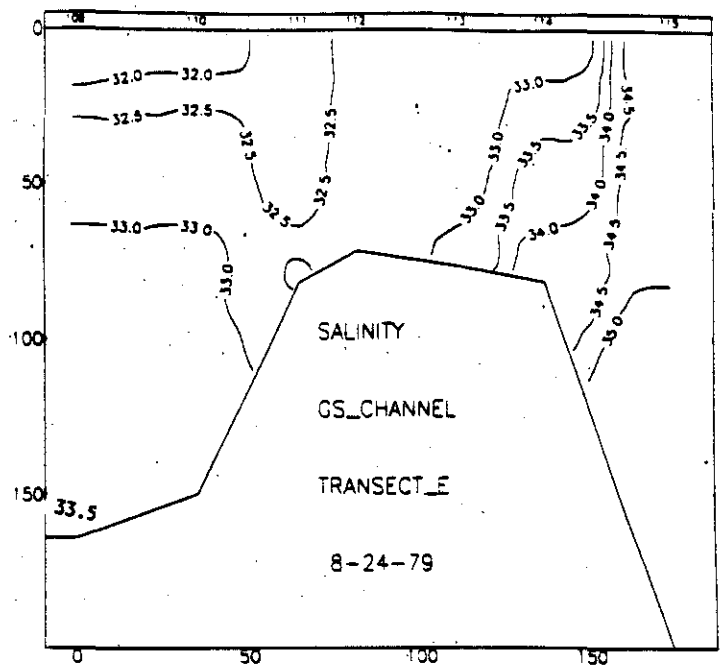


Figure 81. Salinity (PSU) transects: BEL7901.



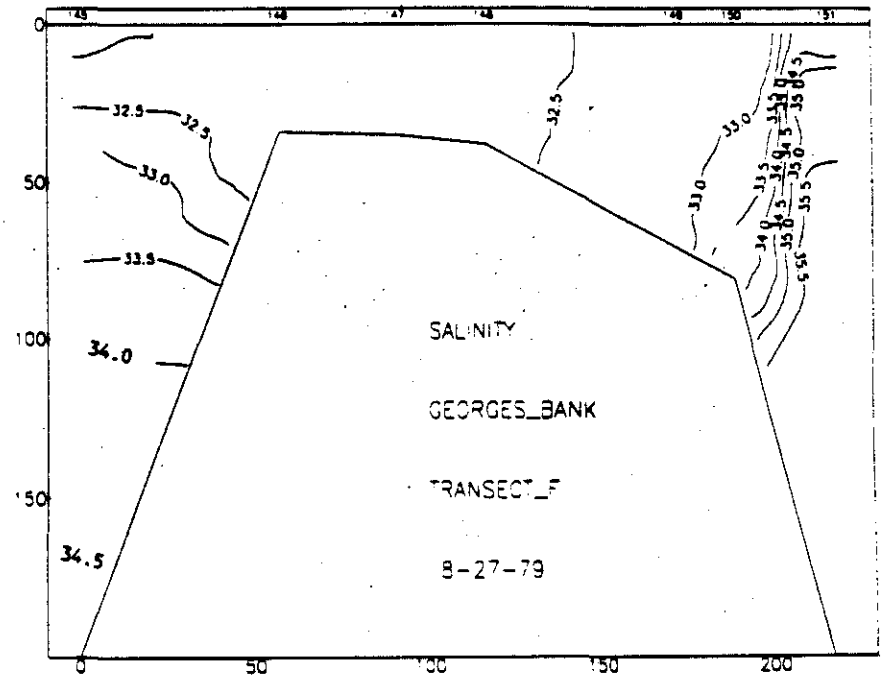


Figure 81. Continued.

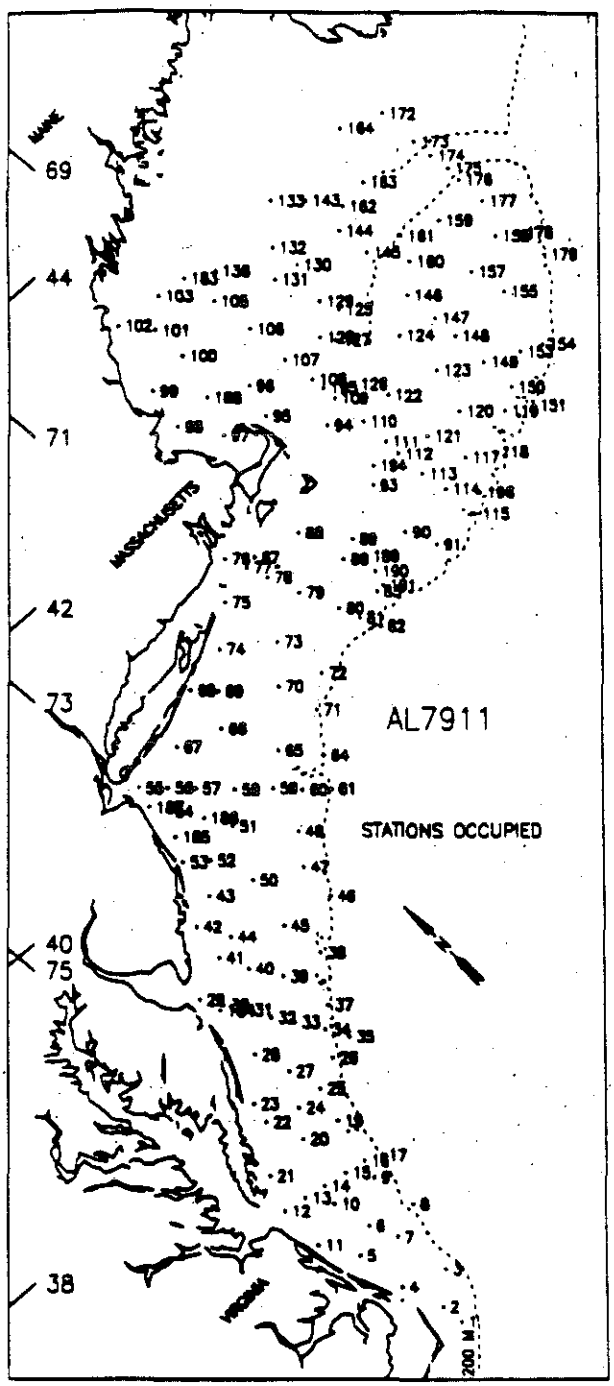


Figure 82. Station positions: ALB7911.

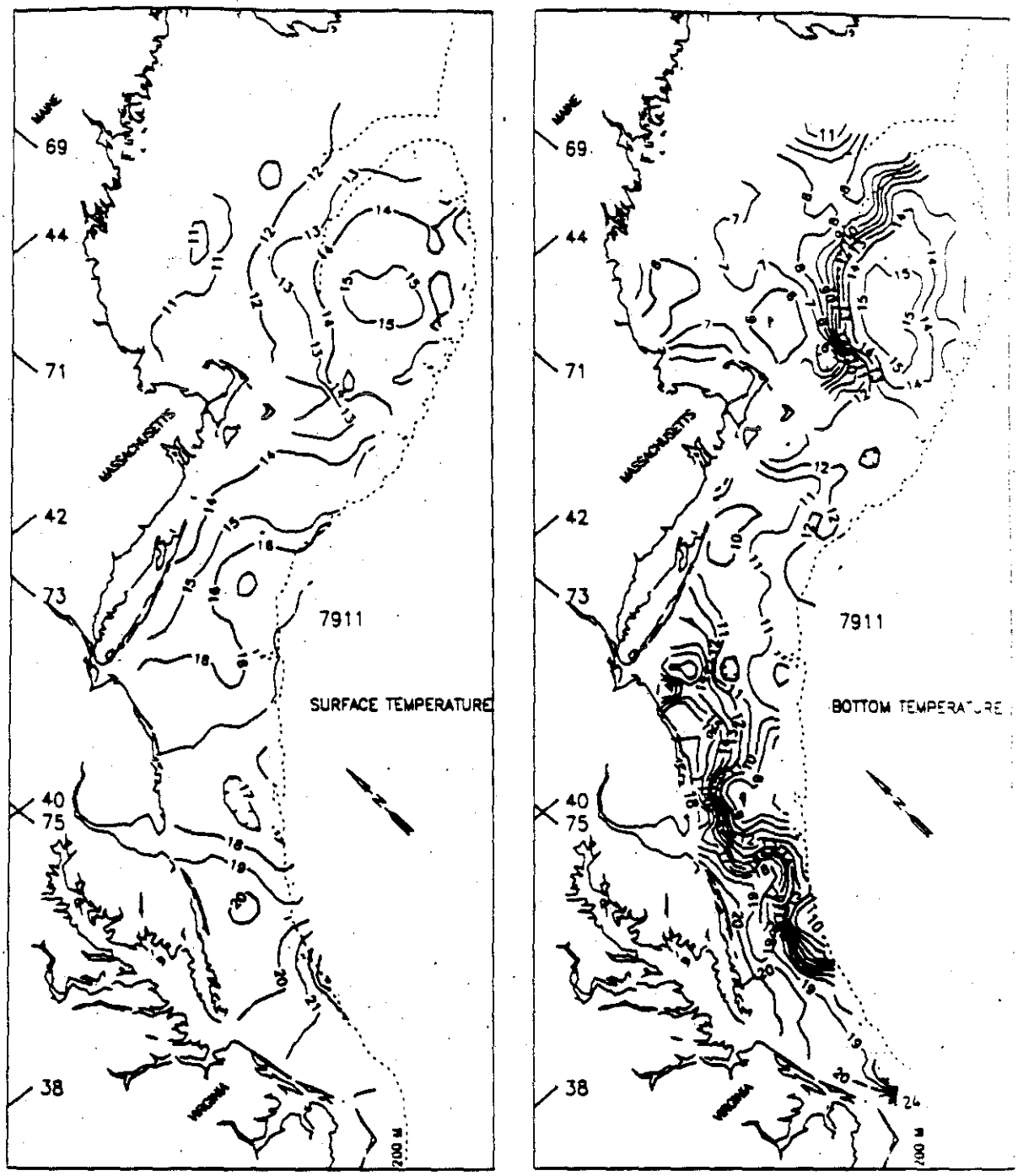


Figure 83. Surface and bottom temperature (°C) distribution: ALB7911.

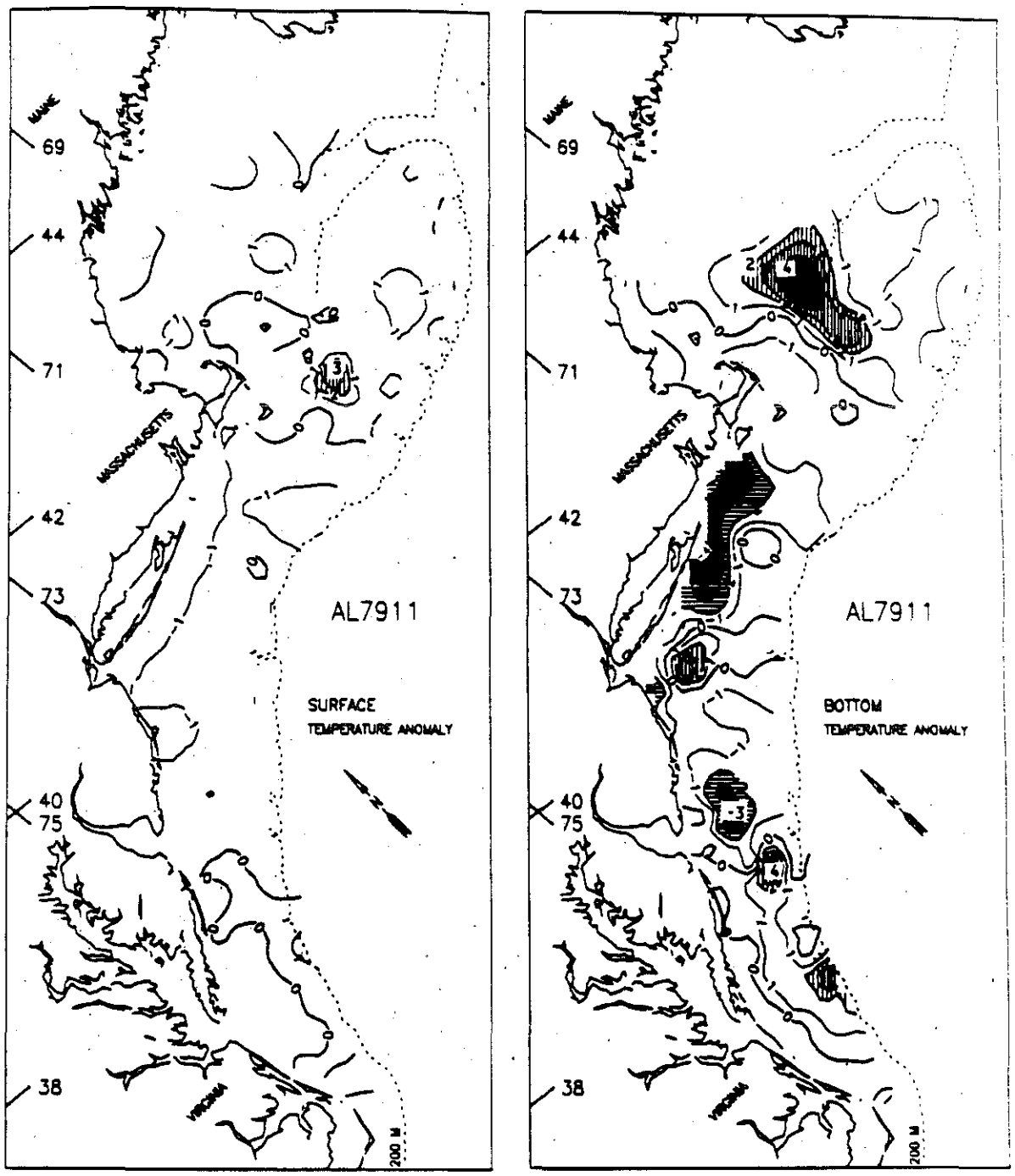


Figure 84. Normalized surface and bottom temperature anomaly: ALB7911. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

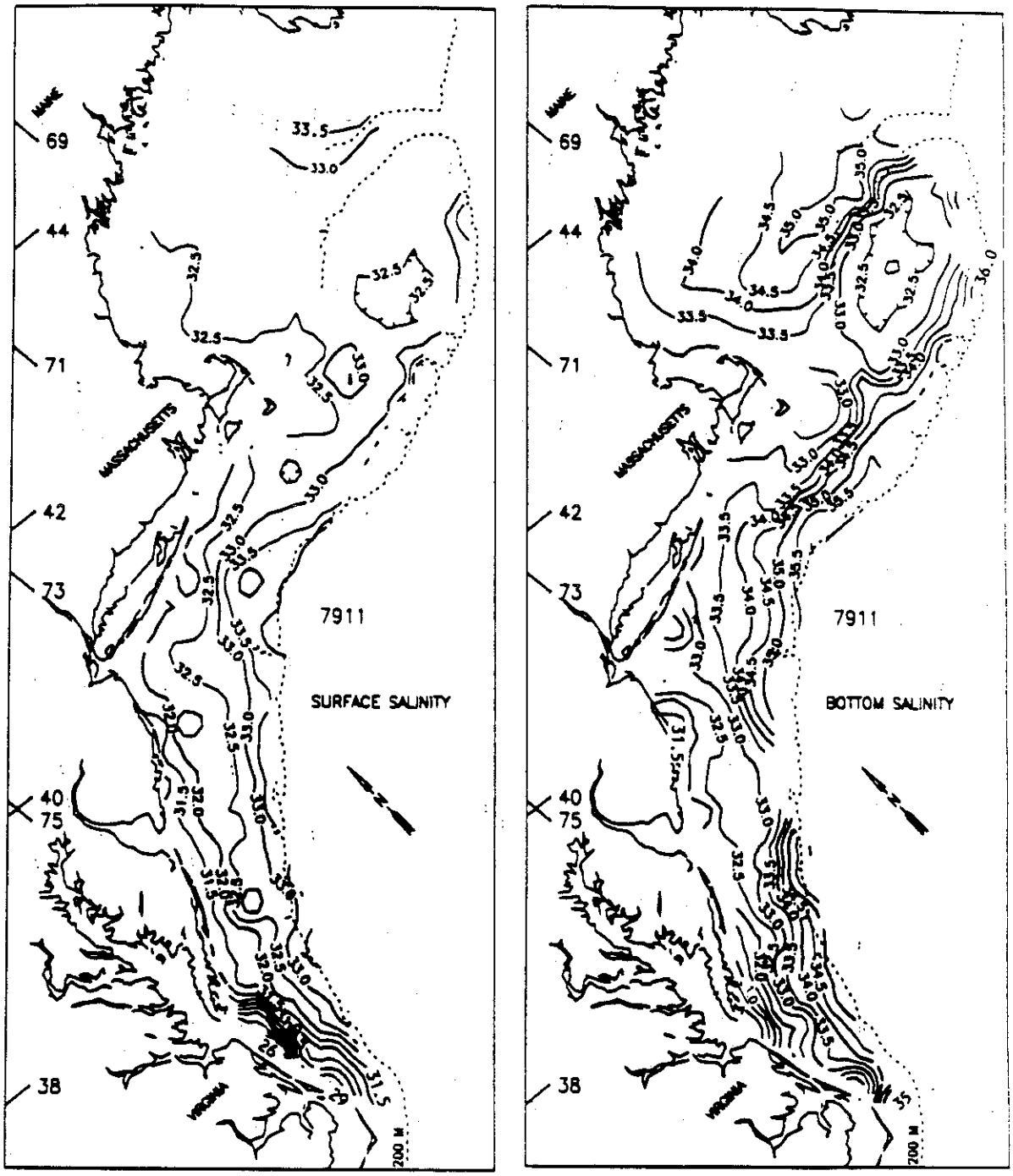


Figure 85. Surface and bottom salinity (PSU) distribution: ALB7911.

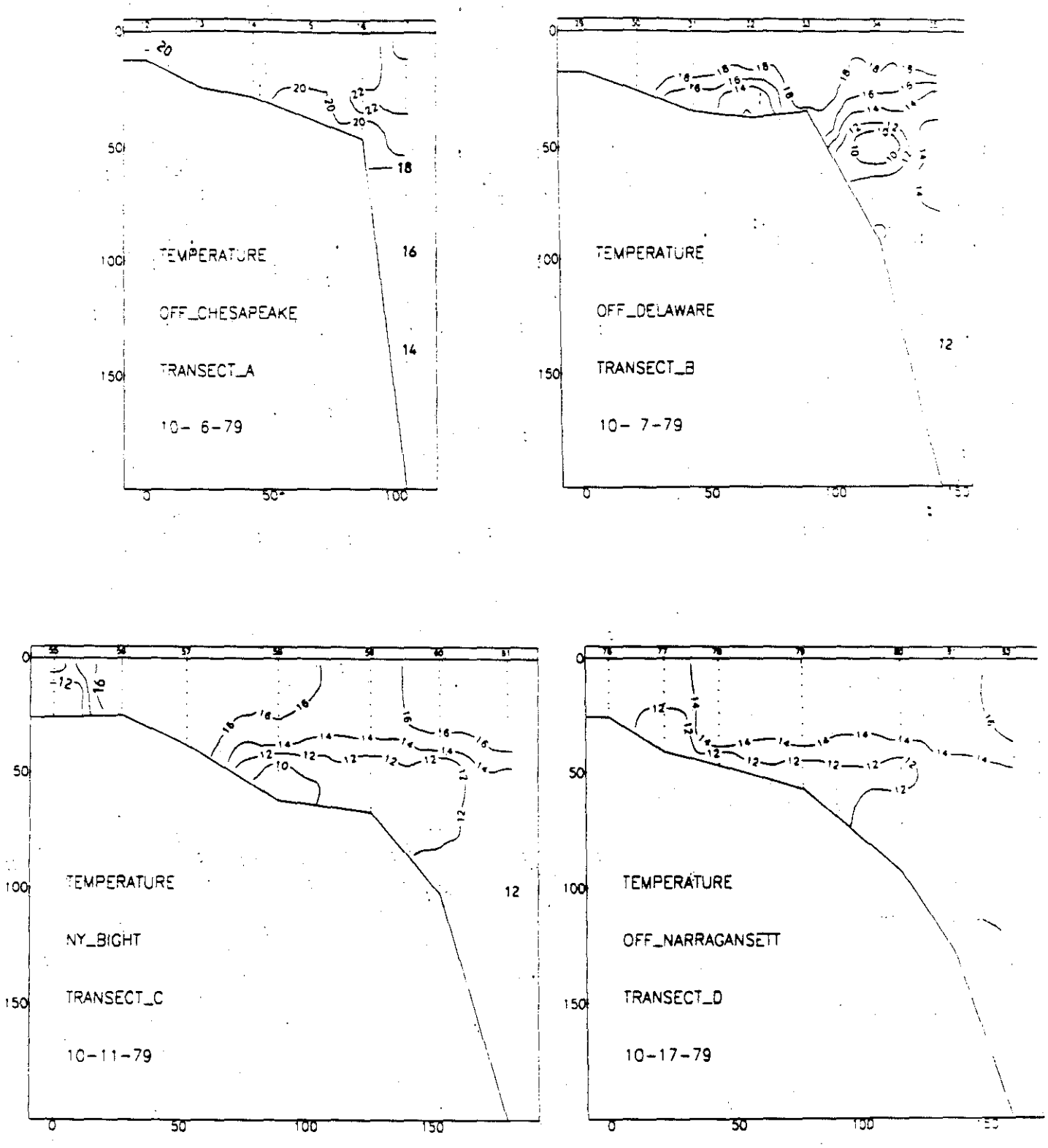
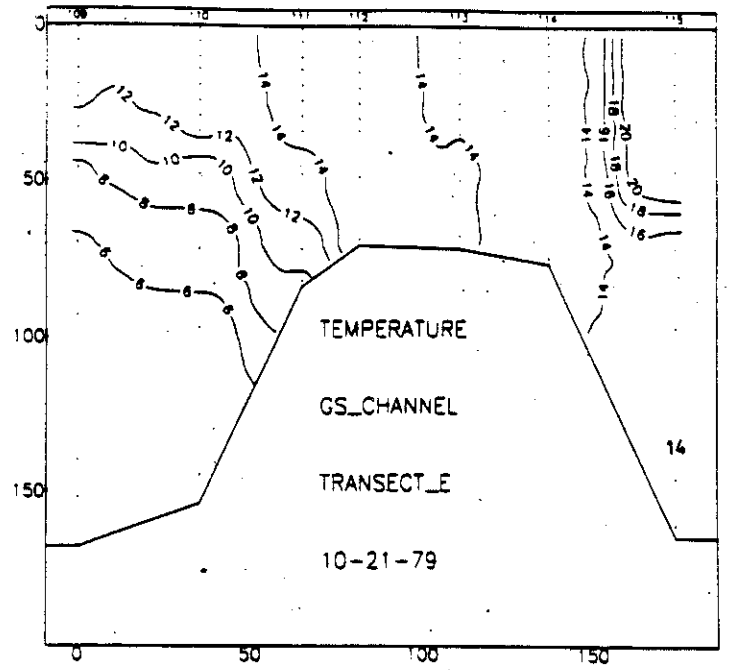


Figure 86. Temperature (°C) transects: ALB7911.



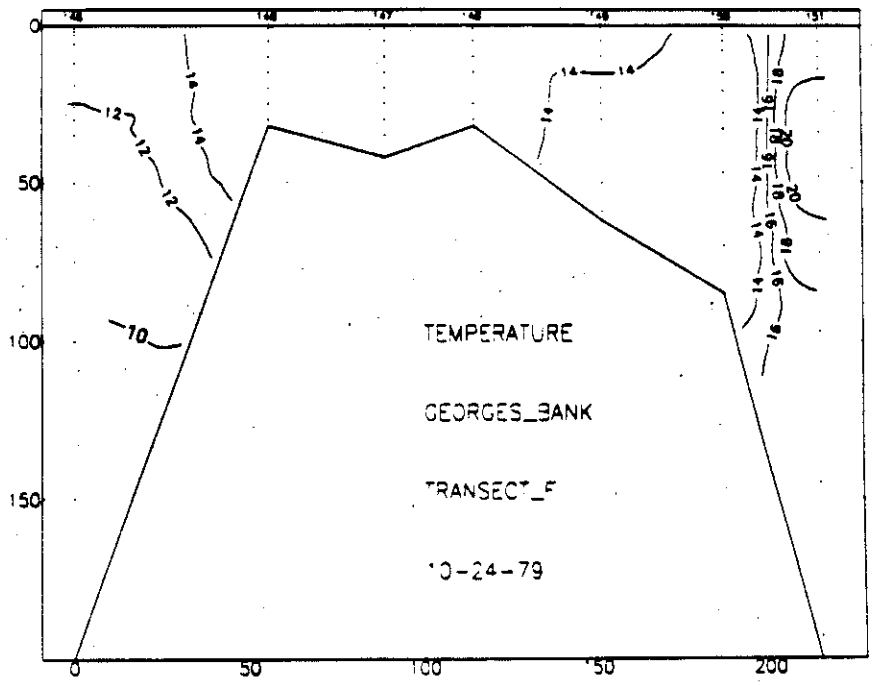


Figure 86. Continued.

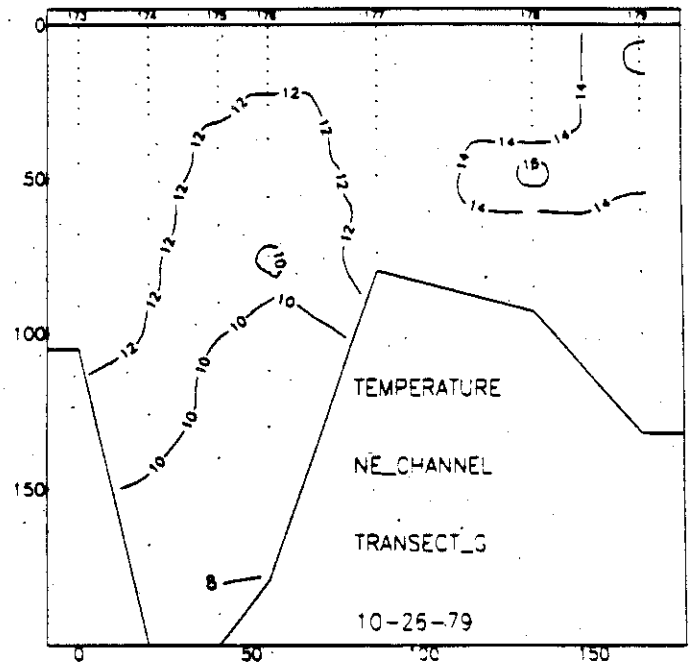


Figure 86. Continued.

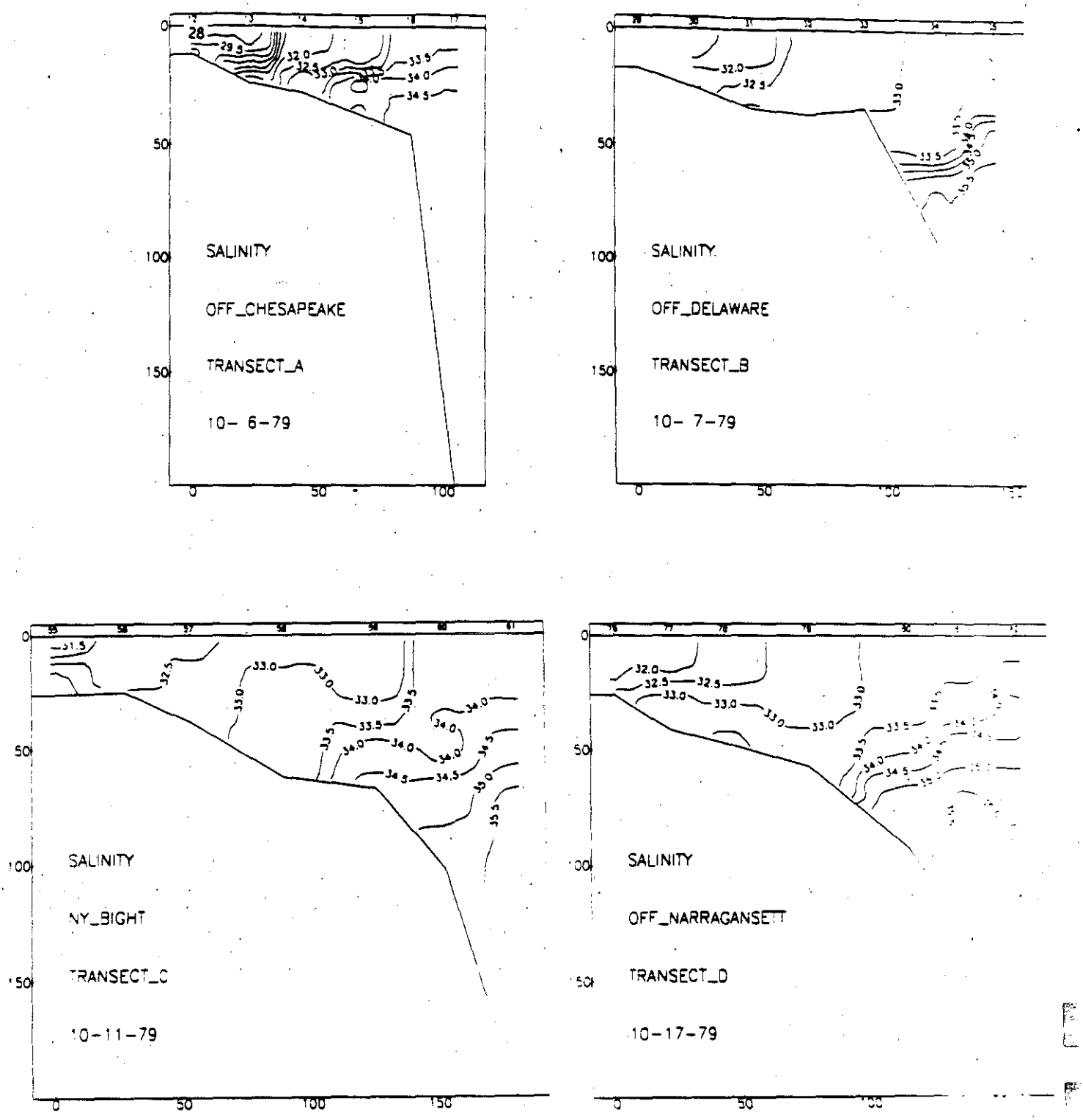
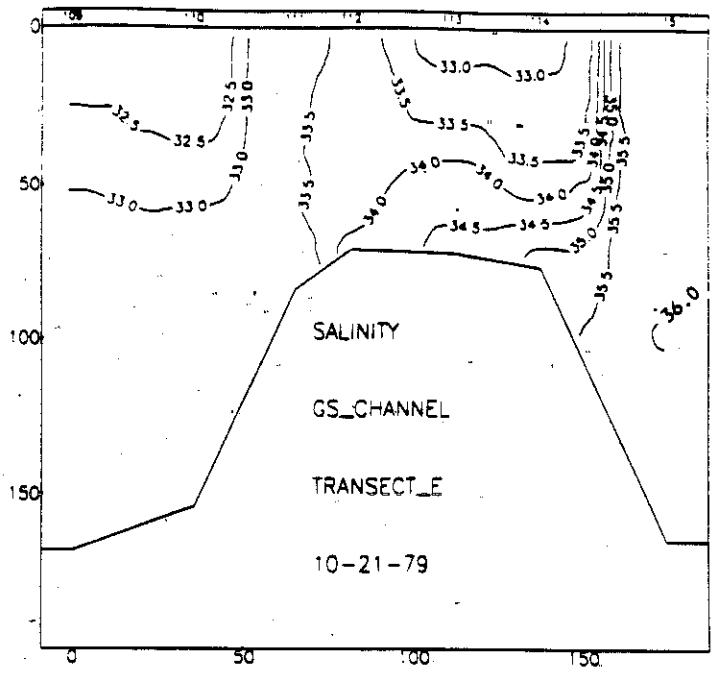
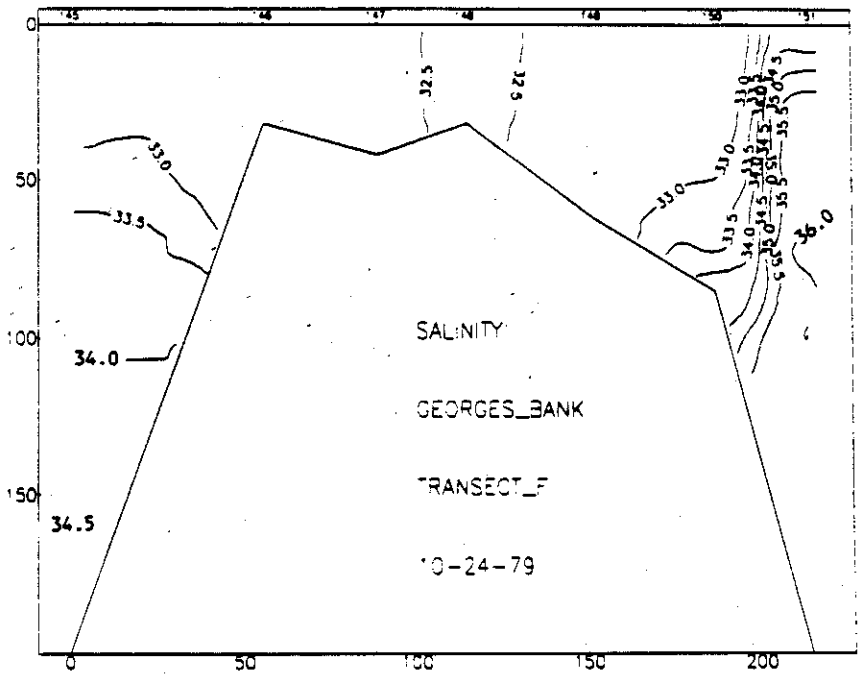


Figure 87. Salinity (PSU) transects: ALB7911.





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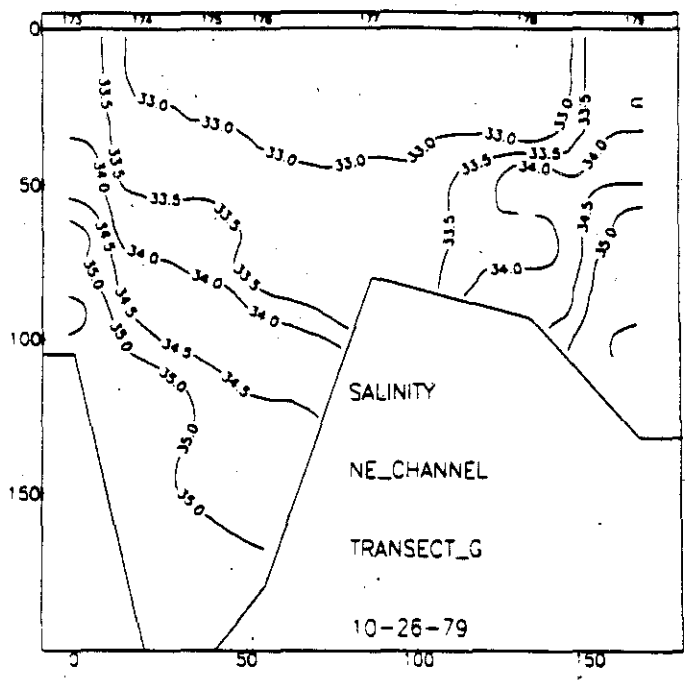

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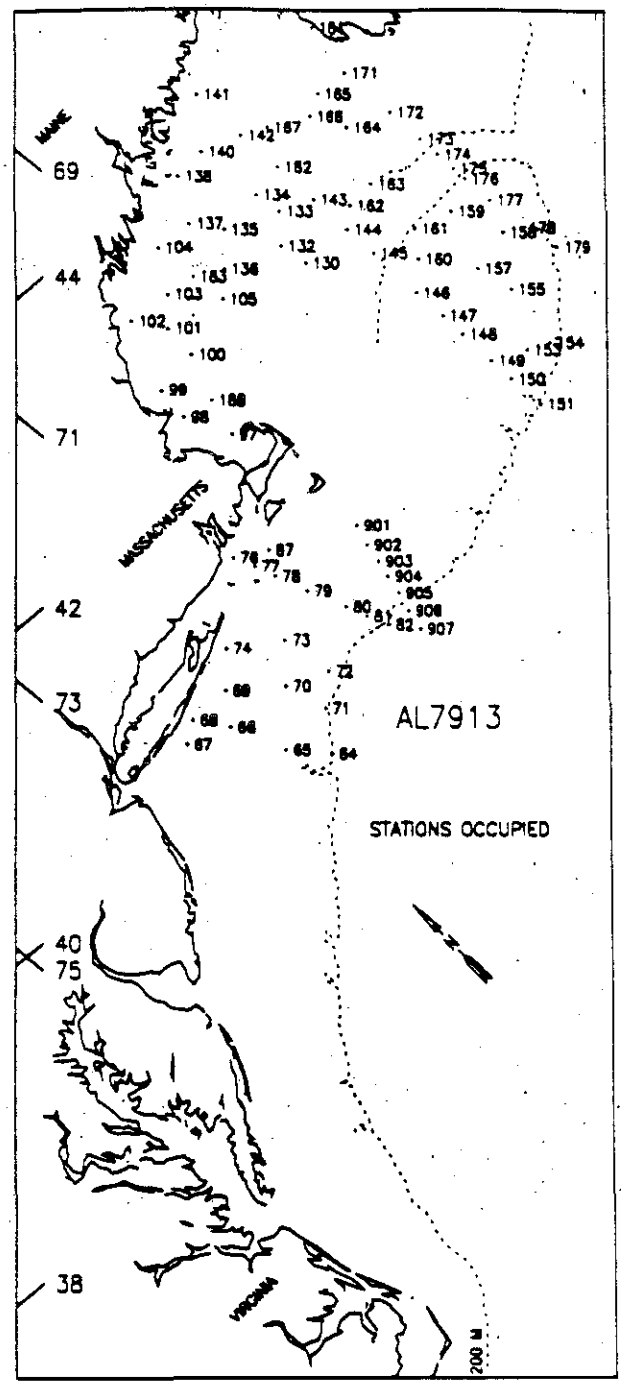


Figure 88. Station positions: ALB7913.

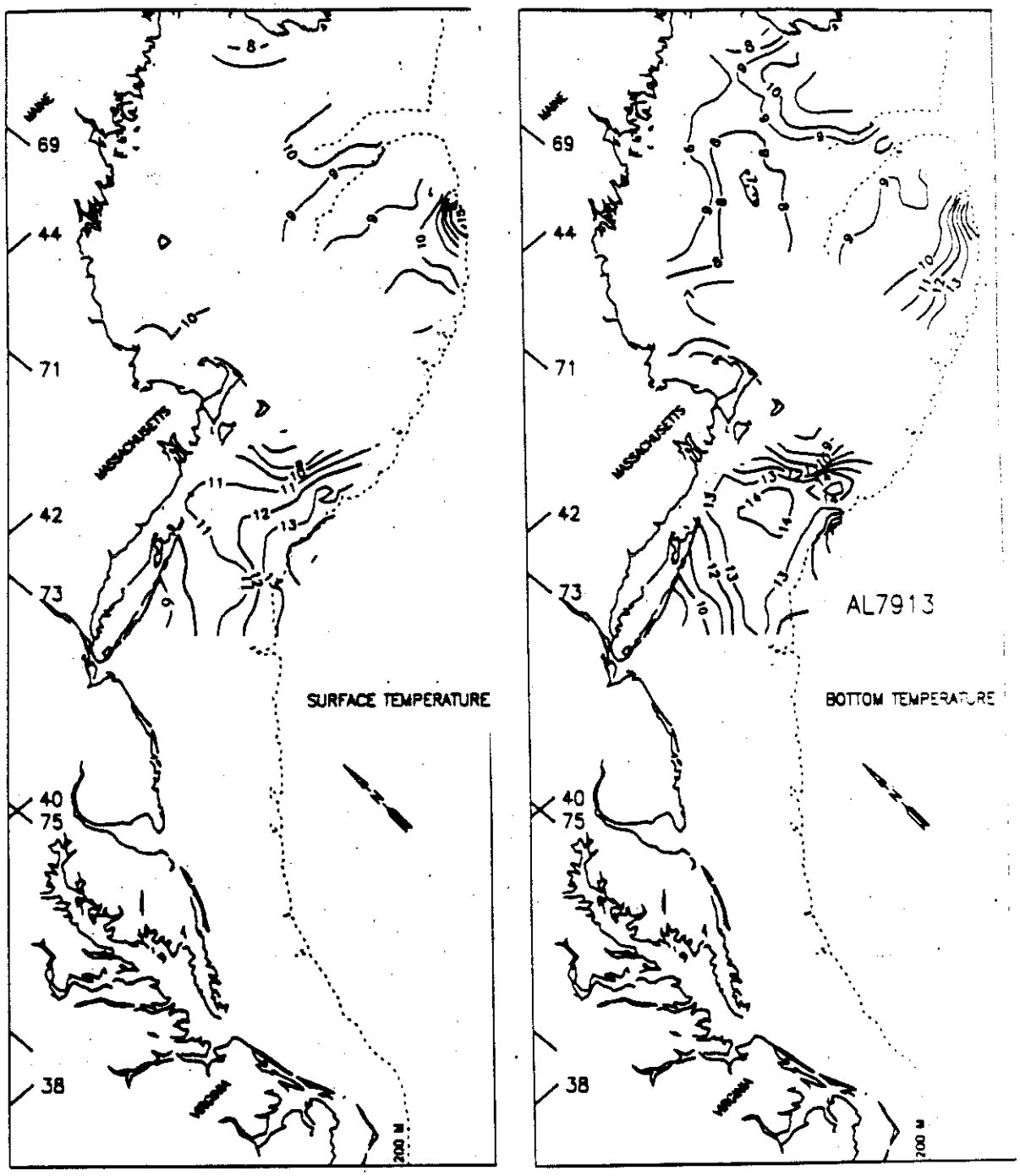


Figure 89. Surface and bottom temperature (°C) distribution: ALB7913.

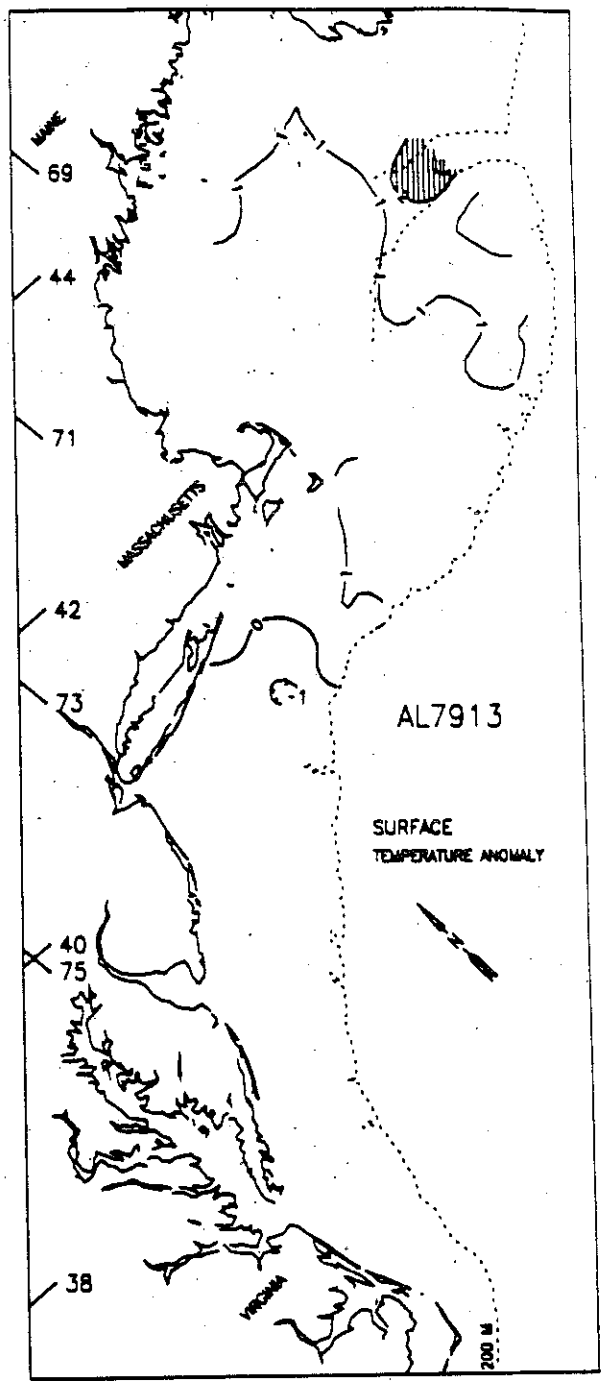


Figure 90. Normalized surface and bottom temperature anomaly: ALB7913. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

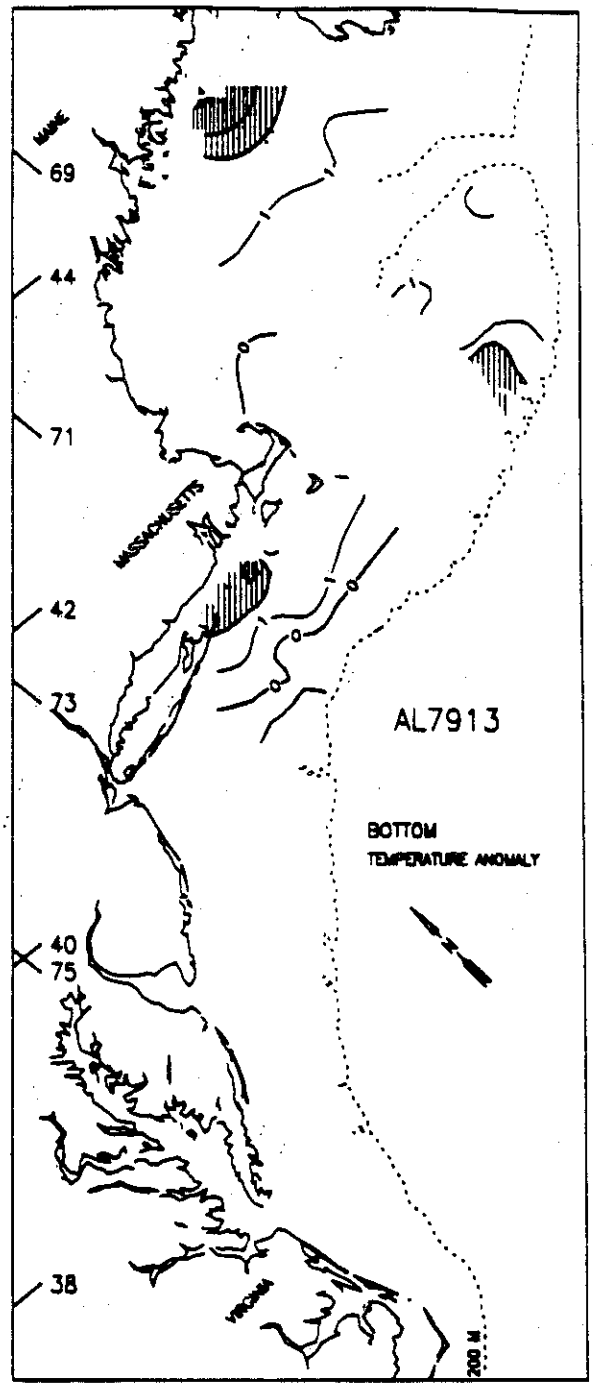


Figure 90. Continued.

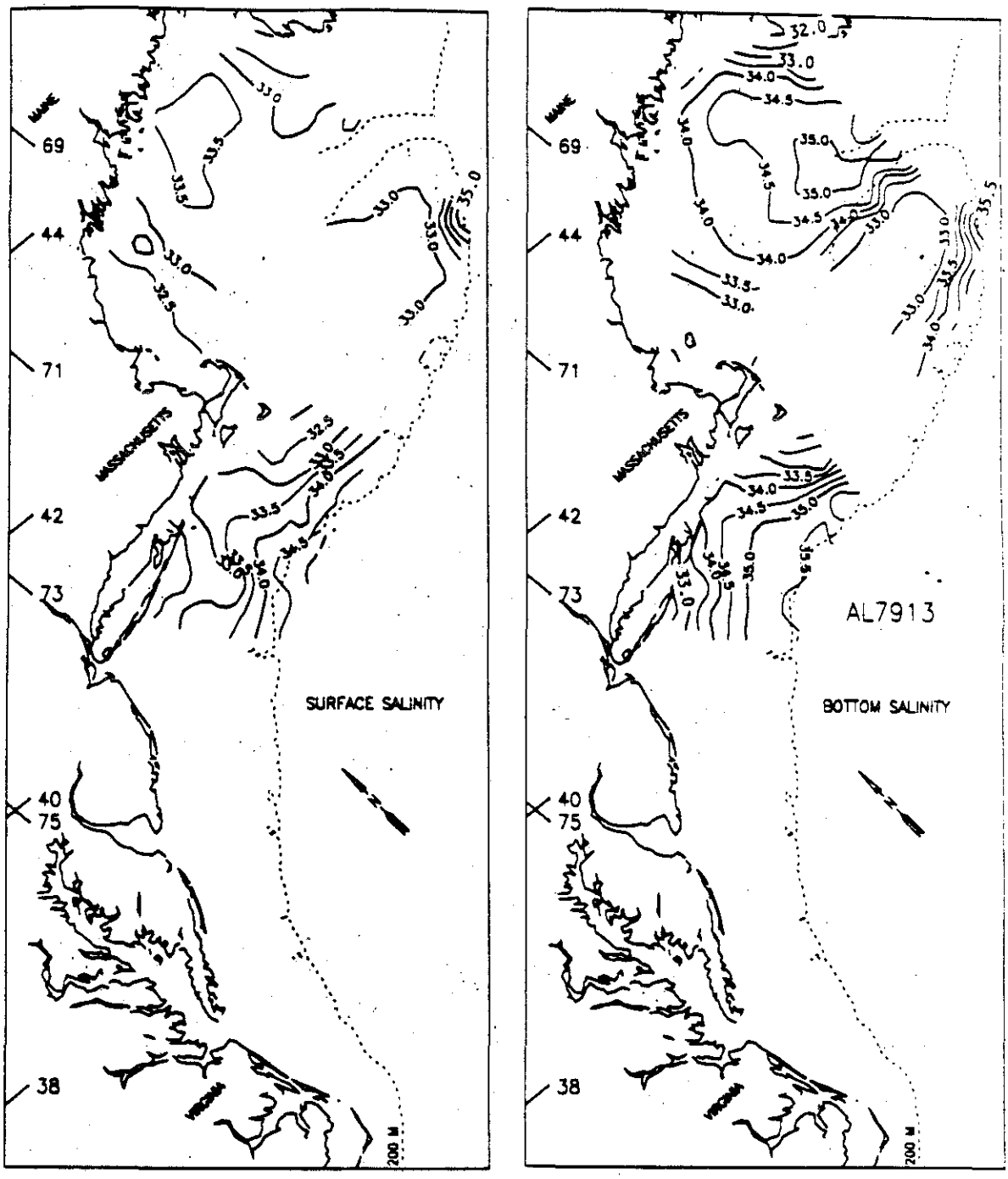


Figure 91. Surface and bottom salinity (PSU) distribution: ALB7913.

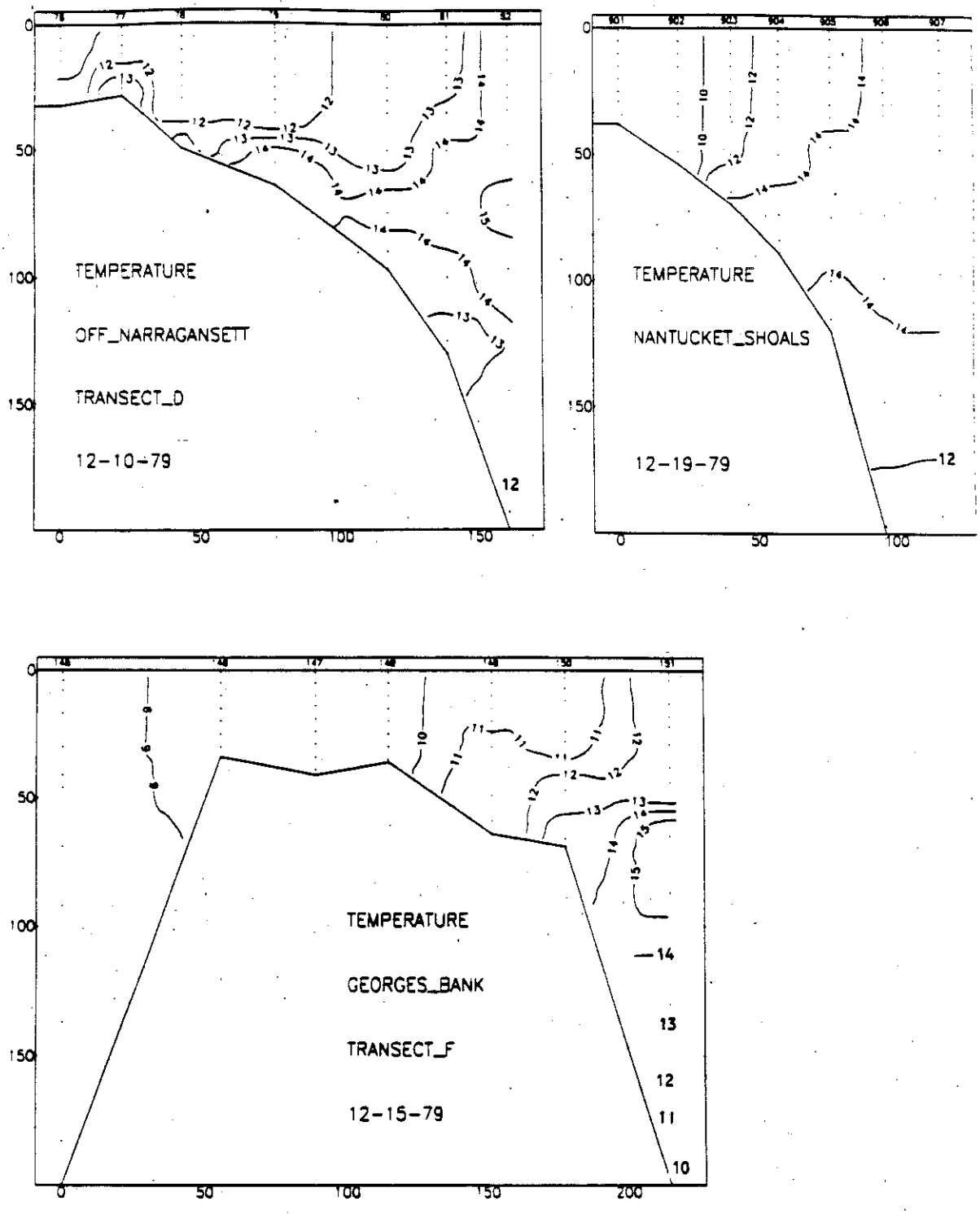


Figure 92. Temperature (°C) transects: ALB7913.

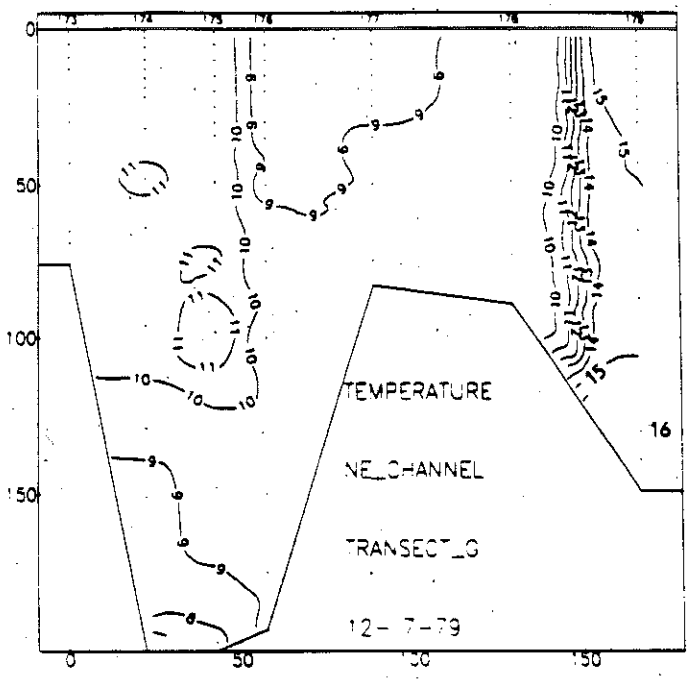


Figure 92. Continued.

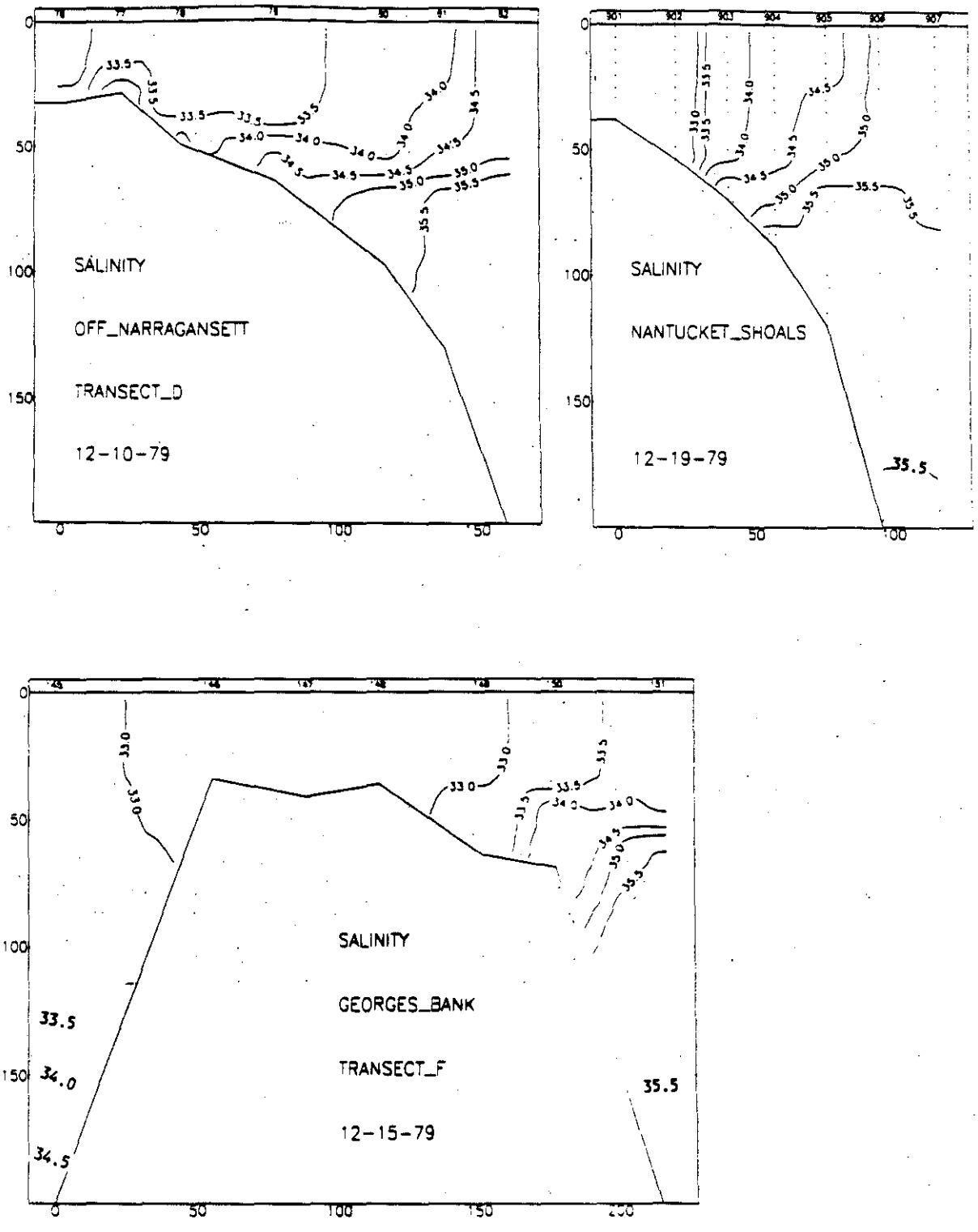


Figure 93. Salinity (PSU) transects: ALB7913.

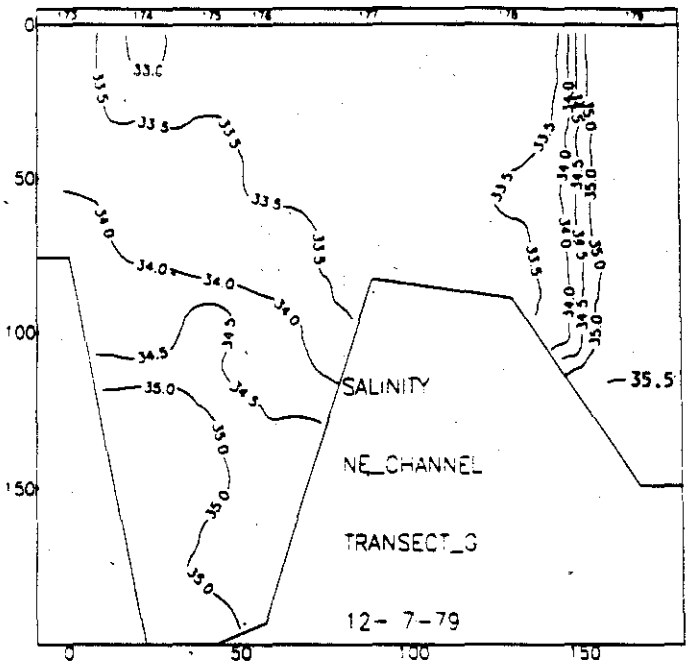


Figure 93. Continued.

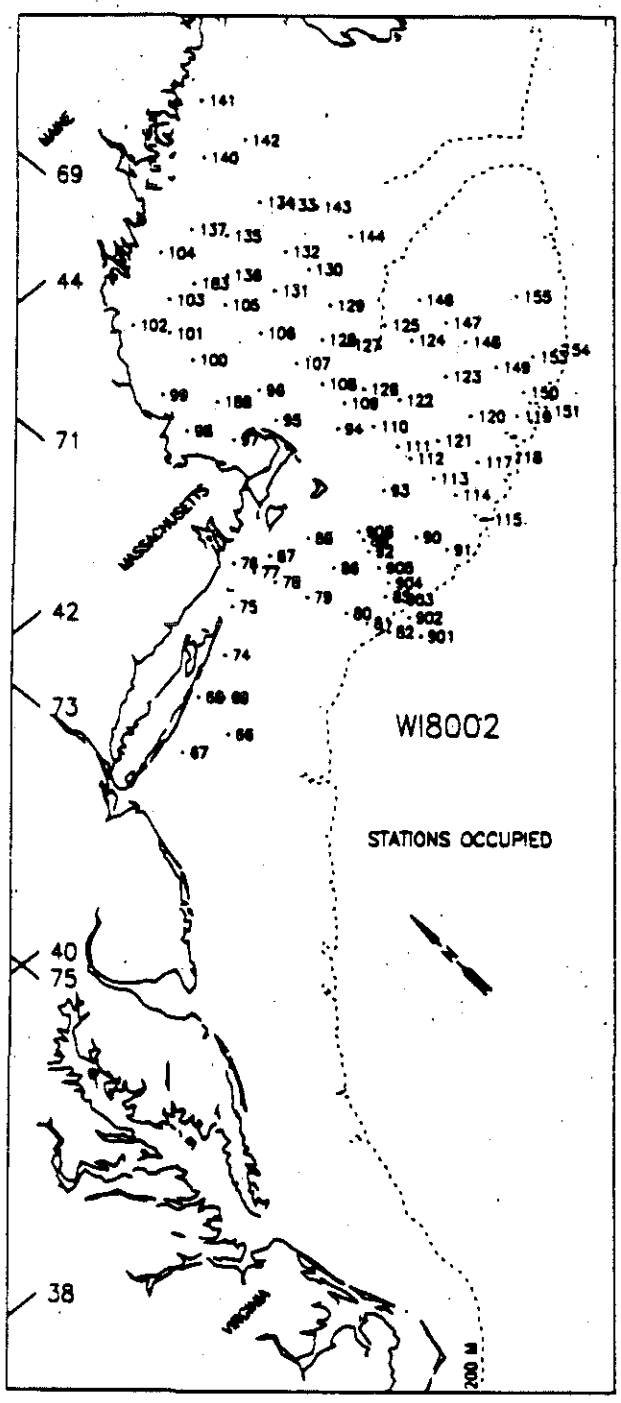


Figure 94. Station positions: WIE8002.

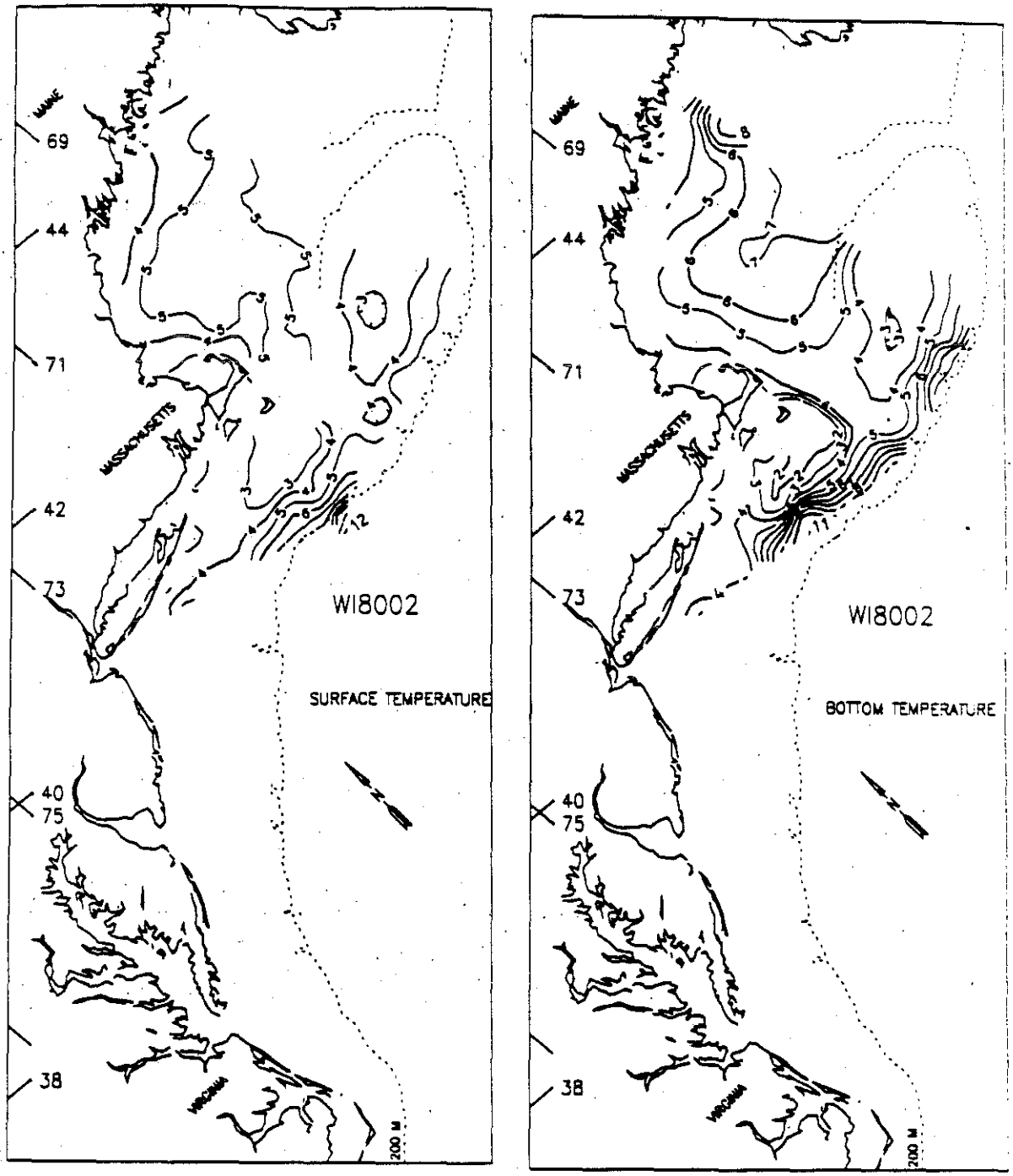


Figure 95. Surface and bottom temperature (°C) distribution: WIE8002.

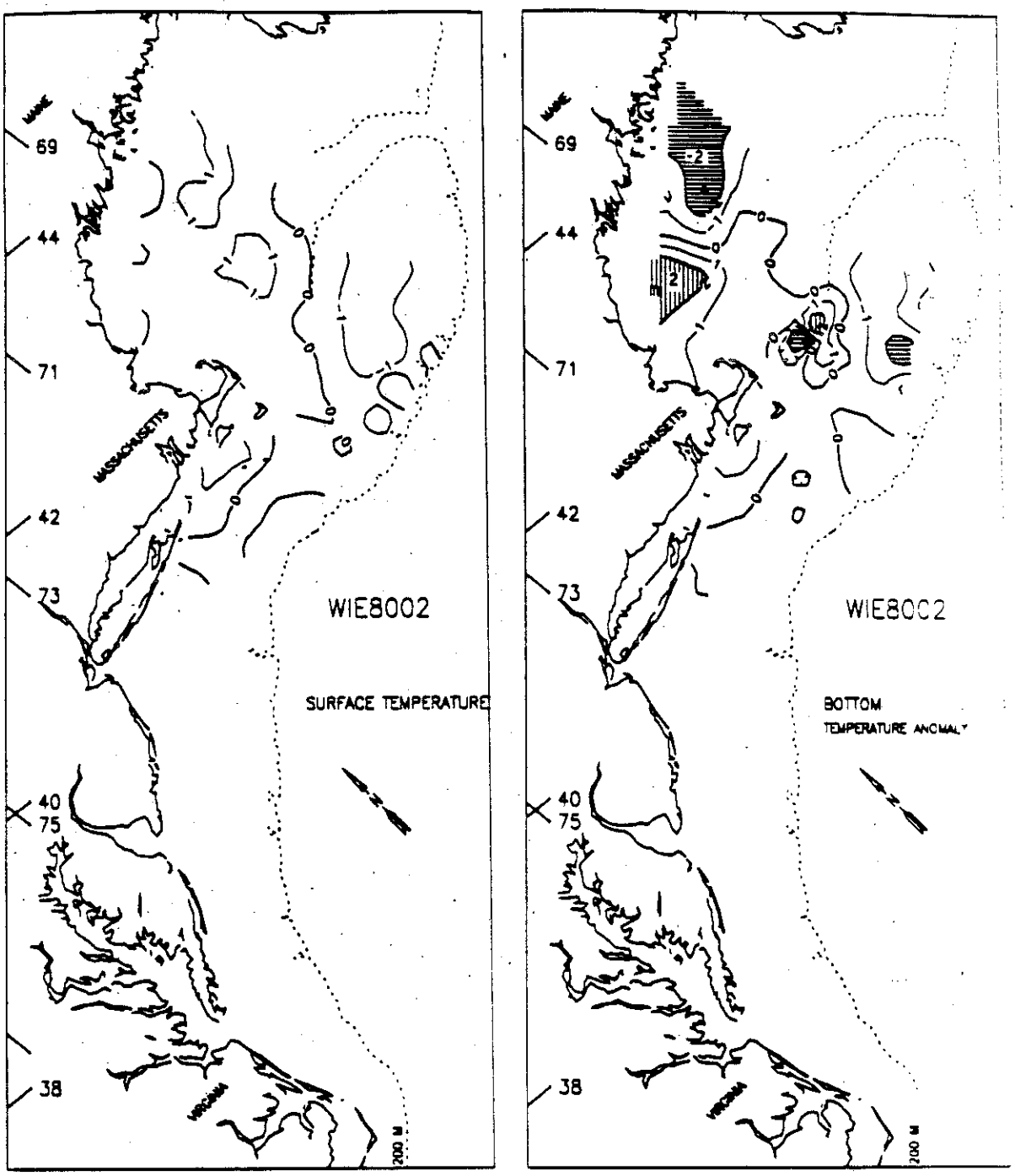


Figure 96. Normalized surface and bottom temperature anomaly: WIE8002. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

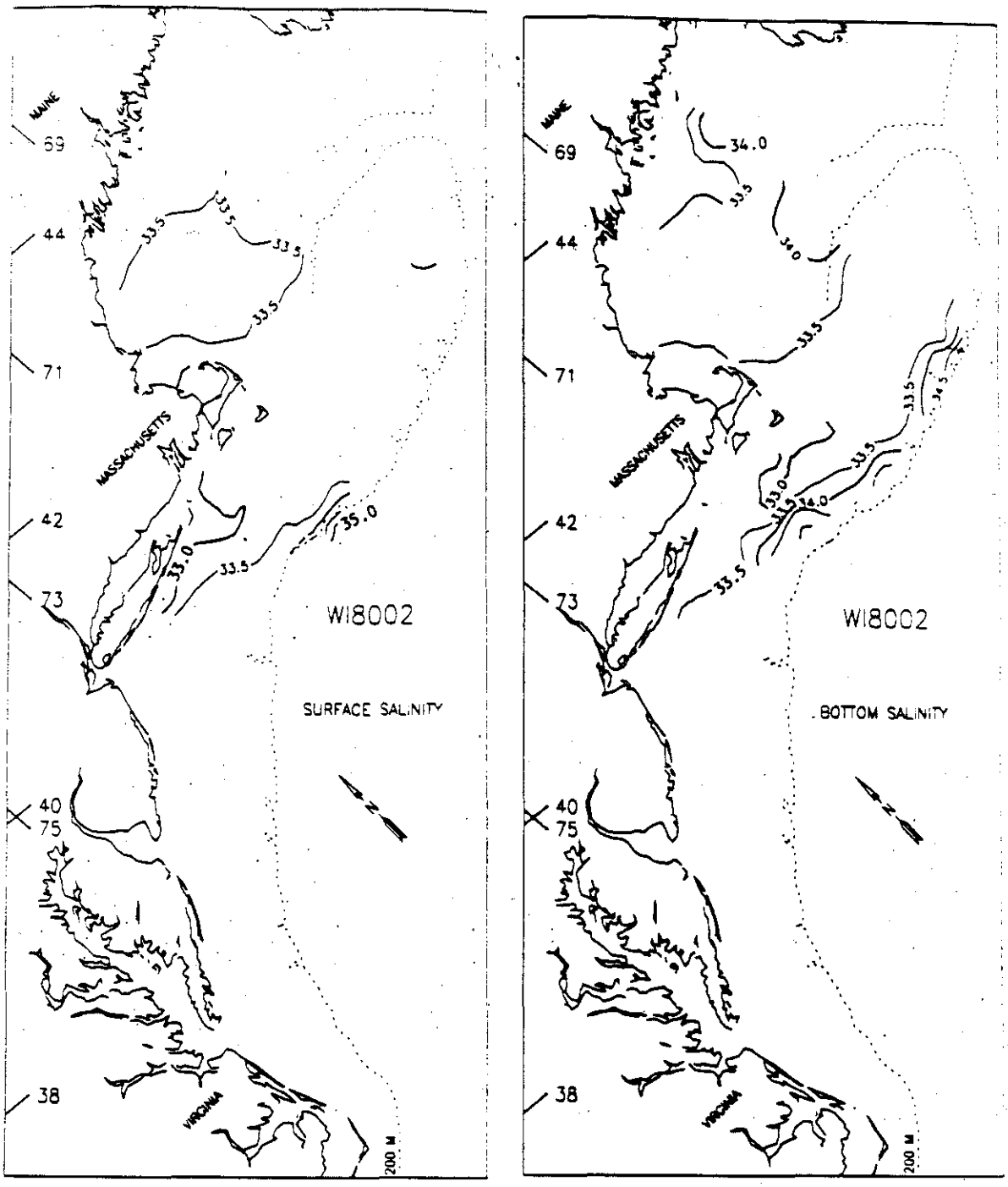


Figure 97. Surface and bottom salinity (PSU) distribution: WIE8002.

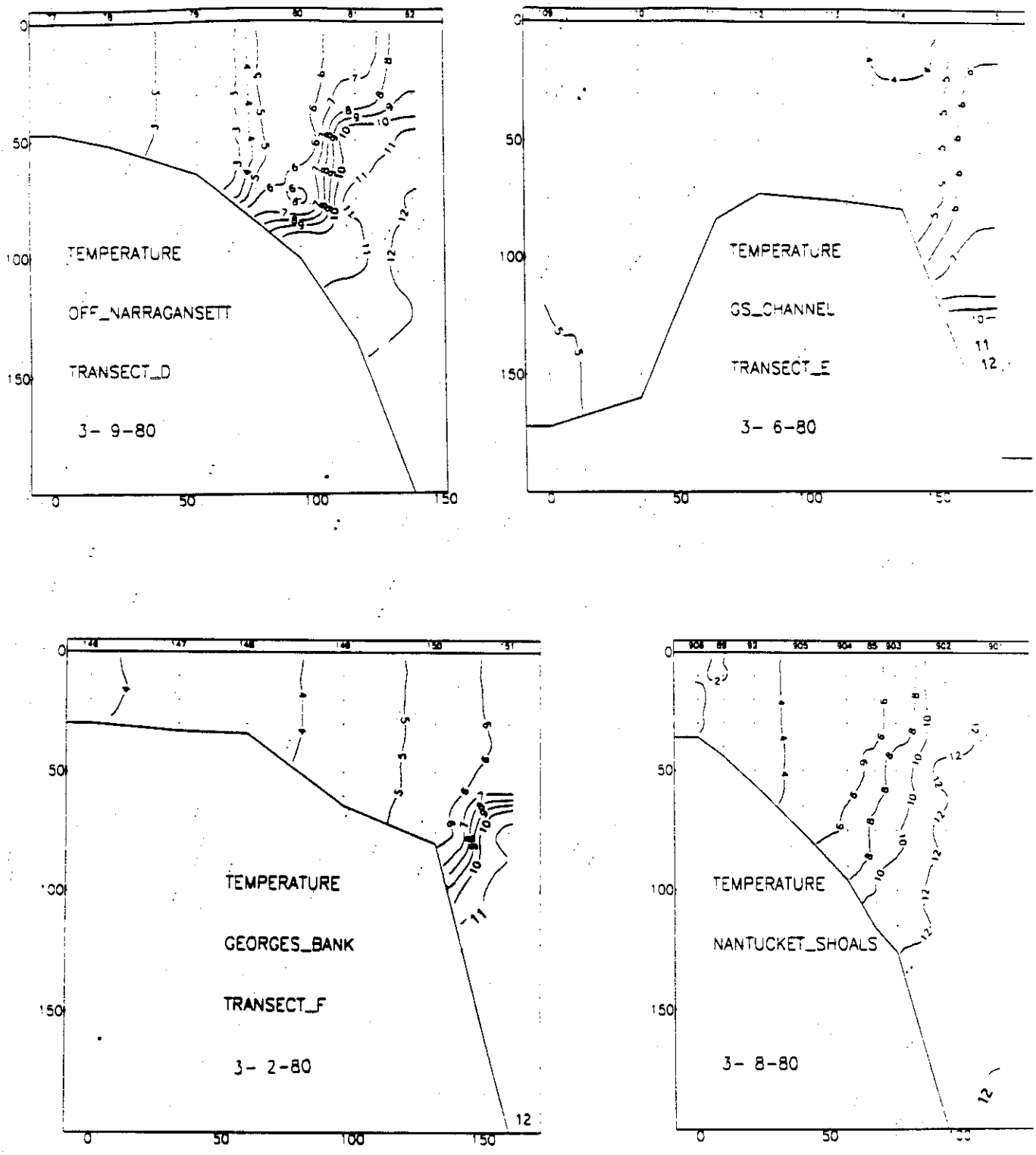


Figure 98. Temperature (°C) transects: WIE8002.

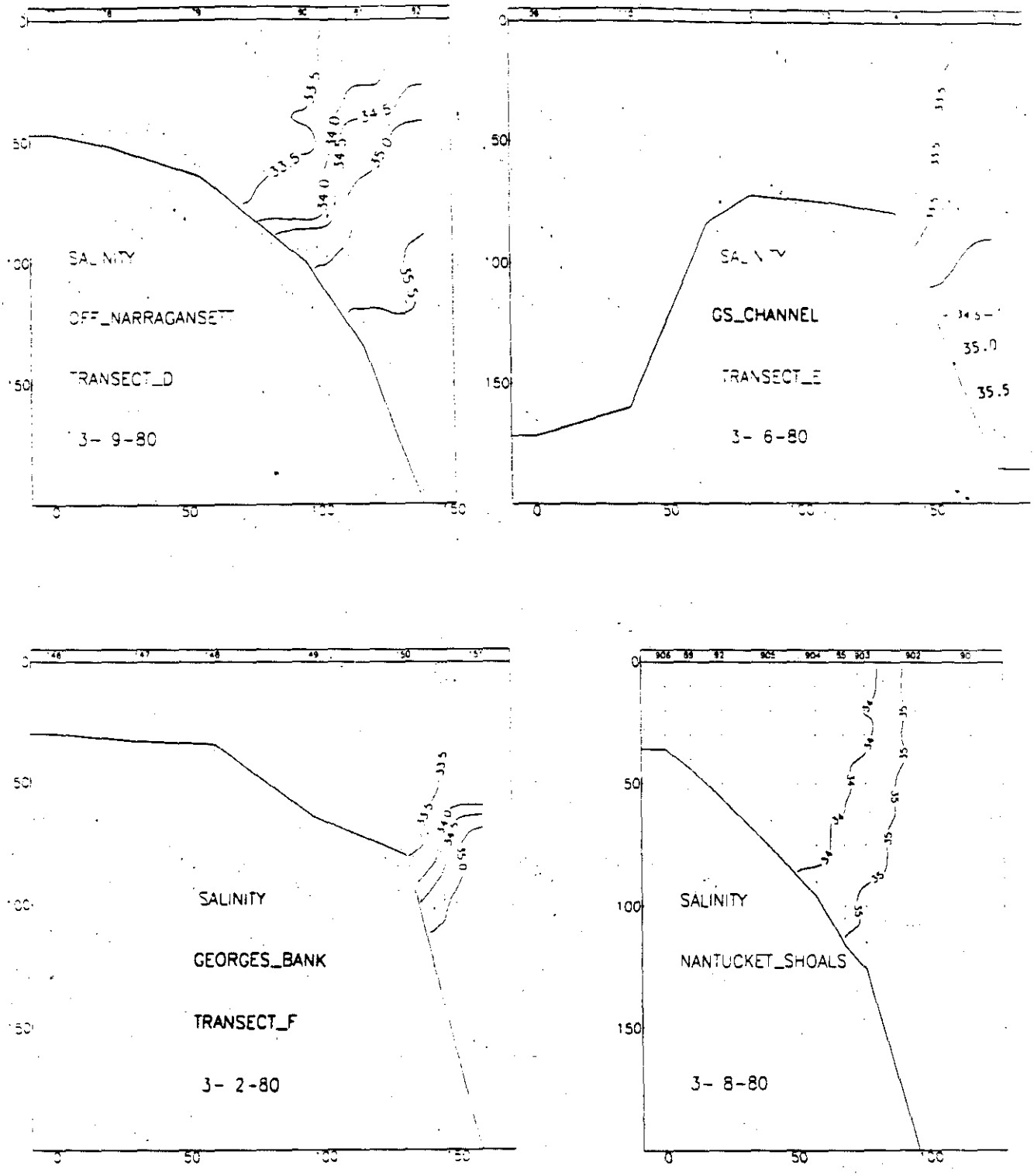


Figure 99. Salinity (PSU) transects: WIE8002.

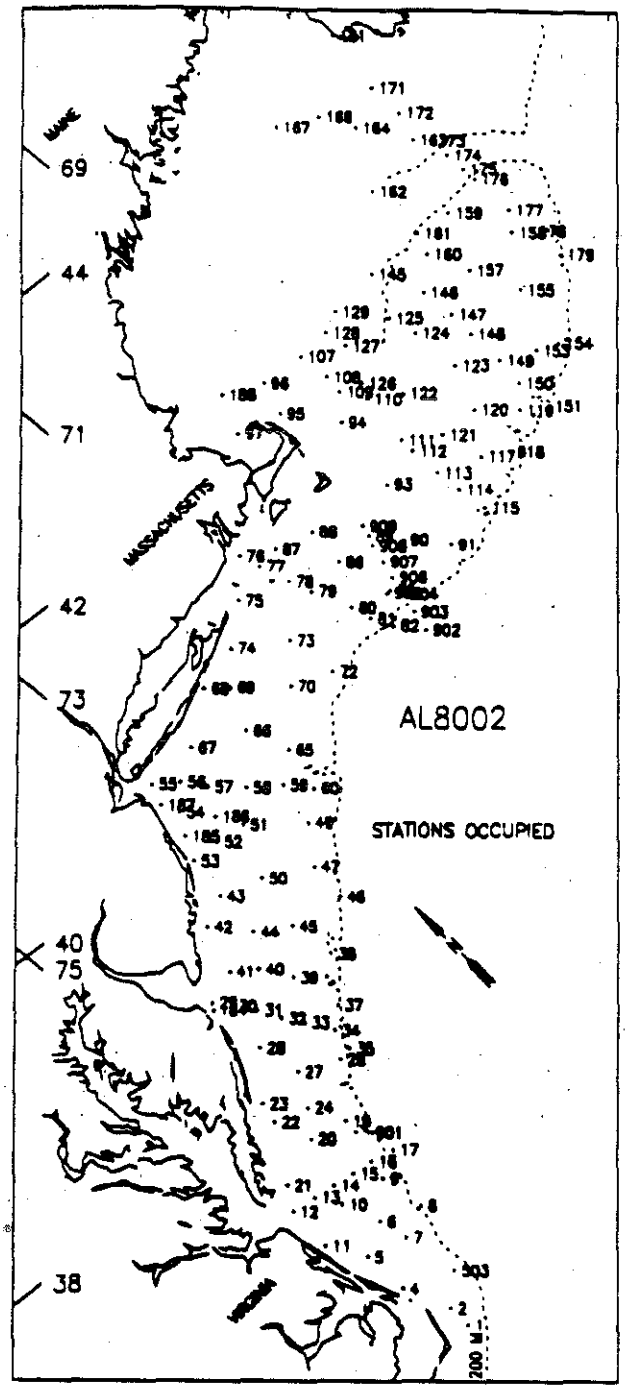


Figure 100. Station positions: ALB8002.

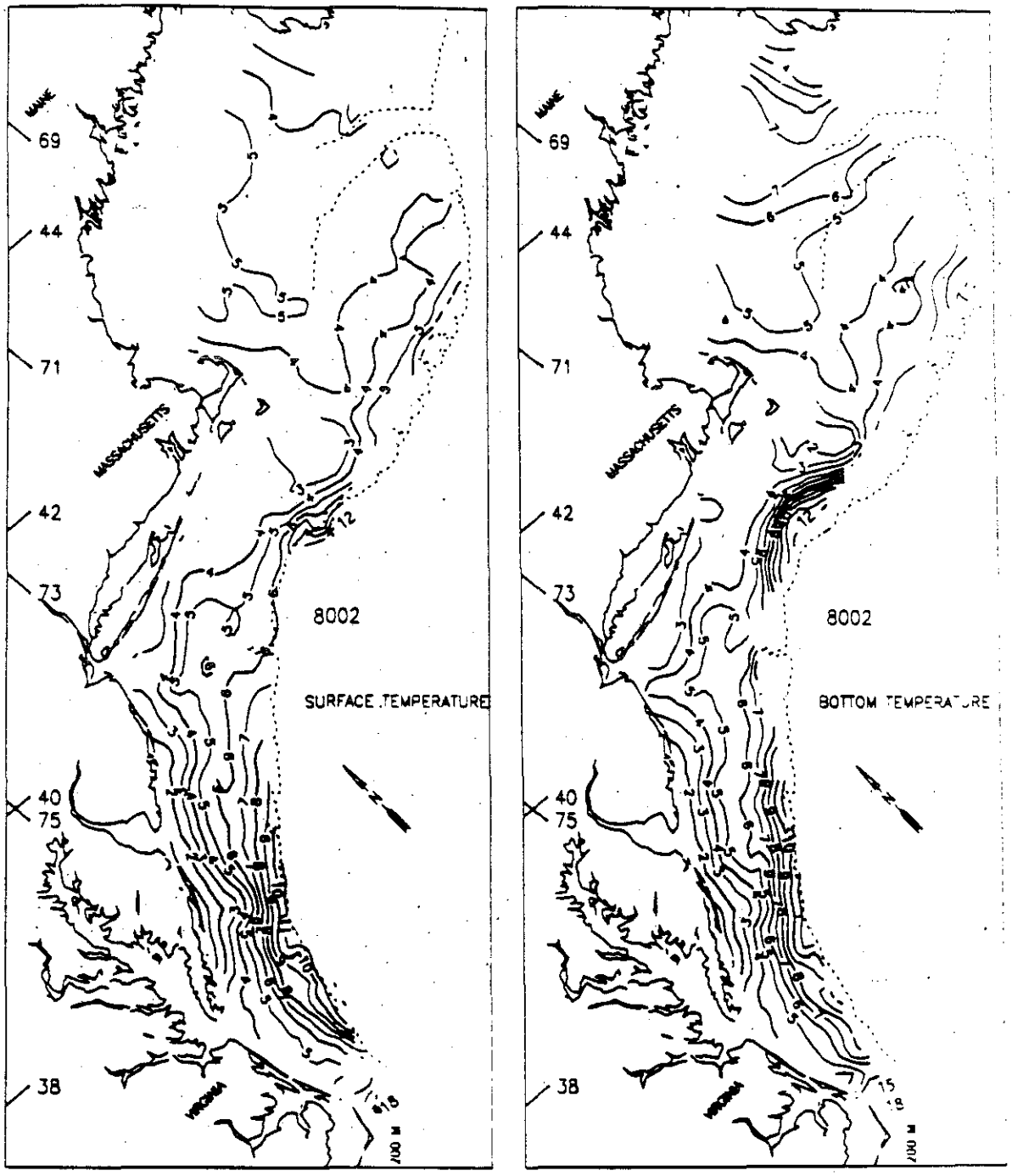


Figure 101. Surface and bottom temperature (°C) distribution: ALB8002.

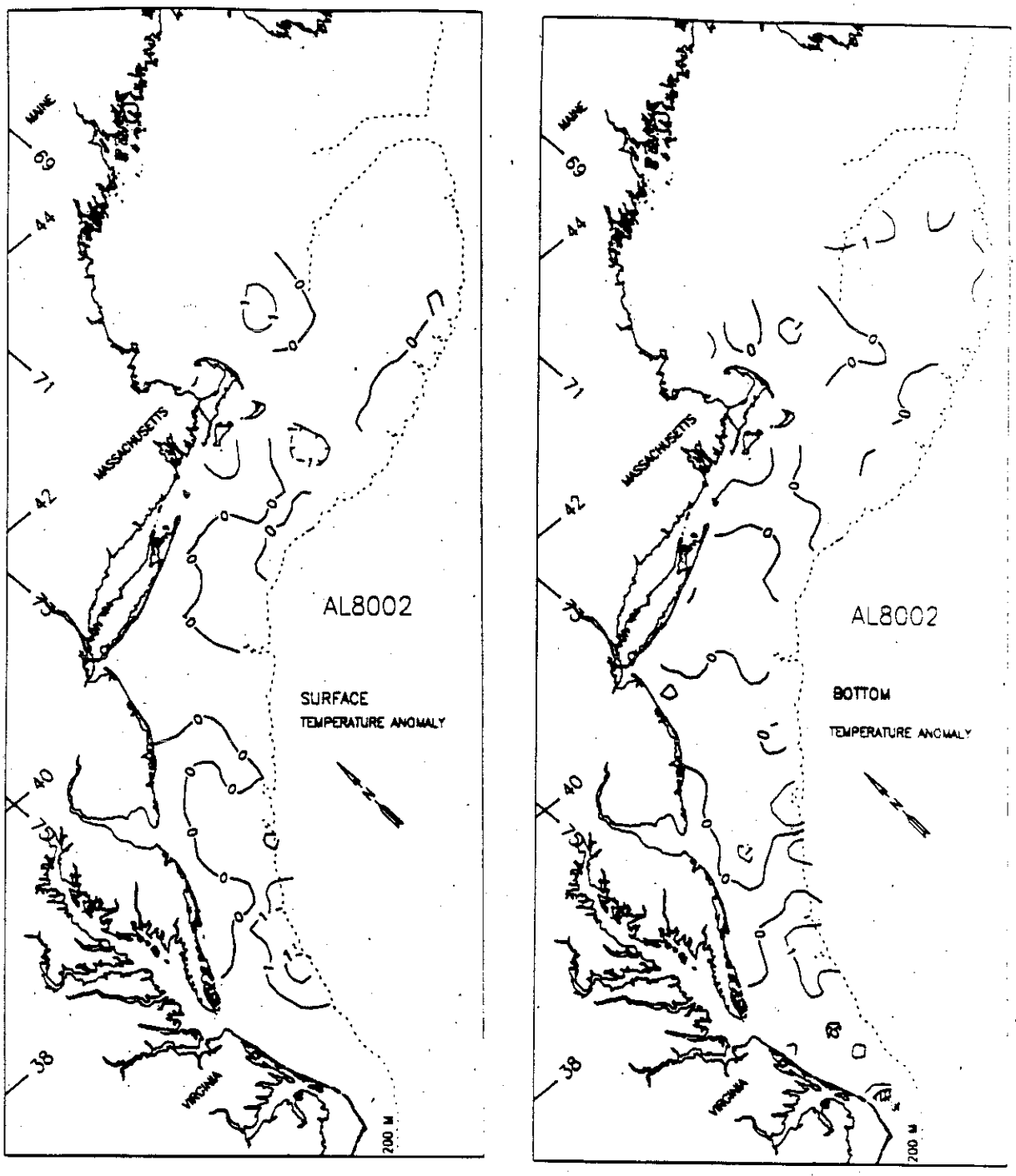


Figure 102. Normalized surface and bottom temperature anomaly: ALB8002. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

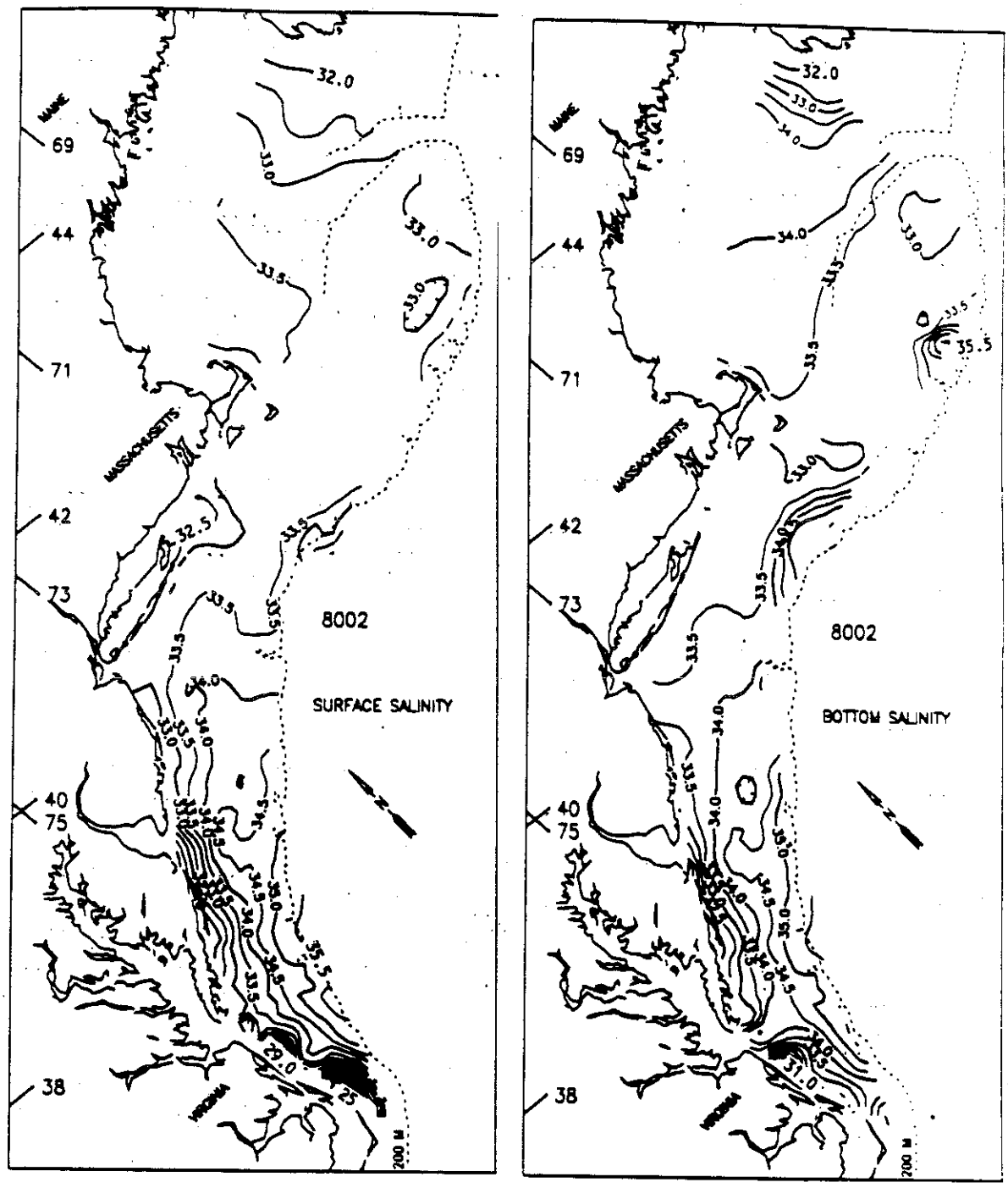
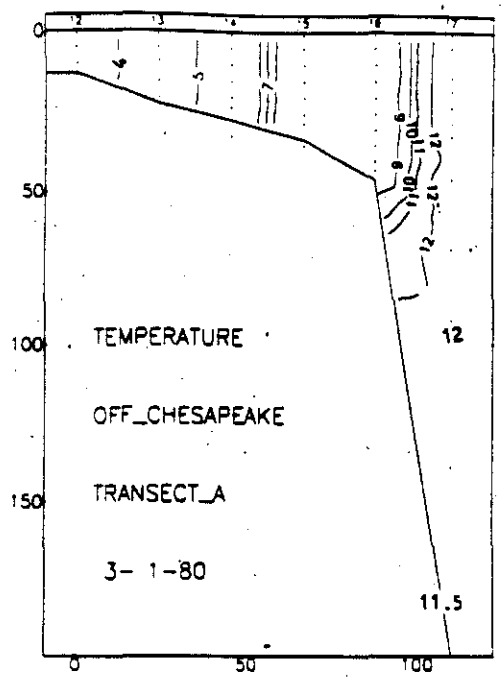
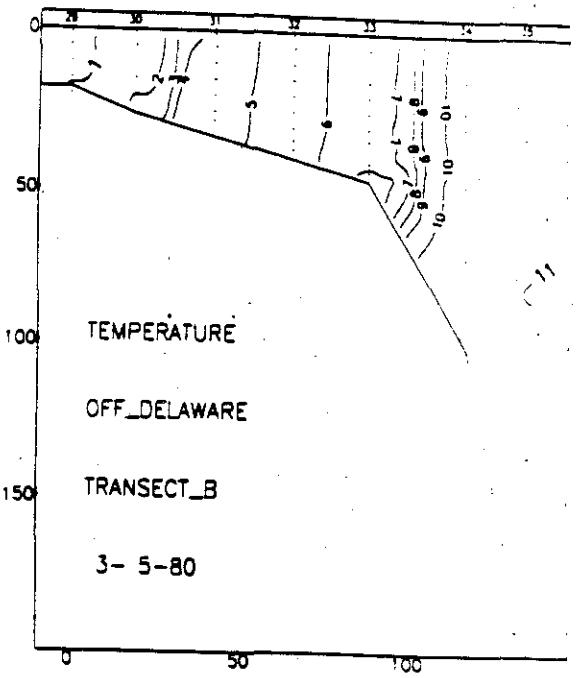
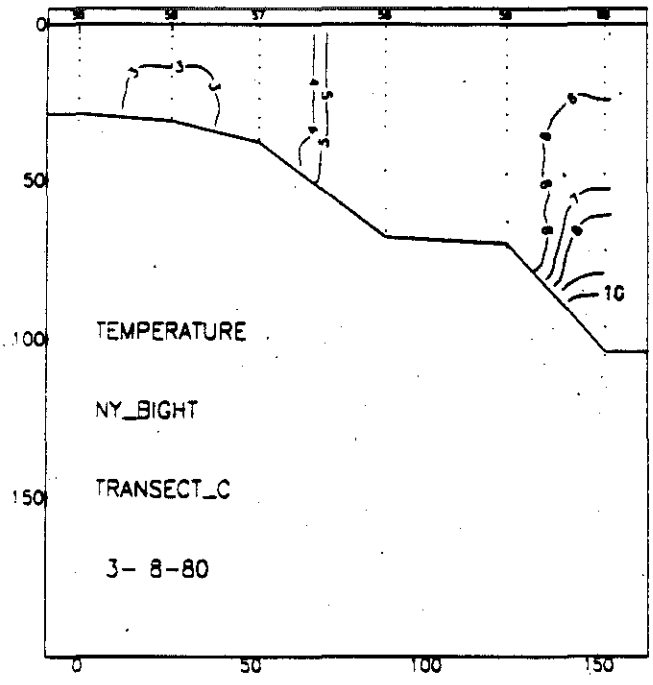


Figure 103. Surface and bottom salinity (PSU) distribution: ALB8002.







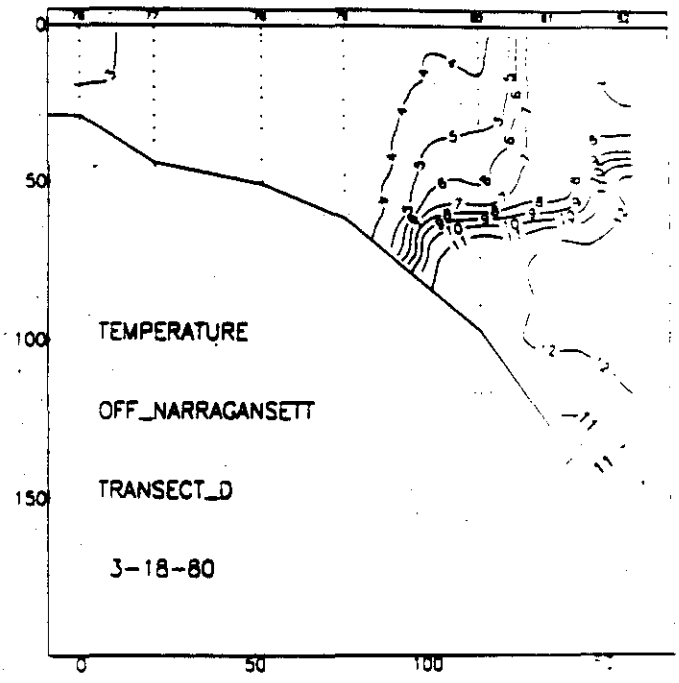
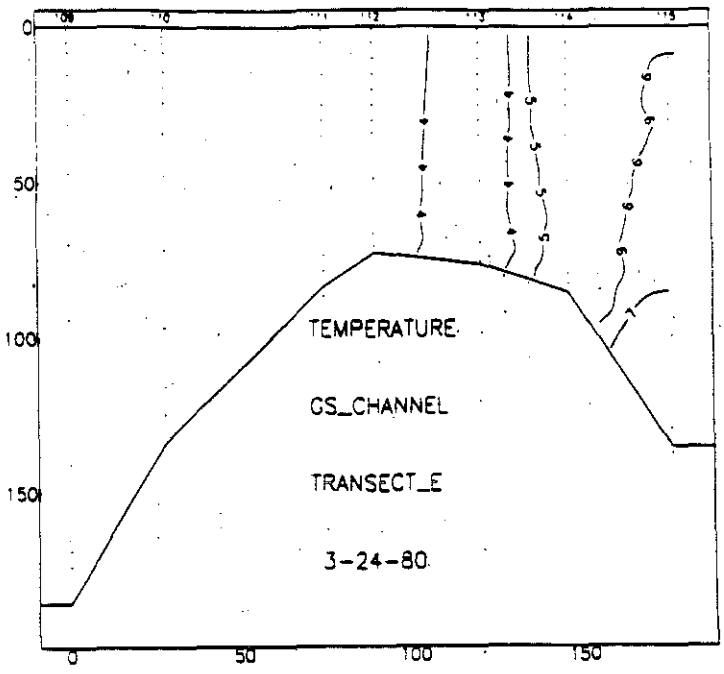


Figure 104. Temperature (°C) transects: ALB8002.



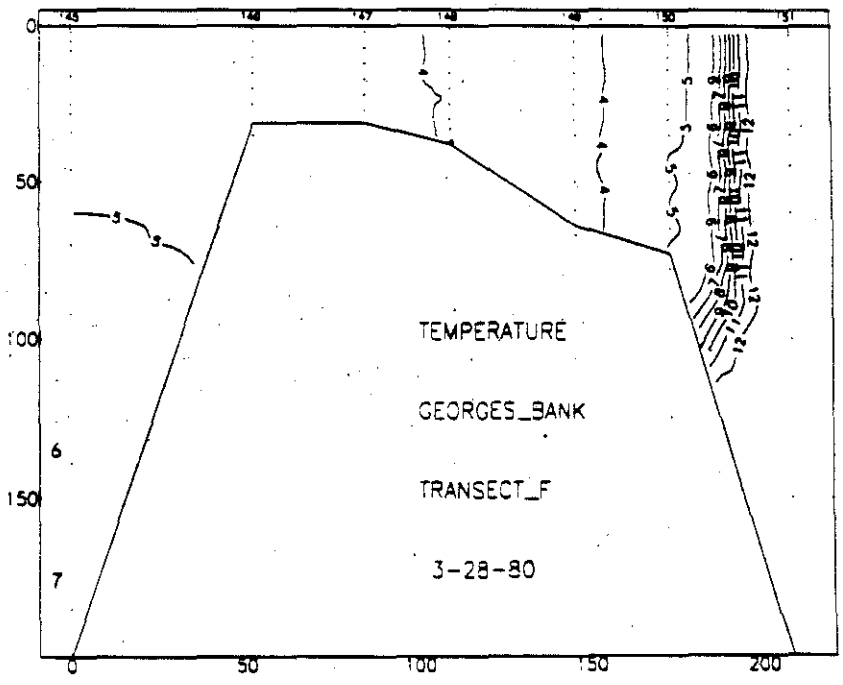


Figure 104. Continued.

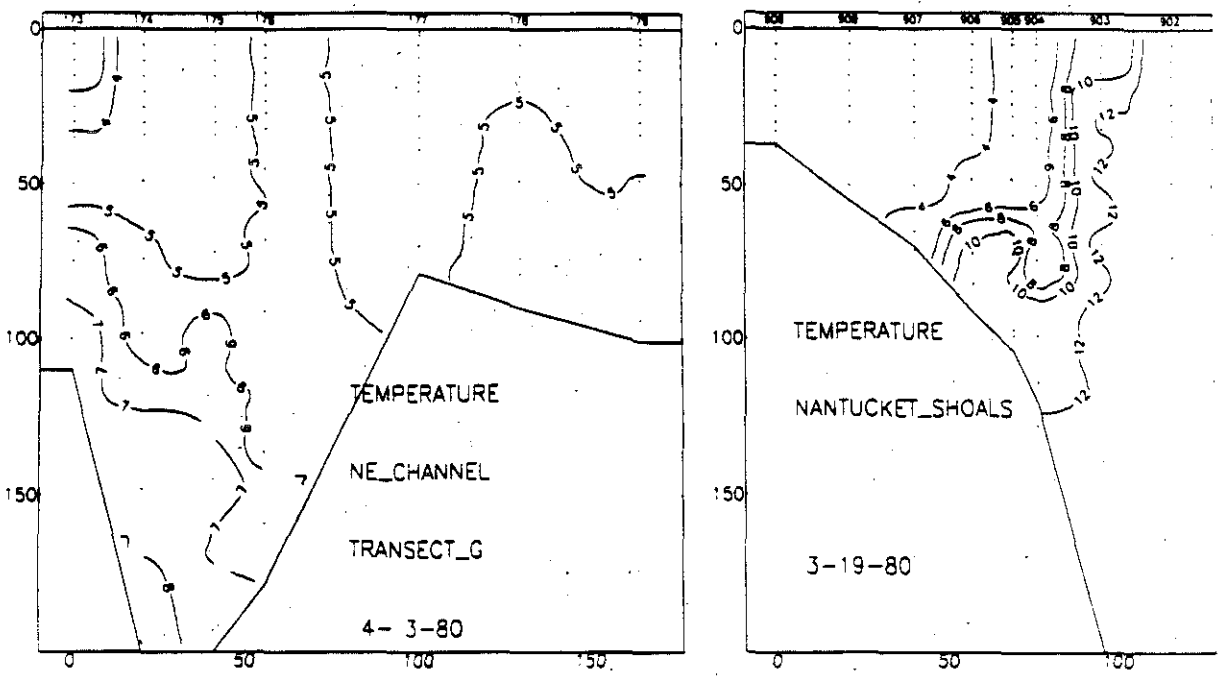
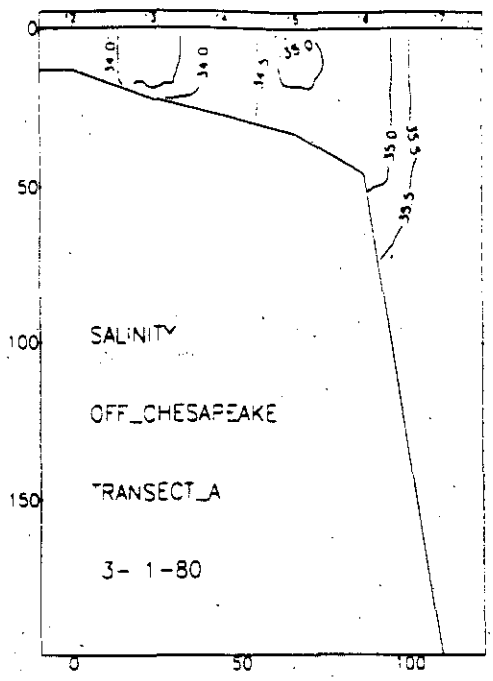
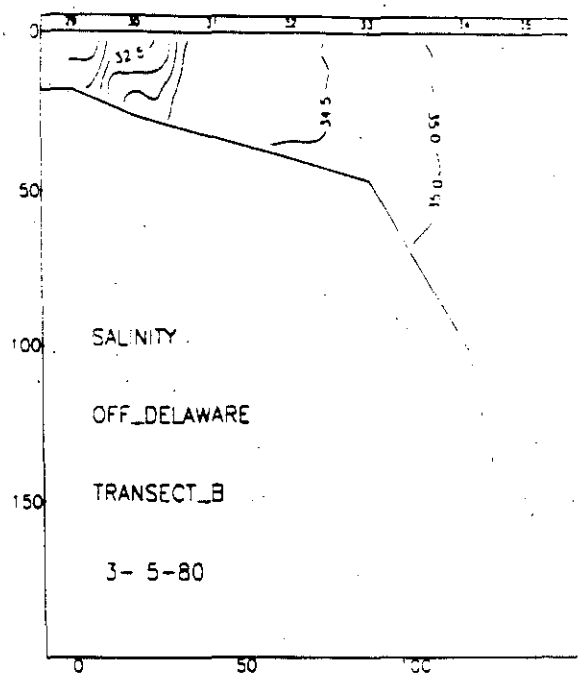
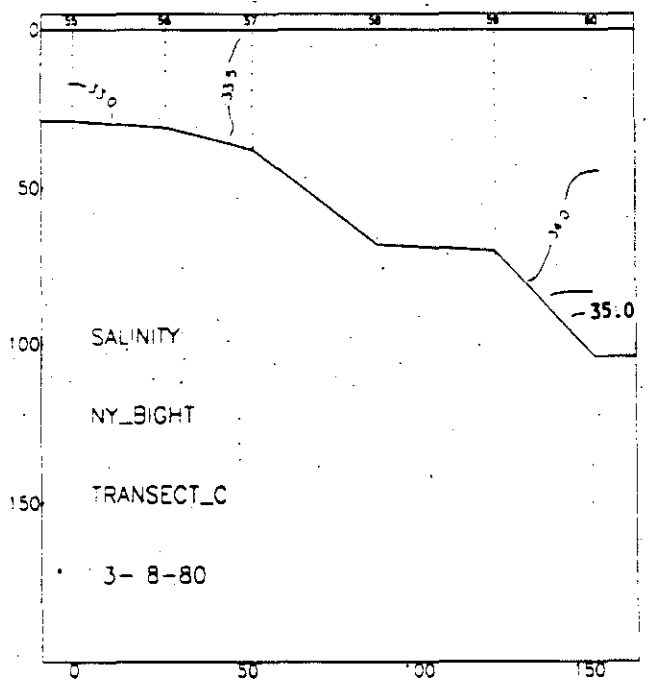


Figure 104. Continued.







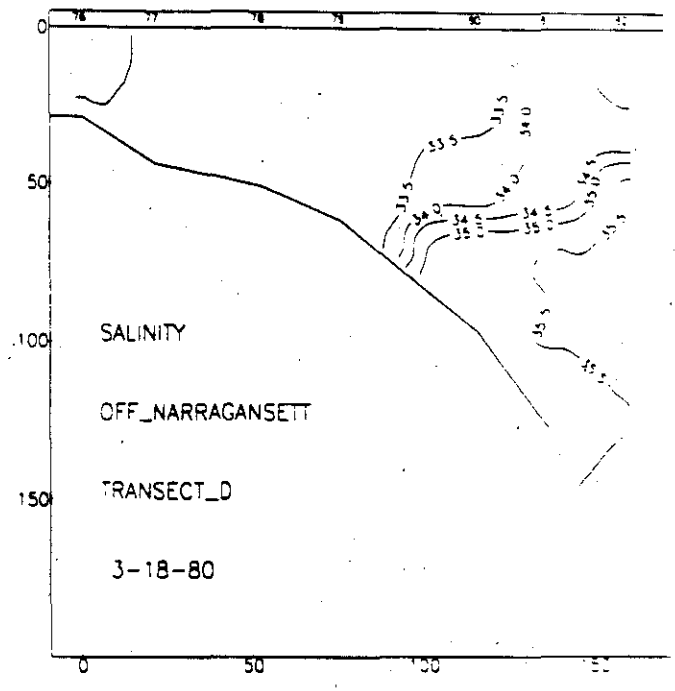
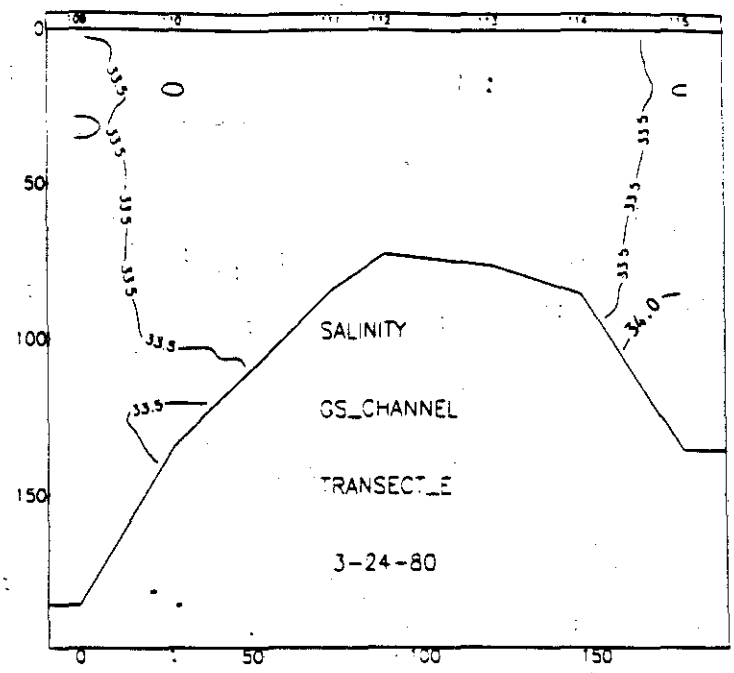


Figure 105. Salinity (PSU) transects: ALB8002.



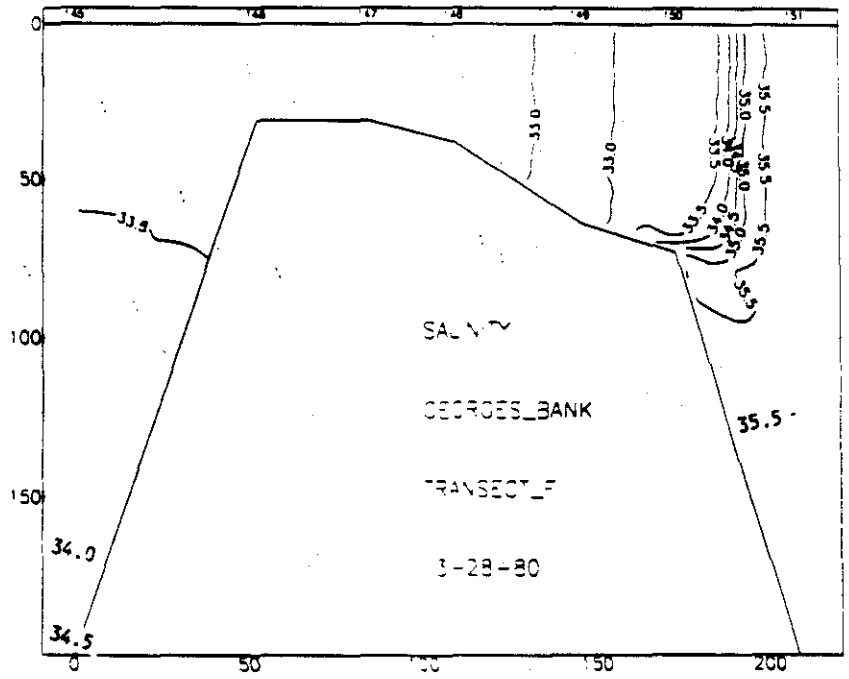


Figure 105. Continued.

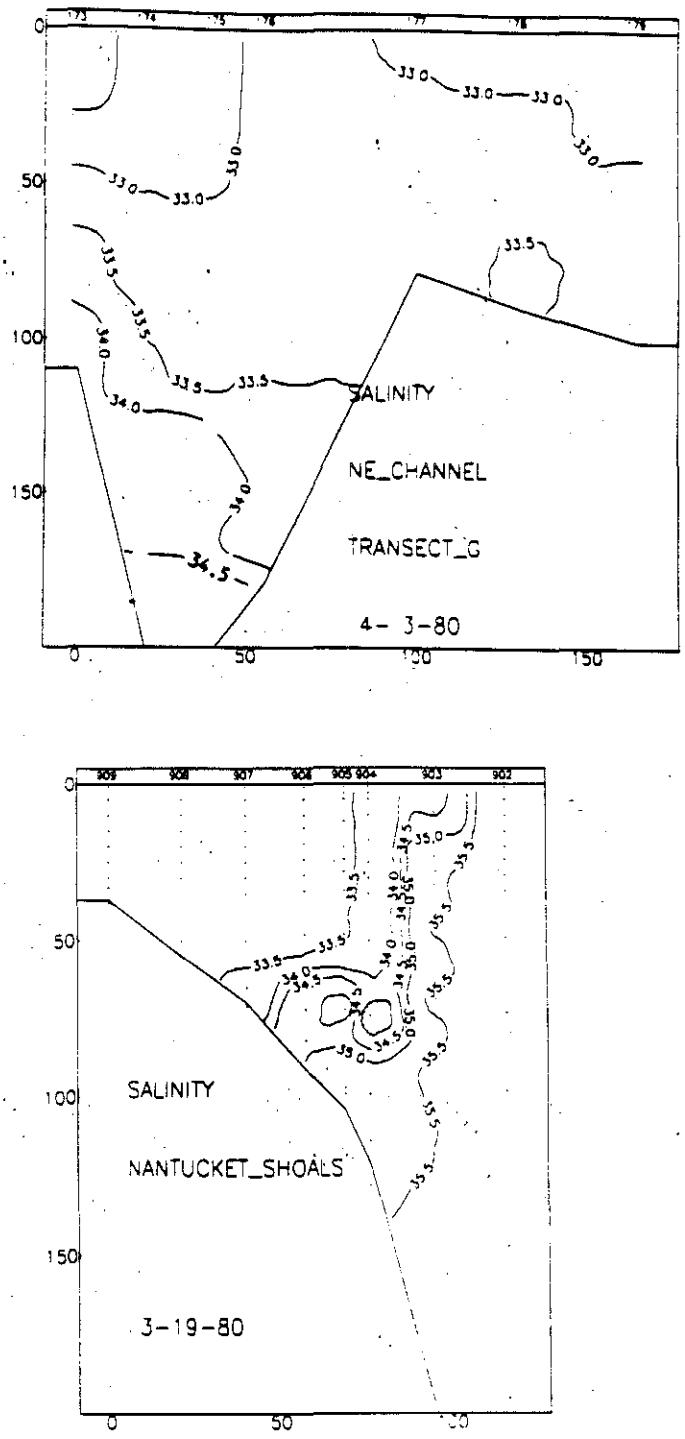


Figure 105. Continued.

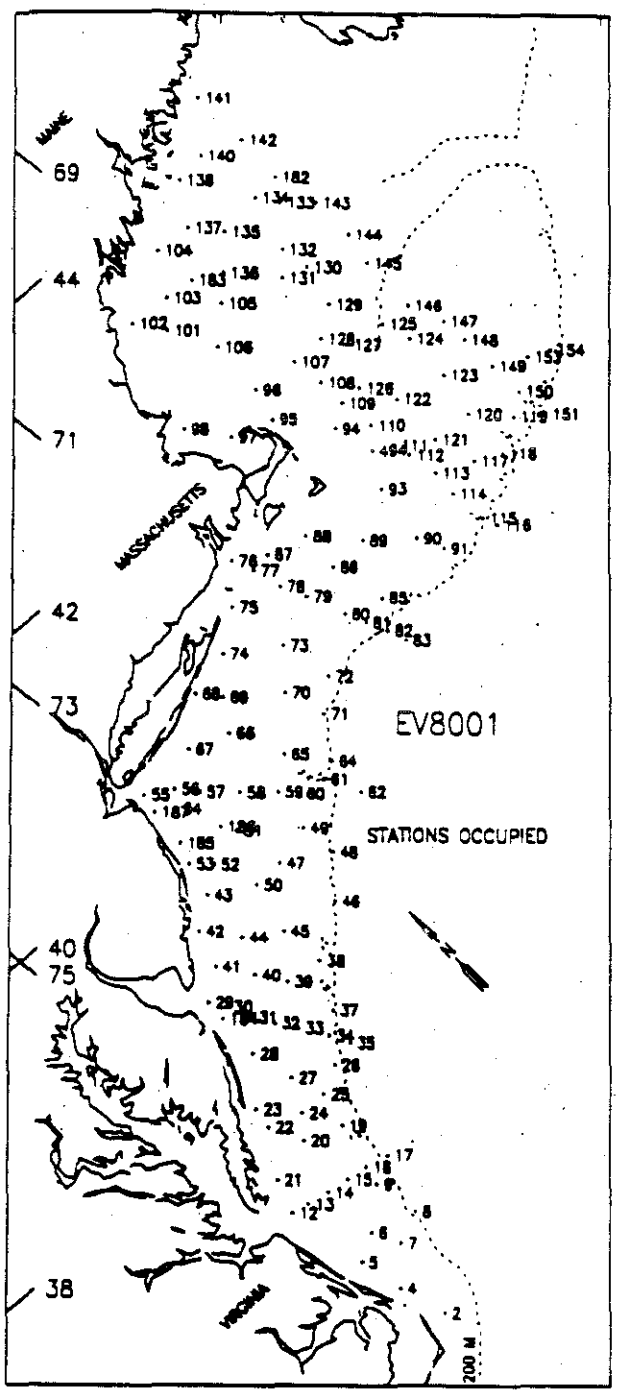


Figure 106. Station positions: EVR8001.

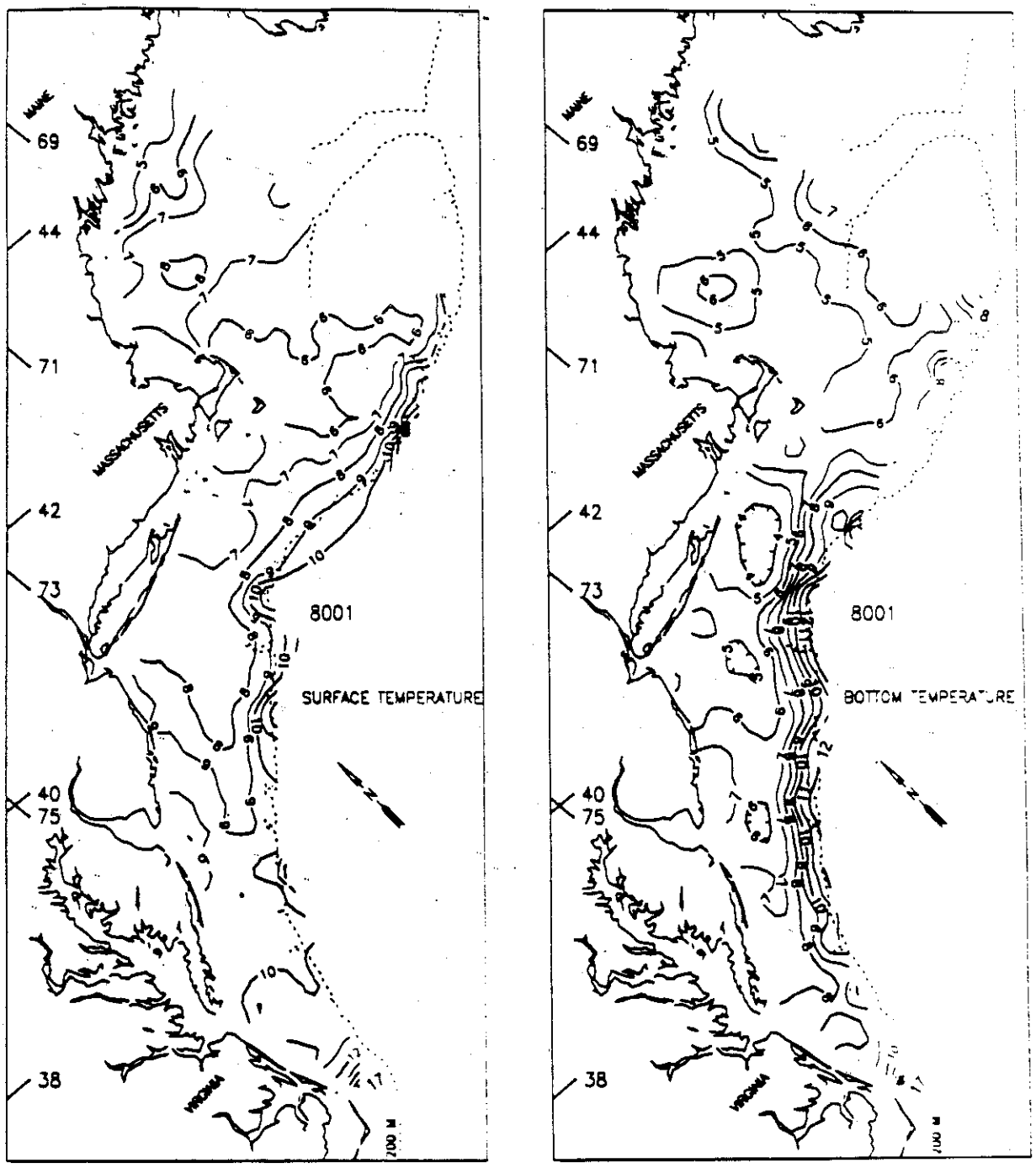


Figure 107. Surface and bottom temperature (°C) distribution: EVR8001.

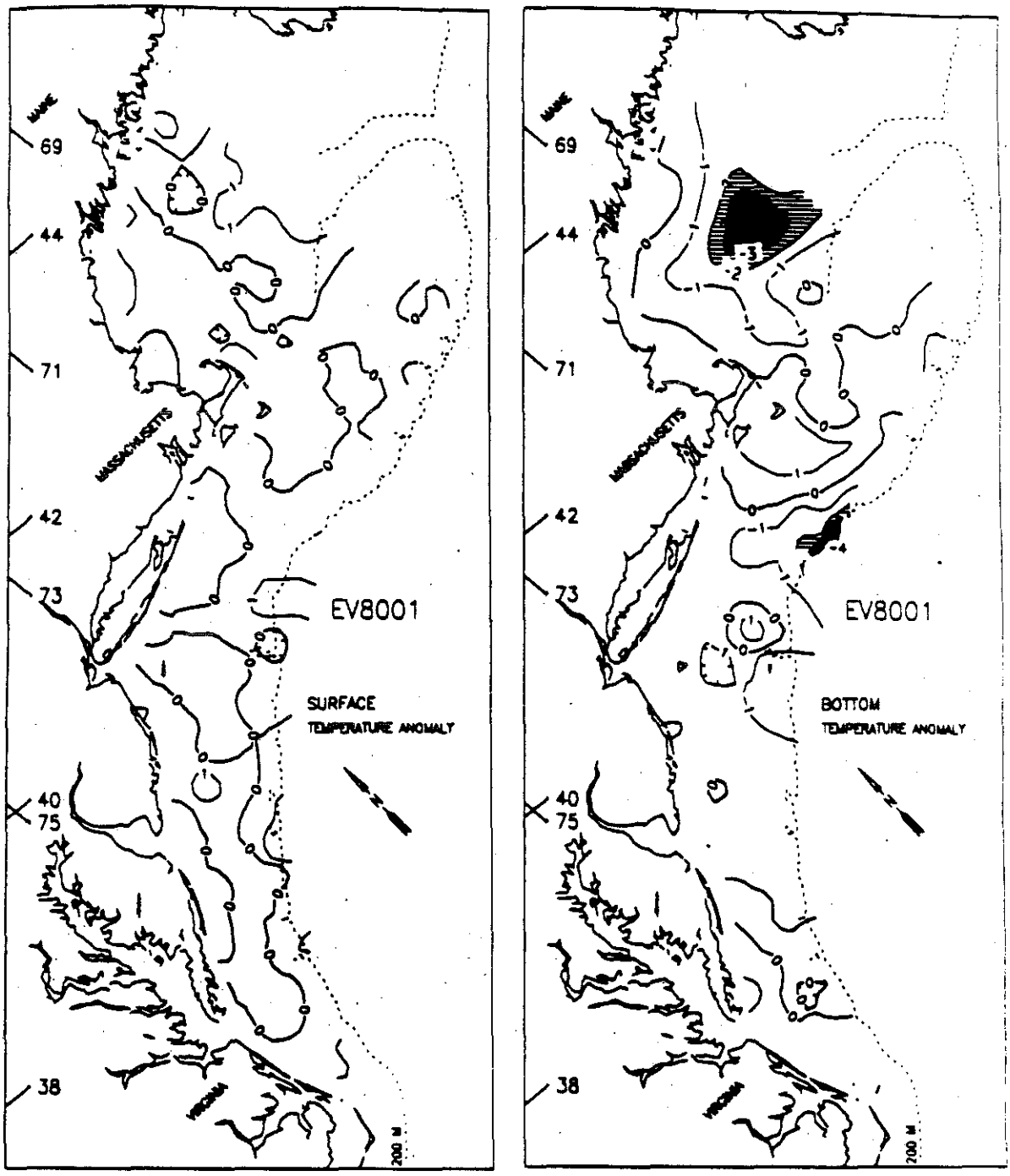


Figure 108. Normalized surface and bottom temperature anomaly: EVR8001. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

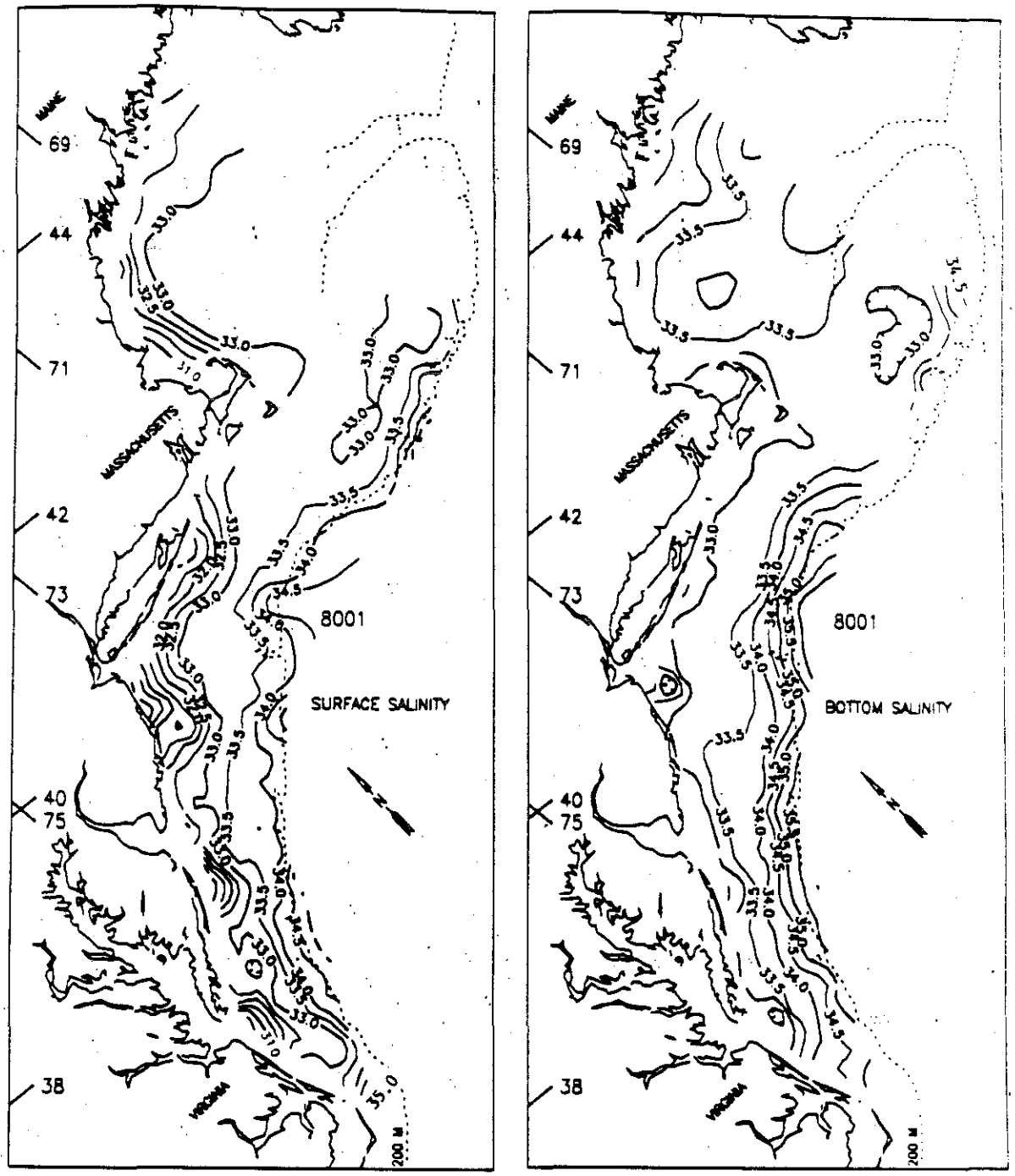
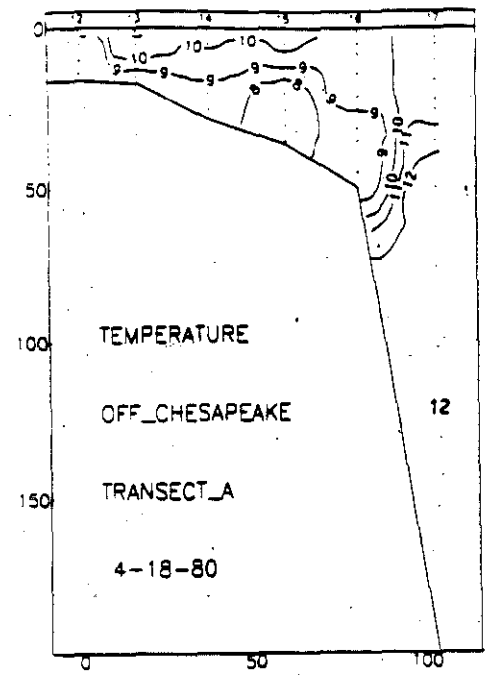
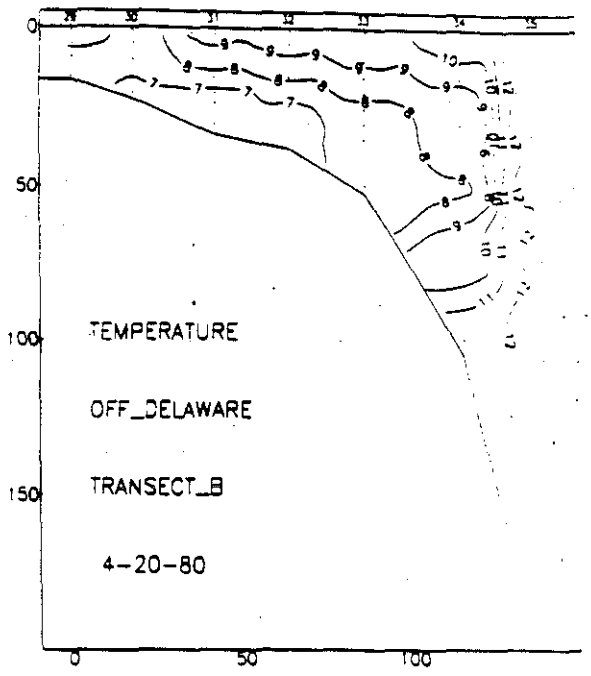
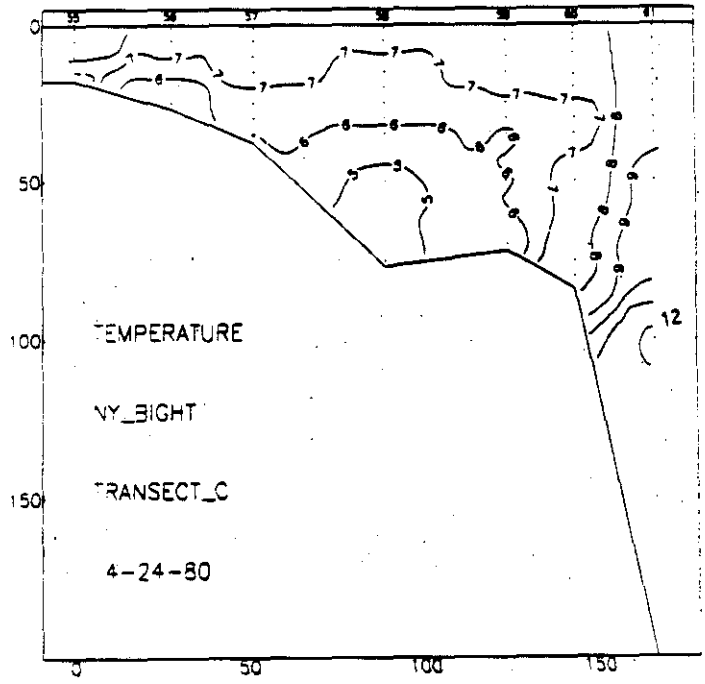


Figure 109. Surface and bottom salinity (PSU) distribution: EVR8001.







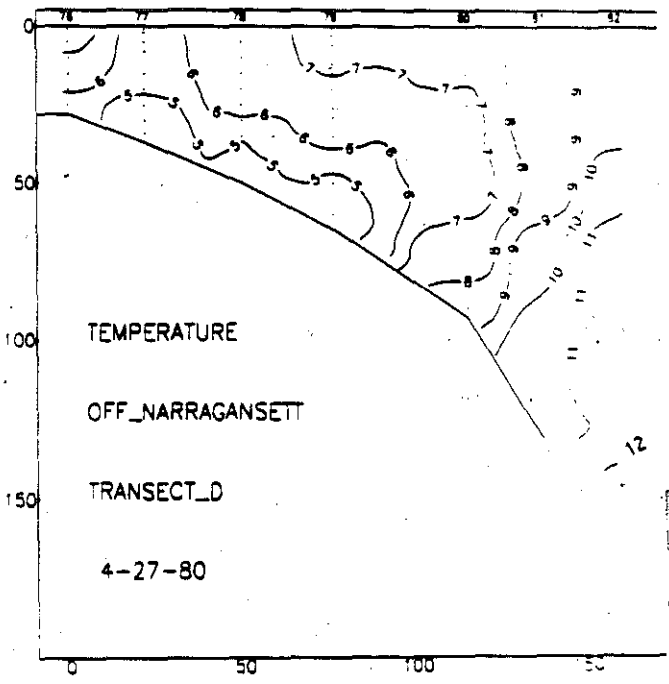
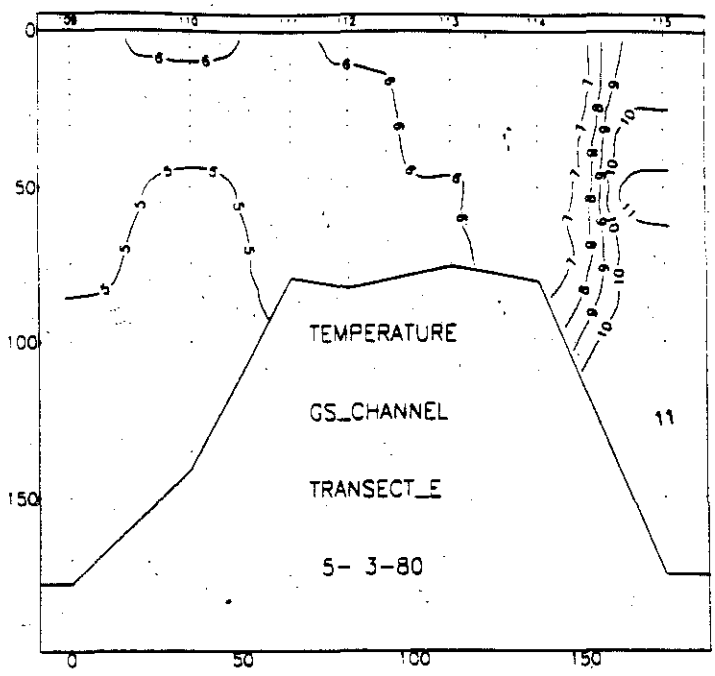


Figure 110. Temperature (°C) transects: EVR8001.



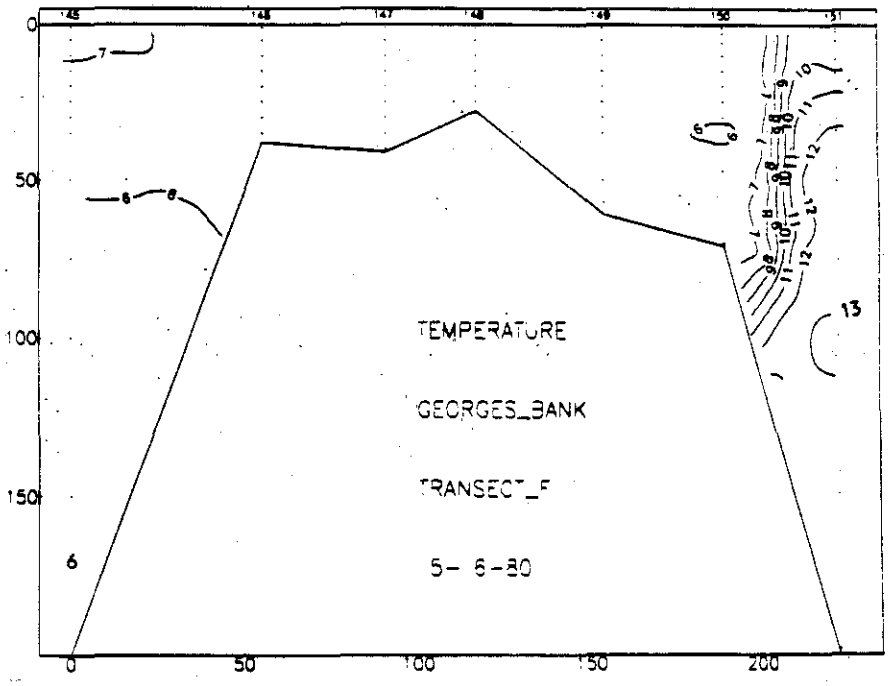
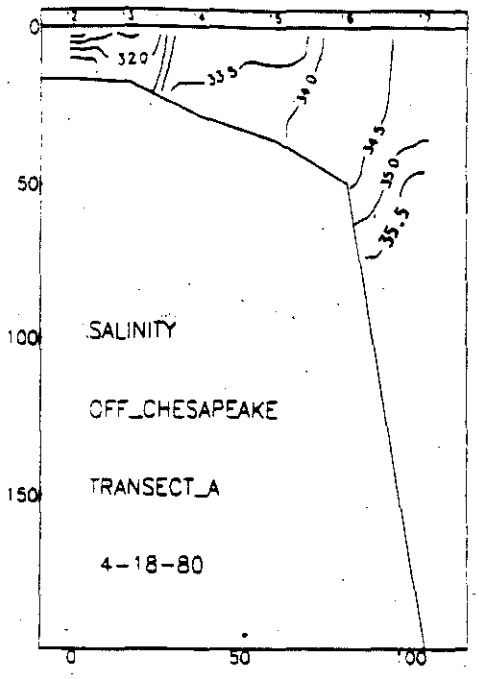
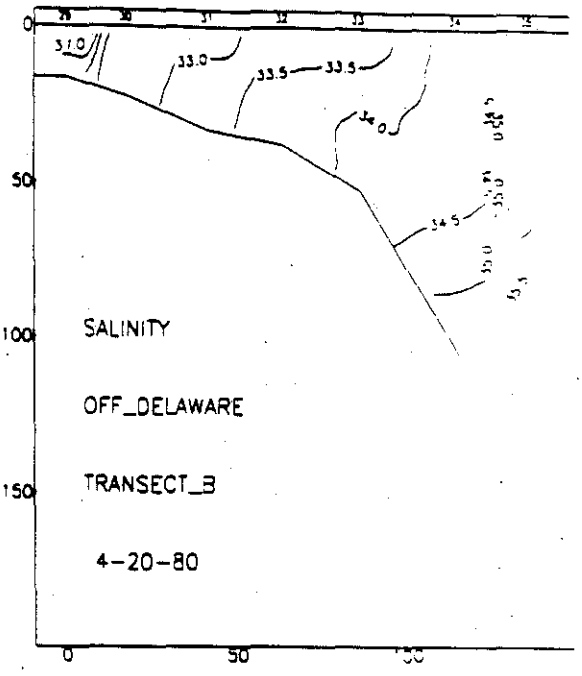
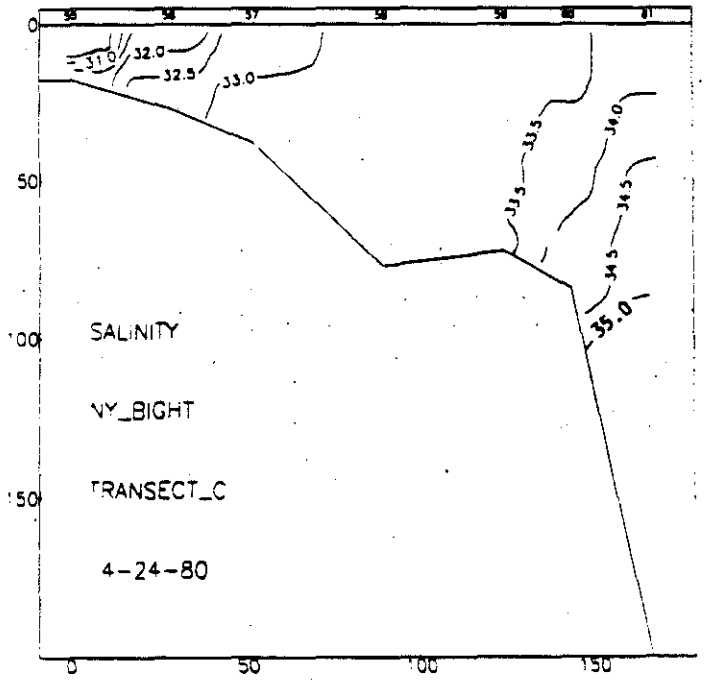


Figure 110. Continued.







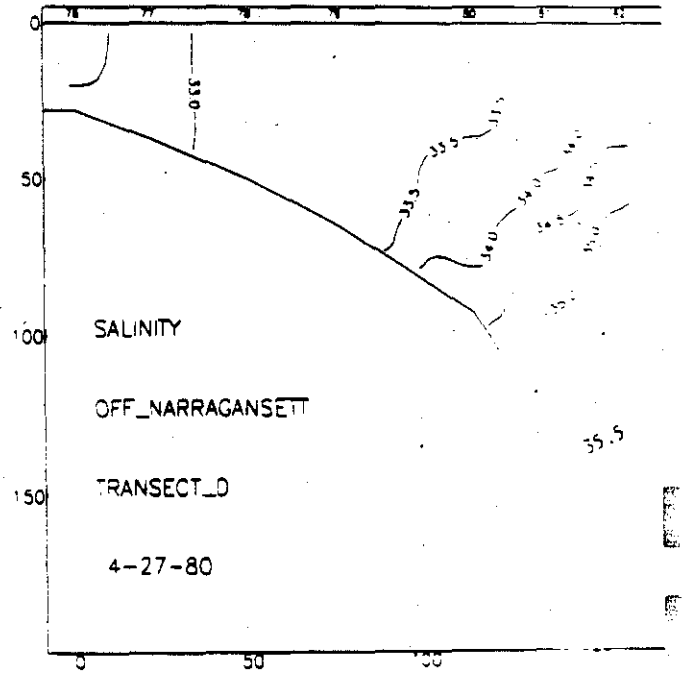
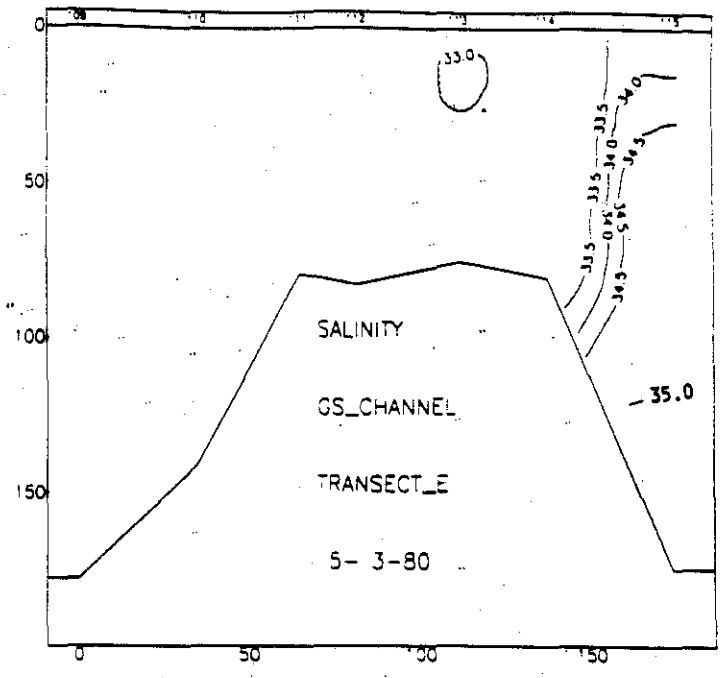


Figure 111. Salinity (PSU) transects: EVR8001.



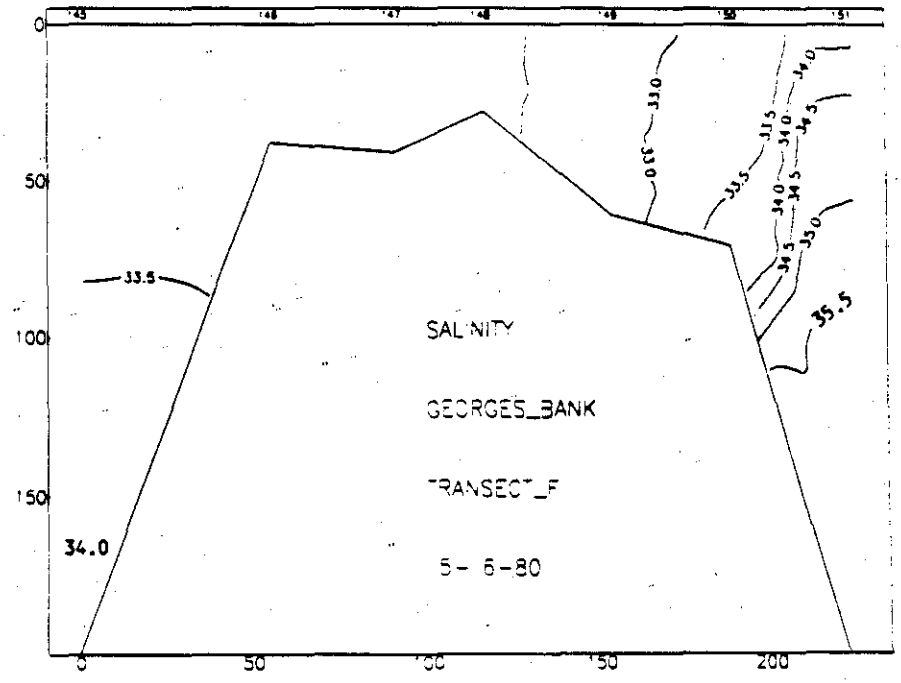


Figure 111. Continued.

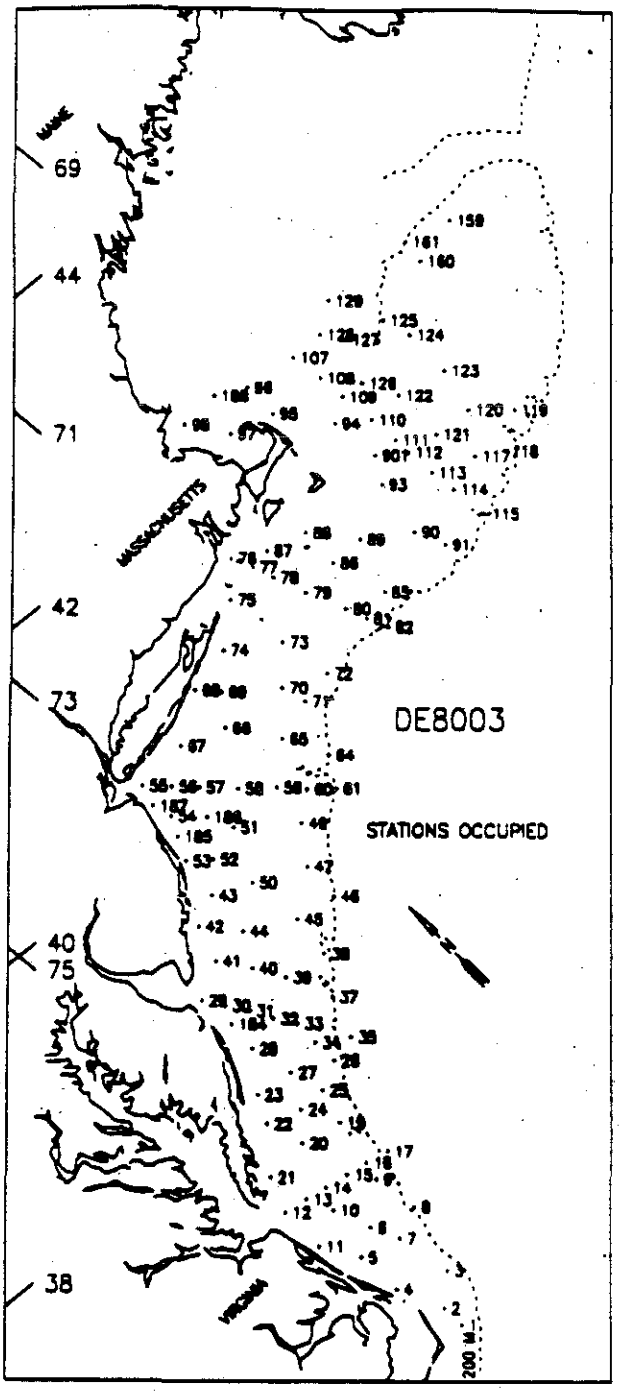


Figure 112. Station positions: DEL8003.

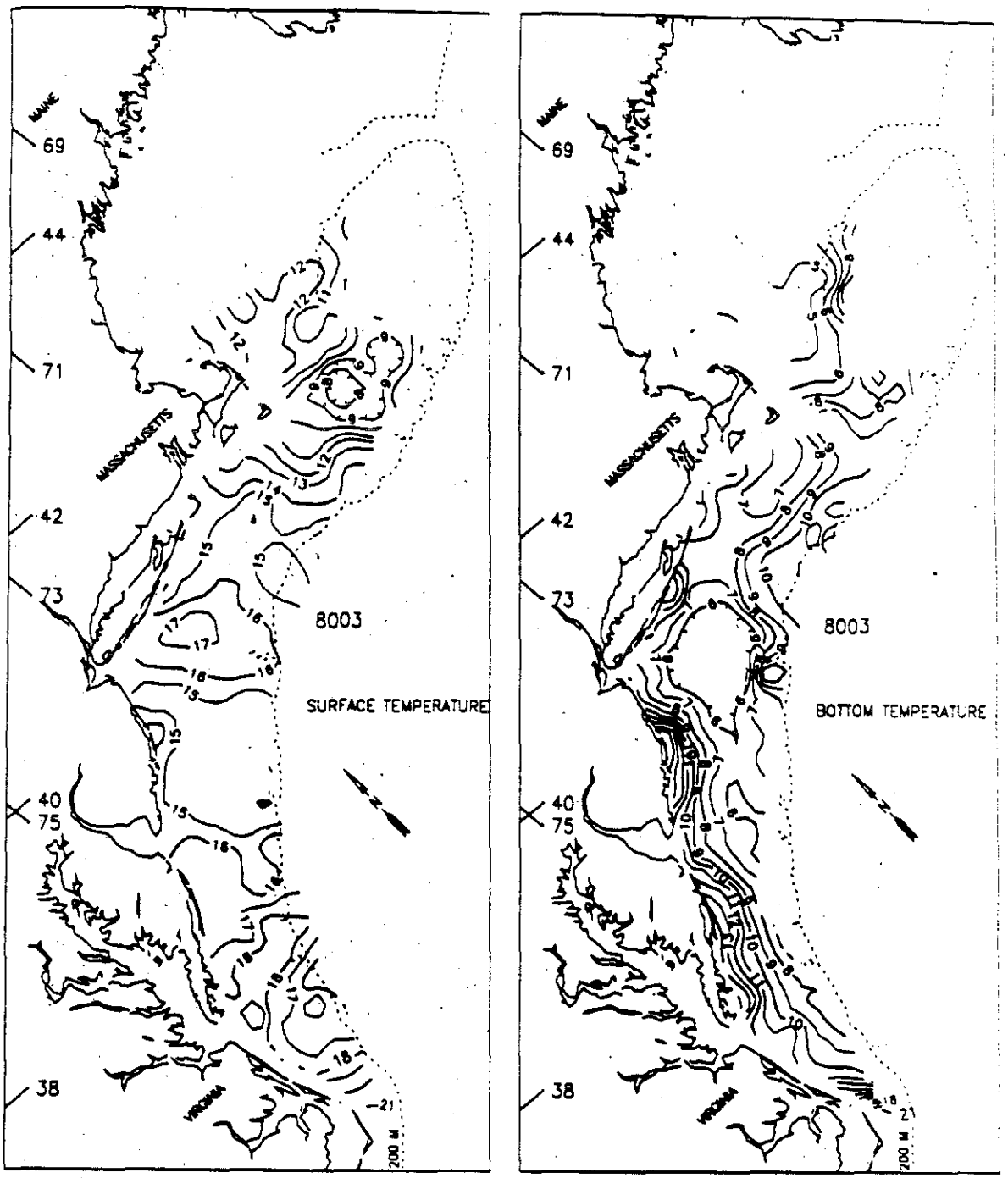


Figure 113. Surface and bottom temperature (°C) distribution: DEL8003.

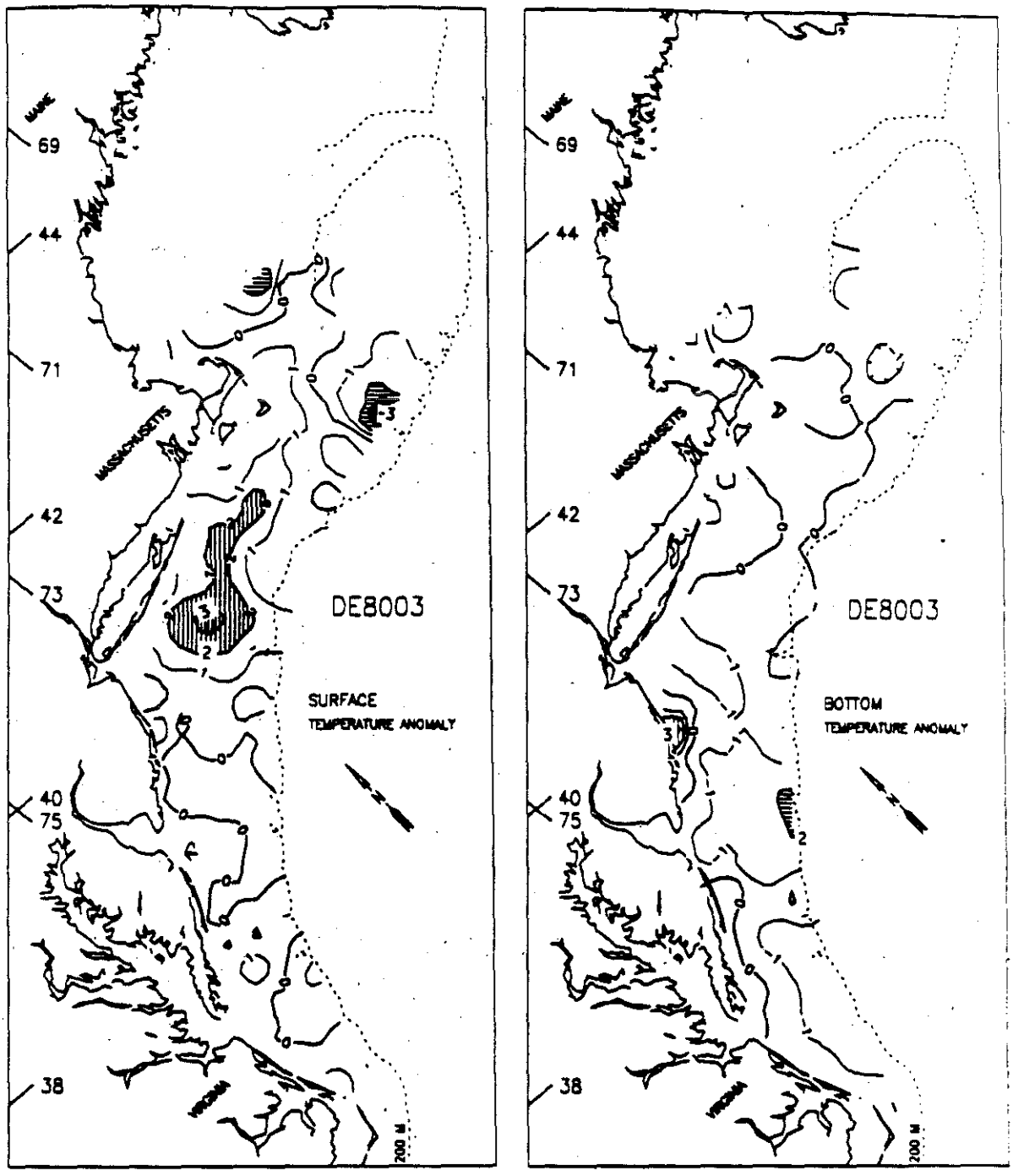


Figure 114. Normalized surface and bottom temperature anomaly: DEL8003. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

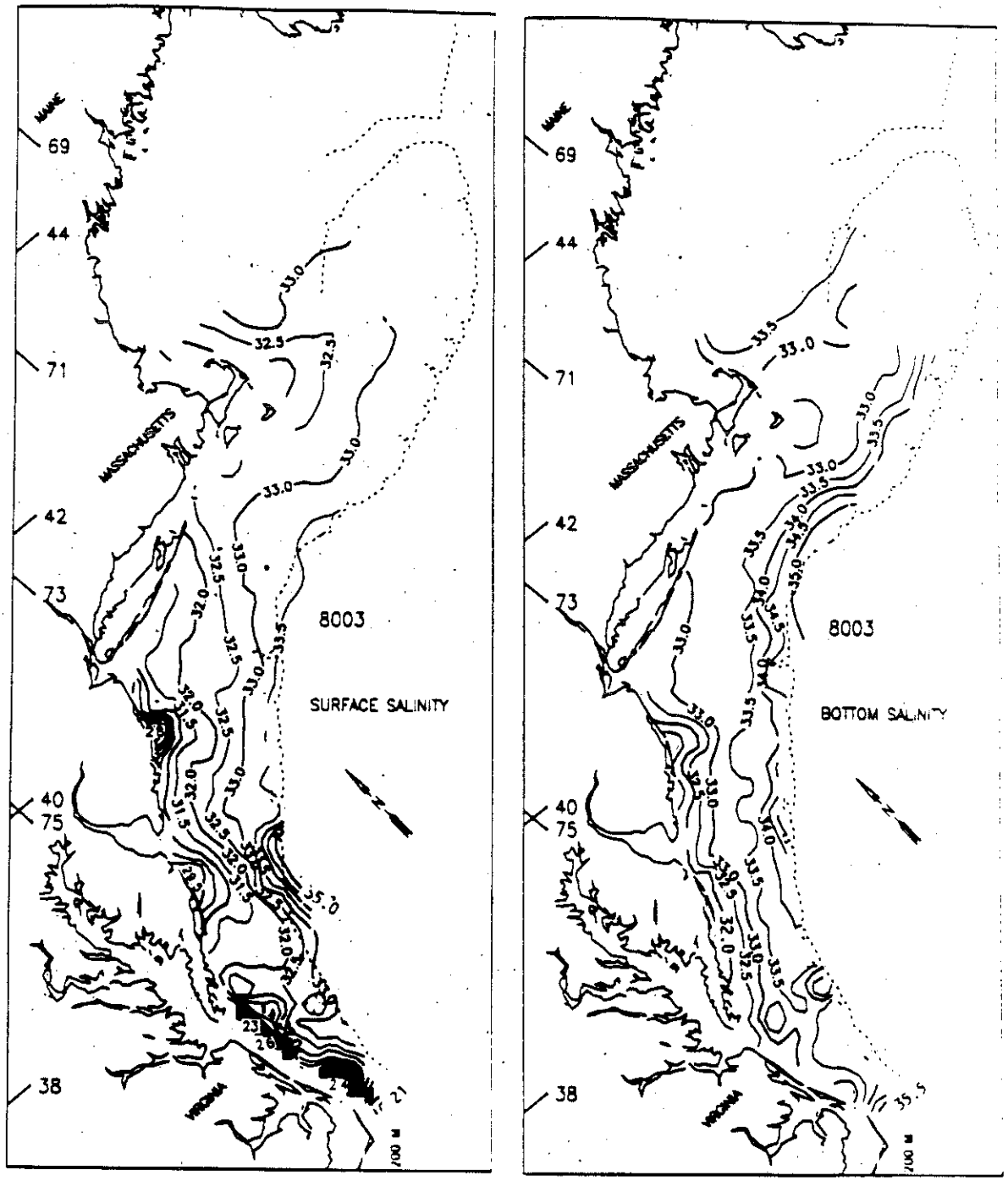
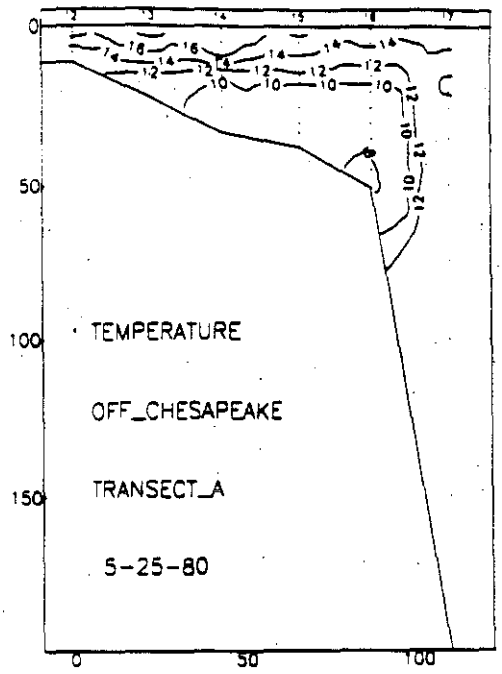
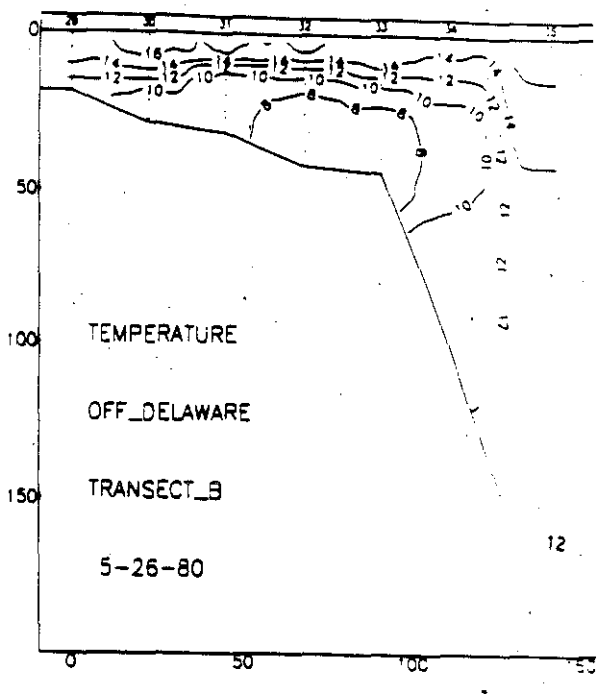
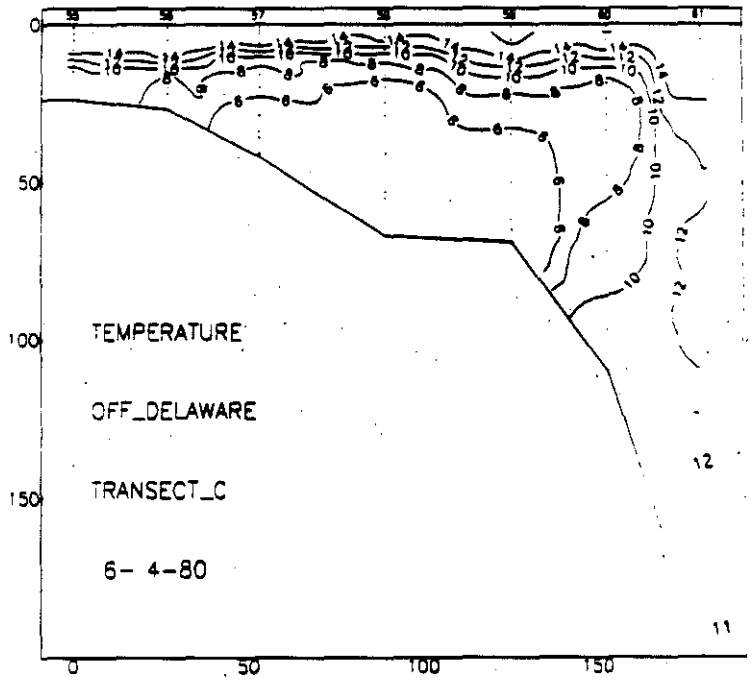


Figure 115. Surface and bottom salinity (PSU) distribution: DEL8003.







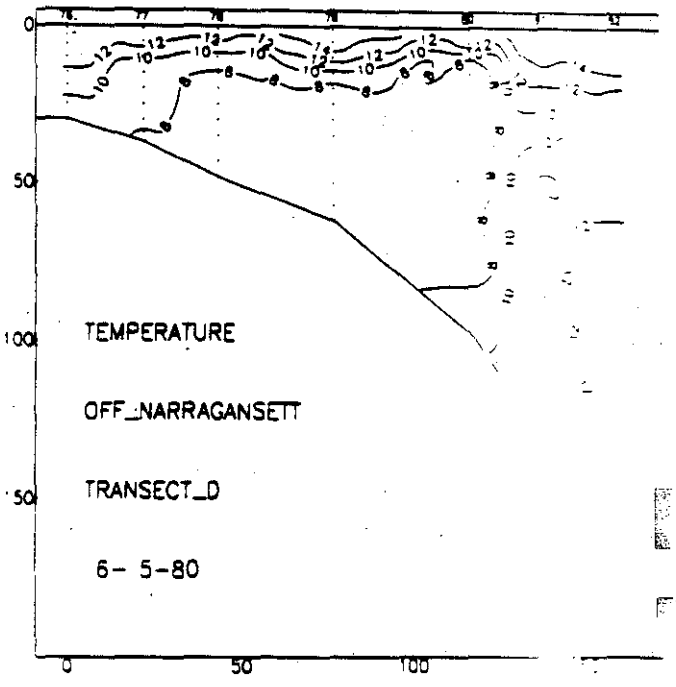


Figure 116. Temperature (°C) transects: DEL8003.

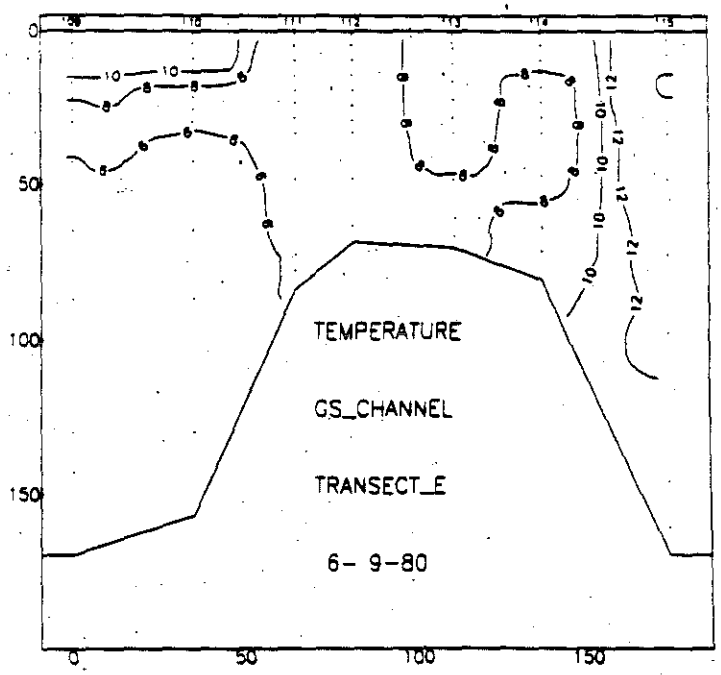
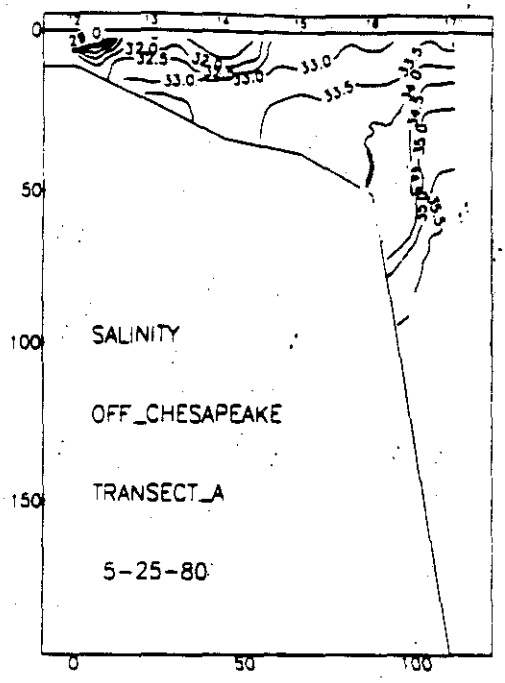
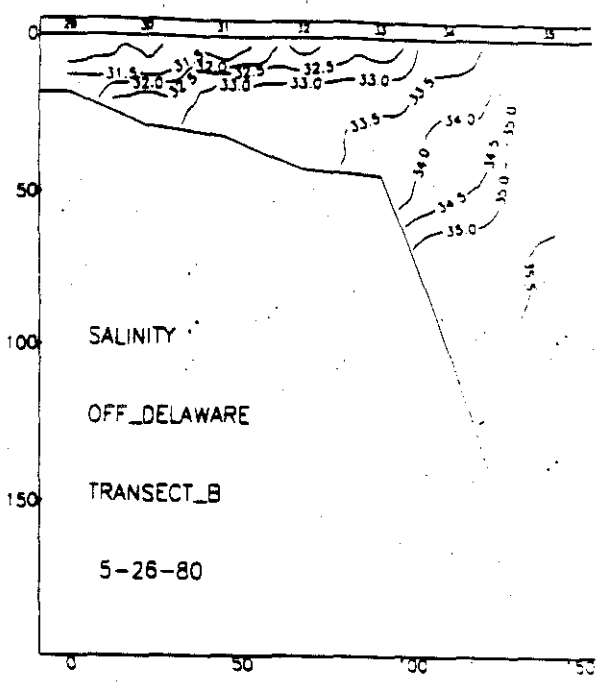
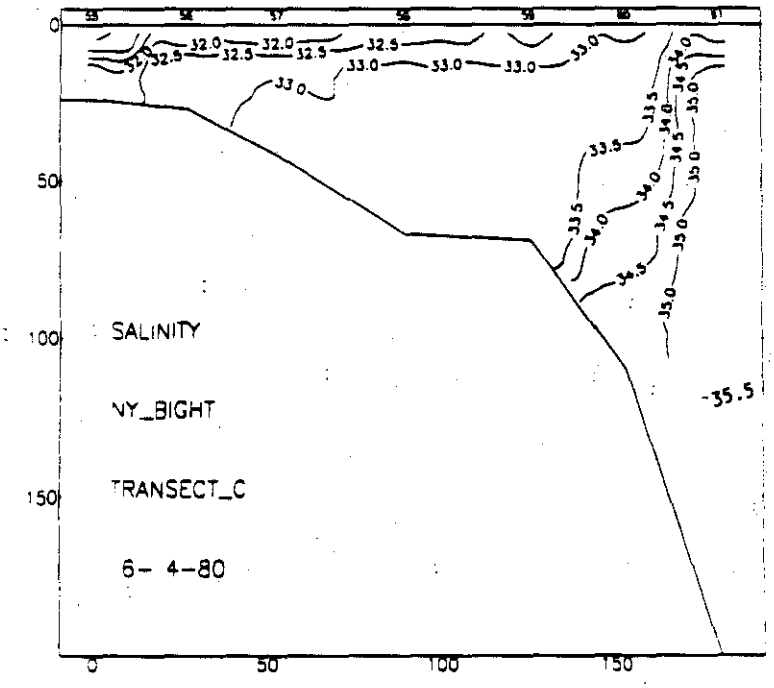


Figure 116. Continued.







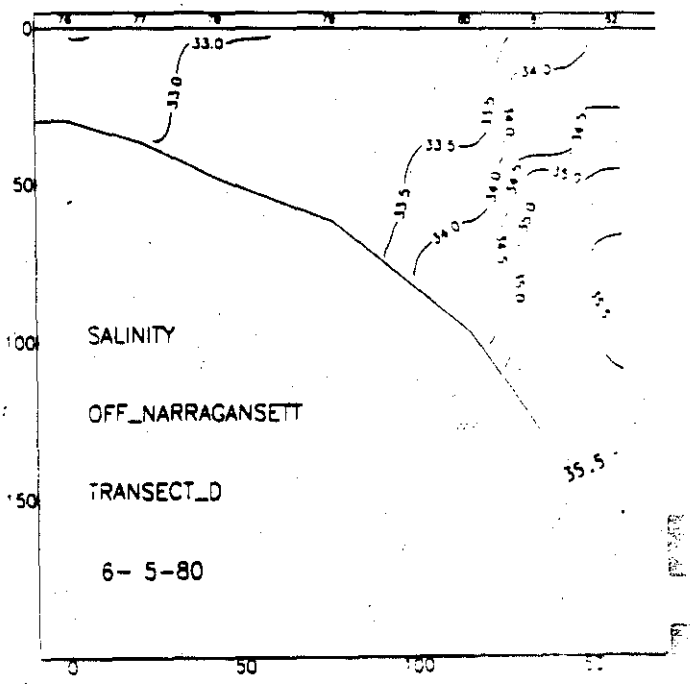


Figure 117. Salinity (PSU) transects: DEL8003.

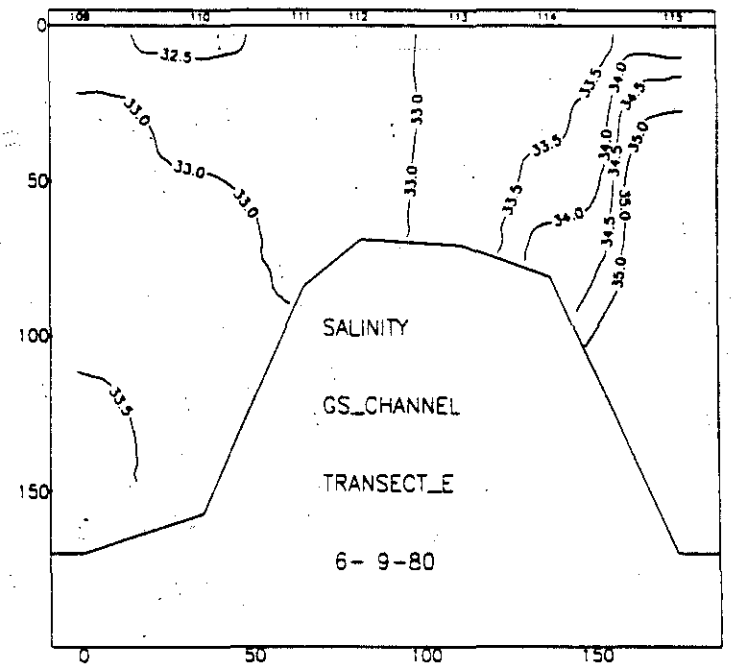


Figure 117. Continued.

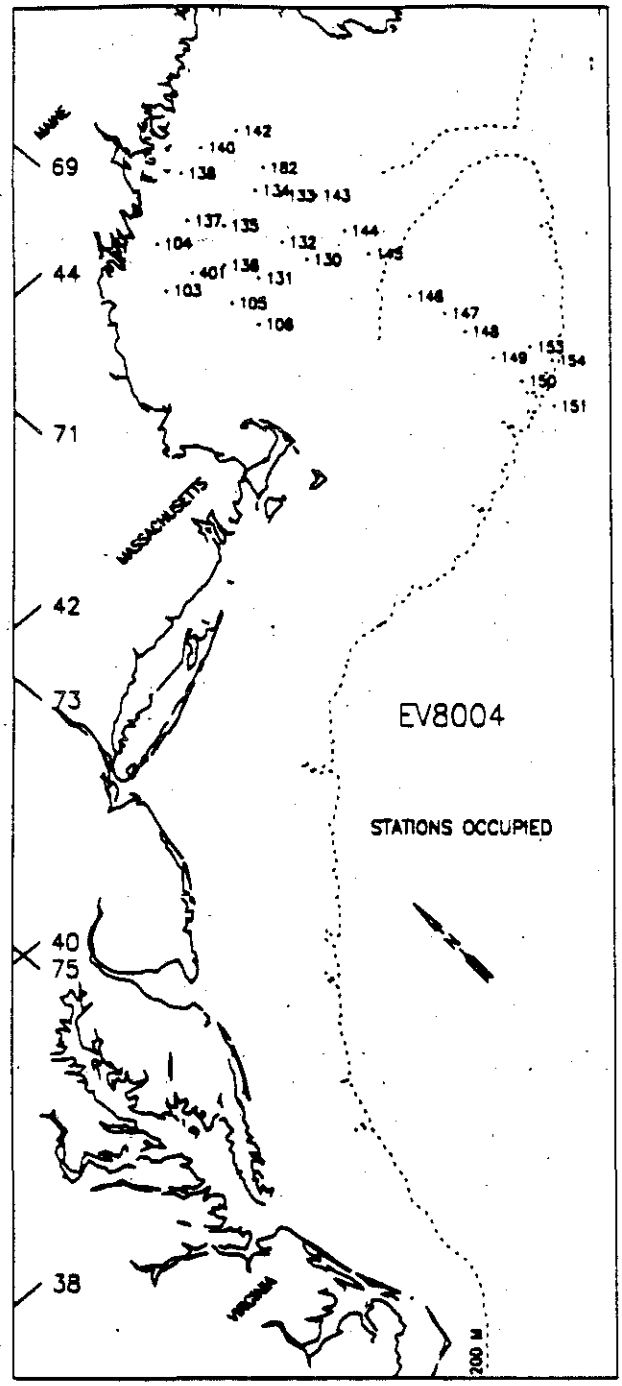


Figure 118. Station positions: EVR8004.

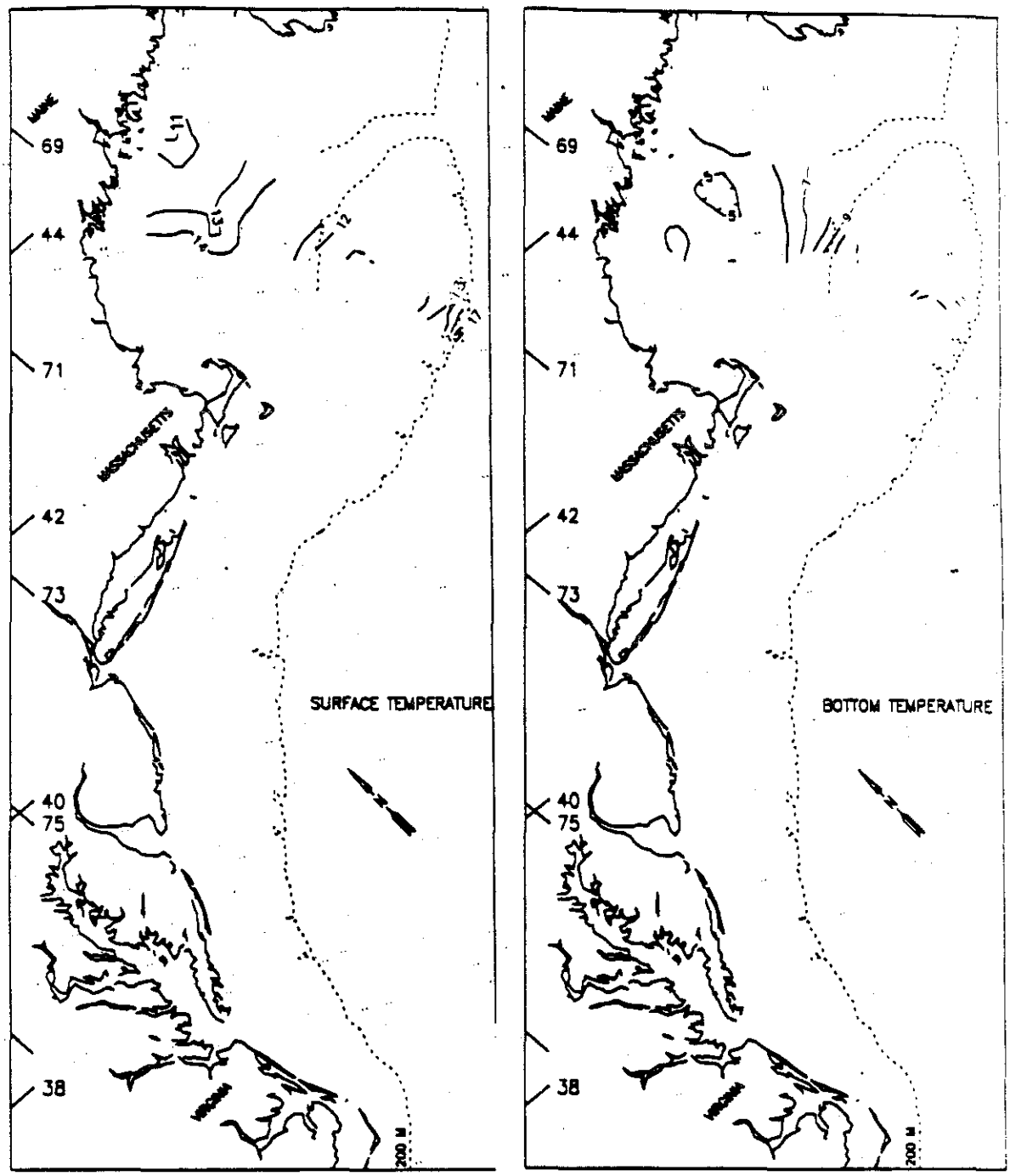
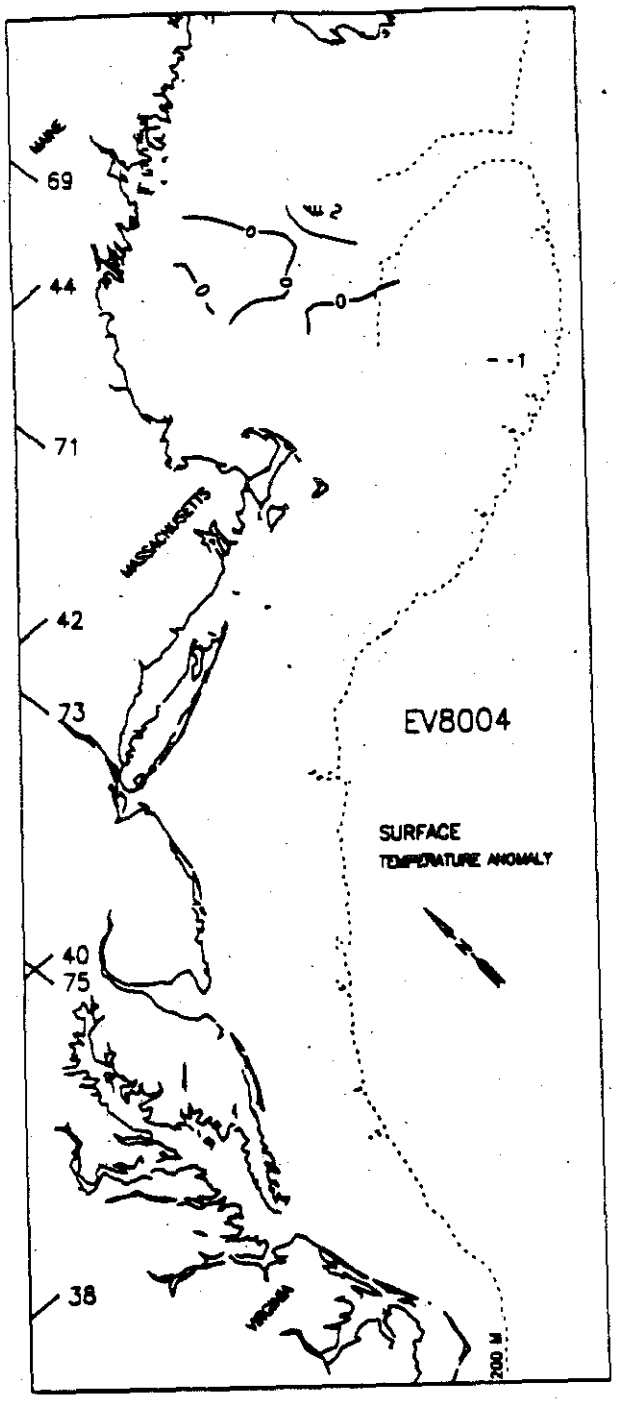


Figure 119. Surface and bottom temperature (°C) distribution: EVR8004.



(NOT ENOUGH POINTS
TO CONTOUR BOTTOM ANOMALIES)

Figure 120. Normalized surface and bottom temperature anomaly: EVR8004. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

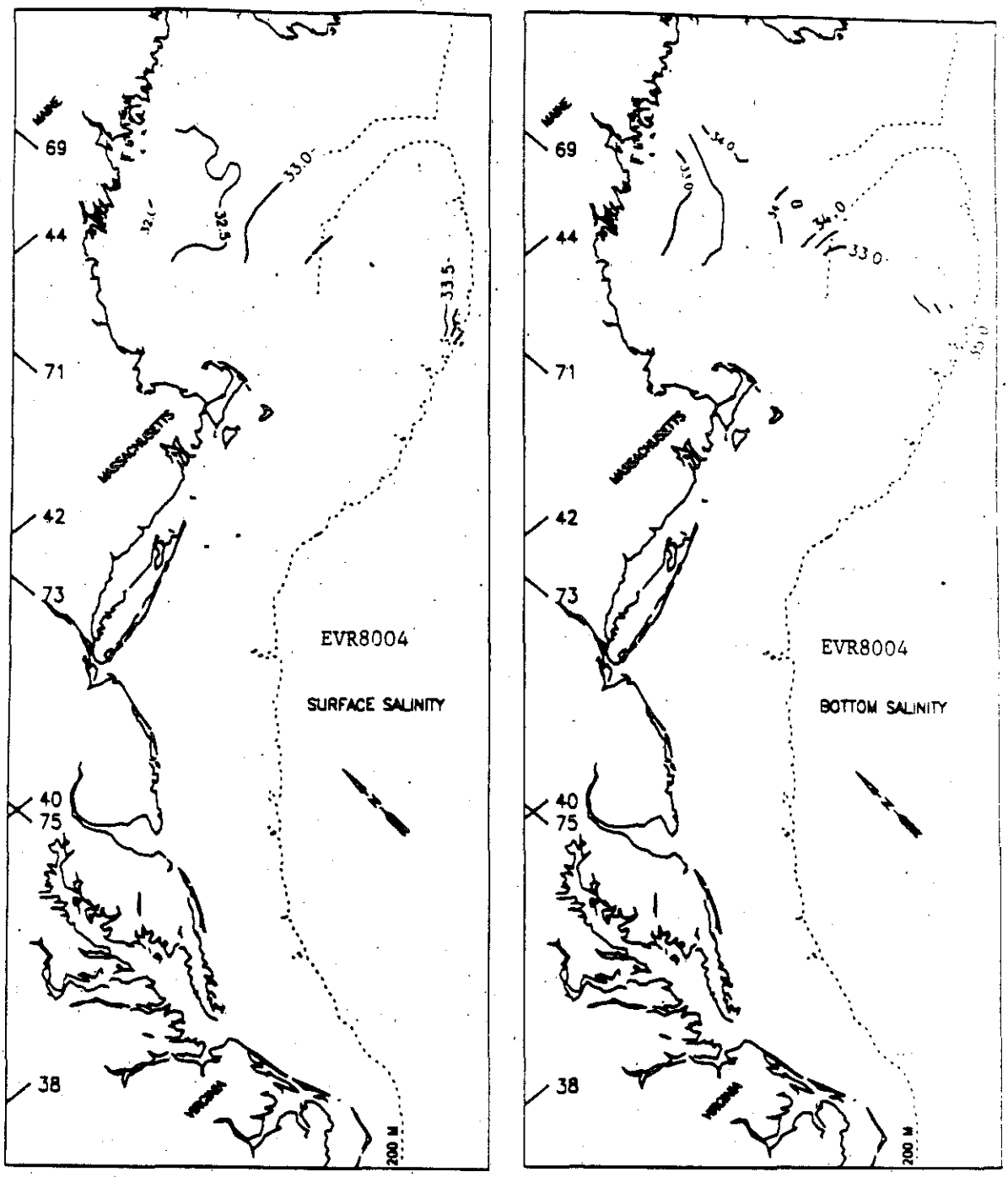


Figure 121. Surface and bottom salinity (PSU) distribution: EVR8004.

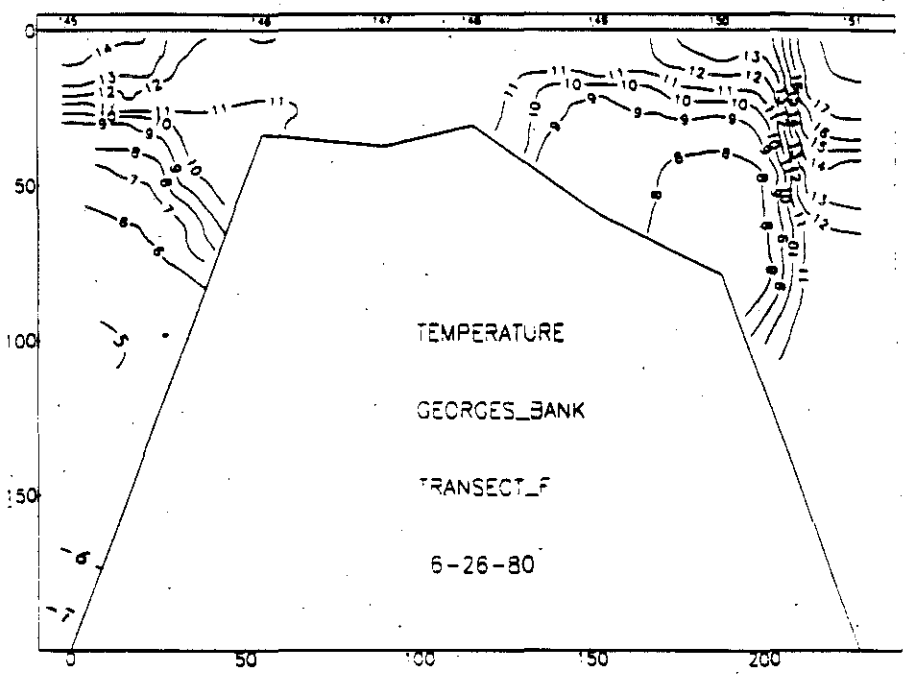


Figure 122. Temperature (°C) transects: EVR8004.

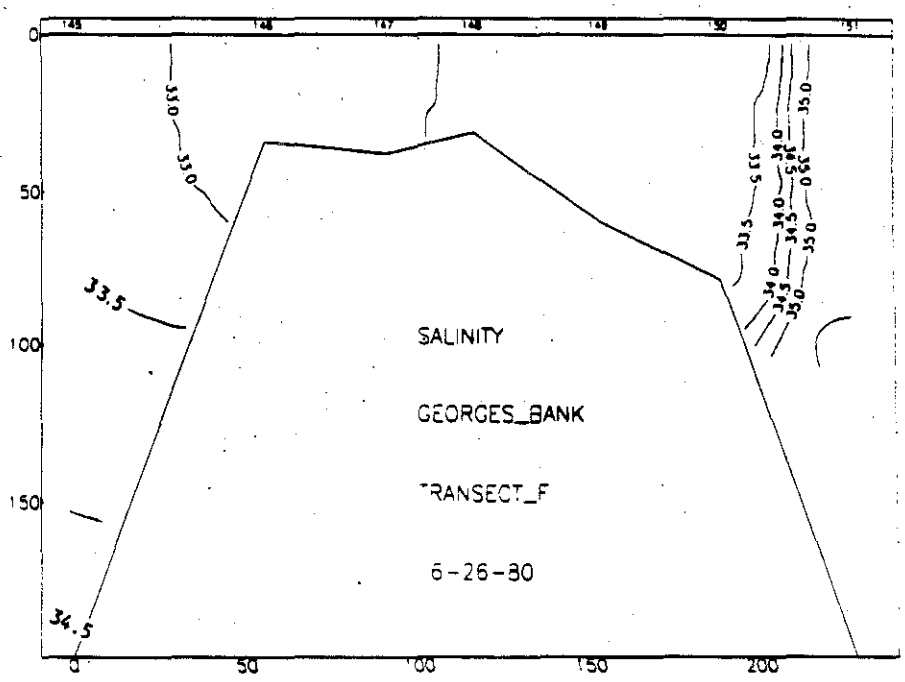


Figure 123. Salinity (PSU) transects: EVR8004.

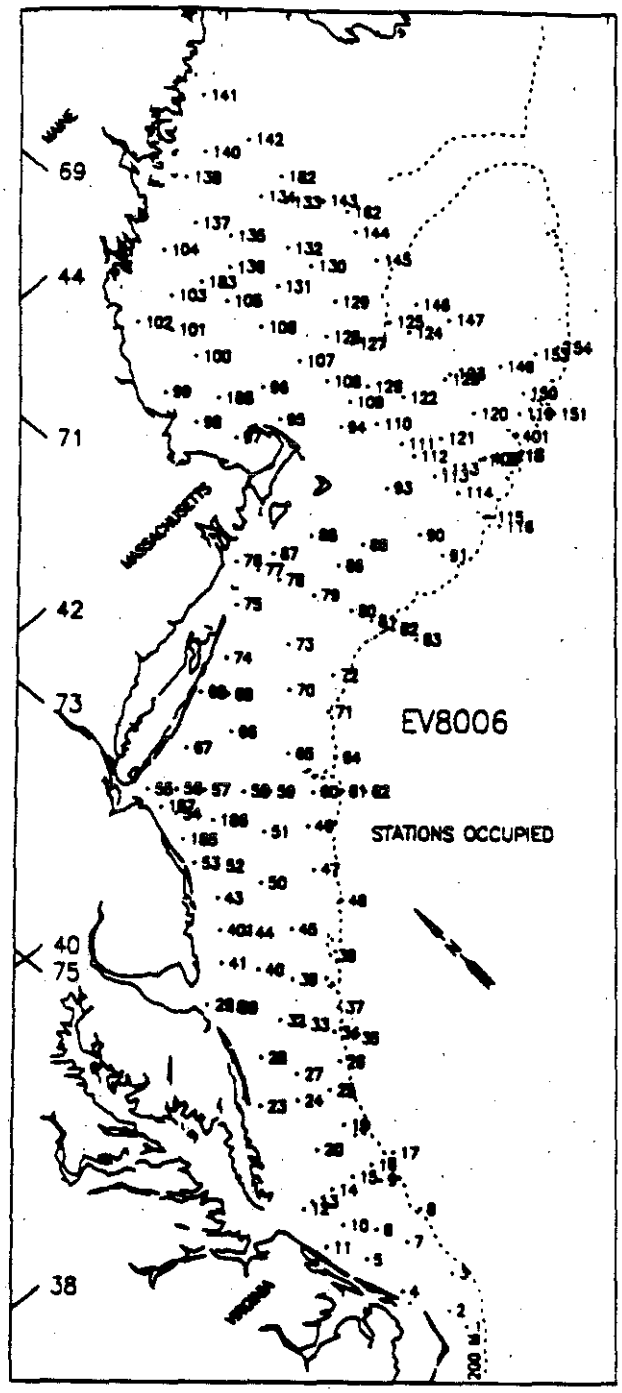


Figure 124. Station positions: EVR8006.

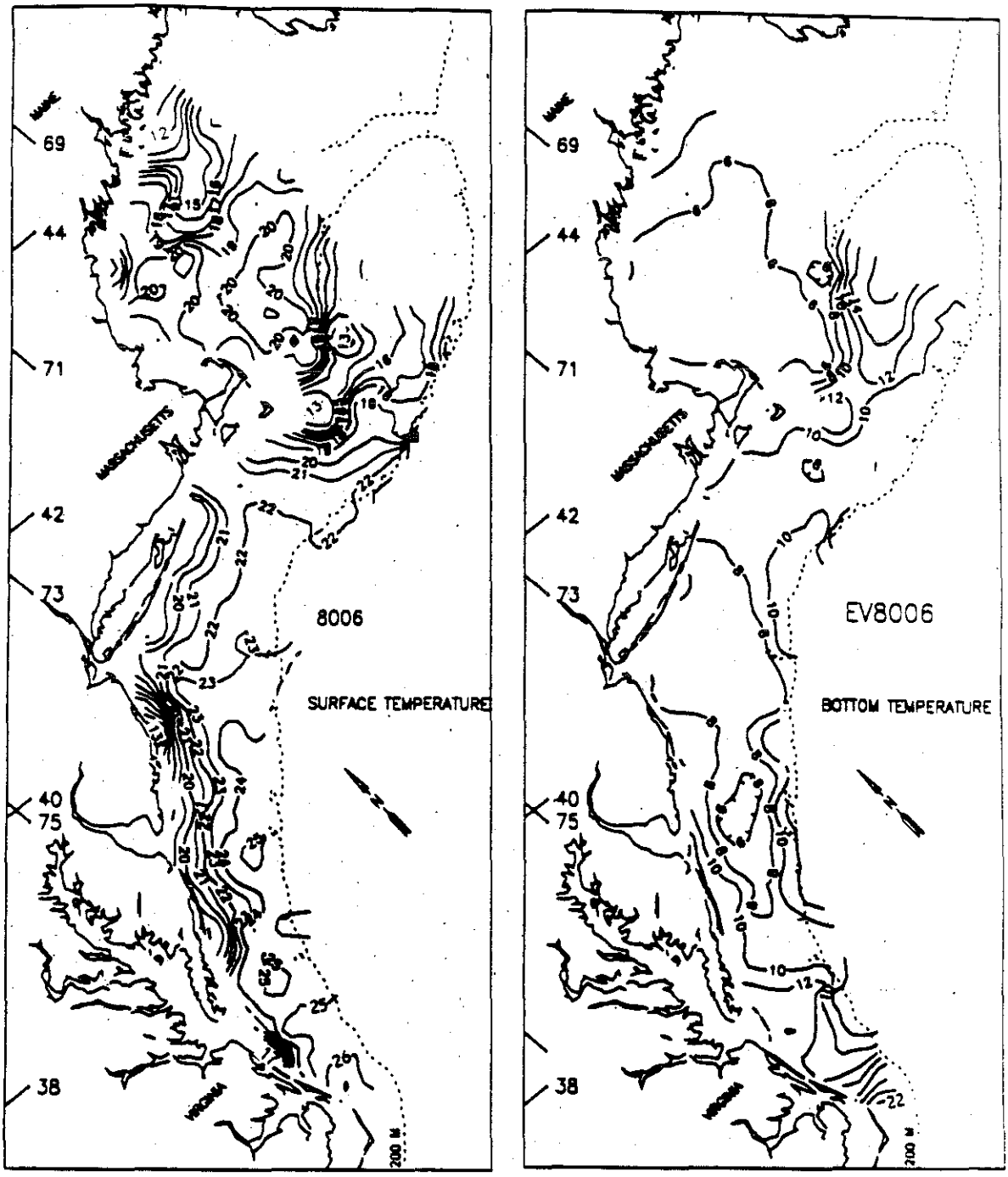


Figure 125. Surface and bottom temperature (°C) distribution: EVR8006.

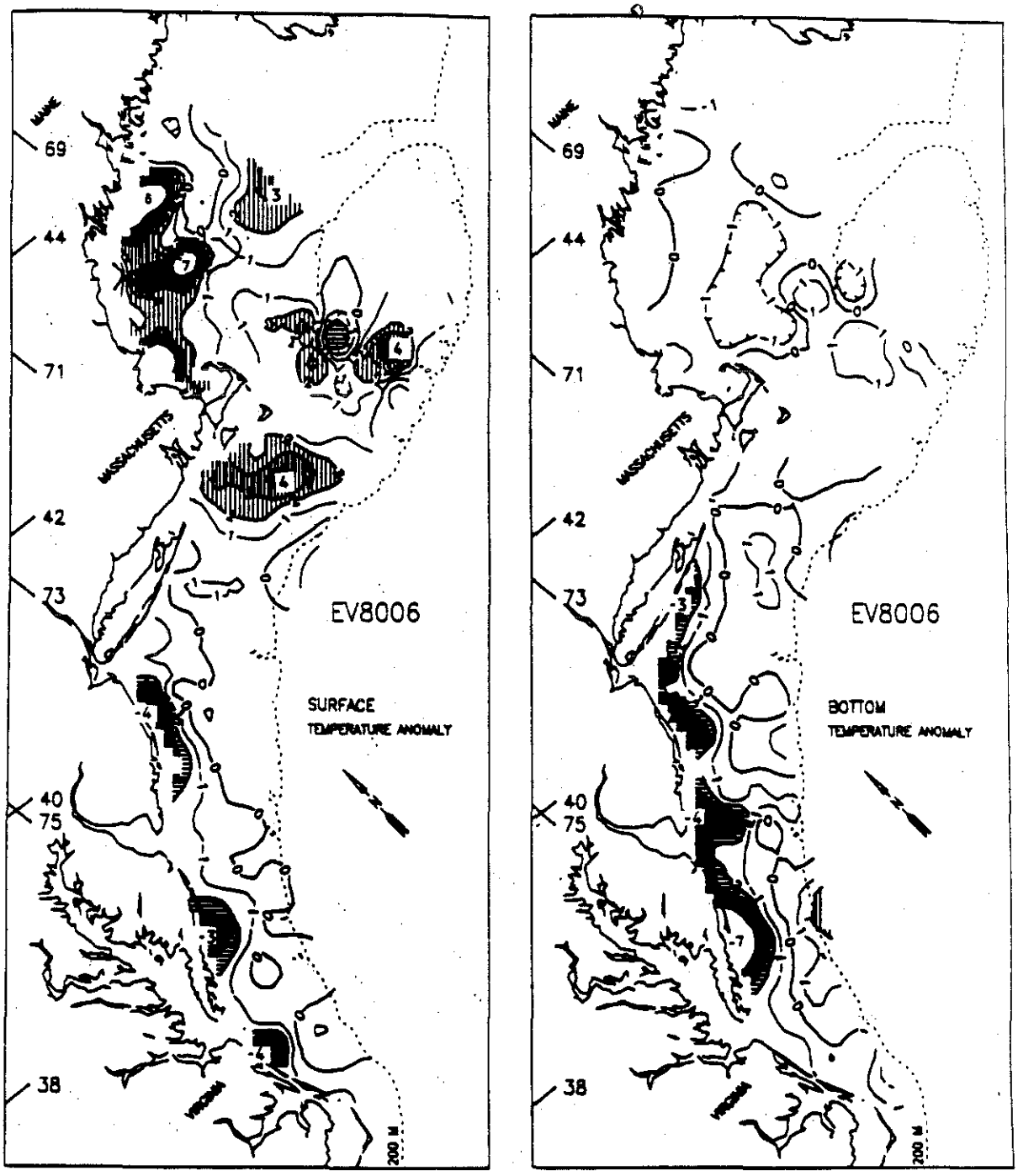


Figure 126. Normalized surface and bottom temperature anomaly: EVR8006. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

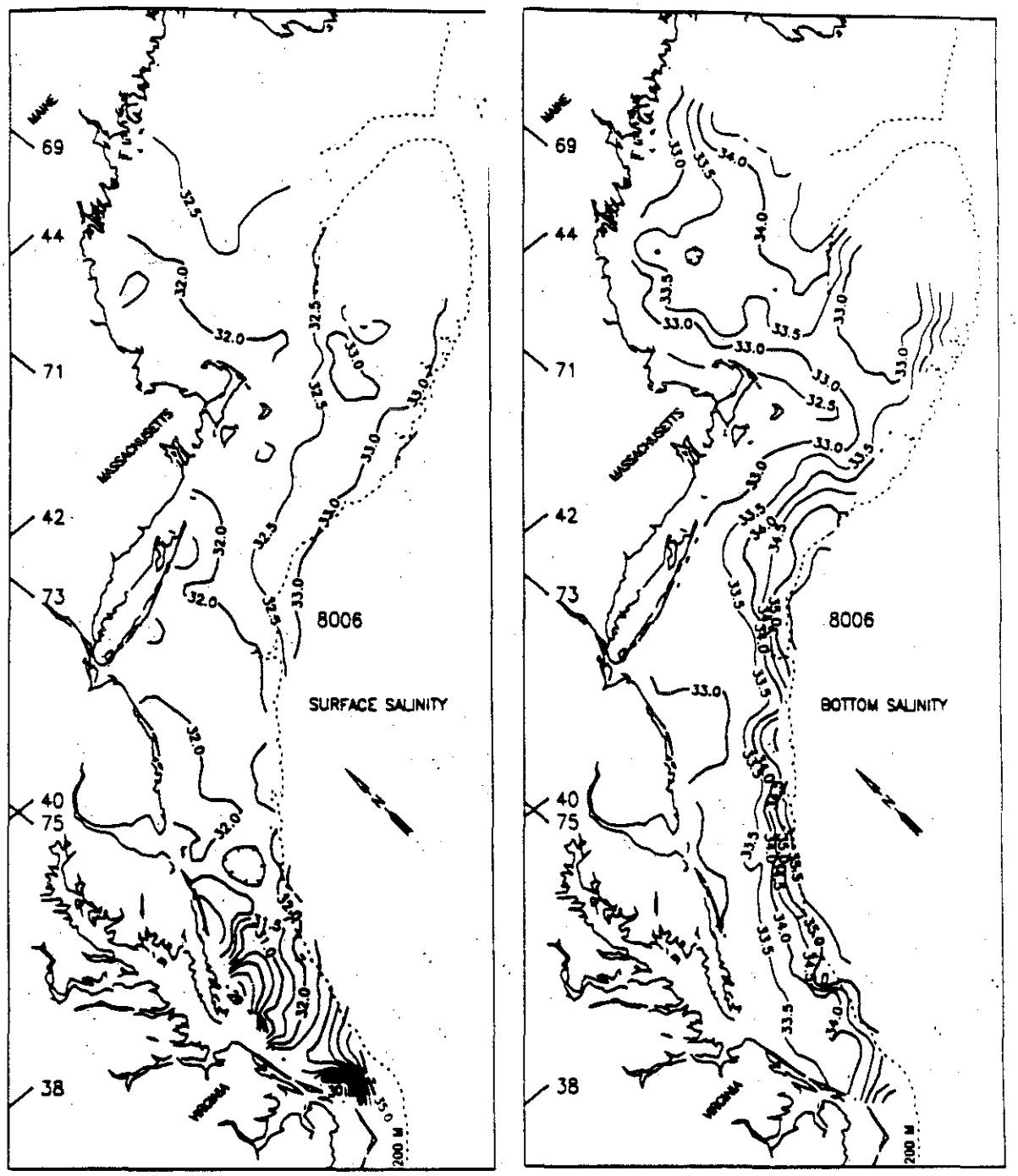
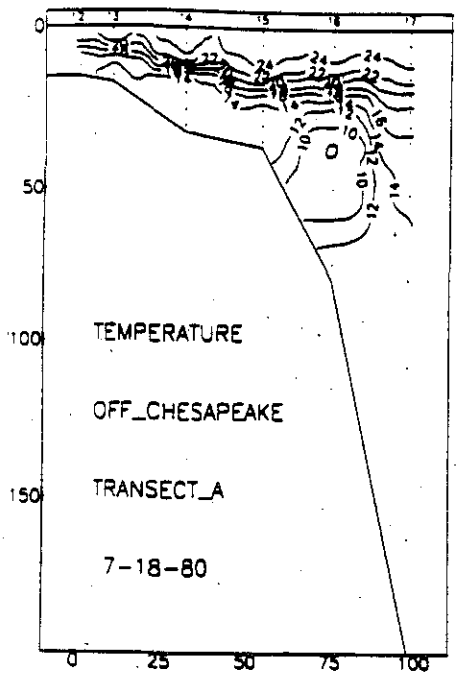
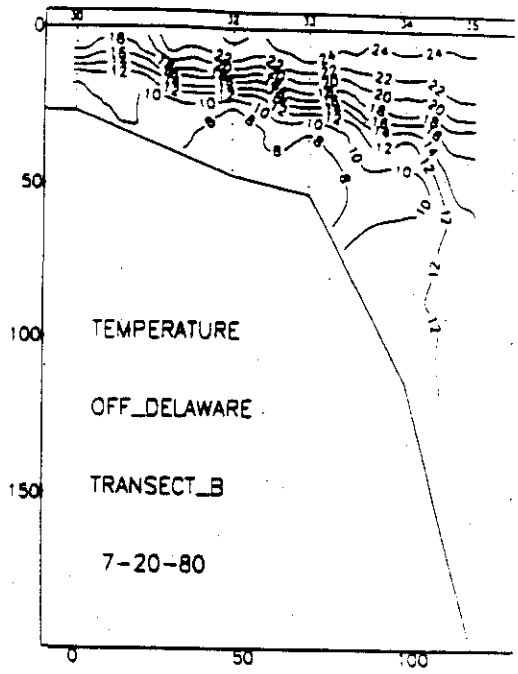
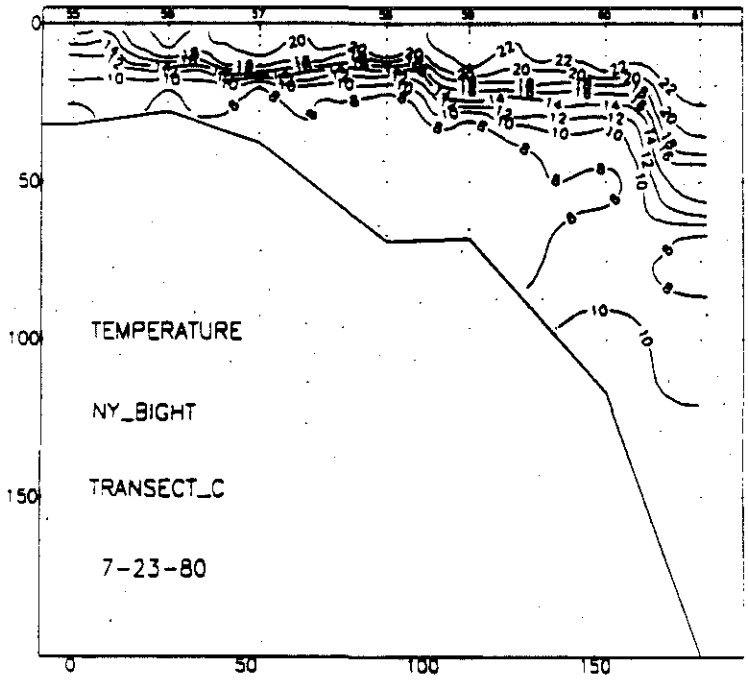


Figure 127. Surface and bottom salinity (PSU) distribution: EVR8006.







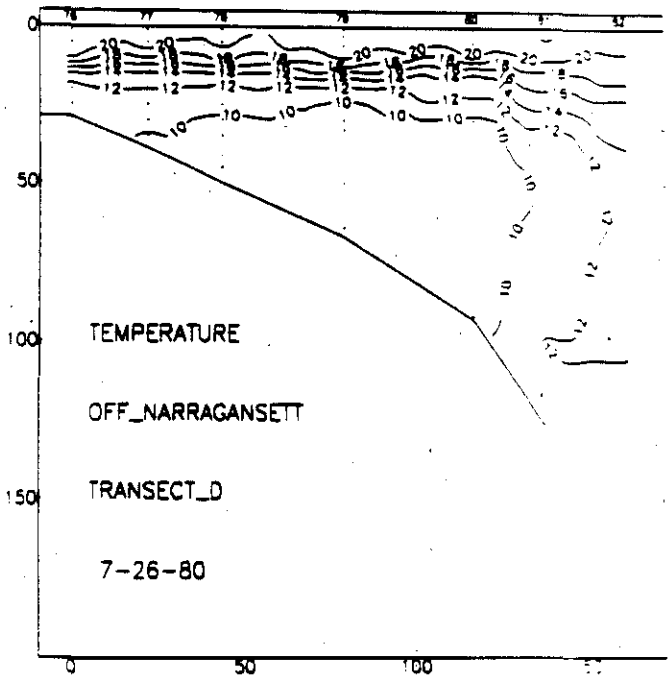
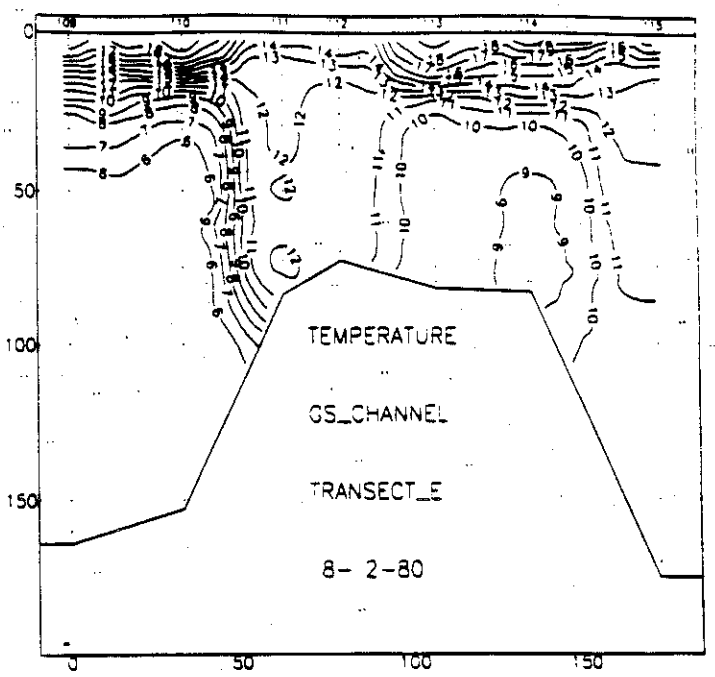


Figure 128. Temperature (°C) transects: EVR8006.



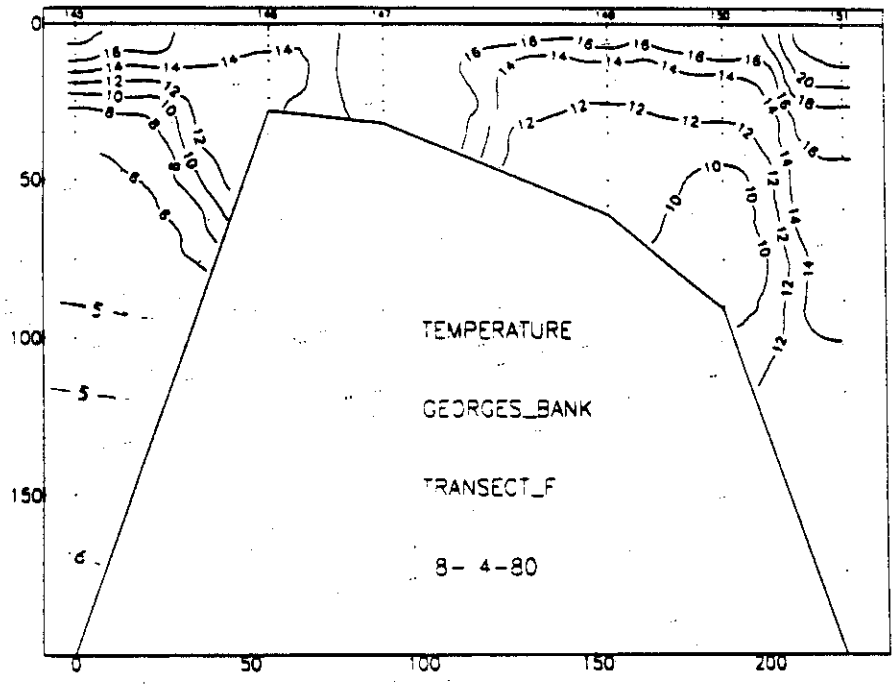


Figure 128. Continued.

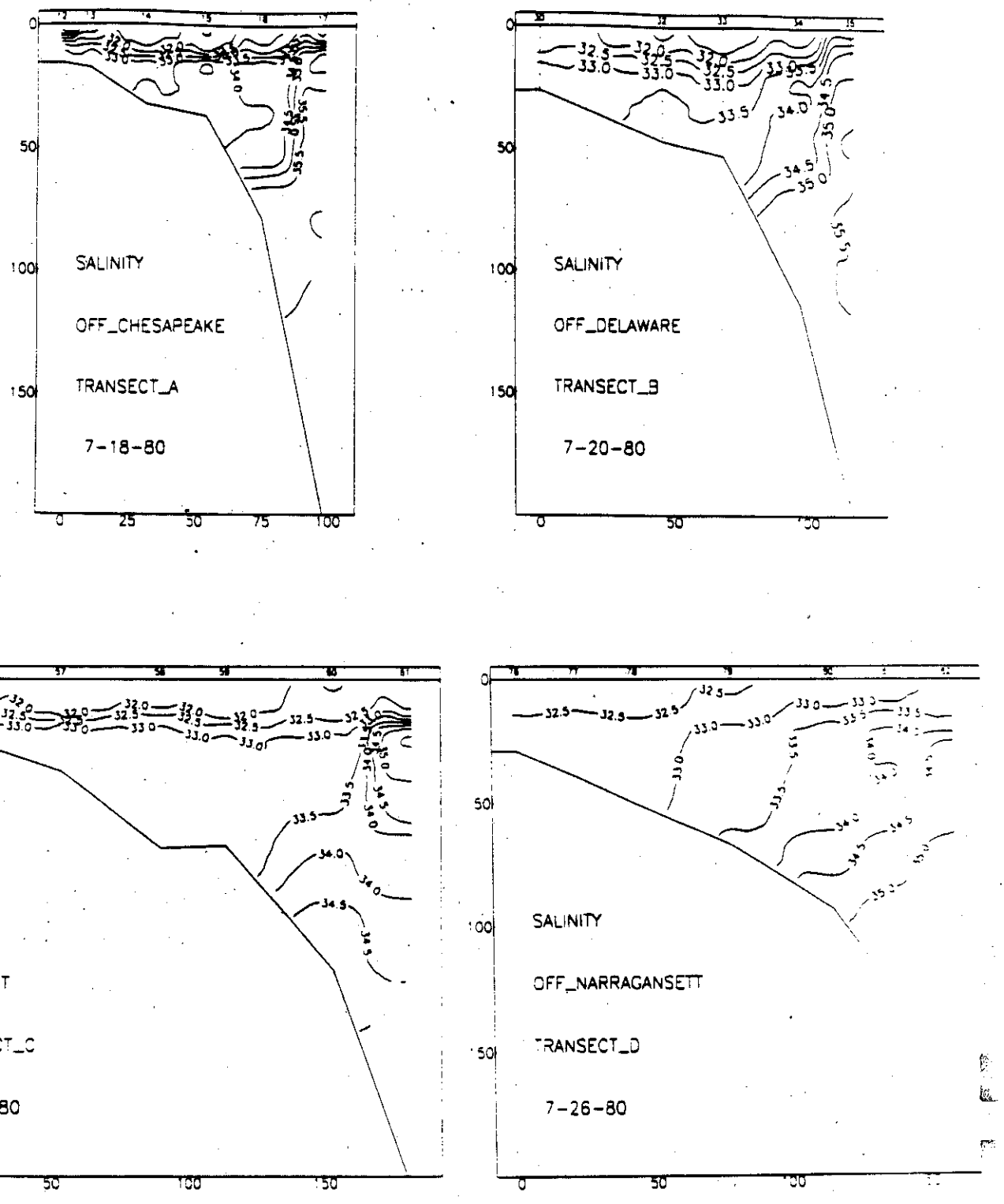
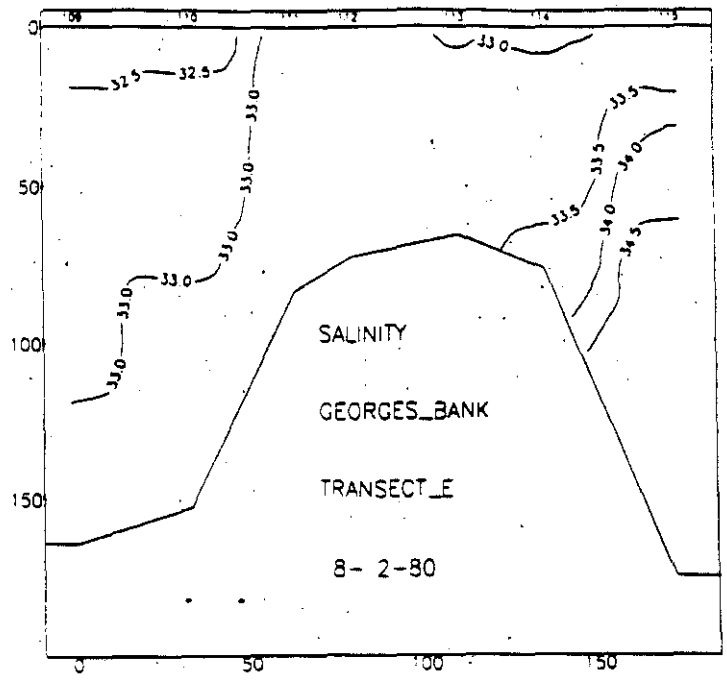


Figure 129. Salinity (PSU) transects: EVR8006.



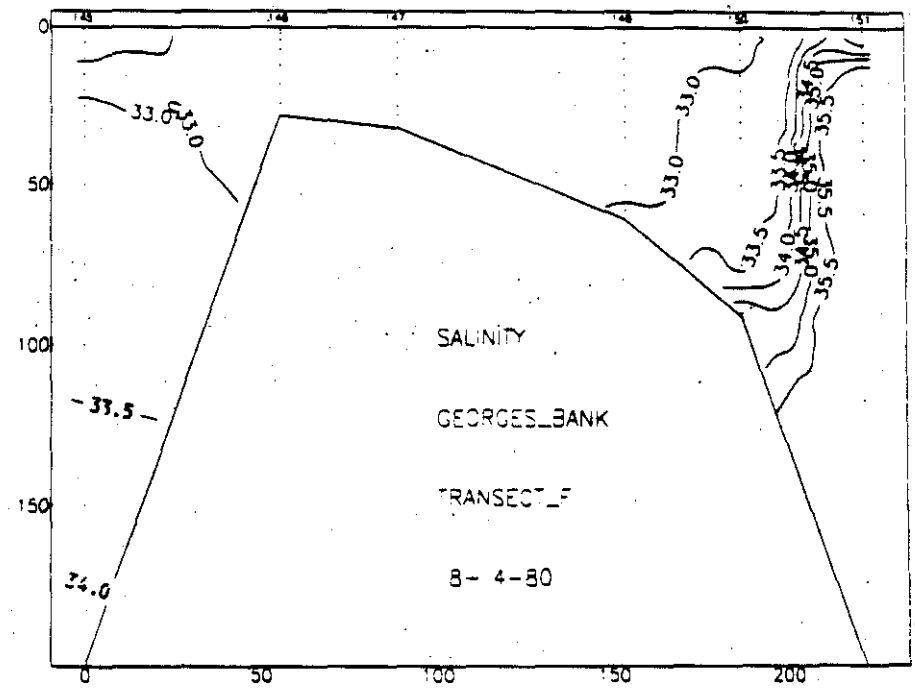


Figure 129. Continued.

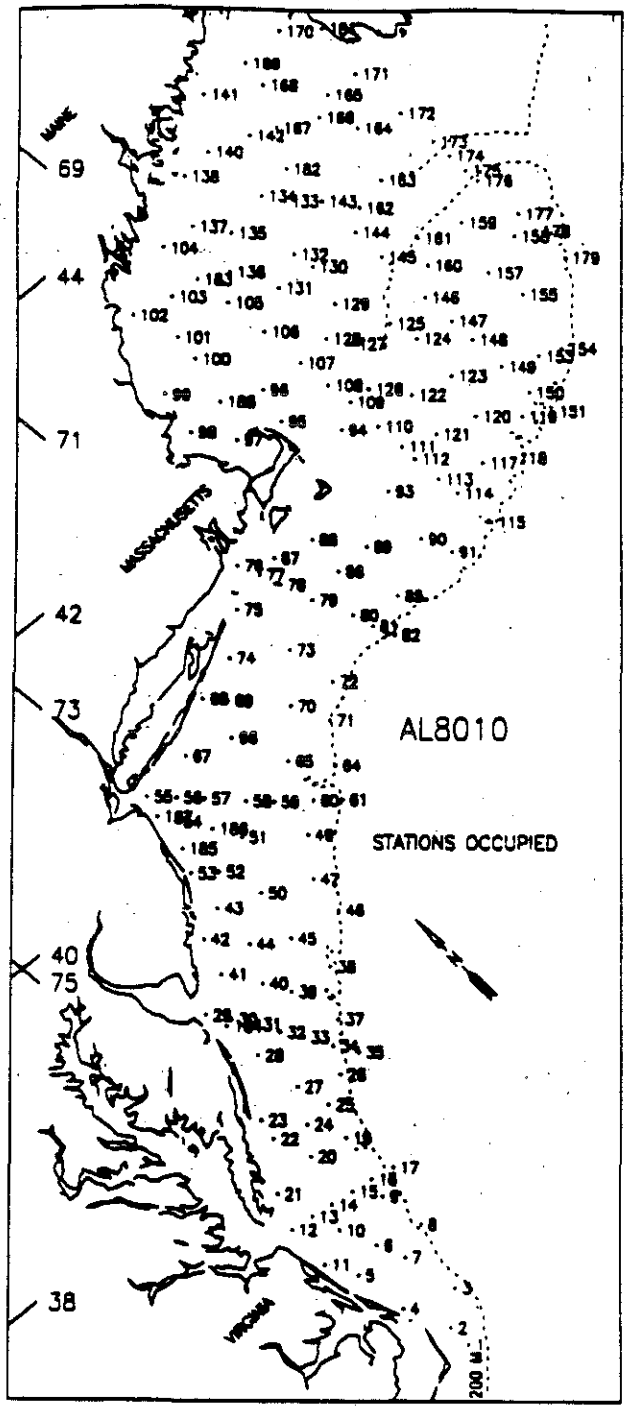


Figure 130. Station positions: ALB8010.

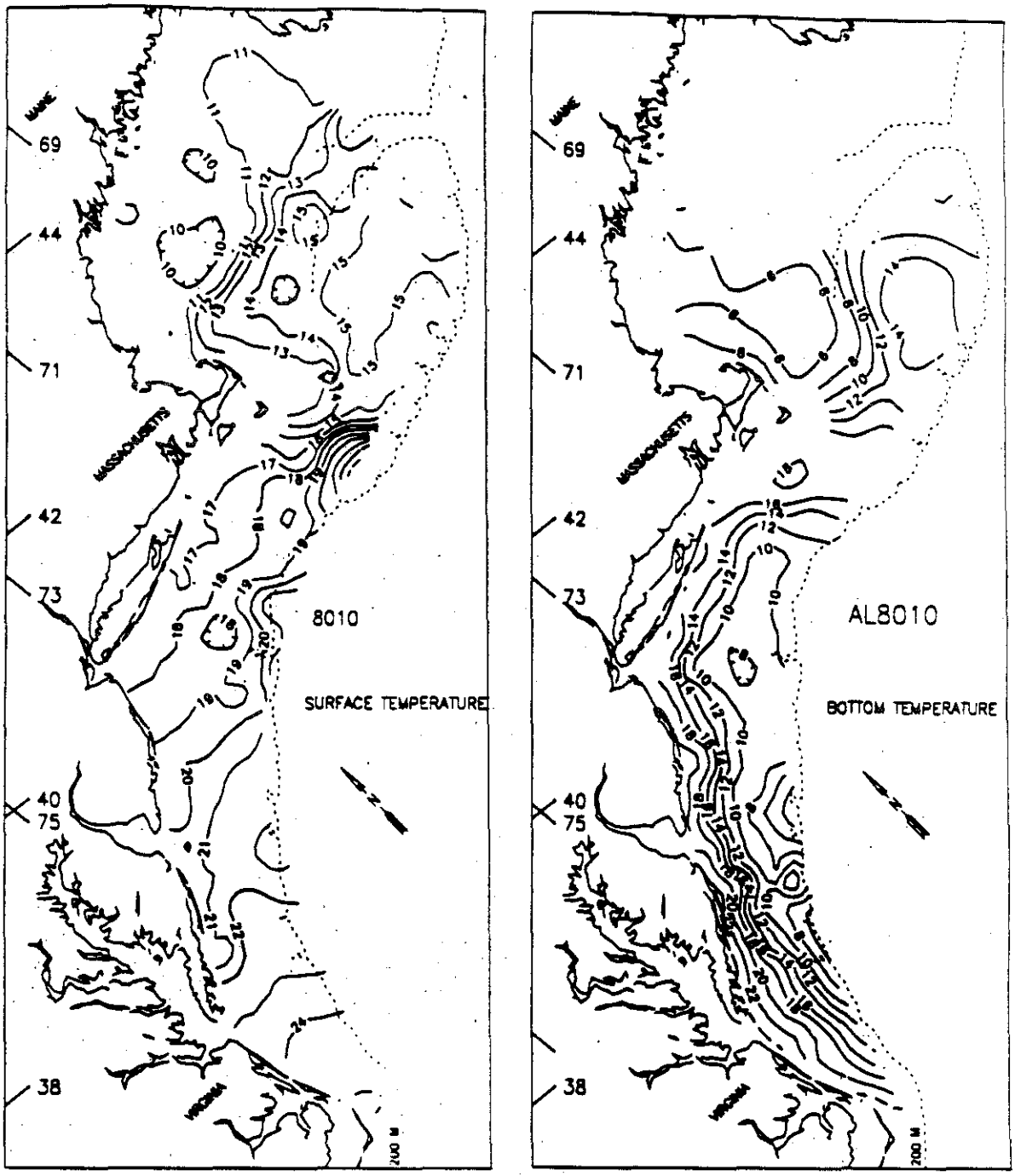


Figure 131. Surface and bottom temperature (°C) distribution: ALB8010.

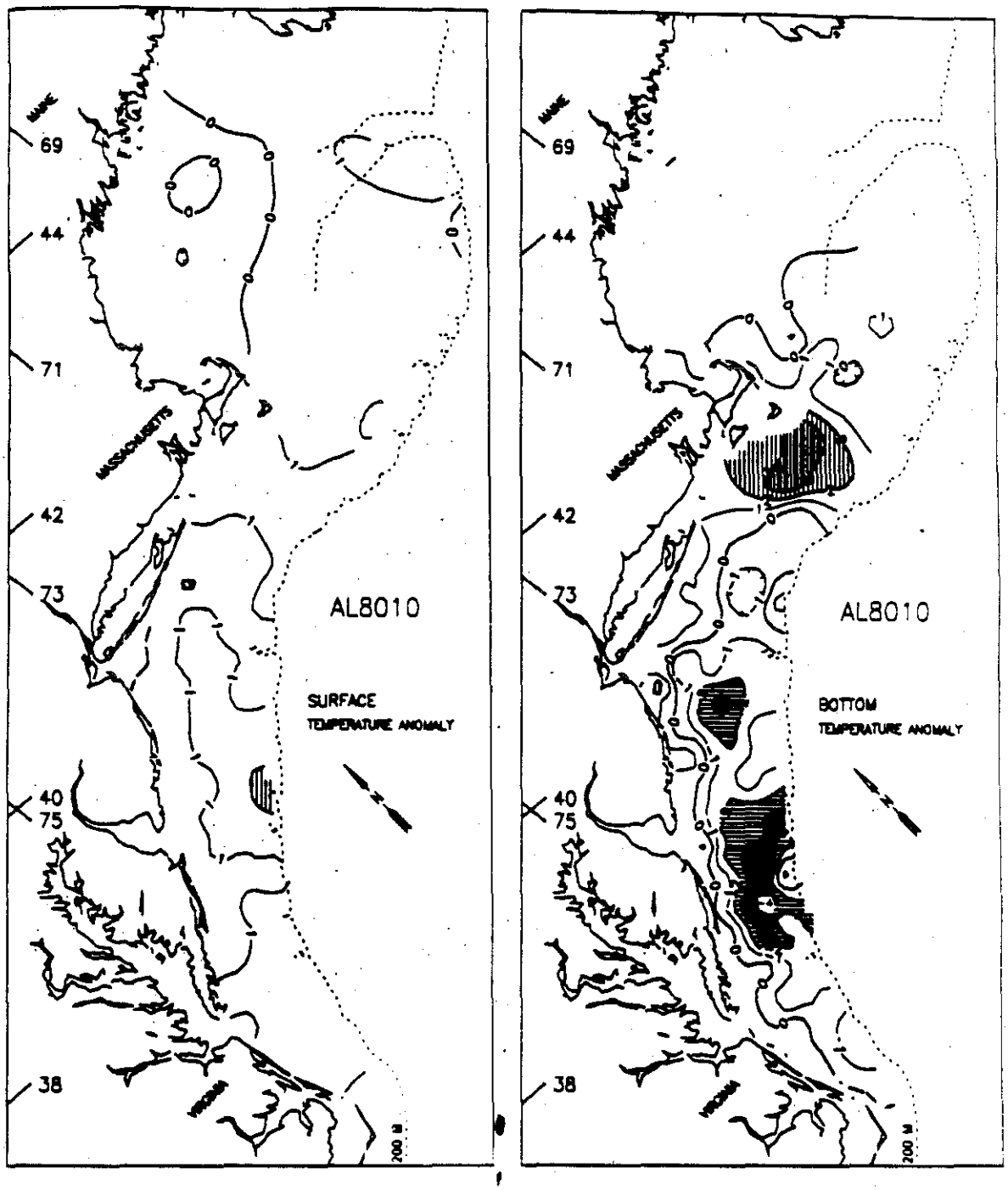


Figure 132. Normalized surface and bottom temperature anomaly: ALB8010. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

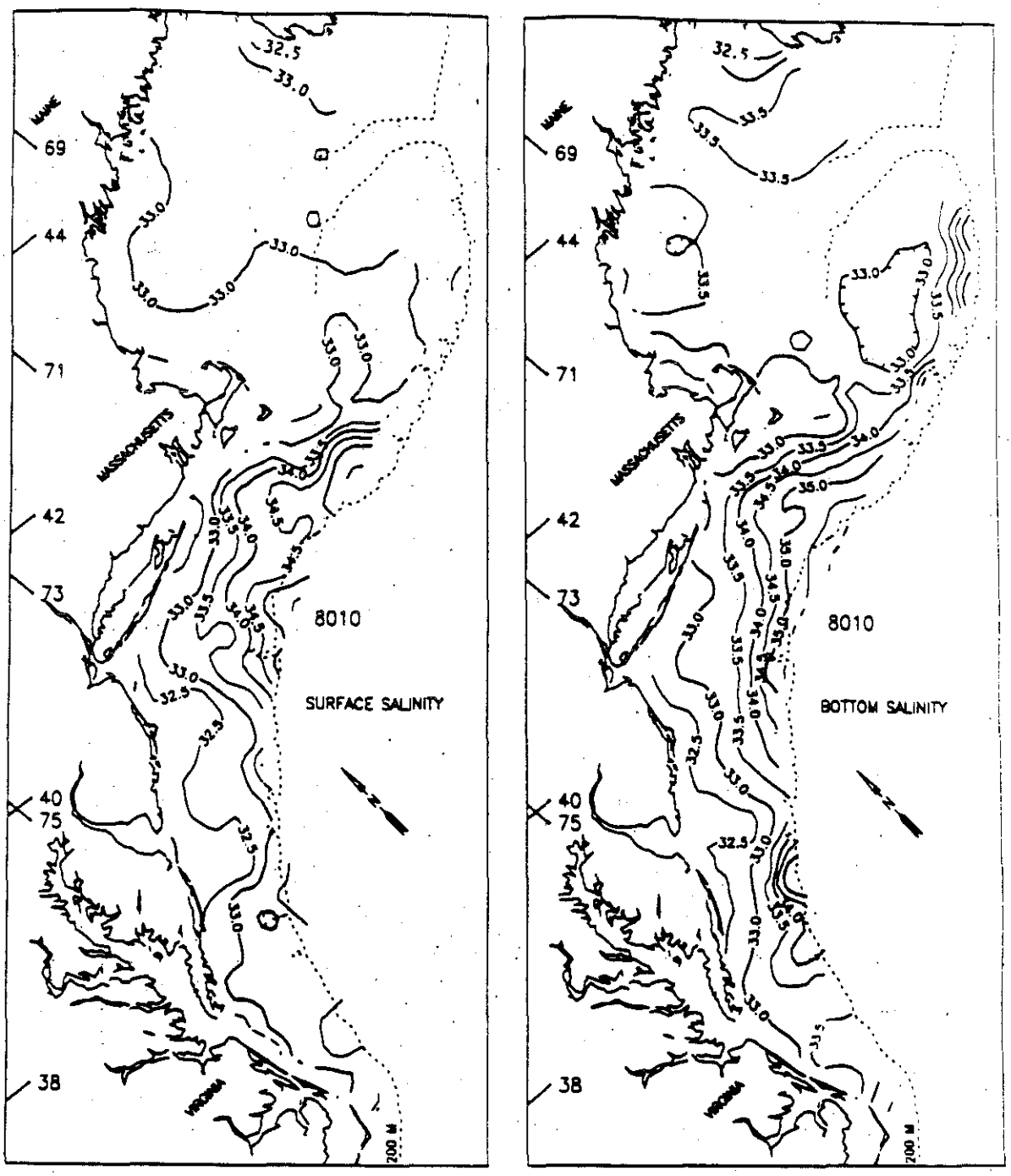


Figure 133. Surface and bottom salinity (PSU) distribution: ALB8010.

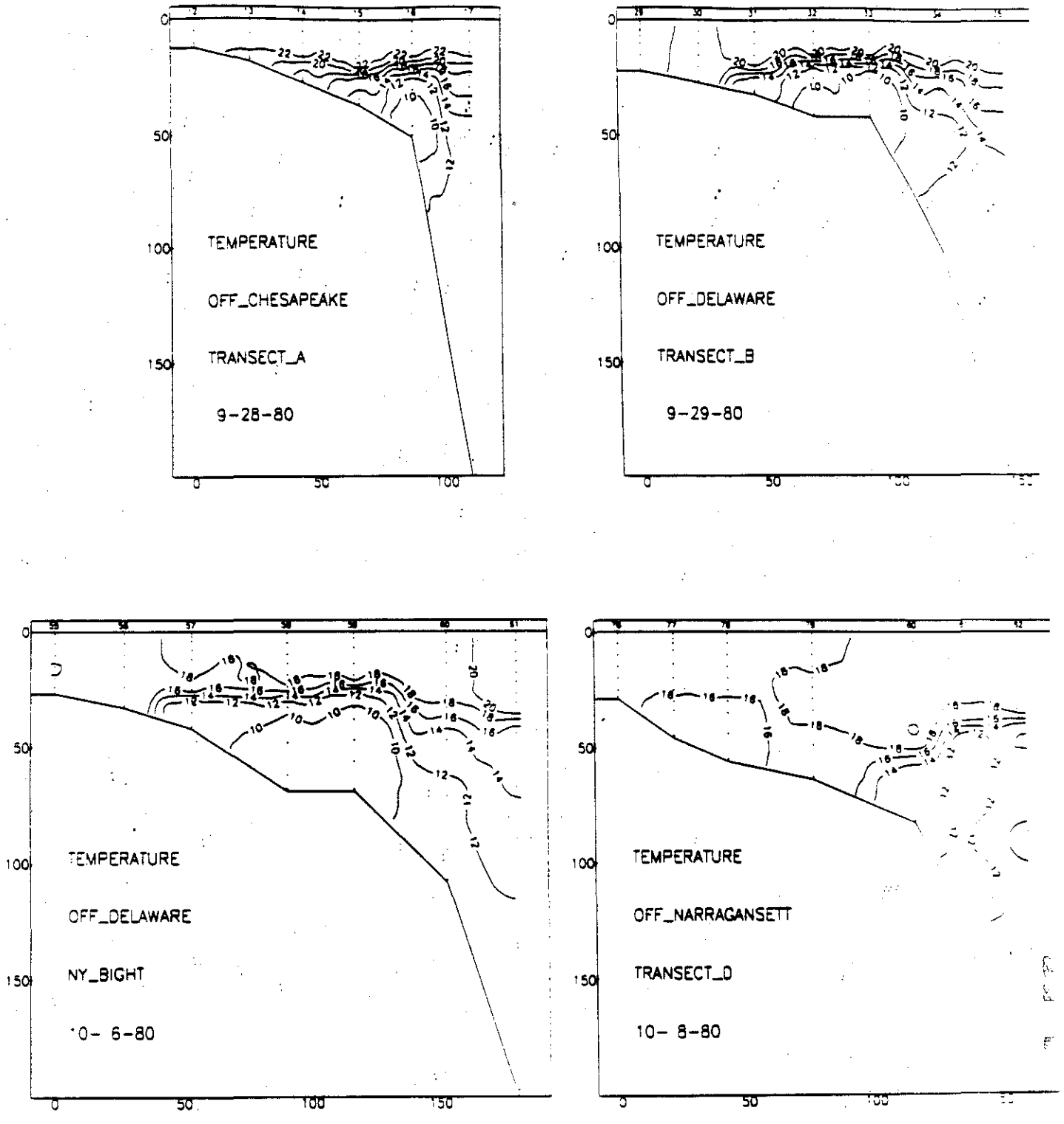


Figure 134. Temperature (°C) transects: ALB8010.

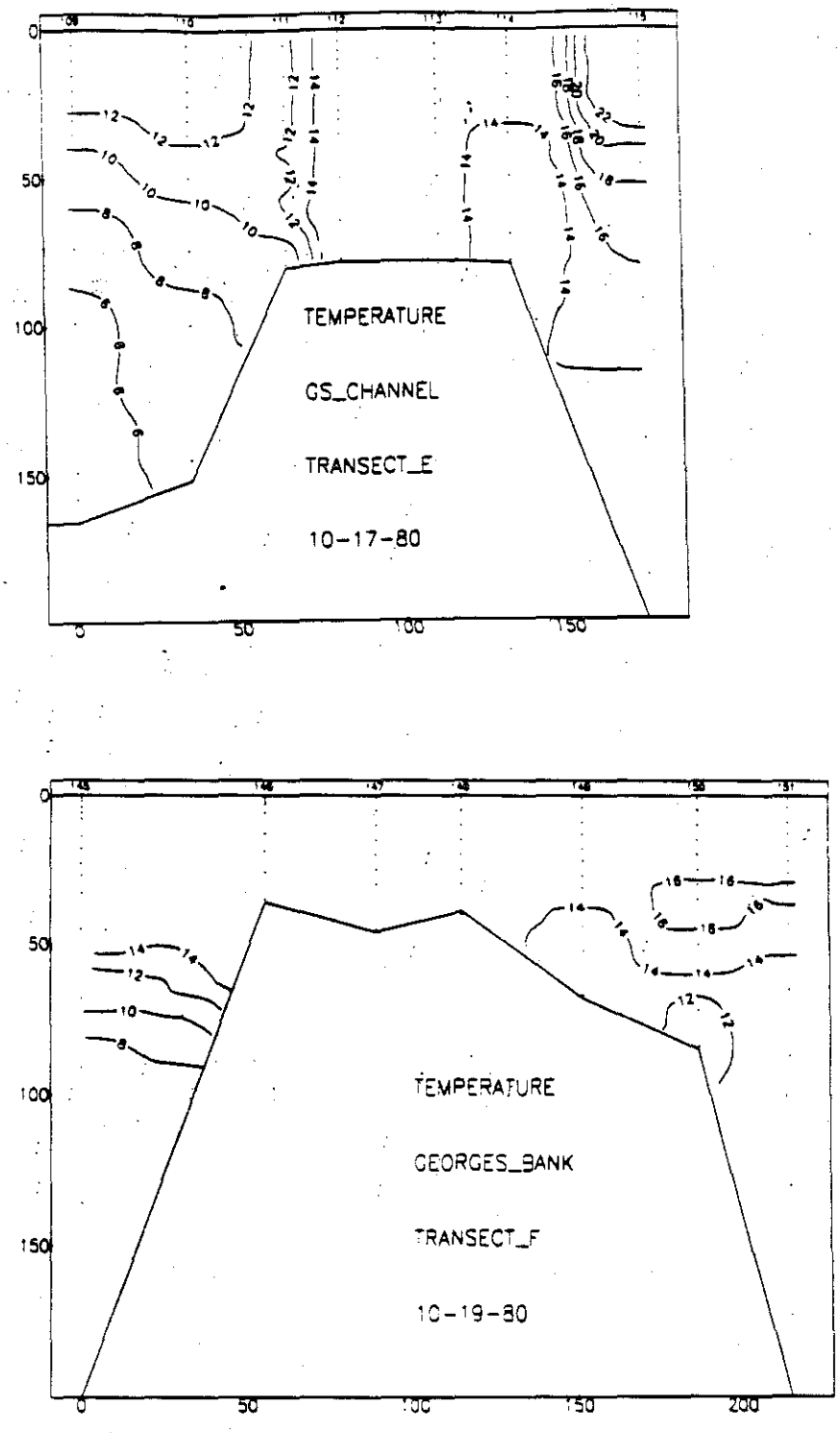


Figure 134. Continued.

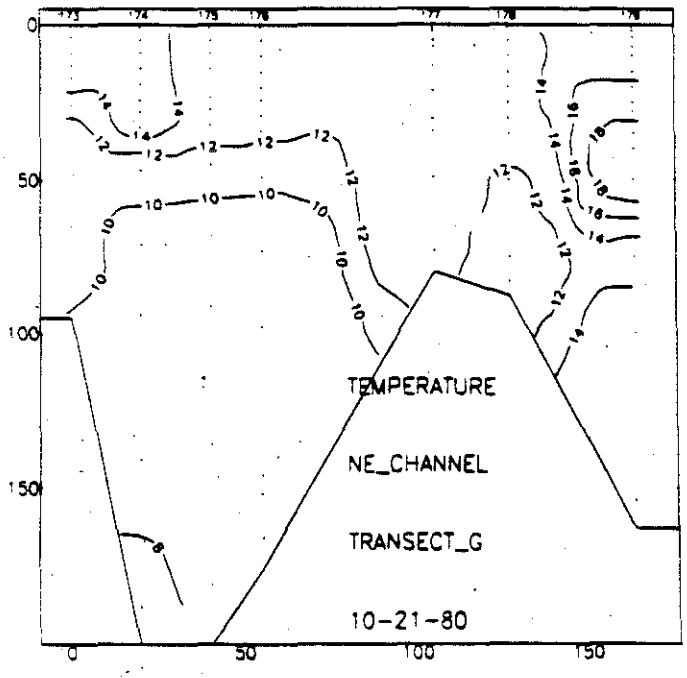


Figure 134. Continued.

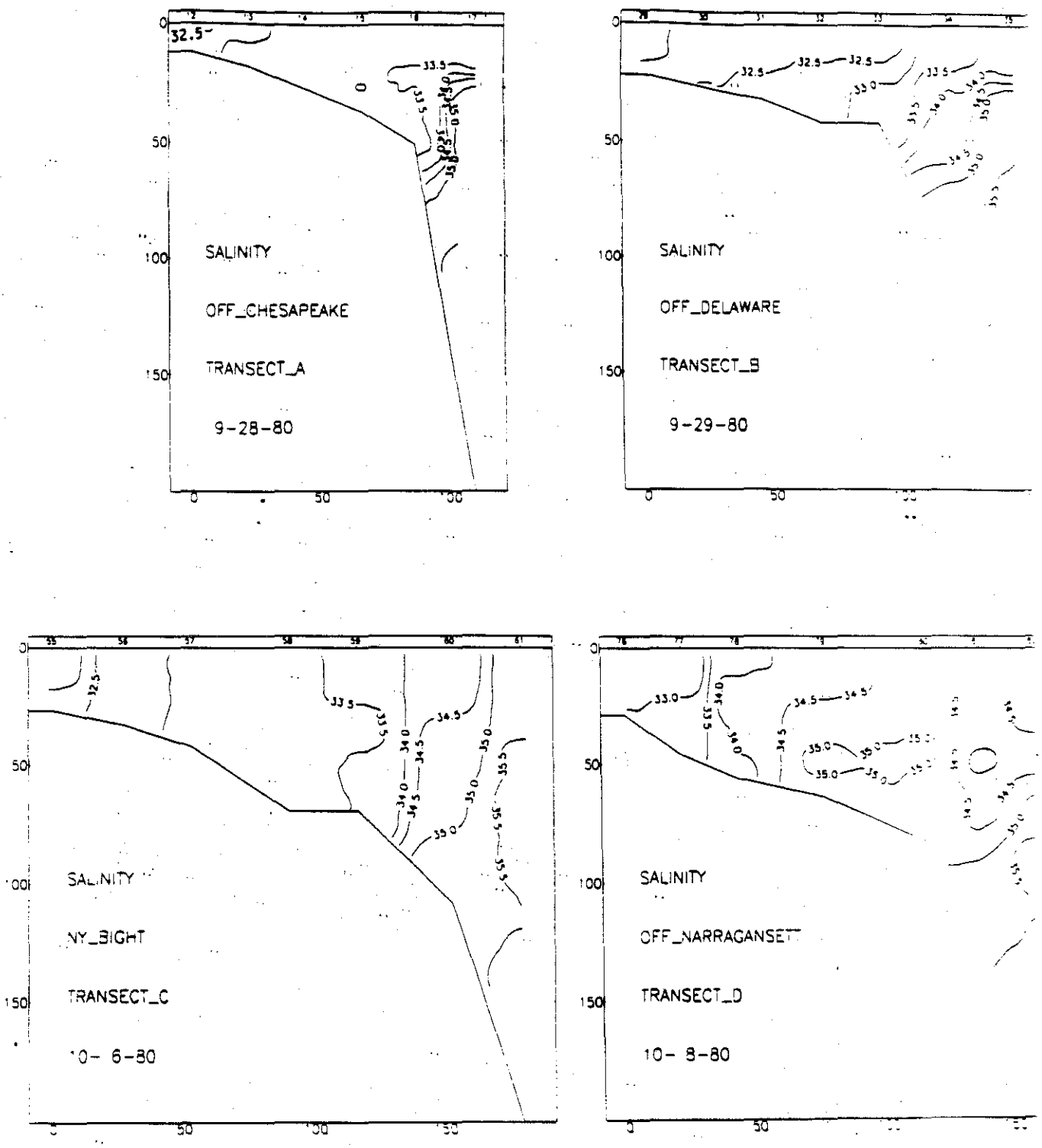


Figure 135. Salinity (PSU) transects: ALB8010.

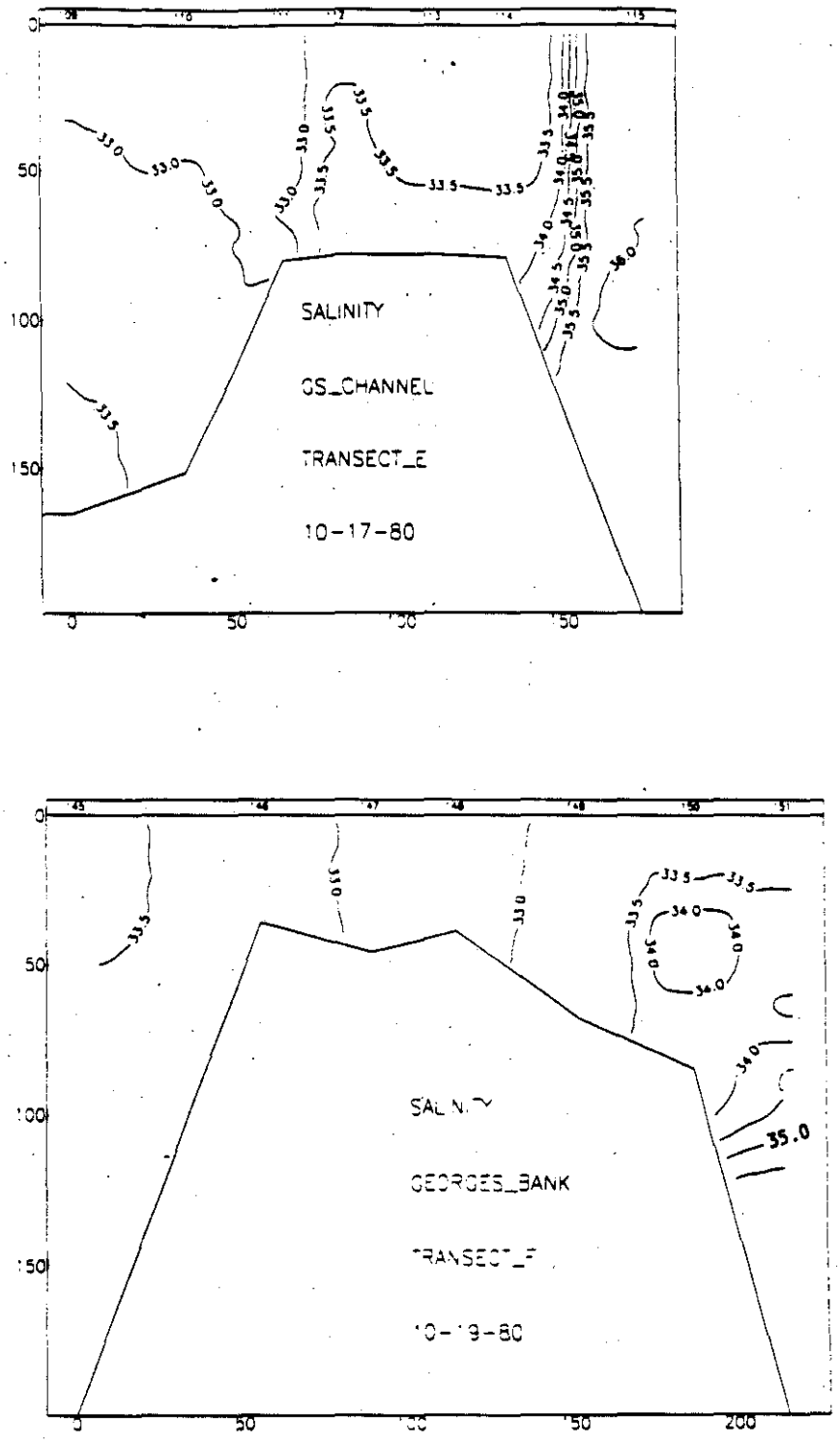


Figure 135. Continued.

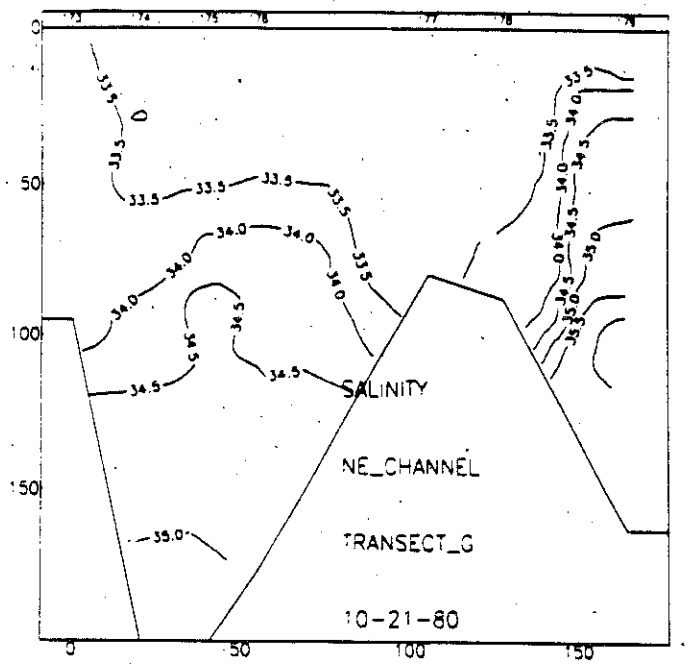


Figure 135. Continued.

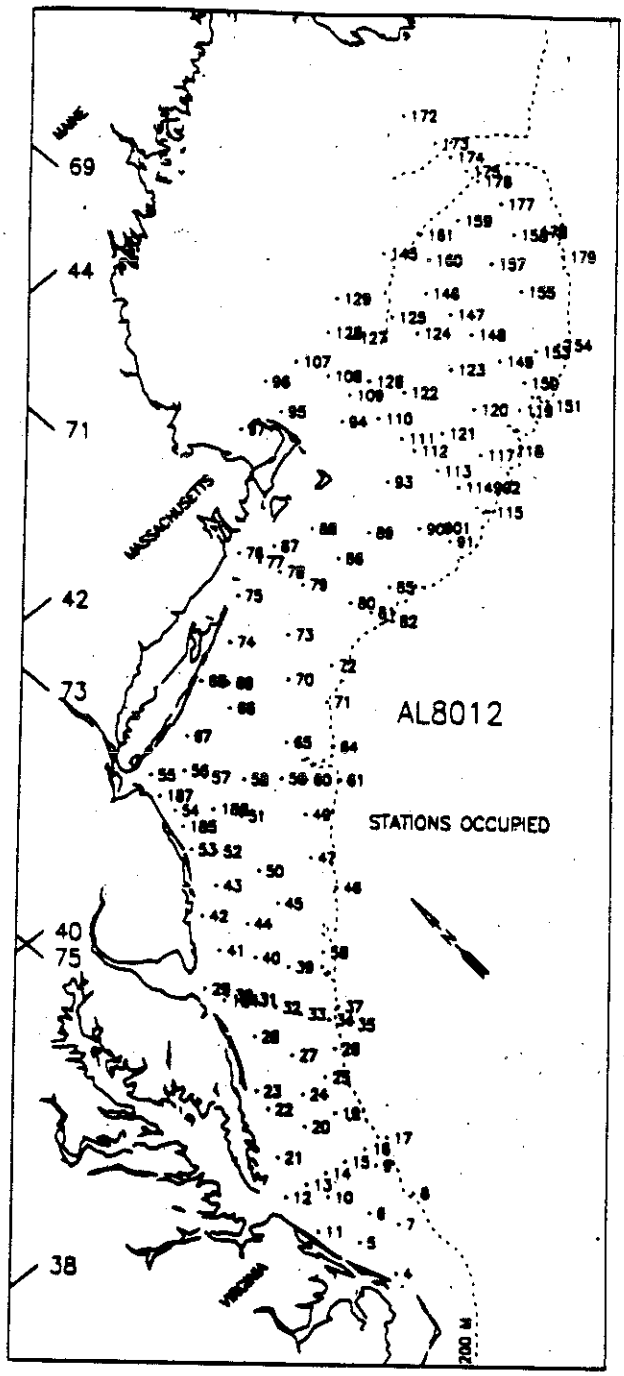


Figure 136. Station positions: ALB8012.

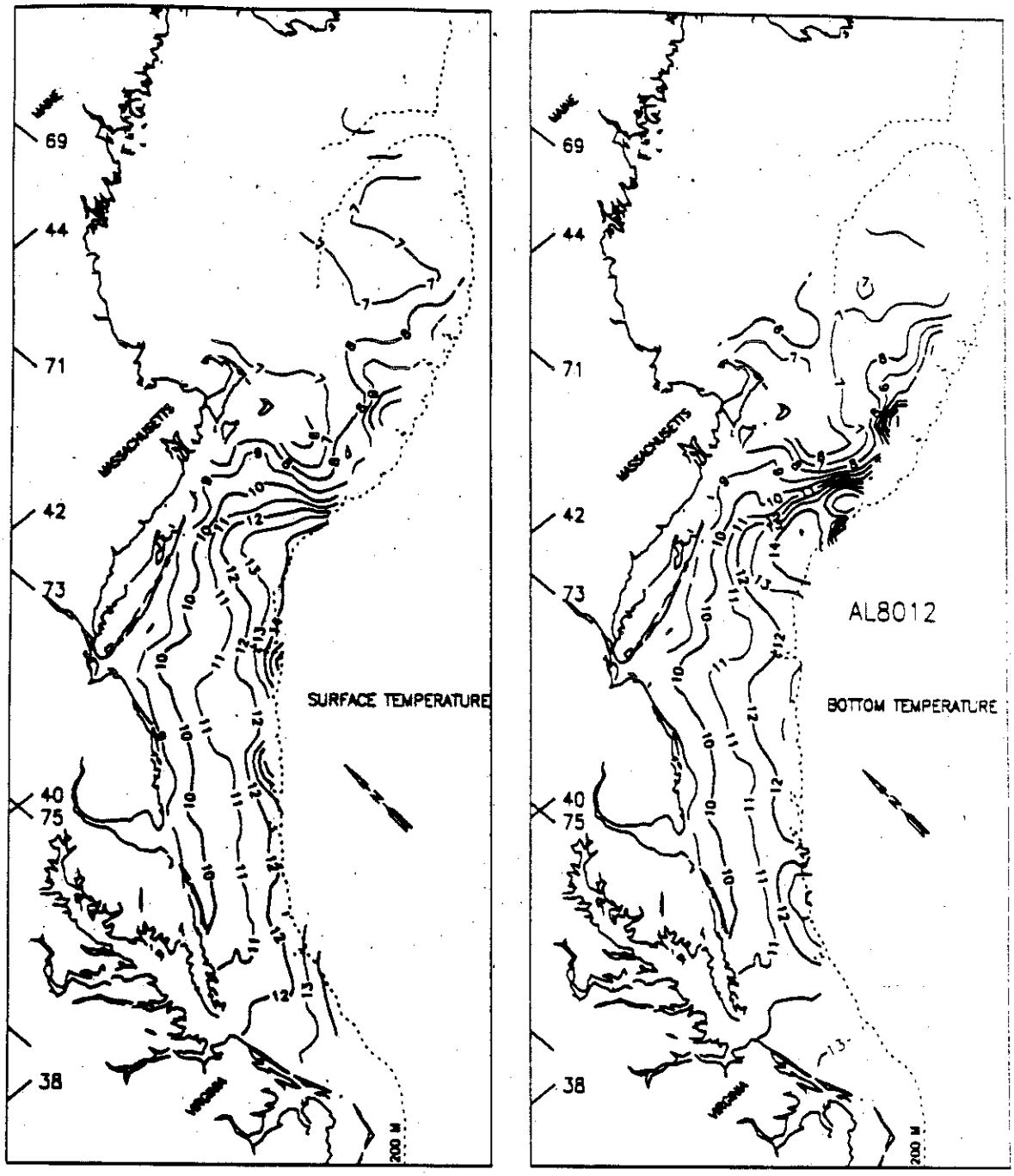


Figure 137. Surface and bottom temperature (°C) distribution: ALB8012.

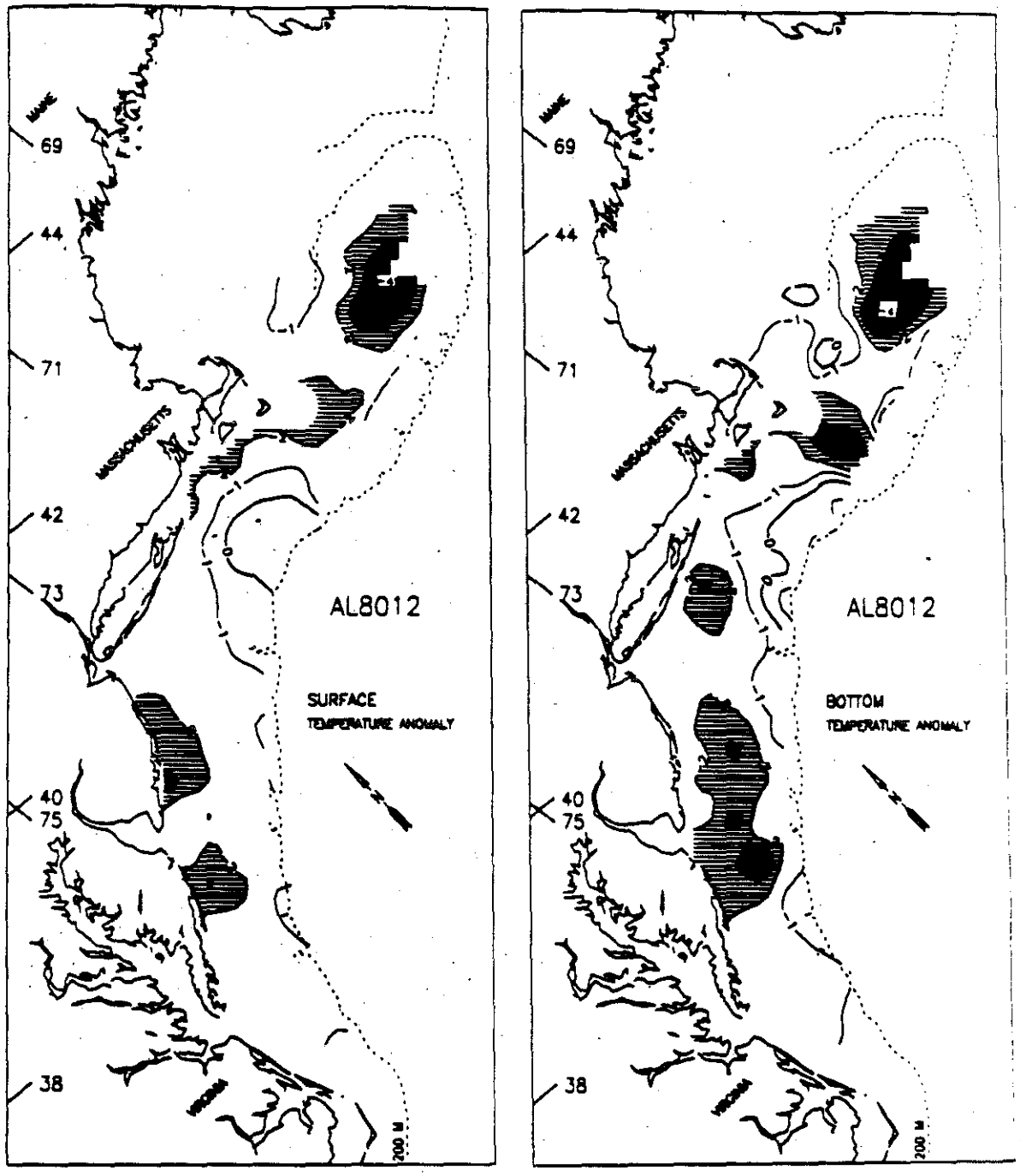


Figure 138. Normalized surface and bottom temperature anomaly: ALB8012. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

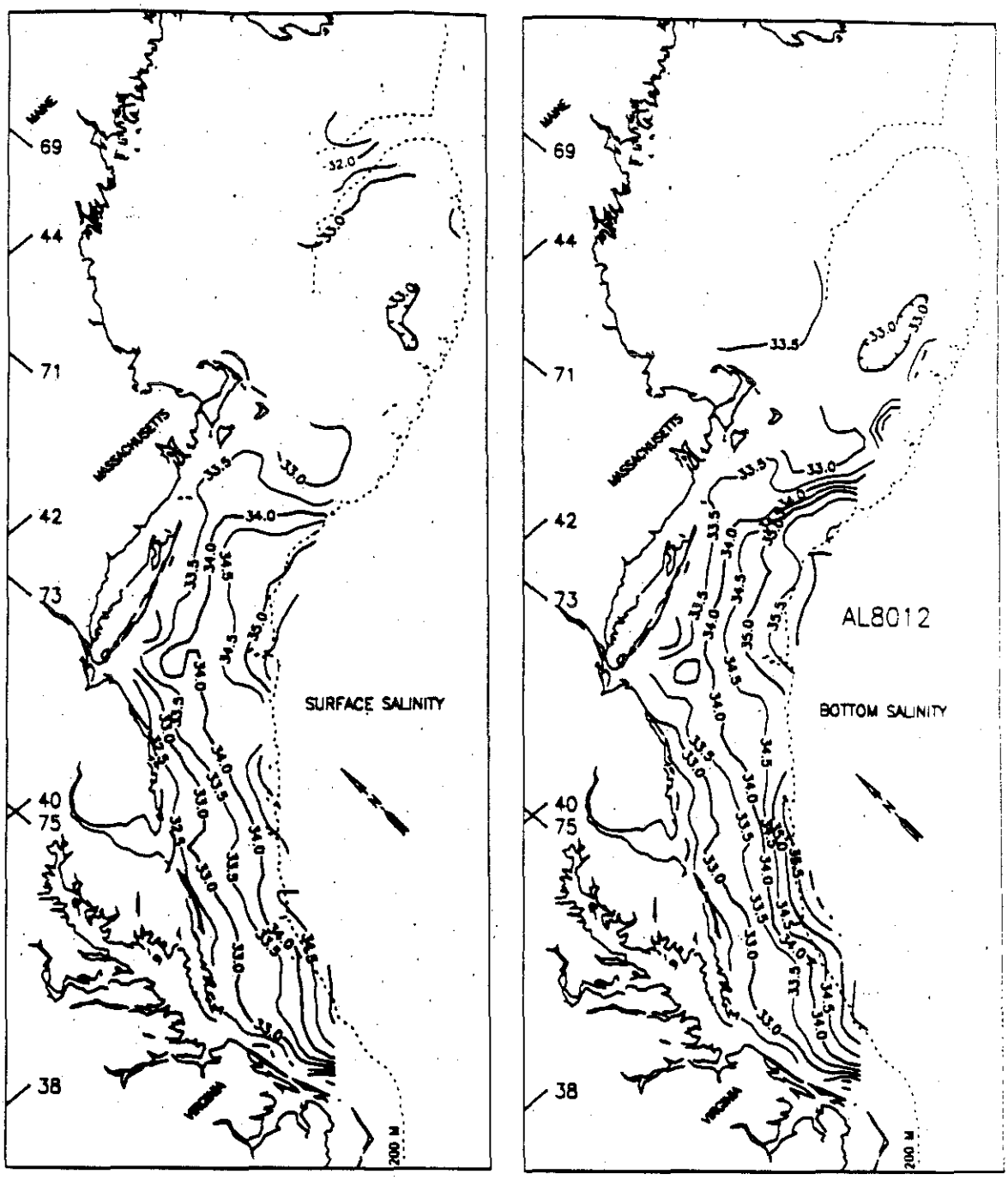
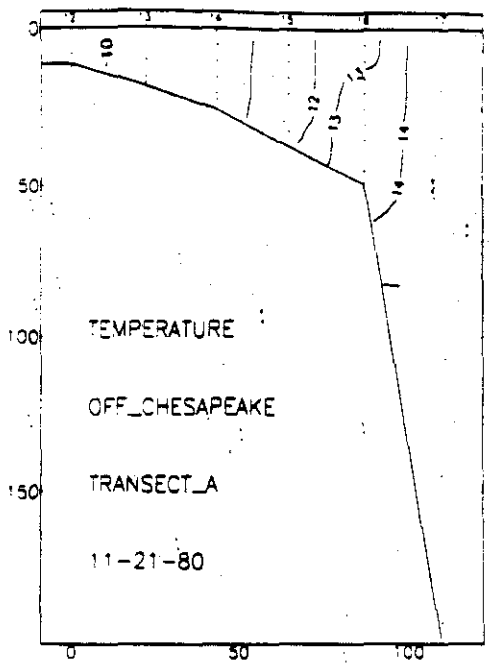
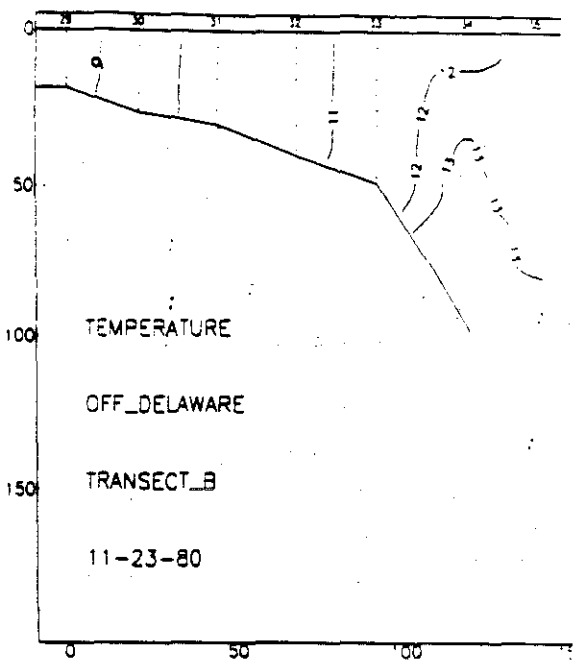
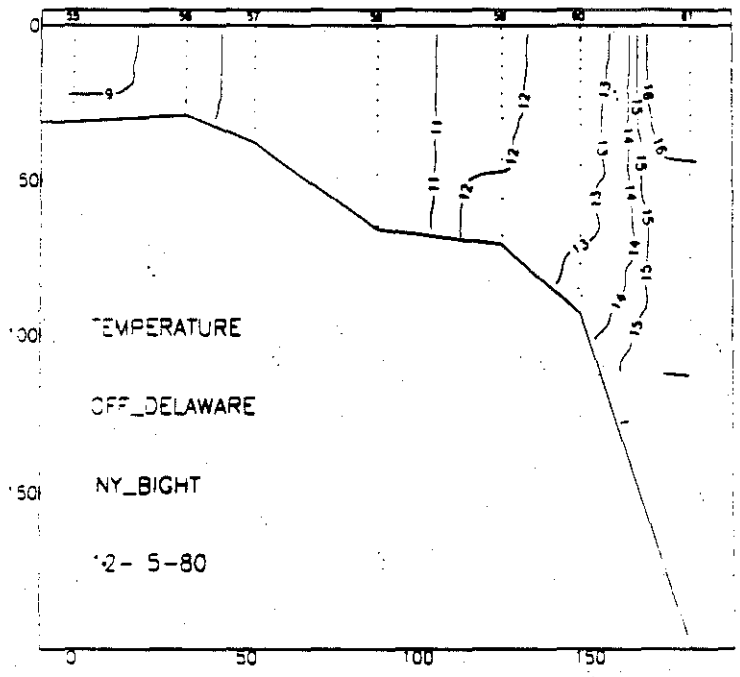


Figure 139. Surface and bottom salinity (PSU) distribution: ALB8012.







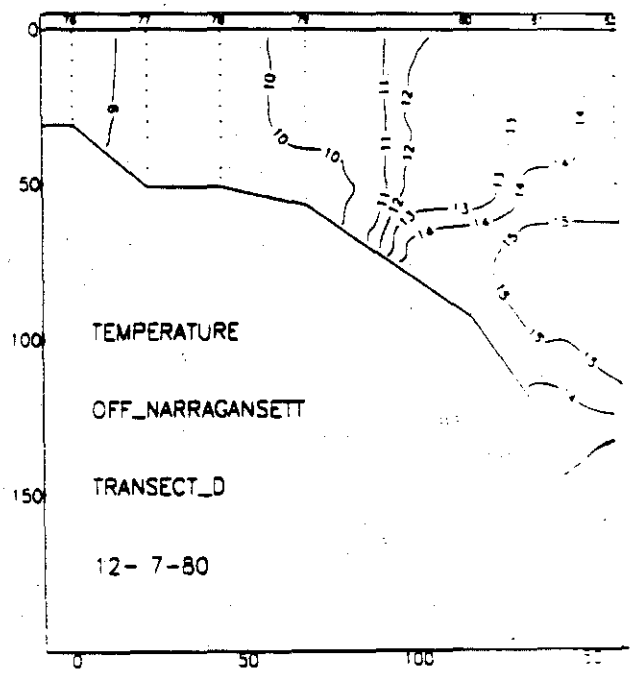
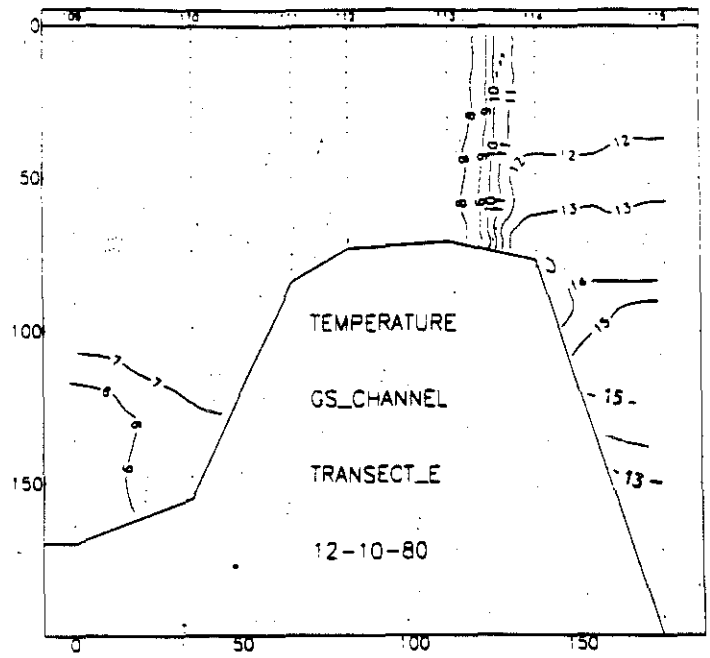


Figure 140. Temperature (°C) transects: ALB8012.



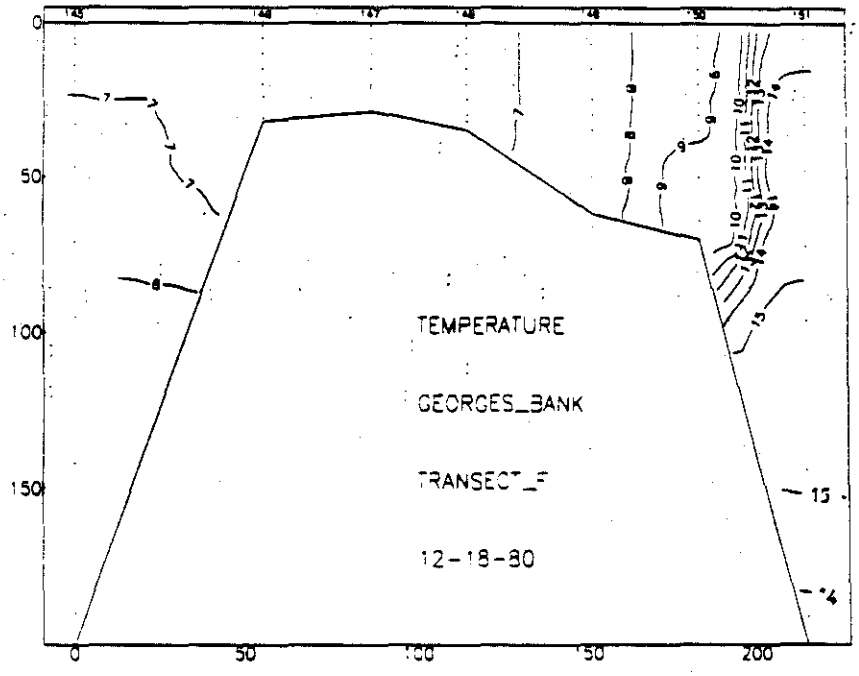


Figure 140. Continued.

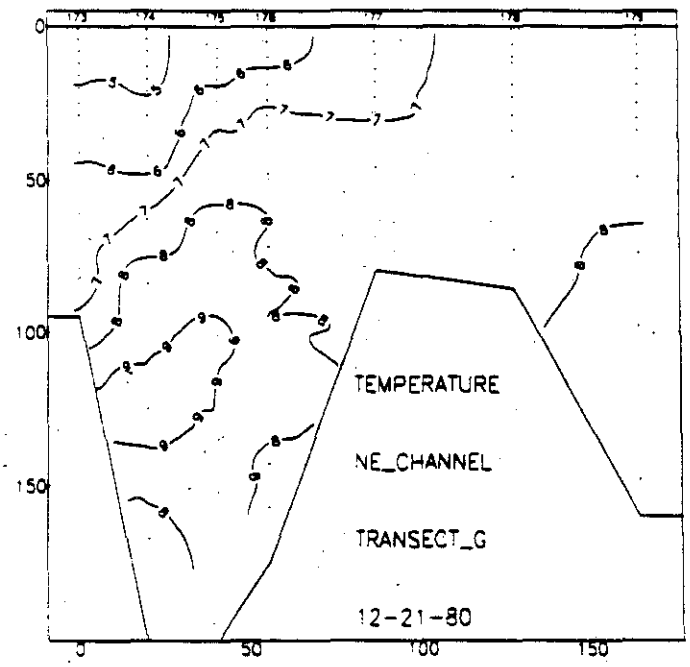
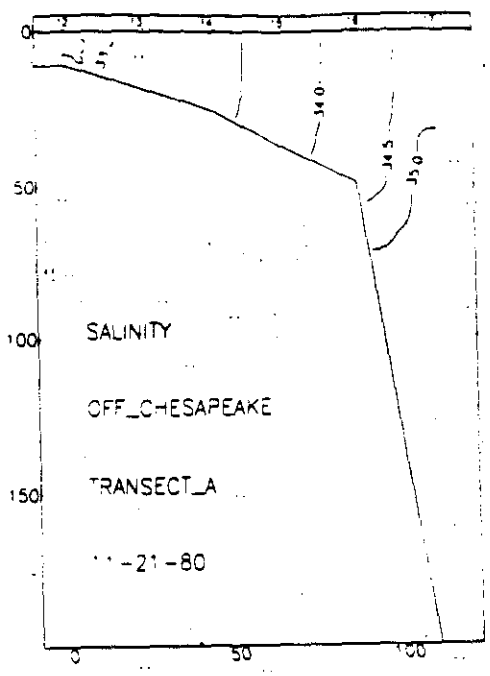
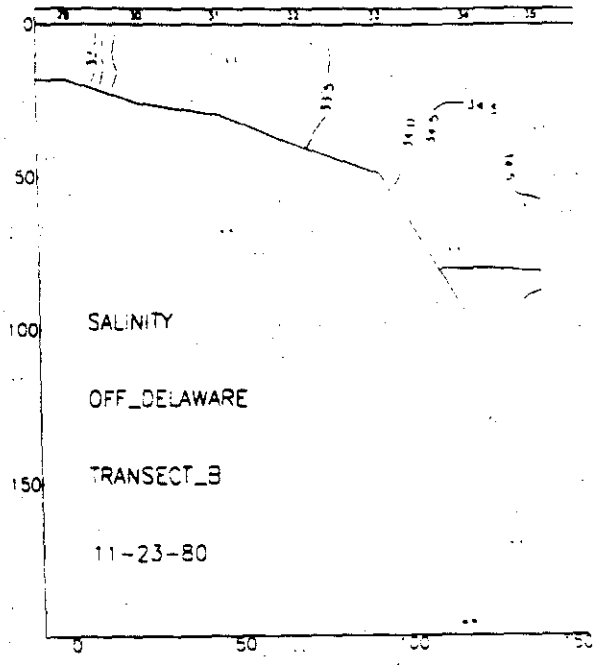
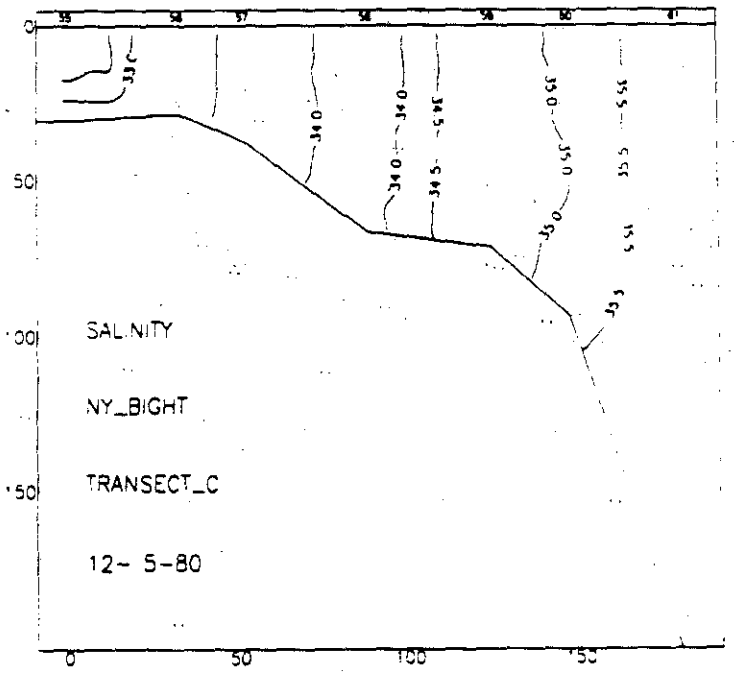


Figure 140. Continued.







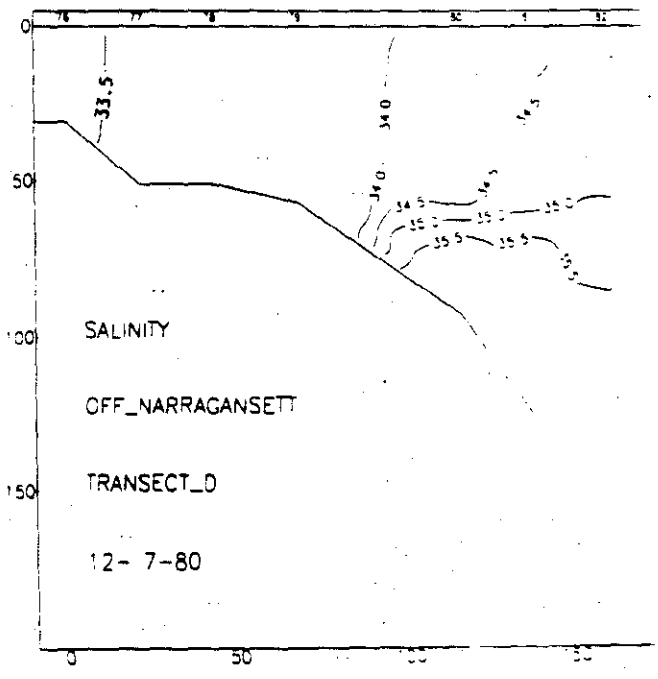
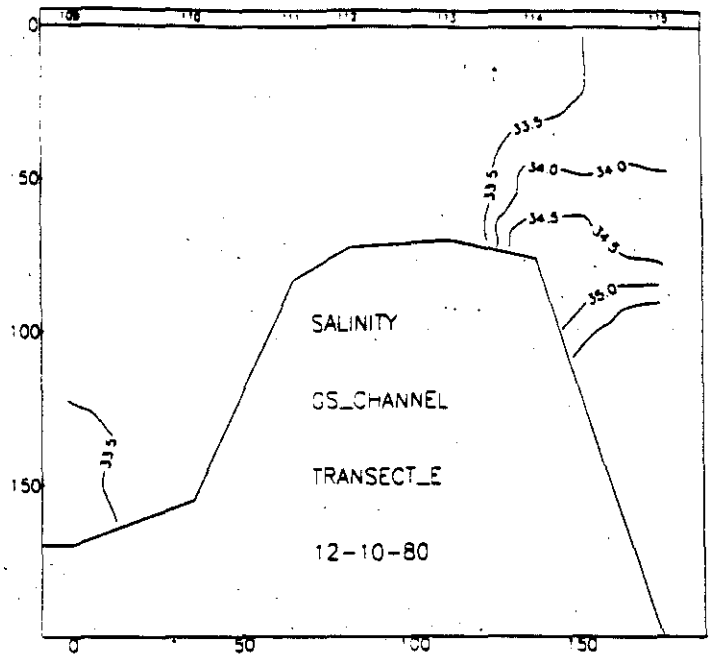


Figure 141. Salinity (PSU) transects: ALB8012.



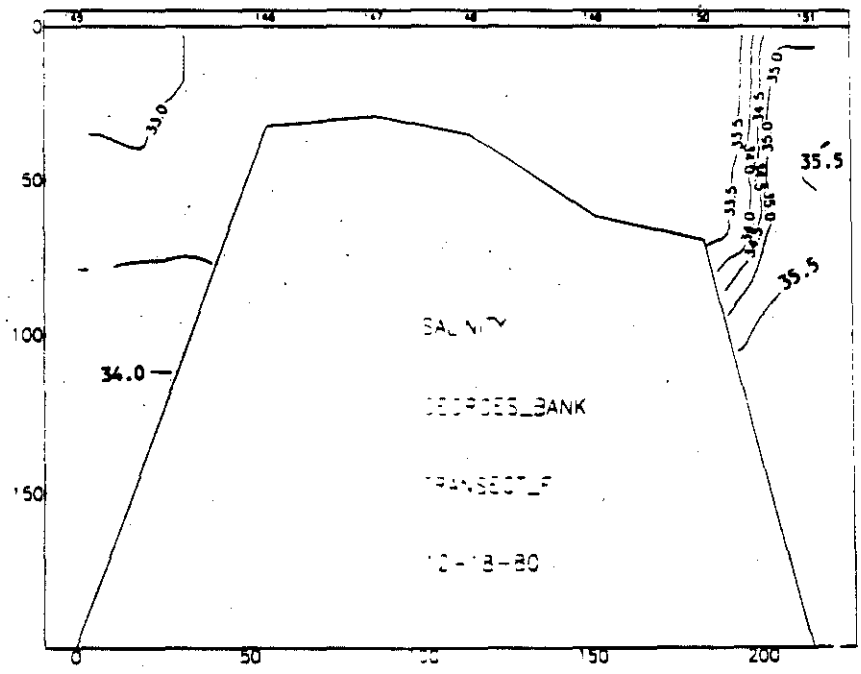


Figure 141. Continued.

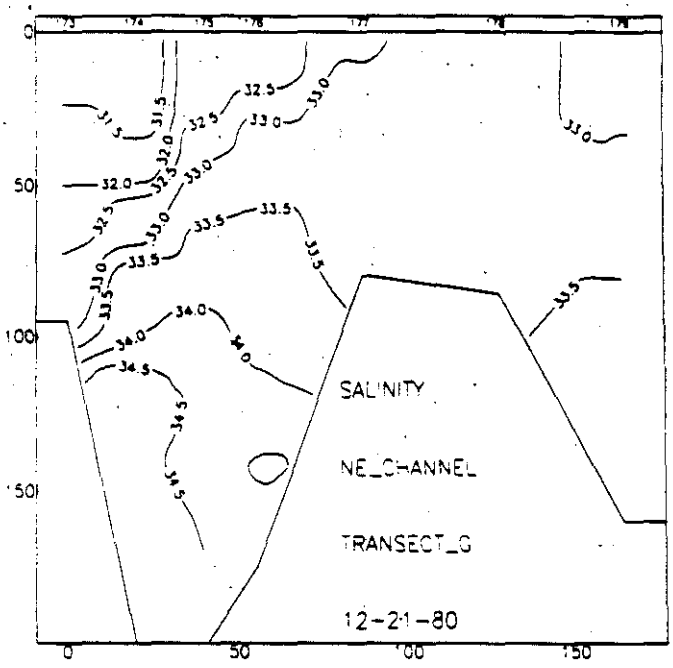


Figure 141. Continued.

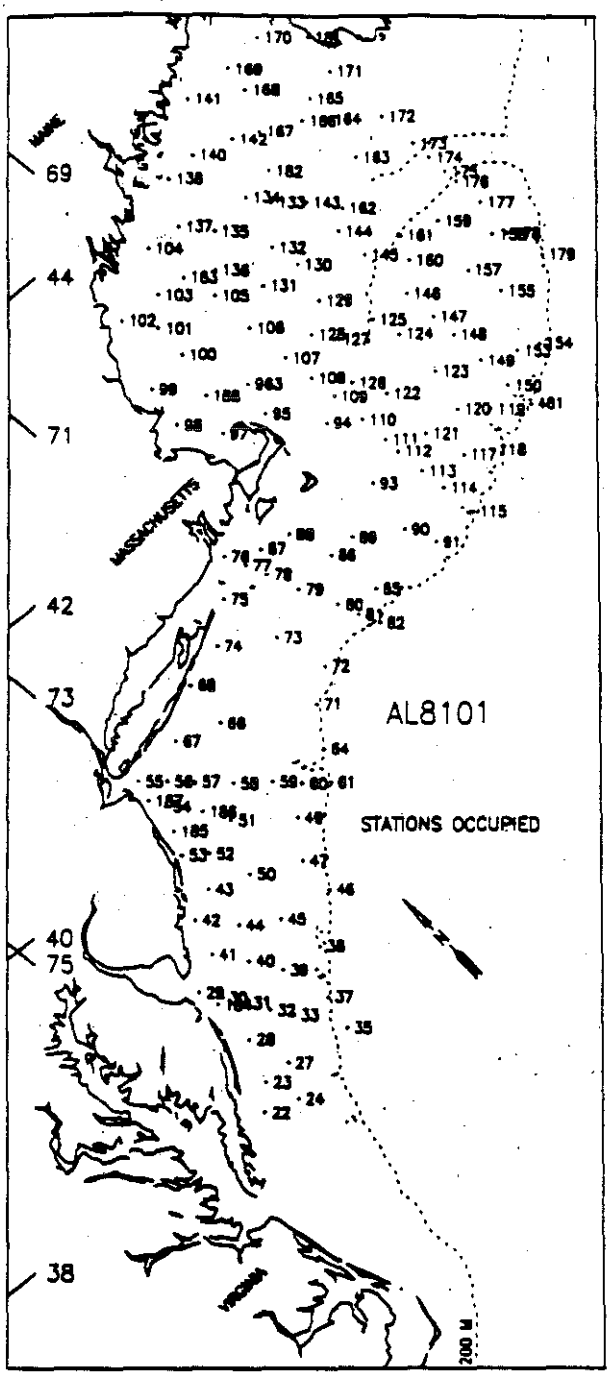


Figure 142. Station positions: ALB8101.

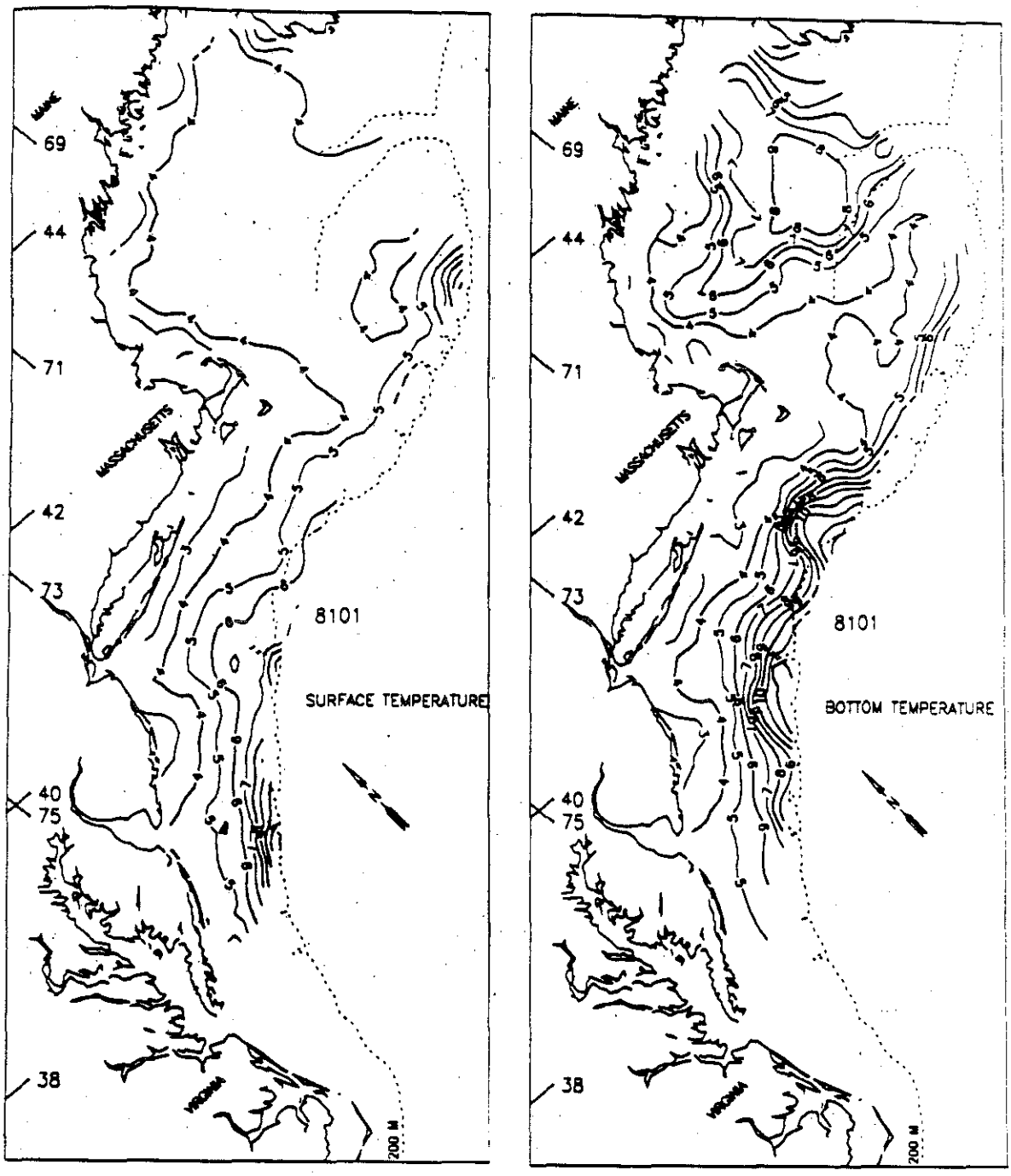


Figure 143. Surface and bottom temperature (°C) distribution: ALB8101.

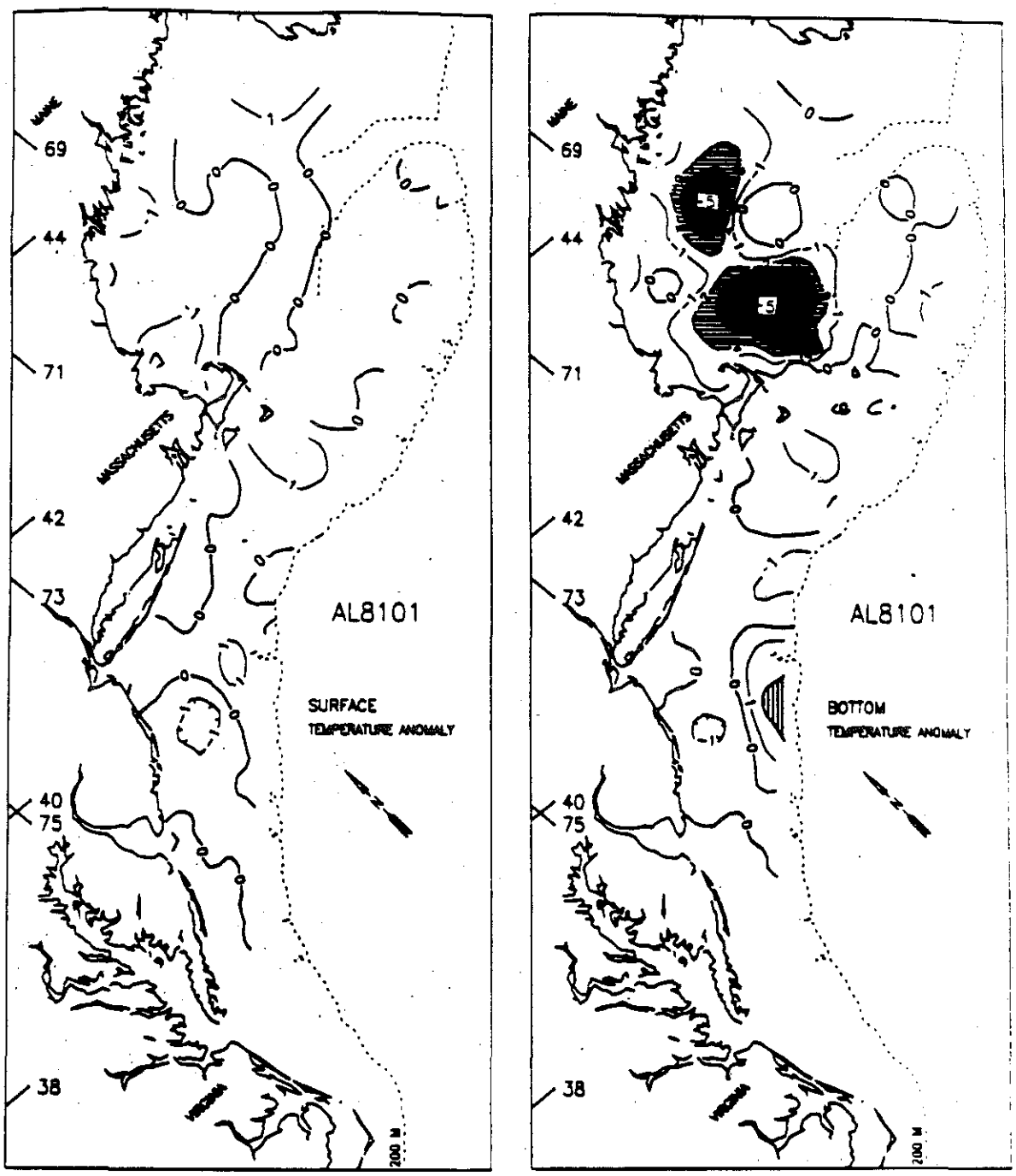


Figure 144. Normalized surface and bottom temperature anomaly: ALB8101. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

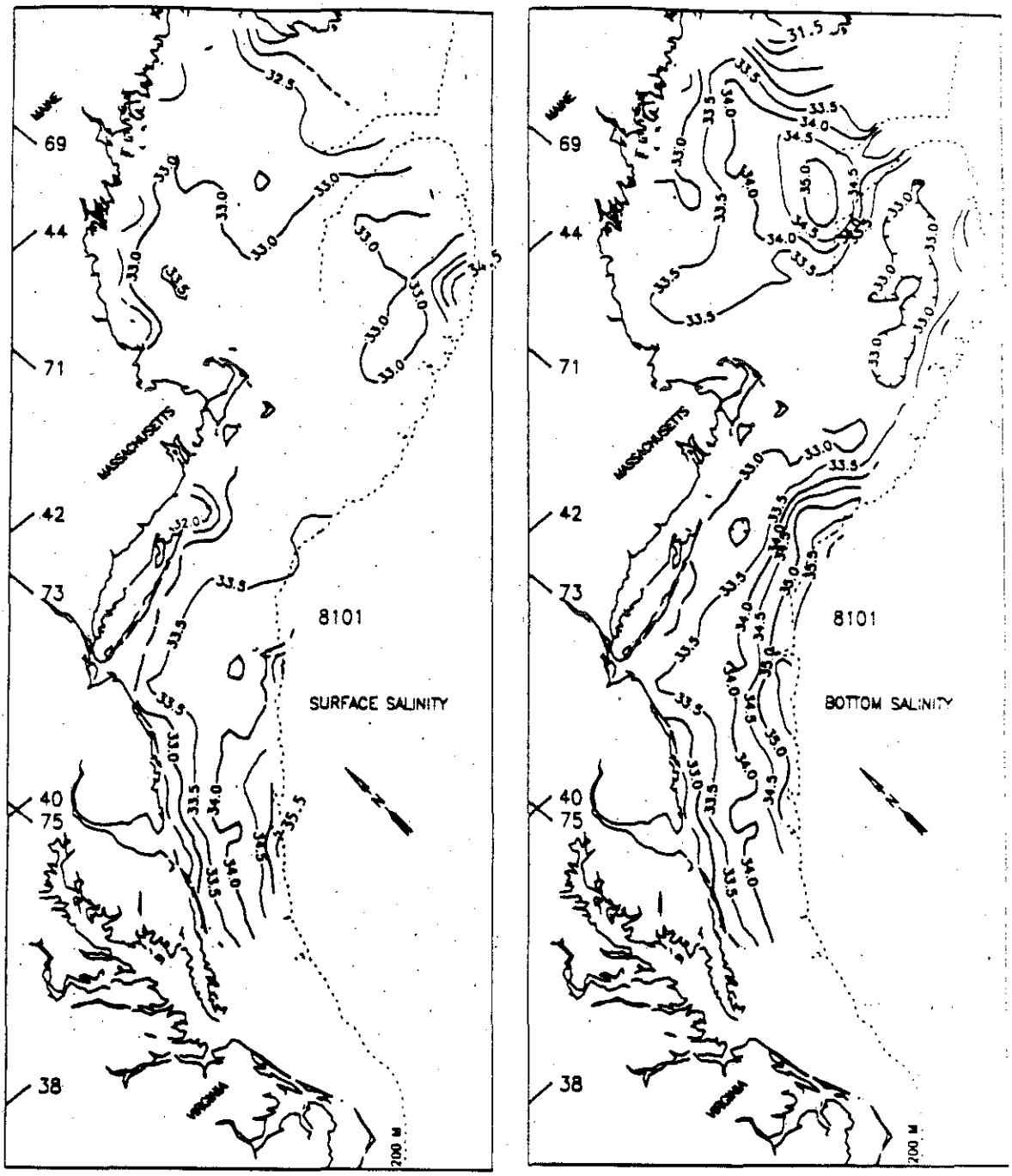
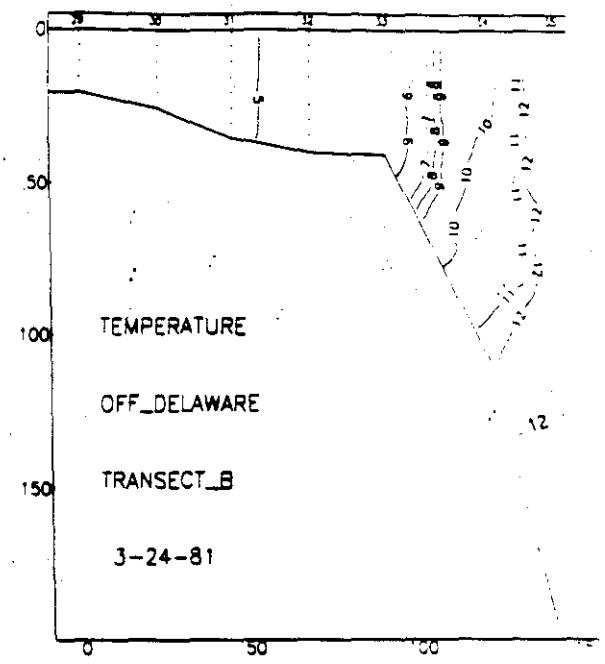
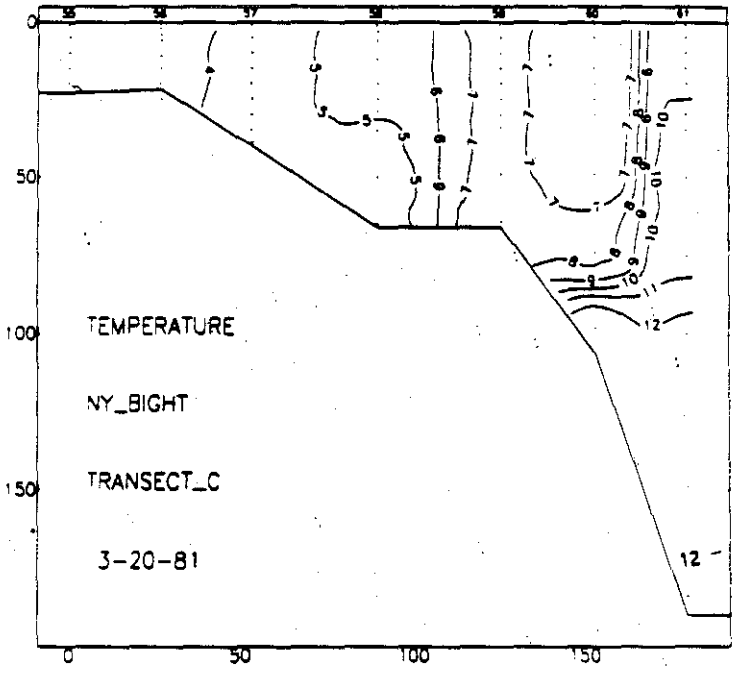


Figure 145. Surface and bottom salinity (PSU) distribution: ALB8101.





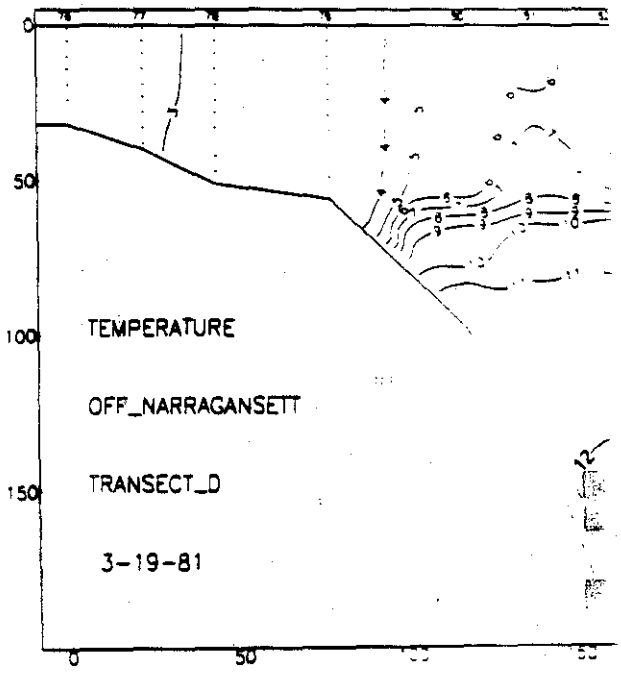


Figure 146. Temperature (°C) transects: ALB8101.

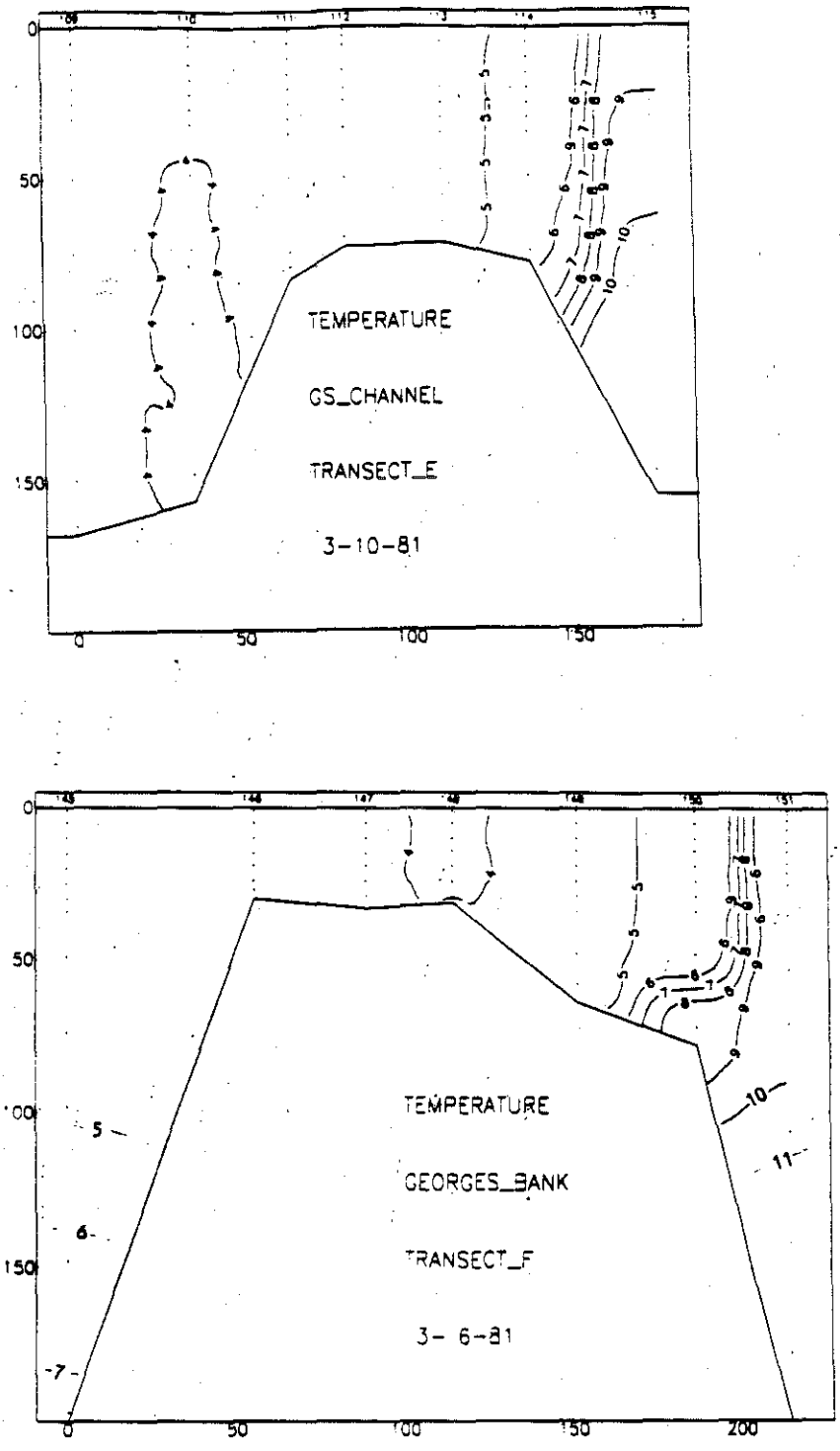


Figure 146. Continued.

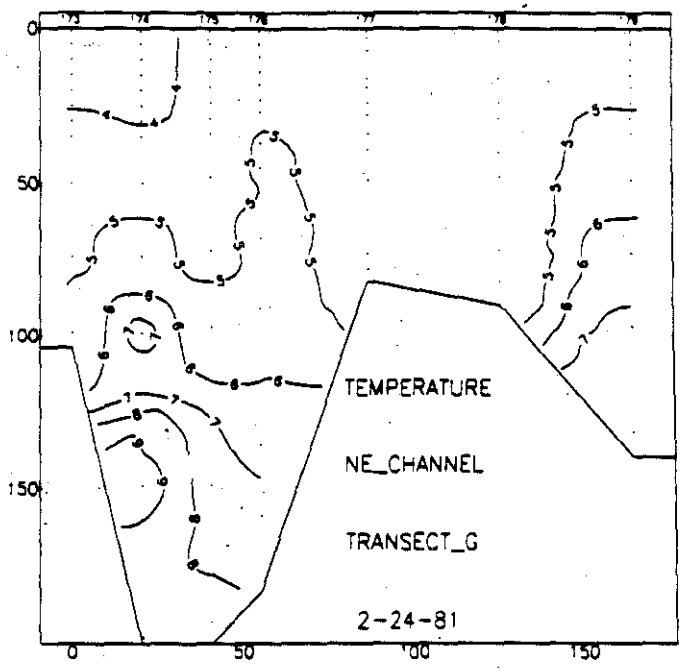
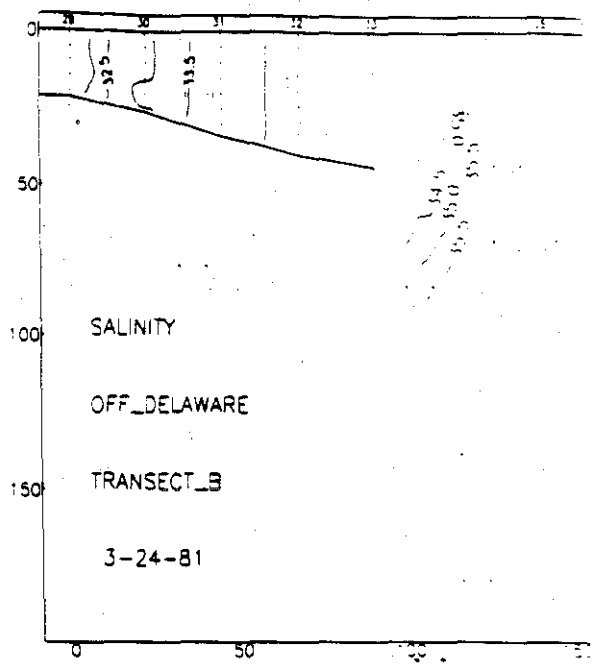
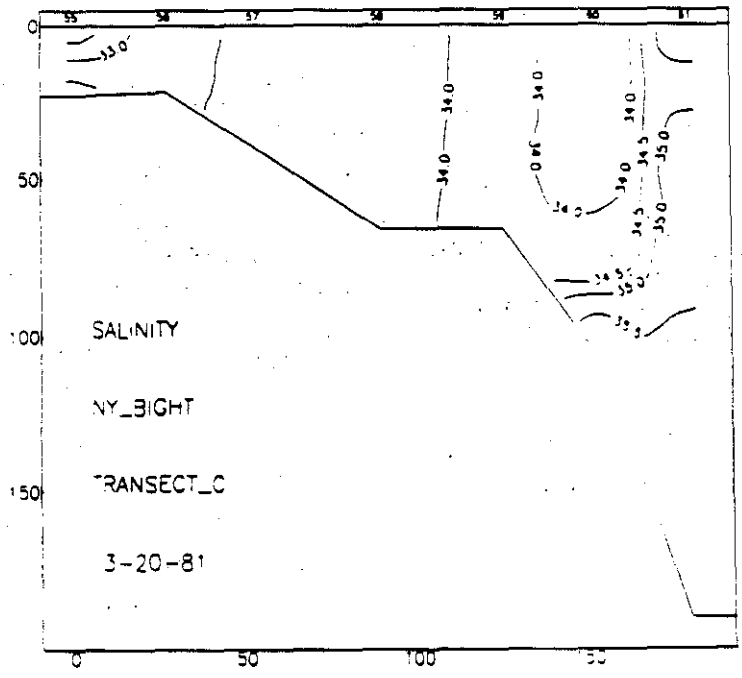


Figure 146. Continued.





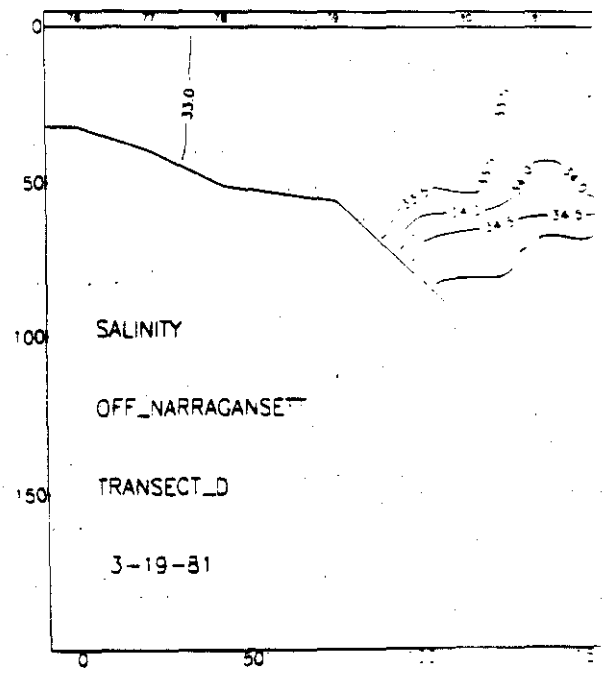
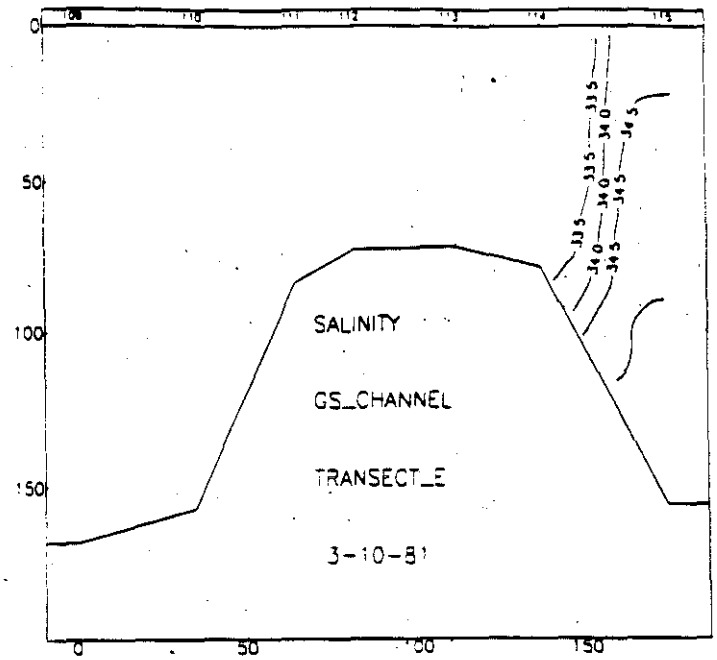


Figure 147. Salinity (PSU) transects: ALB8101.



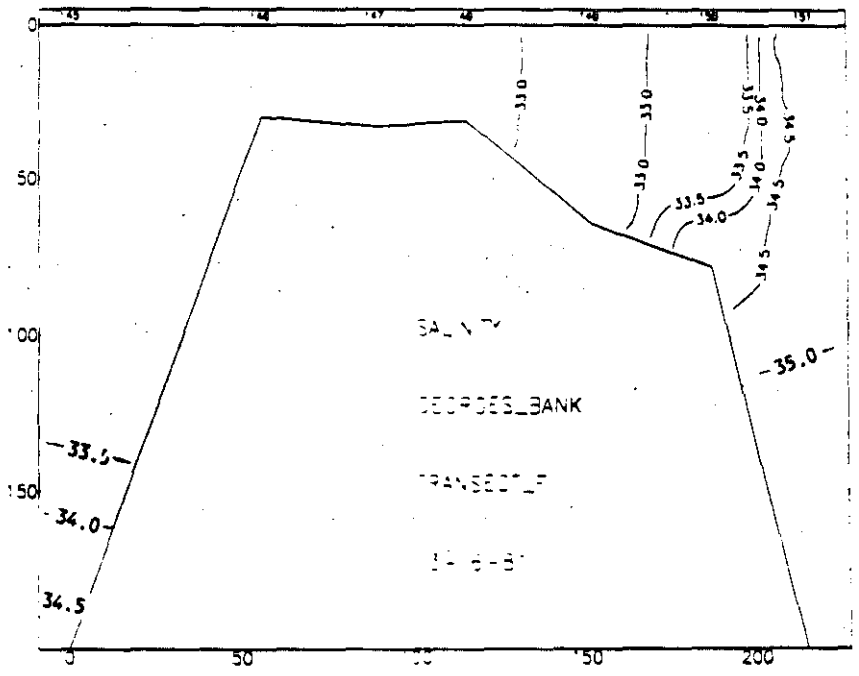


Figure 147. Continued.

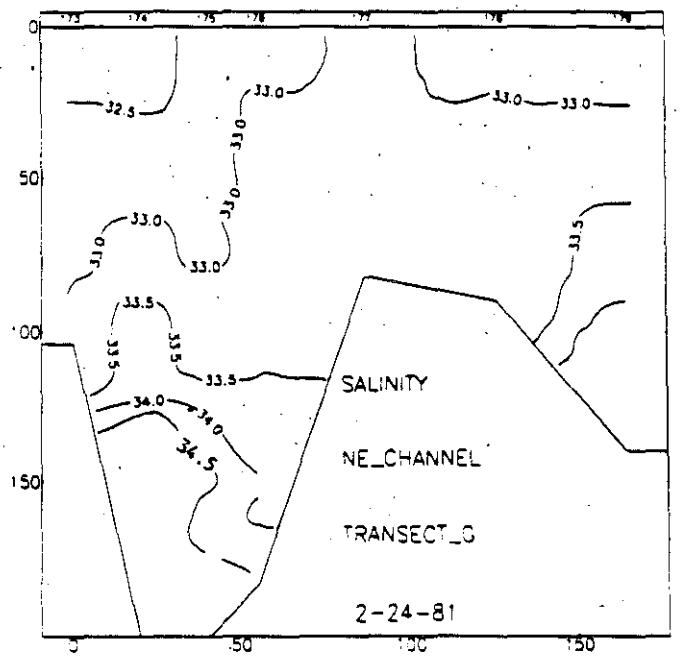


Figure 147. Continued.

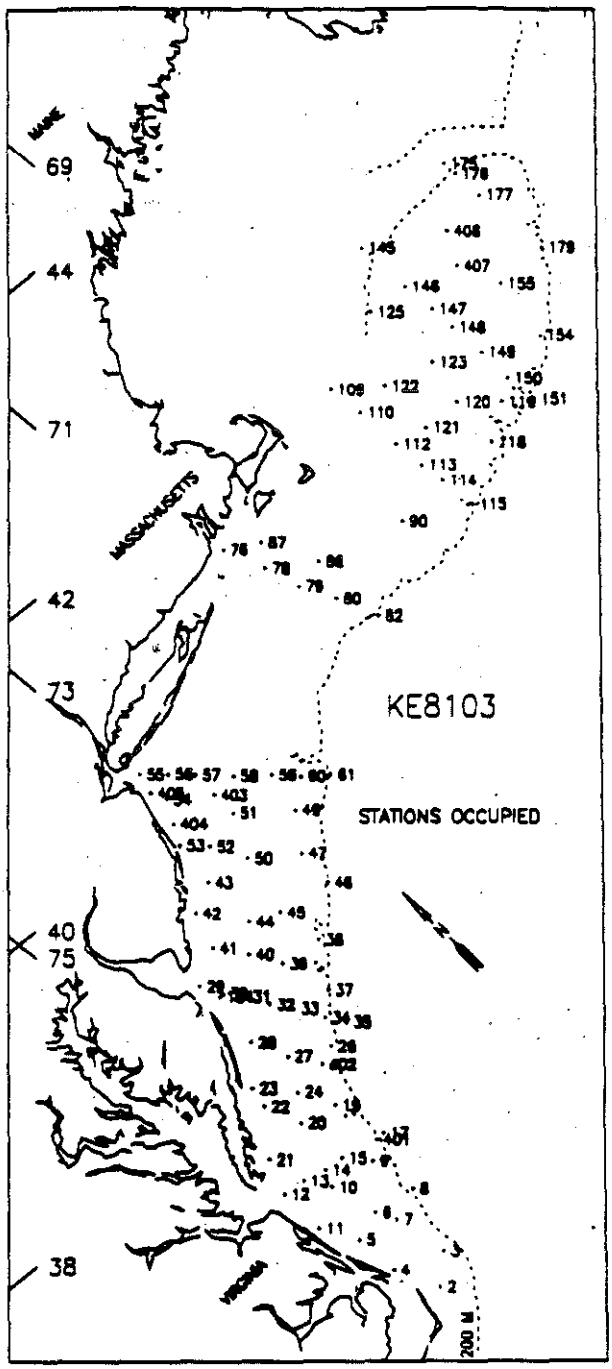


Figure 148. Station positions: KEL8103.

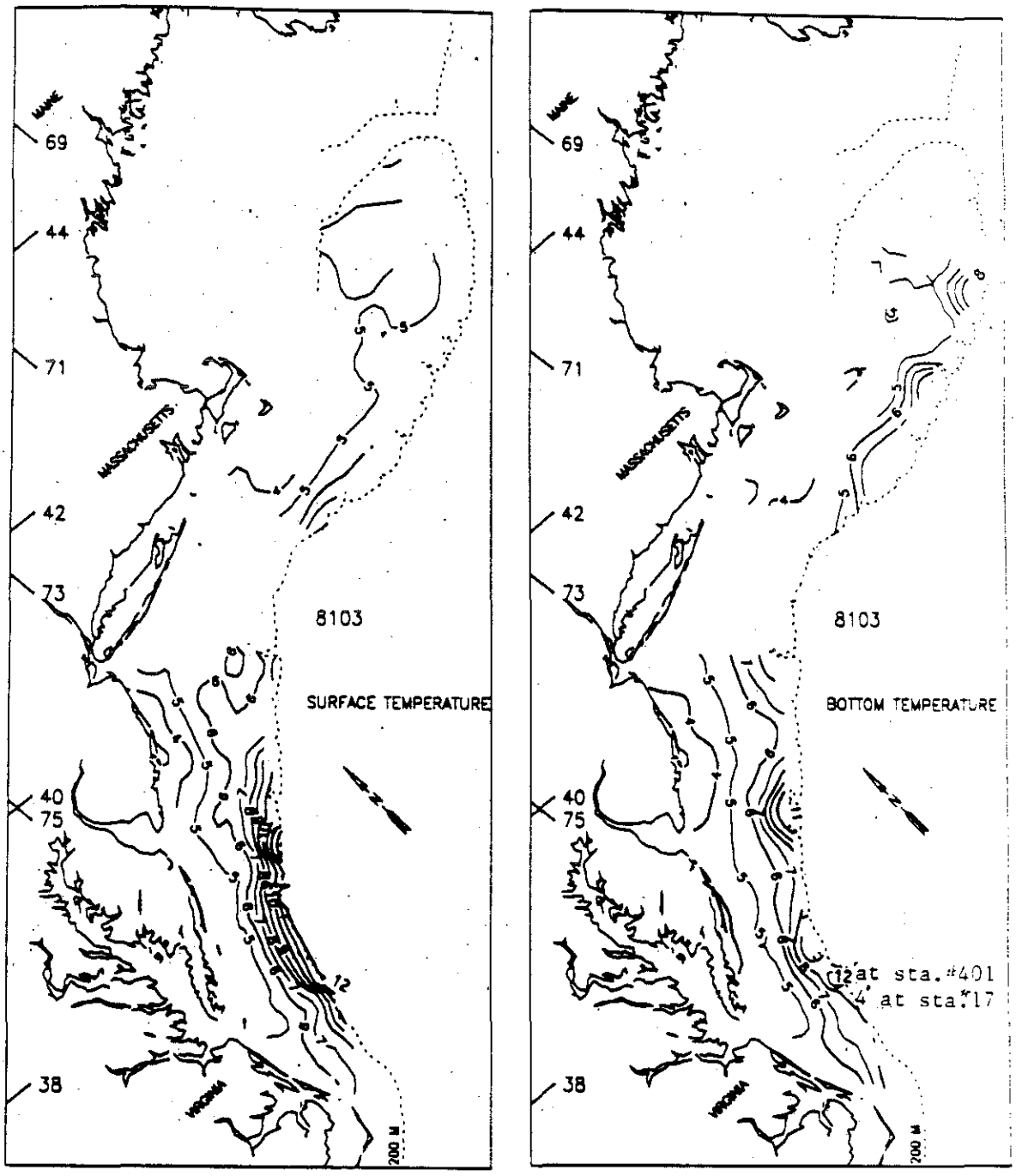


Figure 149. Surface and bottom temperature (°C) distribution: KEL8103.

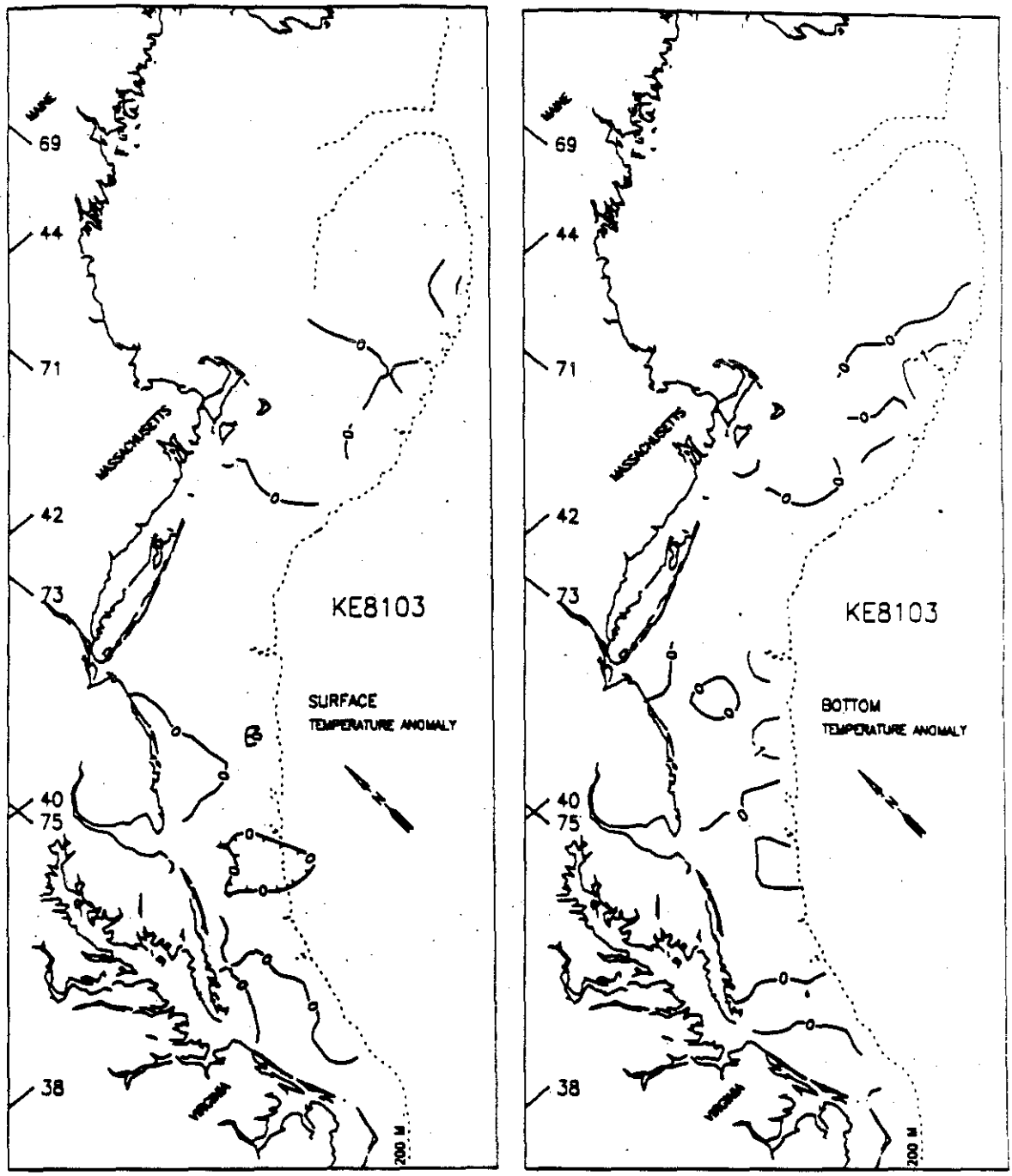


Figure 150. Normalized surface and bottom temperature anomaly: KEL8103. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

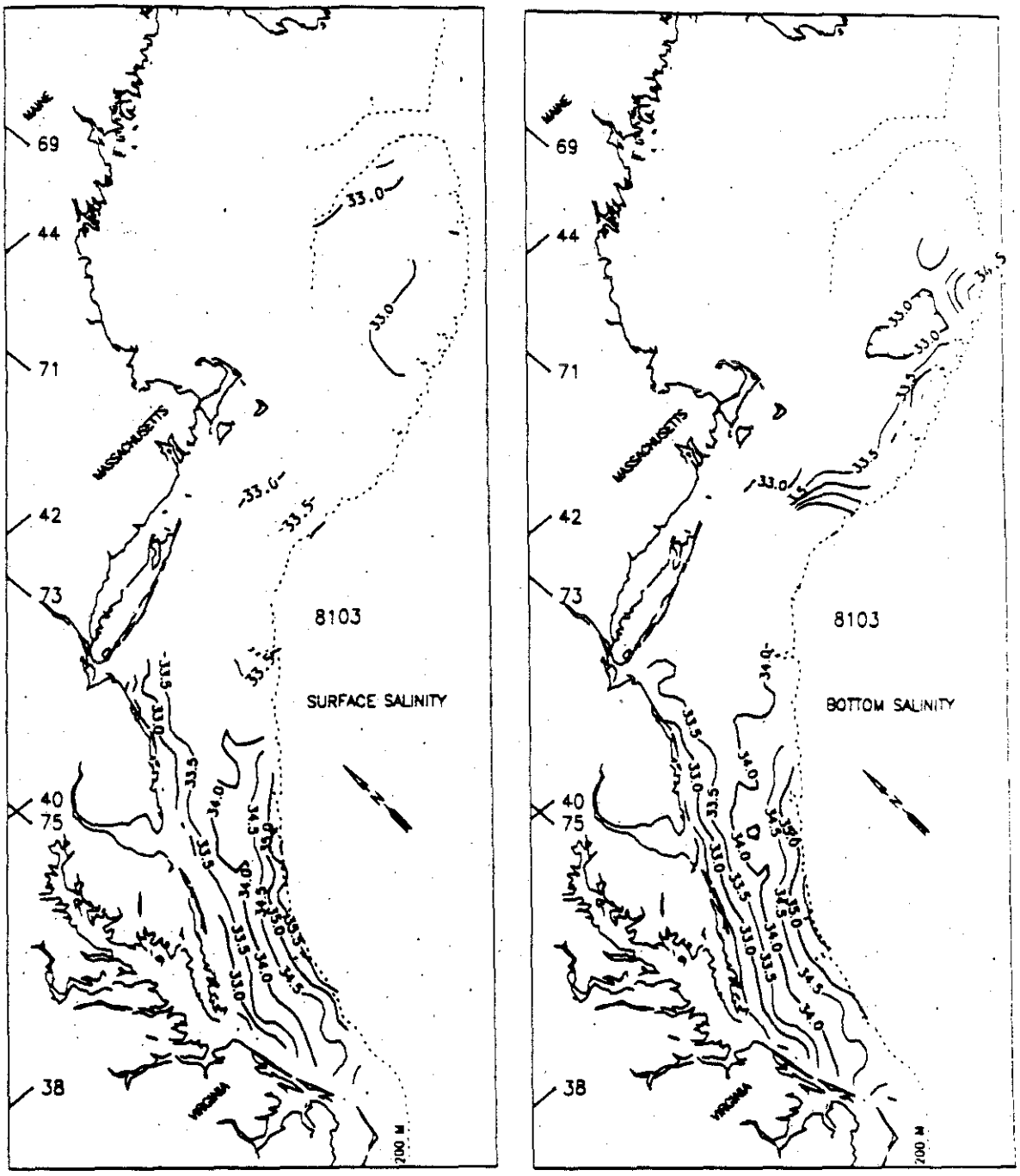


Figure 151. Surface and bottom salinity (PSU) distribution: KEL8103.

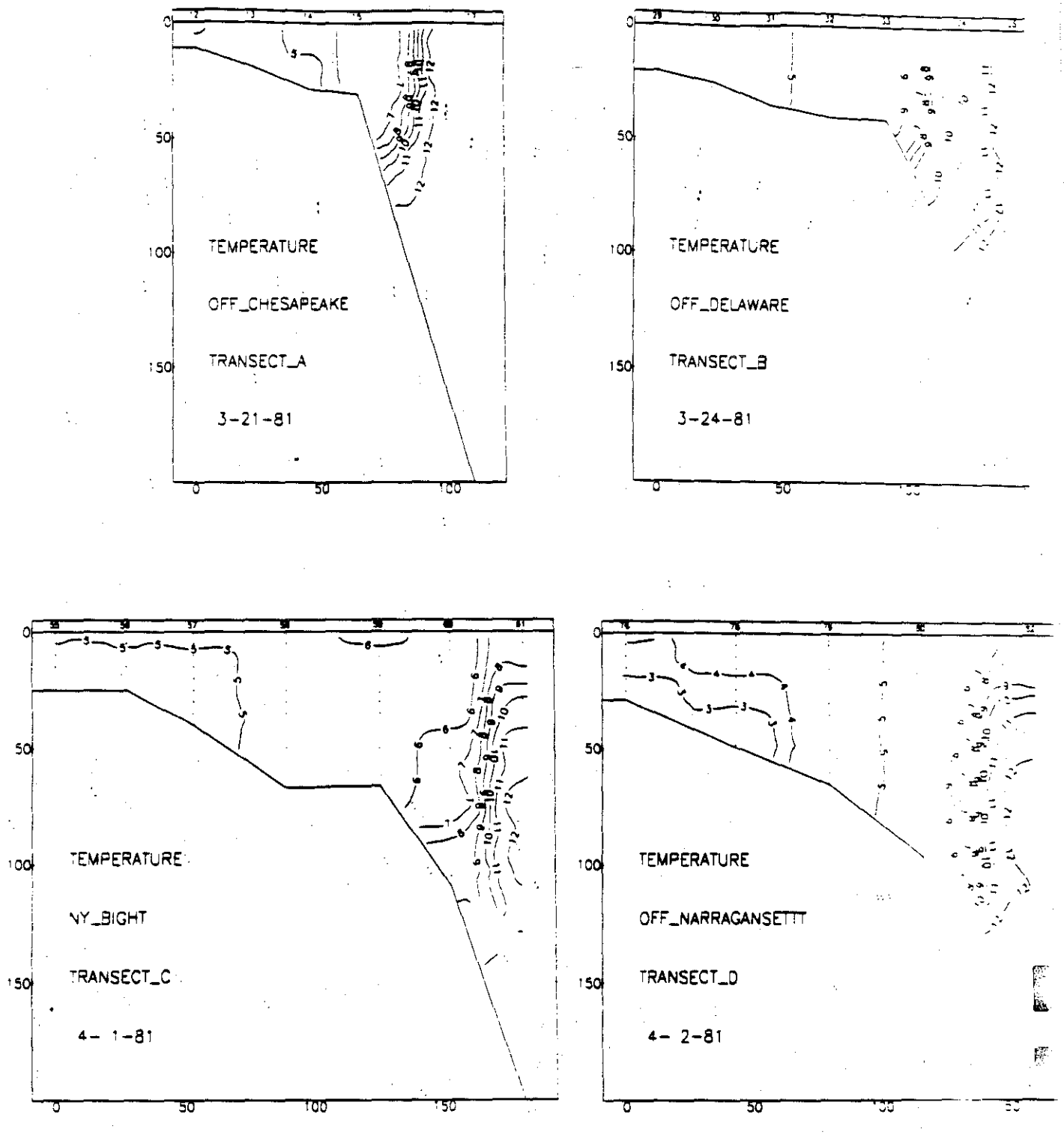
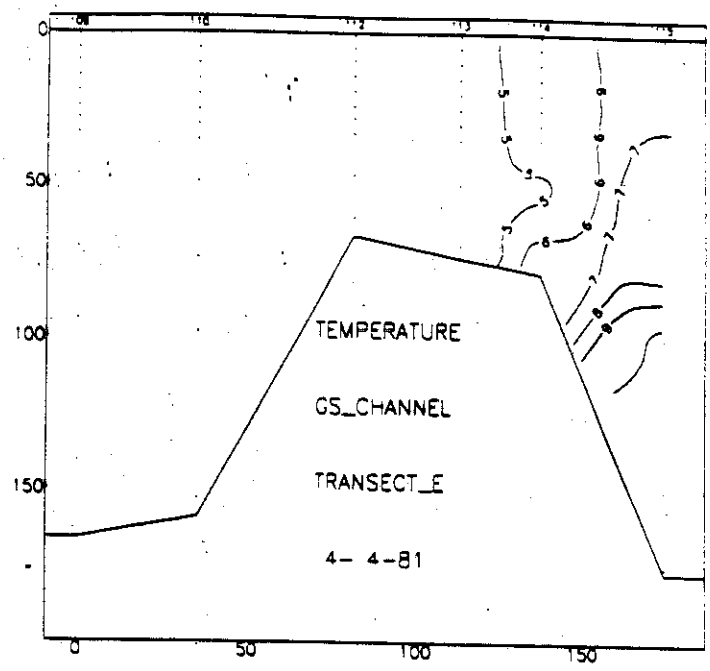
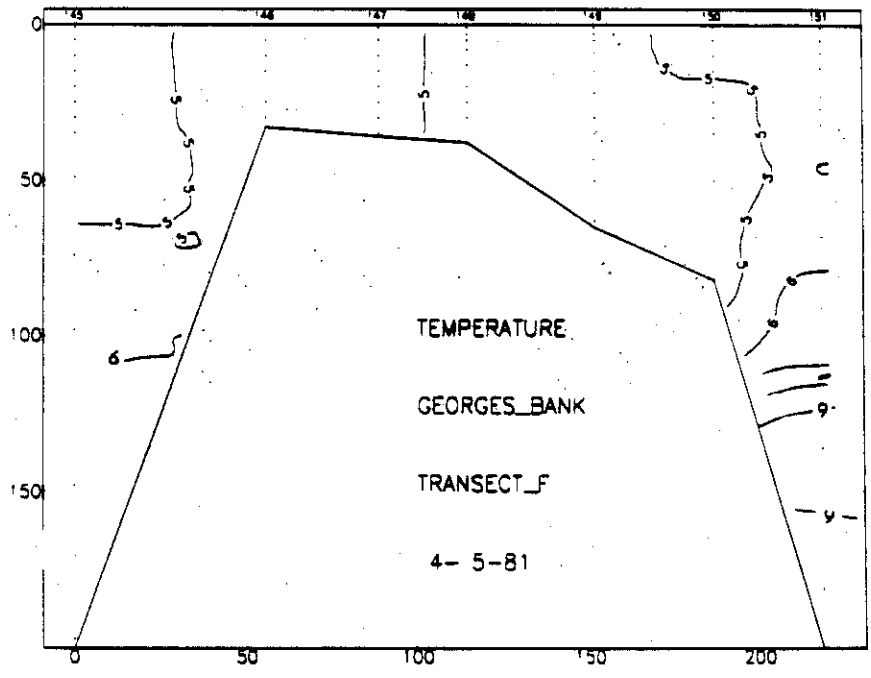


Figure 152. Temperature (°C) transects: KEL8103.





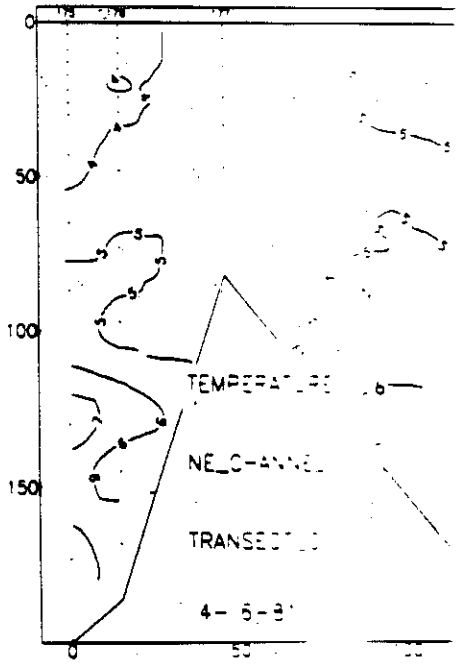


Figure 152. Continued.

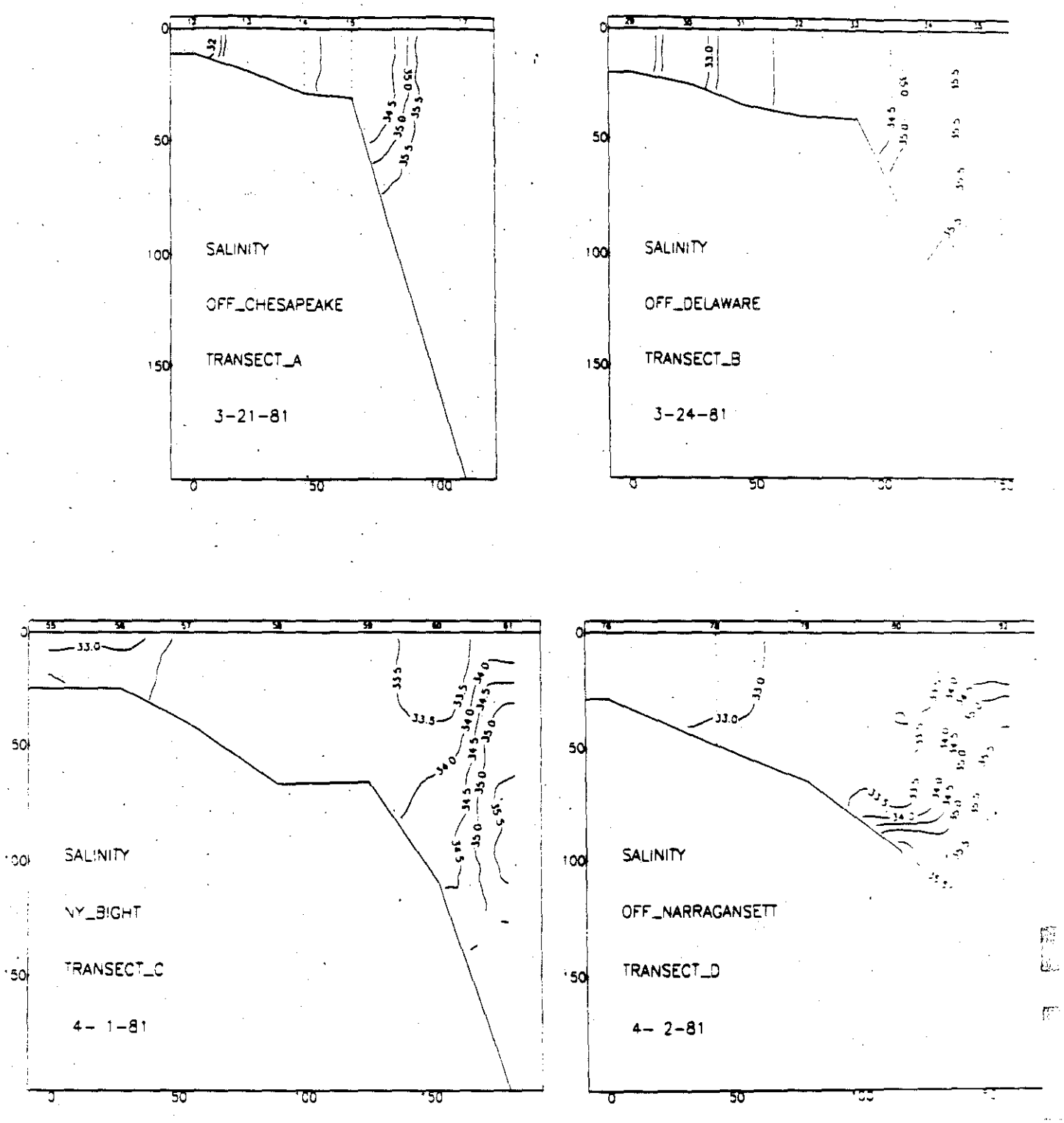
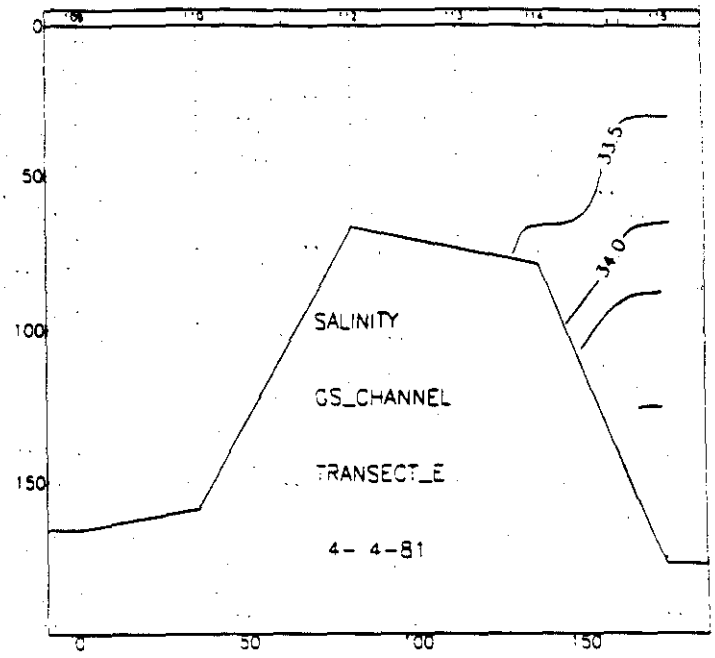
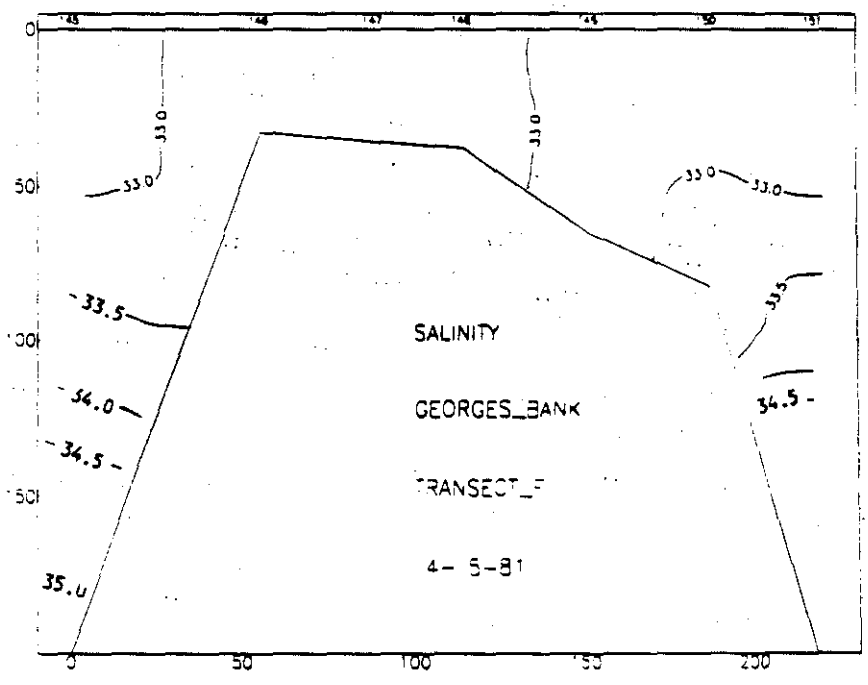


Figure 153. Salinity (PSU) transects: KEL8103.





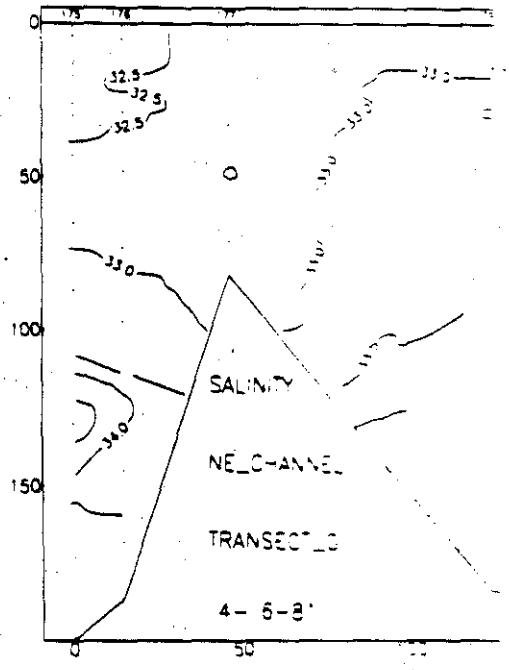


Figure 153. Continued.

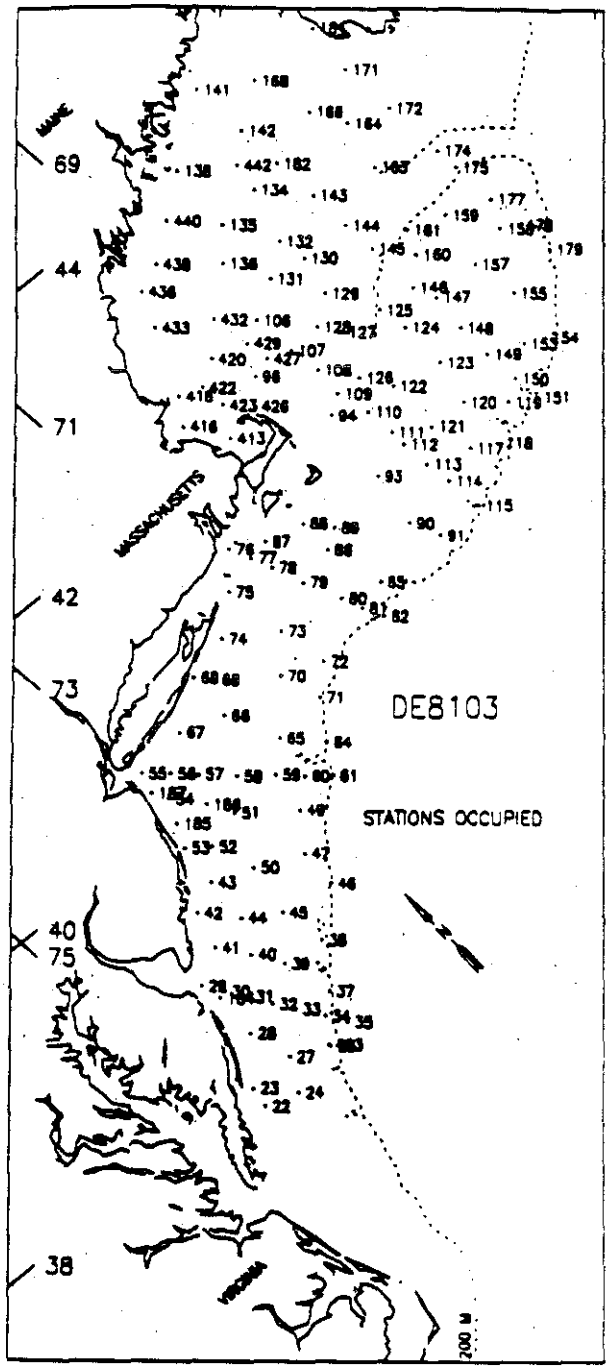


Figure 154. Station positions: DEL8103.

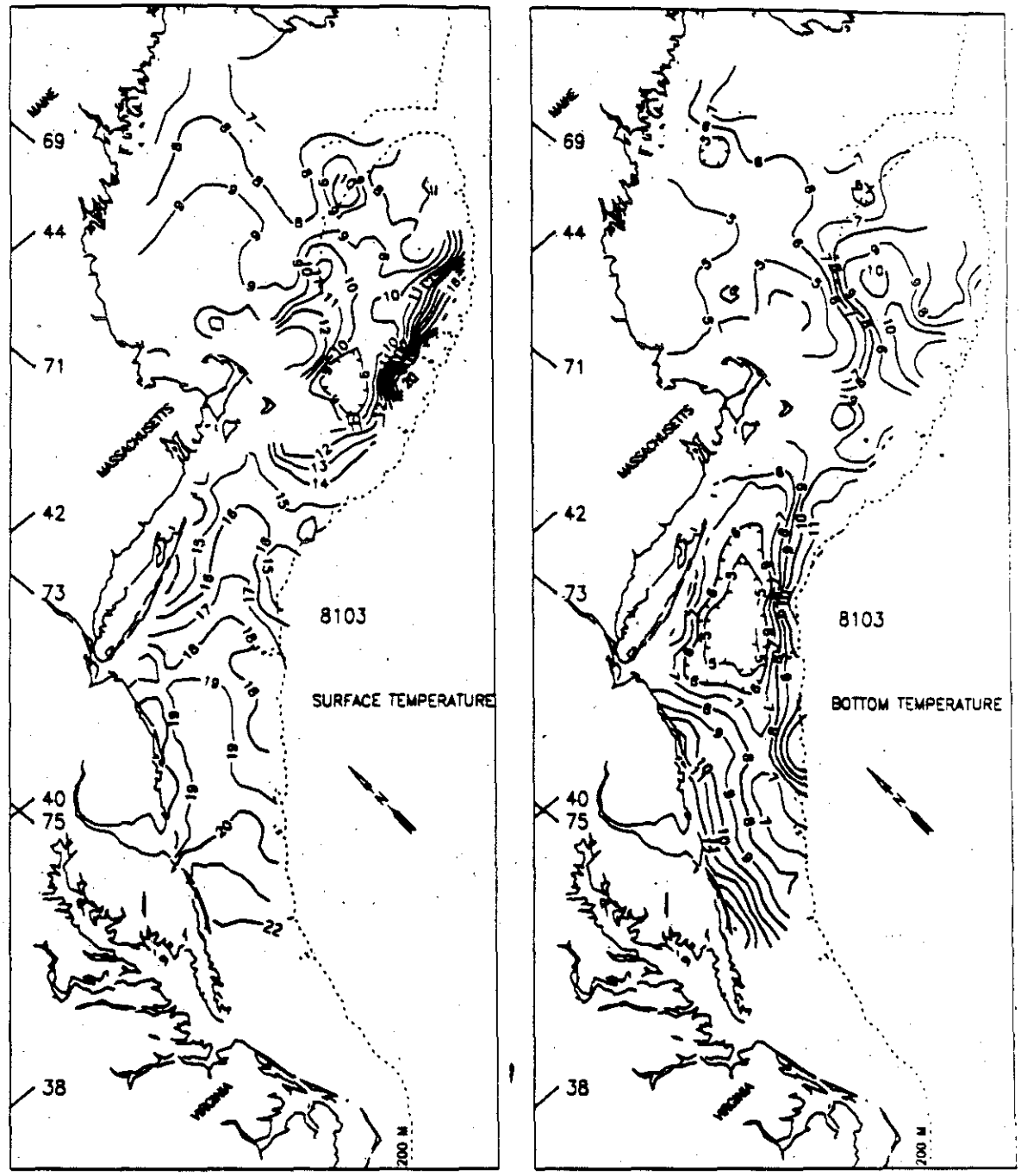


Figure 155. Surface and bottom temperature (°C) distribution: DEL8103.

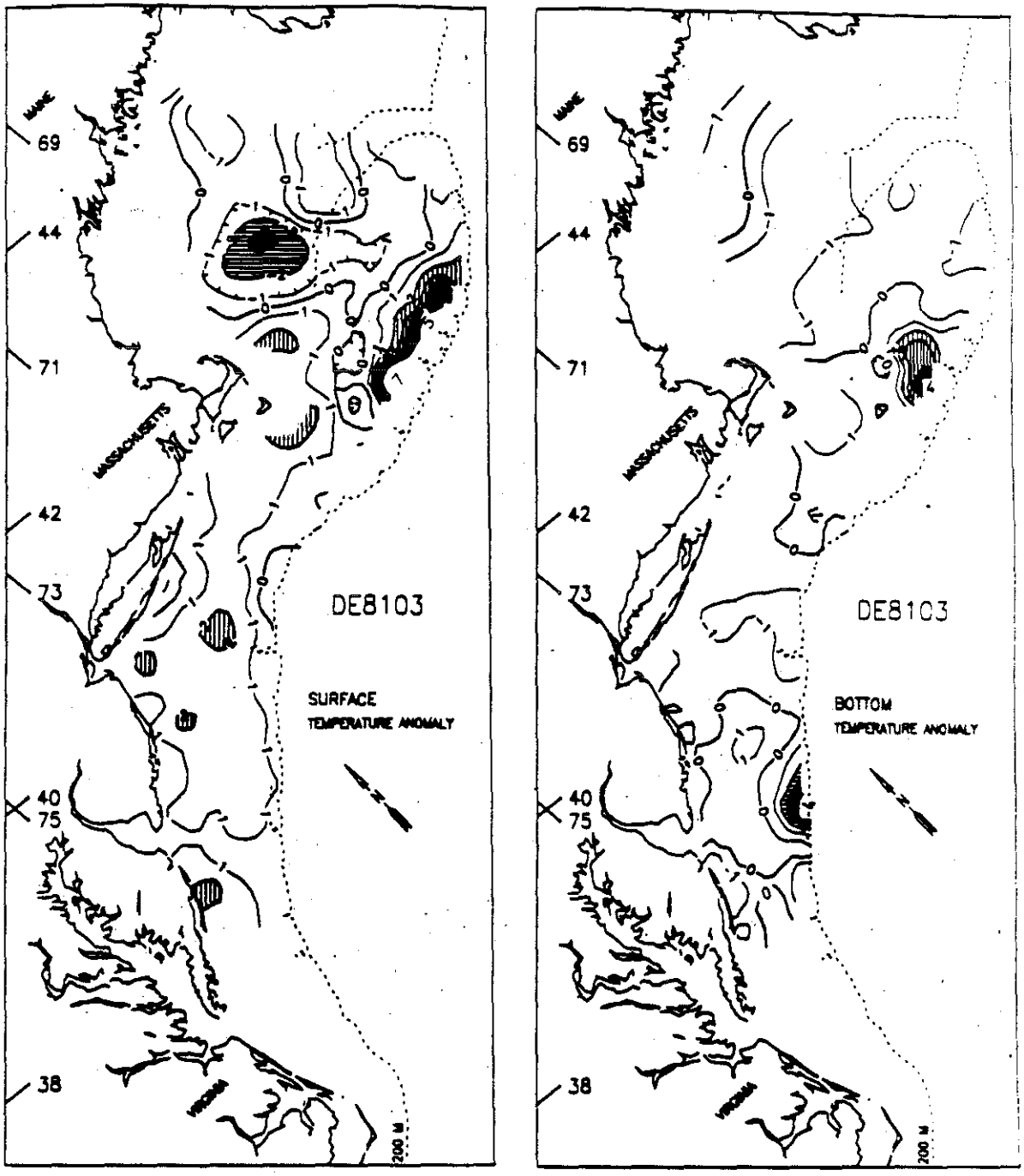


Figure 156. Normalized surface and bottom temperature anomaly: DEL8103. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

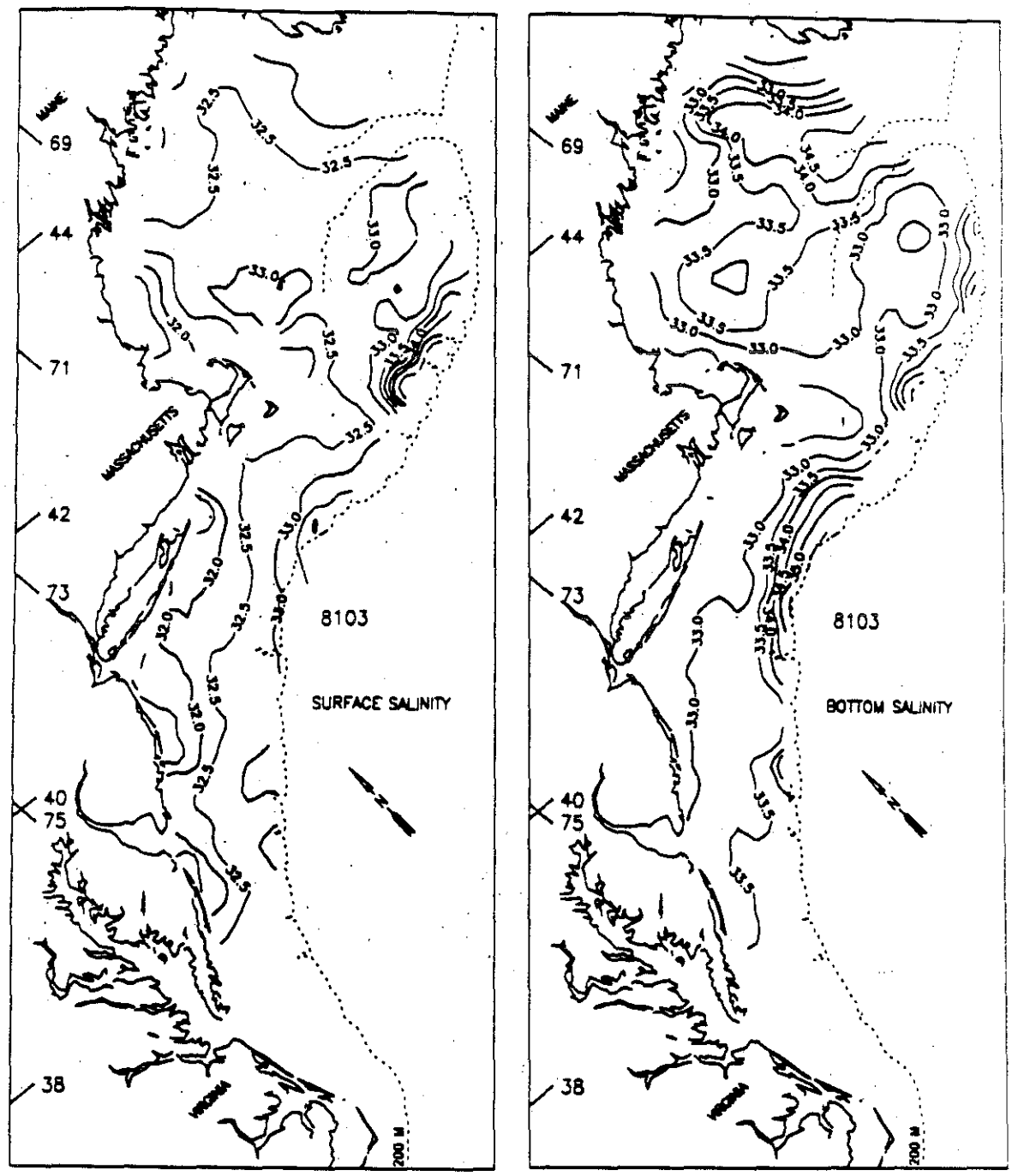
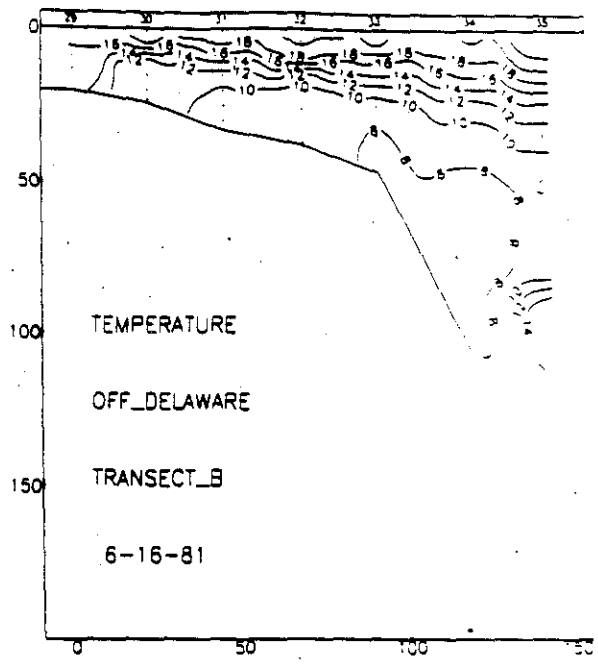
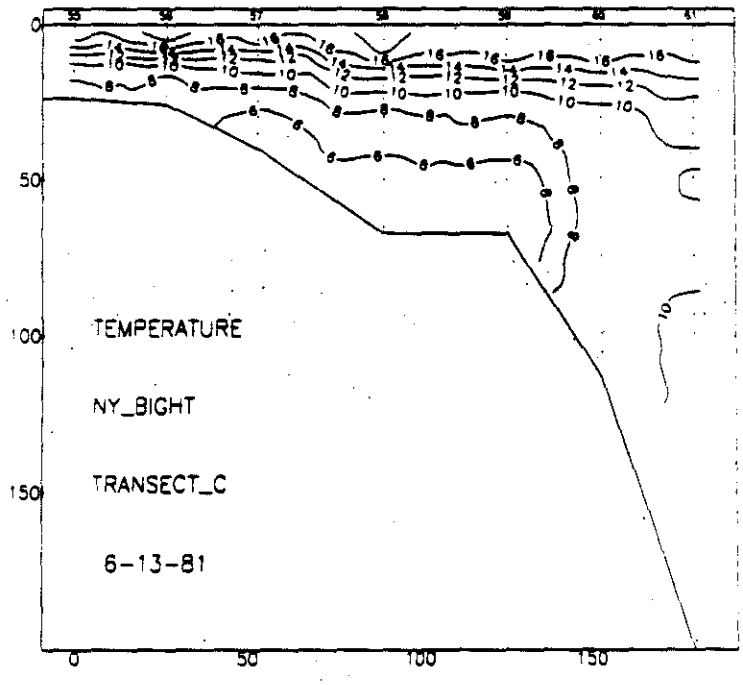


Figure 157. Surface and bottom salinity (PSU) distribution: DEL8103.





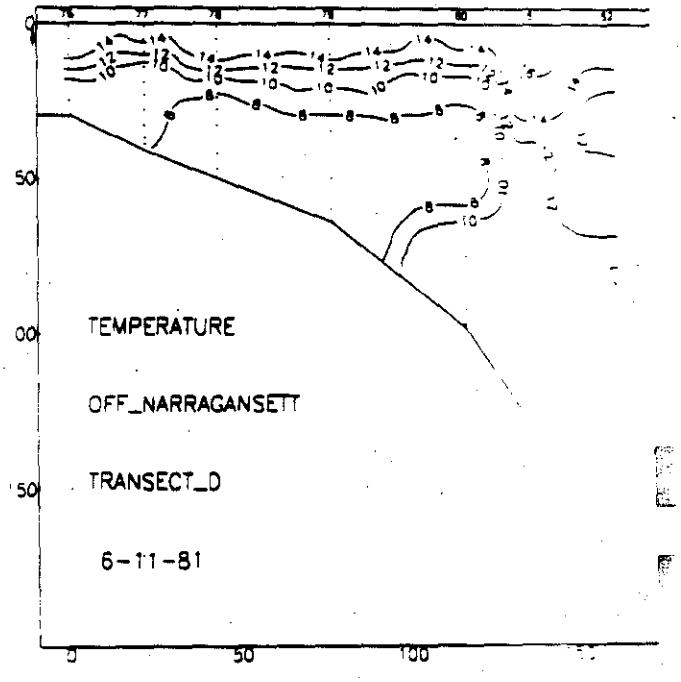
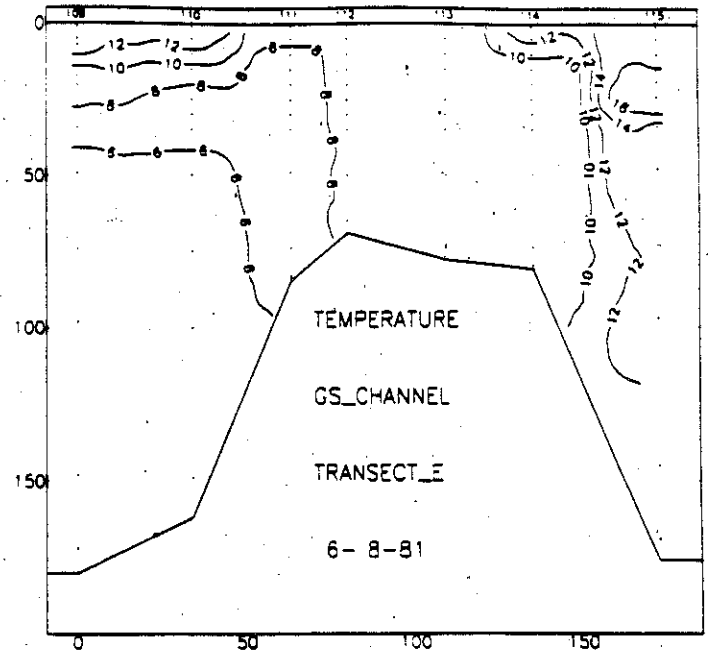


Figure 158. Temperature (°C) transects: DEL8103.



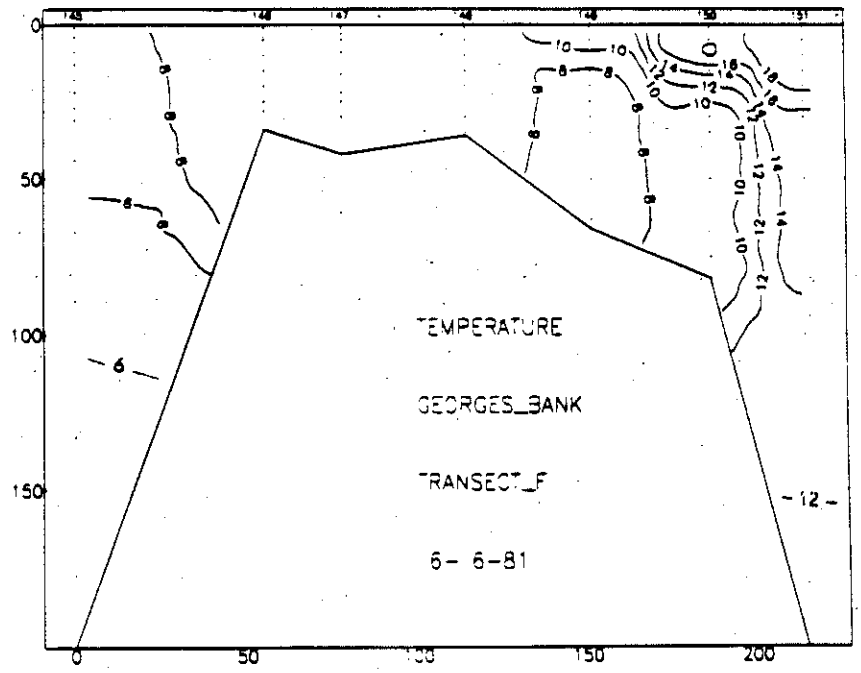


Figure 158. Continued.

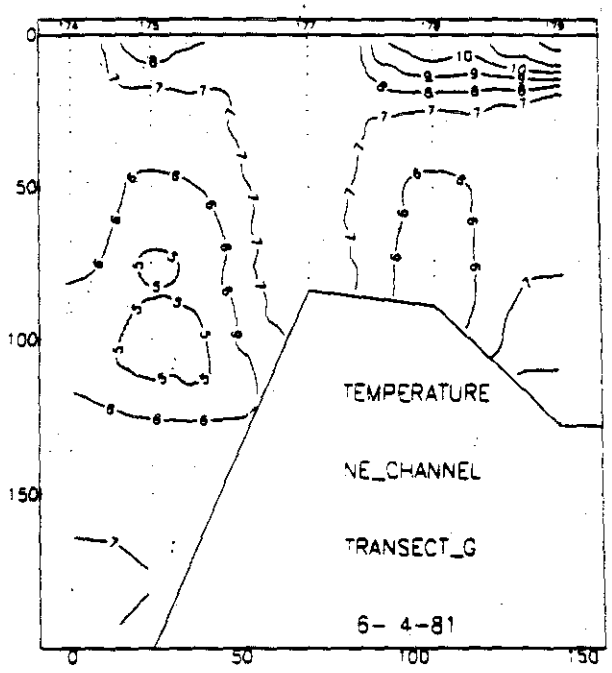


Figure 158. Continued.

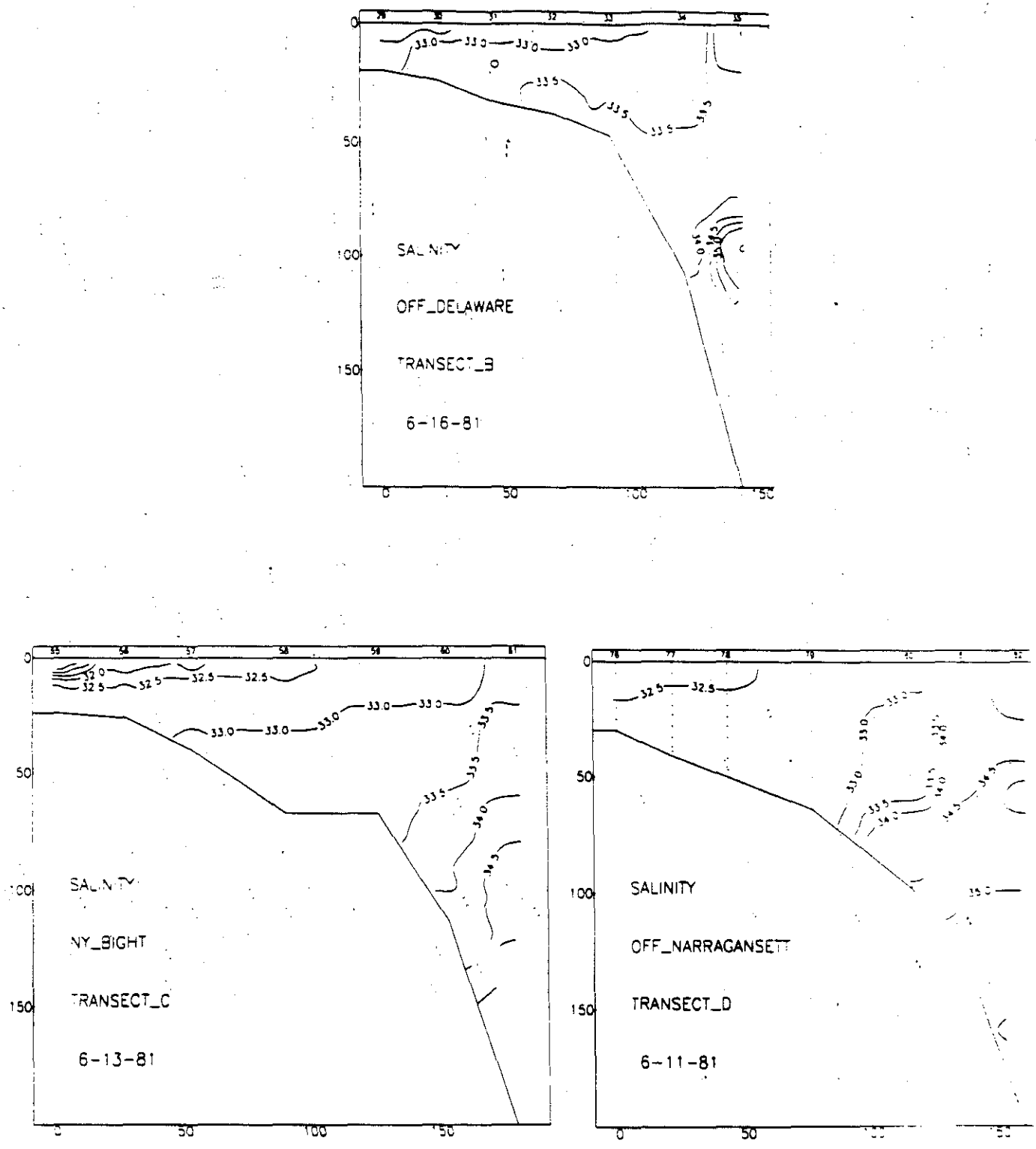
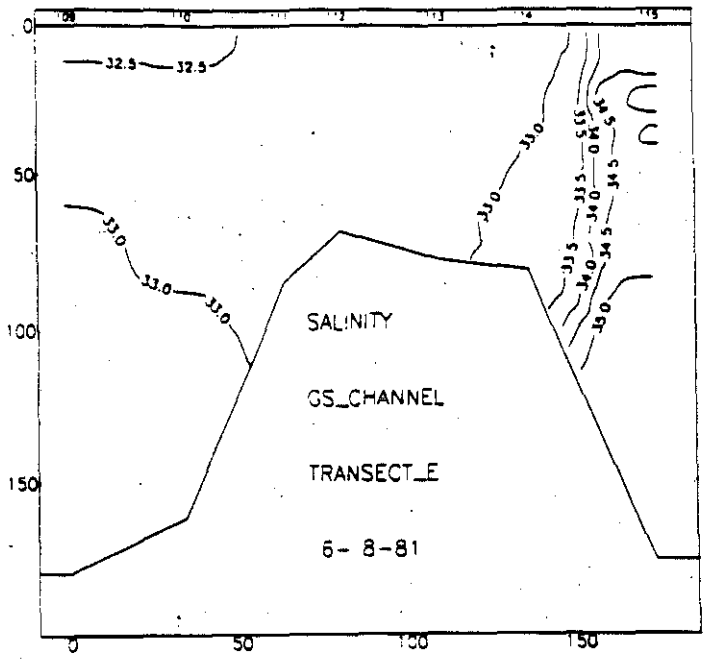


Figure 159. Salinity (PSU) transects: DEL8103.



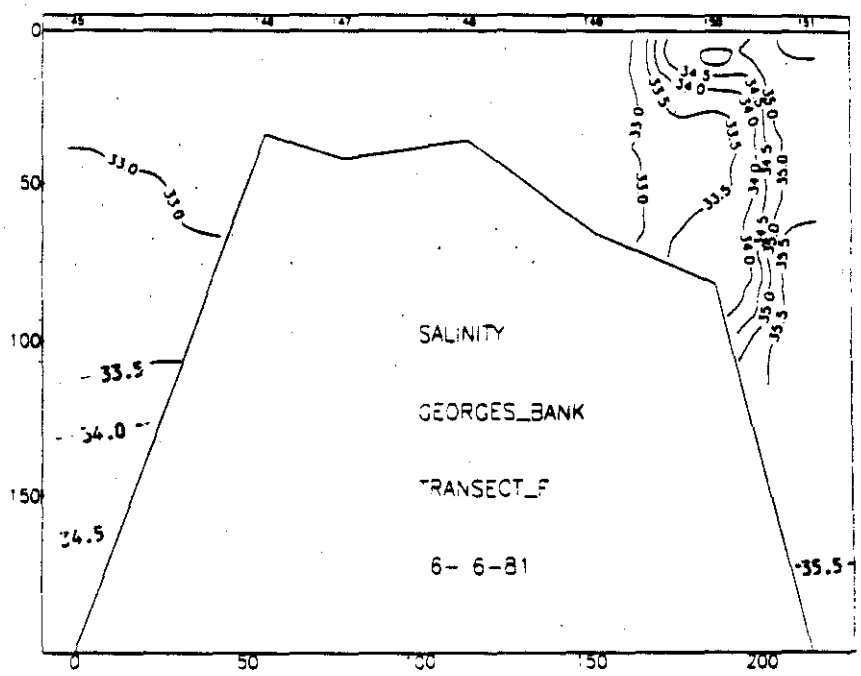


Figure 159. Continued.

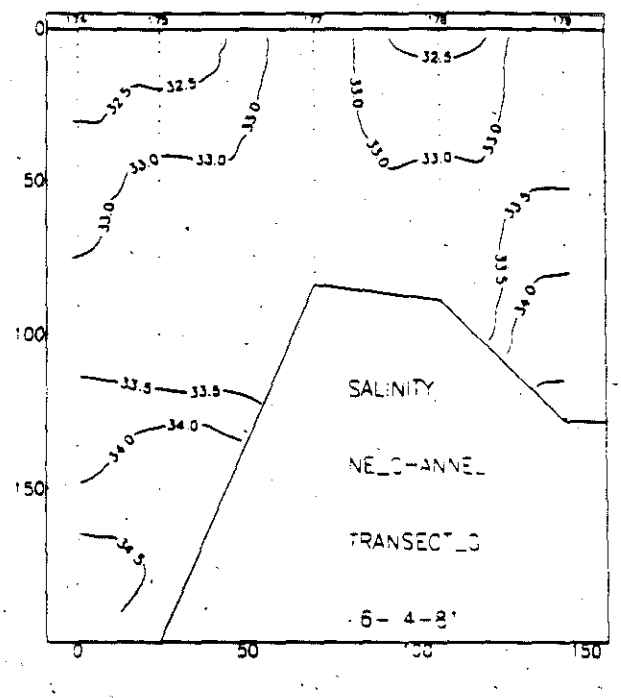


Figure 159. Continued.

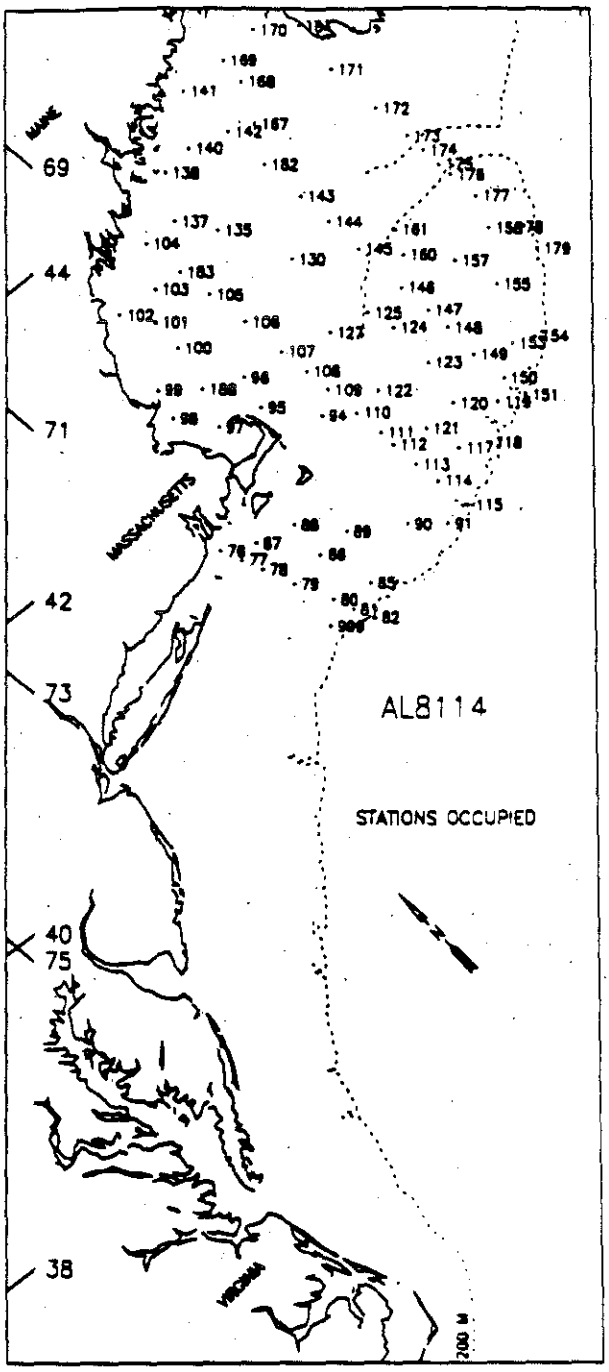


Figure 160. Station positions: ALB8114.

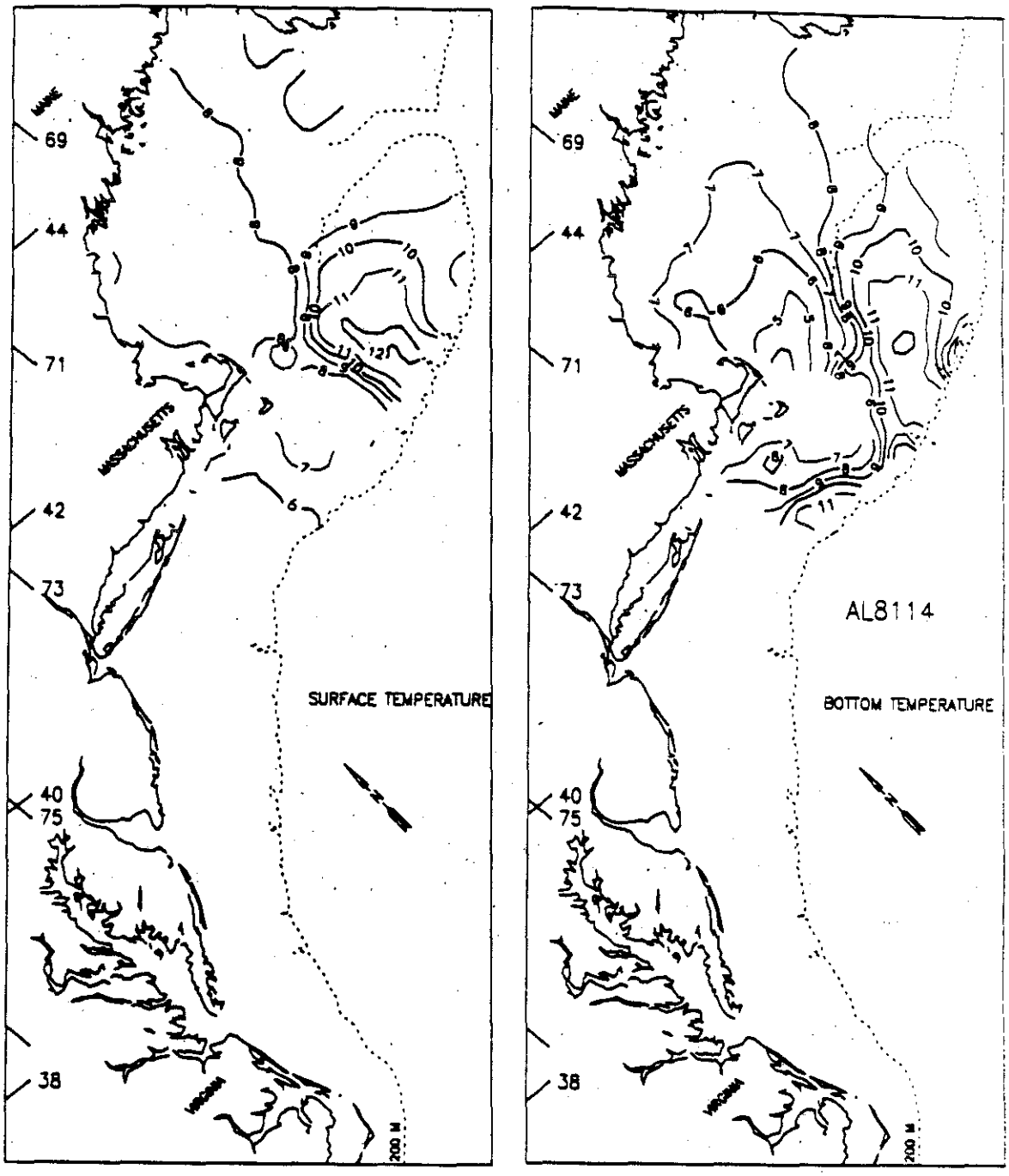


Figure 161. Surface and bottom temperature (°C) distribution: ALB8114.

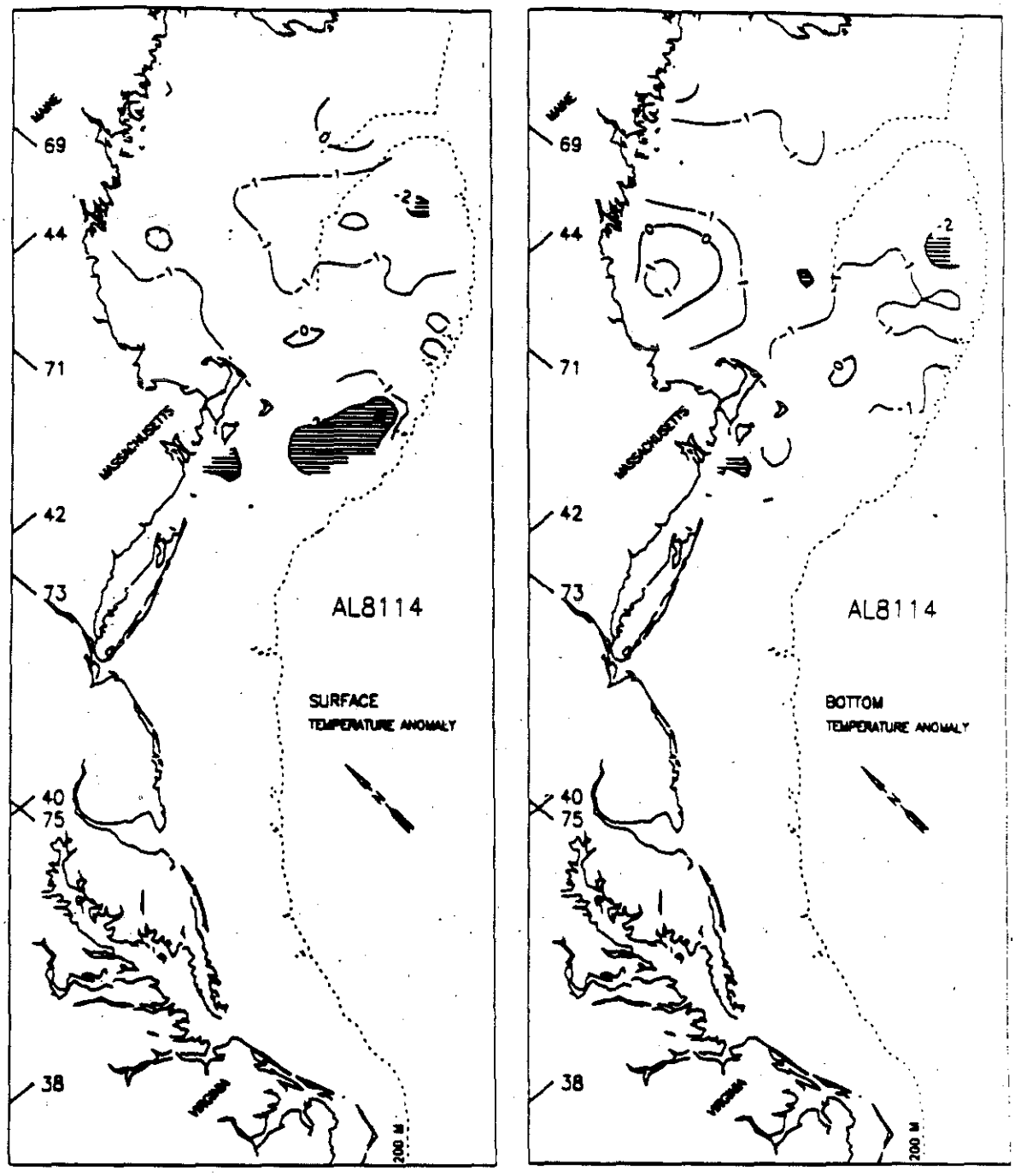


Figure 162. Normalized surface and bottom temperature anomaly: ALB8114. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

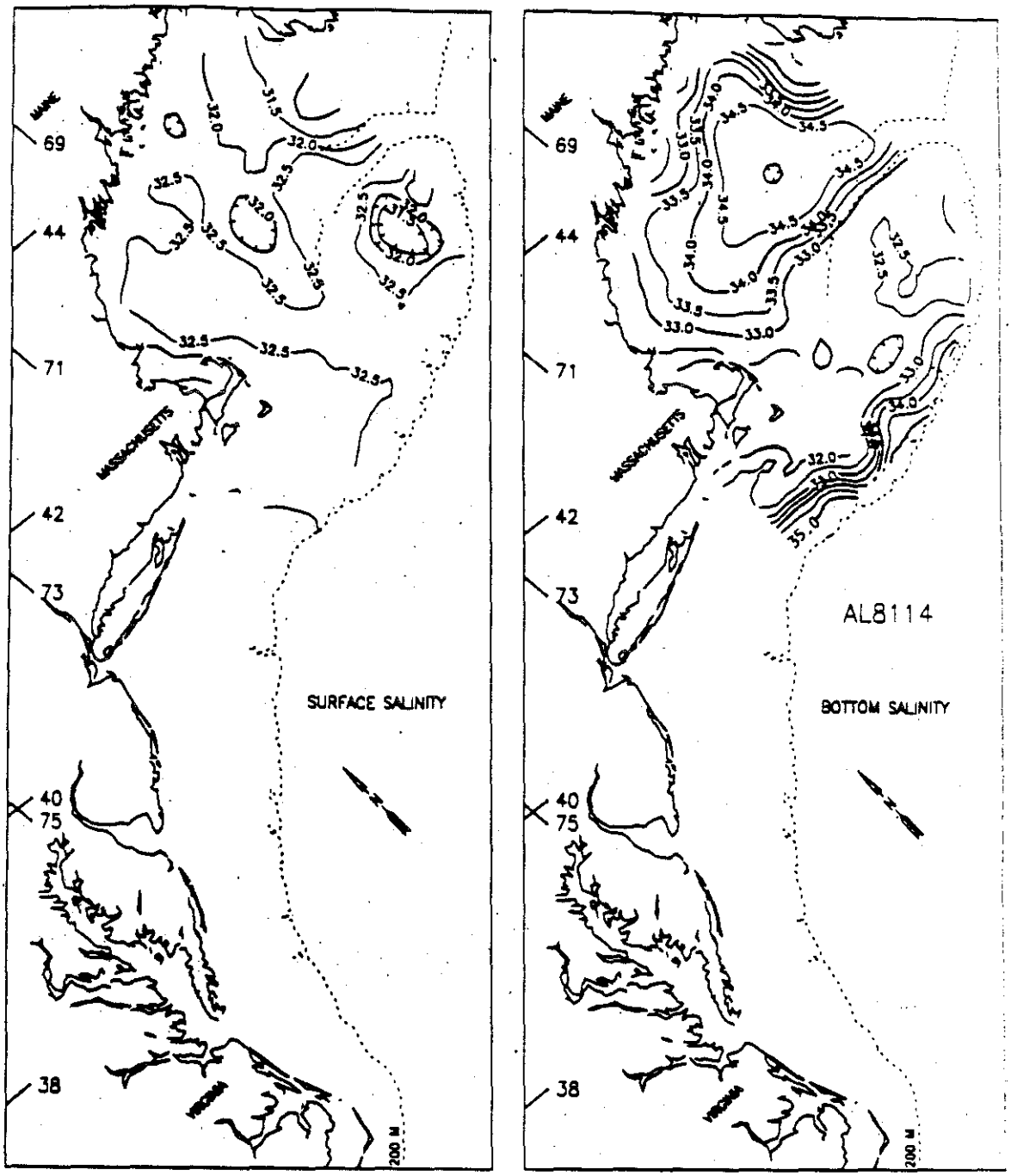


Figure 163. Surface and bottom salinity (PSU) distribution: ALB8114.

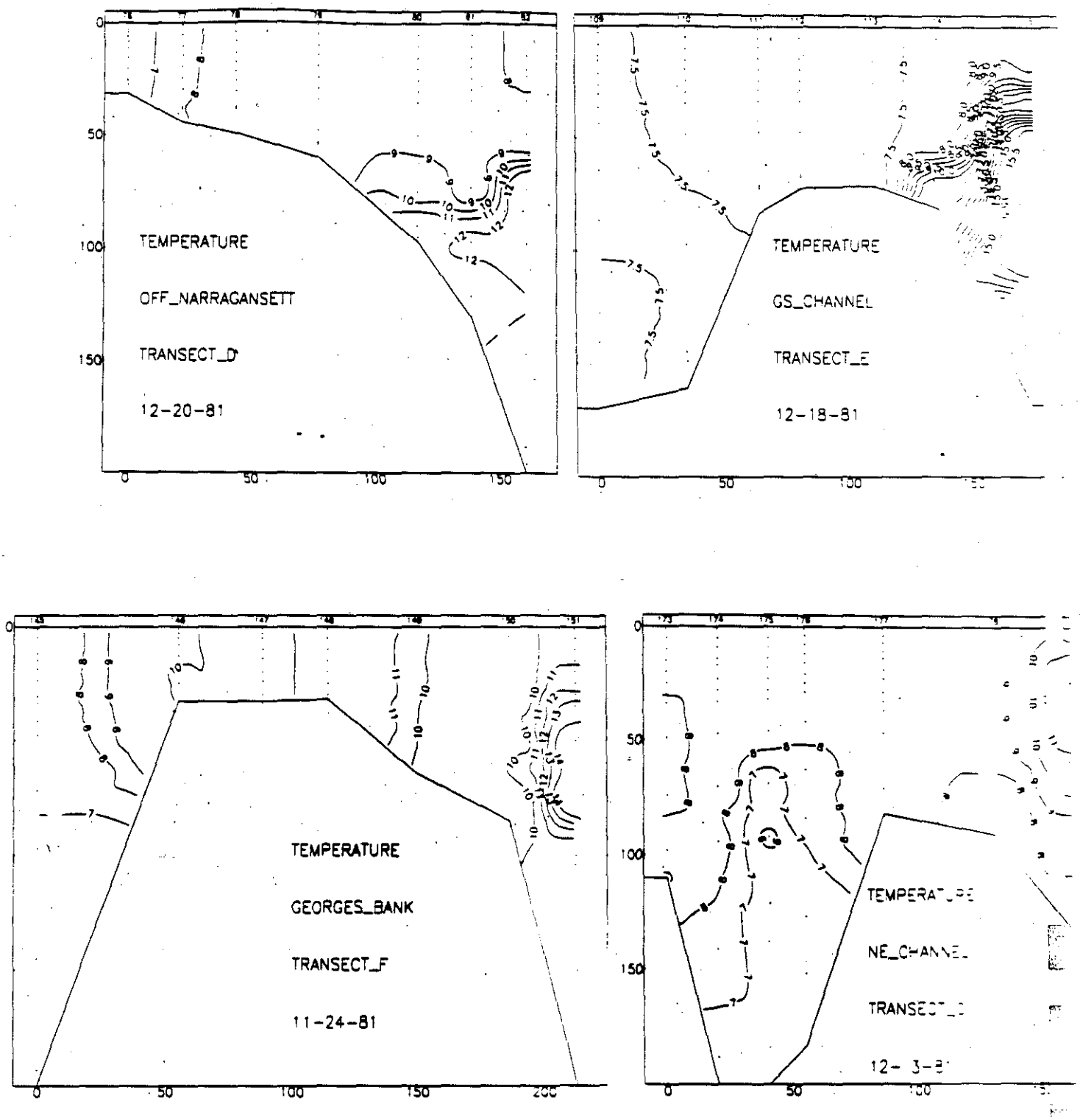
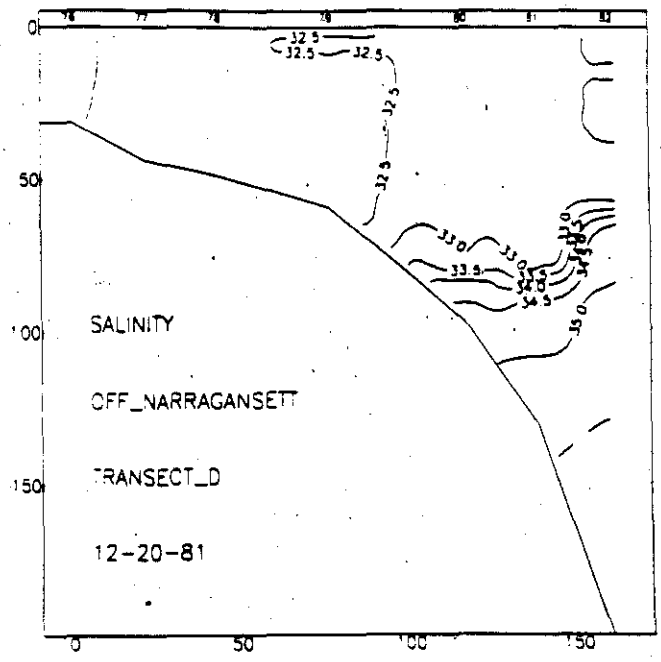


Figure 164. Temperature (°C) transects: ALB8114.



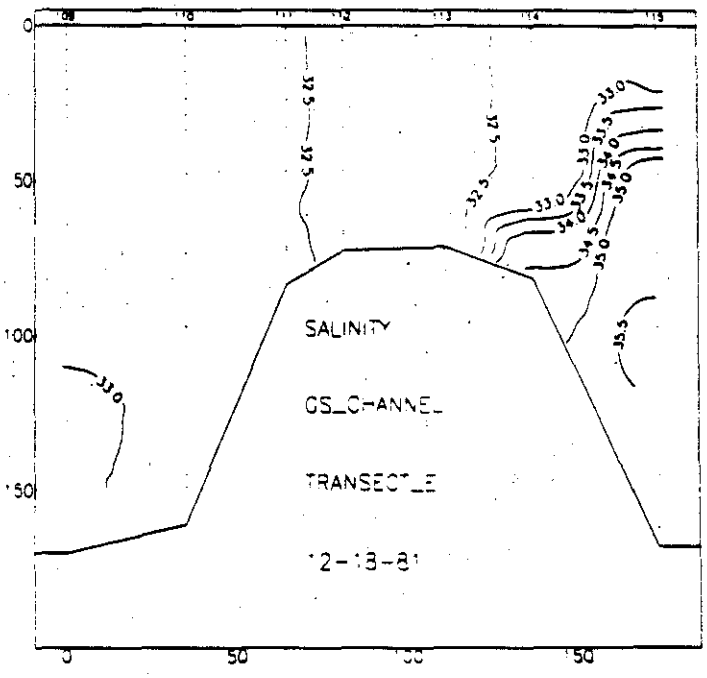
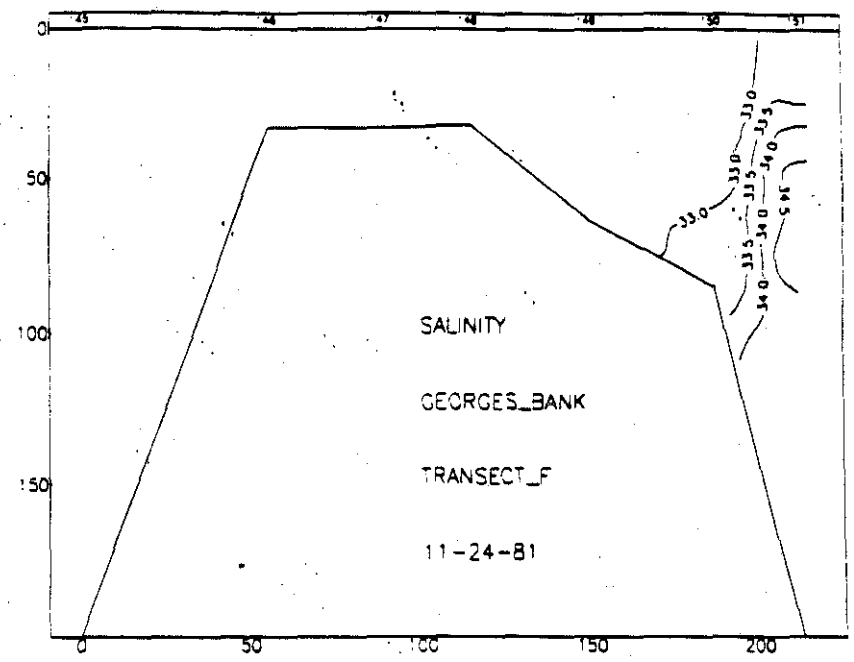


Figure 165. Salinity (PSU) transects: ALB8114.



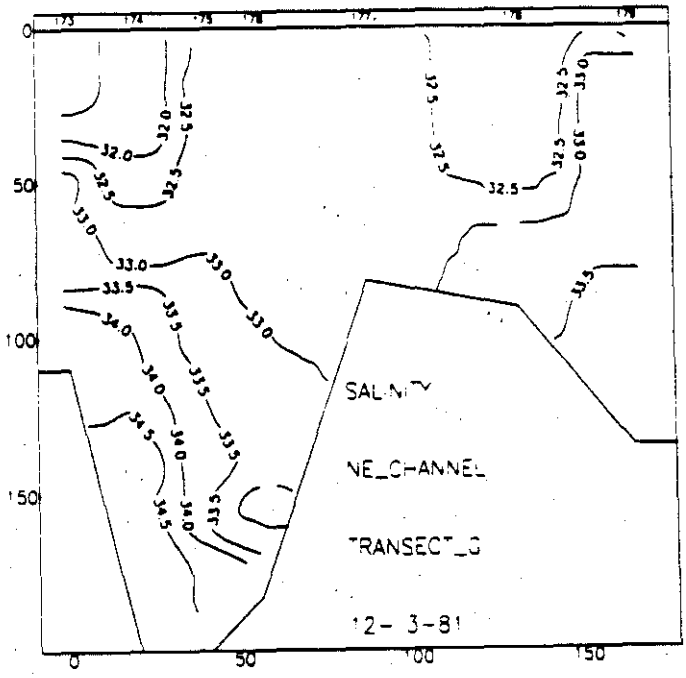


Figure 165. Continued.

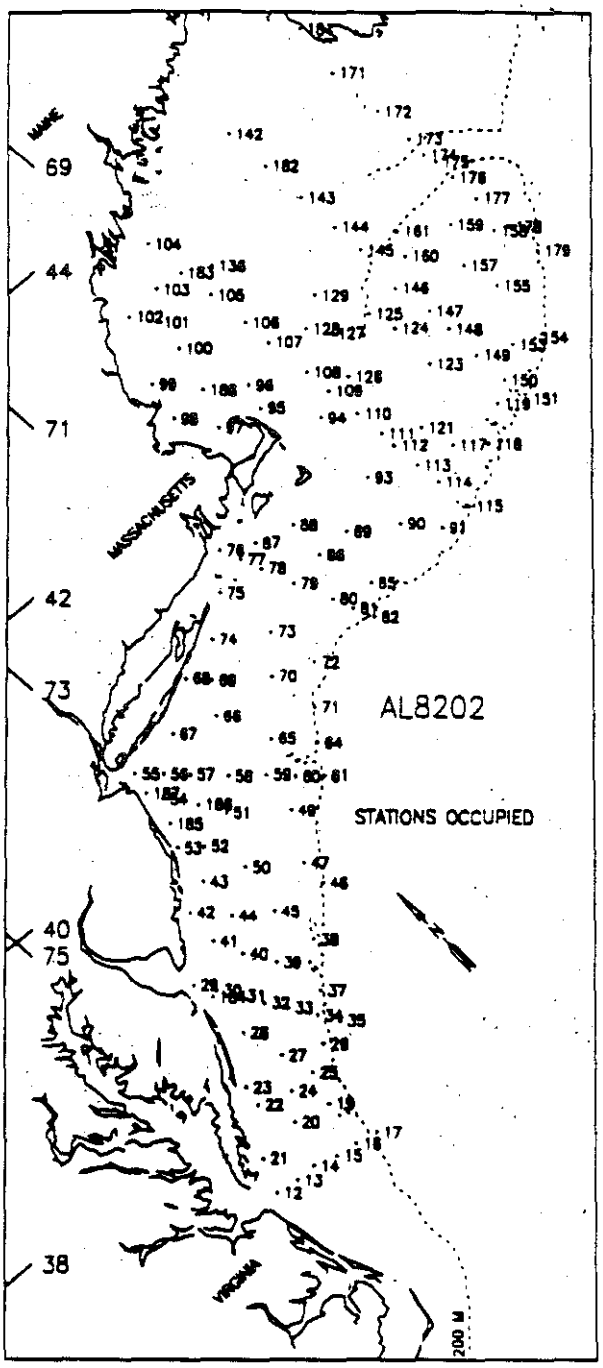
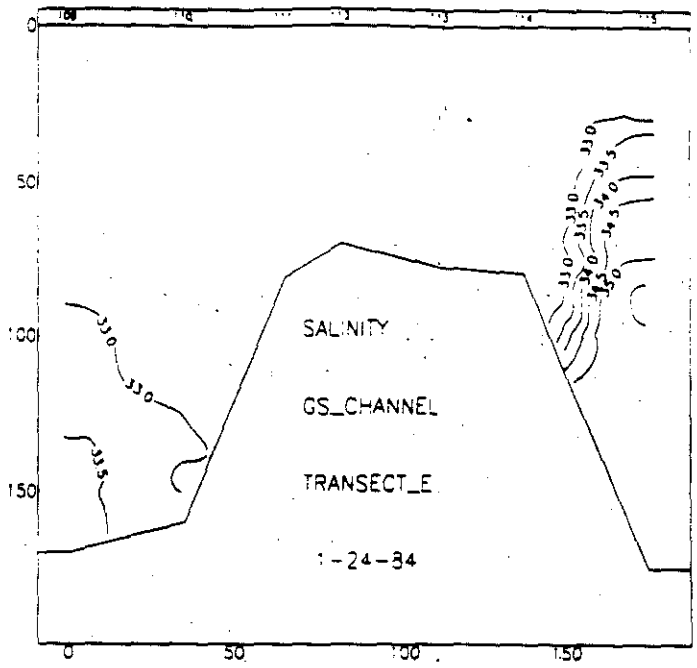


Figure 166. Station positions: ALB8202.



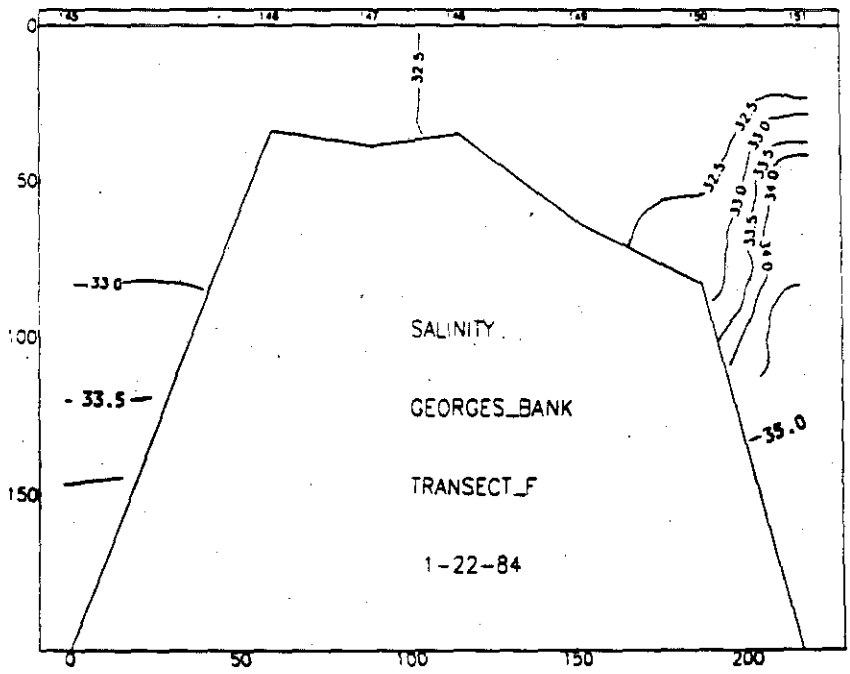


Figure 207. Continued.

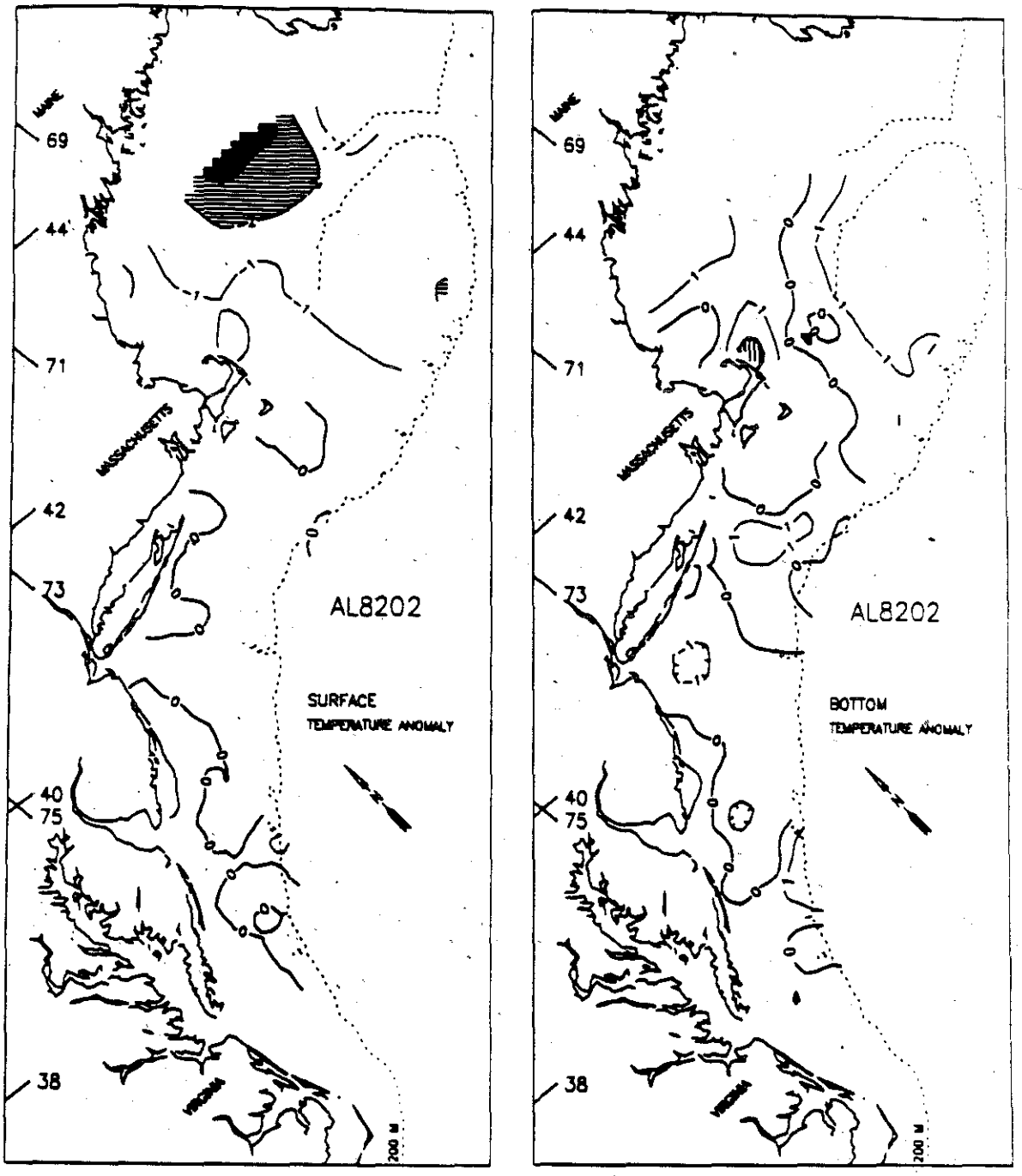


Figure 168. Normalized surface and bottom temperature anomaly: ALB8202. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

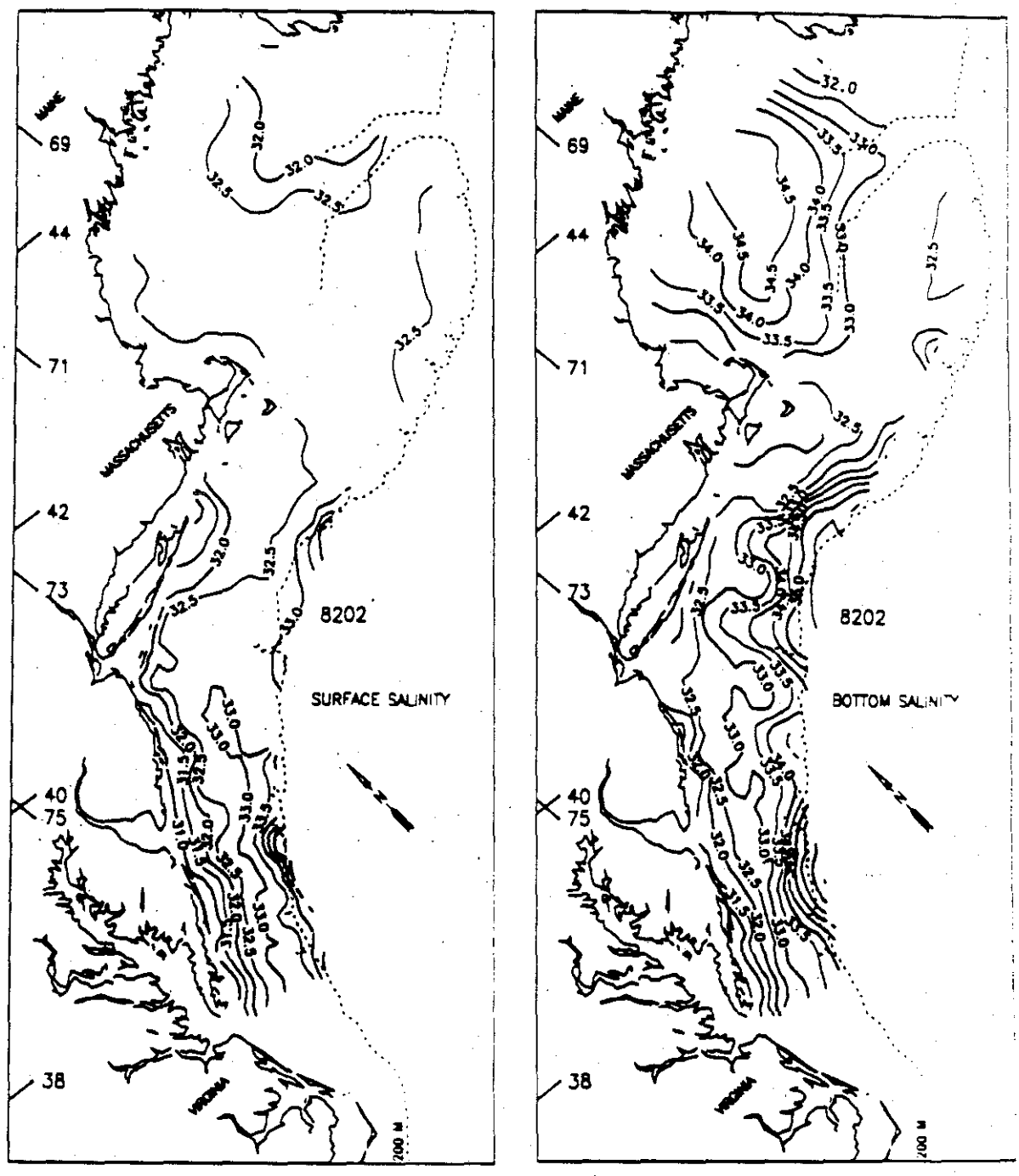


Figure 169. Surface and bottom salinity (PSU) distribution: ALB8202.

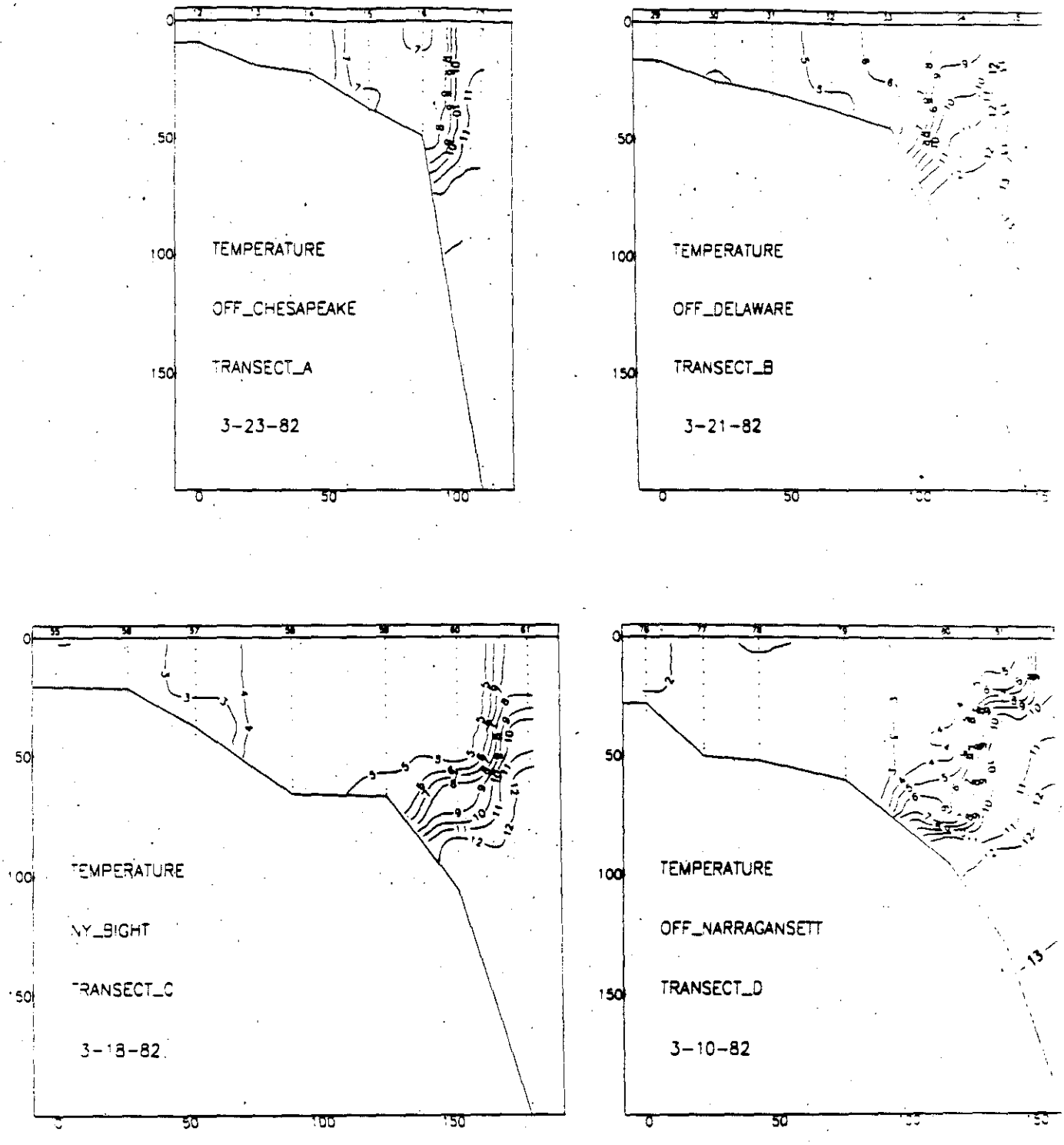
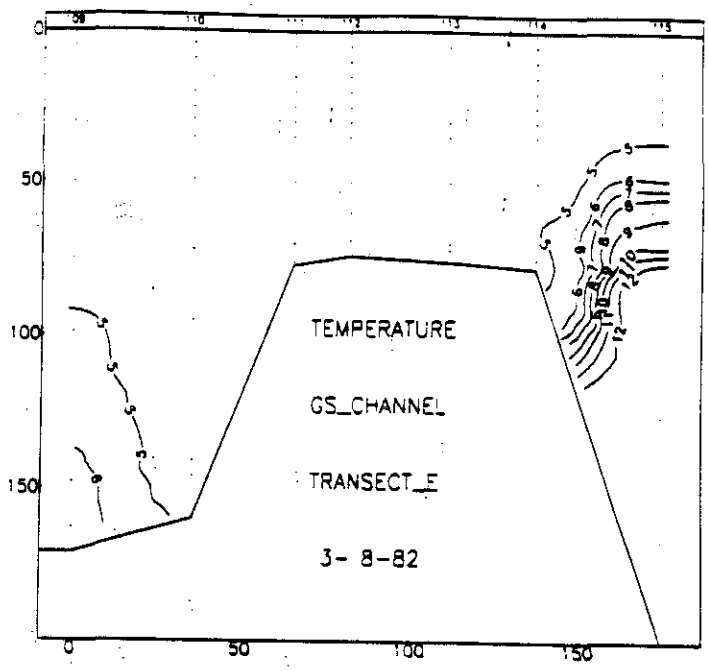


Figure 170. Temperature (°C) transects: ALB8202.



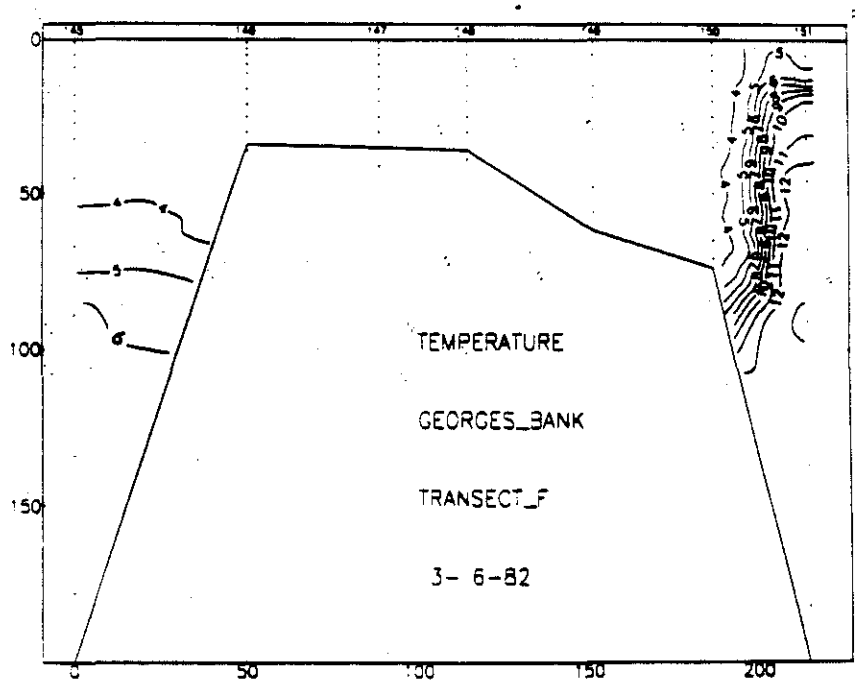


Figure 170. Continued.

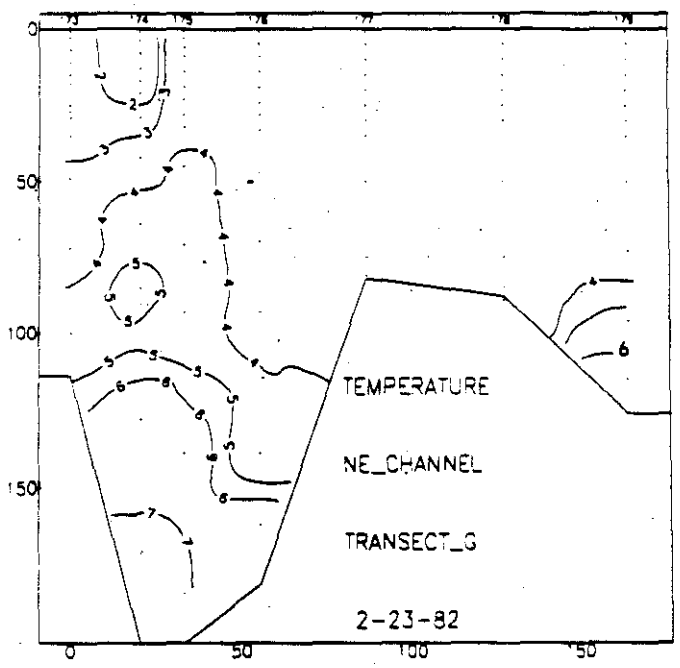


Figure 170. Continued.

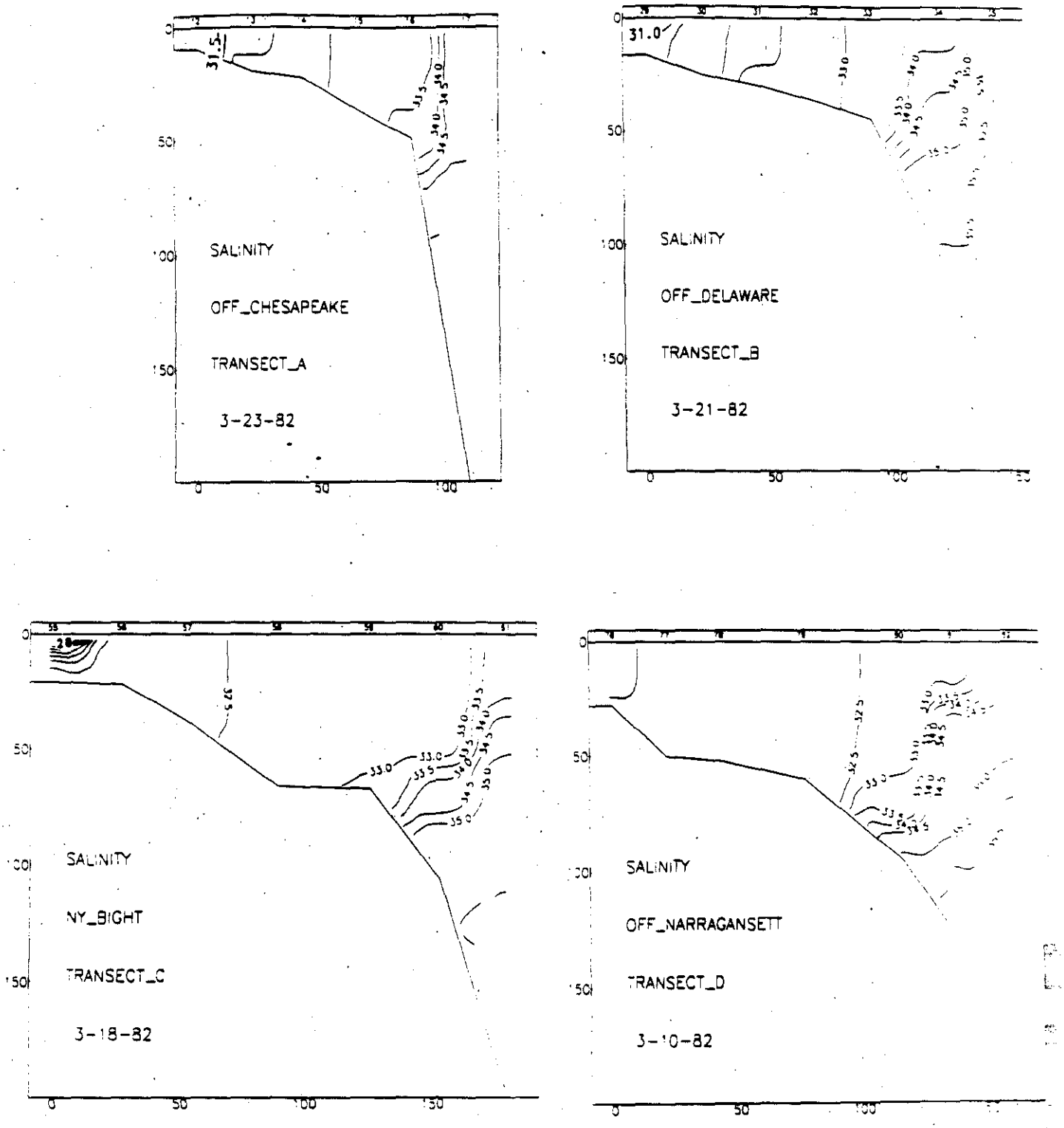


Figure 171. Salinity (PSU) transects: ALB8202.

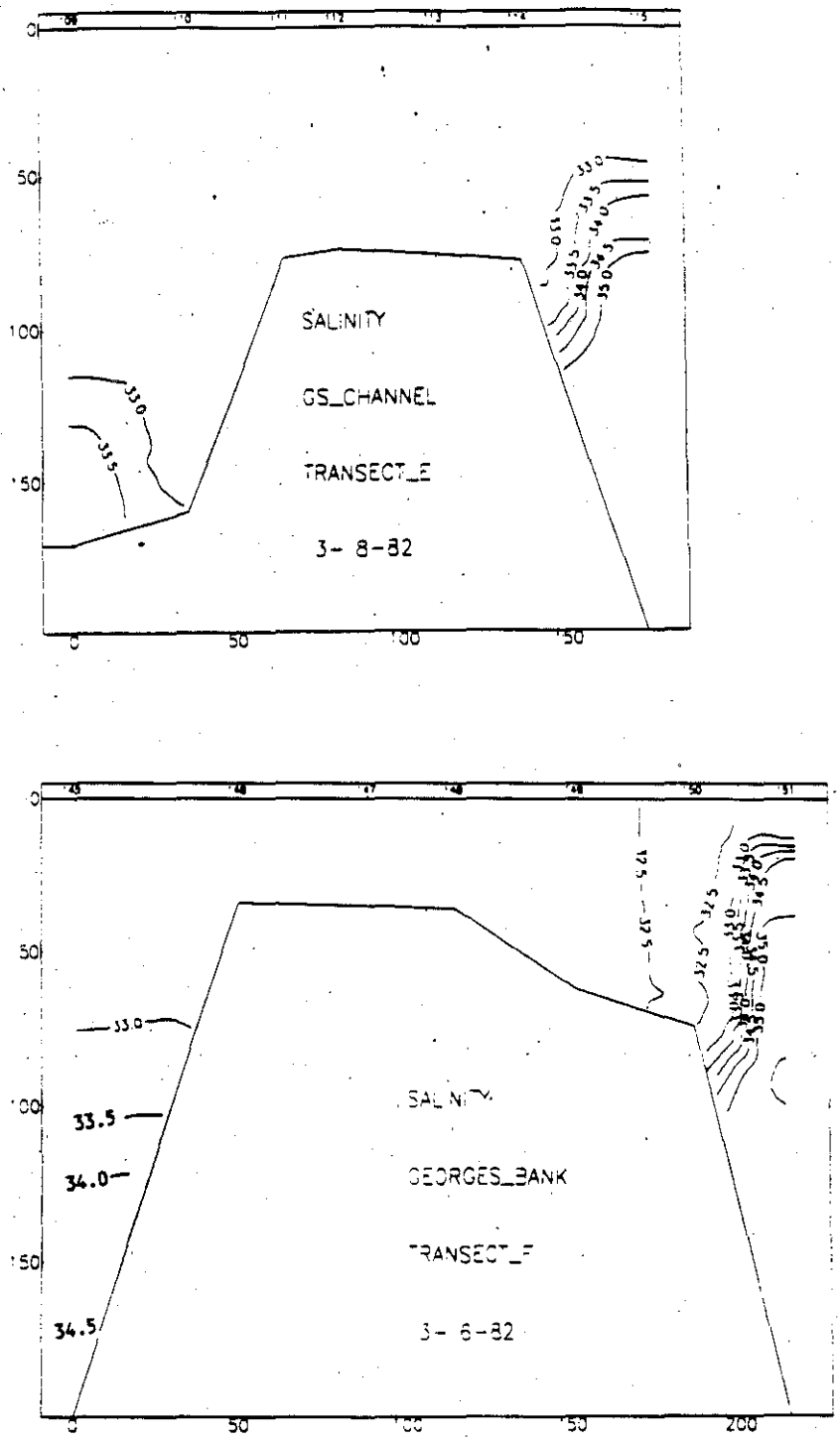


Figure 171. Continued.

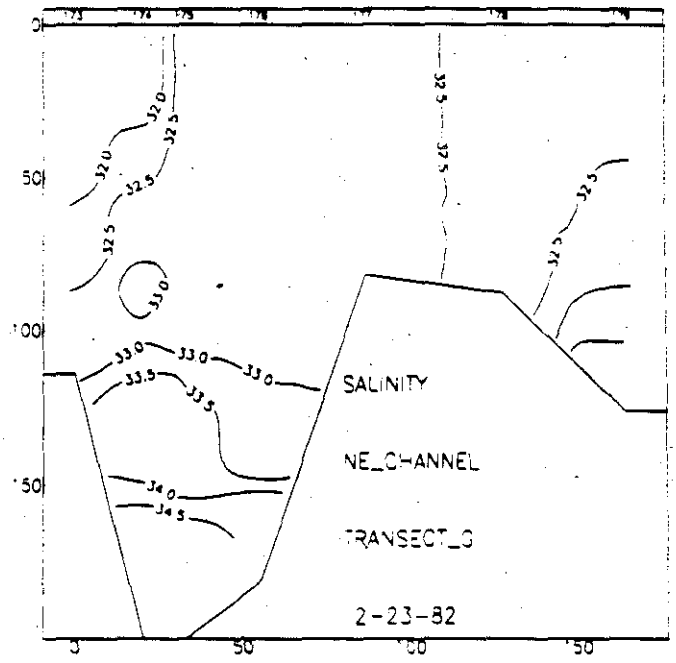


Figure 171. Continued.

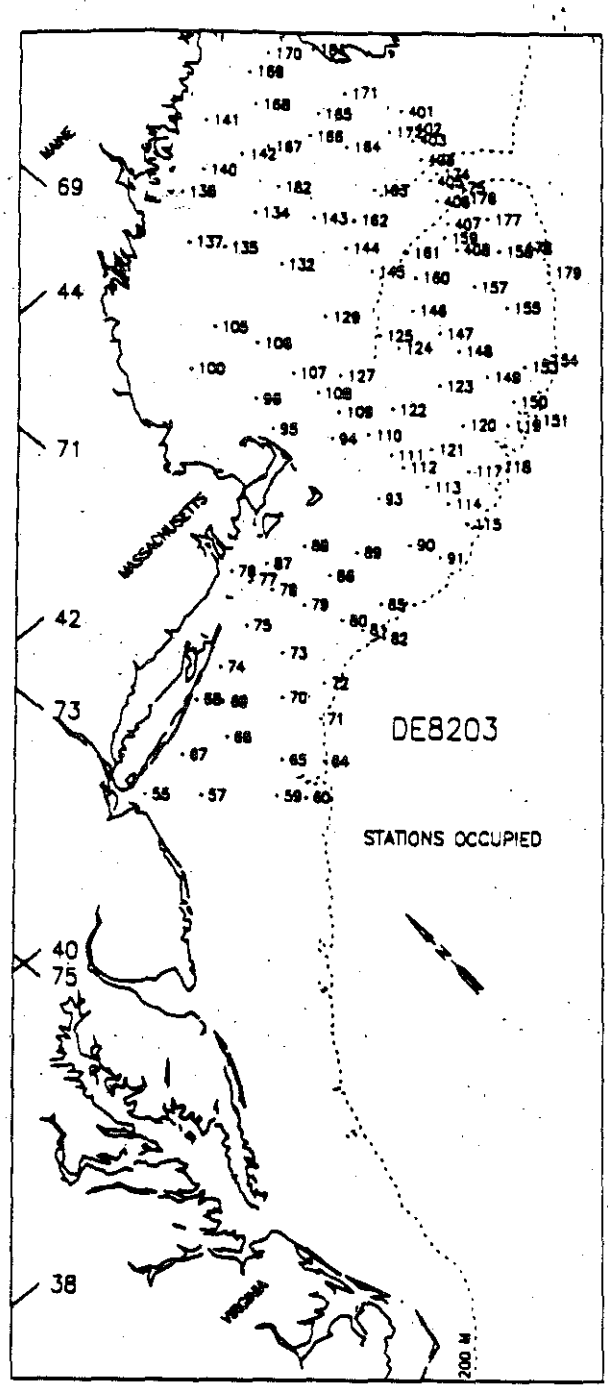


Figure 172. Station positions: DEL8203.

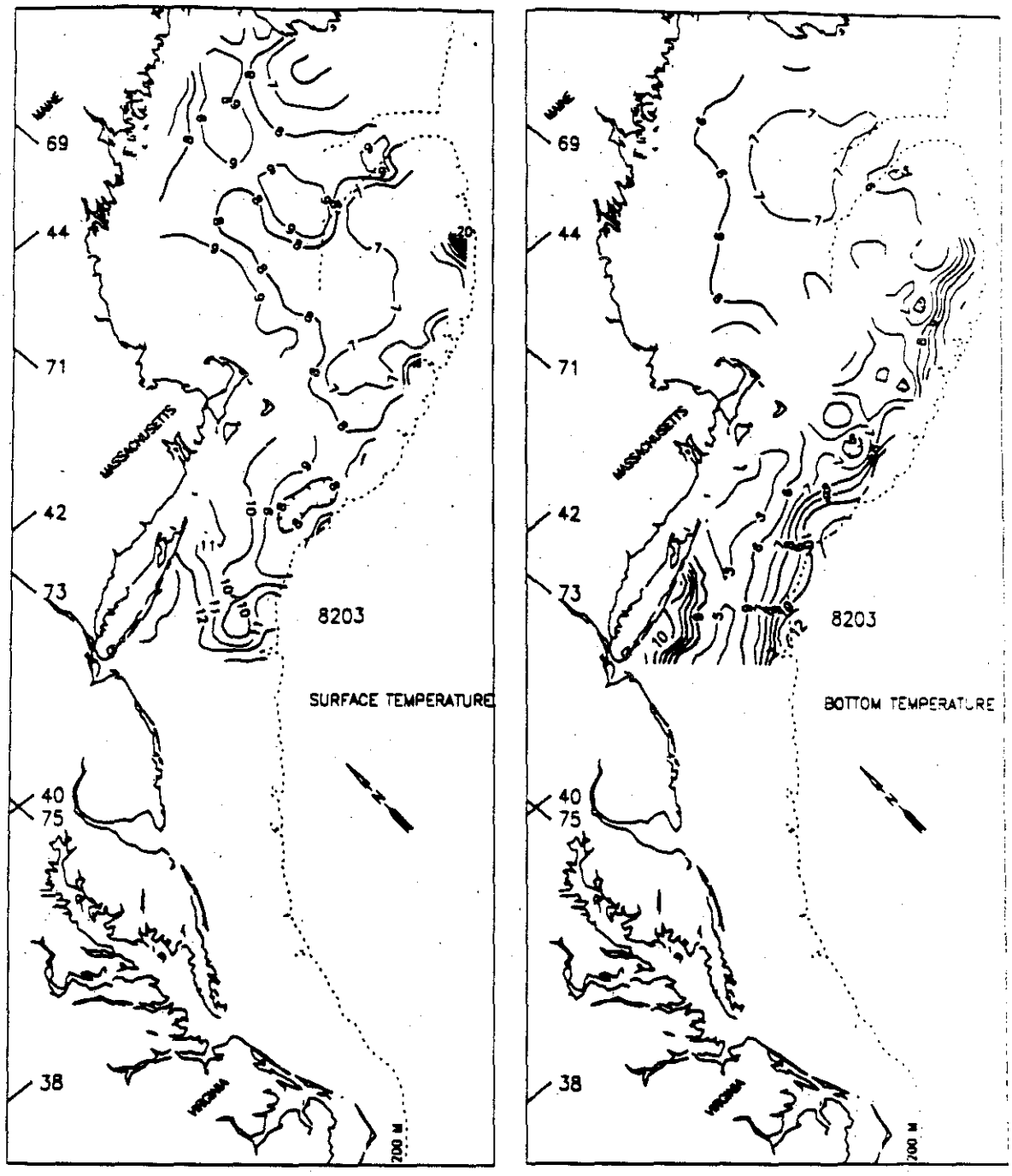


Figure 173. Surface and bottom temperature (°C) distribution: DEL8203.

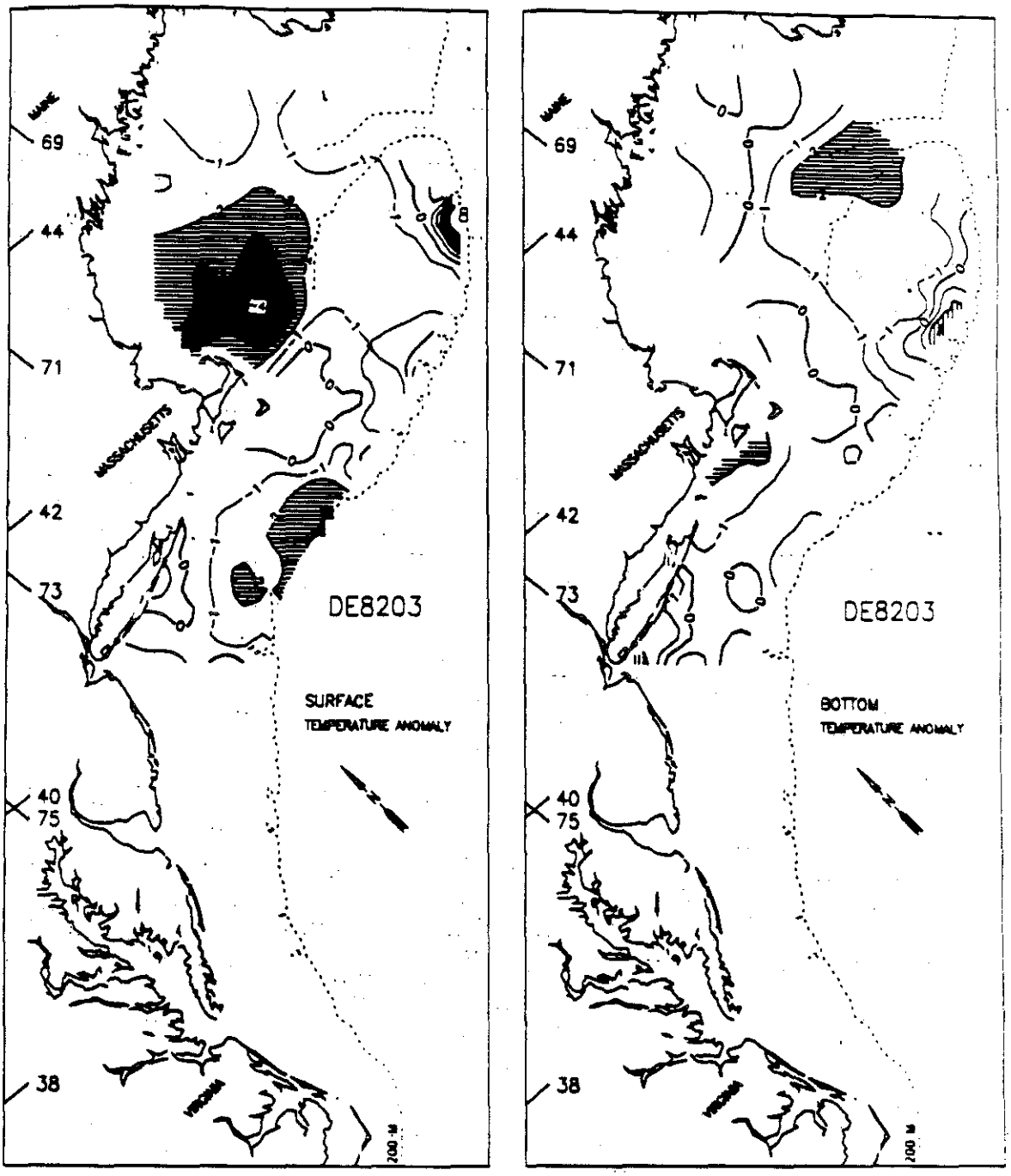


Figure 174. Normalized surface and bottom temperature anomaly: DEL8203. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

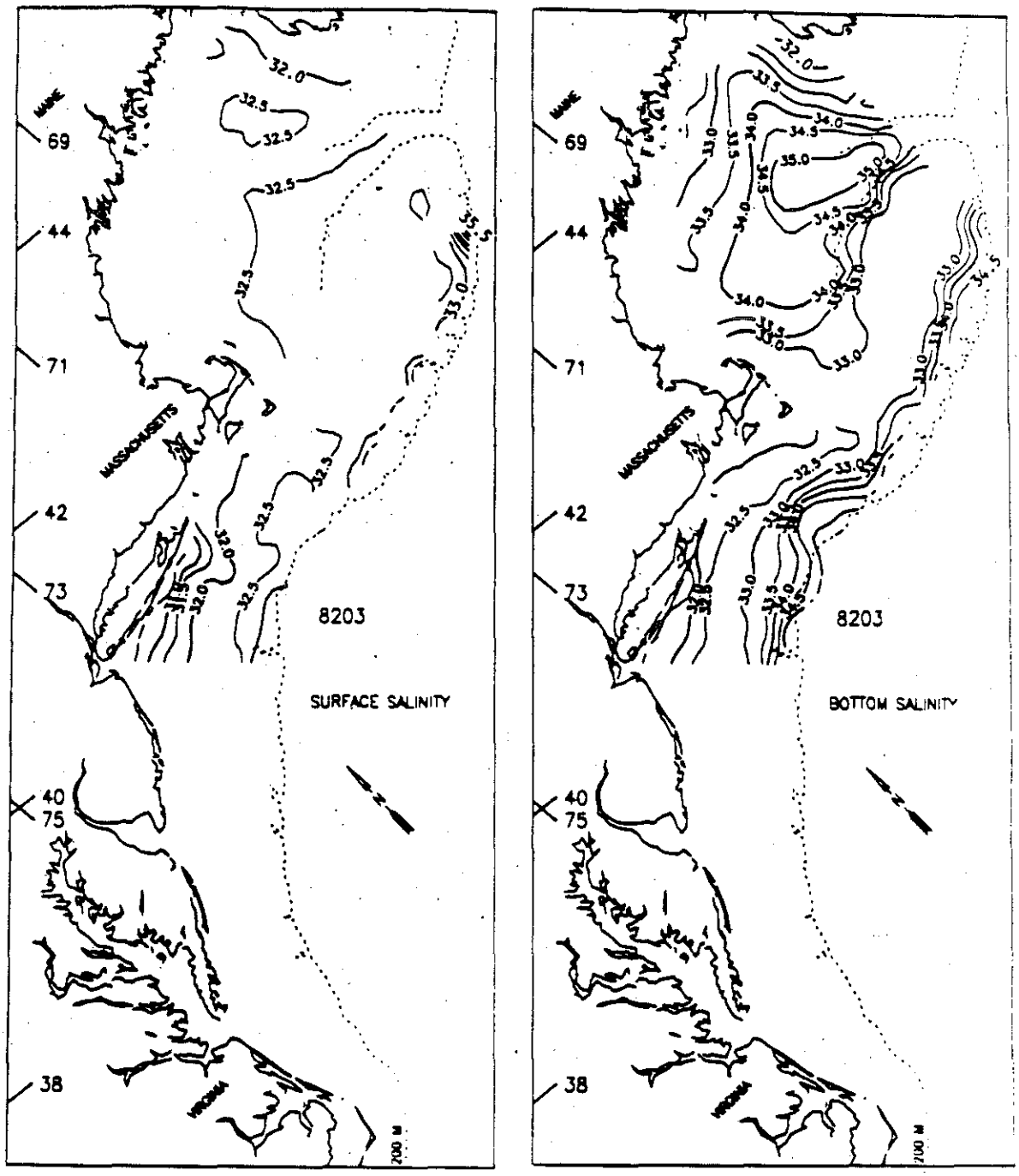


Figure 175. Surface and bottom salinity (PSU) distribution: DEL8203.

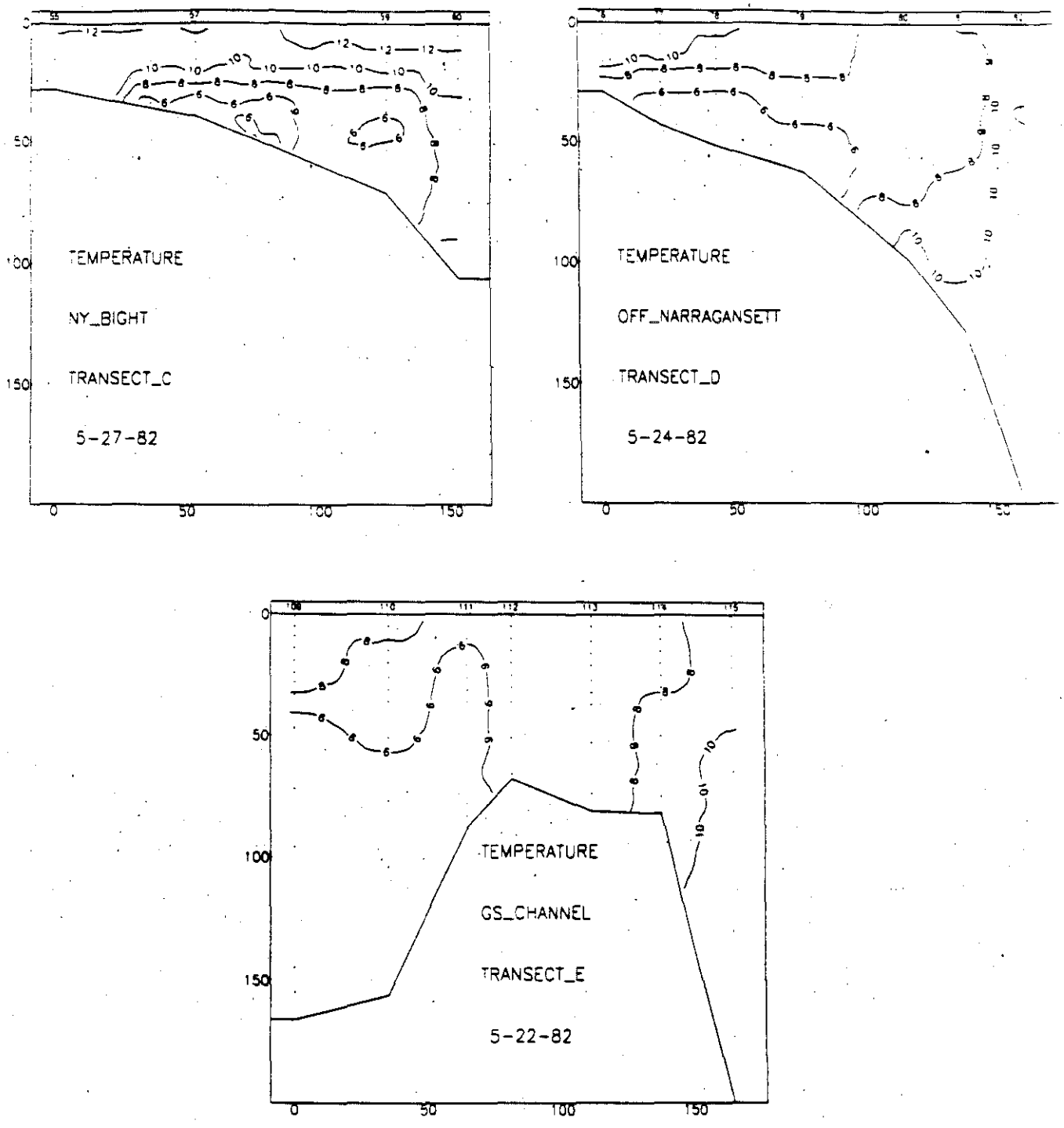
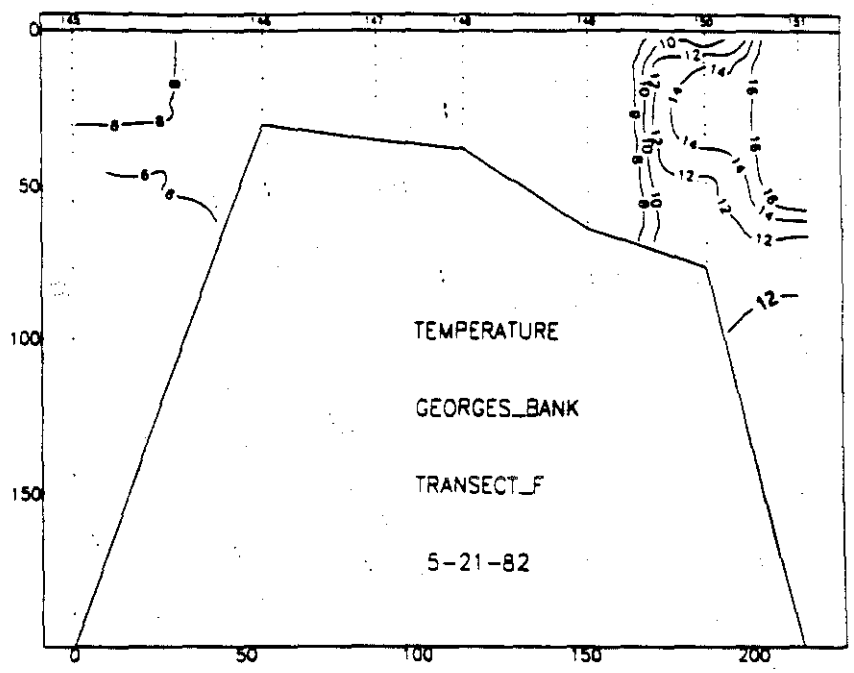


Figure 176. Temperature (°C) transects: DEL8203.



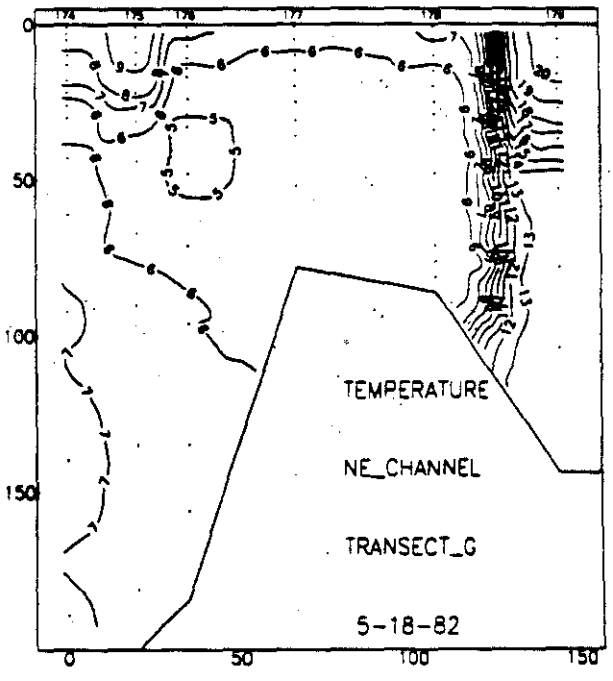
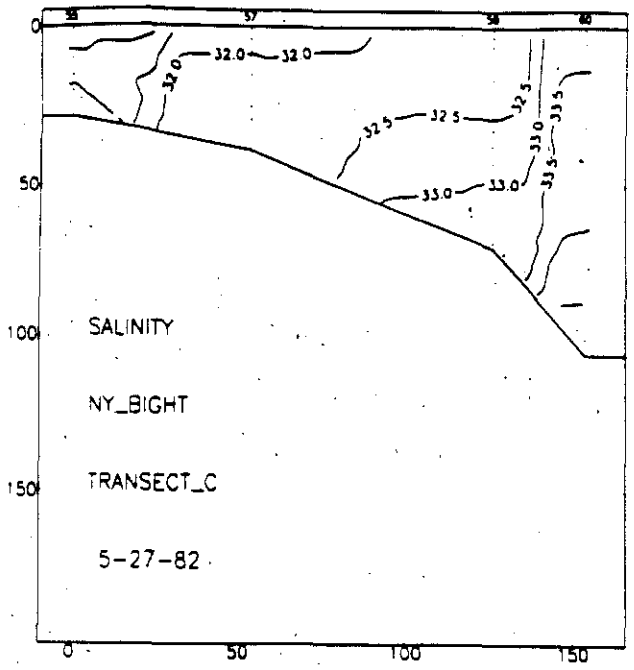
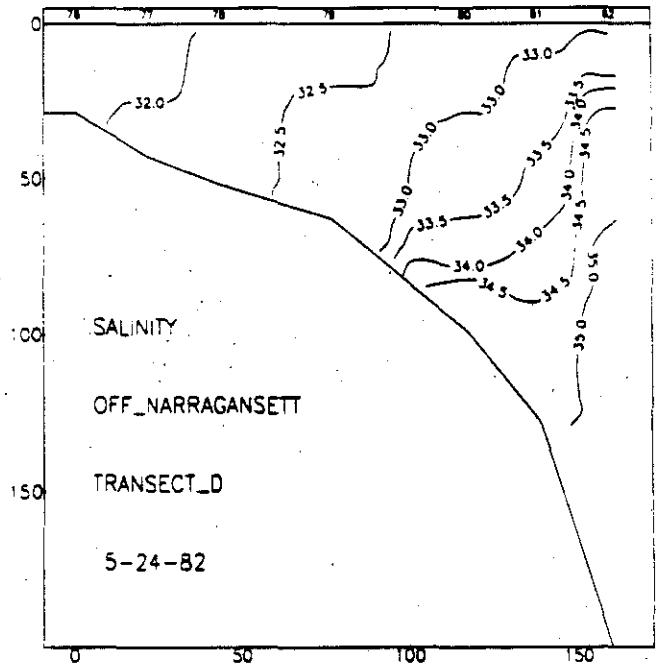


Figure 176. Continued.





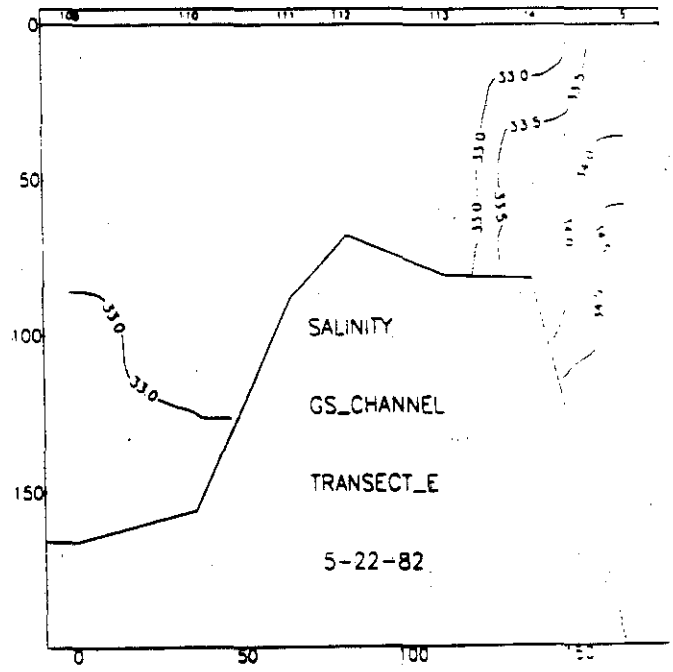
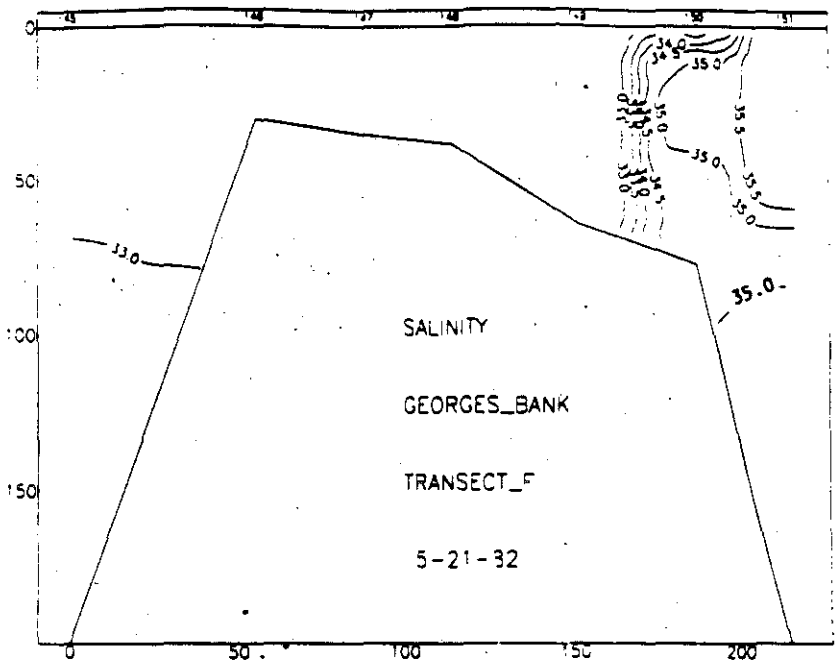


Figure 177. Salinity (PSU) transects: DEL8203.



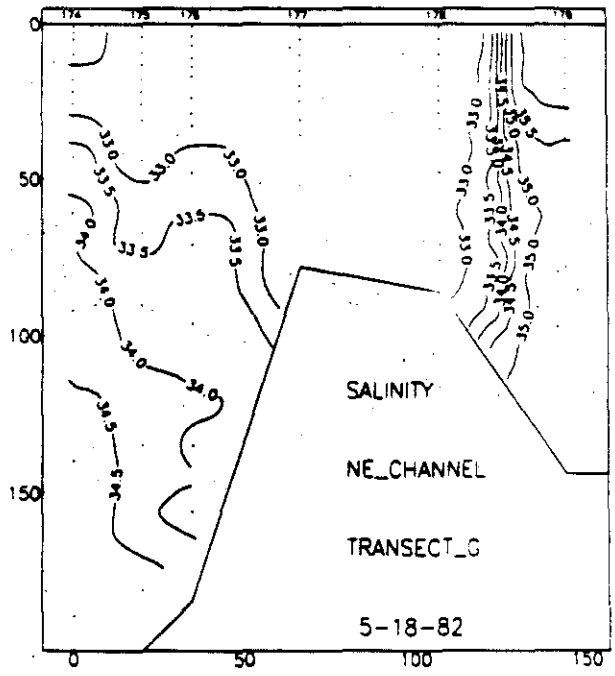


Figure 177. Continued.

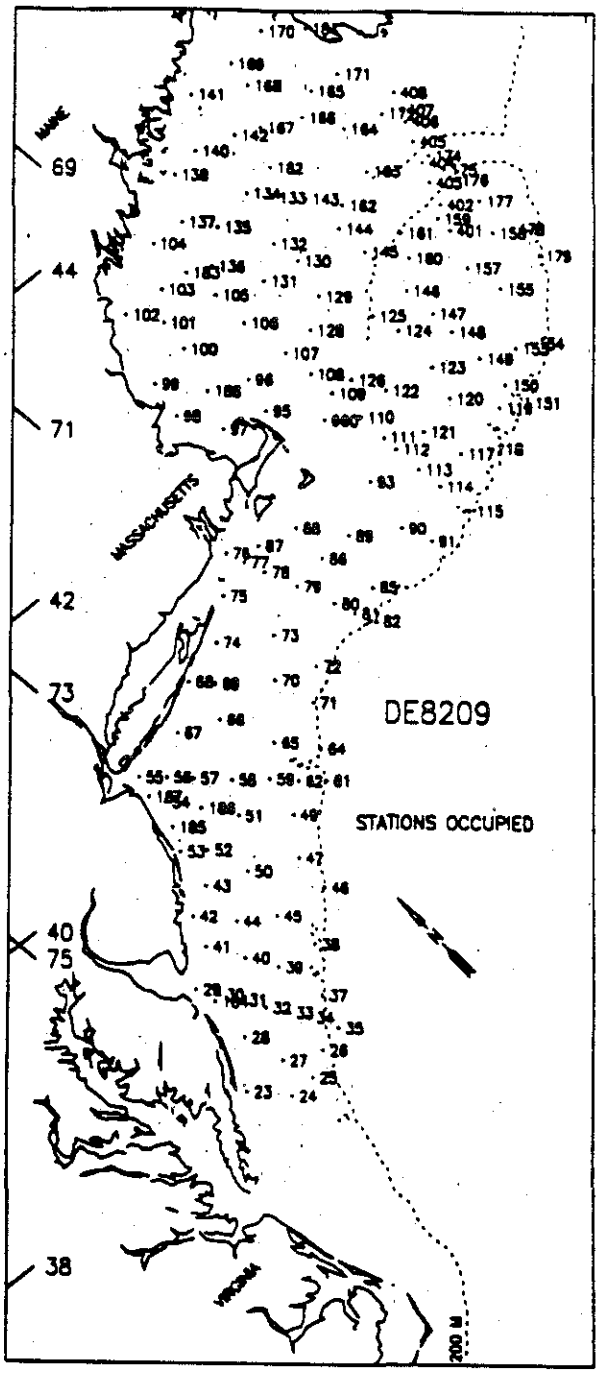


Figure 178. Station positions: DEL8209.

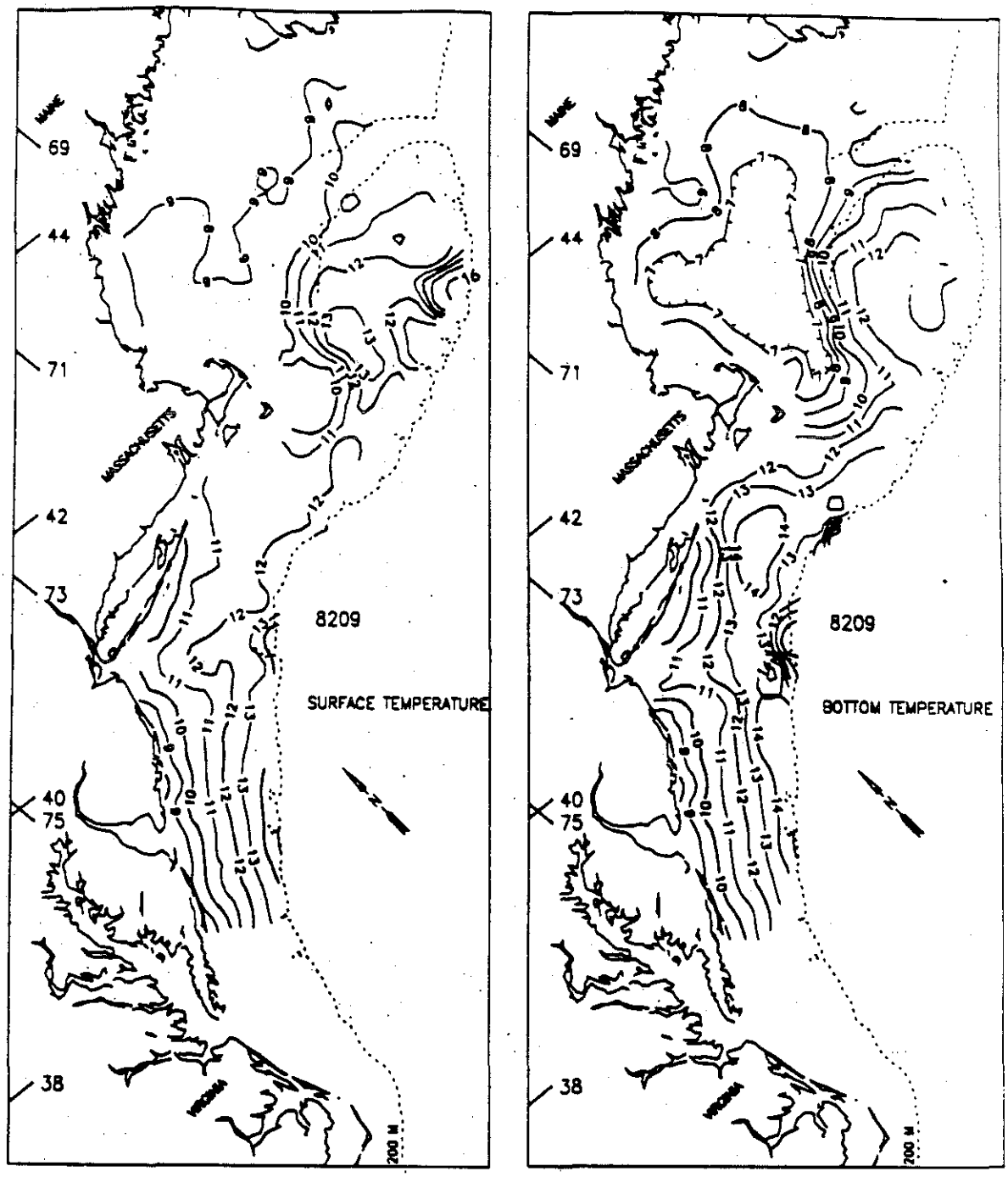


Figure 179. Surface and bottom temperature (°C) distribution: DEL8209.

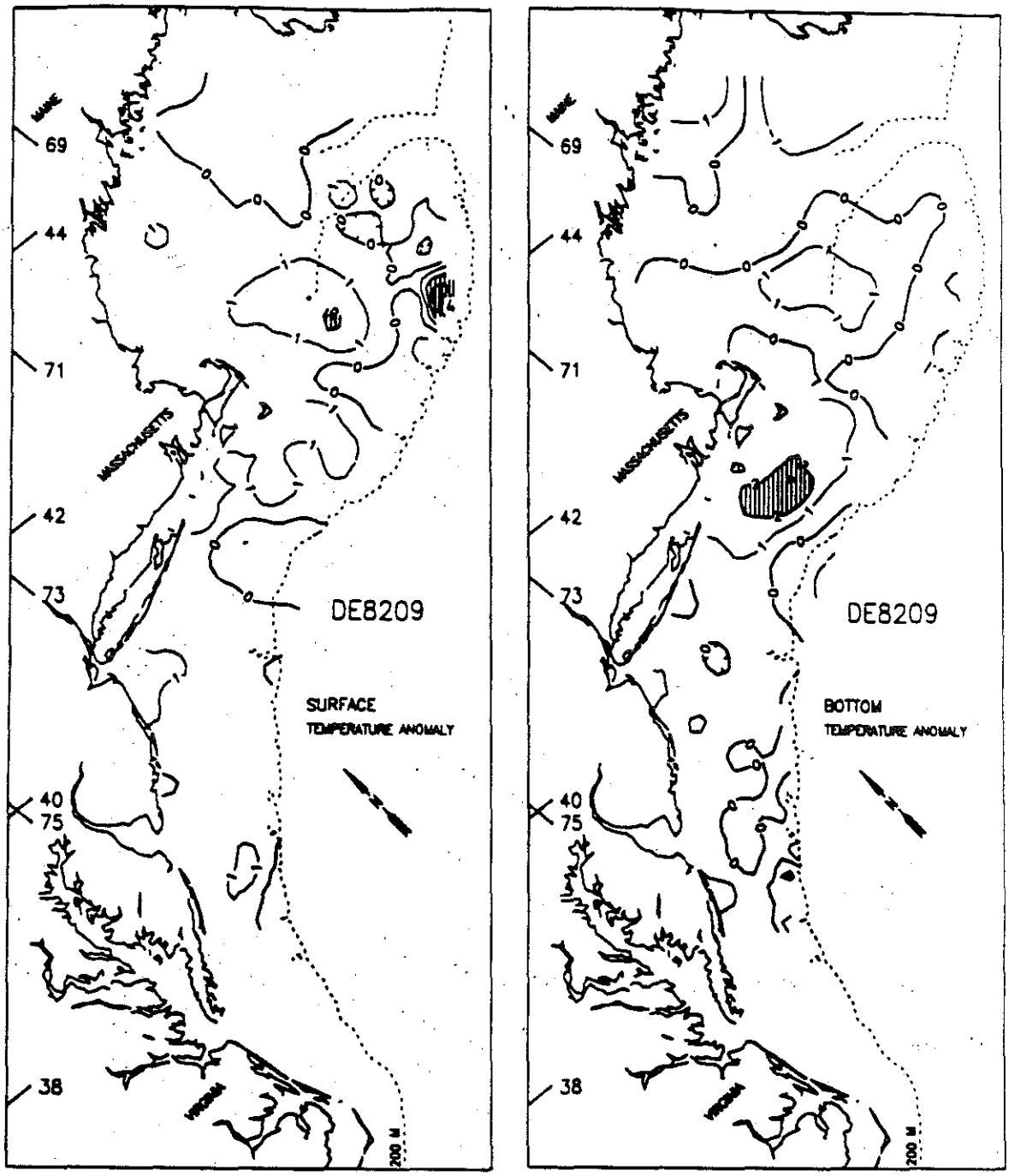


Figure 180. Normalized surface and bottom temperature anomaly: DEL8209.Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

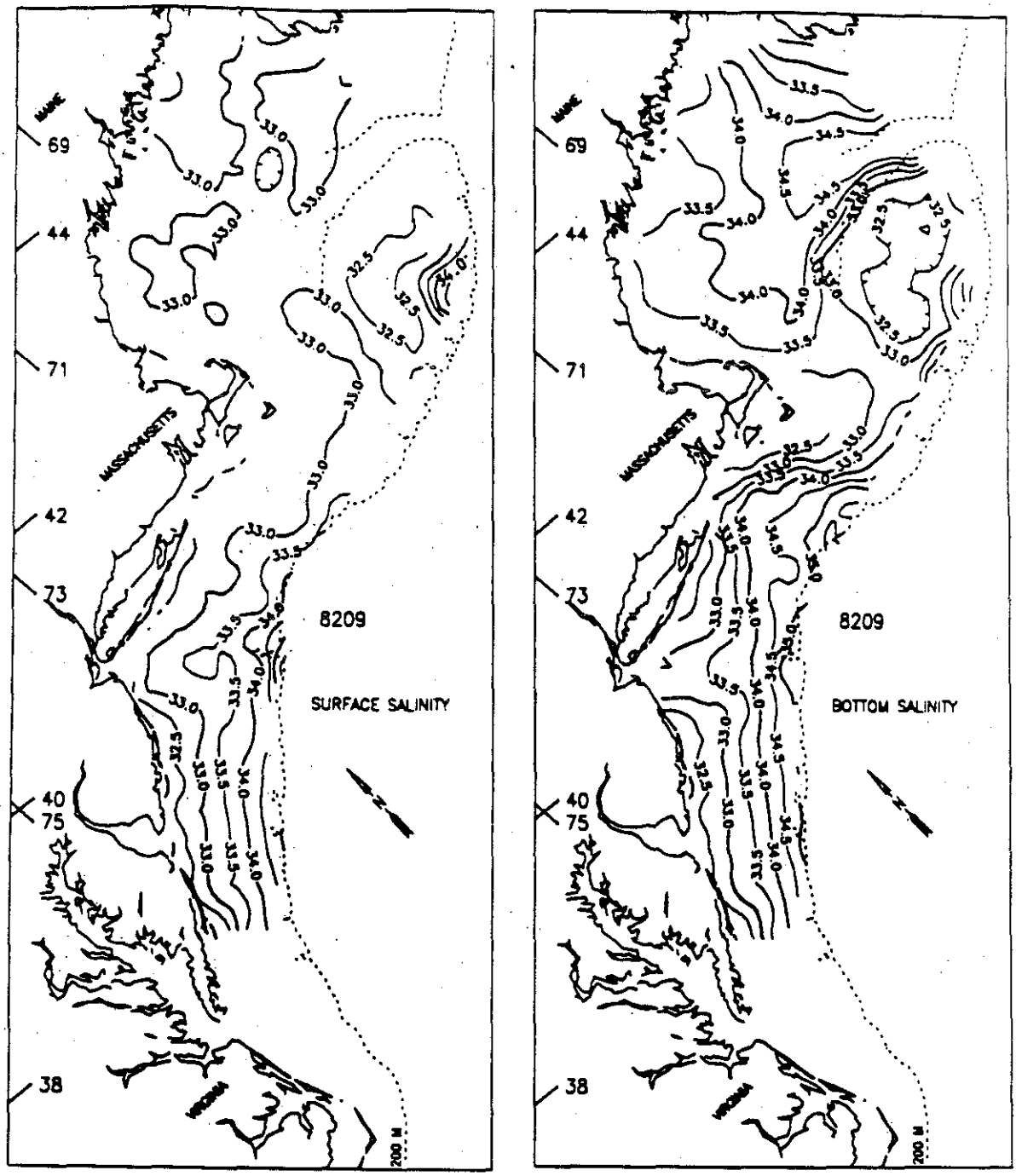


Figure 181. Surface and bottom salinity (PSU) distribution: DEL8209.

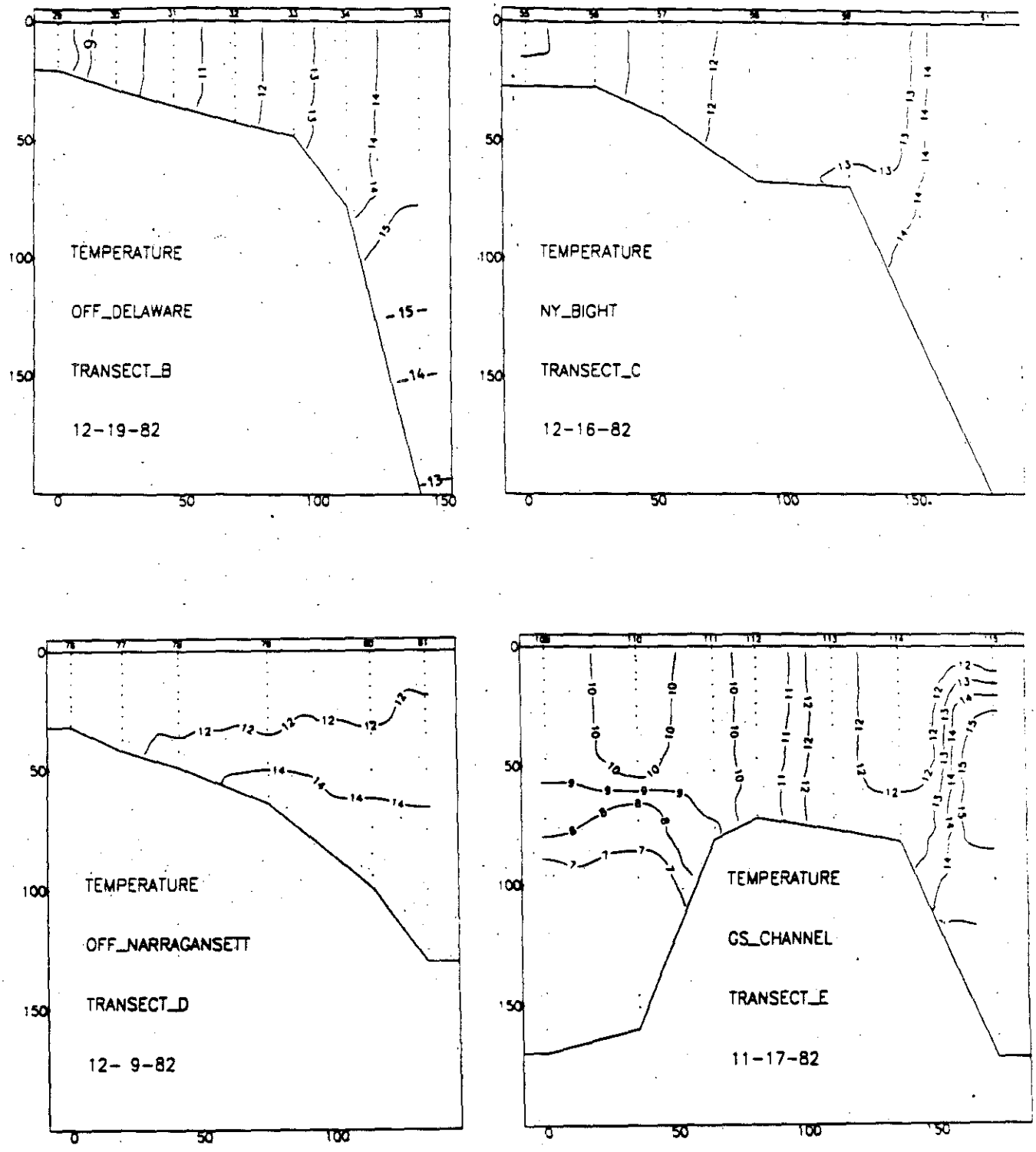
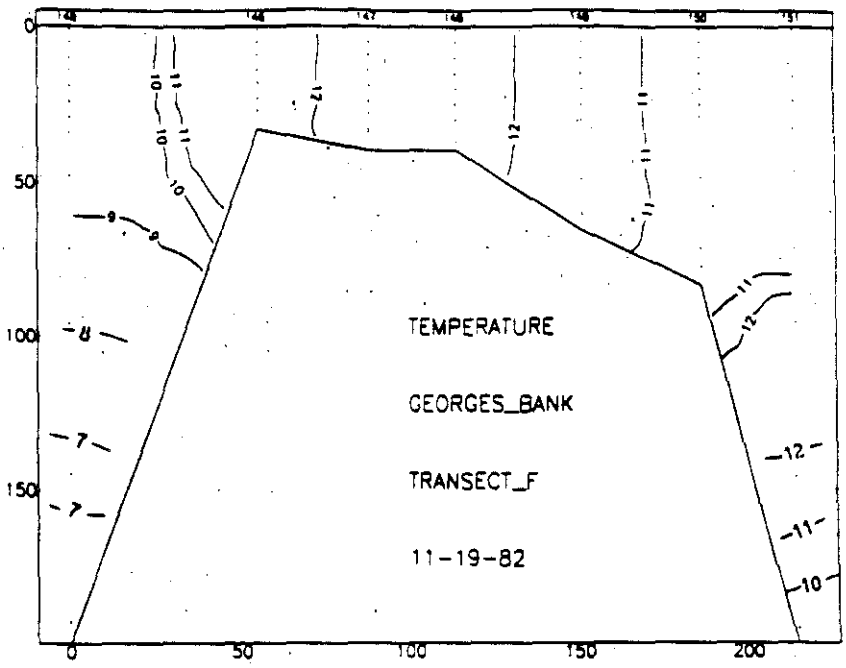


Figure 182. Temperature (°C) transects: DEL8209.



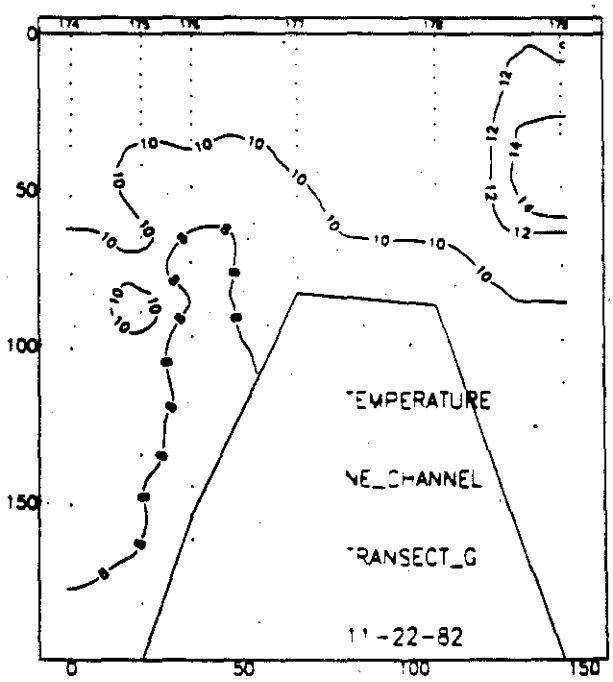


Figure 182. Continued.

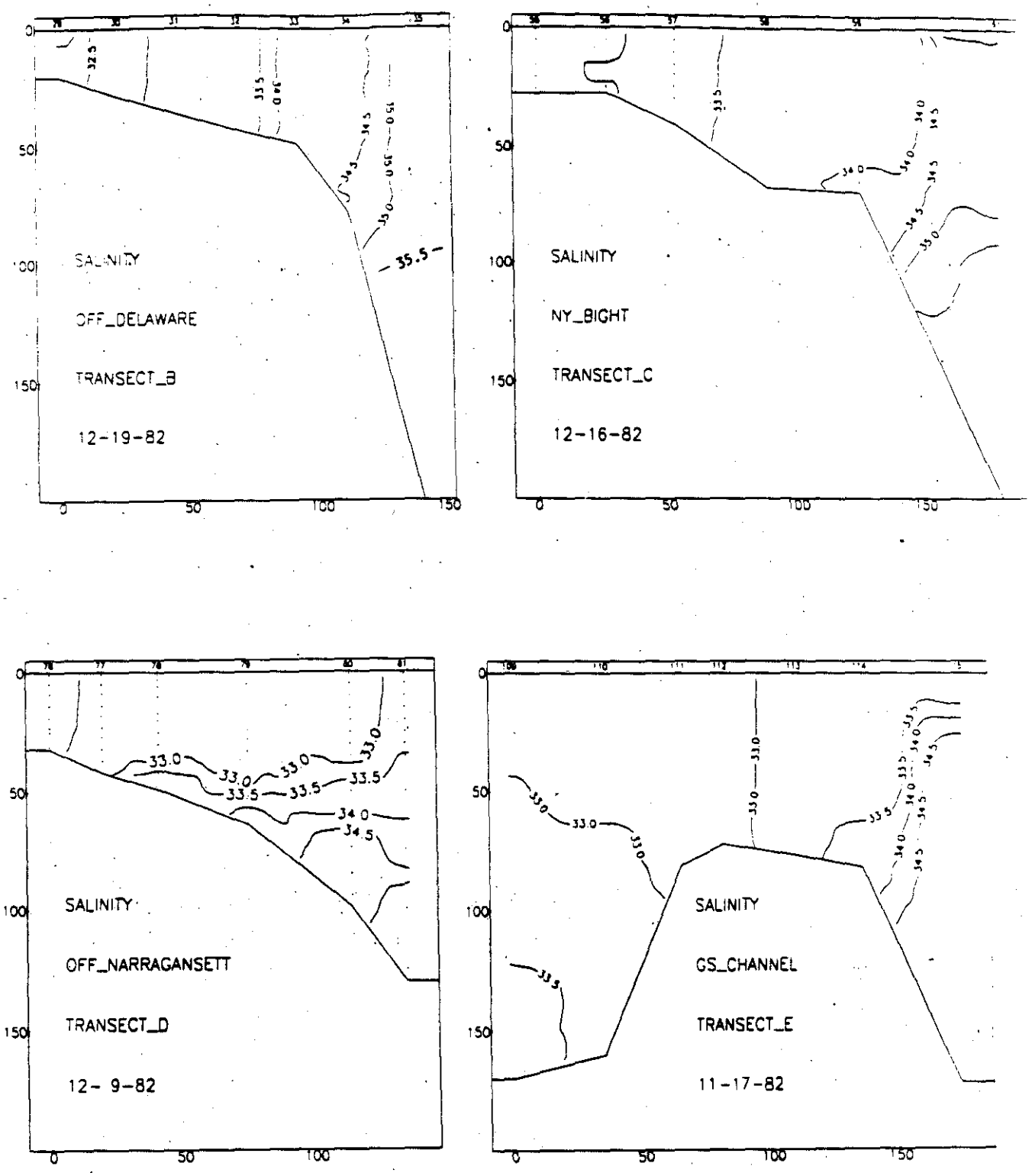
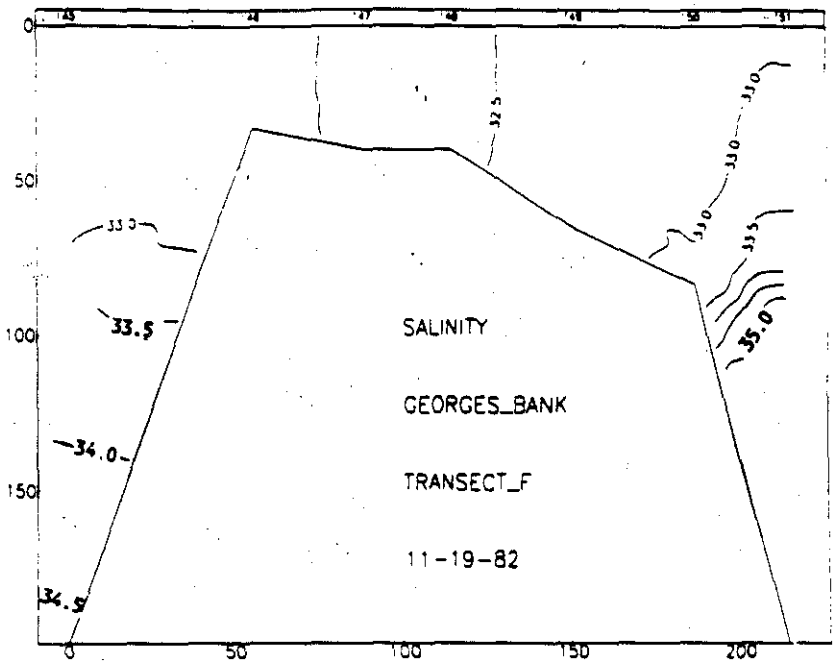


Figure 183. Salinity (PSU) transects: DEL8209.



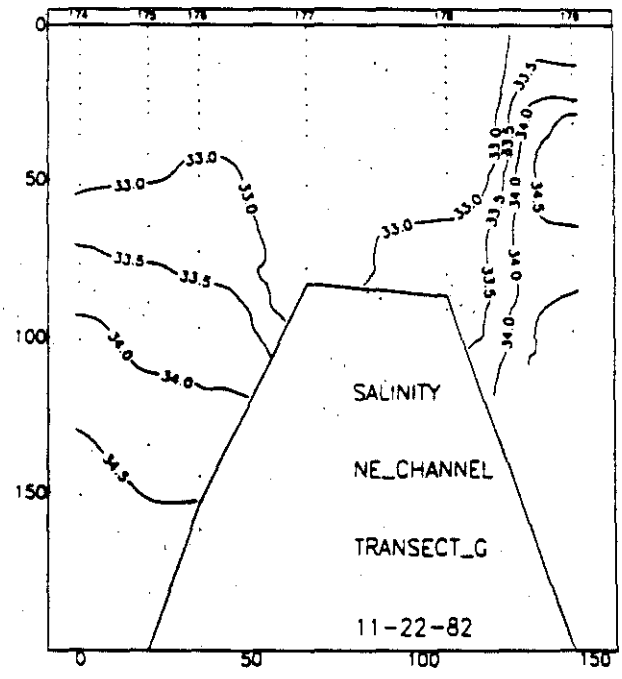


Figure 183. Continued.

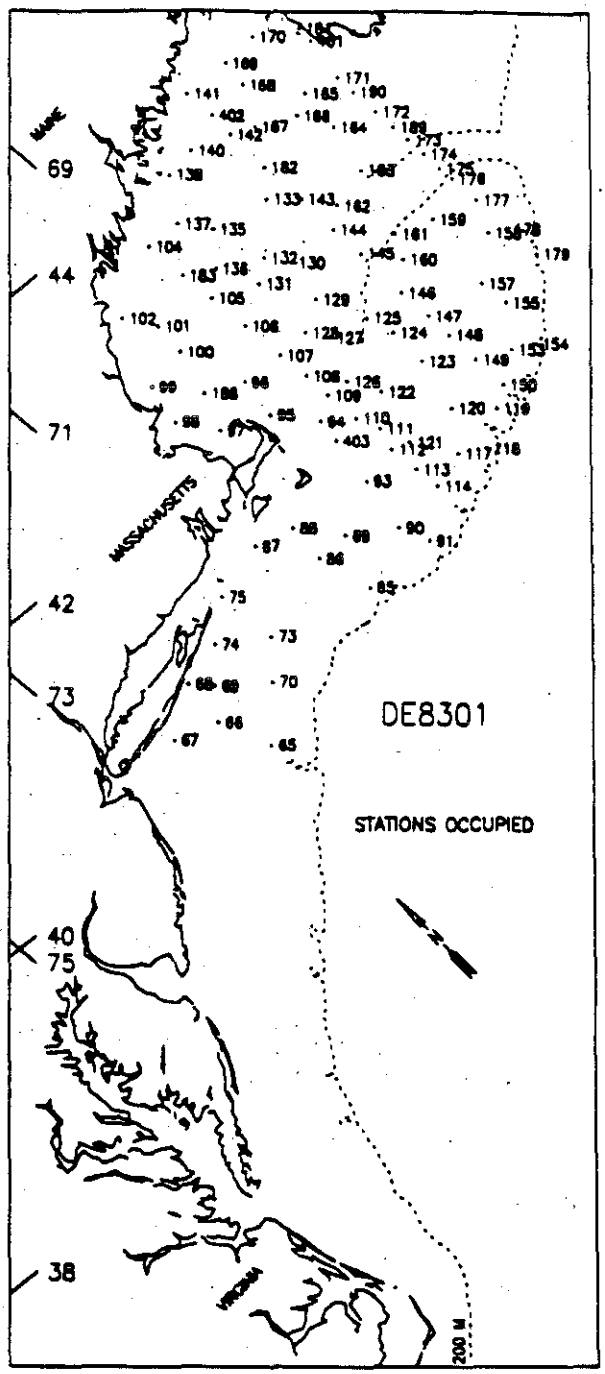


Figure 184. Station positions: DEL8301.

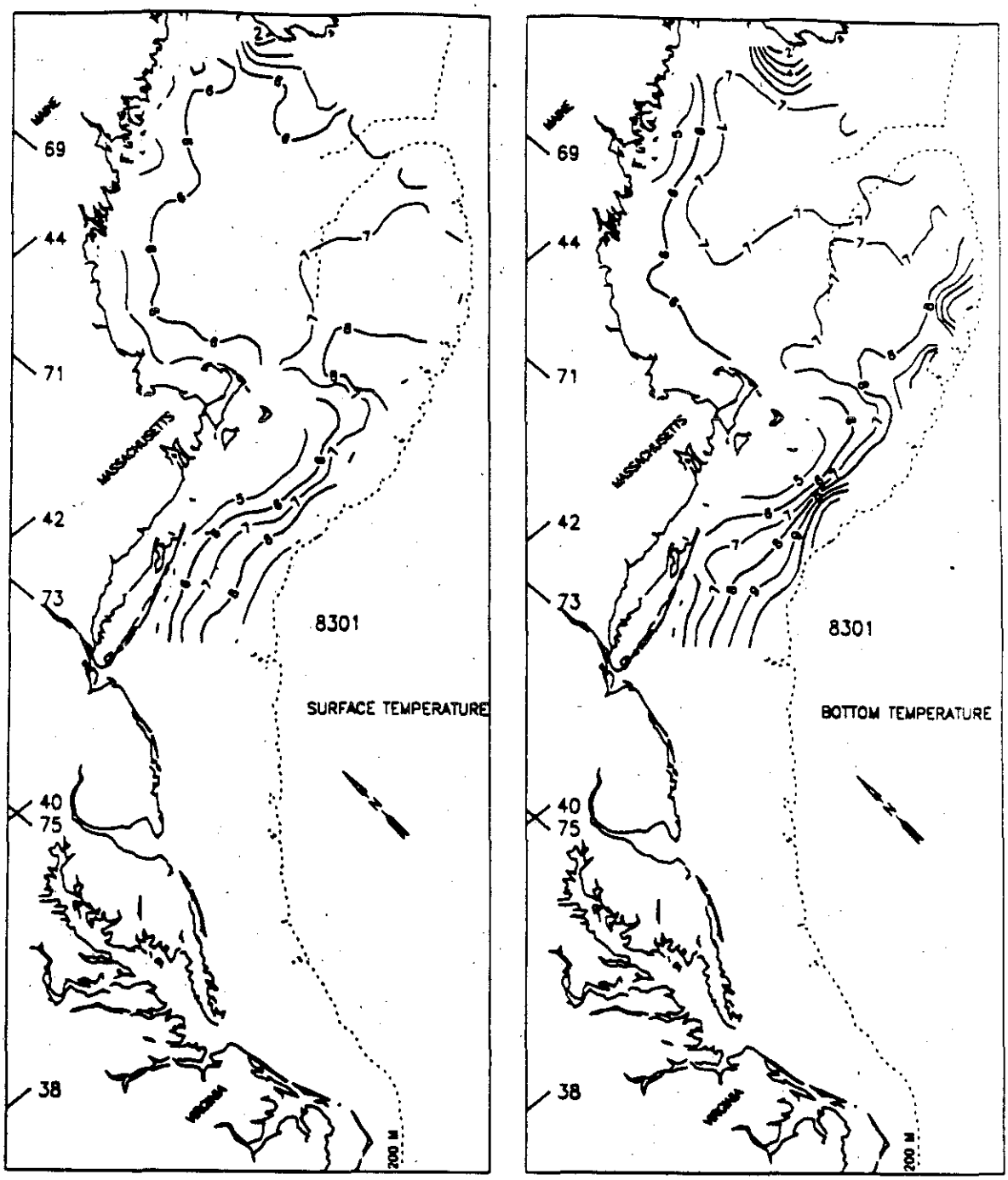


Figure 185. Surface and bottom temperature (°C) distribution: DEL8301.

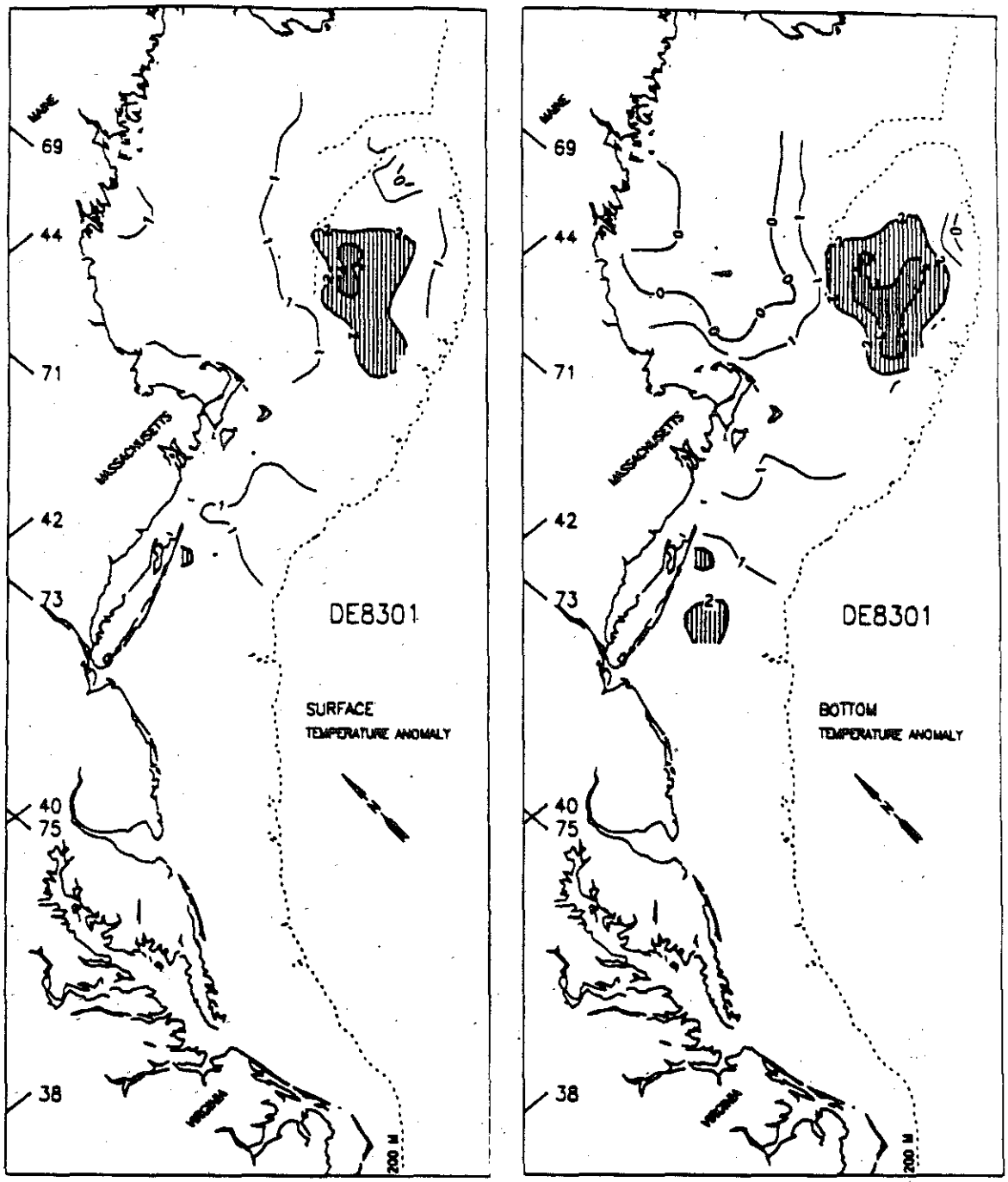


Figure 186. Normalized surface and bottom temperature anomaly: DEL8301.Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

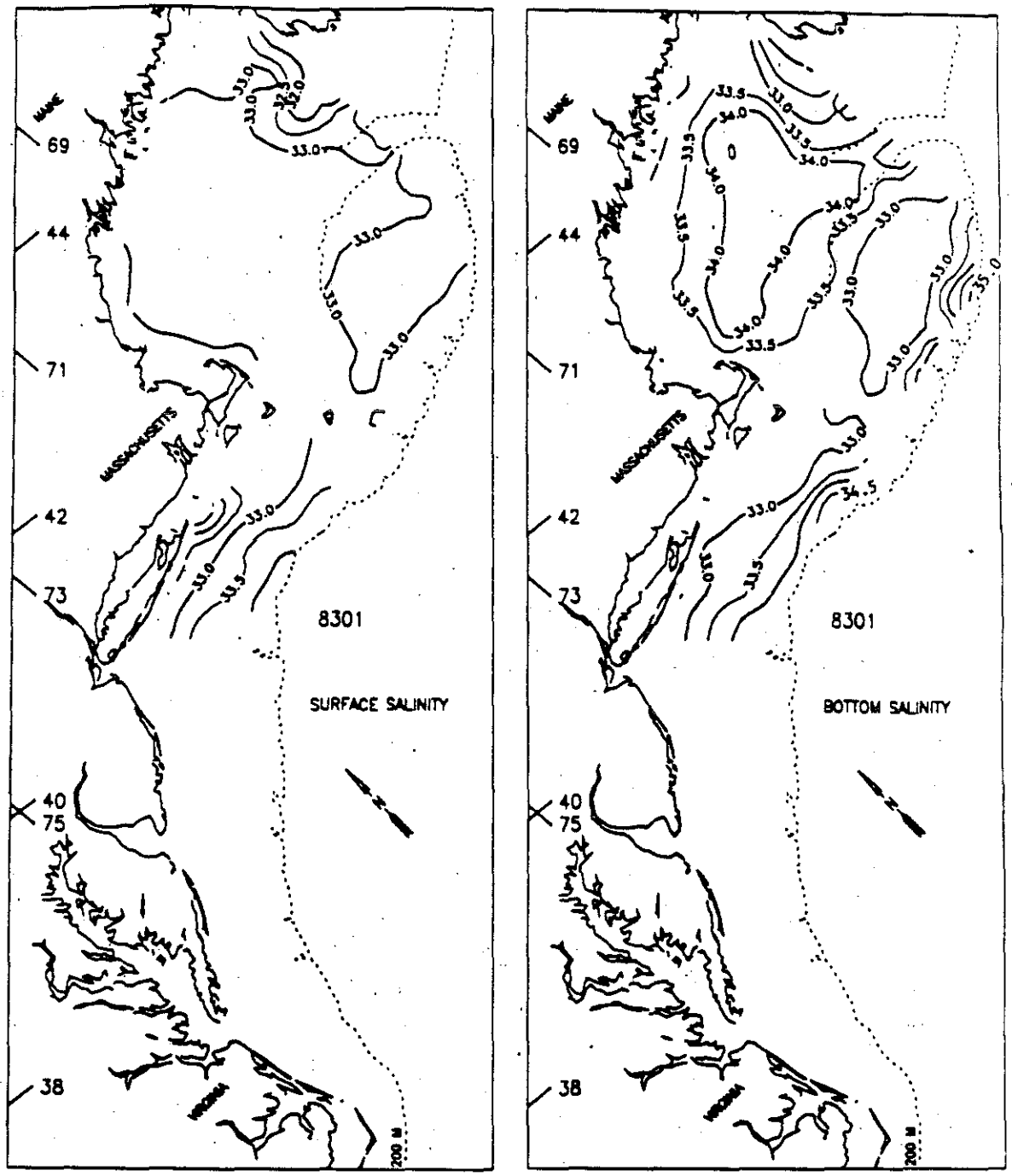


Figure 187. Surface and bottom salinity (PSU) distribution: DEL8301.

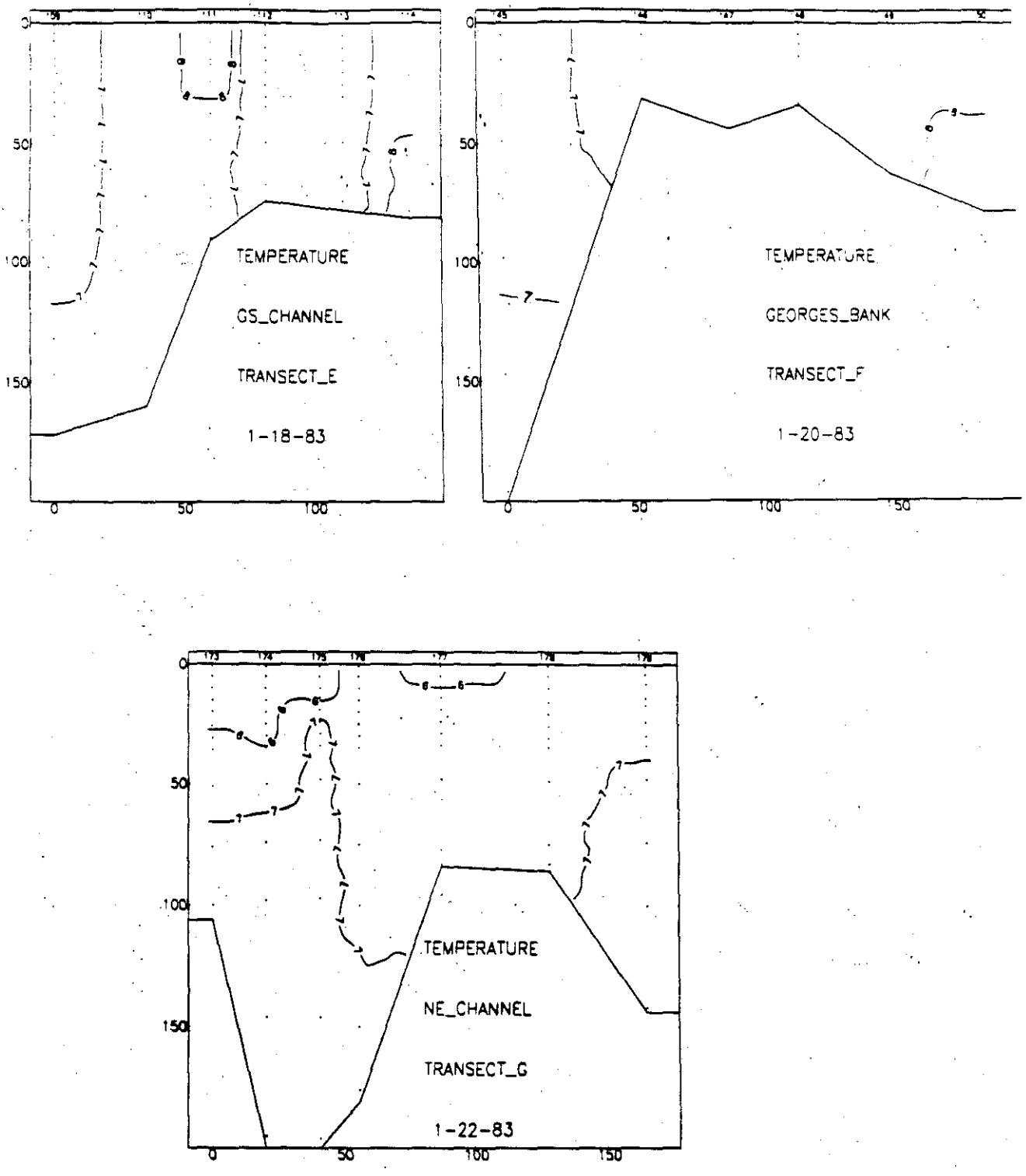


Figure 188. Temperature (°C) transects: DEL8301.

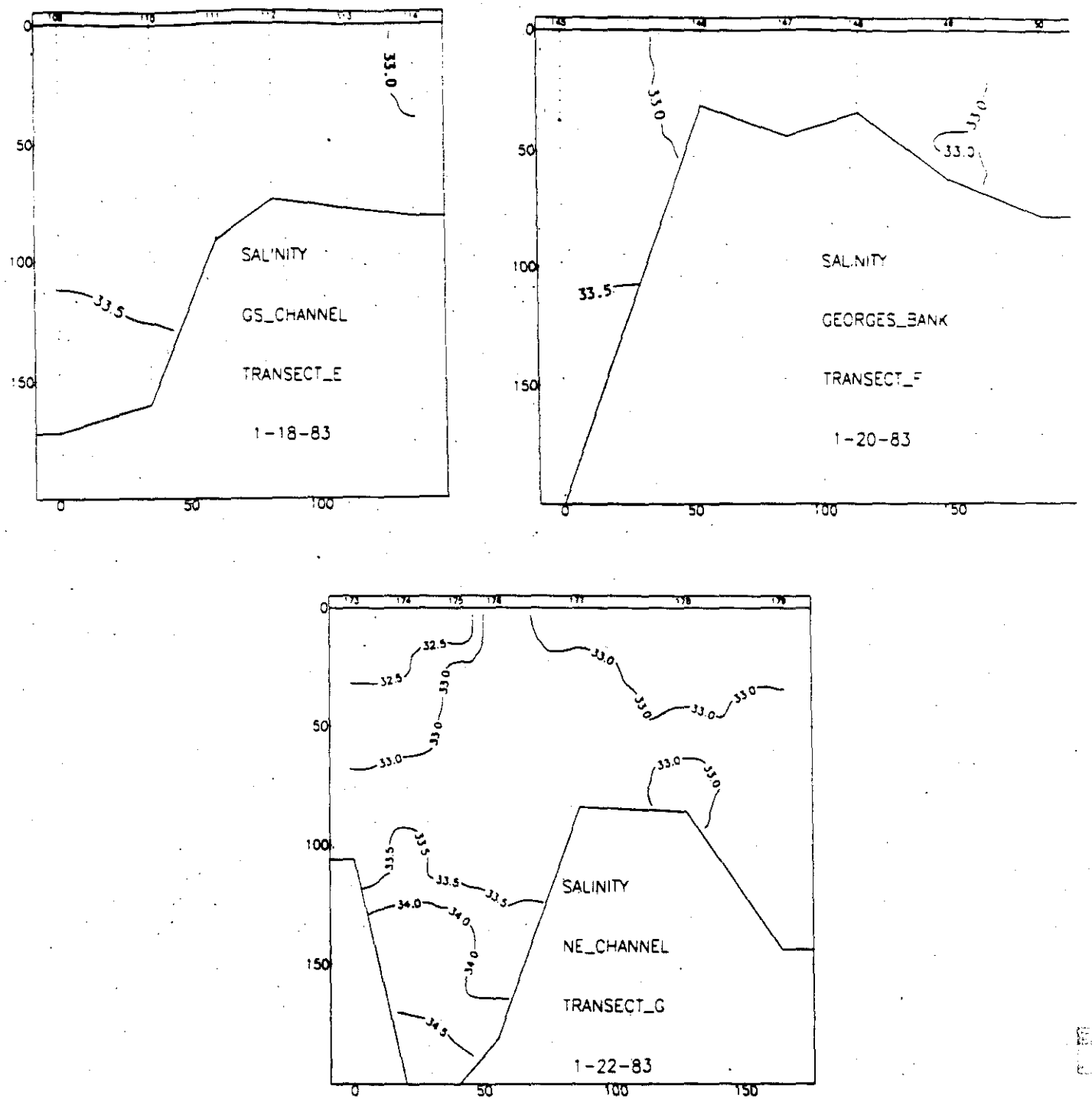


Figure 189. Salinity (PSU) transects: DEL8301.

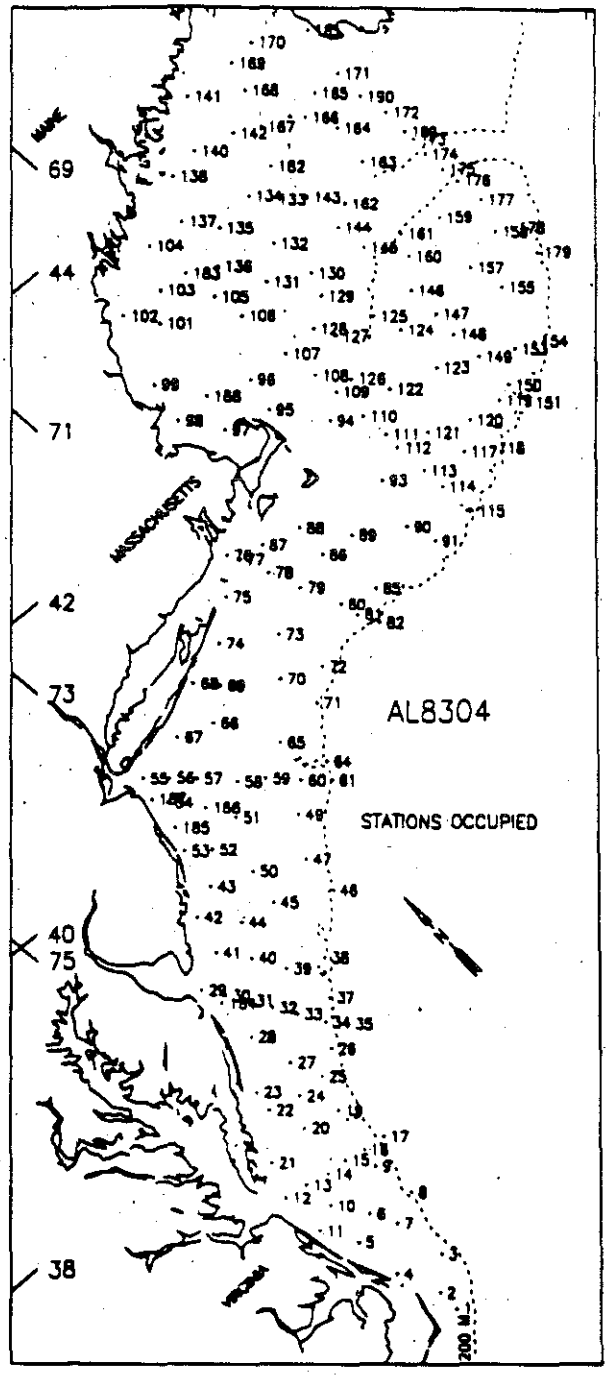


Figure 190. Station positions: ALB8304.

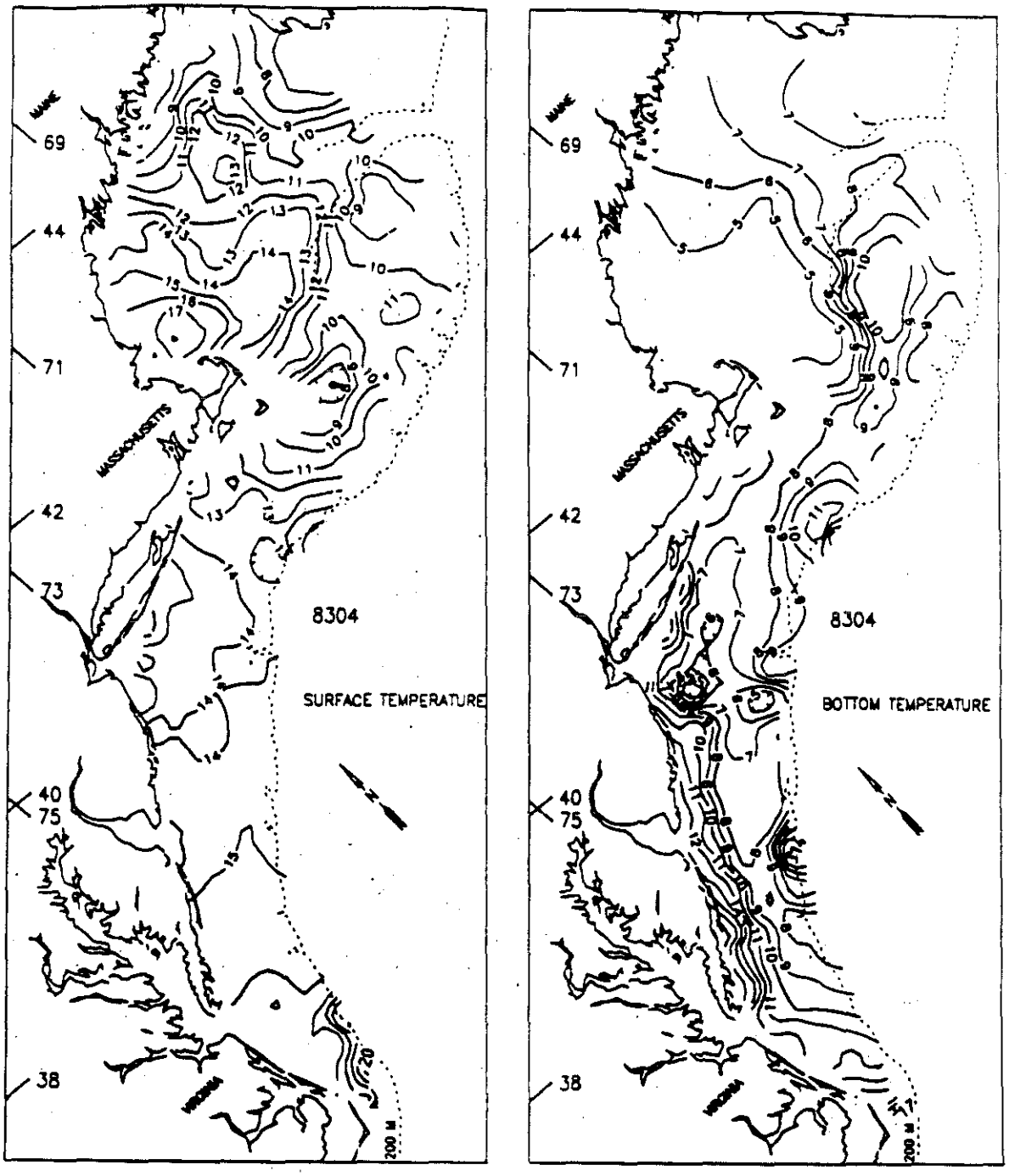


Figure 191. Surface and bottom temperature (°C) distribution: ALB8304.

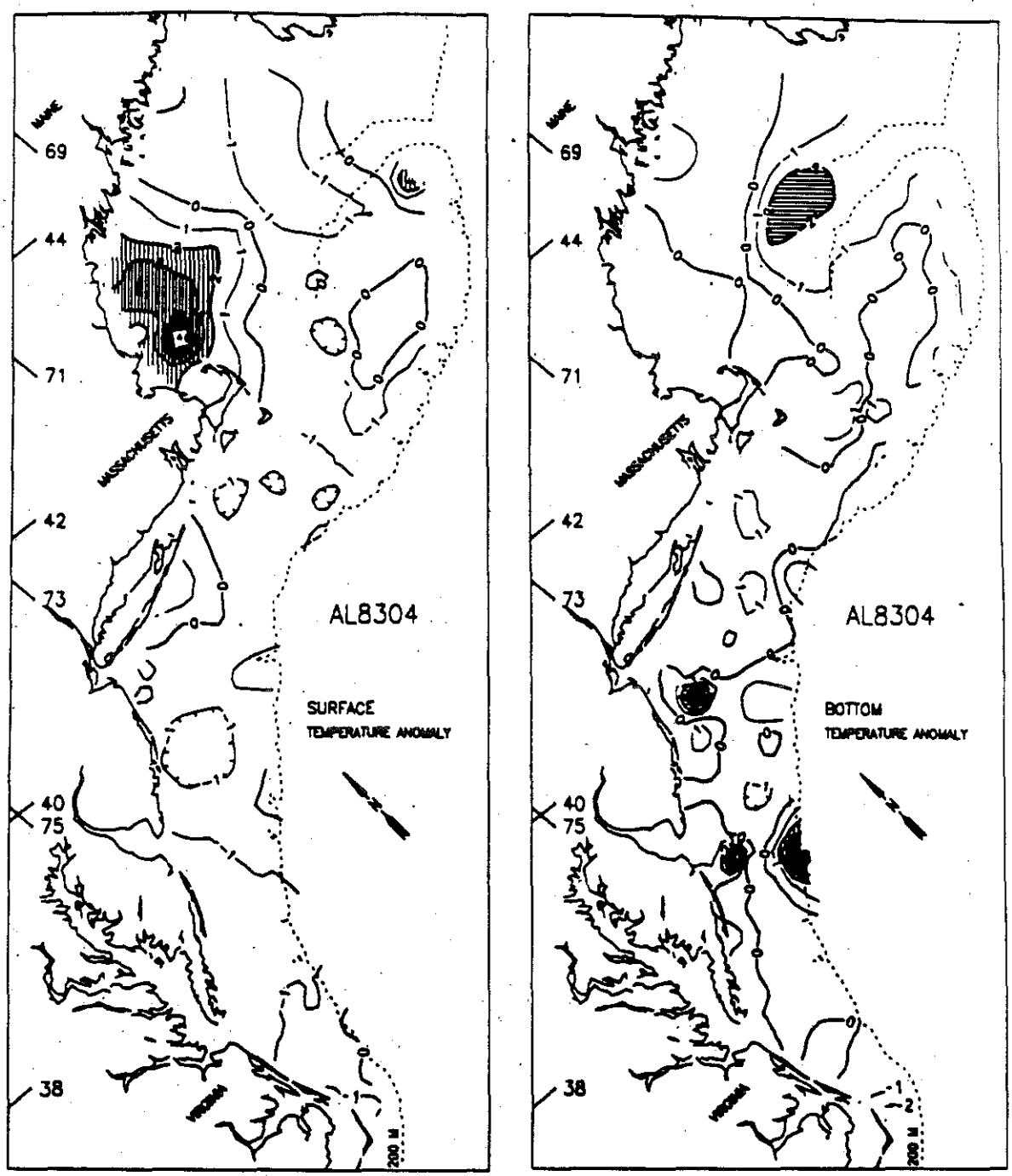


Figure 192. Normalized surface and bottom temperature anomaly: ALB8304.Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

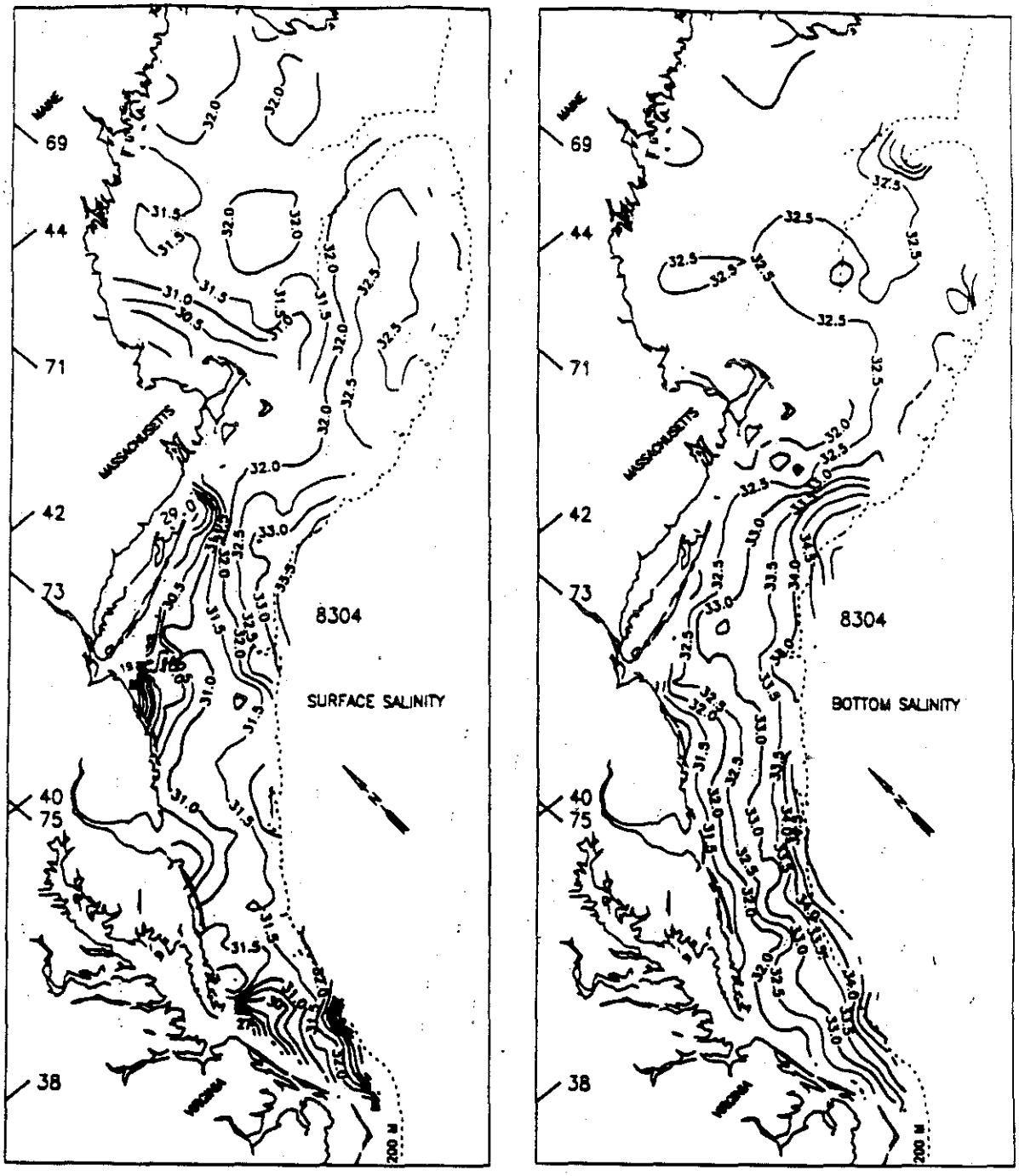


Figure 193. Surface and bottom salinity (PSU) distribution: ALB8304.

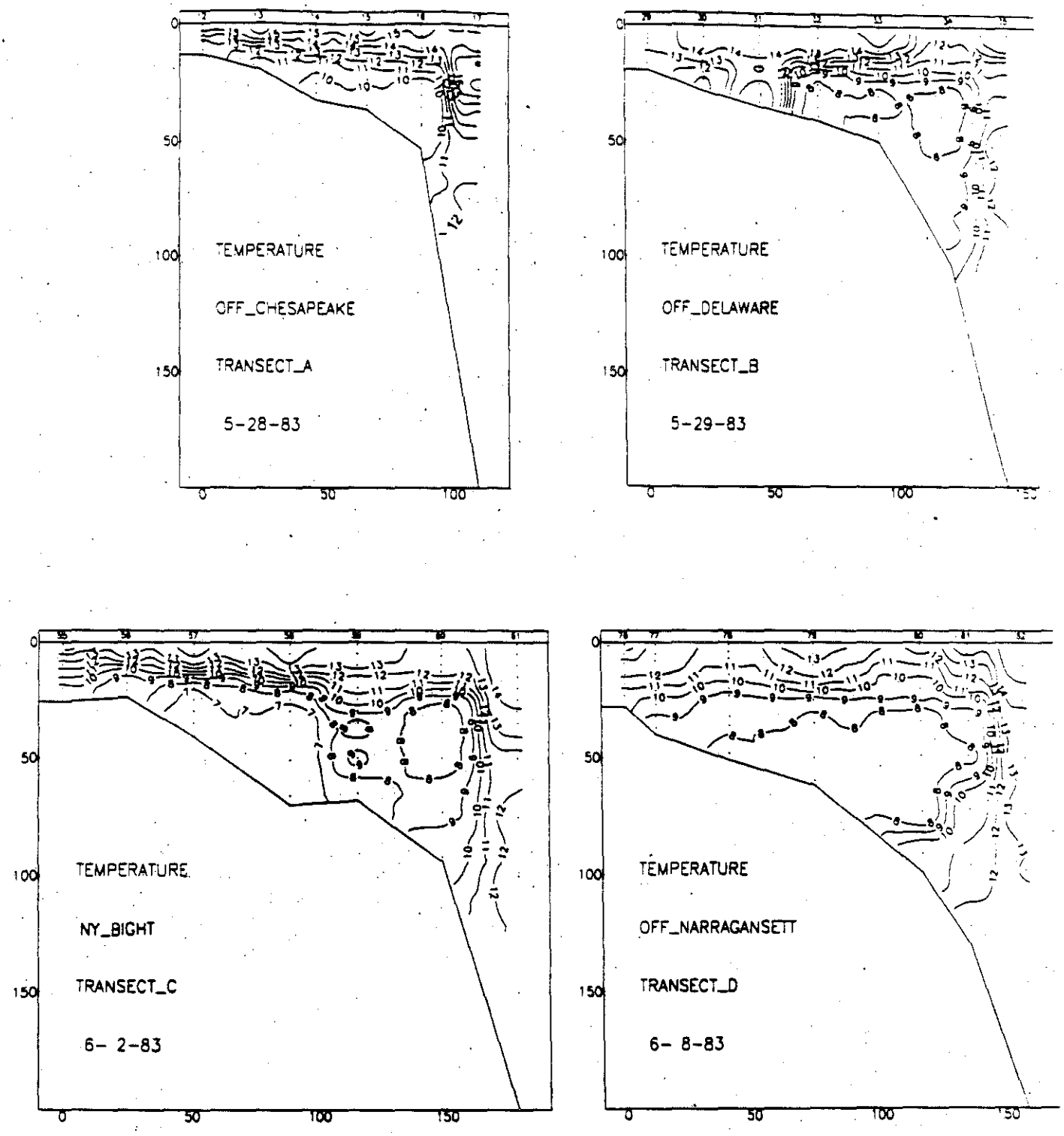
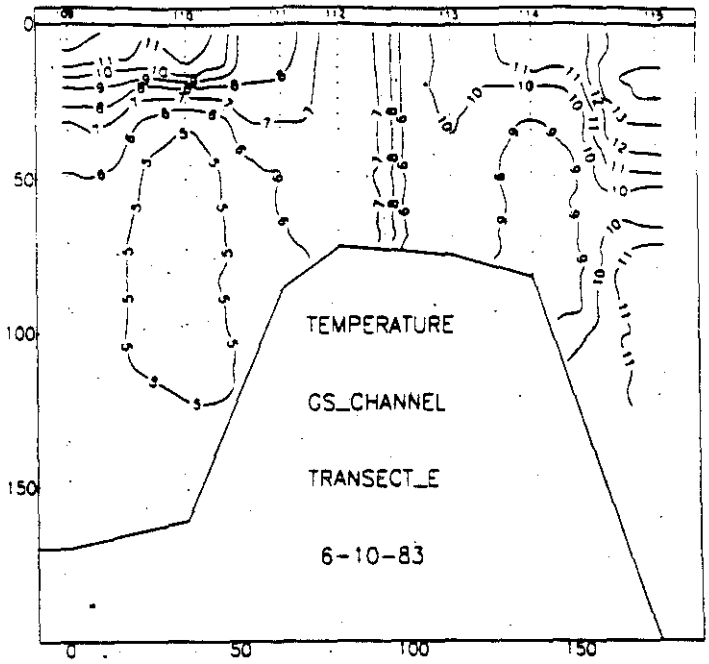


Figure 194. Temperature (°C) transects: ALB8304.



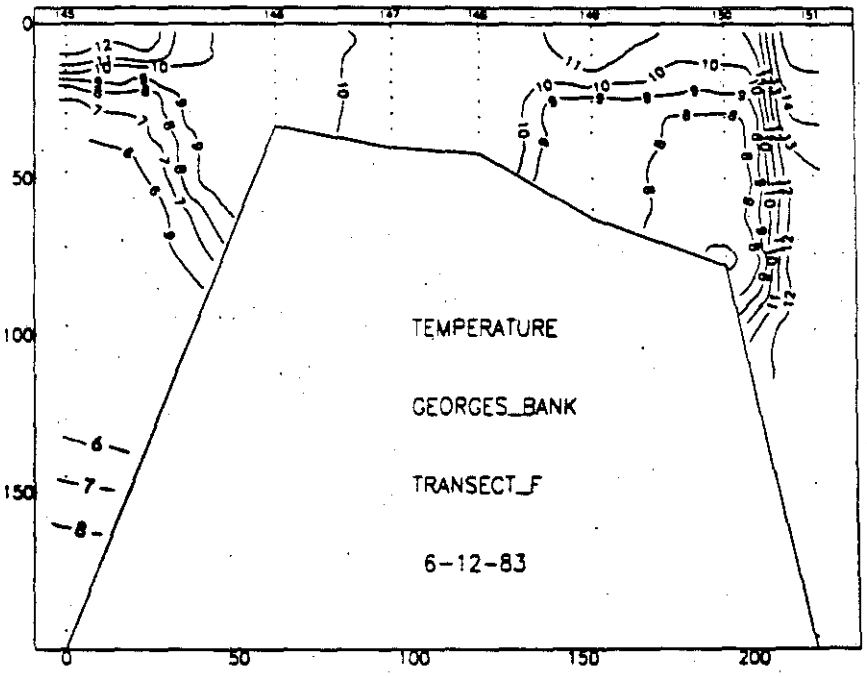


Figure 194. Continued.

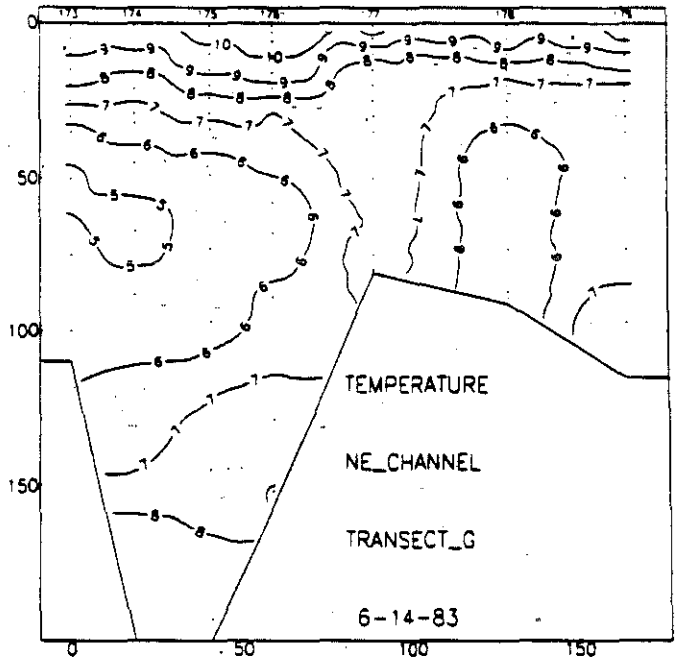


Figure 194. Continued.

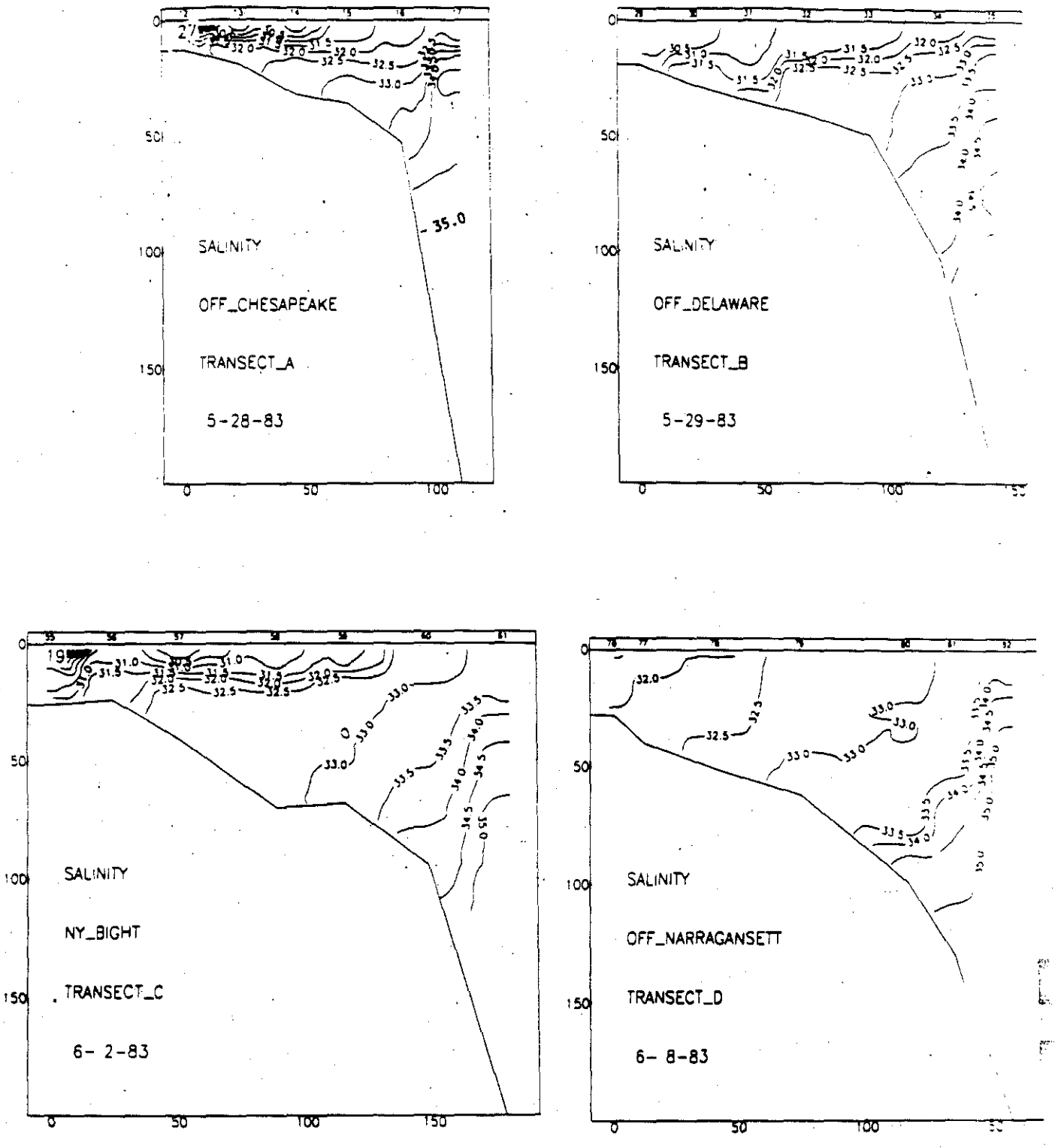
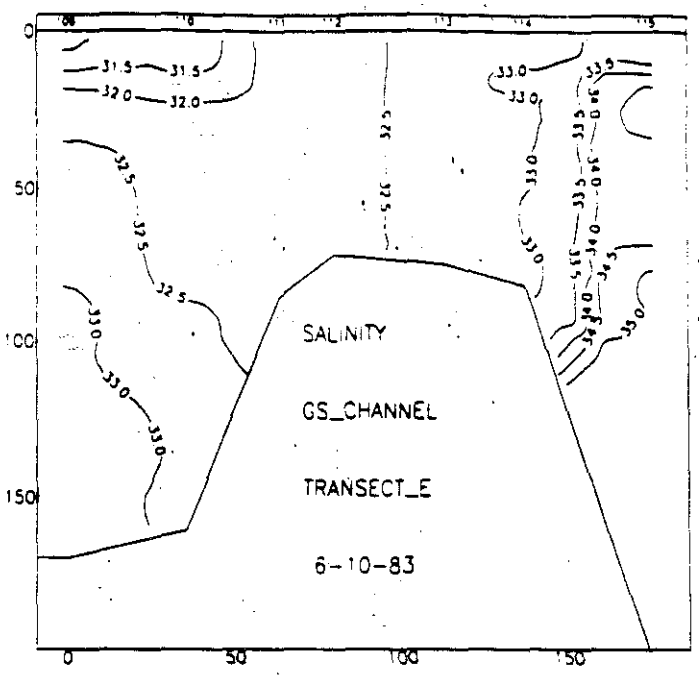


Figure 195. Salinity (PSU) transects: ALB8304.



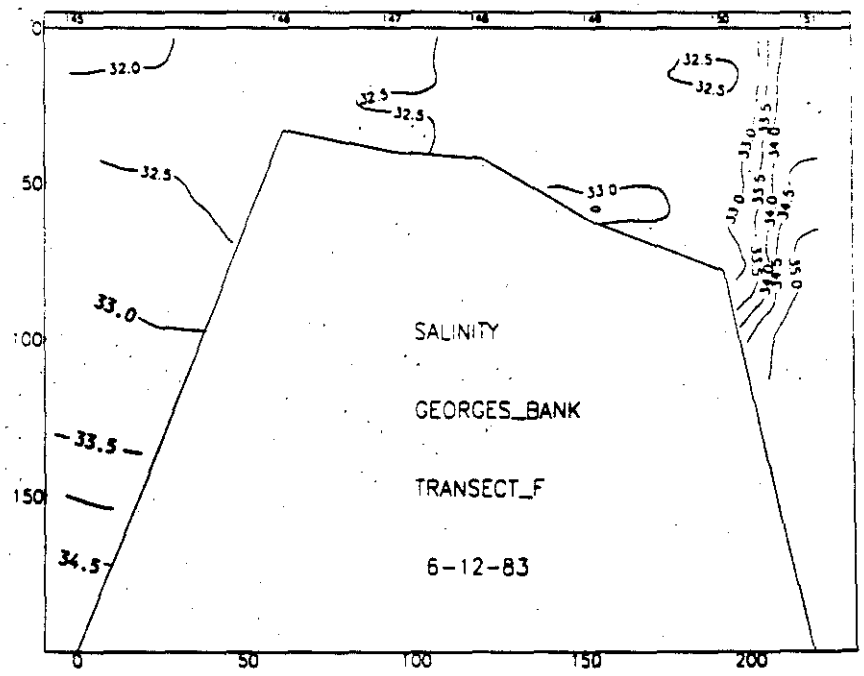


Figure 195. Continued.

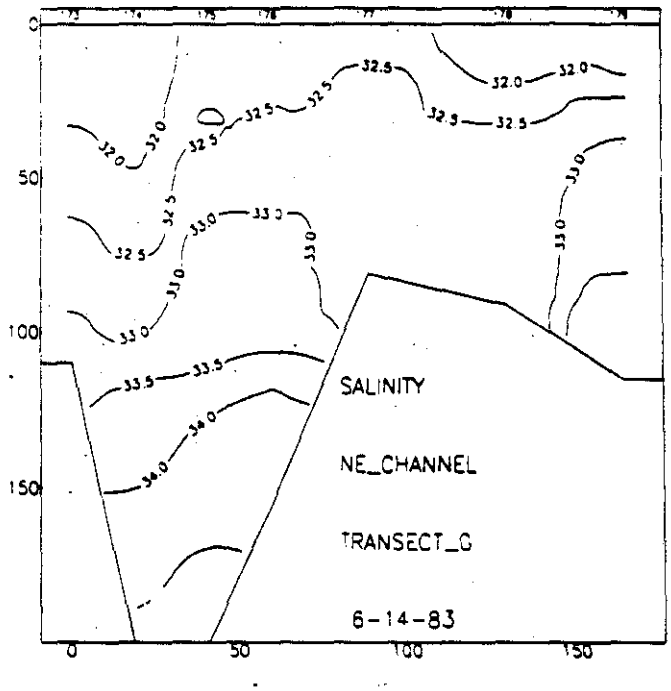


Figure 195. Continued.

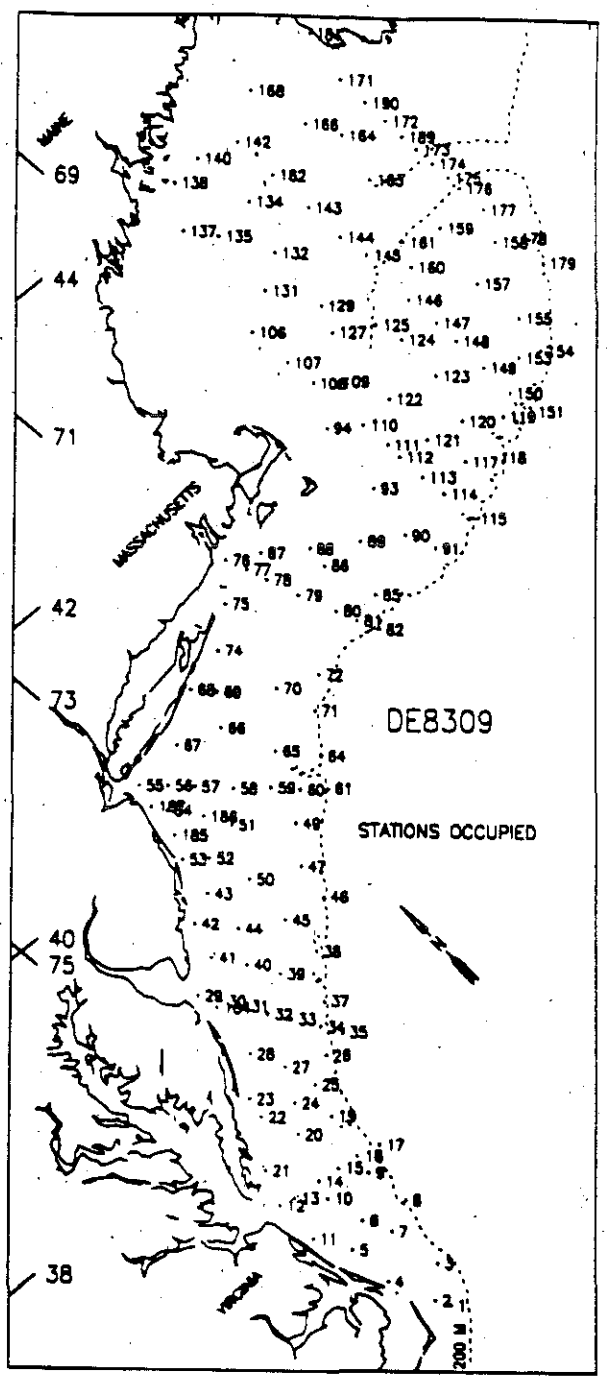


Figure 196. Station positions: DEL8309.

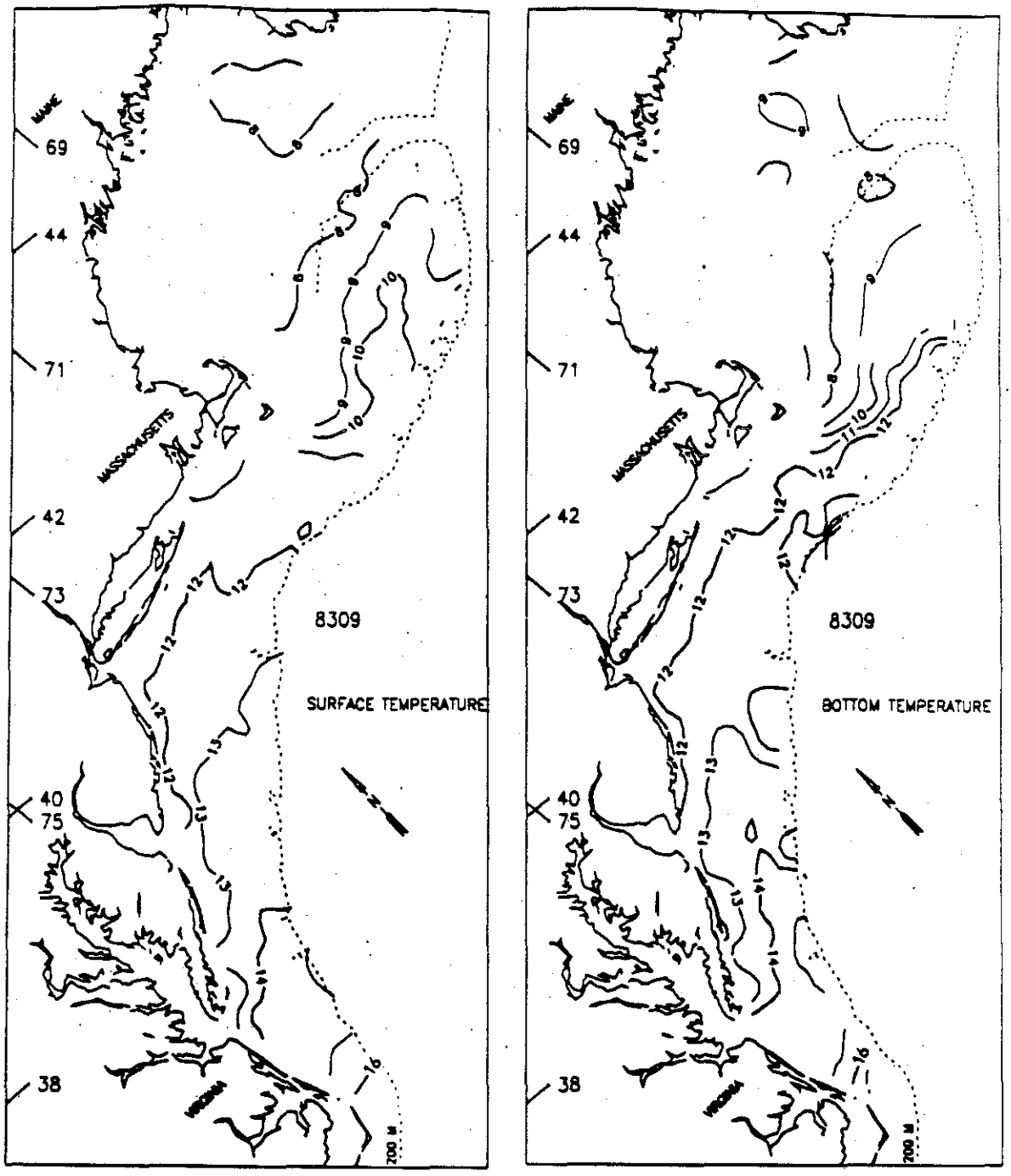


Figure 197. Surface and bottom temperature (°C) distribution: DEL8309.

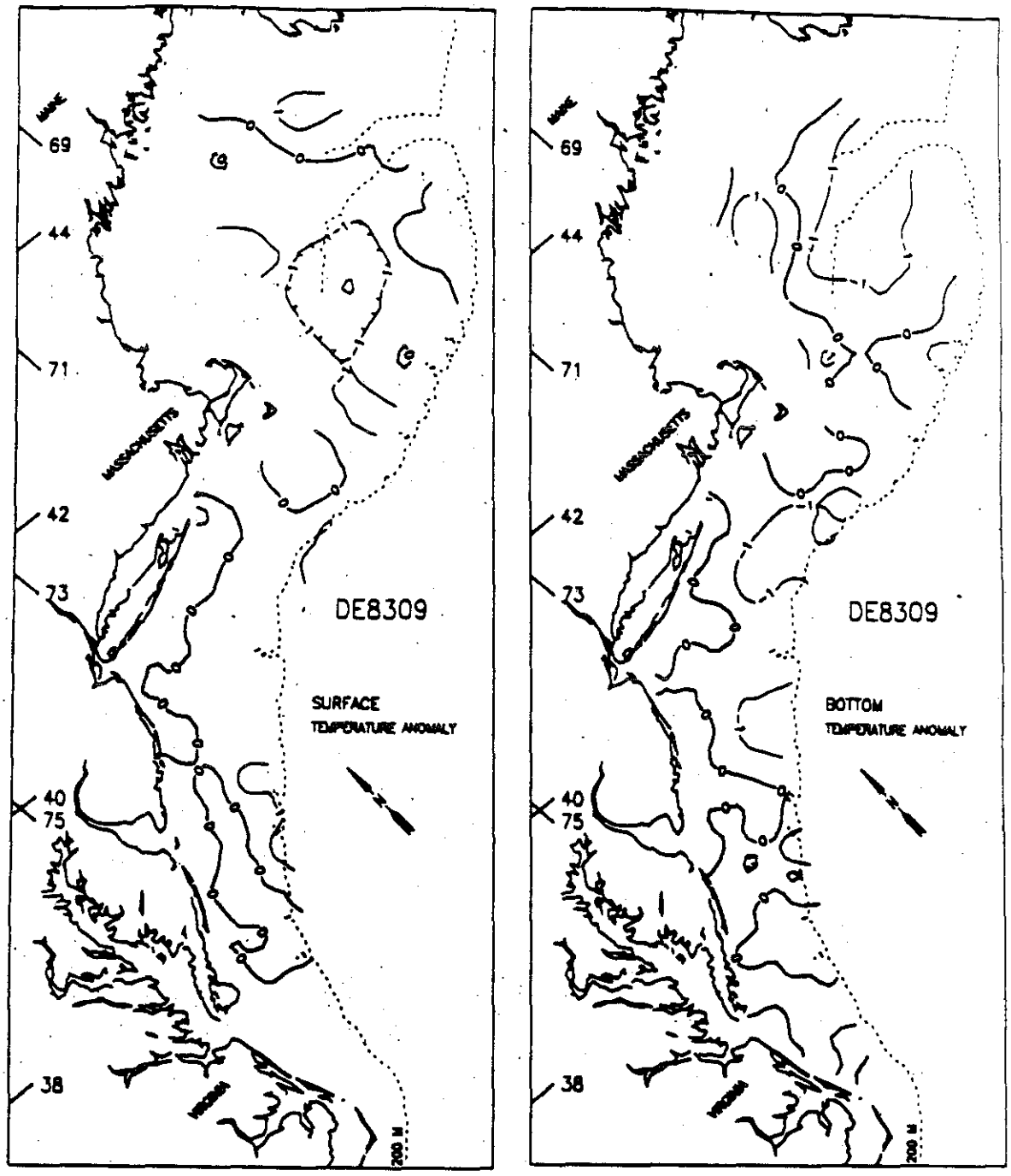


Figure 198. Normalized surface and bottom temperature anomaly: DEL8309.Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

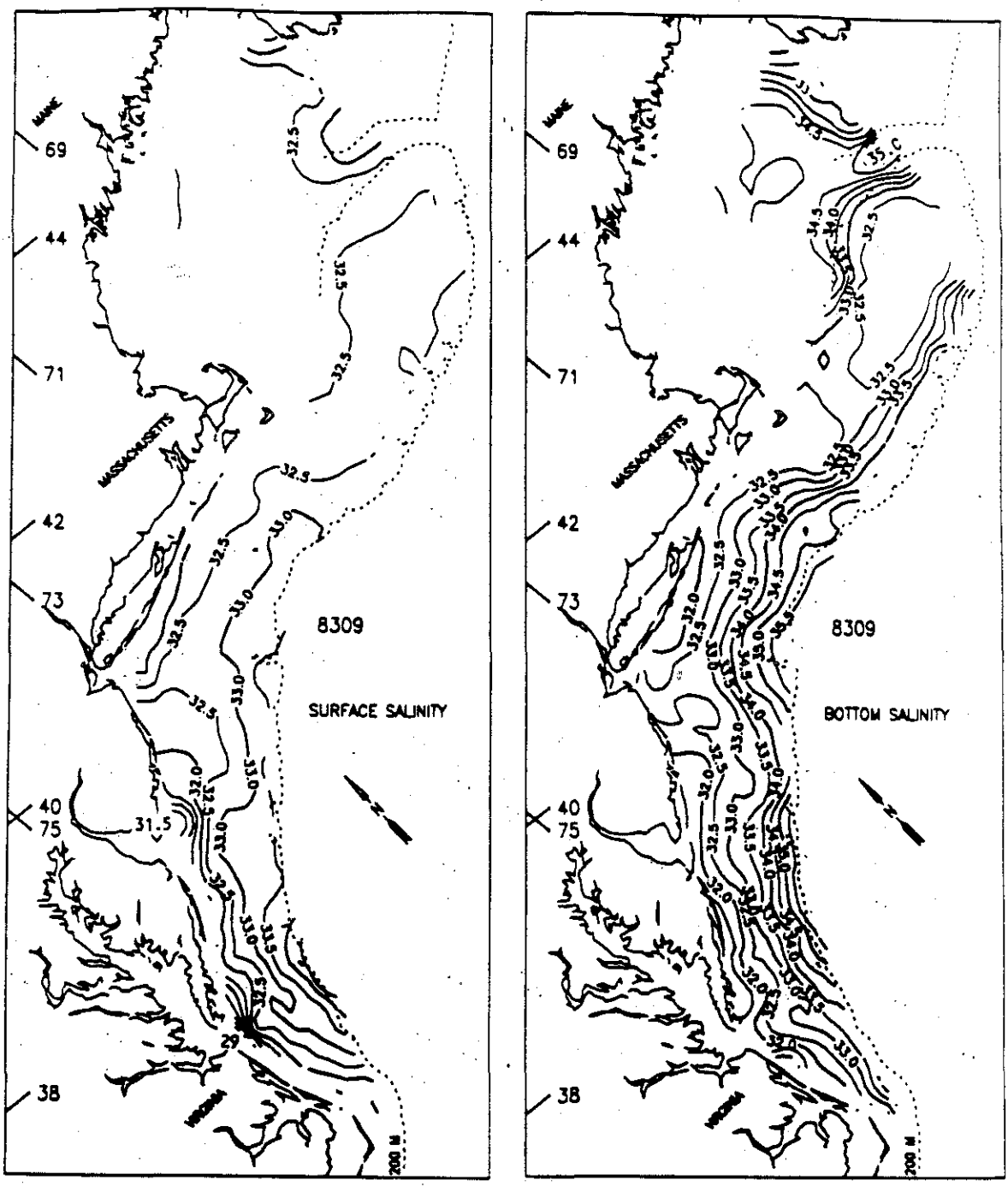
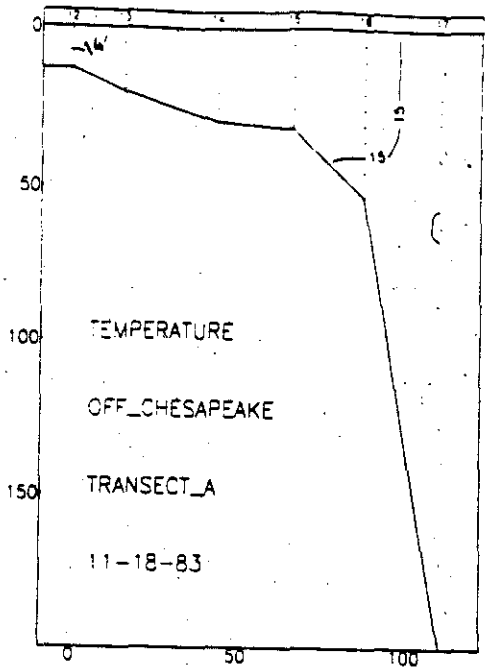
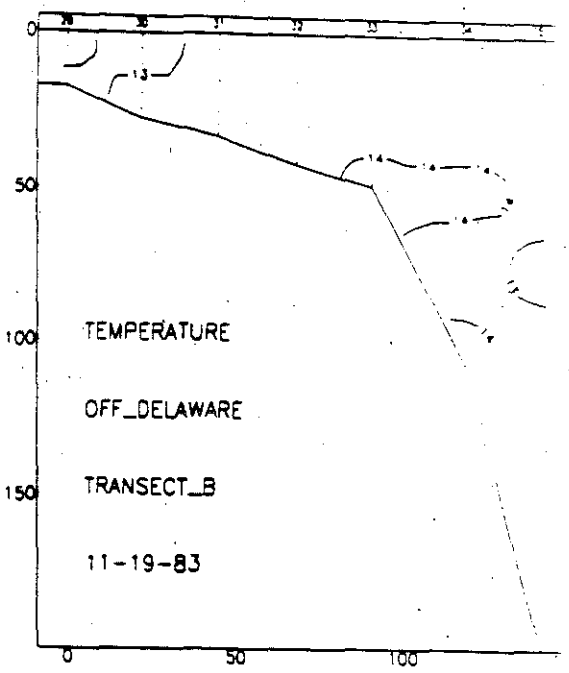
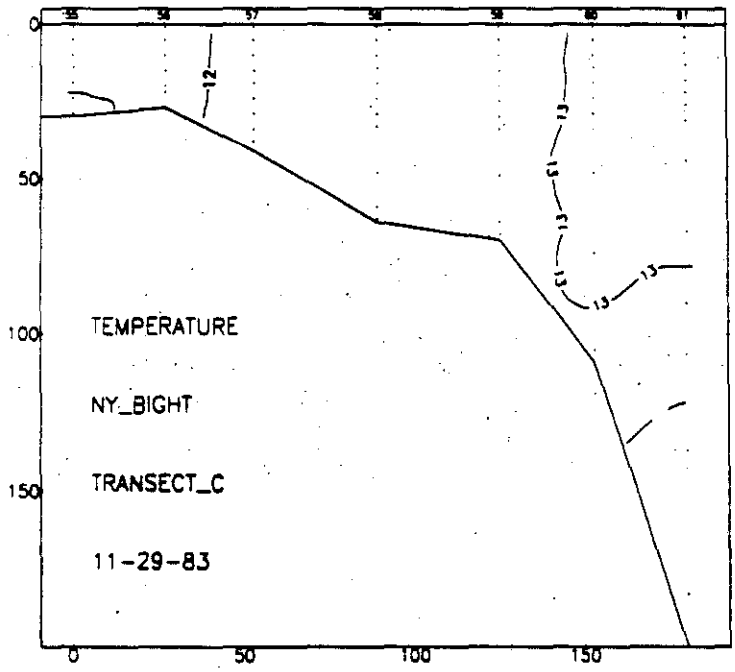


Figure 199. Surface and bottom salinity (PSU) distribution: DEL8309.







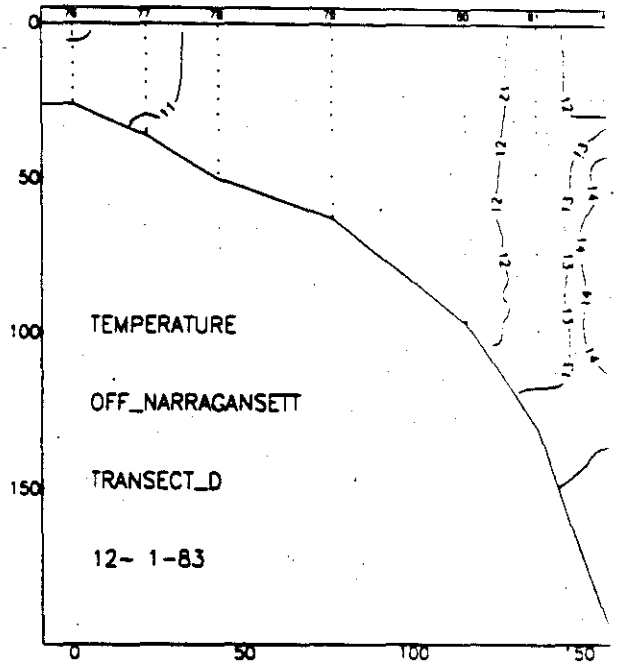
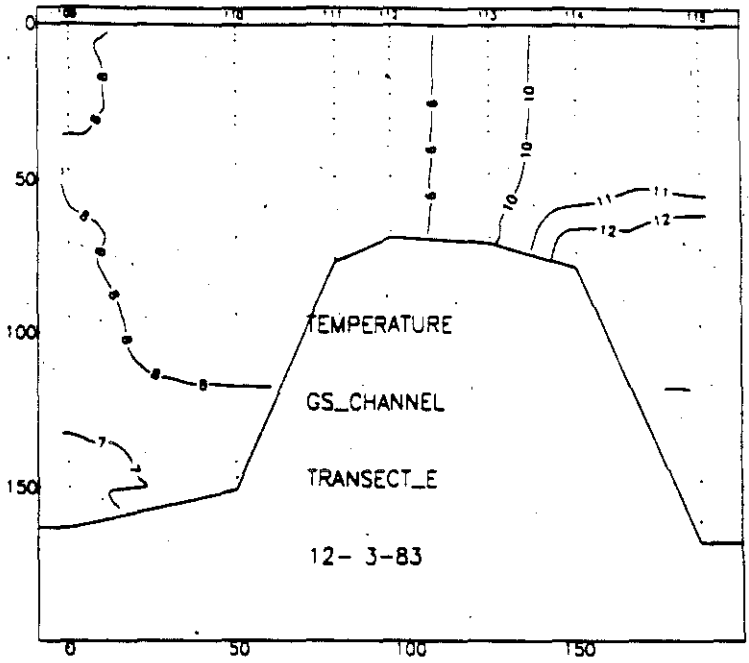


Figure 200. Temperature (°C) transects: DEL8309.



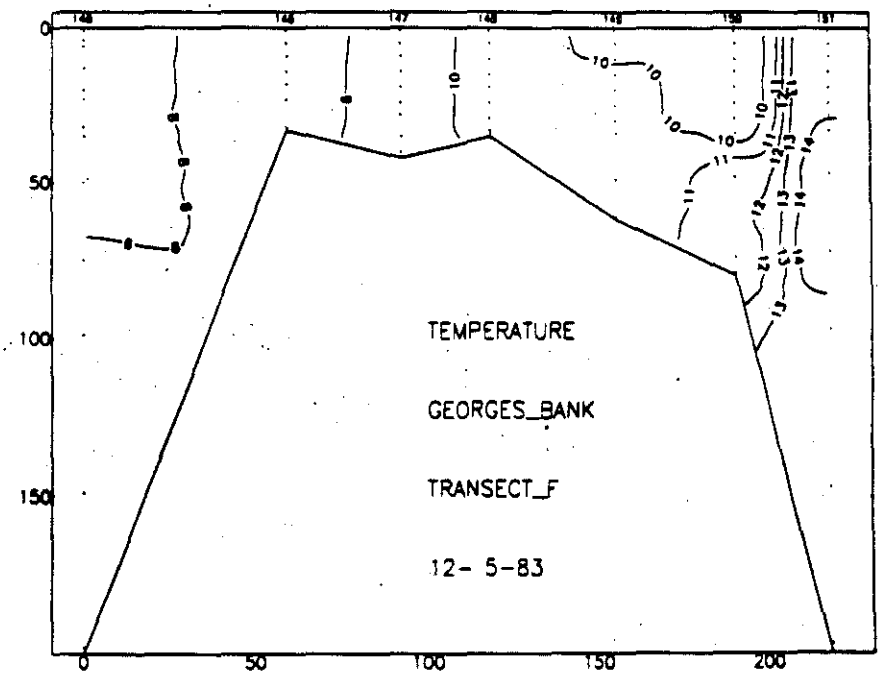


Figure 200. Continued.

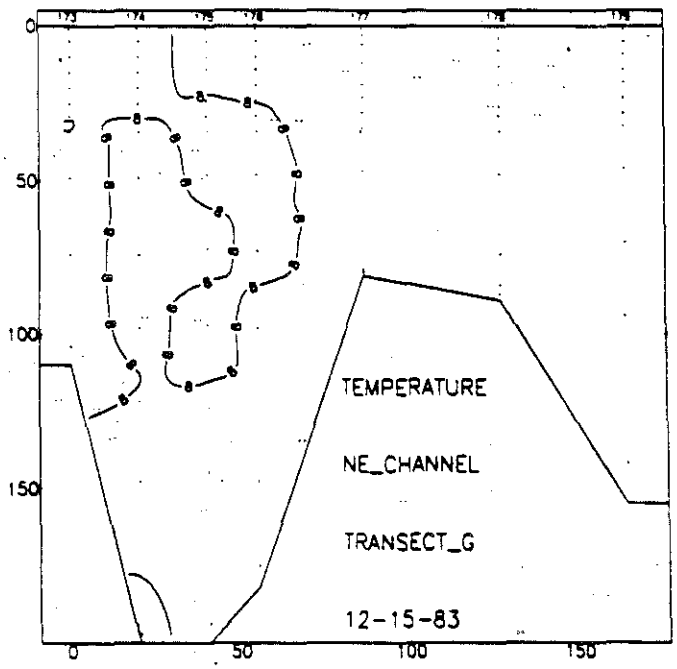
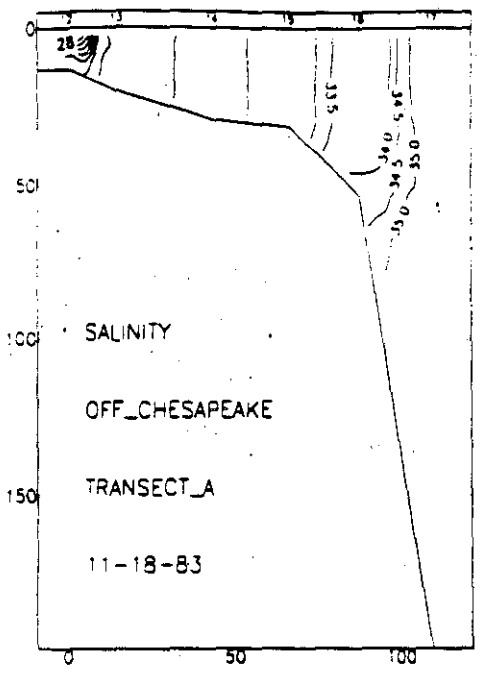
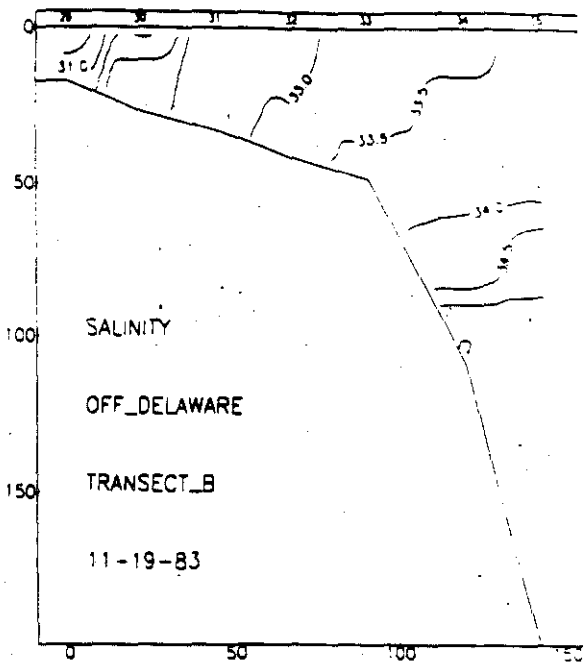
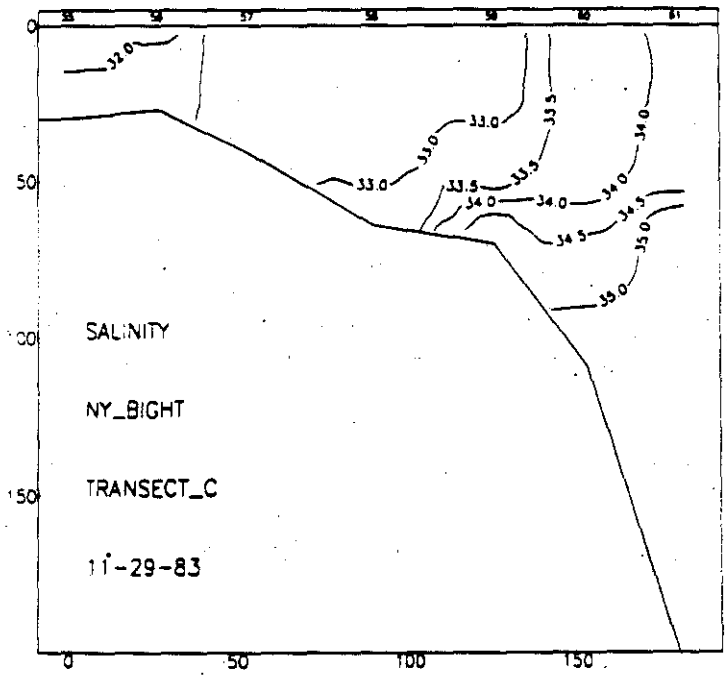


Figure 200. Continued.







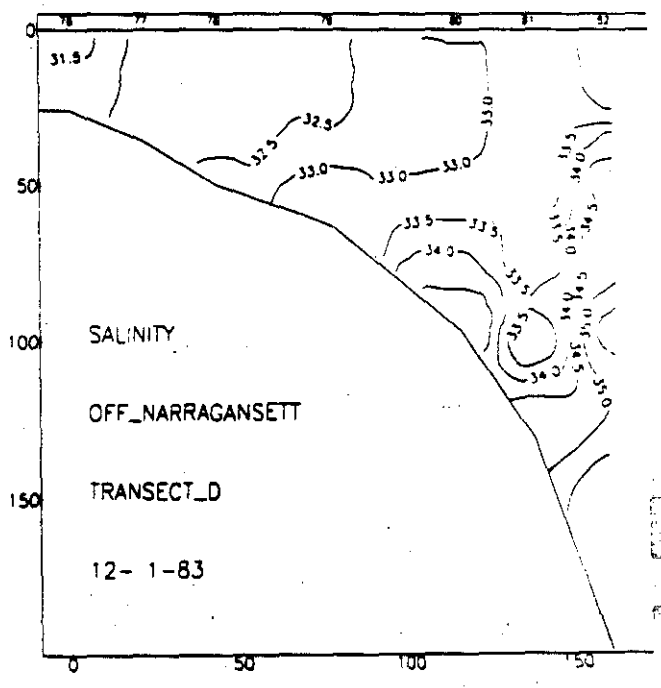
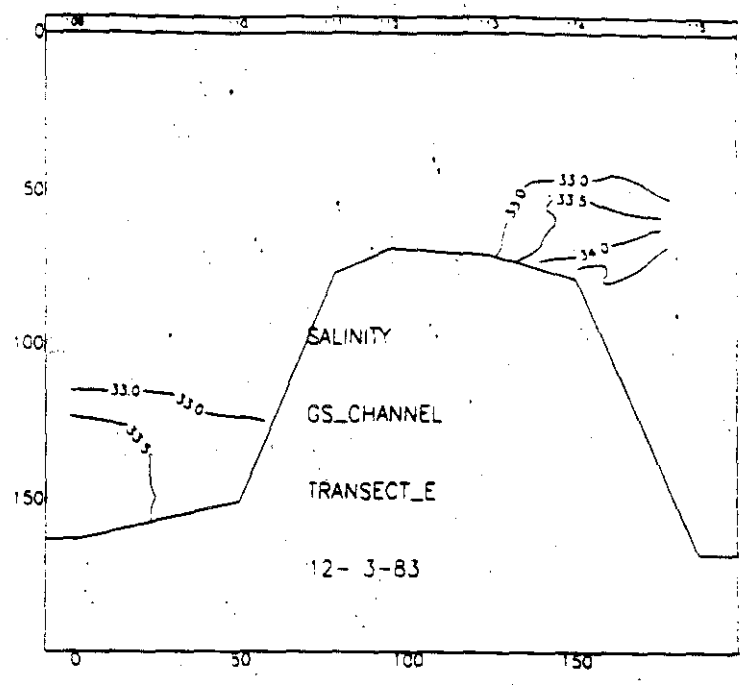


Figure 201. Salinity (PSU) transects: DEL8309.



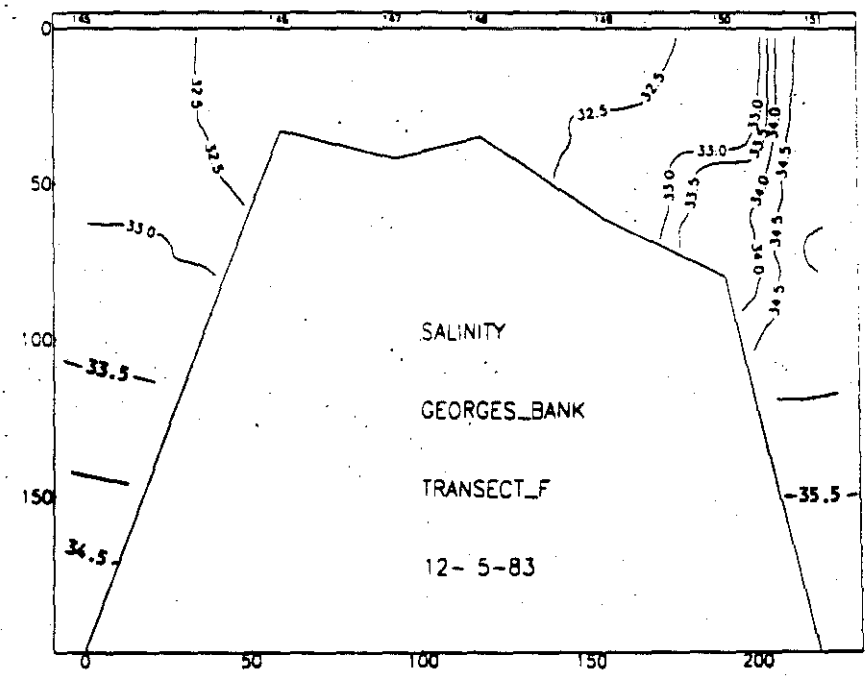


Figure 201. Continued.

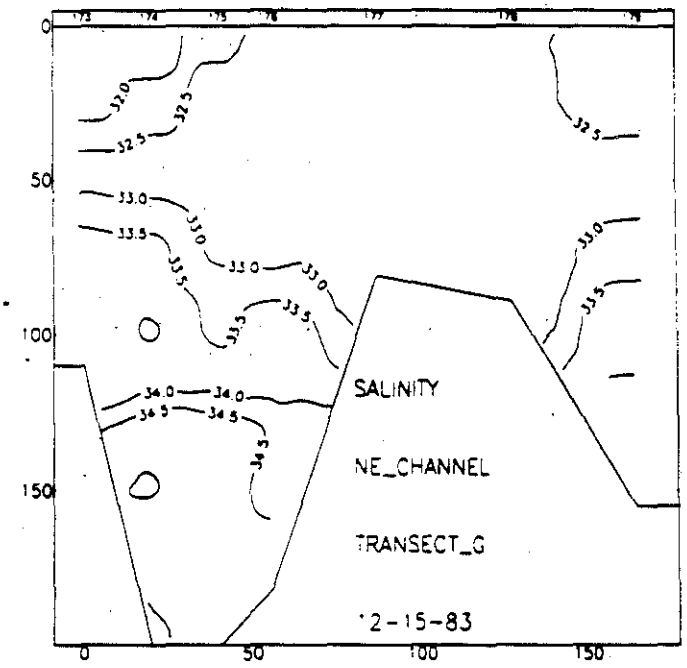


Figure 201. Continued.

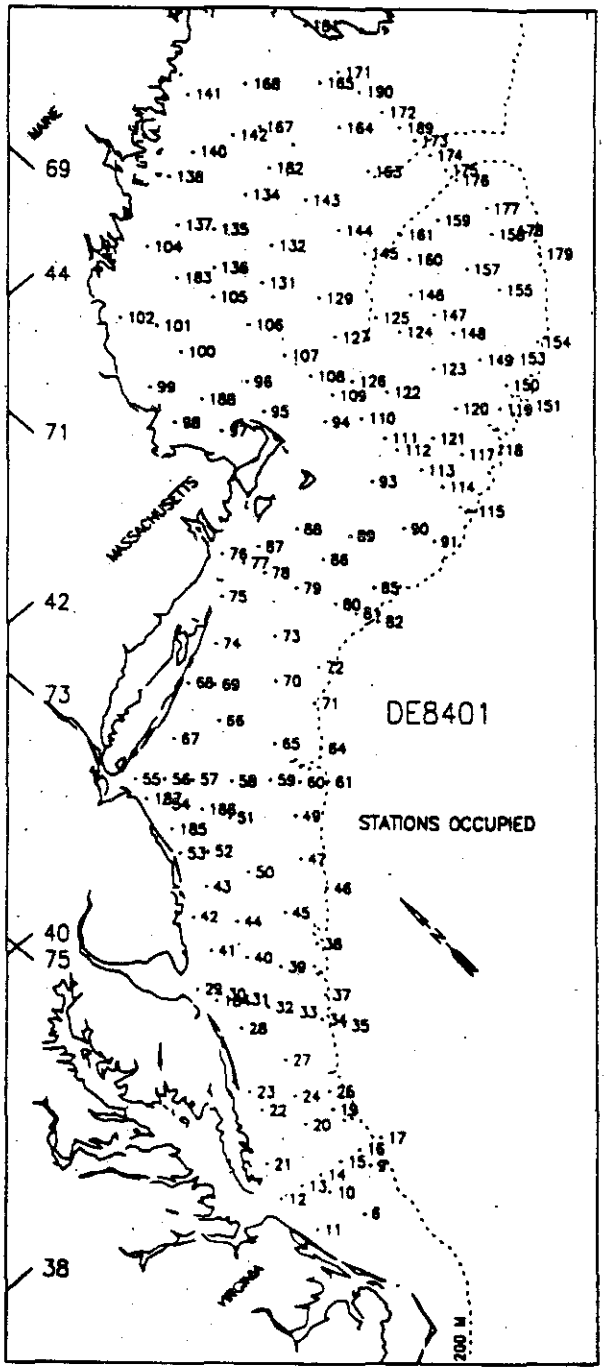


Figure 202. Station positions: DEL8401.

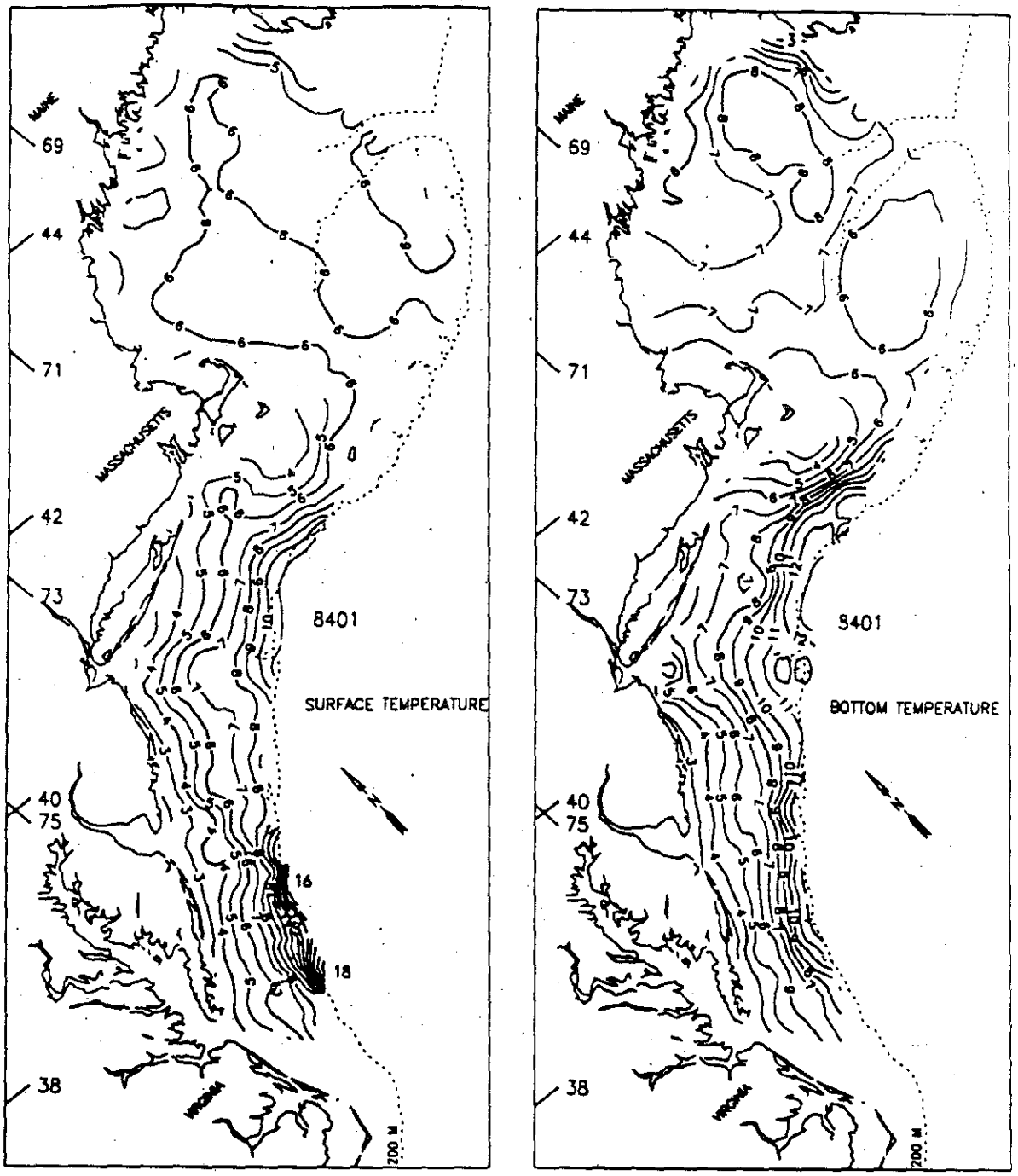


Figure 203. Surface and bottom temperature (°C) distribution: DEL8401.

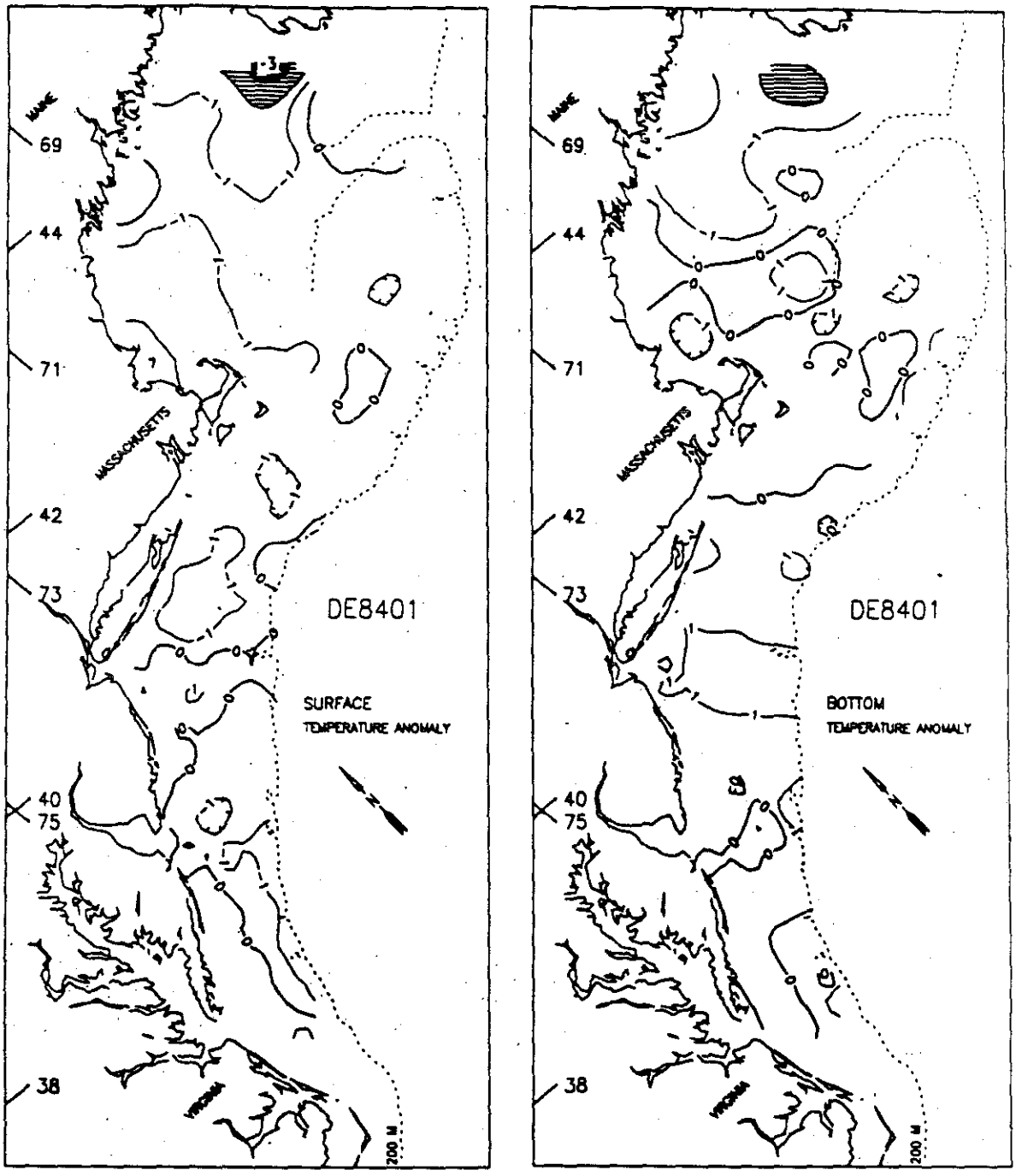


Figure 204. Normalized surface and bottom temperature anomaly: DEL8401.Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

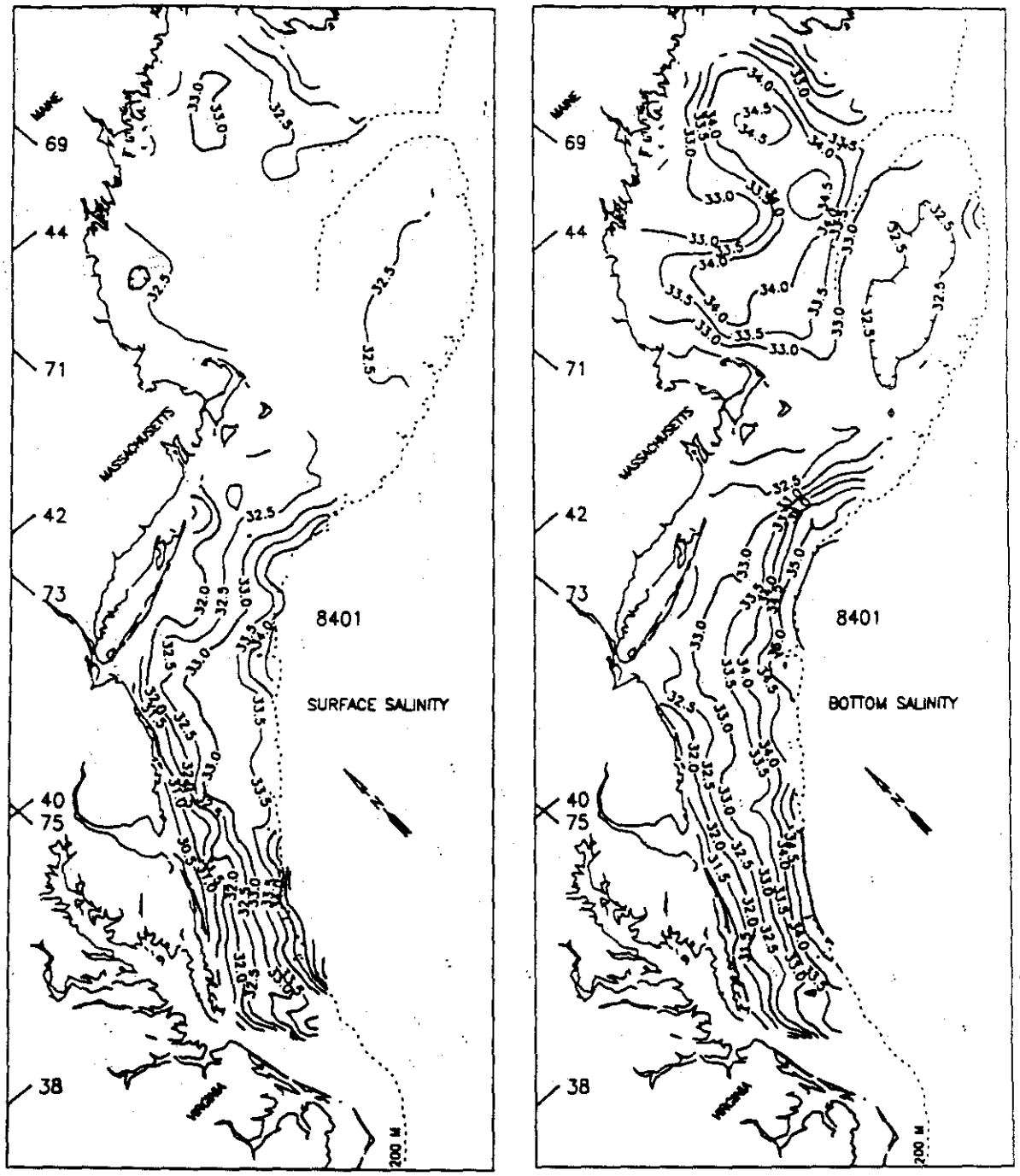


Figure 205. Surface and bottom salinity (PSU) distribution: DEL8401.

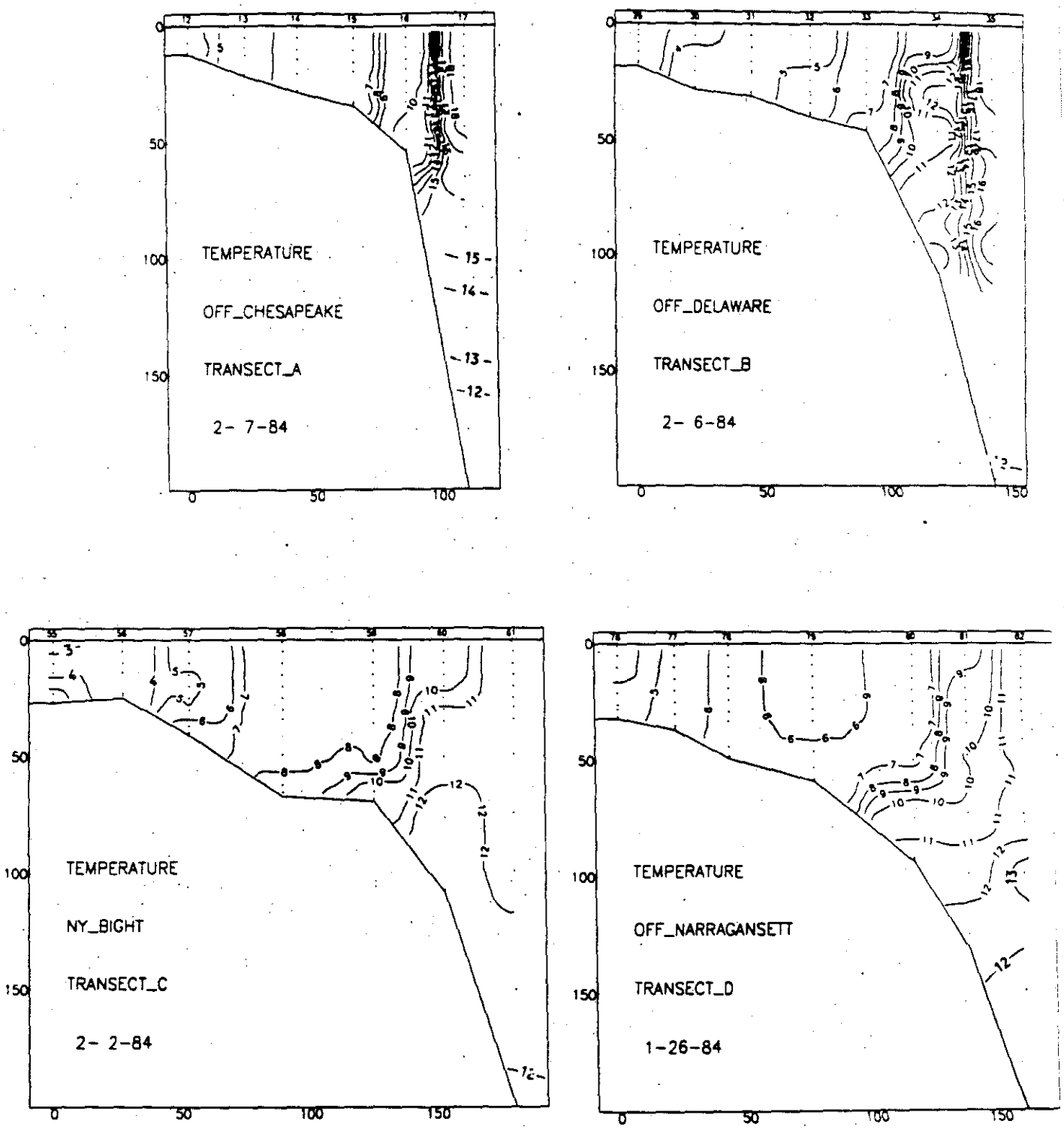


Figure 206. Temperature (°C) transects: DEL8401.

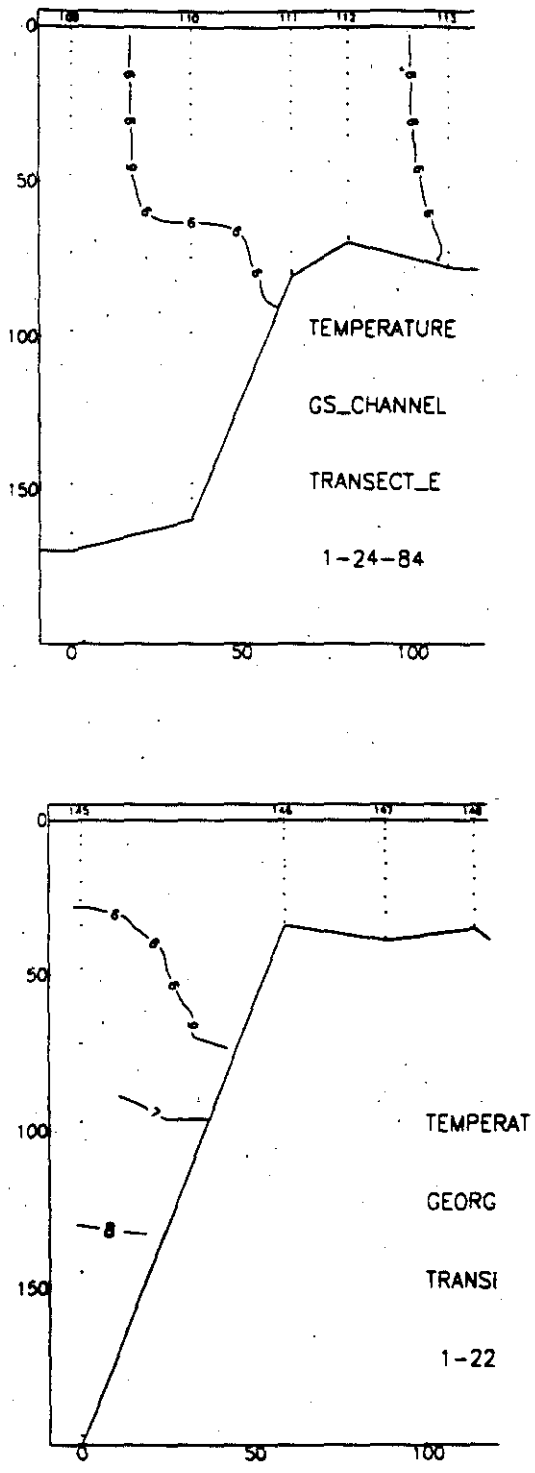


Figure 206. Continued.

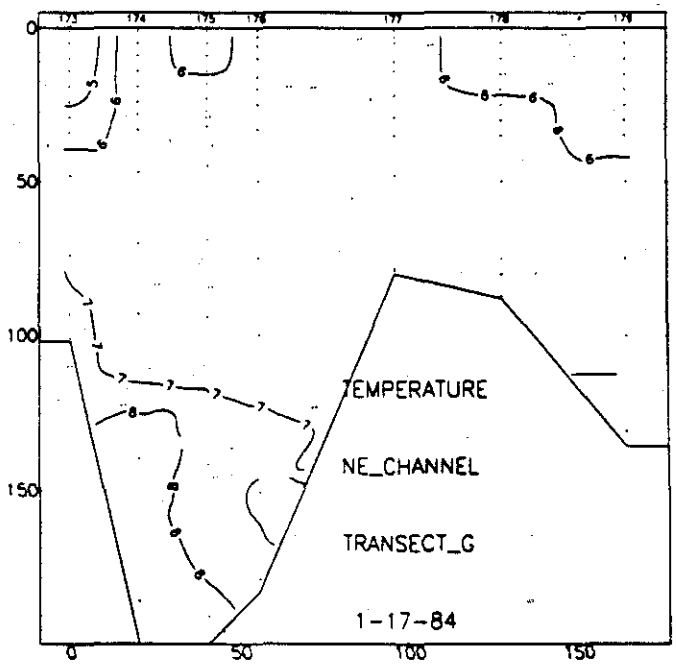


Figure 206. Continued.

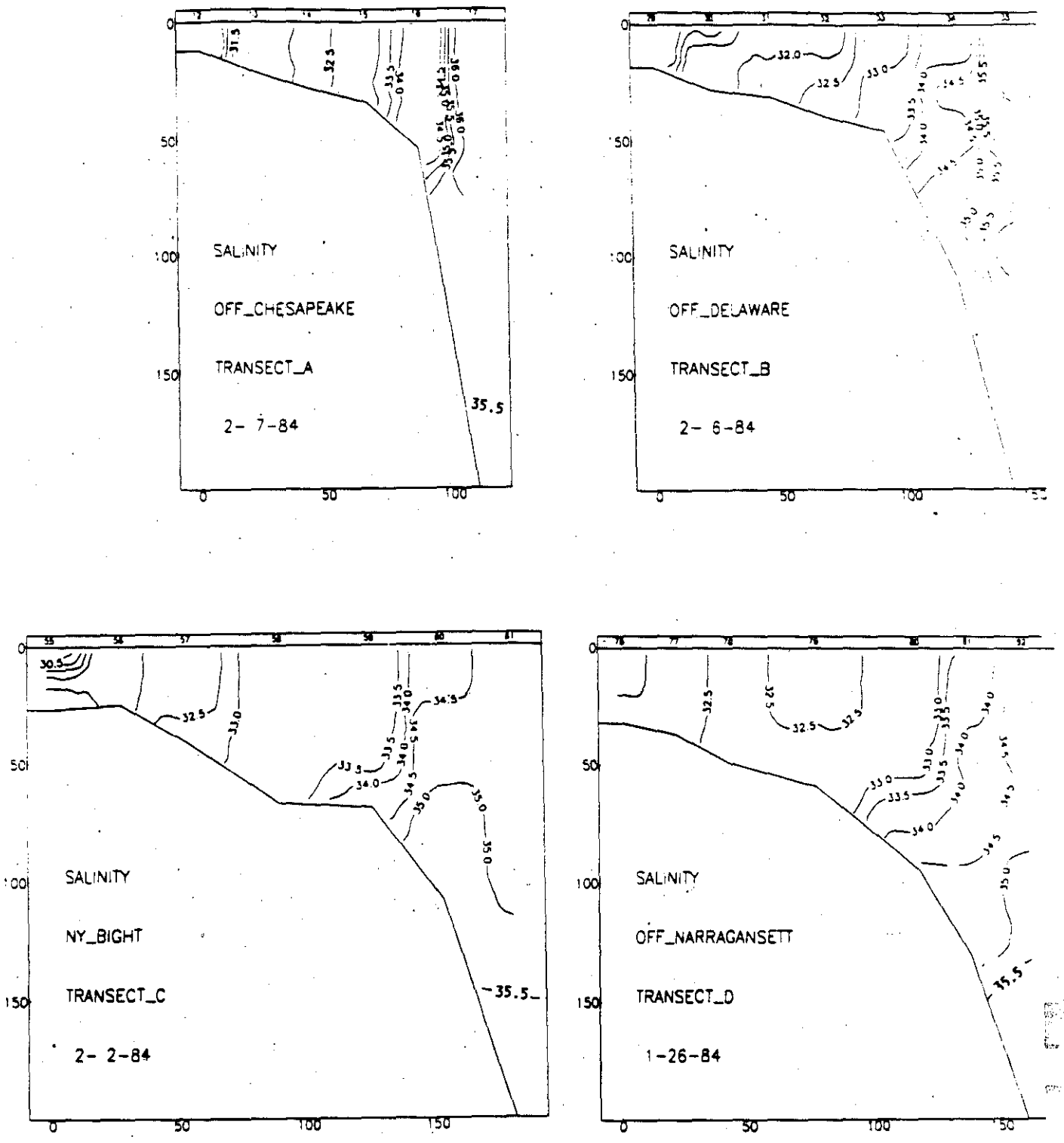
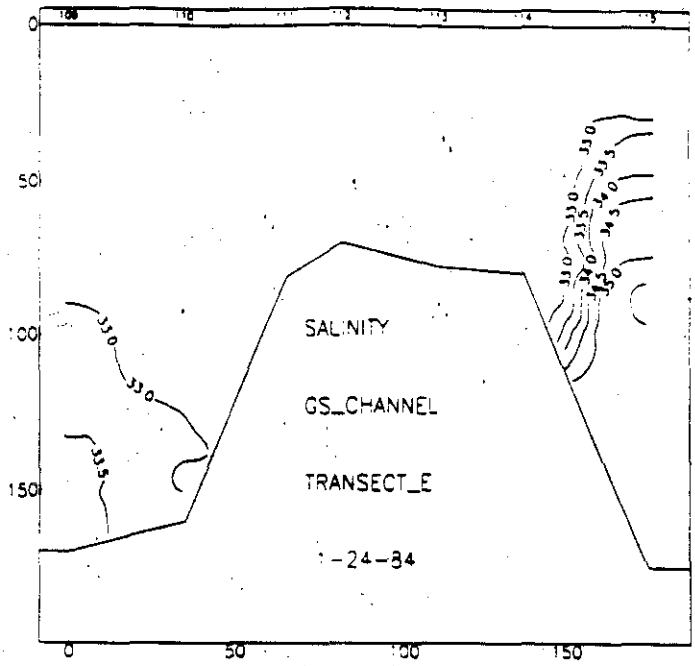


Figure 207. Salinity (PSU) transects: DEL8401.



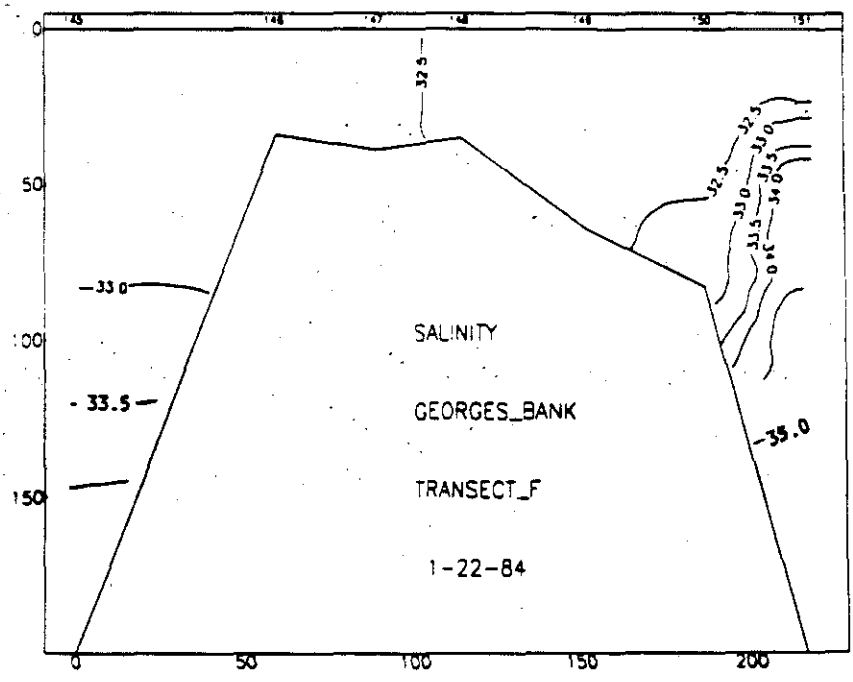


Figure 207. Continued.

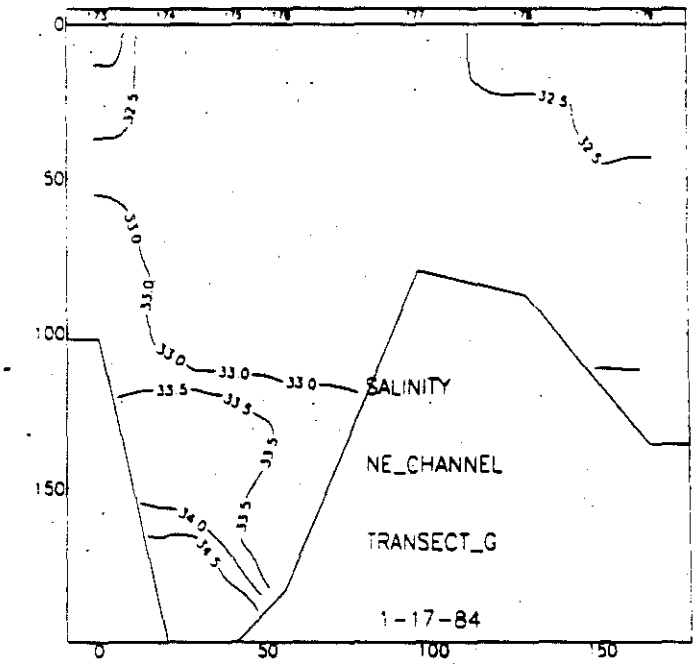


Figure 207. Continued.

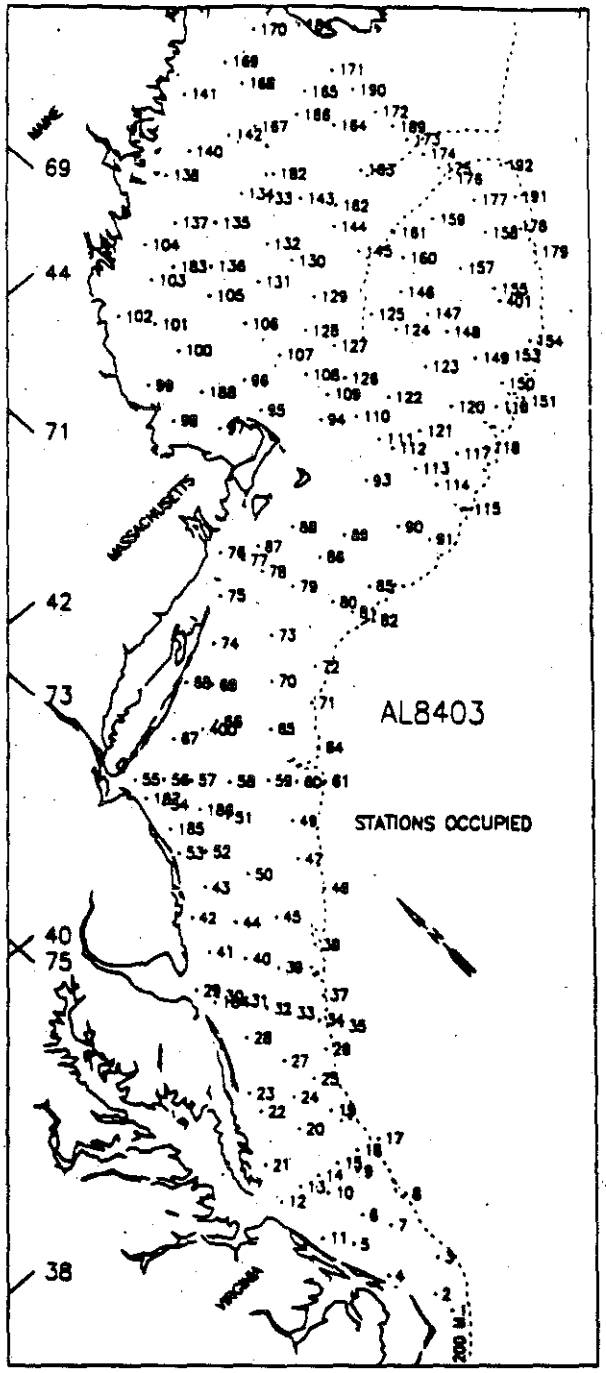


Figure 208. Station positions: ALB8403.

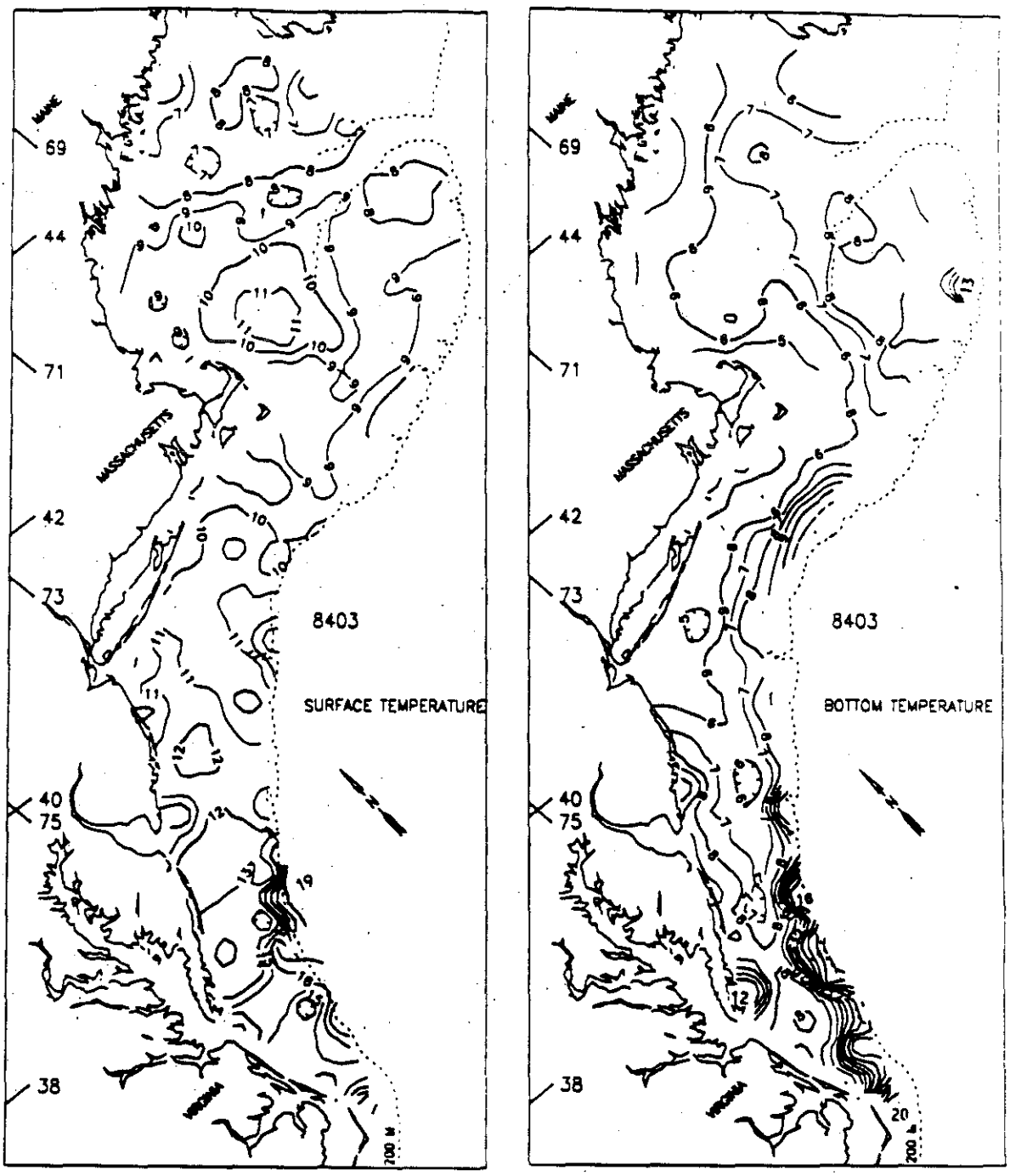


Figure 209. Surface and bottom temperature (°C) distribution: ALB8403.

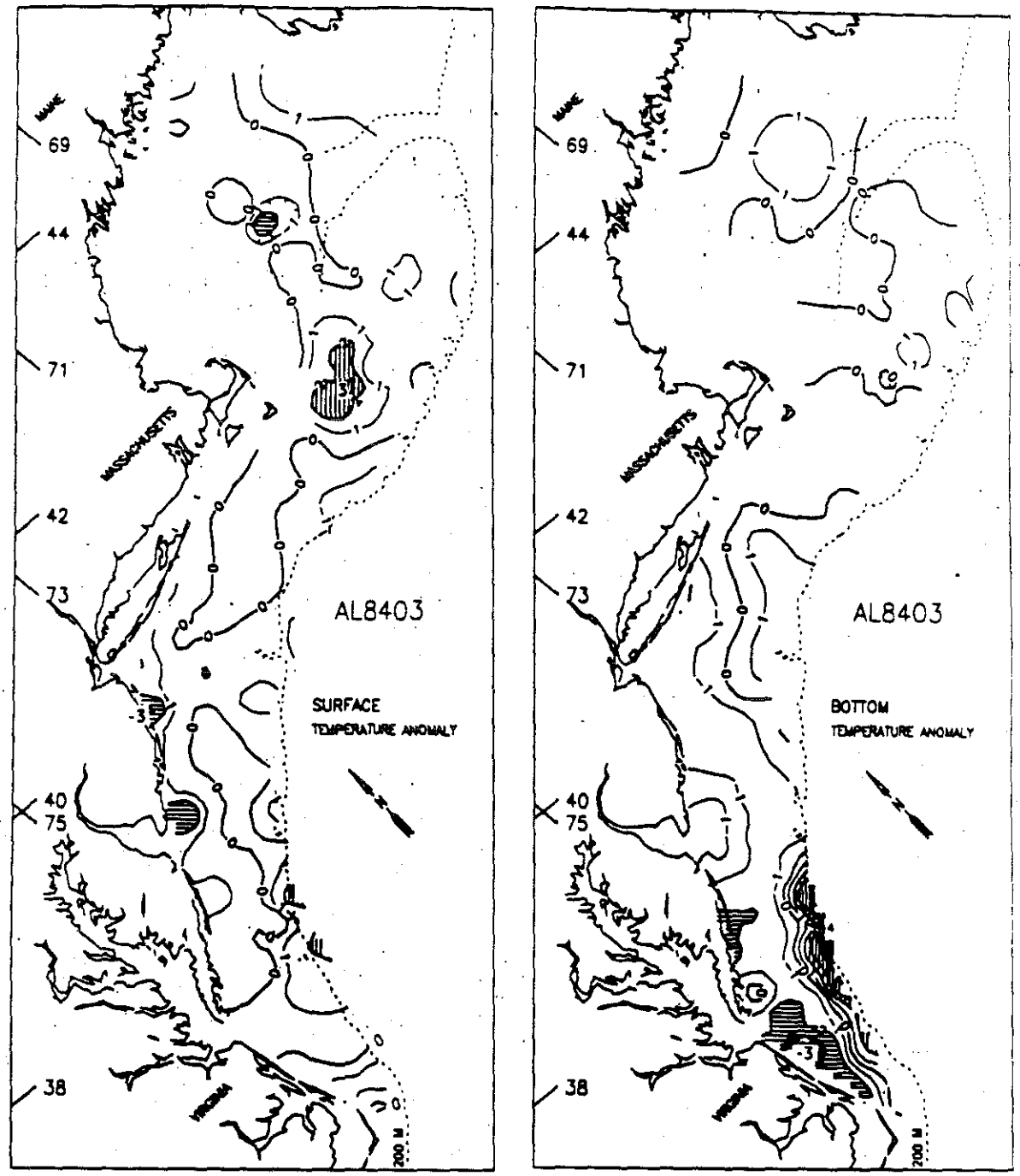


Figure 210. Normalized surface and bottom temperature anomaly: ALB8403.Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

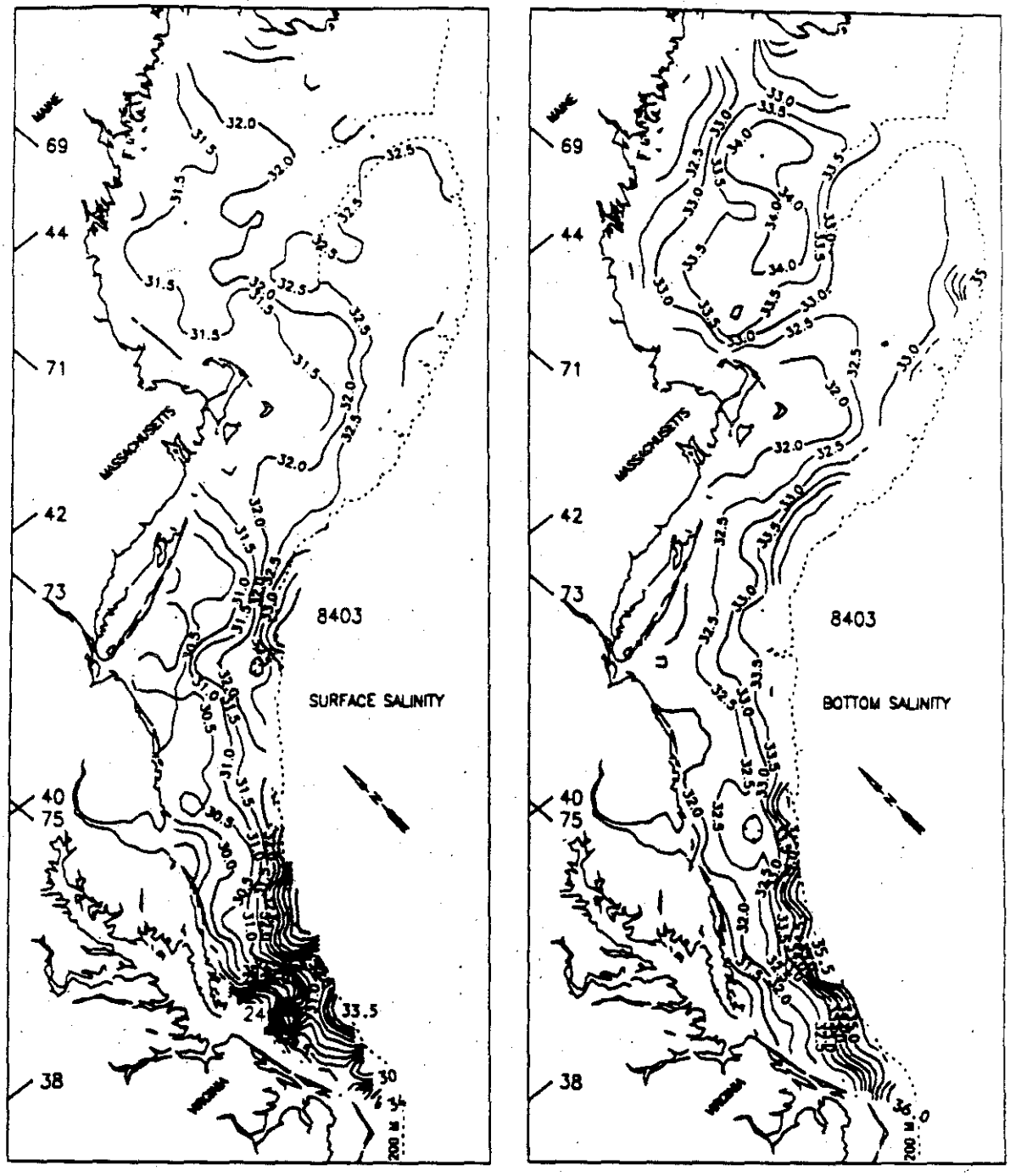


Figure 211. Surface and bottom salinity (PSU) distribution: ALB8403.

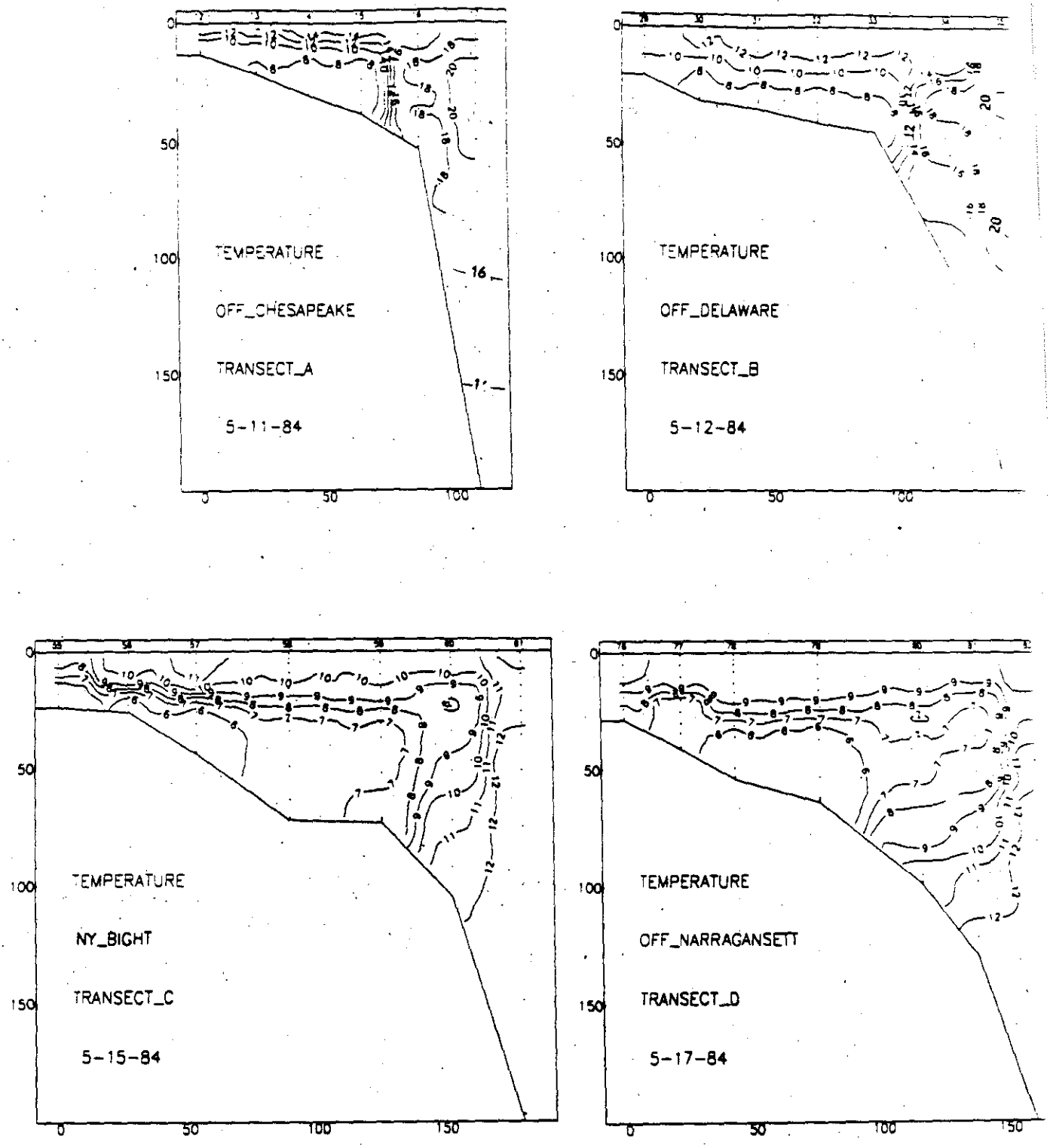
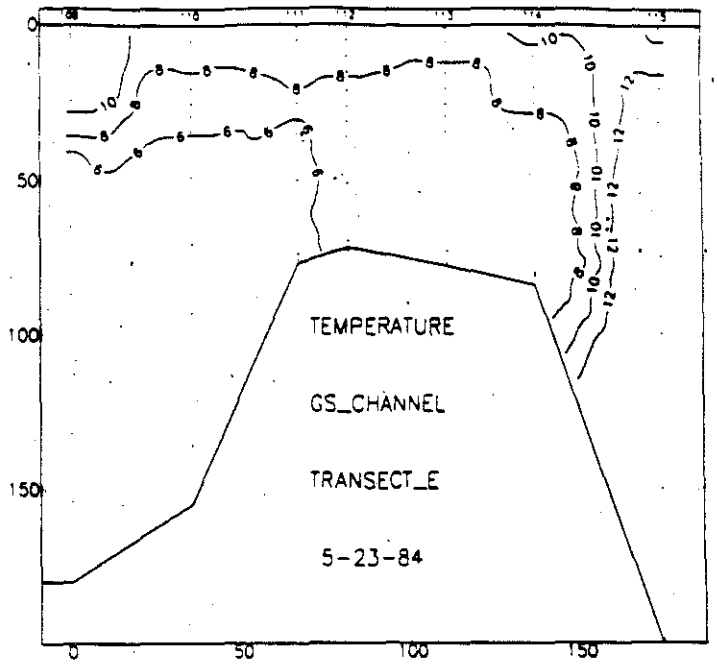


Figure 212. Temperature (°C) transects: ALB8403.



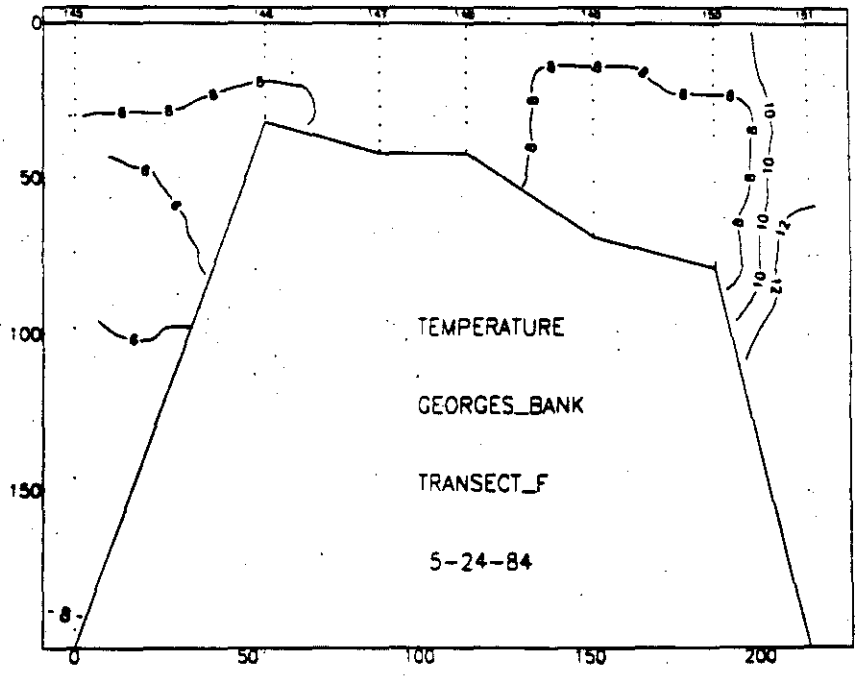


Figure 212. Continued.

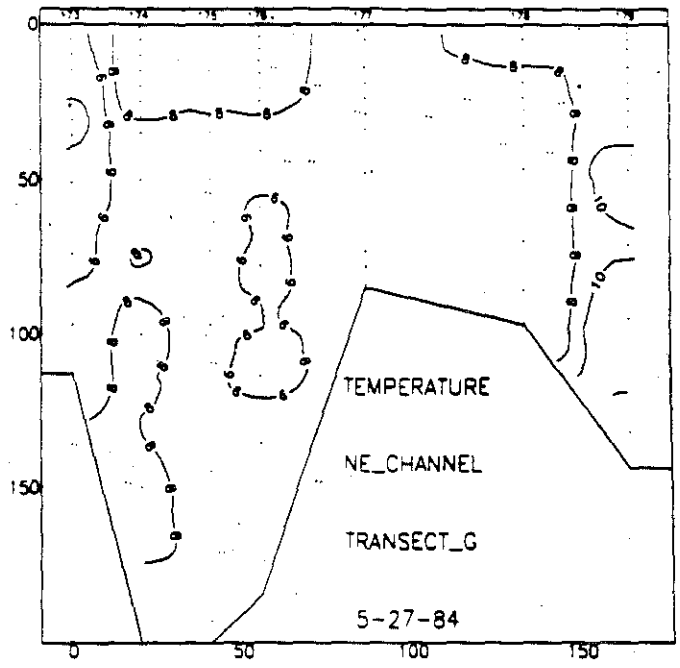


Figure 212. Continued.

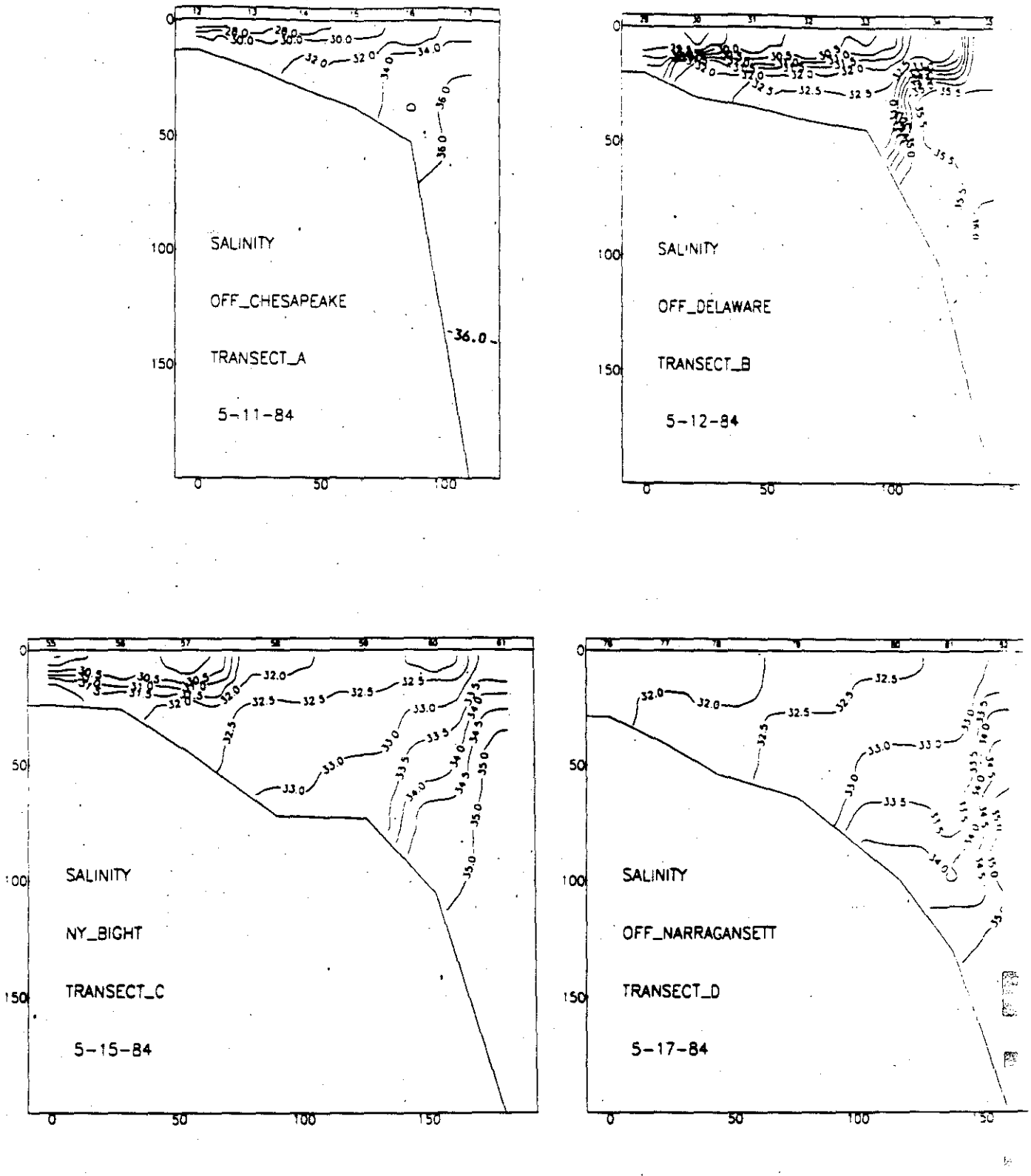
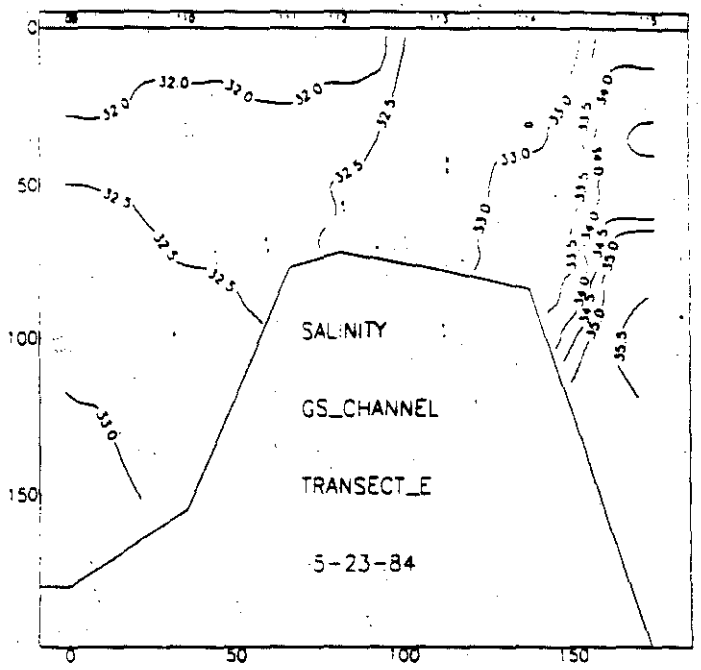


Figure 213. Salinity (PSU) transects: ALB8403.



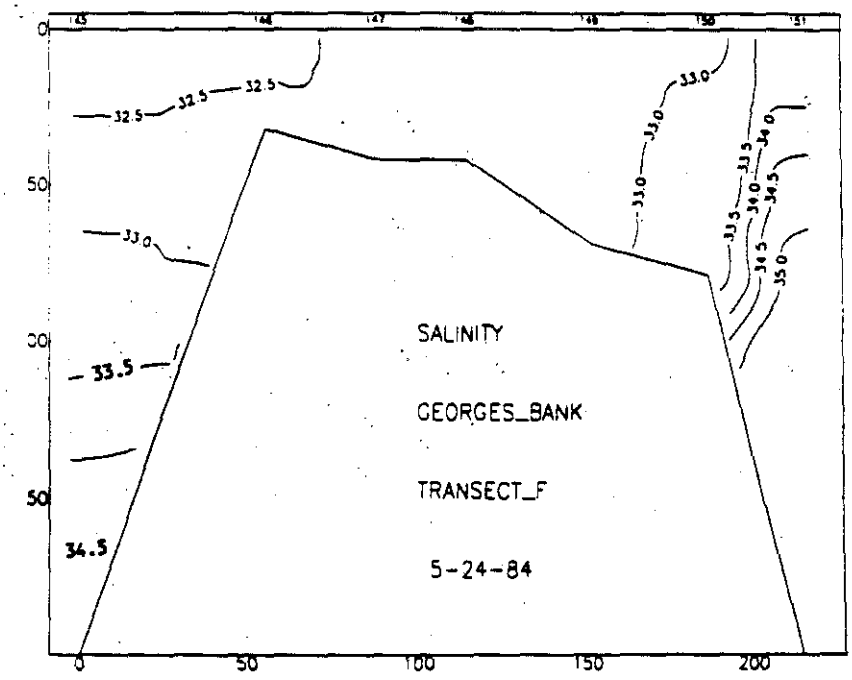


Figure 213. Continued.

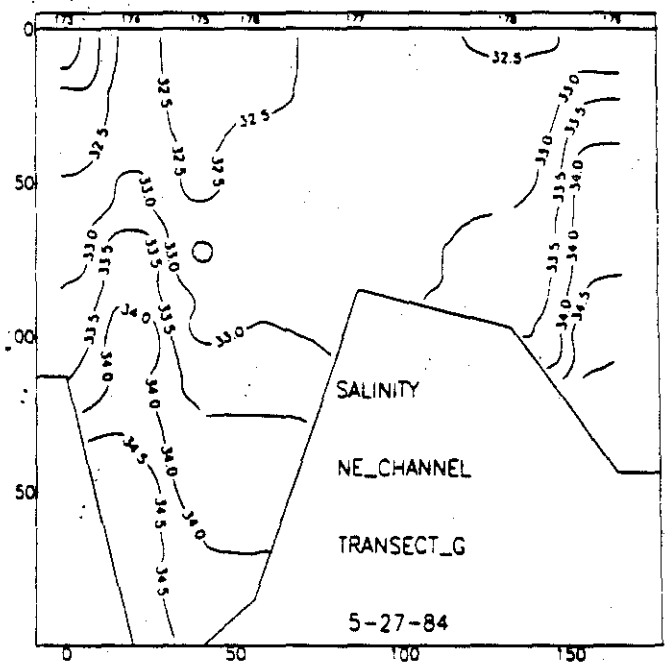


Figure 213. Continued.

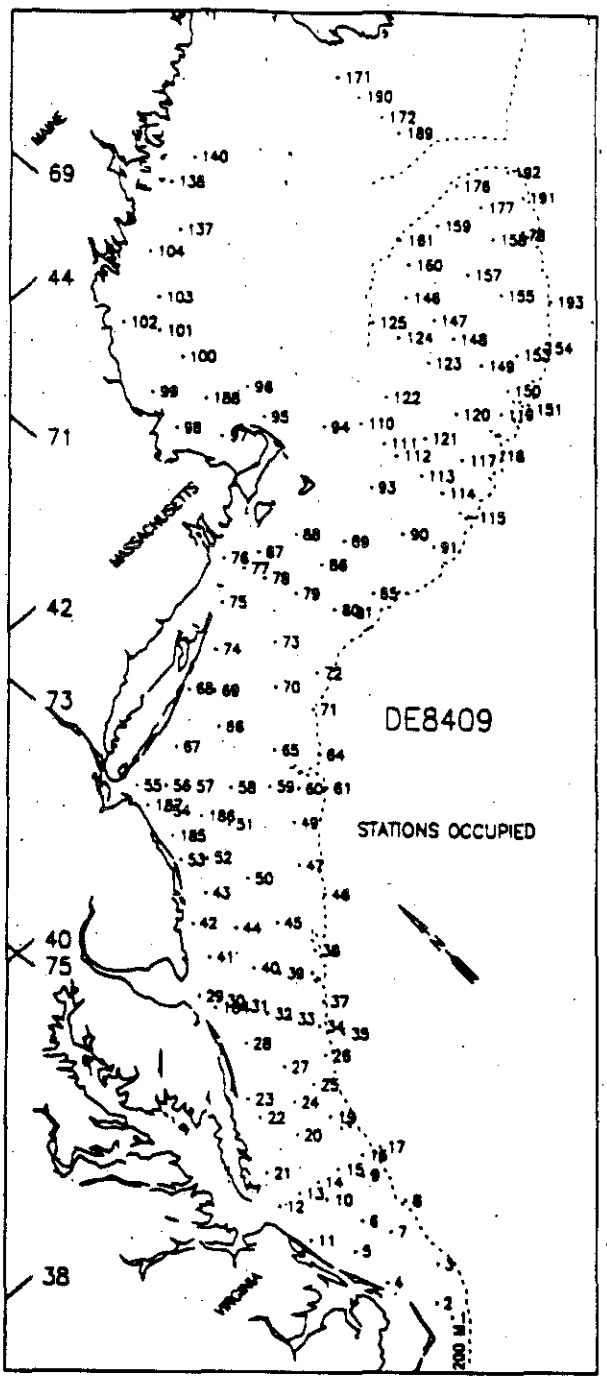


Figure 214. Station positions: DEL8409.

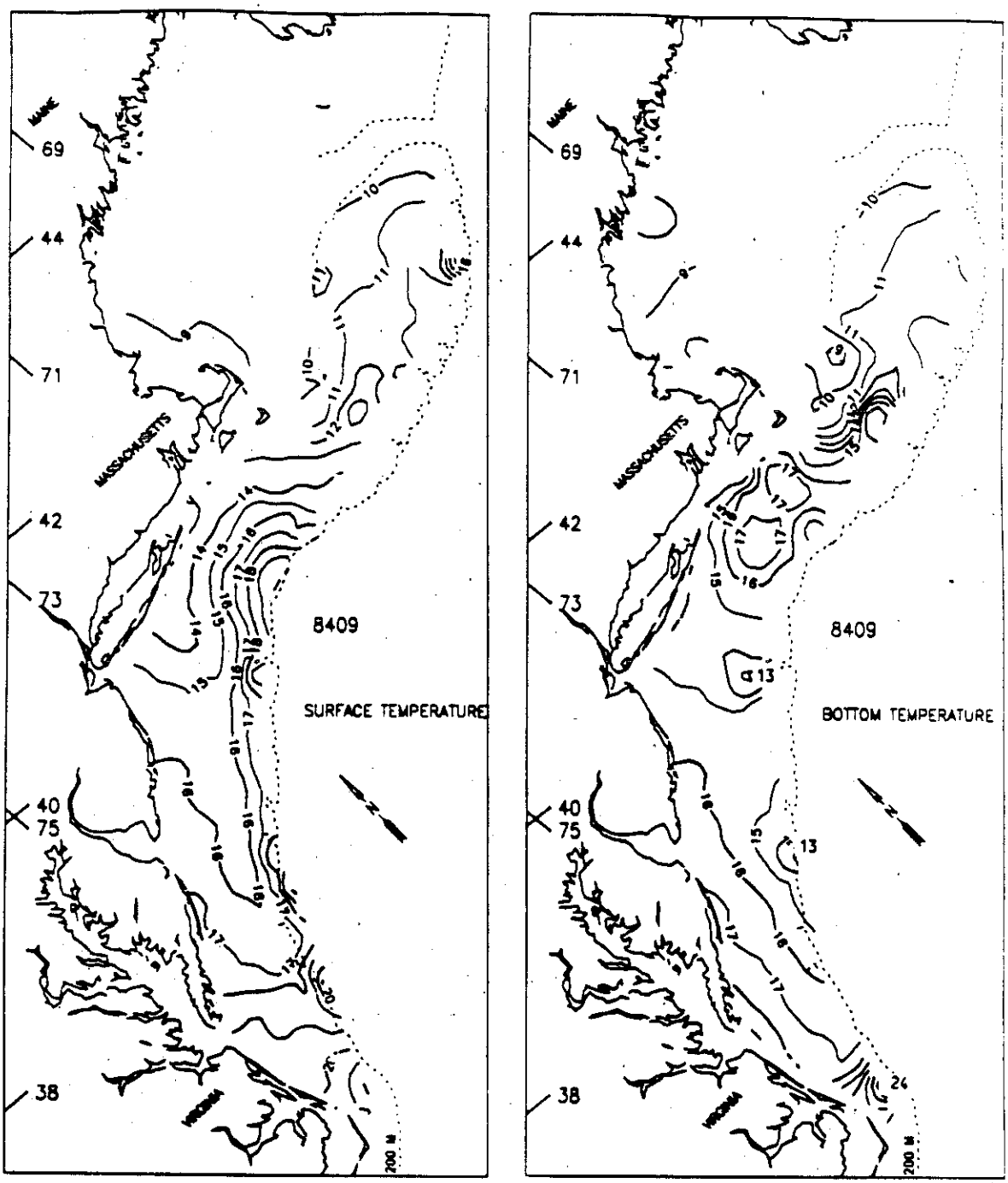


Figure 215. Surface and bottom temperature (°C) distribution: DEL8409.

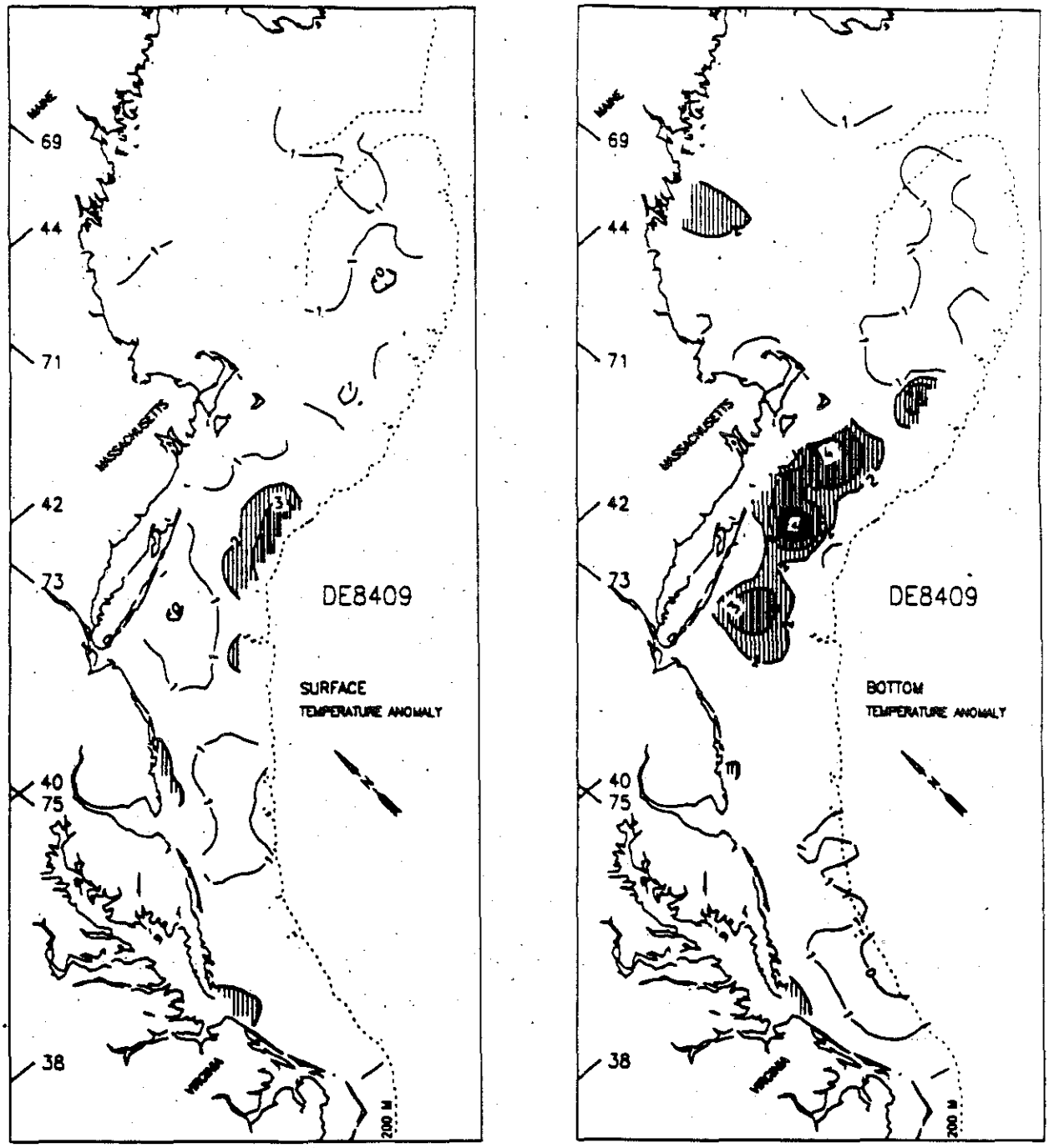


Figure 216. Normalized surface and bottom temperature anomaly: DEL8409. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

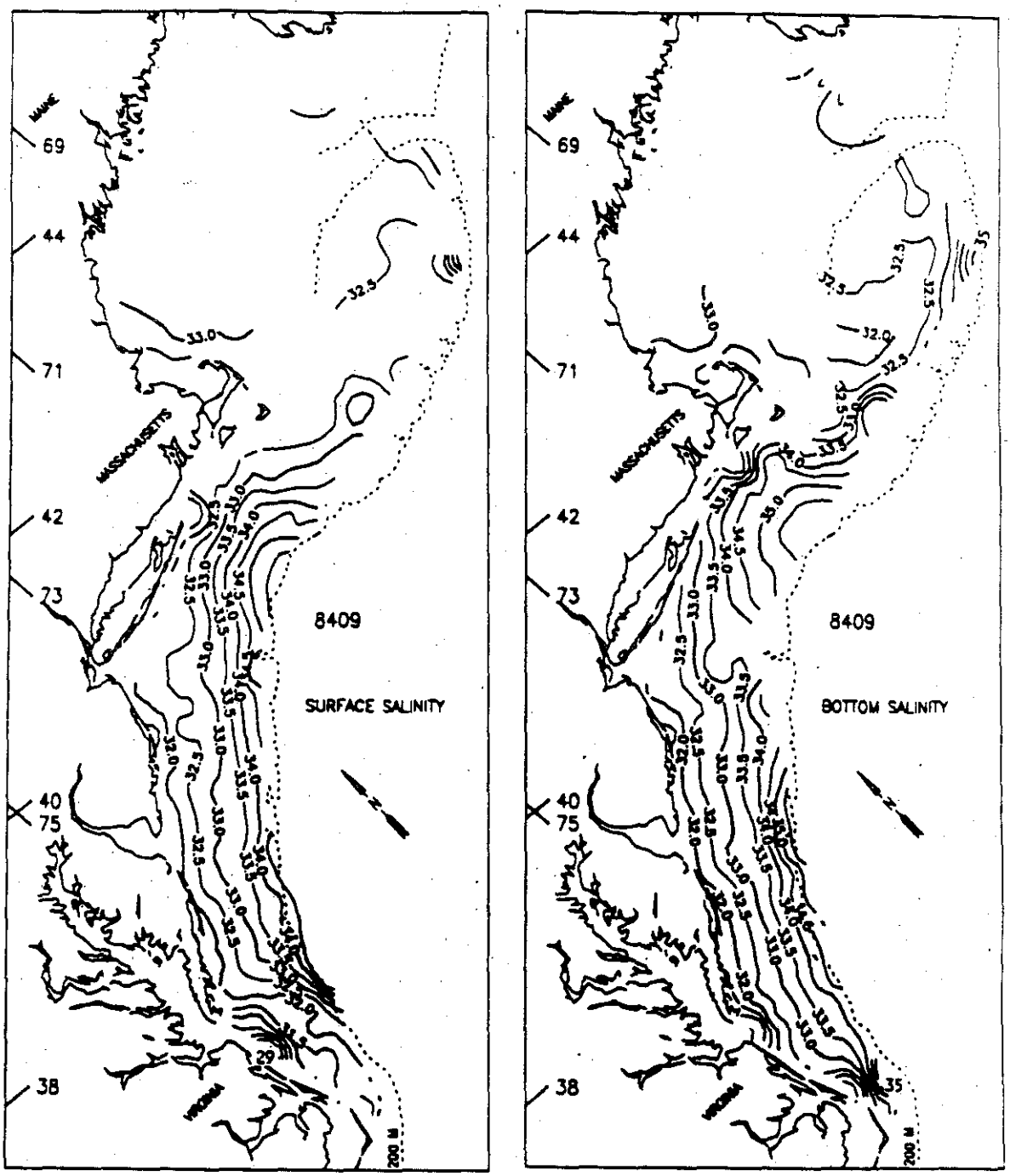


Figure 217. Surface and bottom salinity (PSU) distribution: DEL8409.

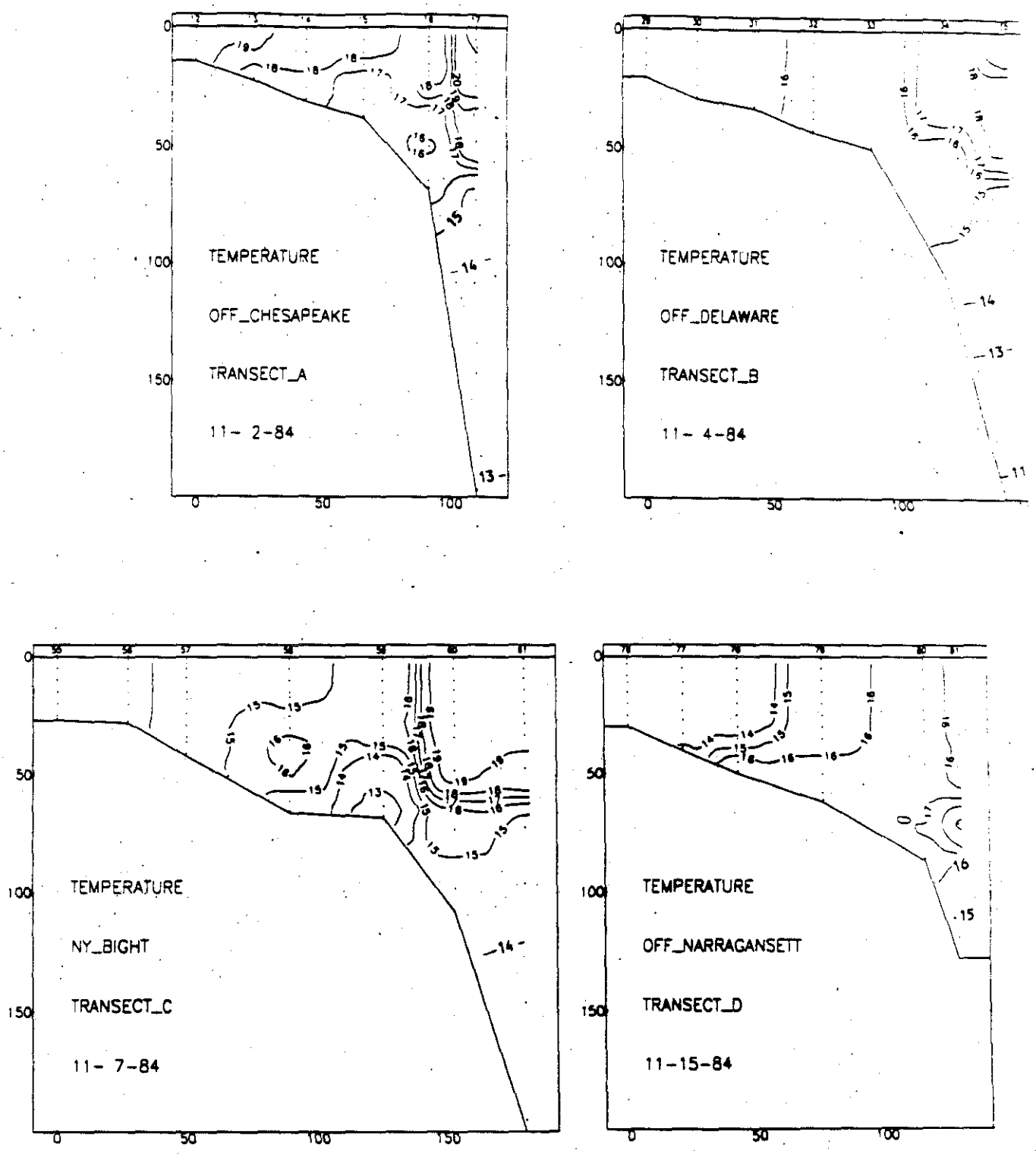
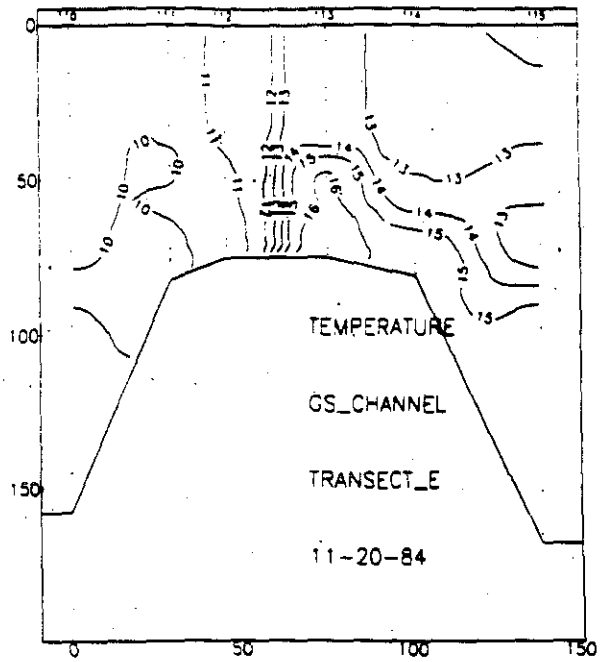


Figure 218. Temperature (°C) transects: DEL8409.



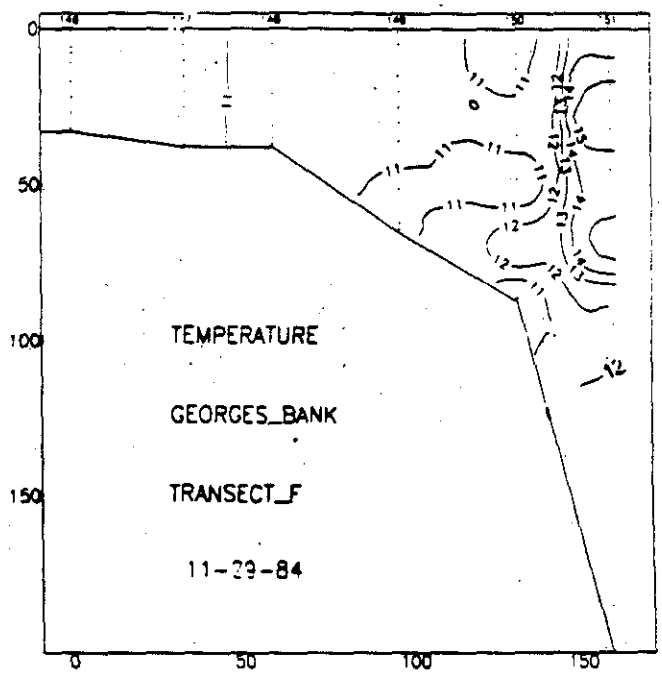


Figure 218. Continued.

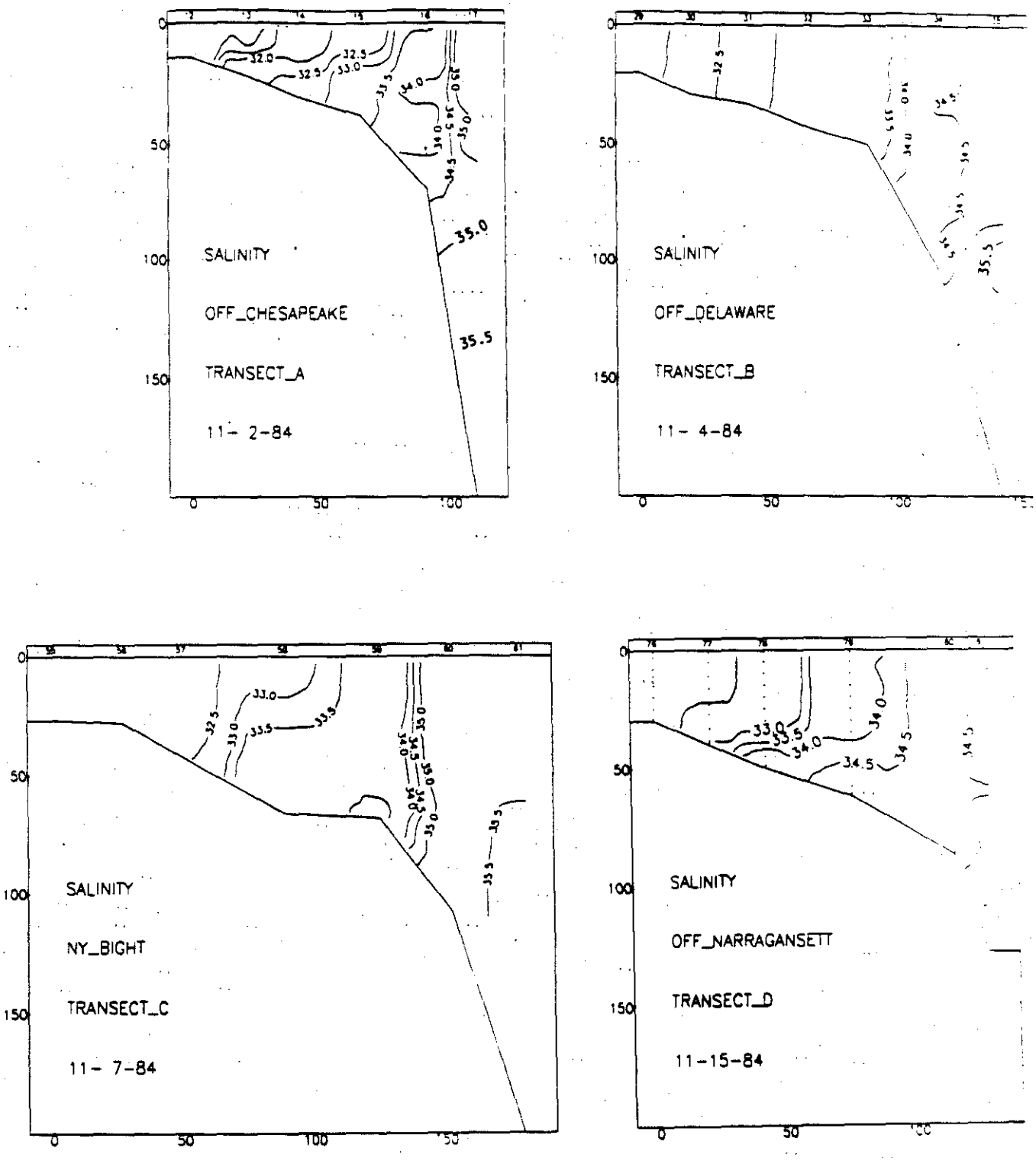
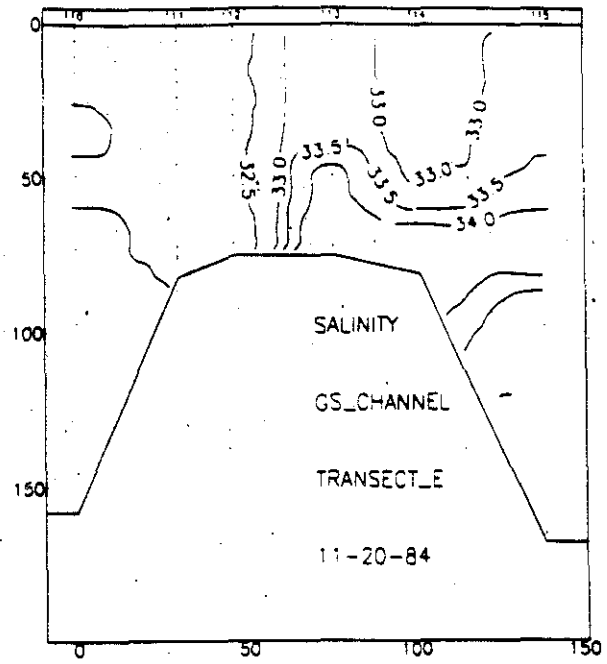


Figure 219. Salinity (PSU) transects: DEL8409.



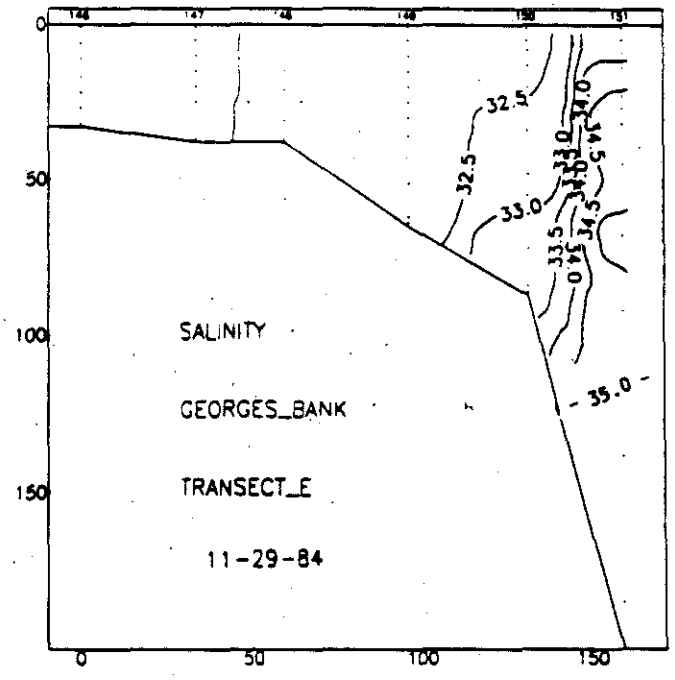


Figure 219. Continued.

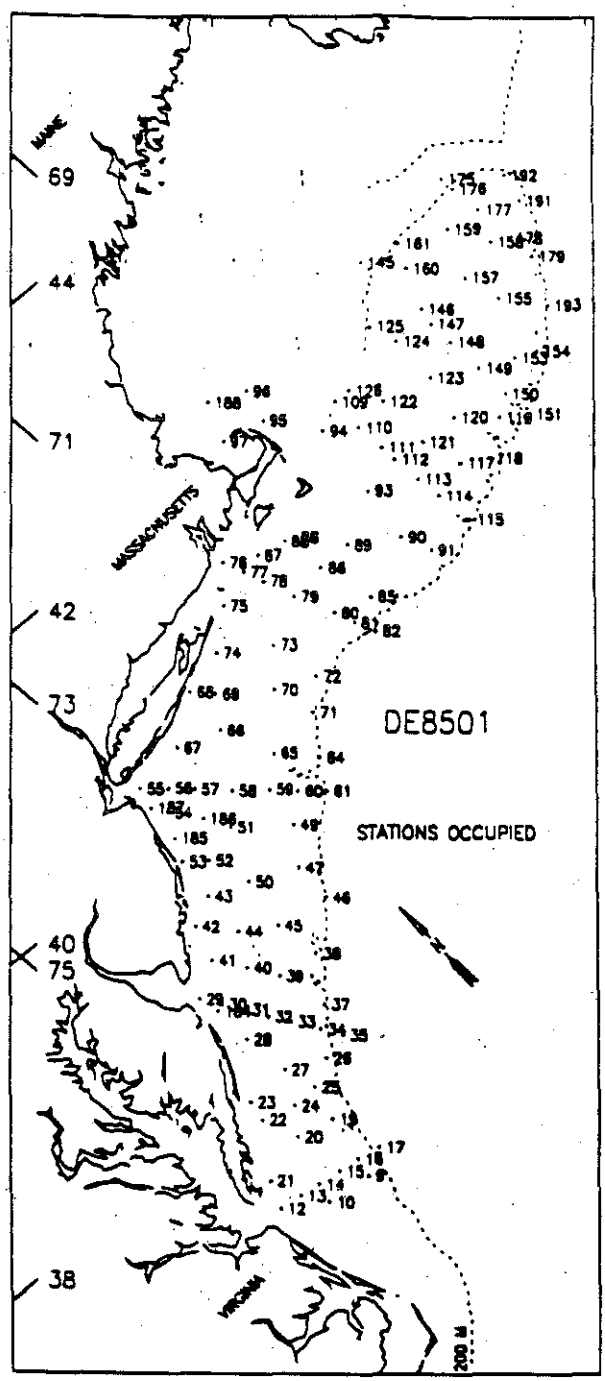


Figure 220. Station positions: DEL8501.

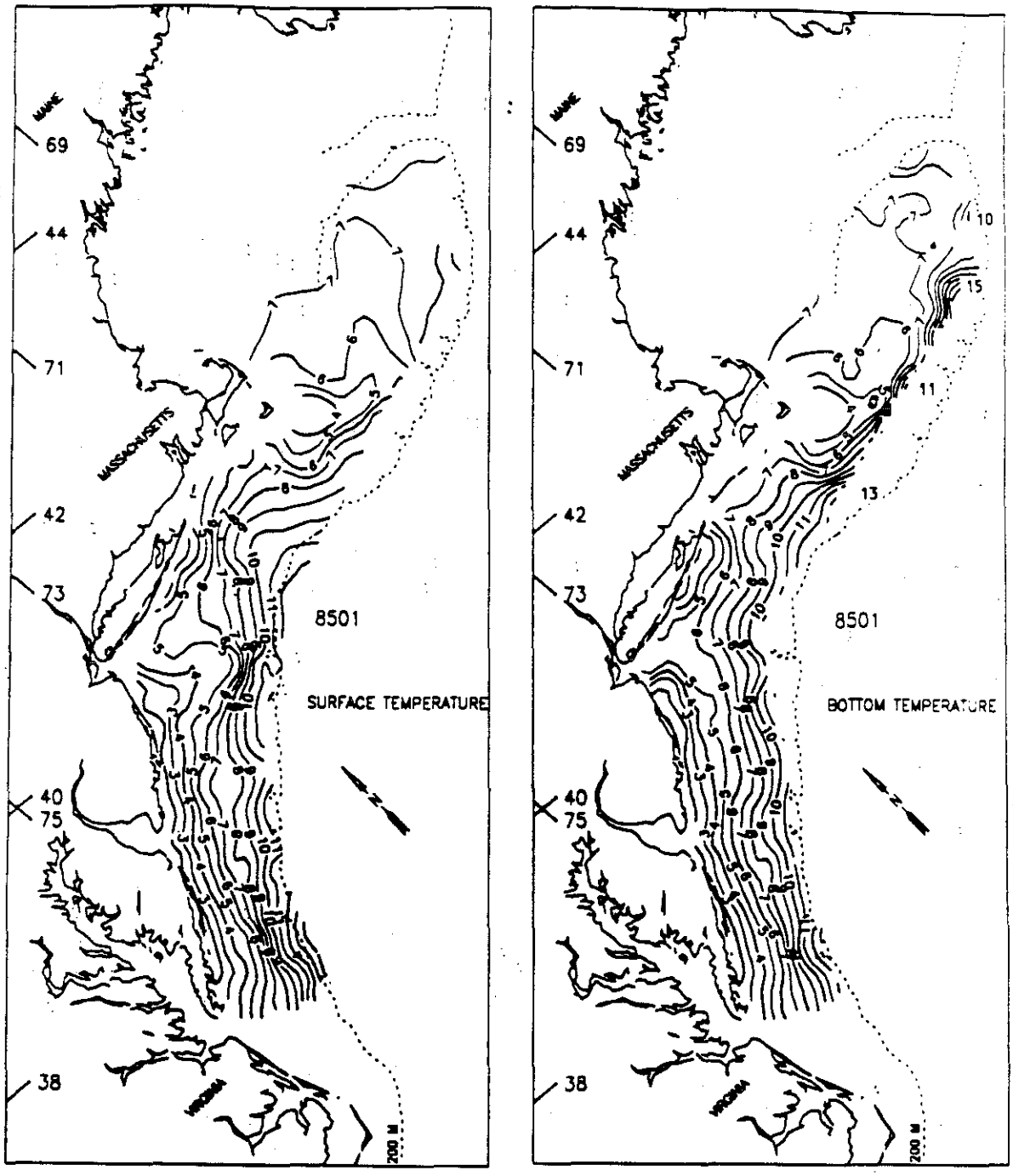


Figure 221. Surface and bottom temperature (°C) distribution: DEL8501.

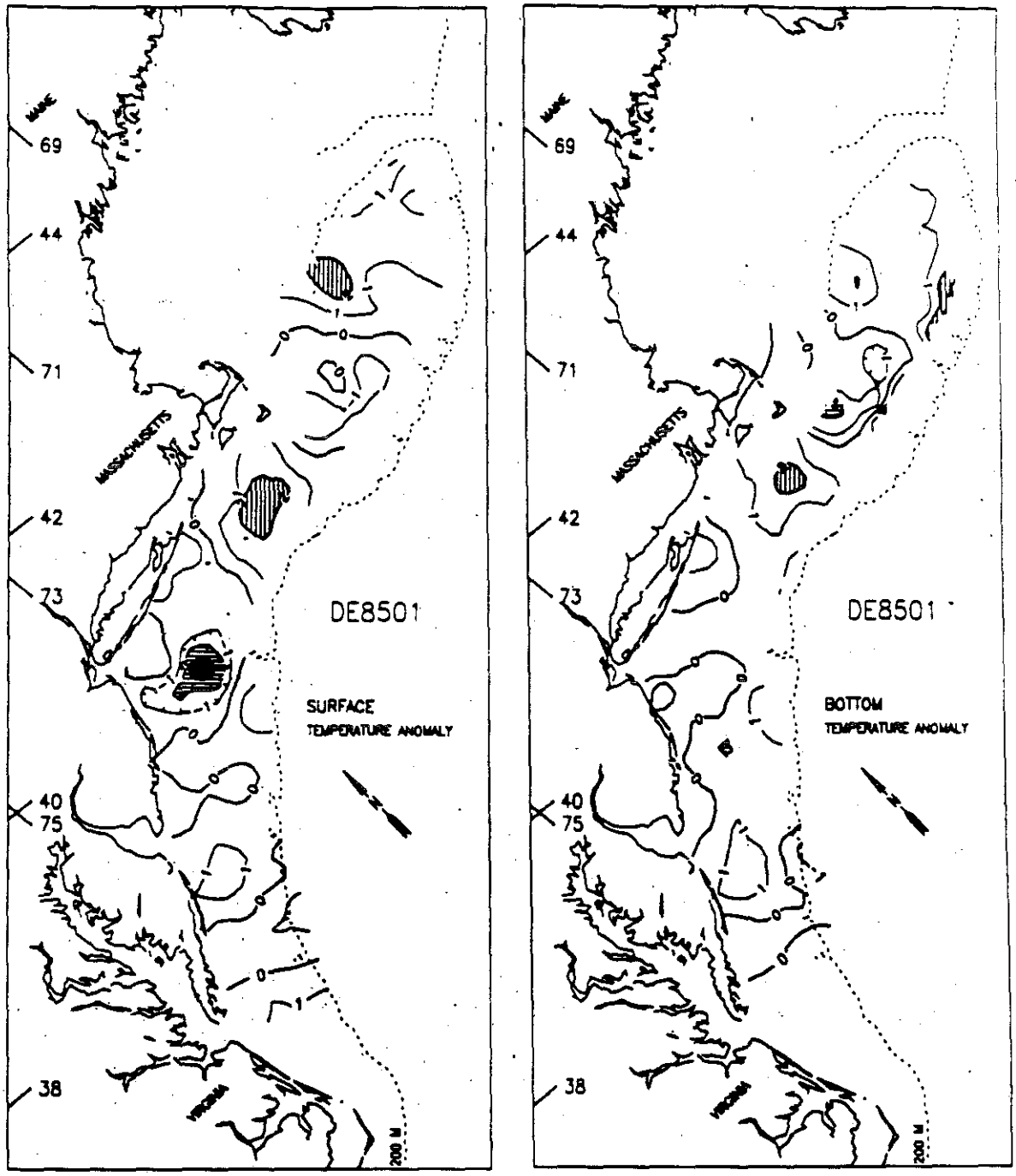


Figure 222. Normalized surface and bottom temperature anomaly: DEL8501. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

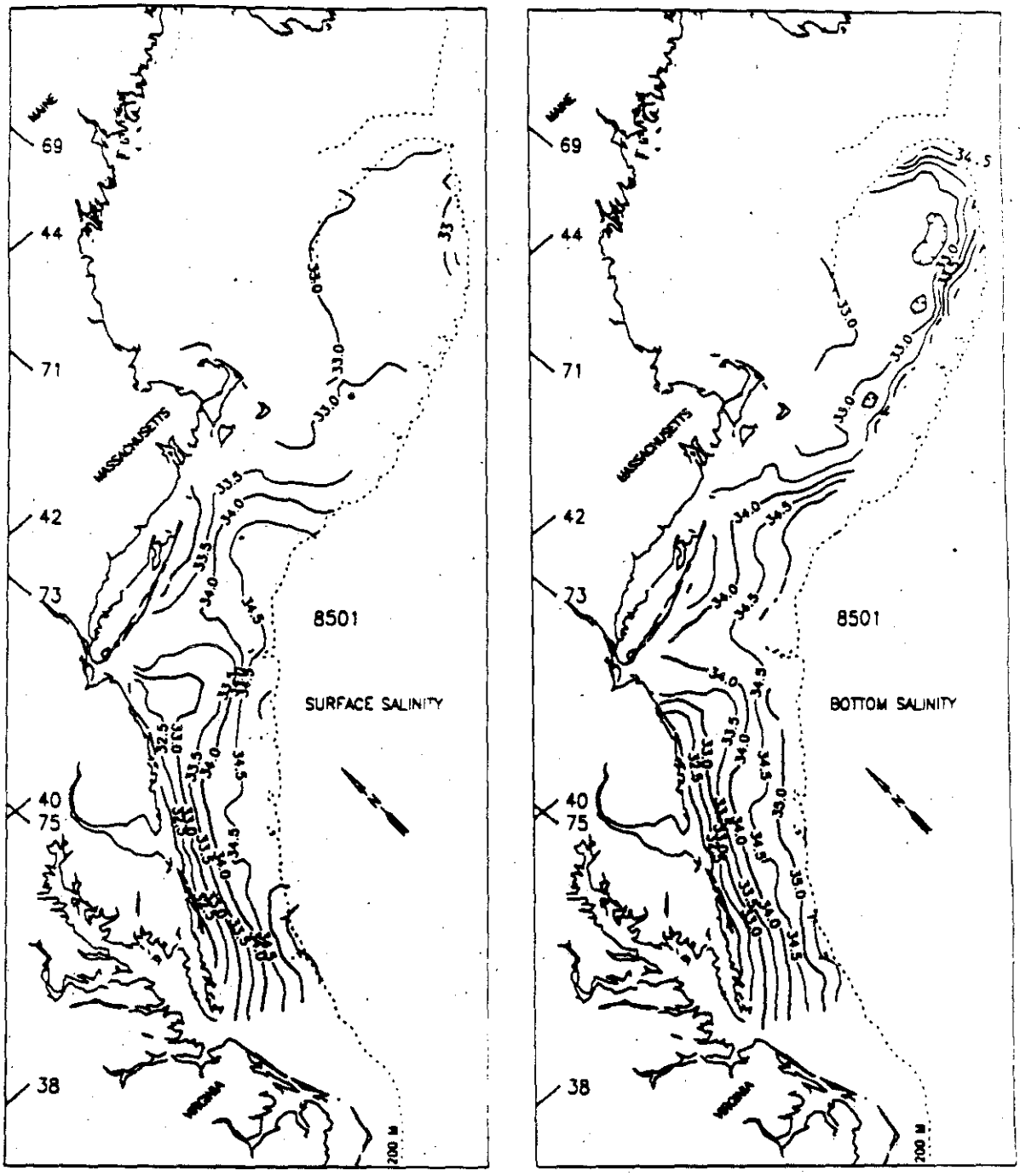


Figure 223. Surface and bottom salinity (PSU) distribution: DEL8501.

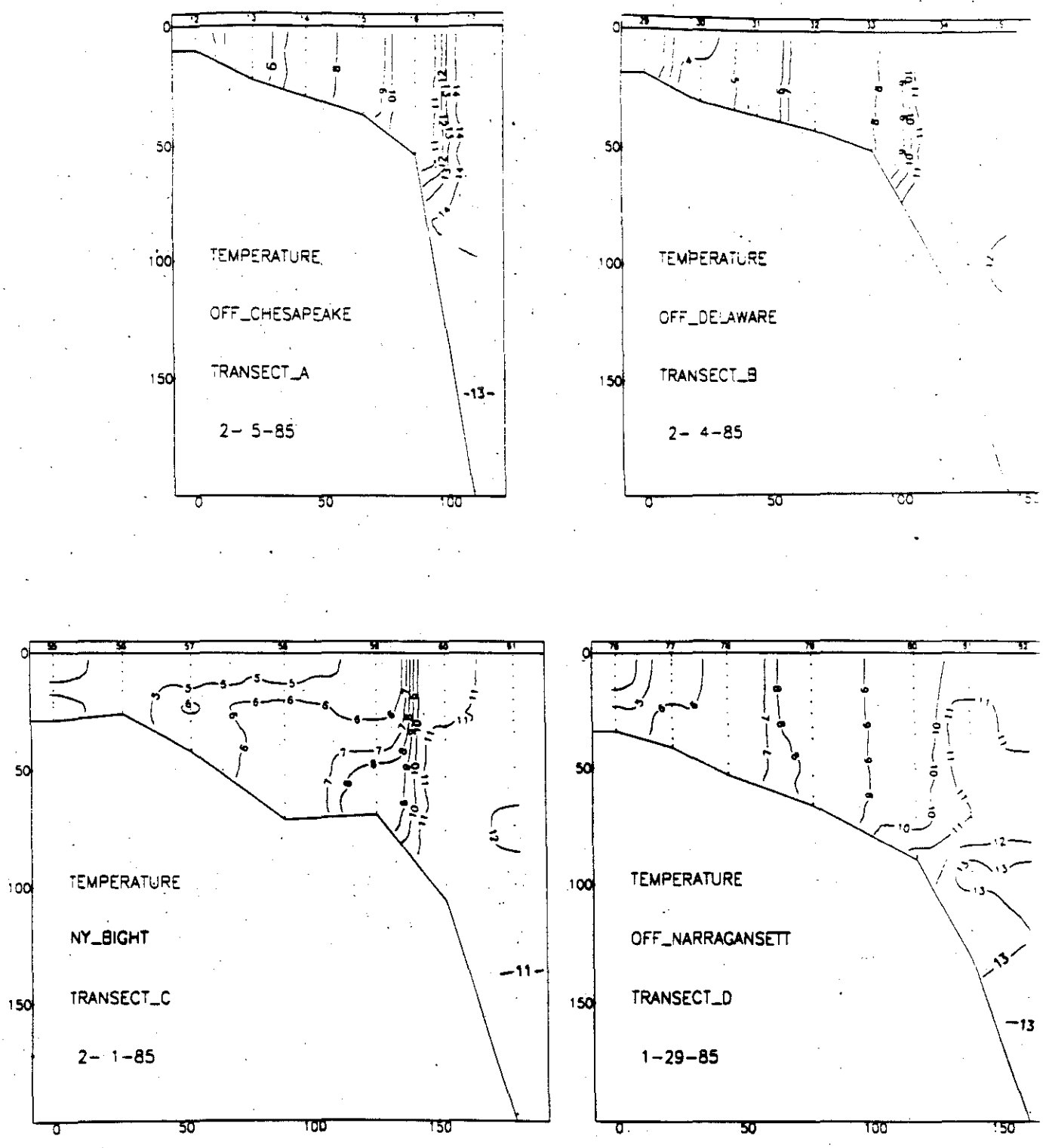
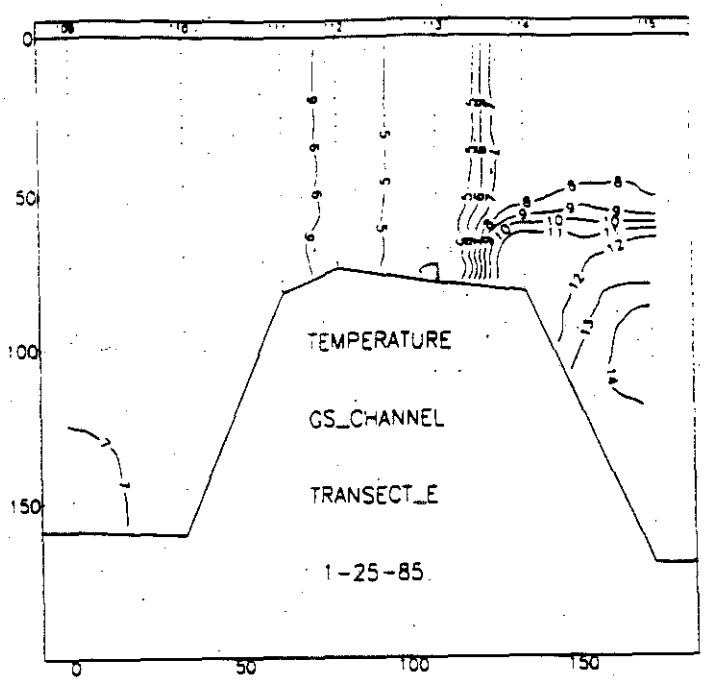
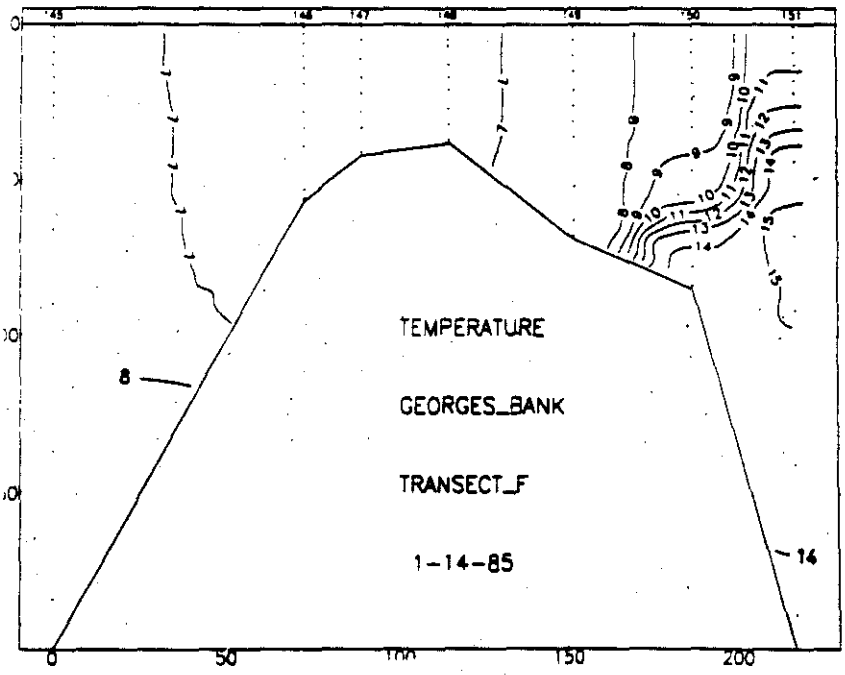


Figure 224. Temperature (°C) transects: DEL8501.





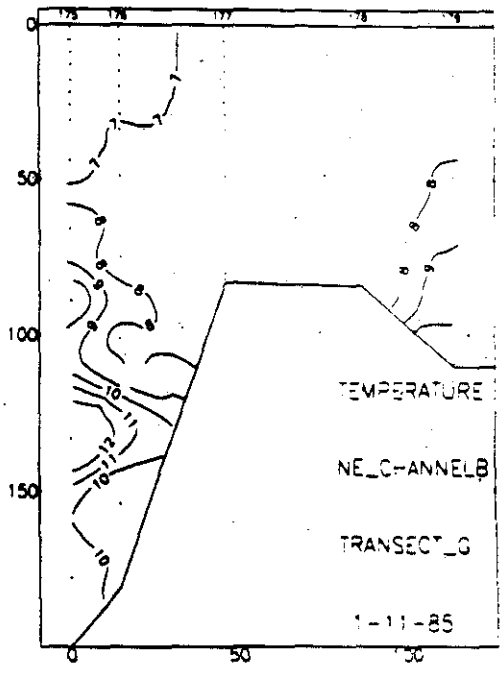


Figure 224. Continued.

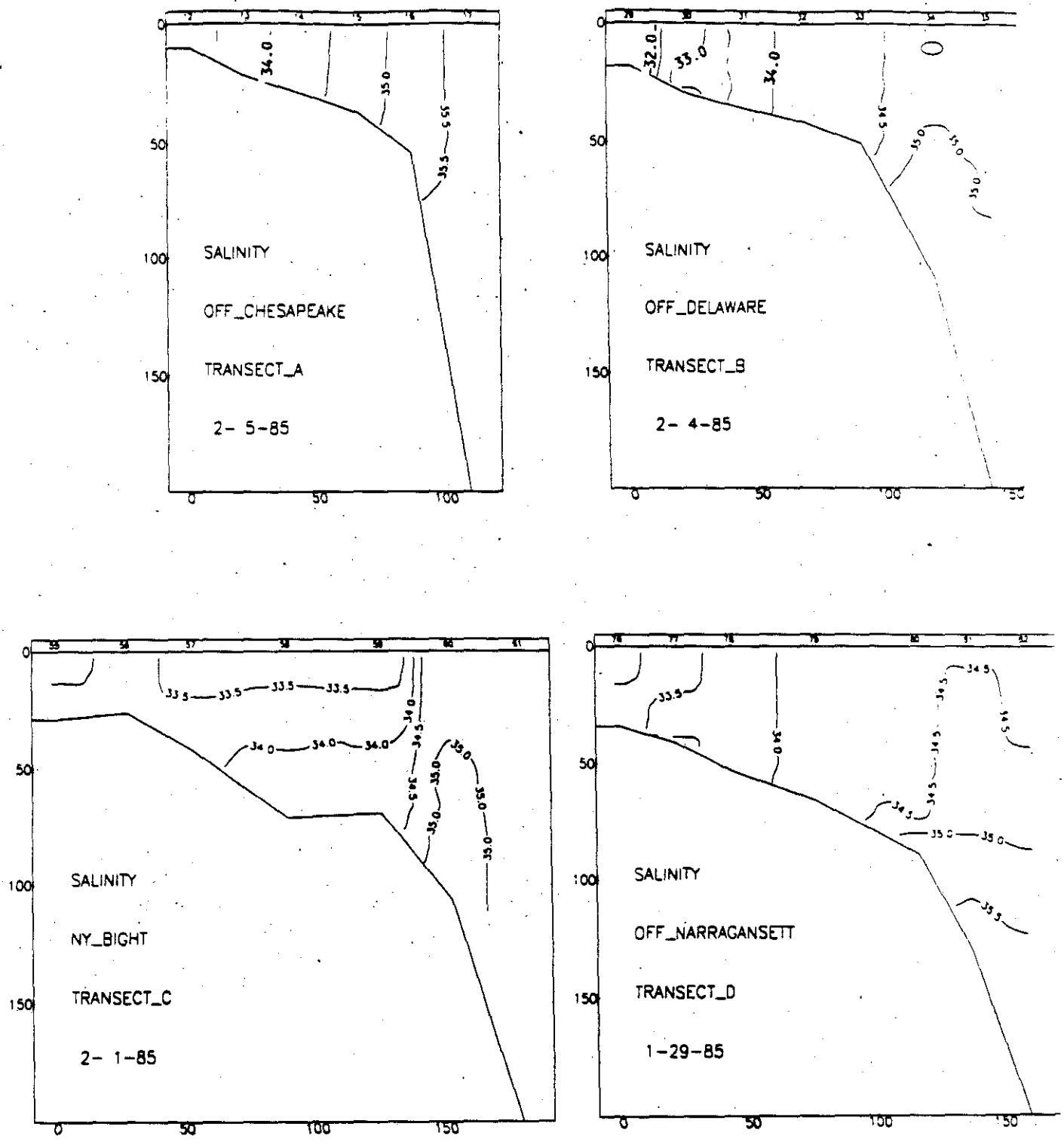
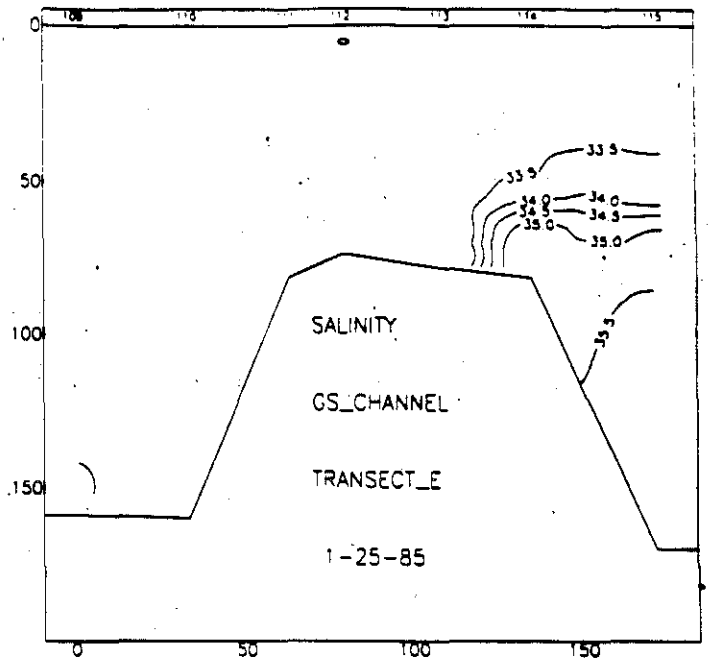
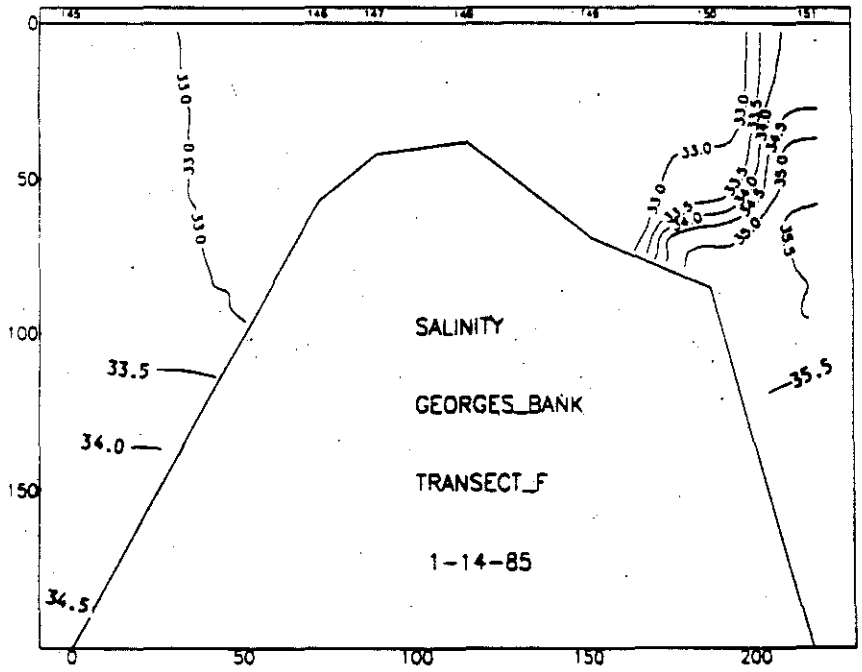


Figure 225. Salinity (PSU) transects: DEL8501.





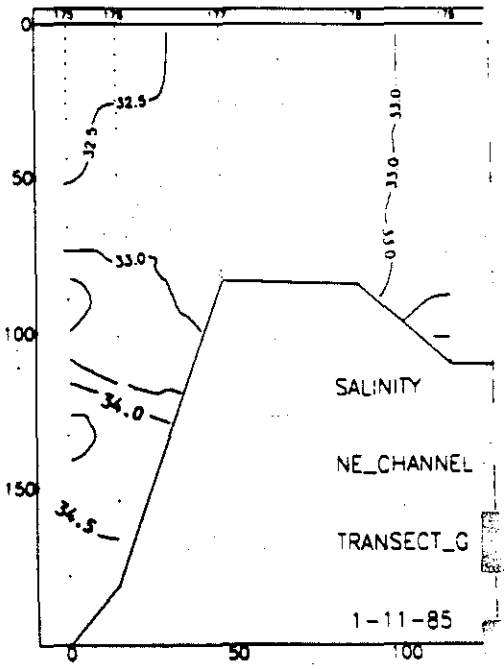


Figure 225. Continued.

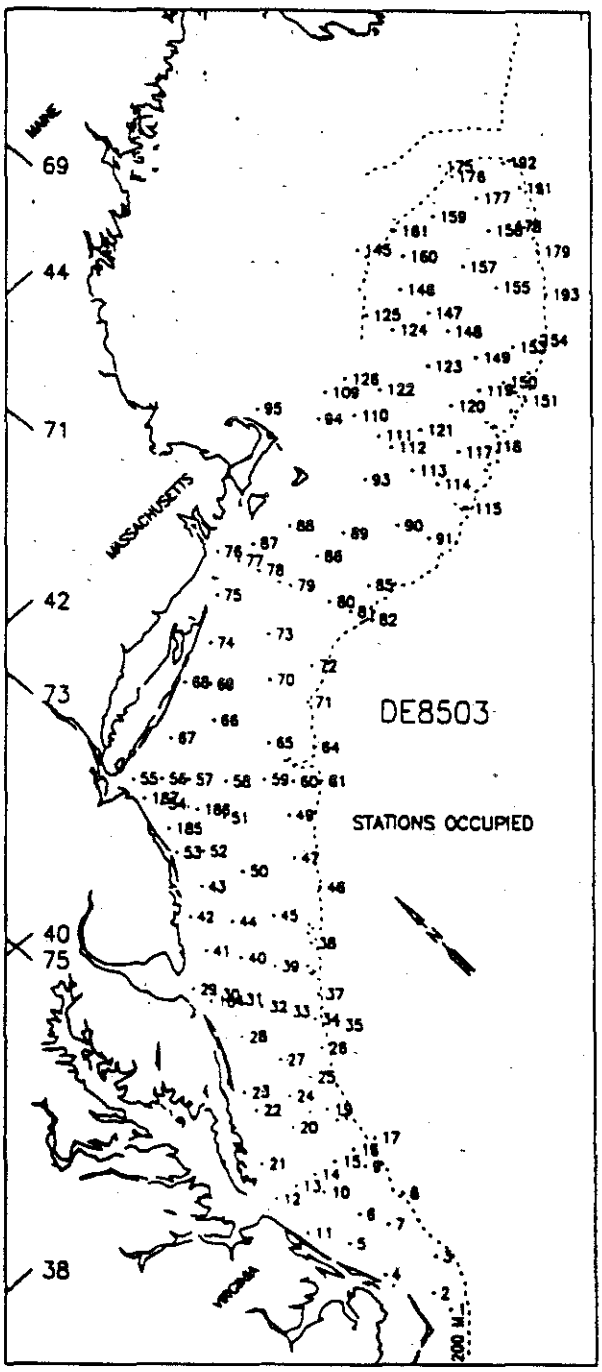


Figure 226. Station positions: ALB8504.

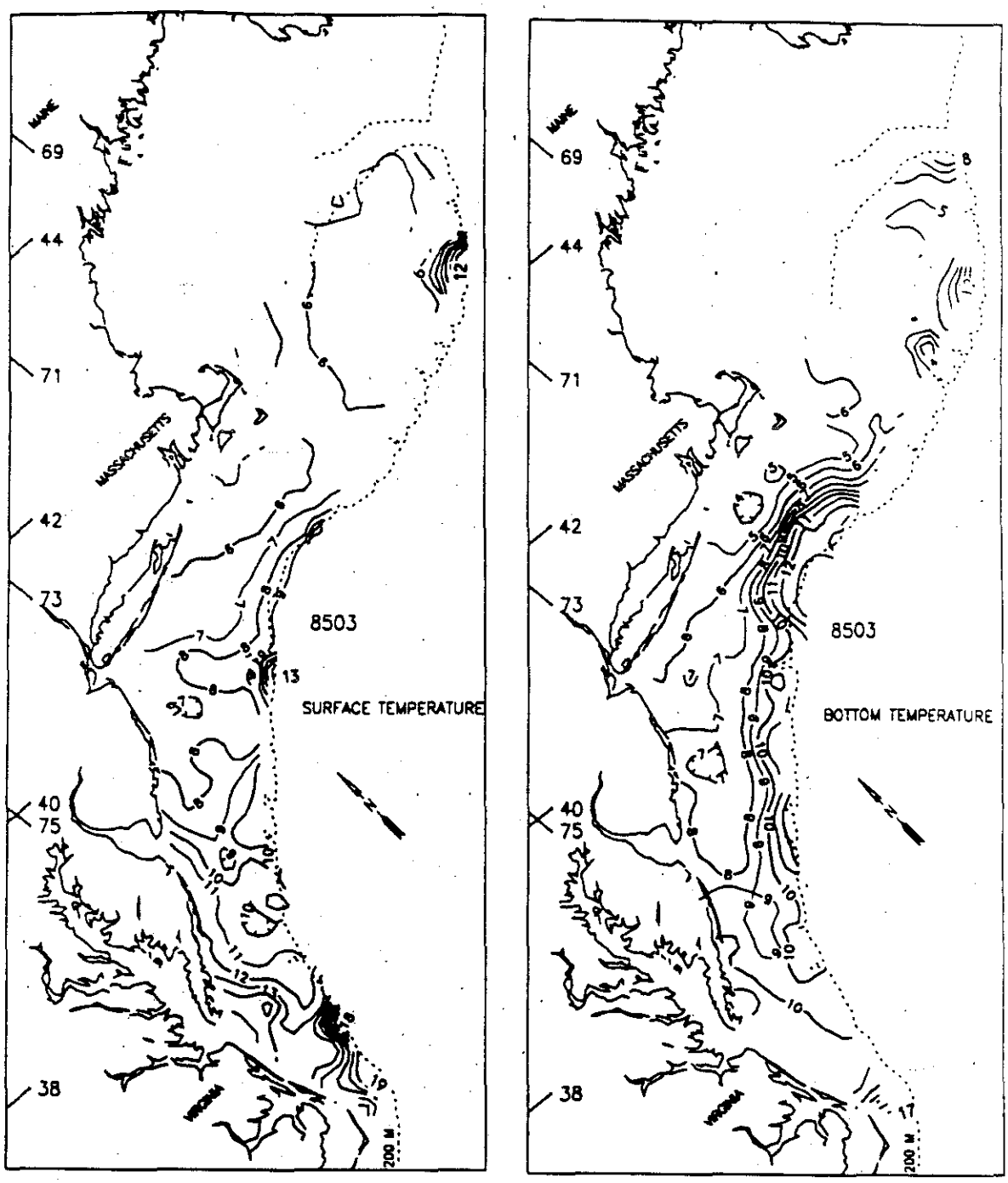


Figure 227. Surface and bottom temperature (°C) distribution: DEL8503.

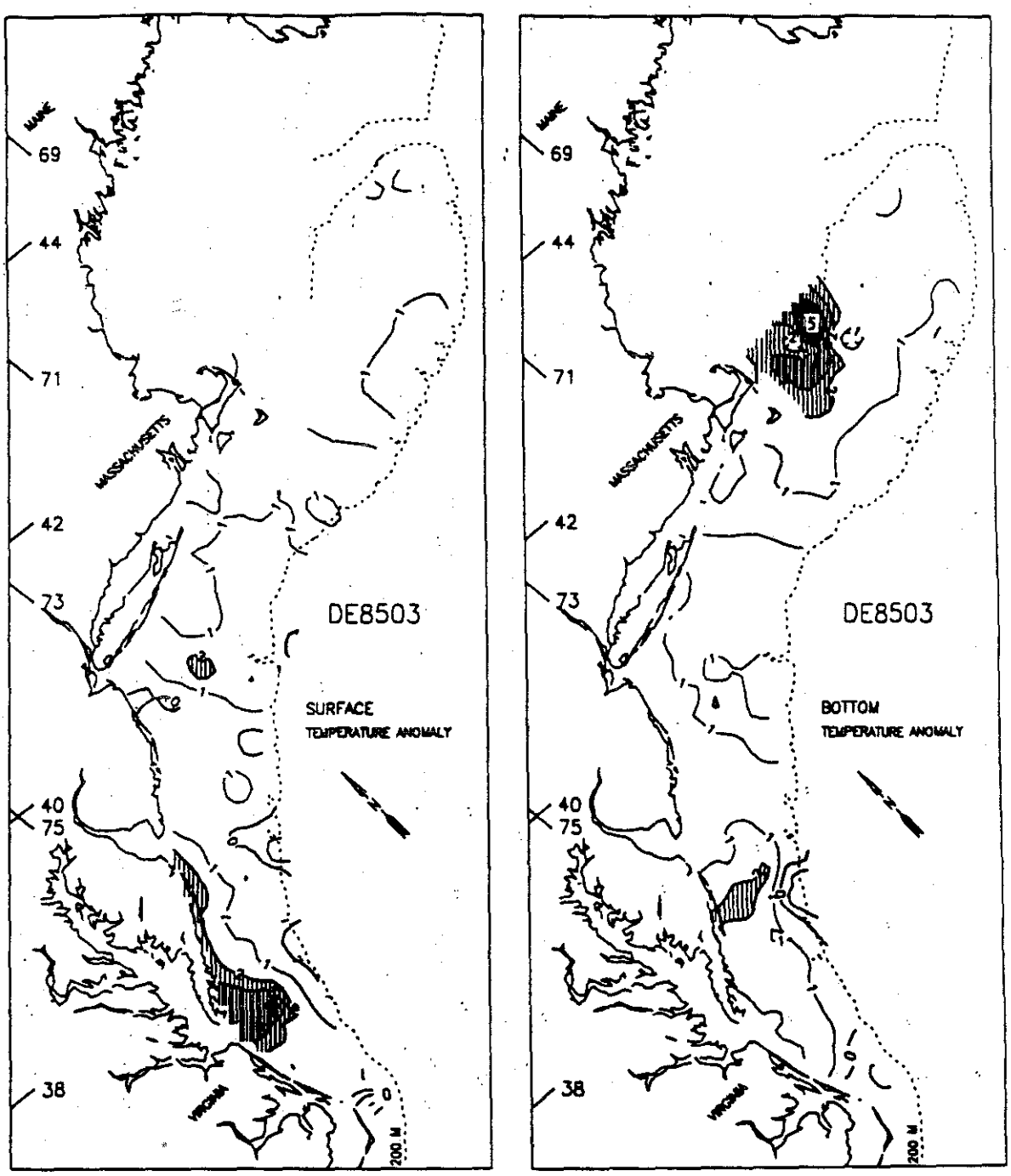


Figure 228. Normalized surface and bottom temperature anomaly: DEL8503. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

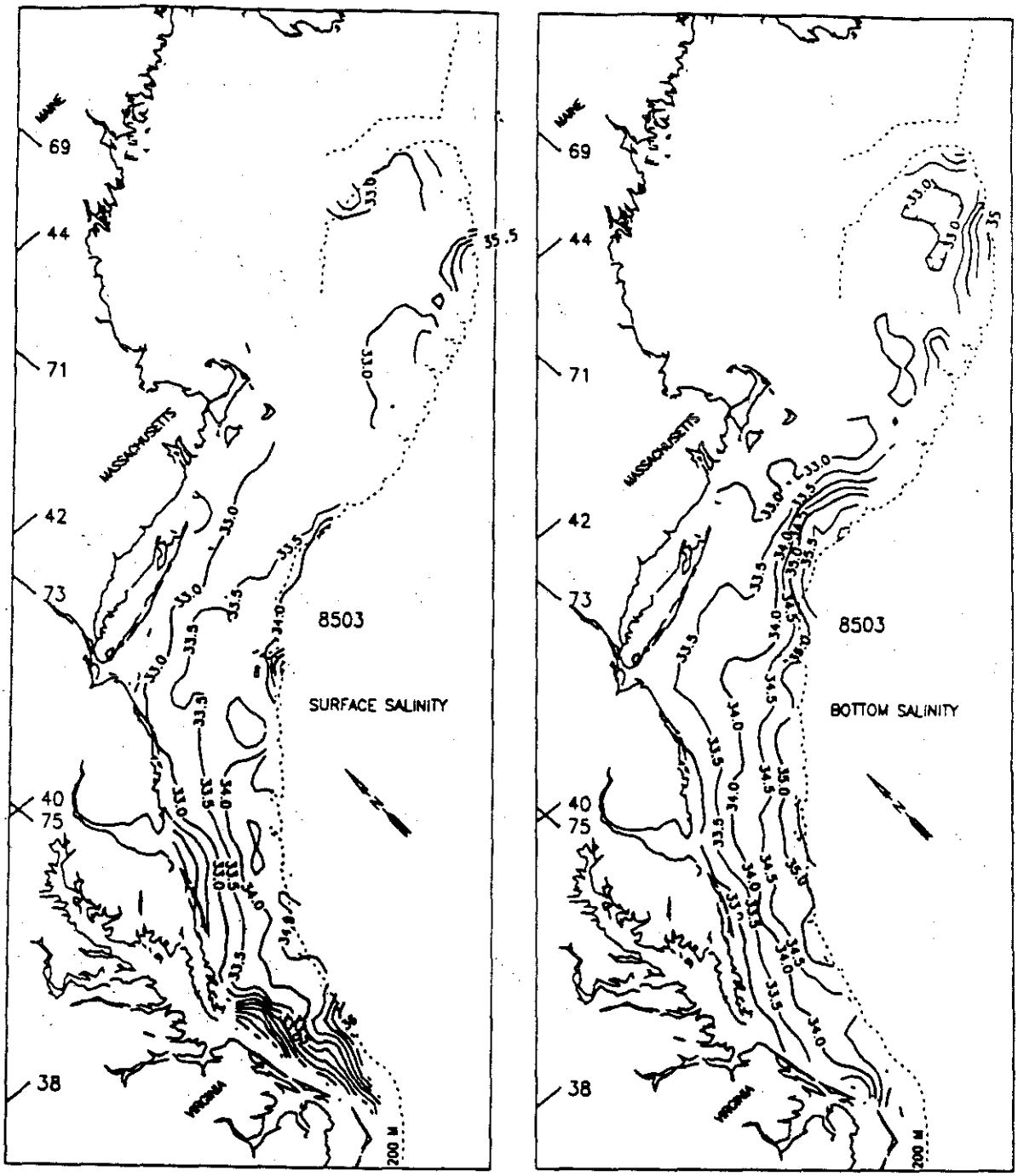


Figure 229. Surface and bottom salinity (PSU) distribution: DEL8503.

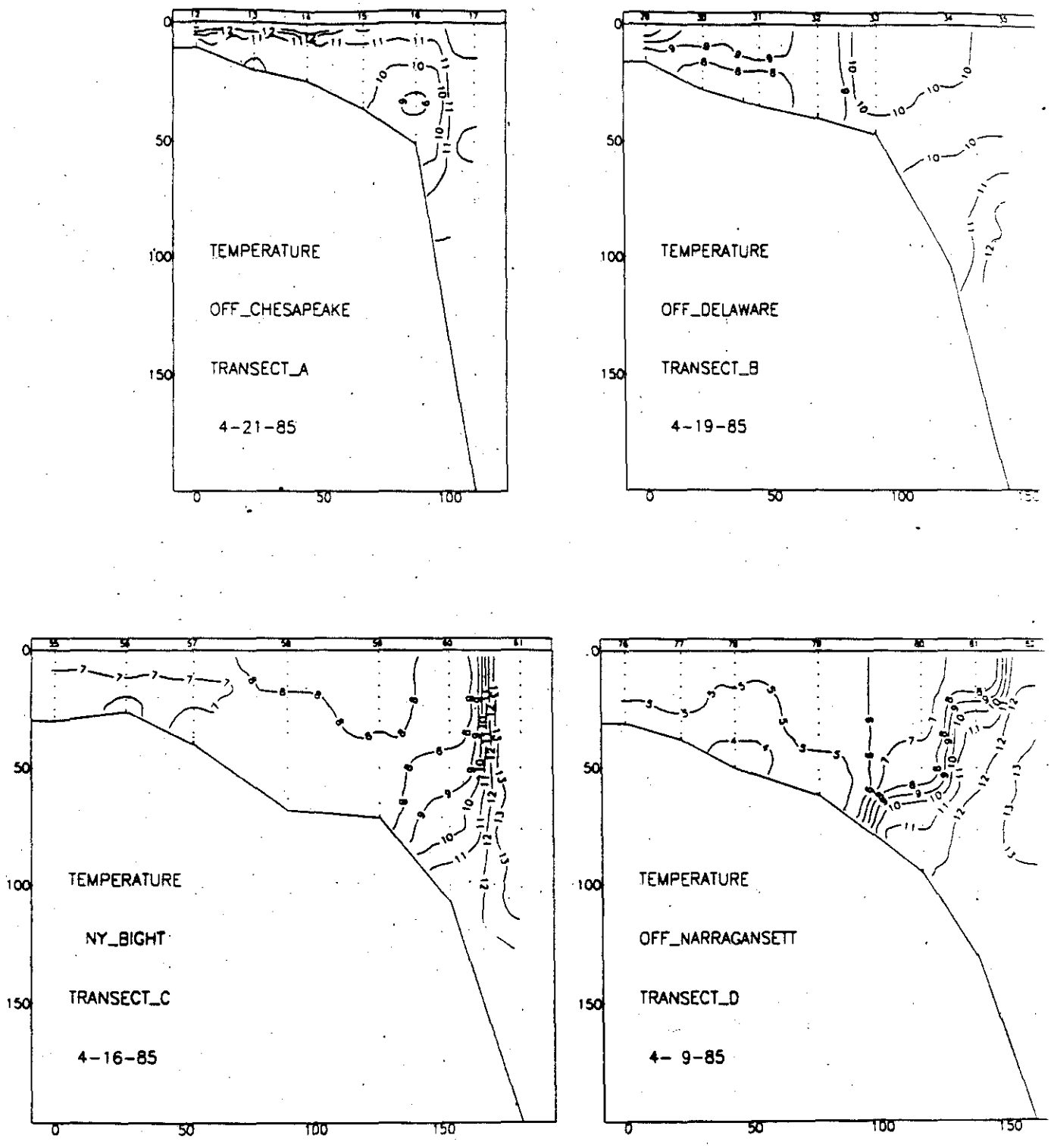
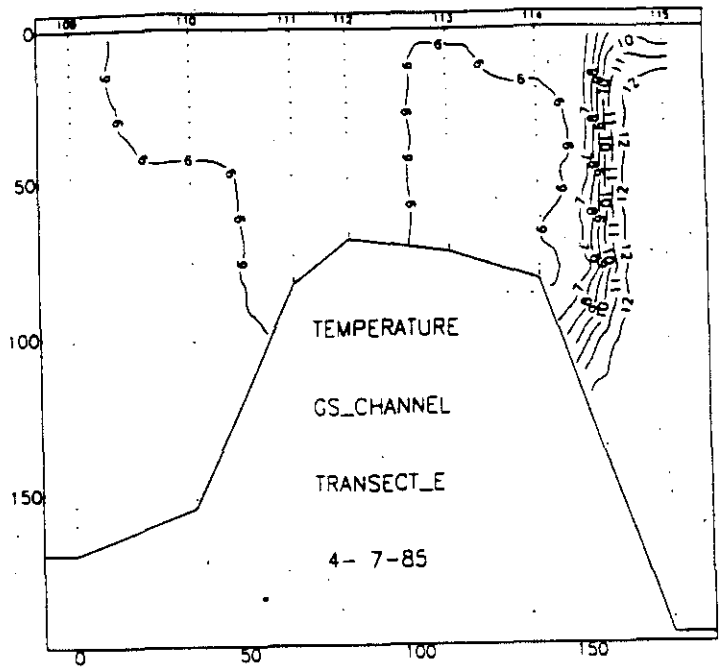
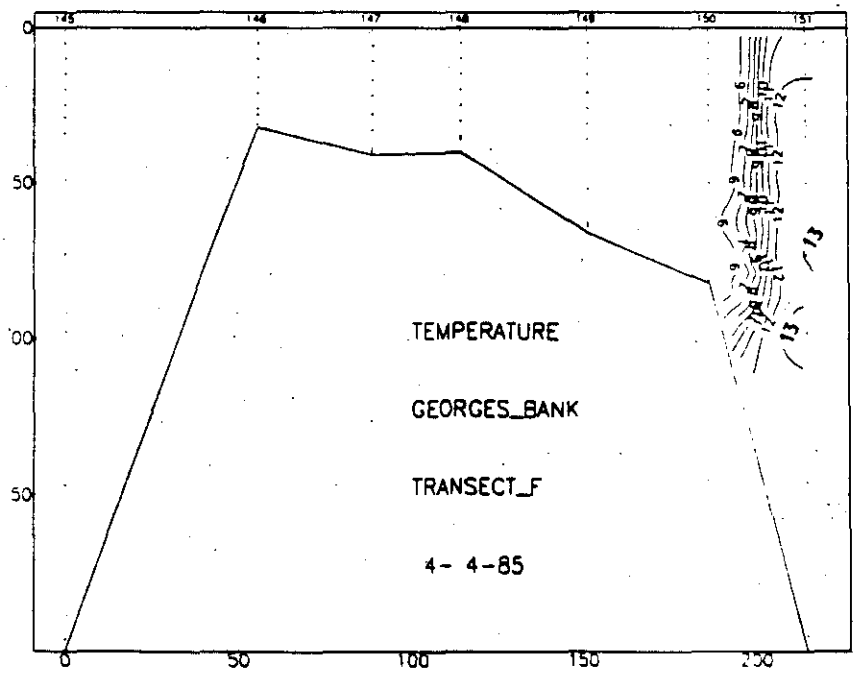


Figure 230. Temperature (°C) transects: DEL8503.





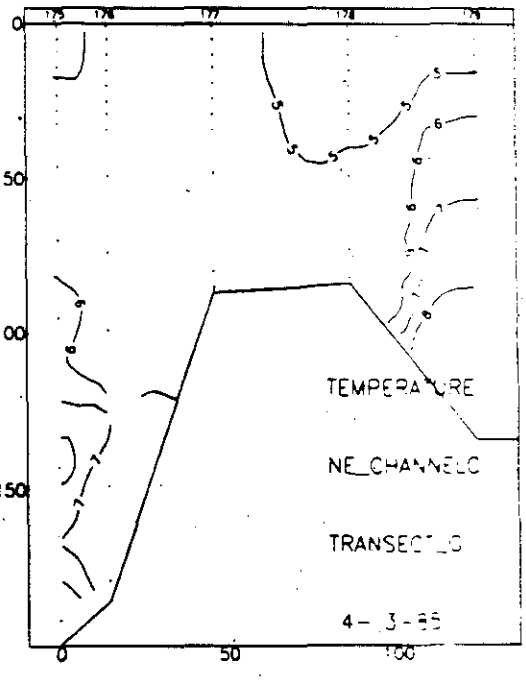


Figure 230. Continued.

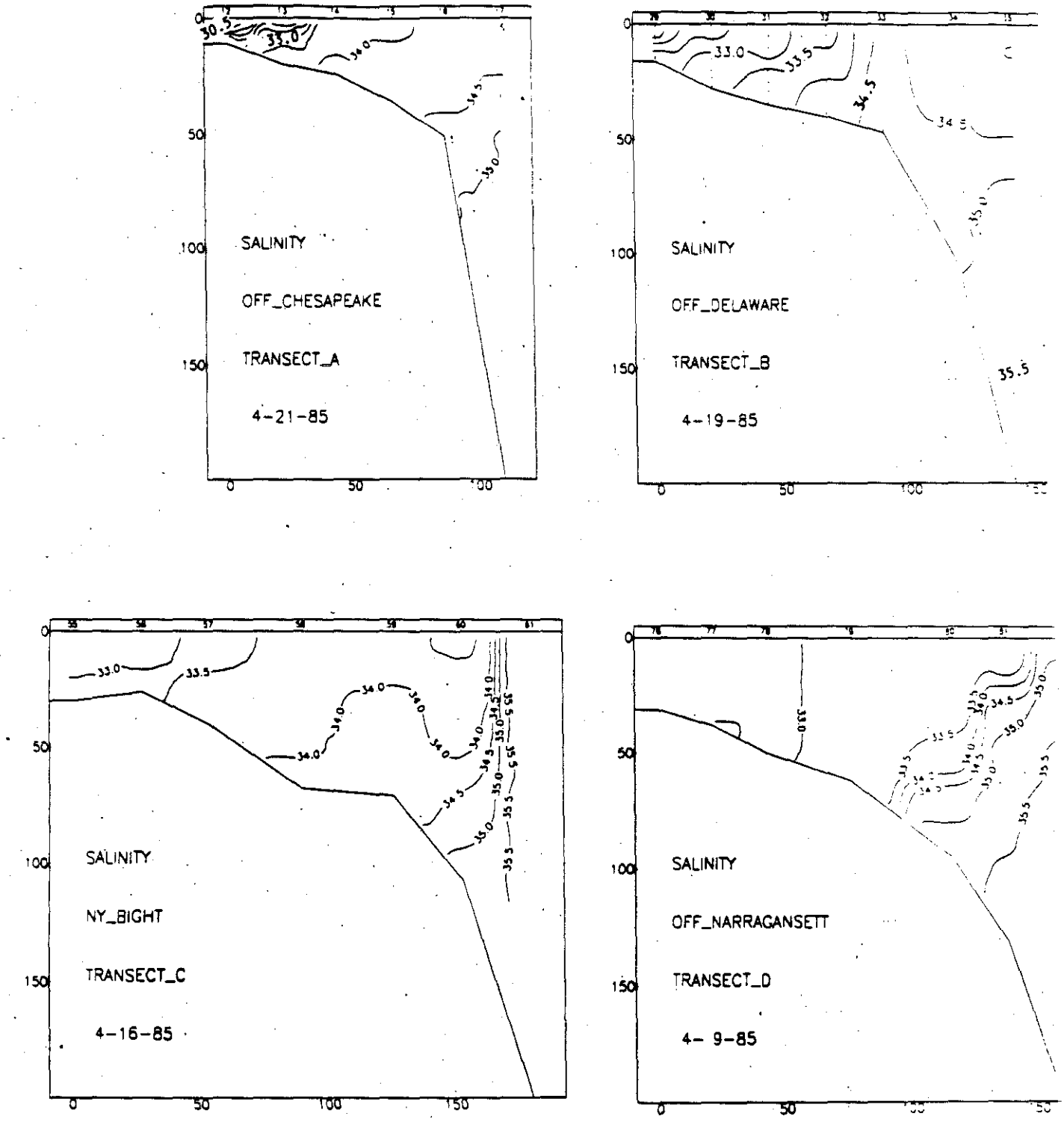


Figure 231. Salinity (PSU) transects: DEL8503.

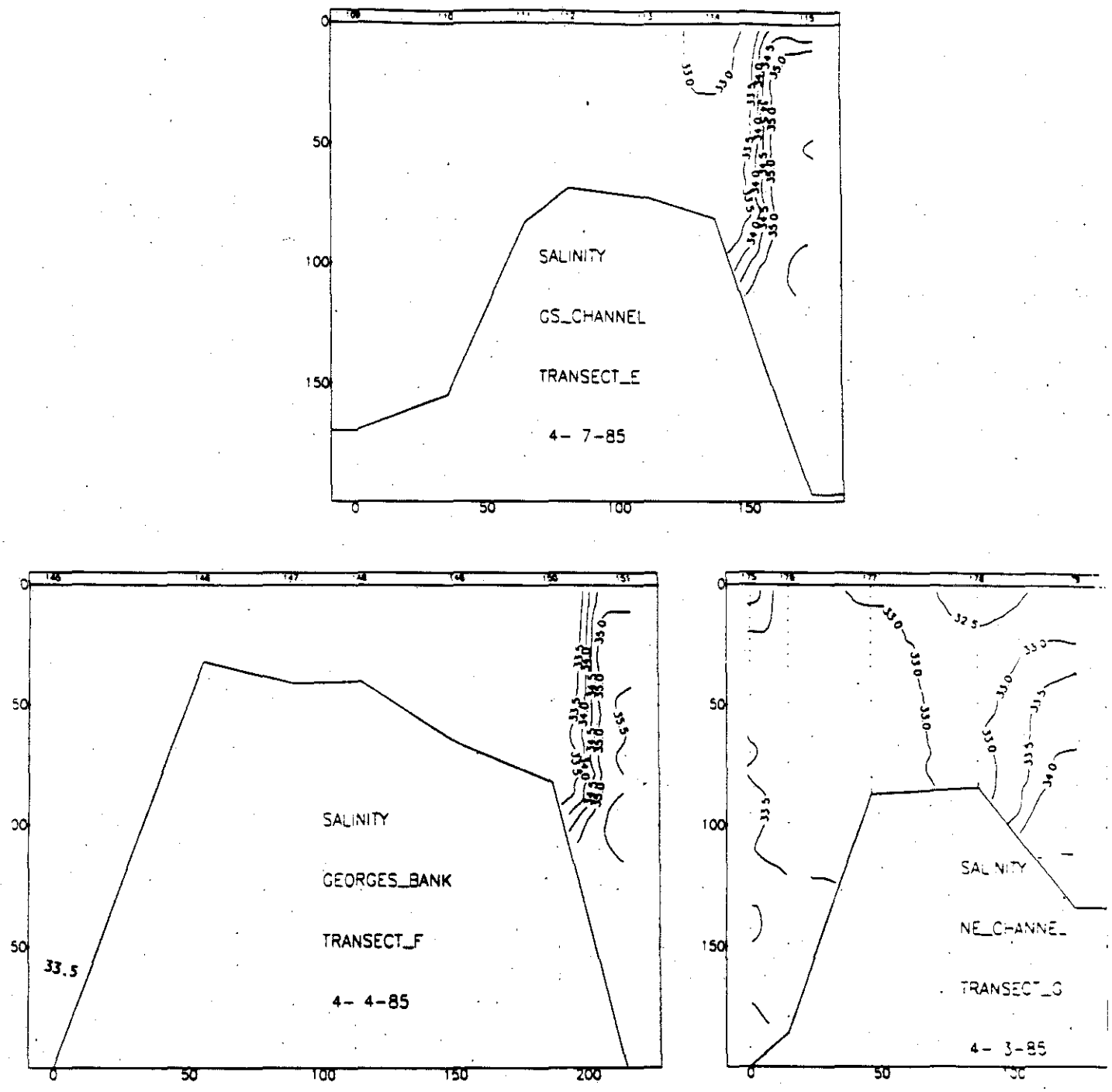


Figure 231. Continued.

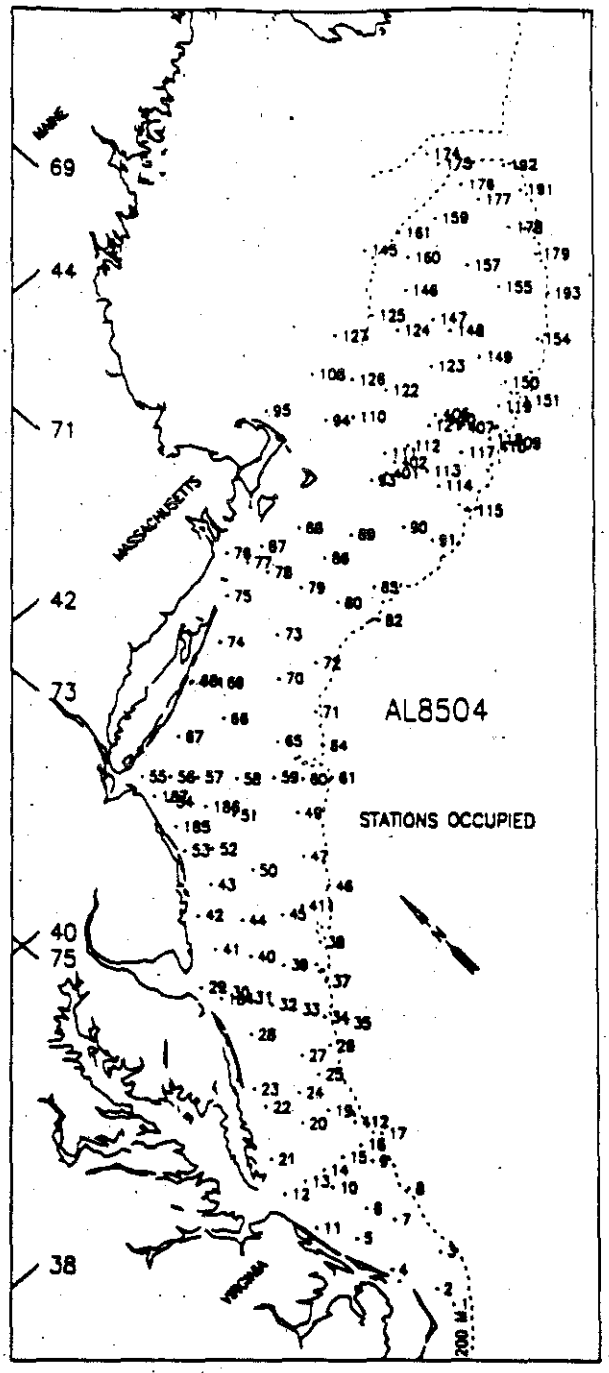


Figure 232. Station positions: ALB8504.

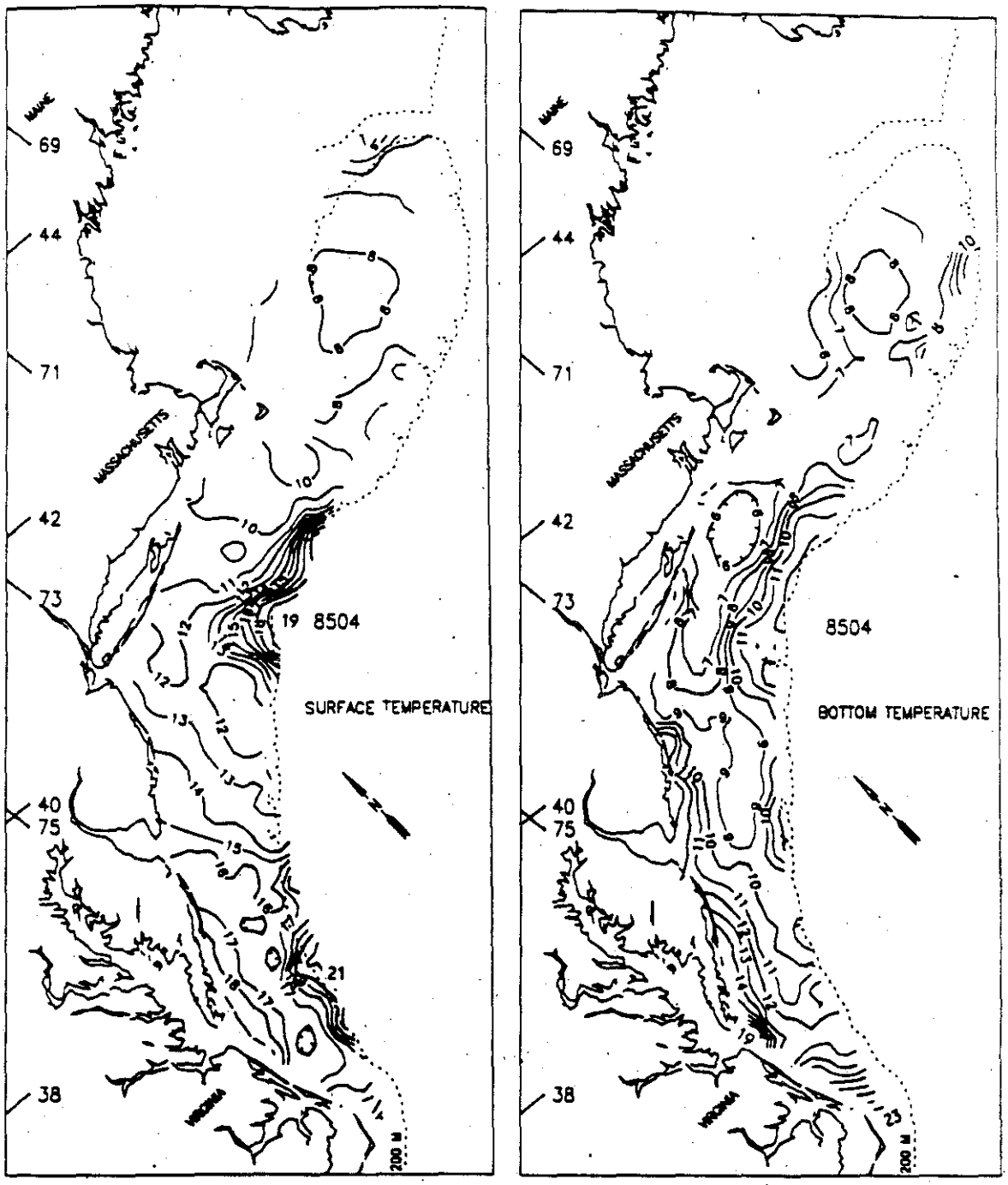


Figure 233. Surface and bottom temperature (°C) distribution: ALB8504.

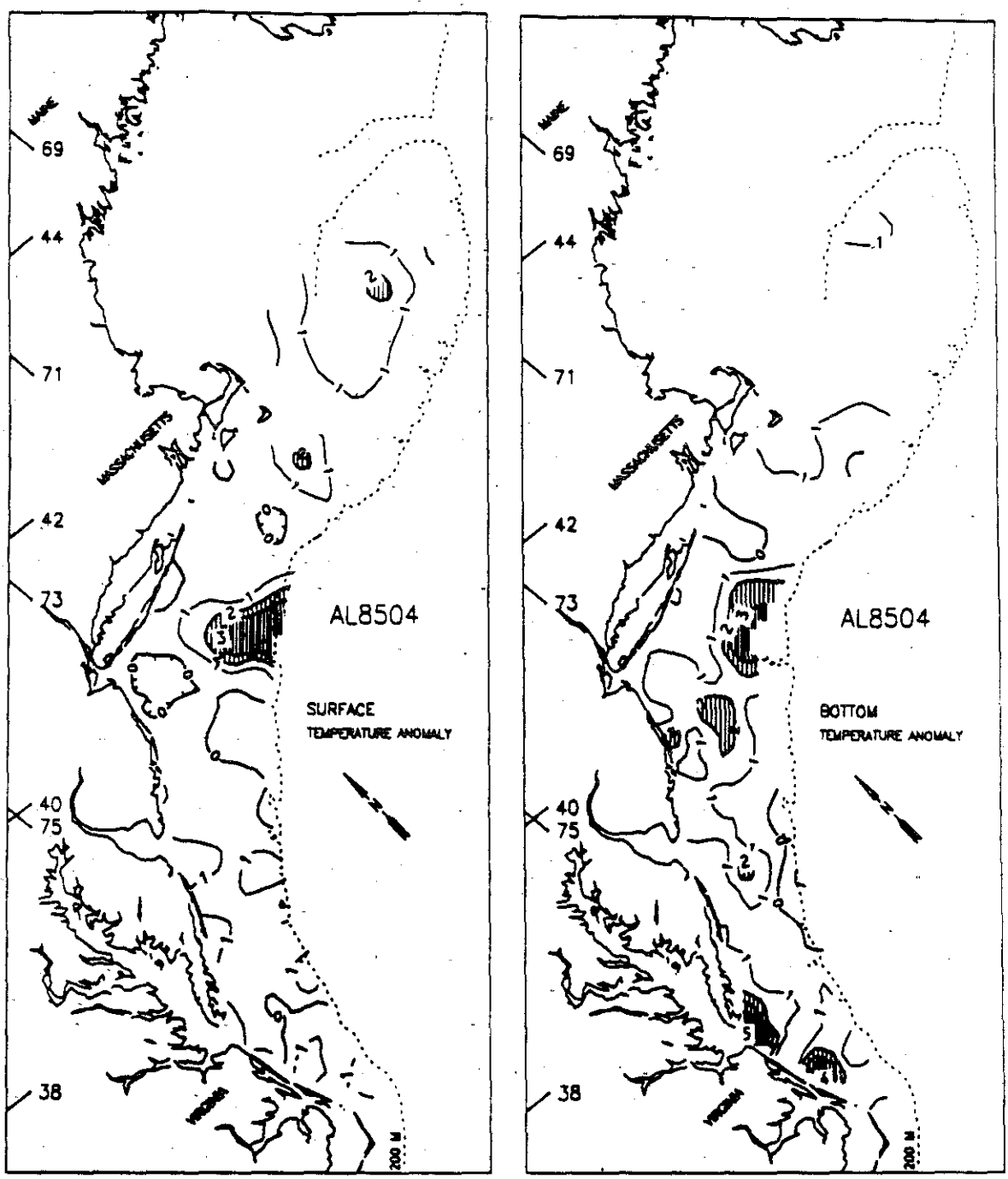


Figure 234. Normalized surface and bottom temperature anomaly: ALB8504. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

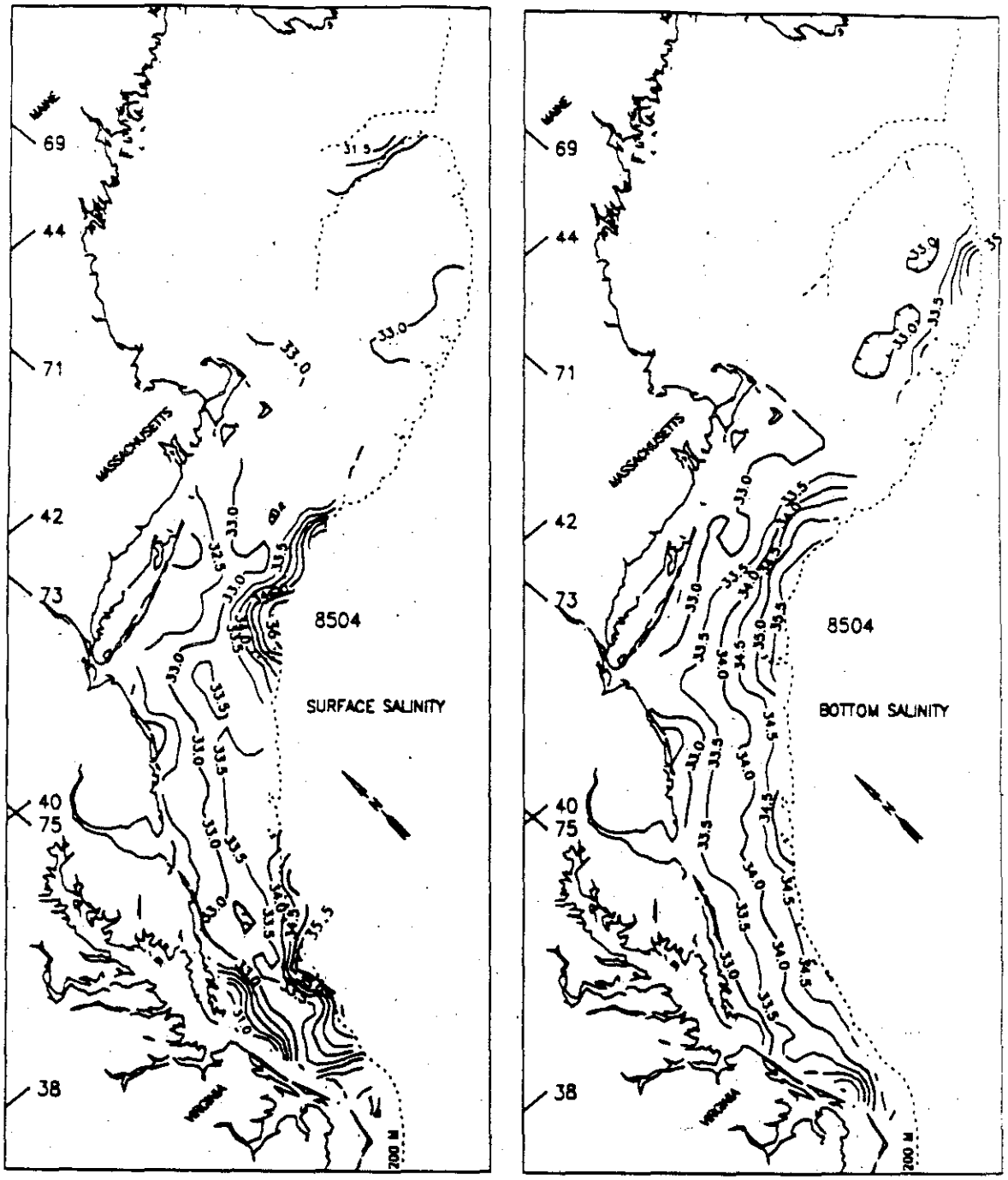


Figure 235. Surface and bottom salinity (PSU) distribution: ALB8504.

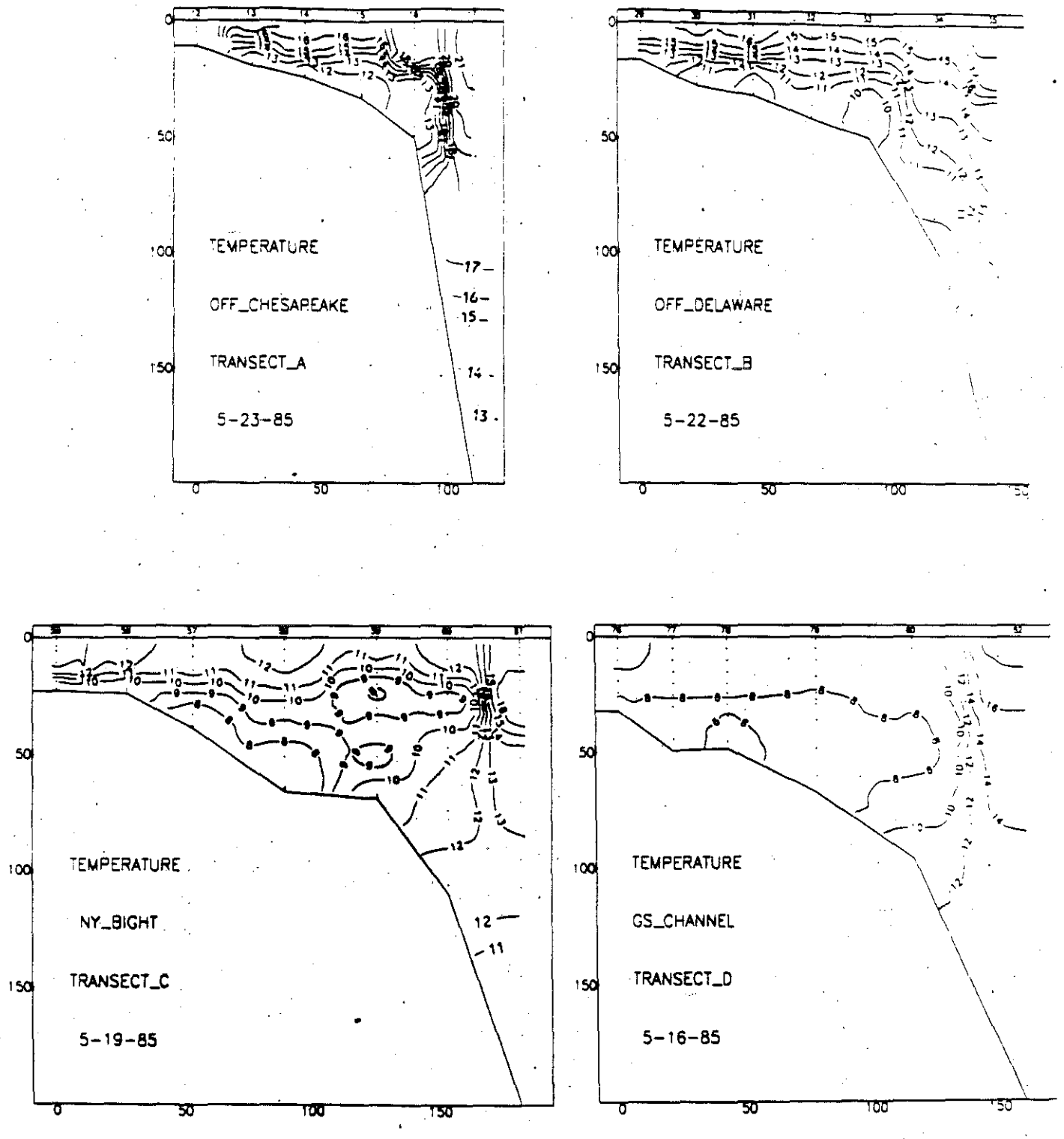
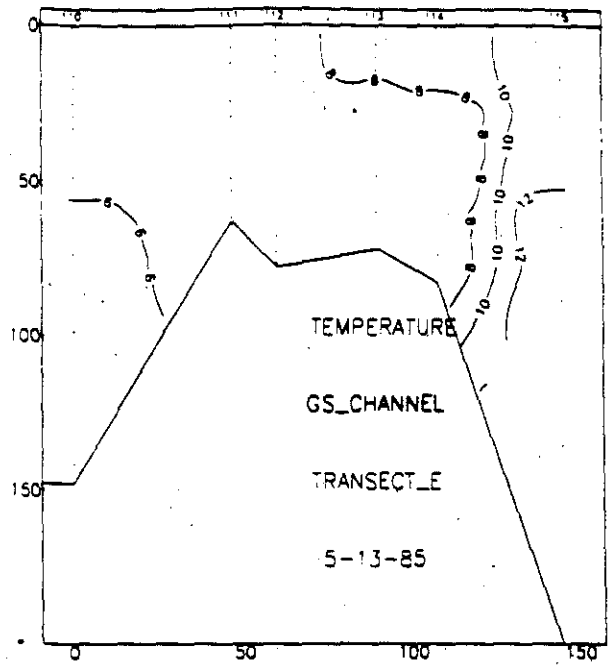
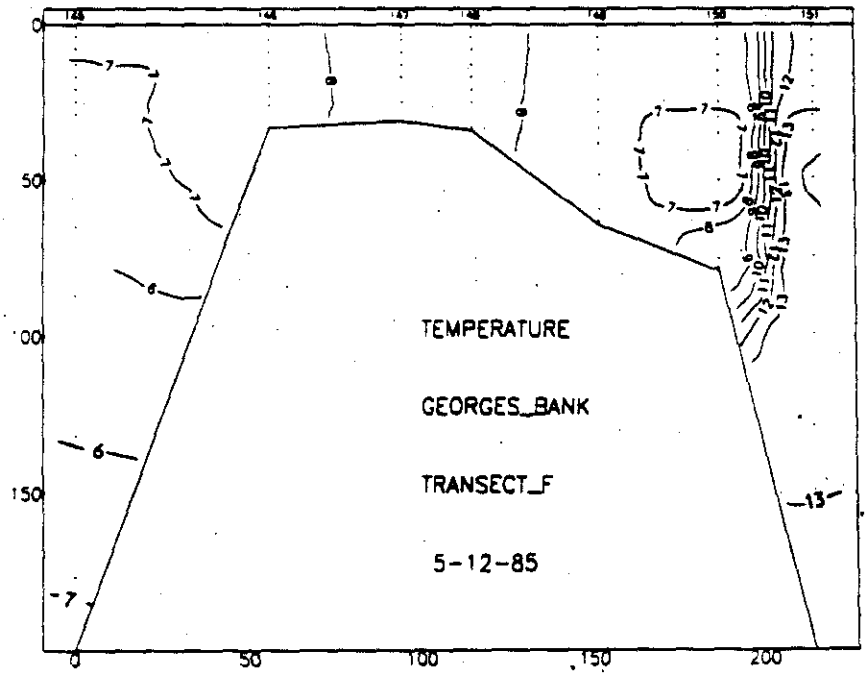


Figure 236. Temperature (°C) transects: ALB8504.





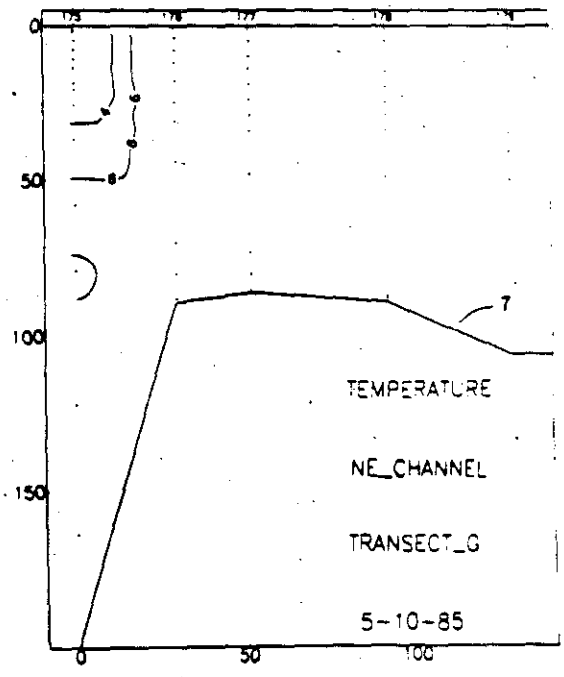


Figure 236. Continued.

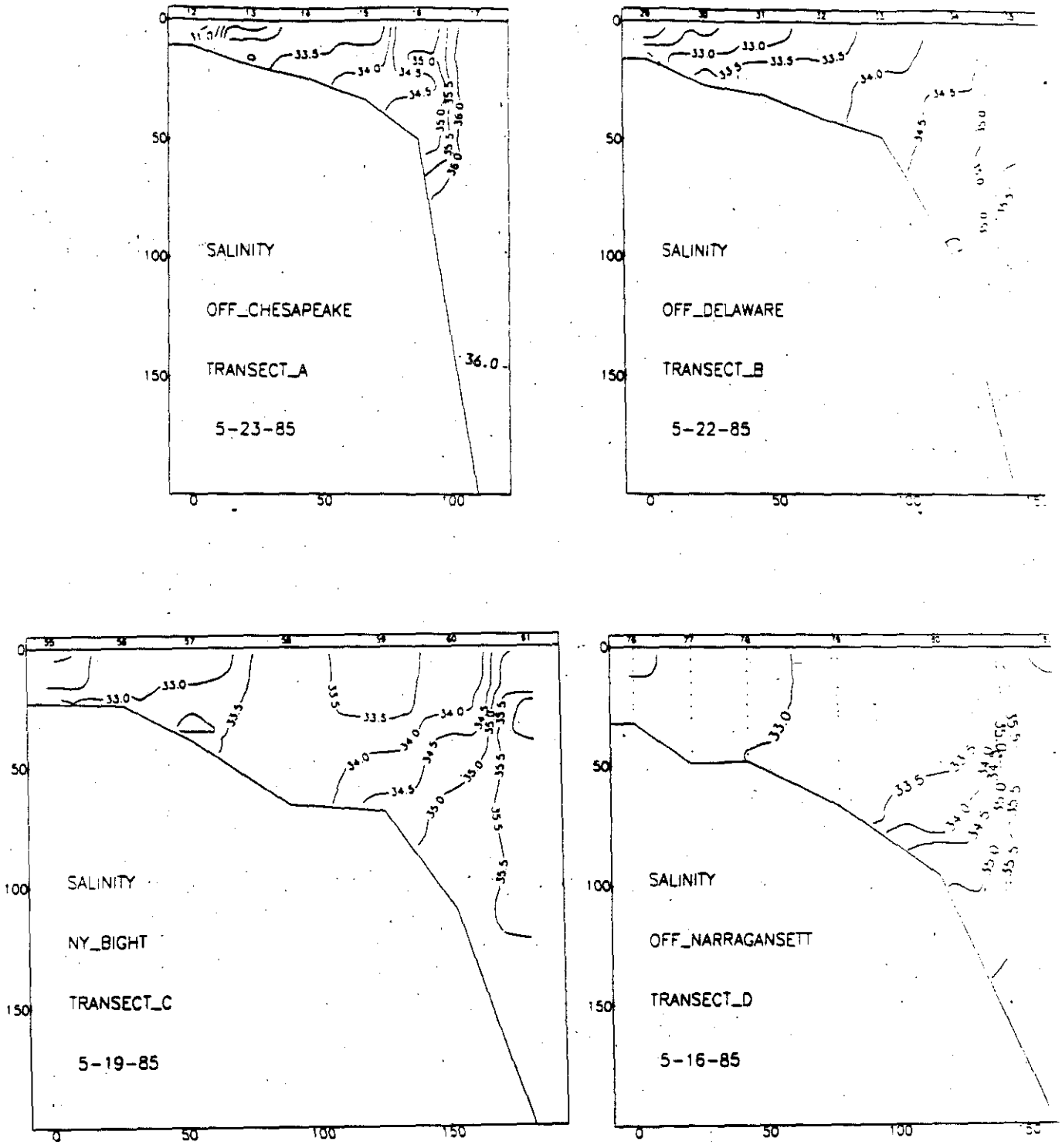
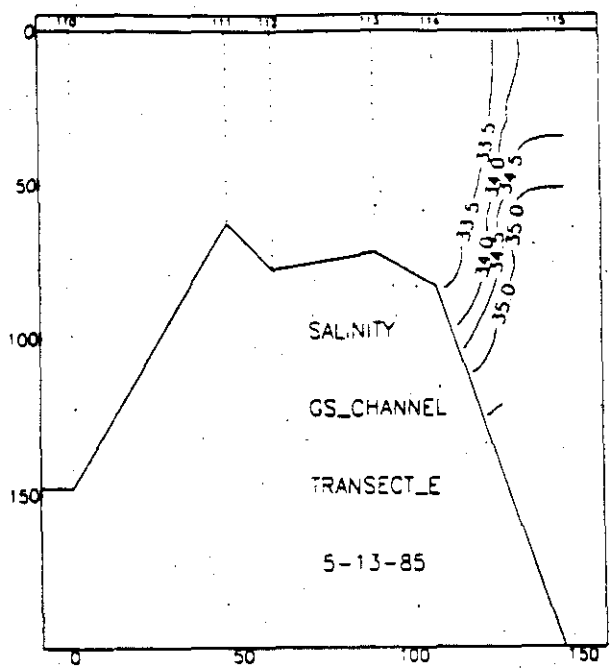


Figure 237. Salinity (PSU) transects: ALB8504.



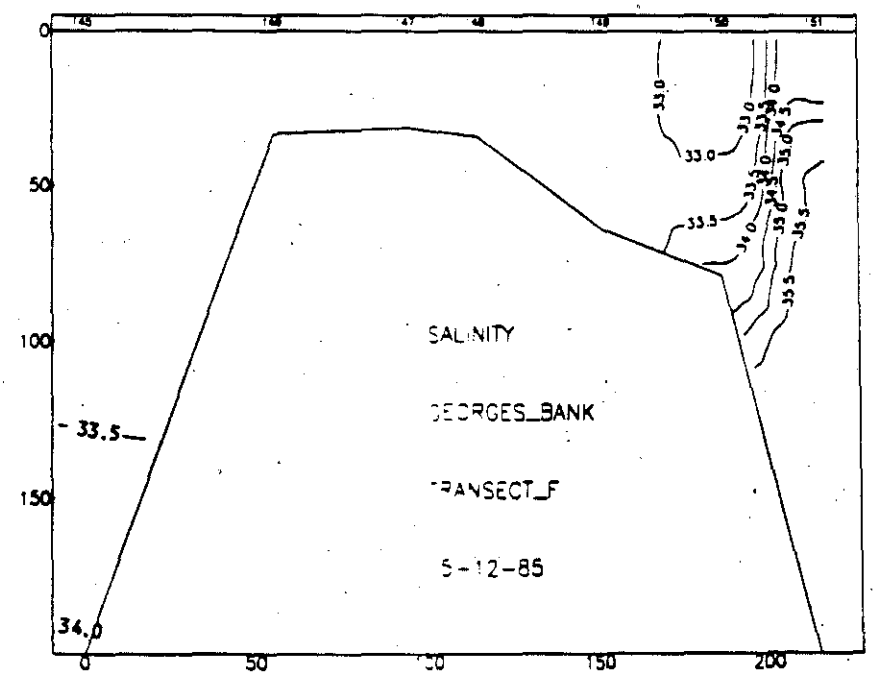


Figure 237. Continued.

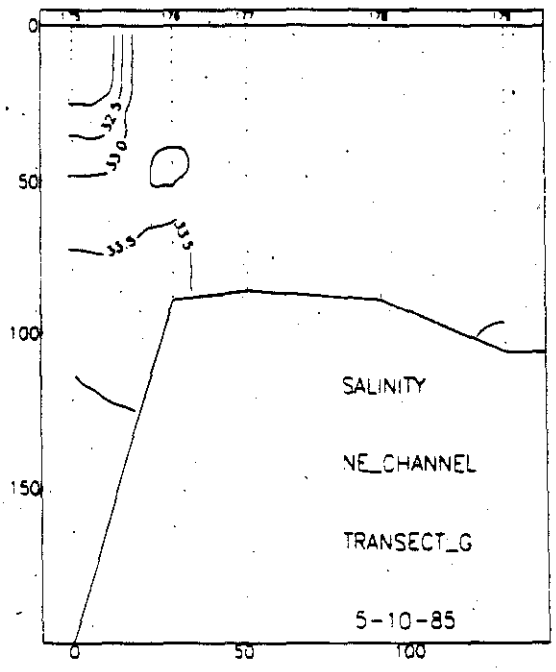


Figure 237. Continued.

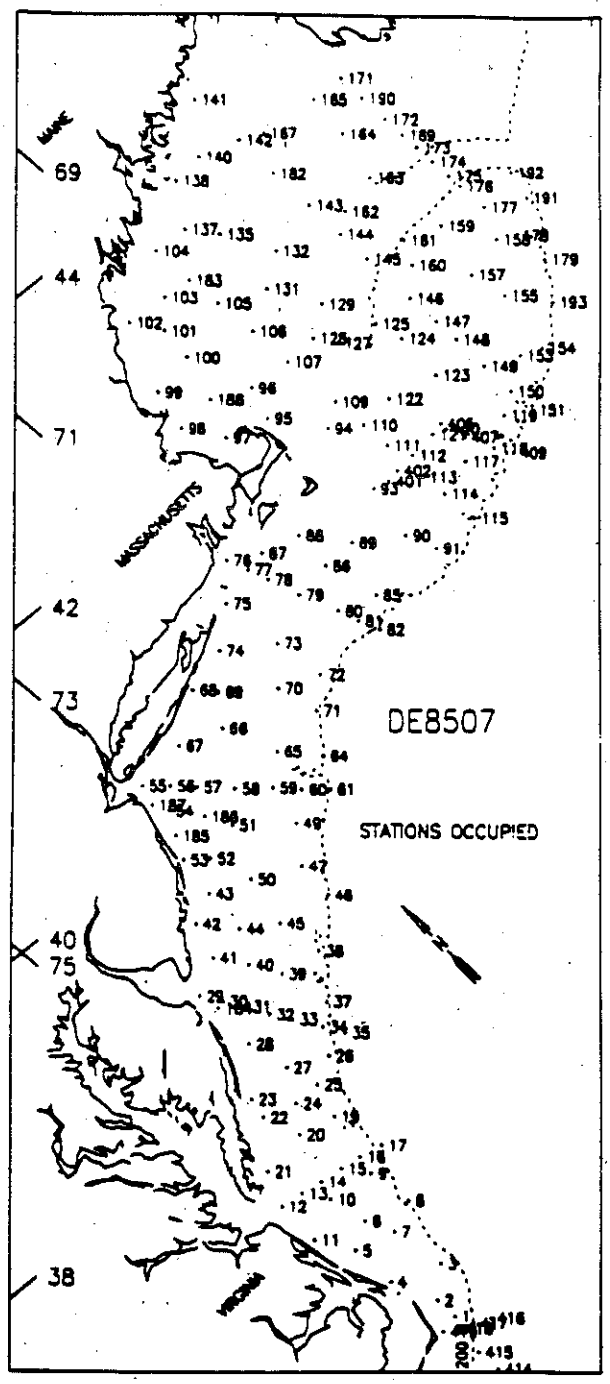


Figure 238. Station positions: DEL8507.

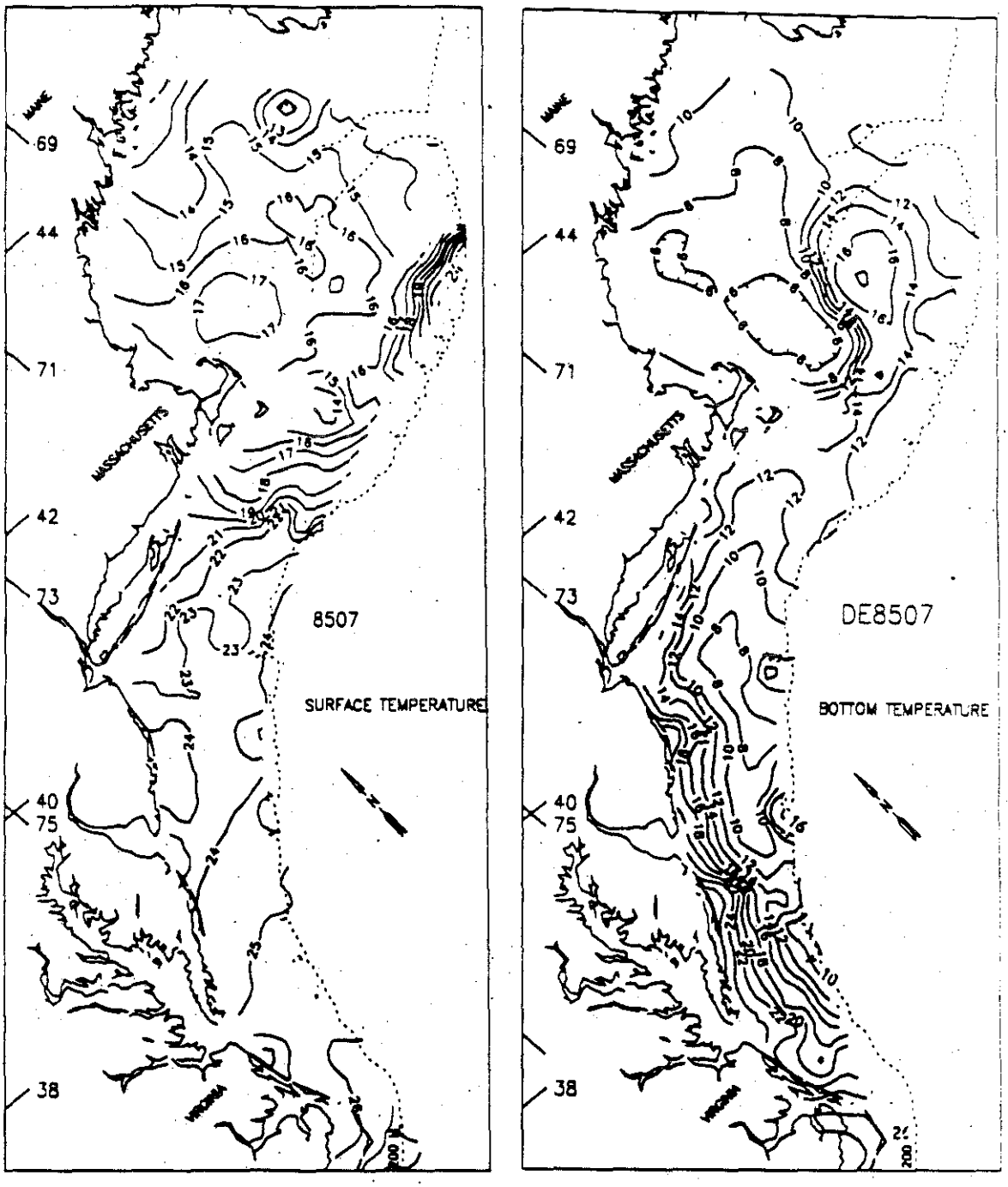


Figure 239. Surface and bottom temperature (°C) distribution: DEL8507.

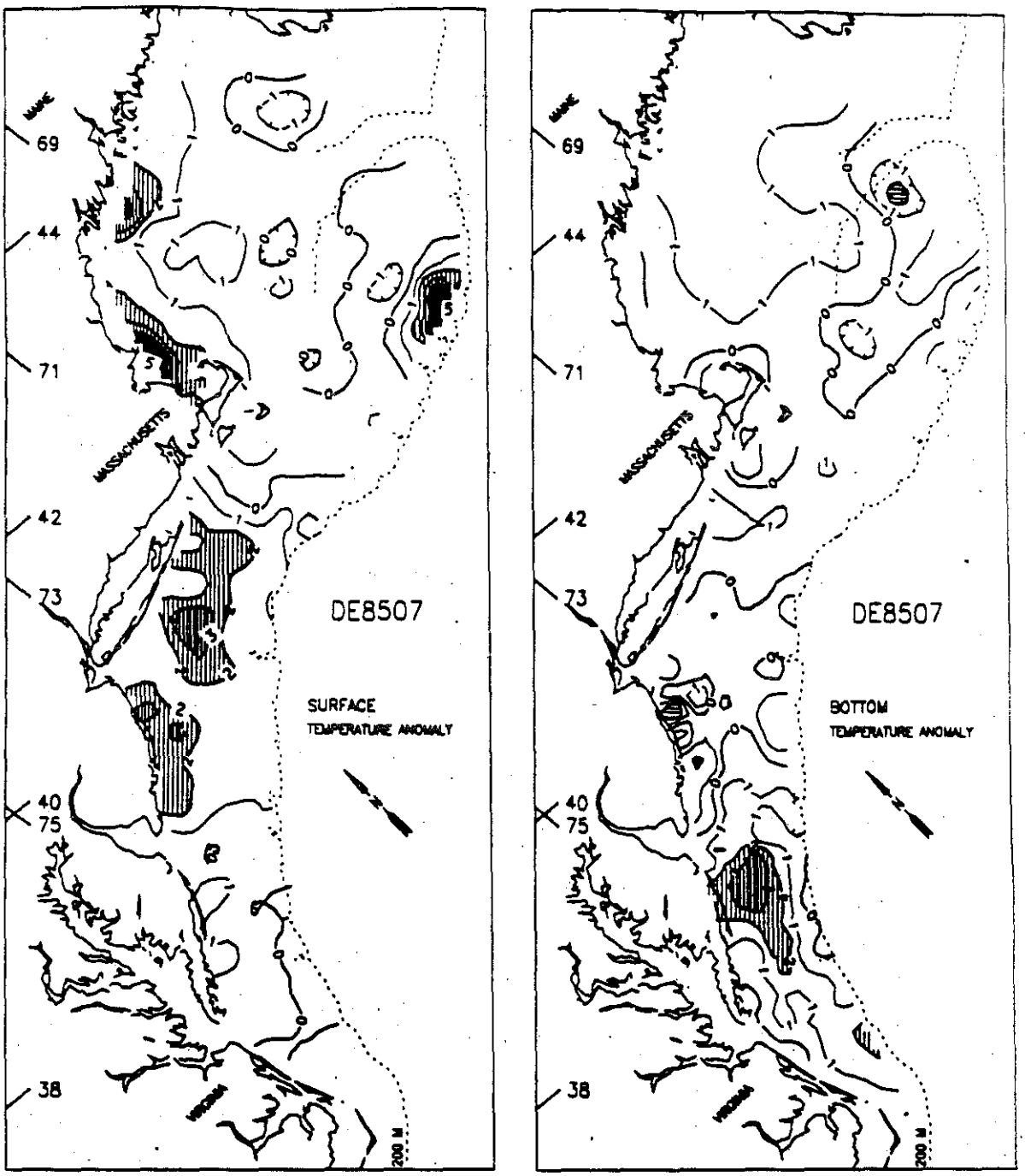


Figure 240. Normalized surface and bottom temperature anomaly: DEL8507. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

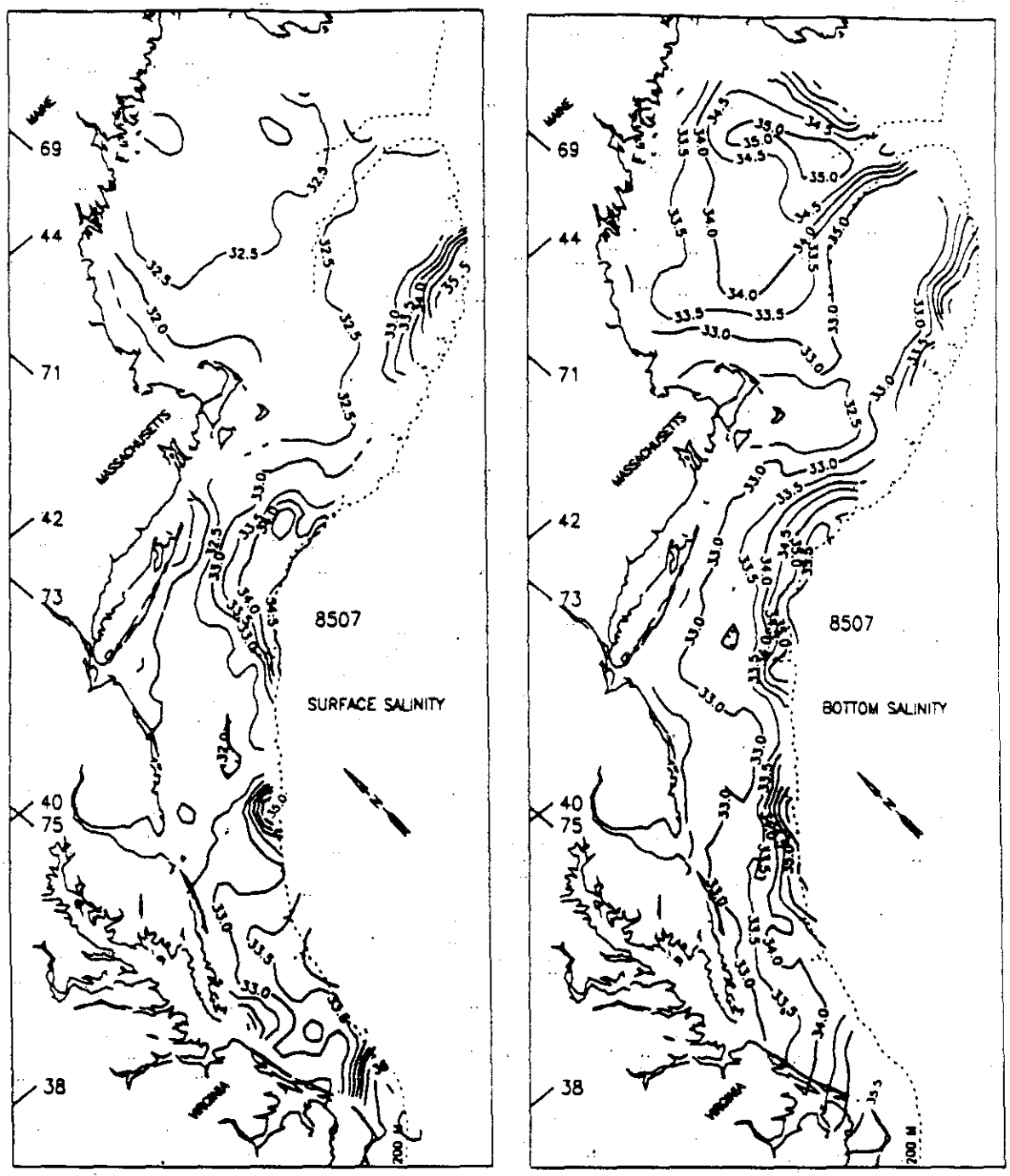


Figure 241. Surface and bottom salinity (PSU) distribution: DEL8507.

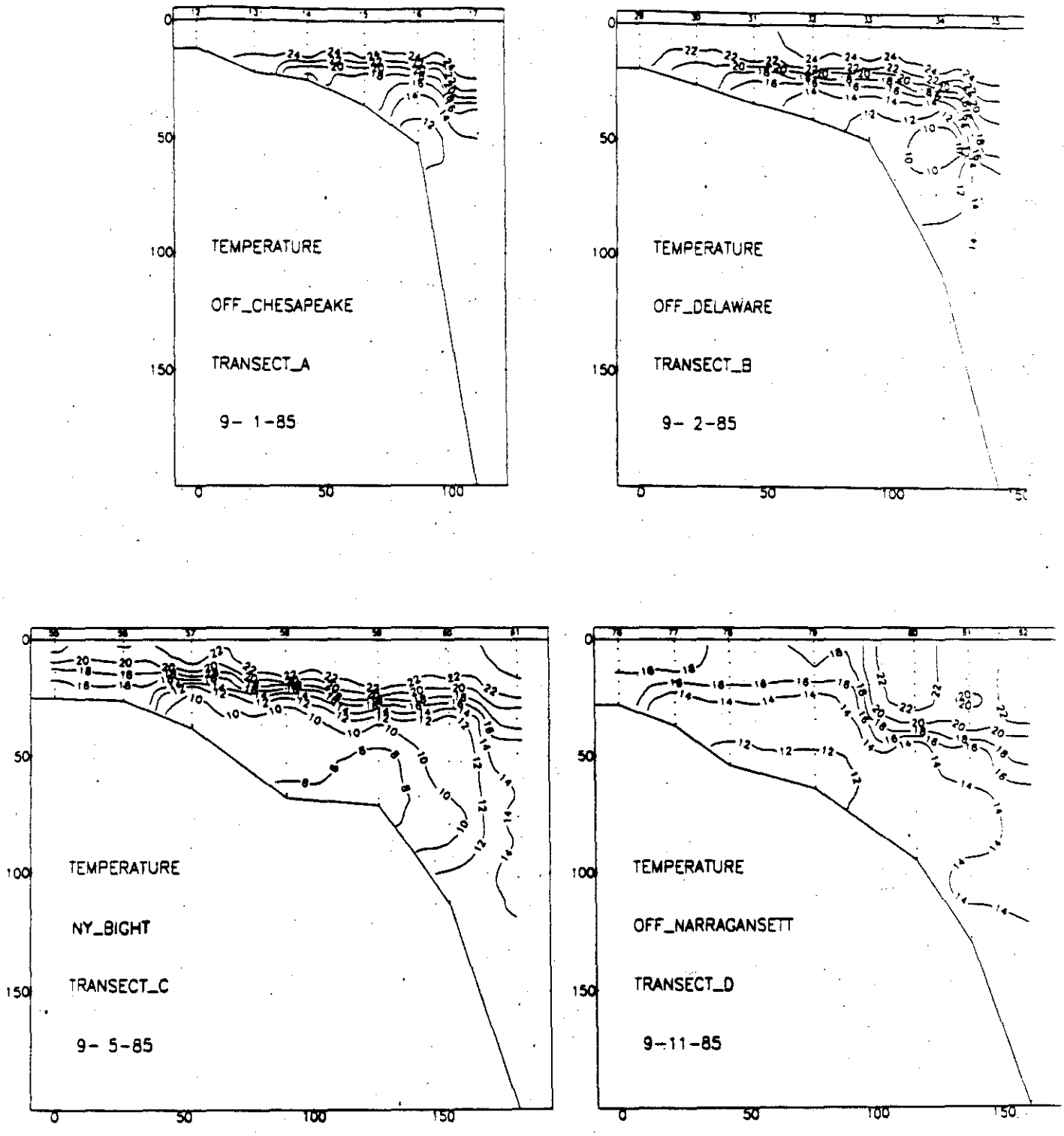
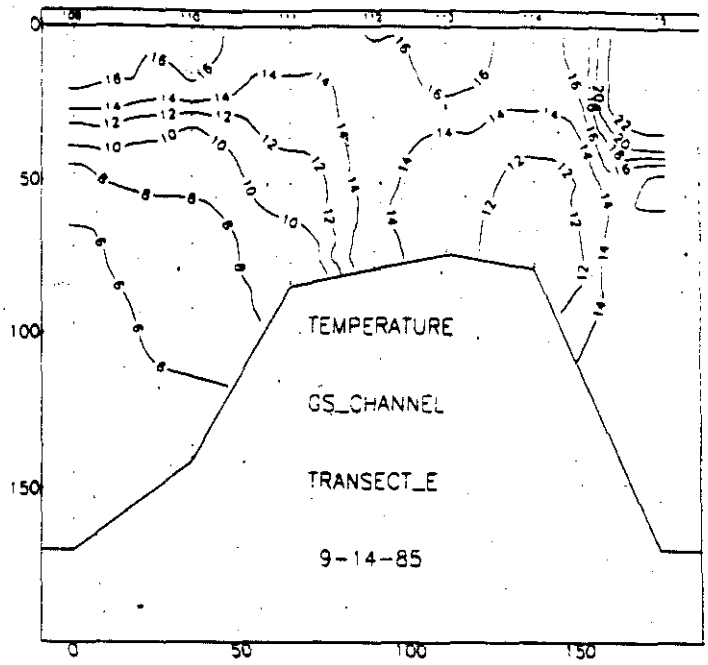


Figure 242. Temperature (°C) transects: DEL8507.



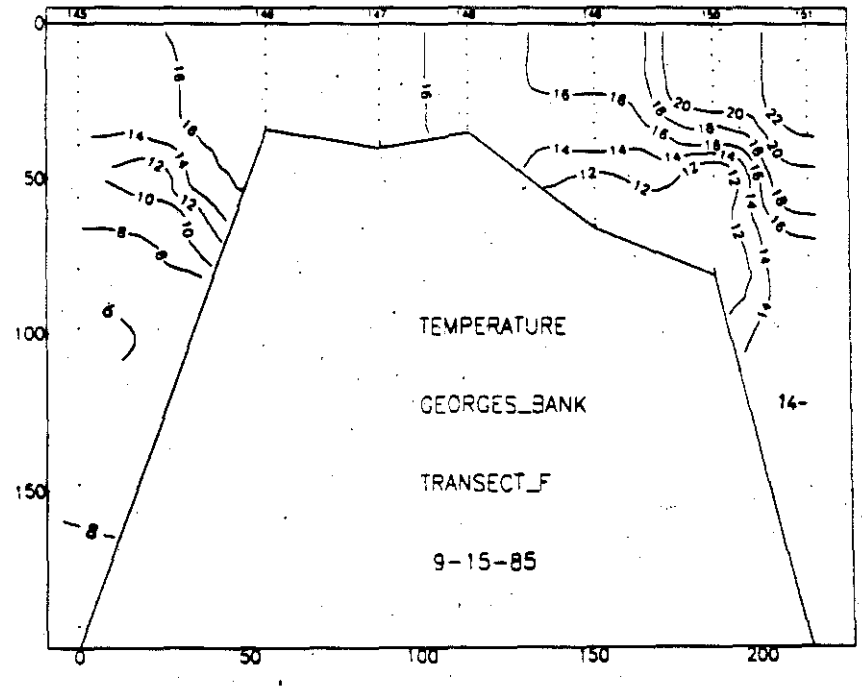


Figure 242. Continued.

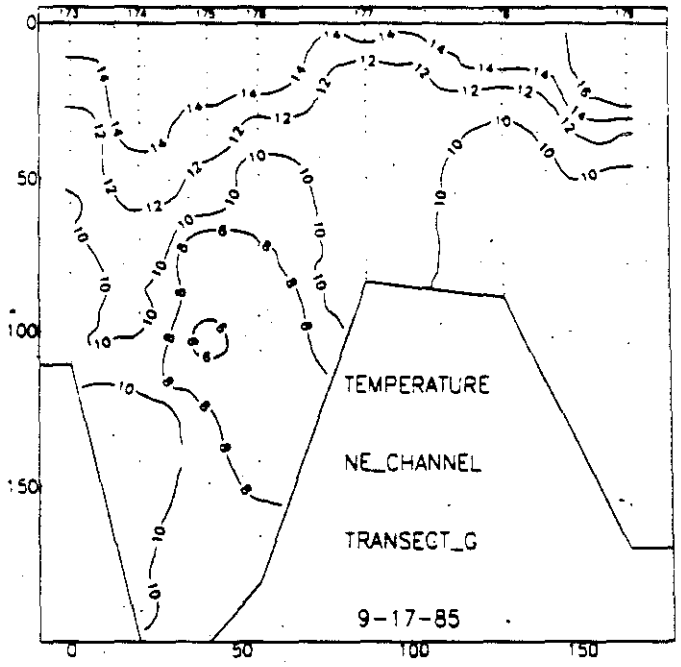


Figure 242. Continued.

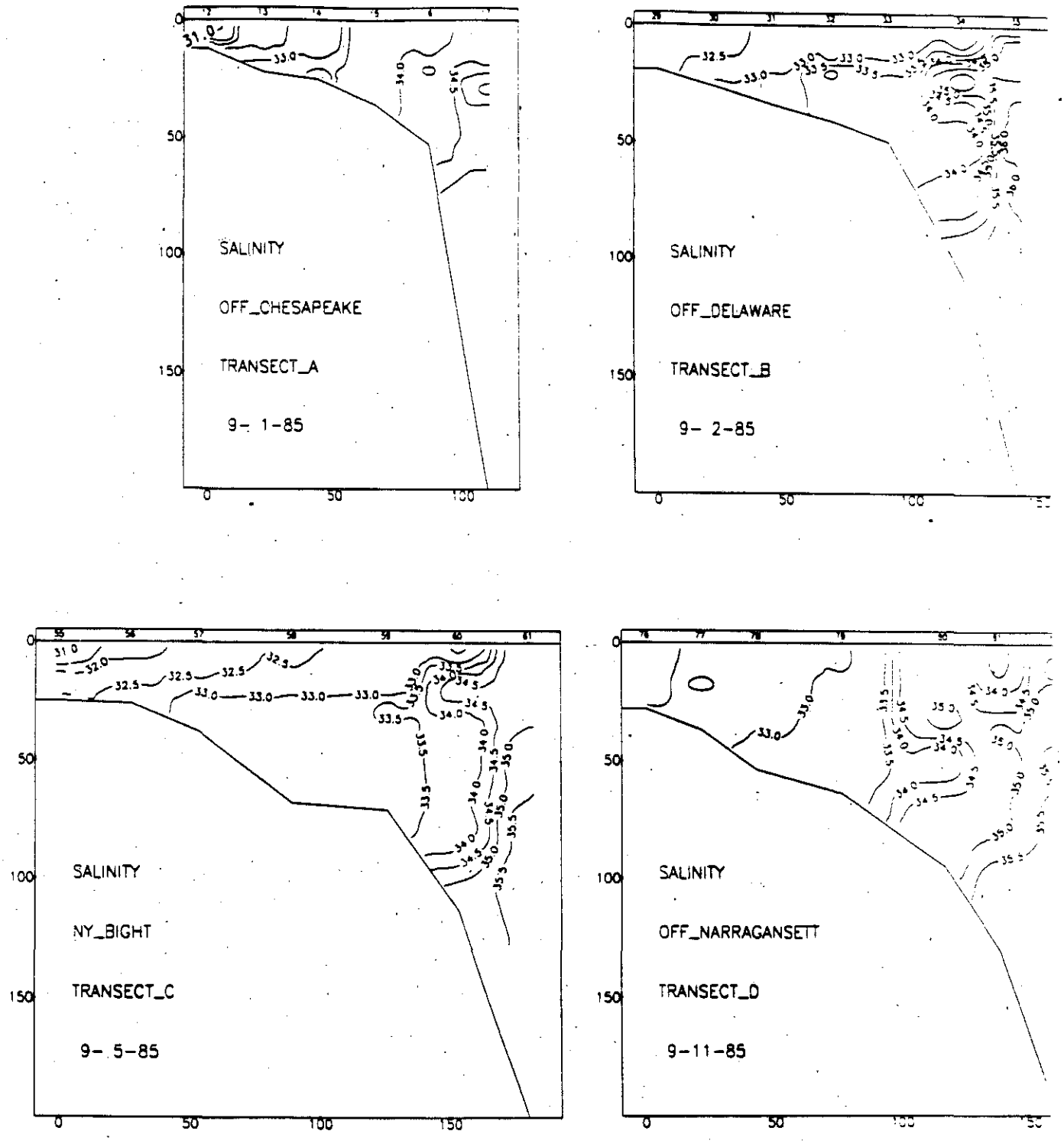


Figure 243. Salinity (PSU) transects: DEL8507.

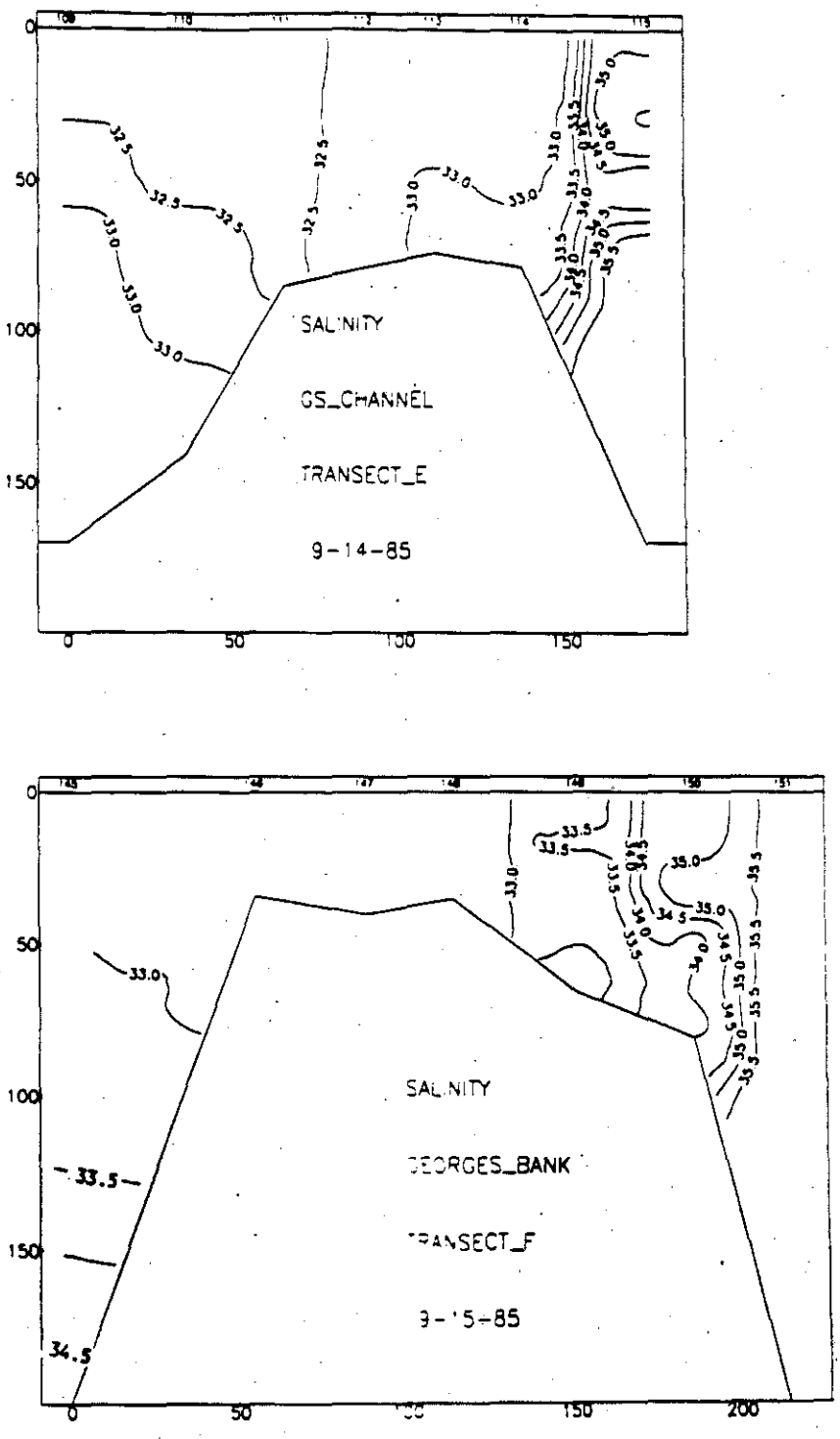


Figure 243. Continued.

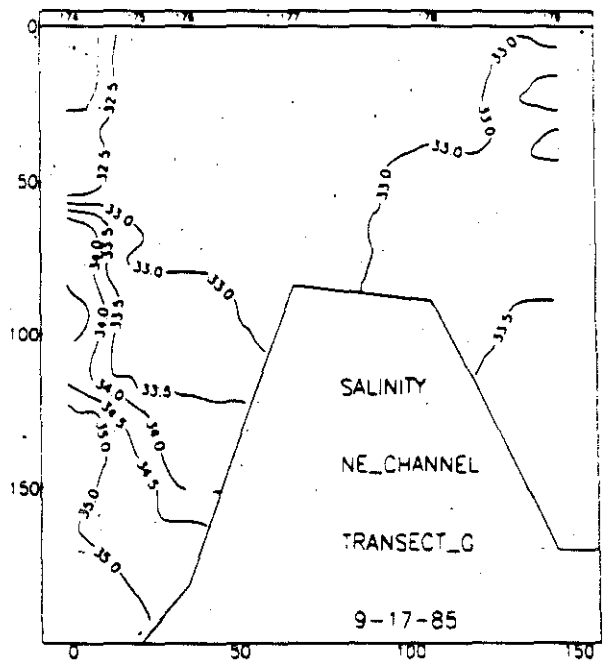


Figure 243. Continued.

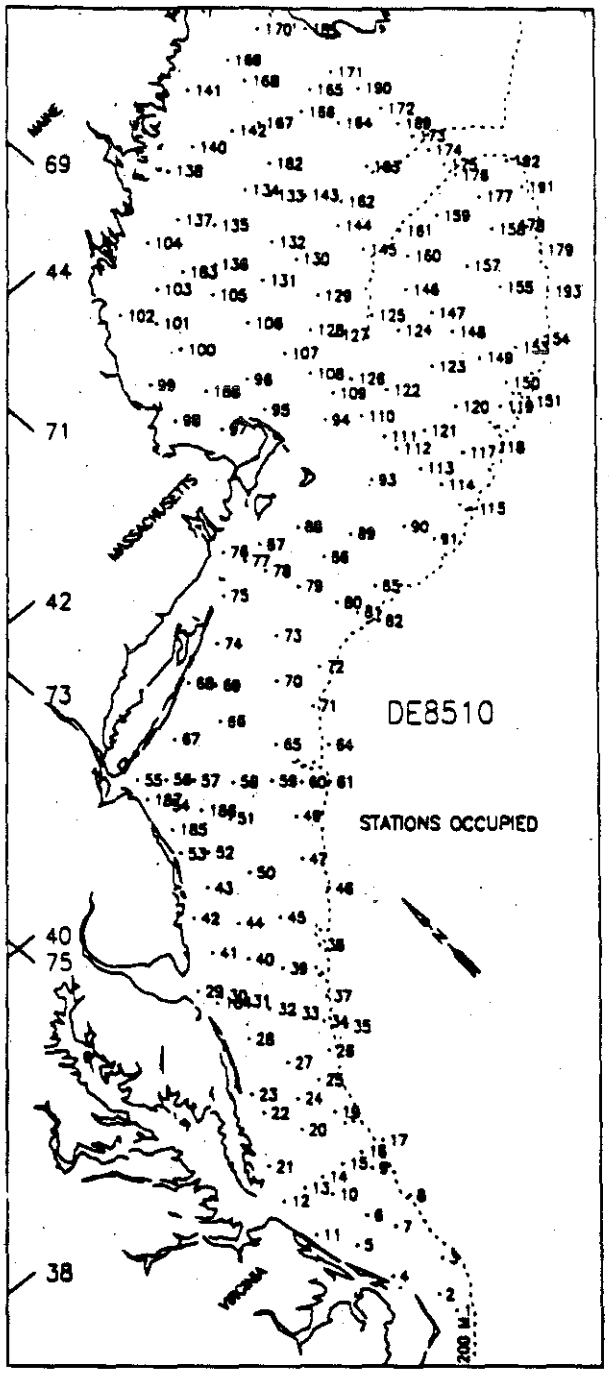


Figure 244. Station positions: DEL8510.

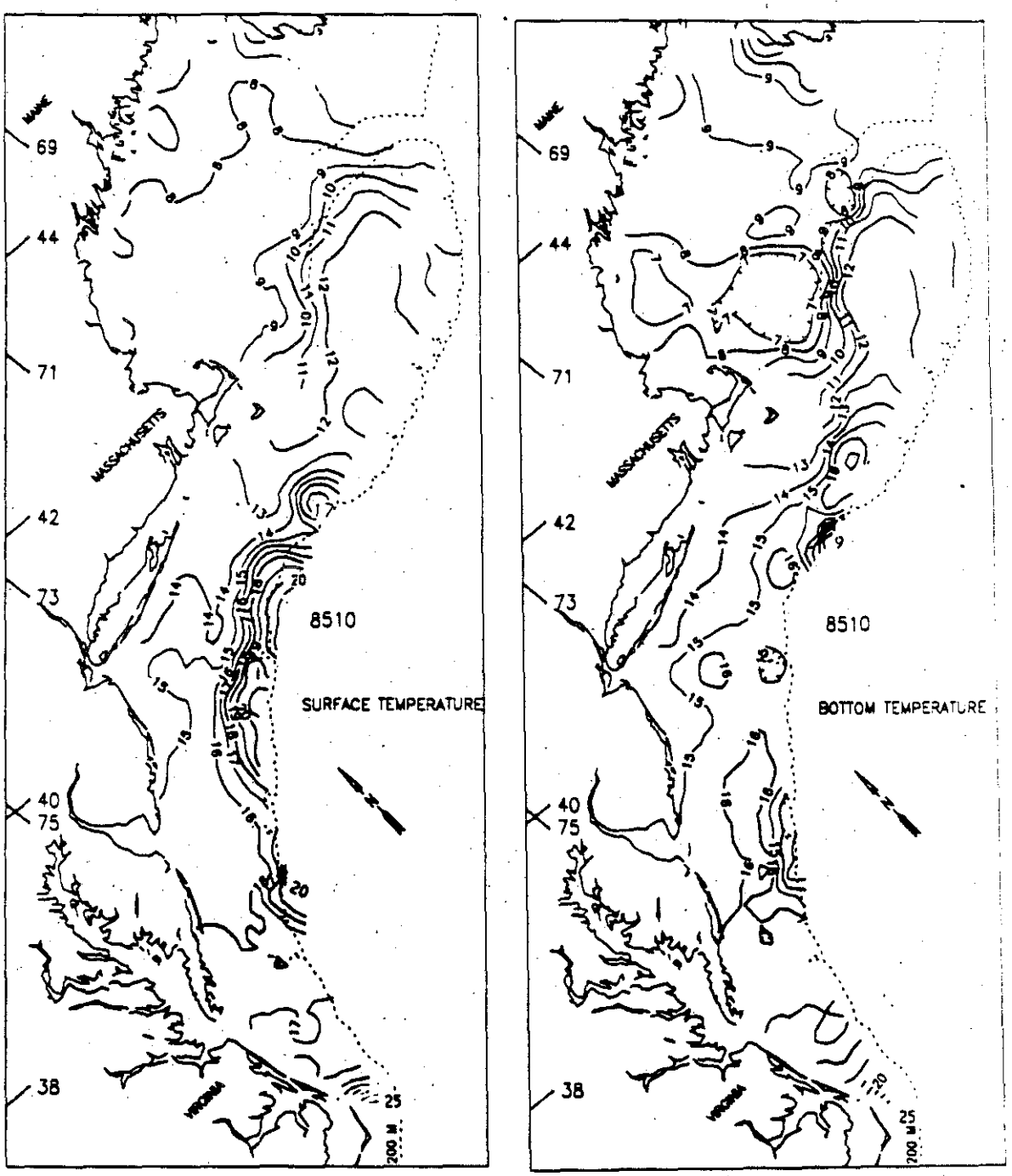


Figure 245. Surface and bottom temperature (°C) distribution: DEL8510.

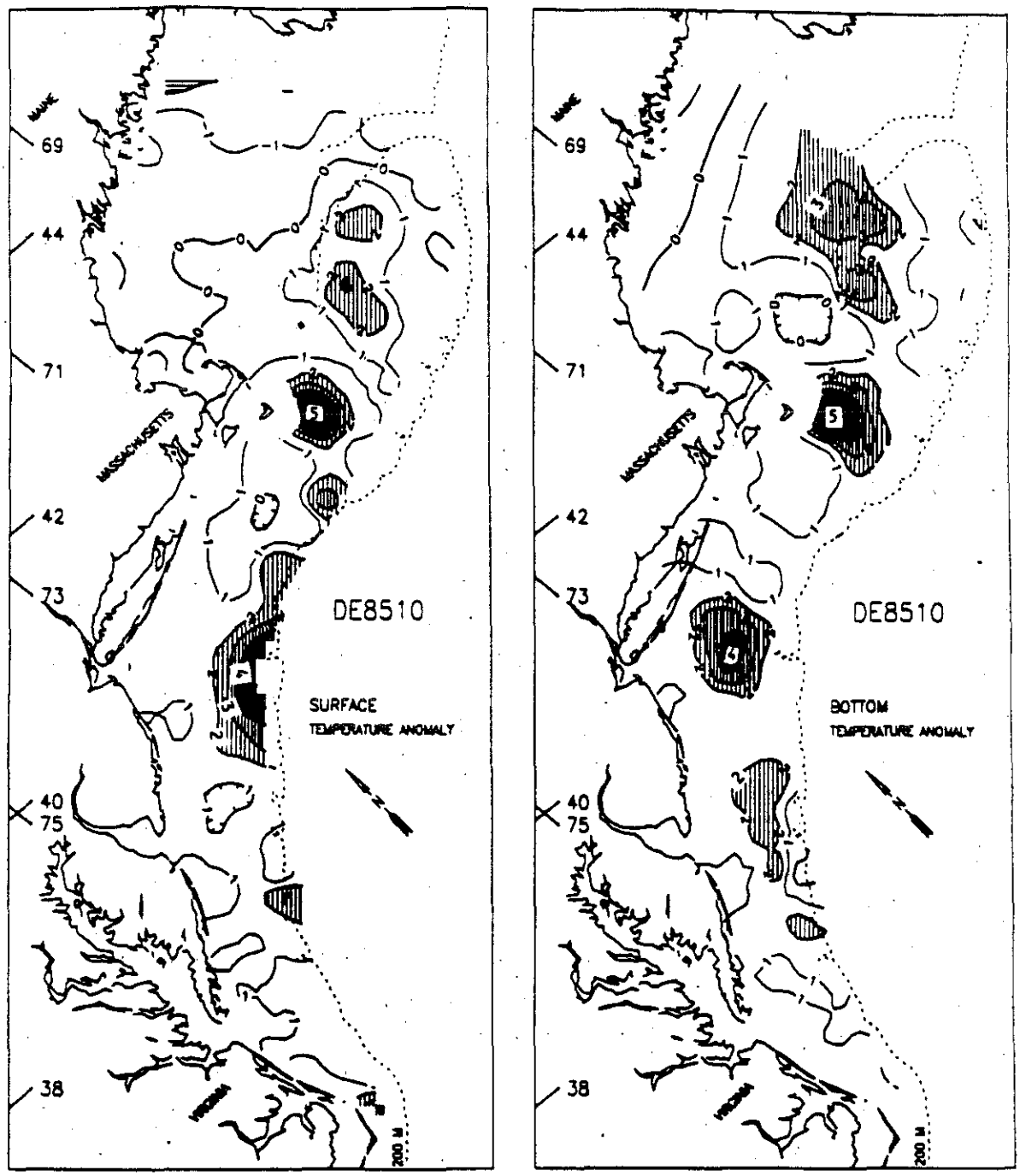


Figure 246. Normalized surface and bottom temperature anomaly: DEL8510. Contours are multiples of the standard deviation for the mean annual temperature curves. Hachured areas are more than two standard deviations above (vertical) or below (horizontal) the 11-year mean.

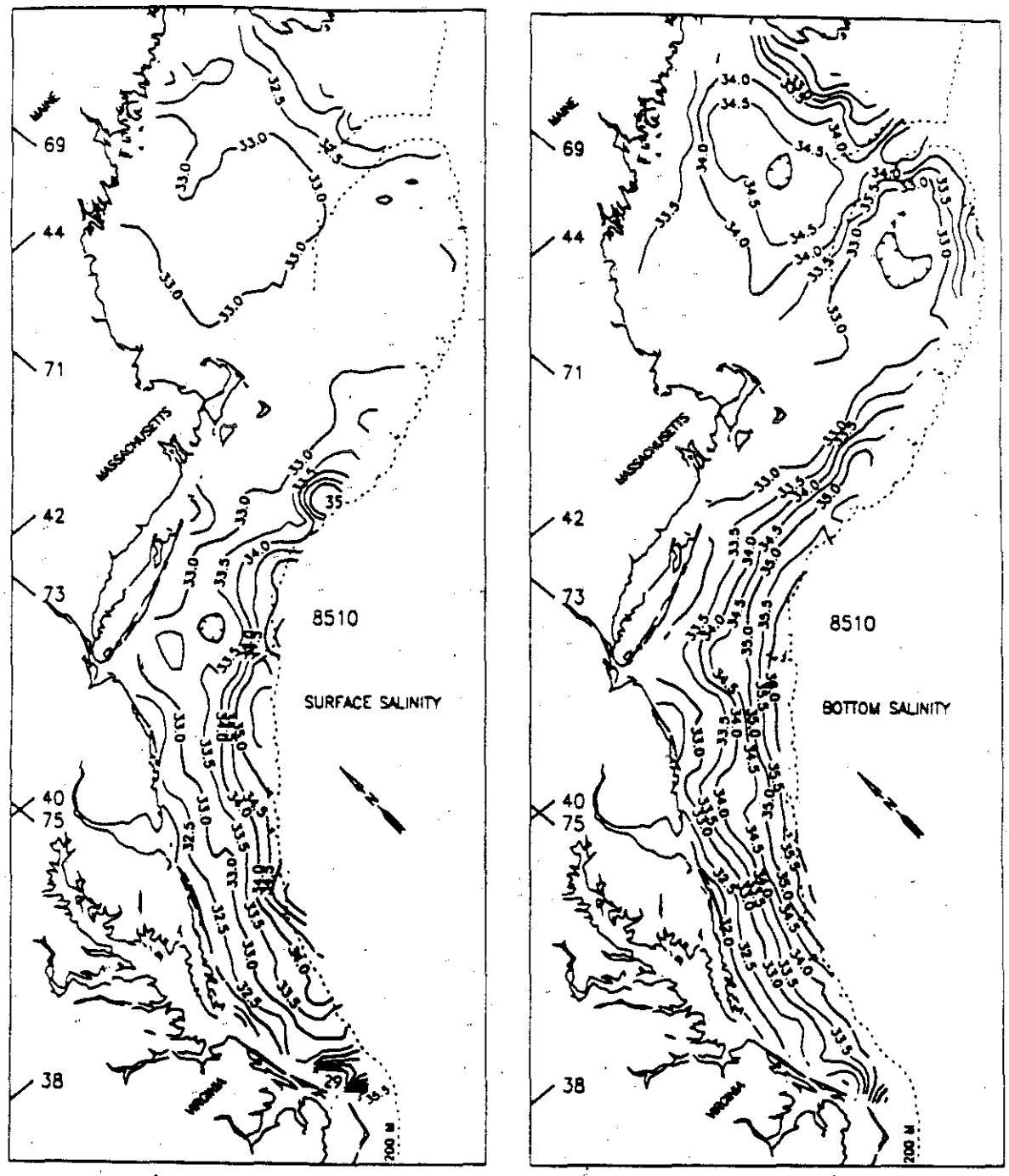


Figure 247. Surface and bottom salinity (PSU) distribution: DEL8510.

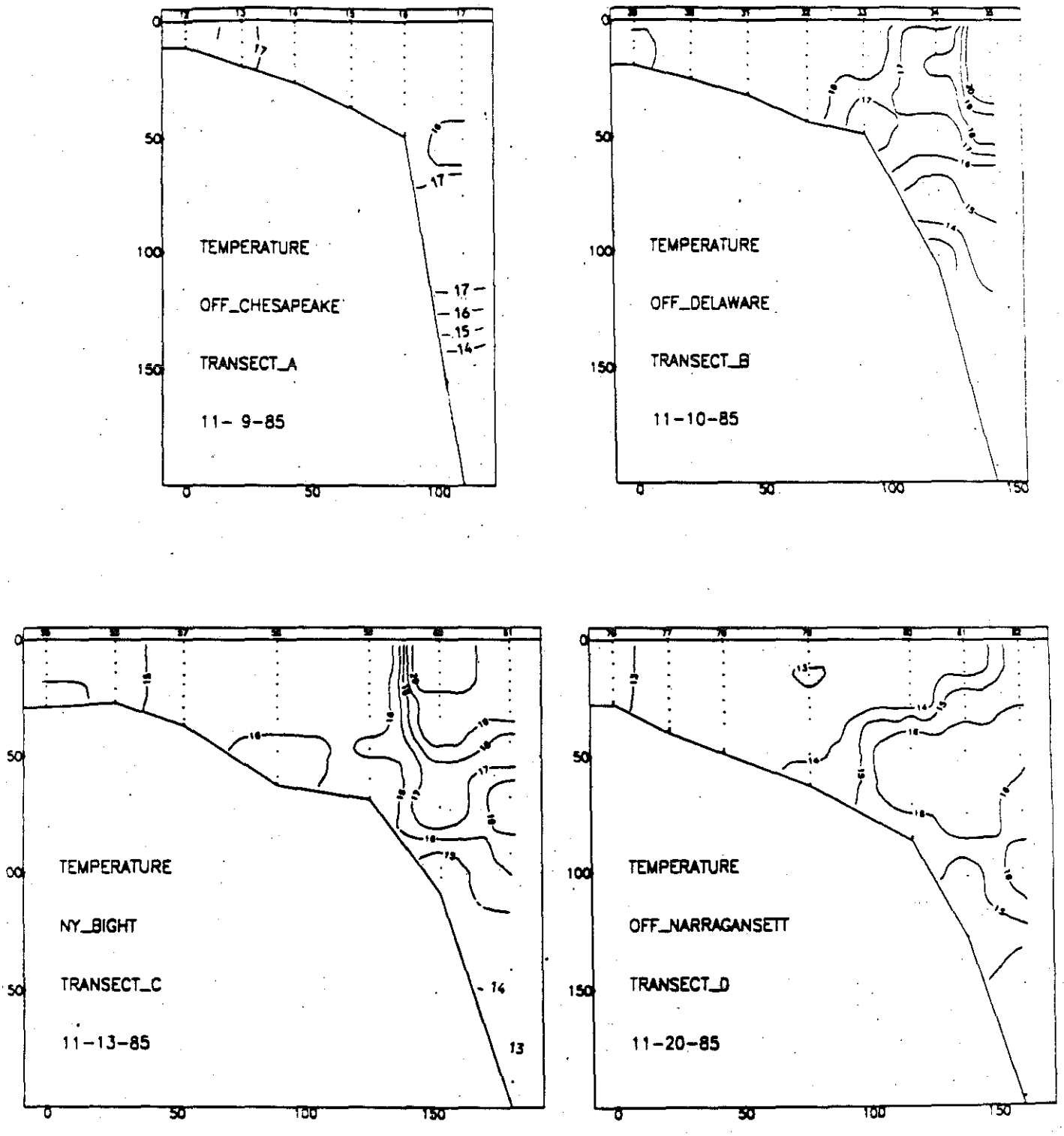
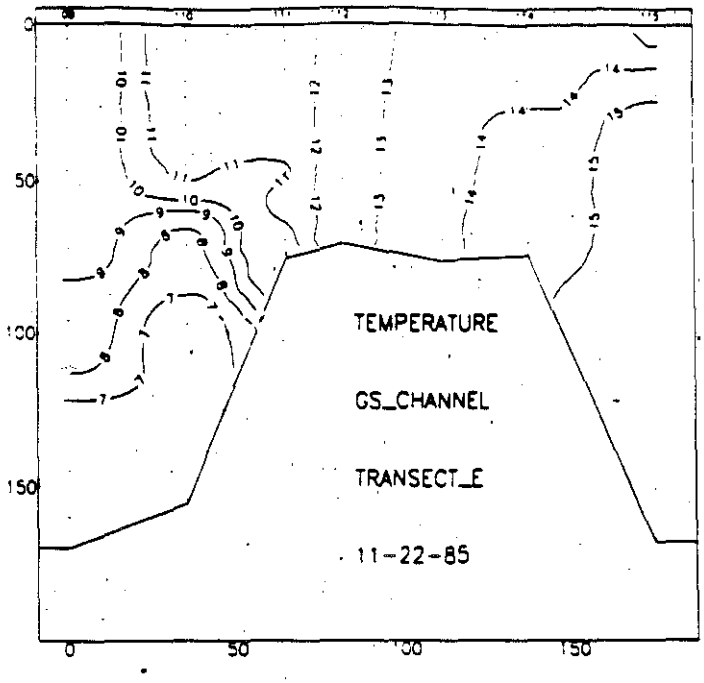


Figure 248. Temperature (°C) transects: DEL8510.



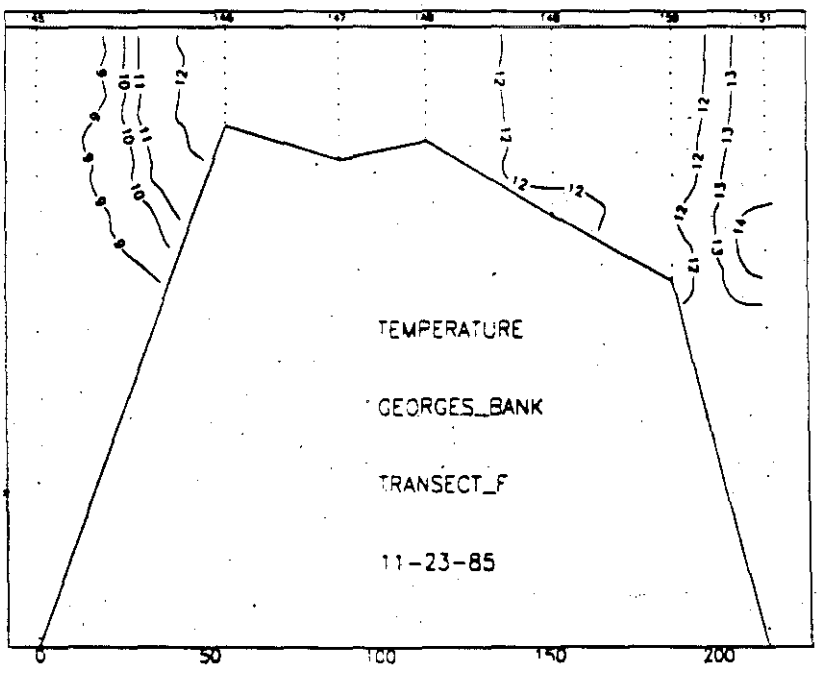


Figure 248. Continued.

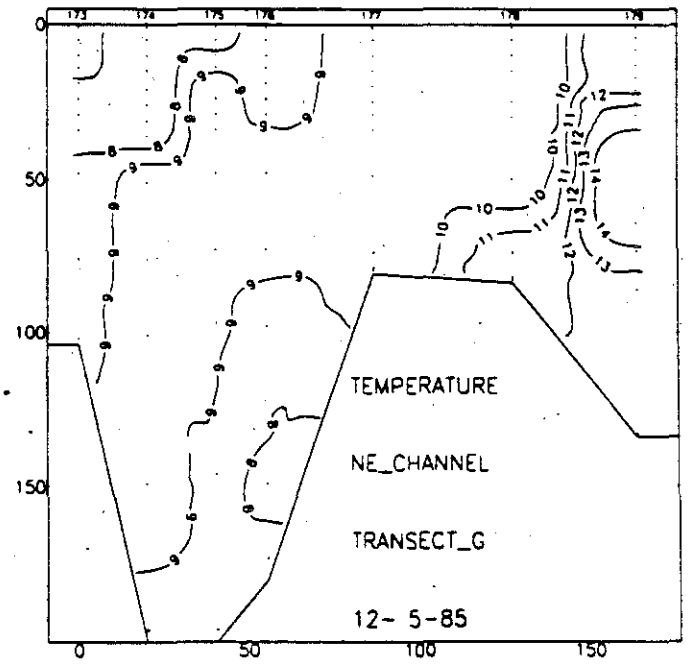


Figure 248. Continued.

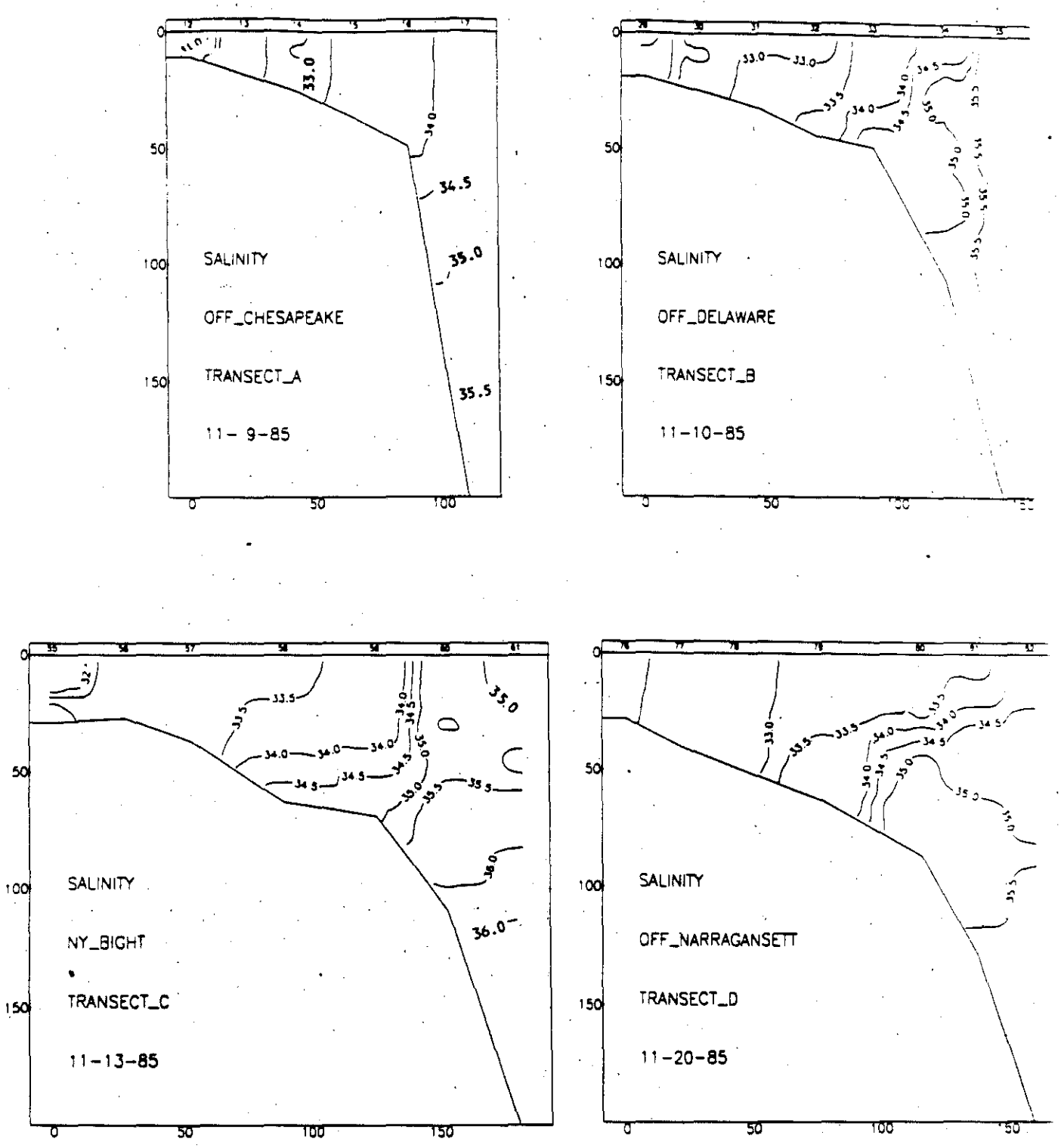
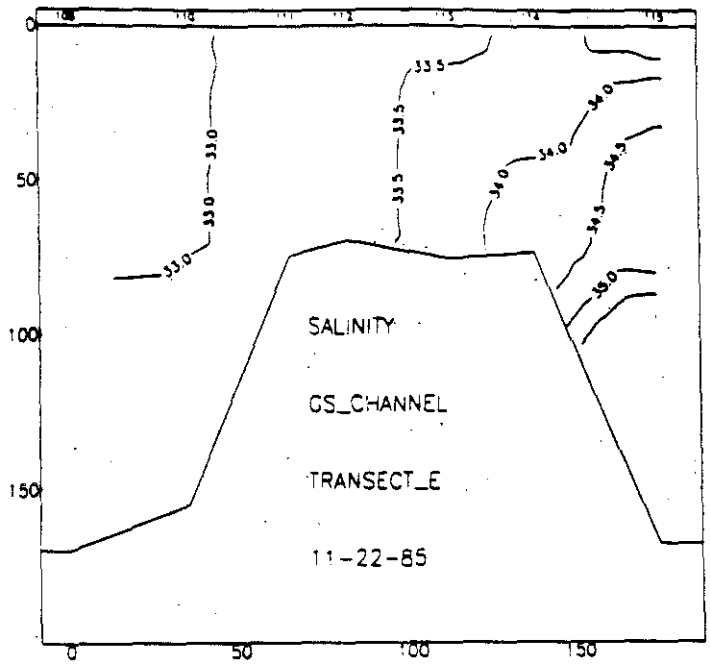


Figure 249. Salinity (PSU) transects: DEL8510.



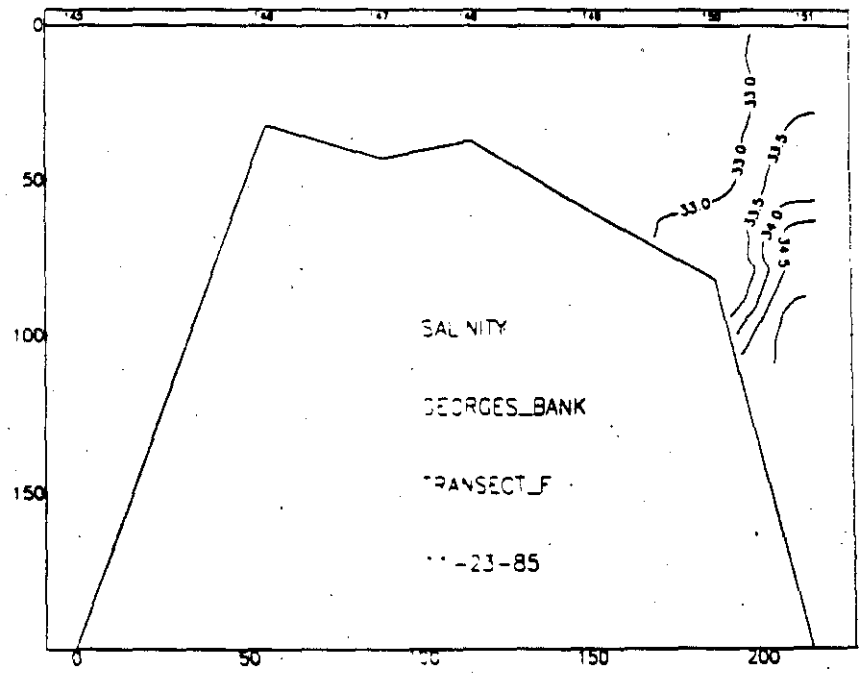


Figure 249. Continued.

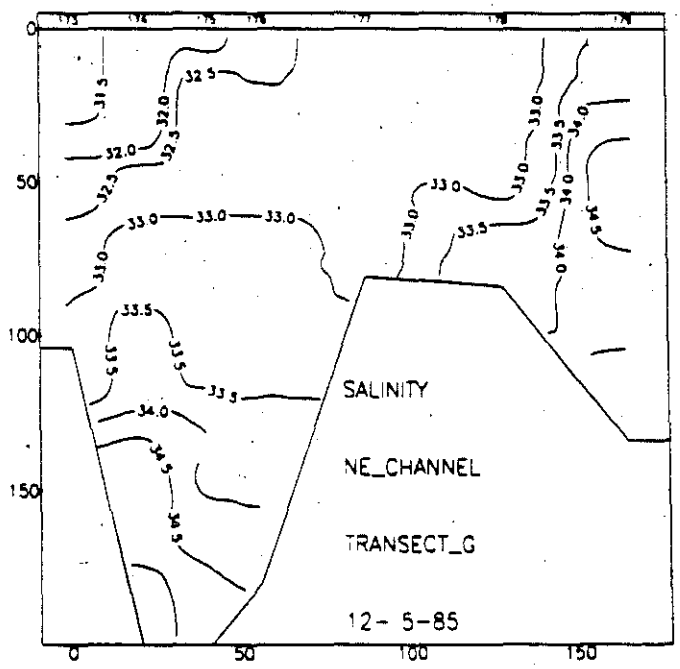


Figure 249. Continued.

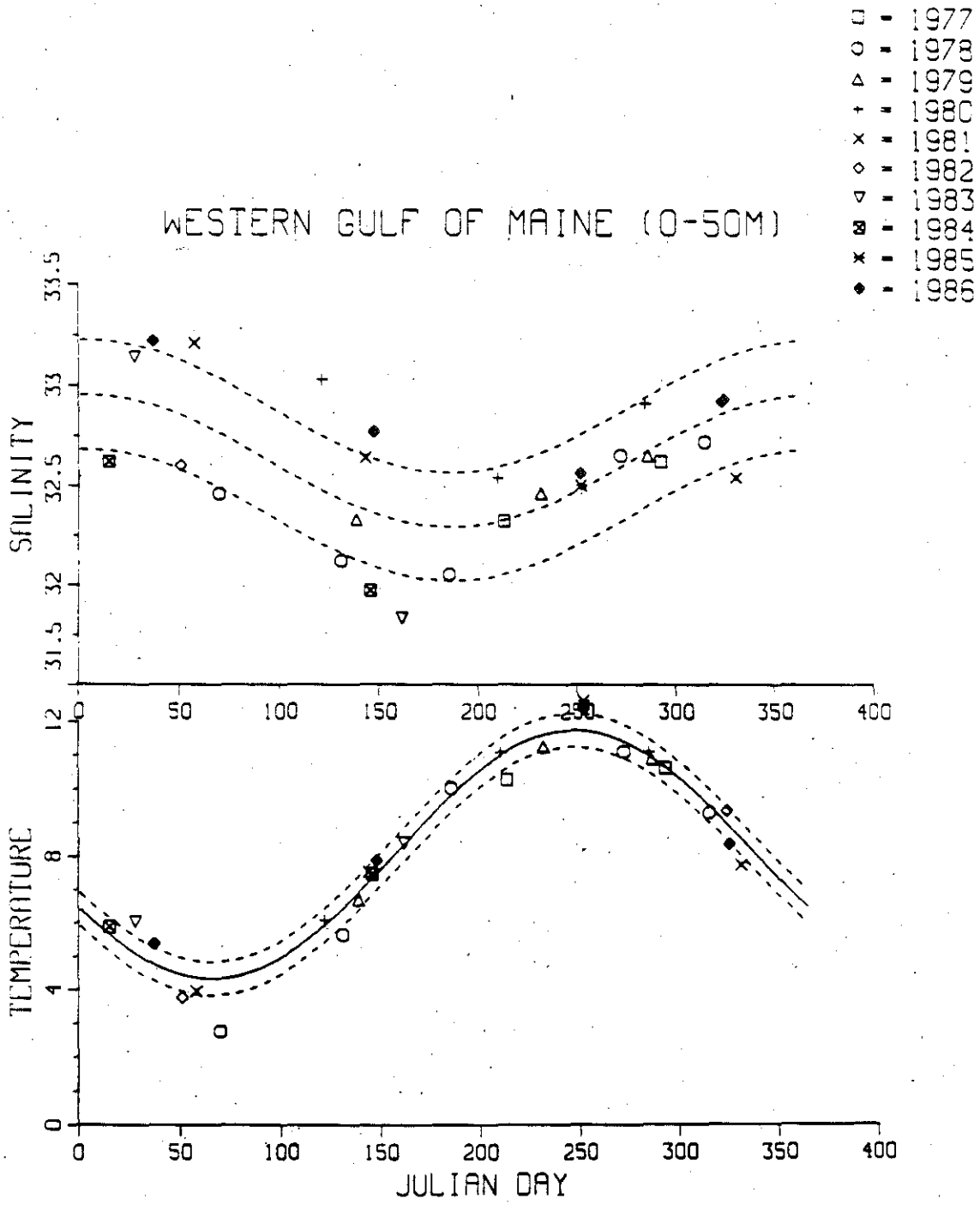


Figure 250. Mean values of temperature and salinity for the surface layer (0-50 m) in the western sector of the Gulf of Maine (1977-1987). The bold and dashed lines in the lower panel represent the mean and standard deviation of temperature as obtained by Mountain and Holzwarth (in press).

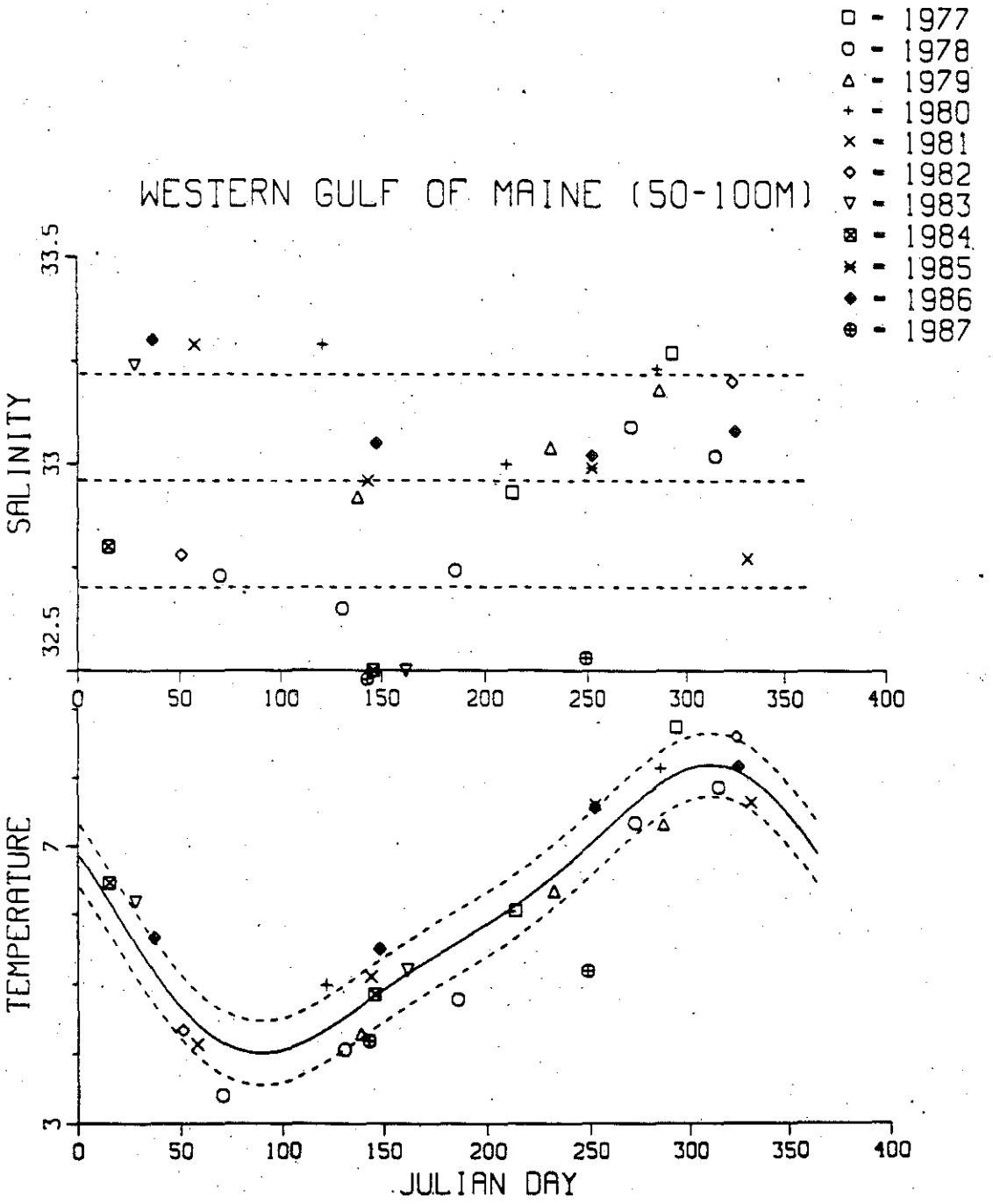


Figure 251. Mean values of temperature and salinity for the subsurface layer (50-100 m) in the western sector of the Gulf of Maine.

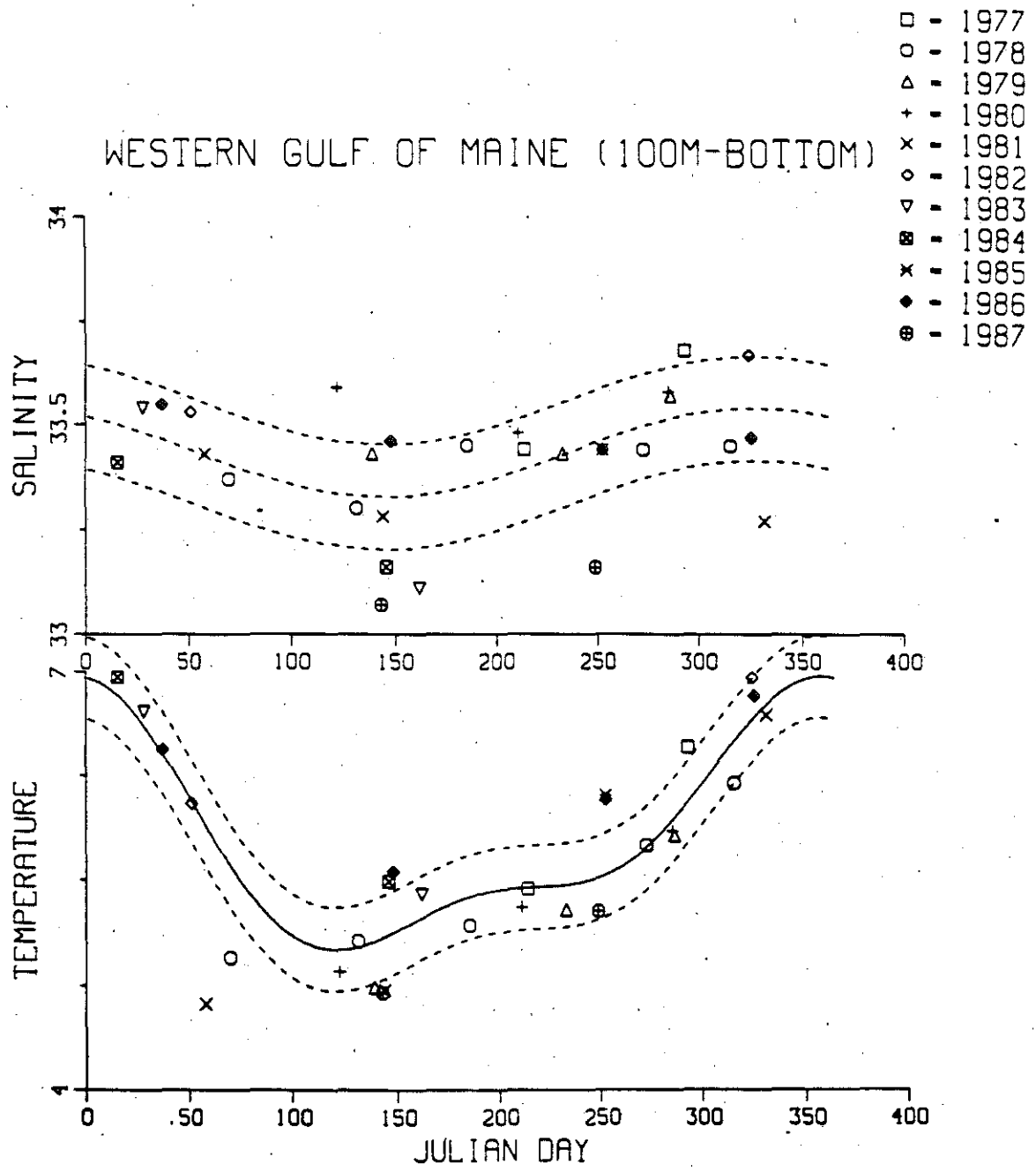


Figure 252. Mean values of temperature and salinity for the bottom layer (>100 m) in the western sector of the Gulf of Maine.

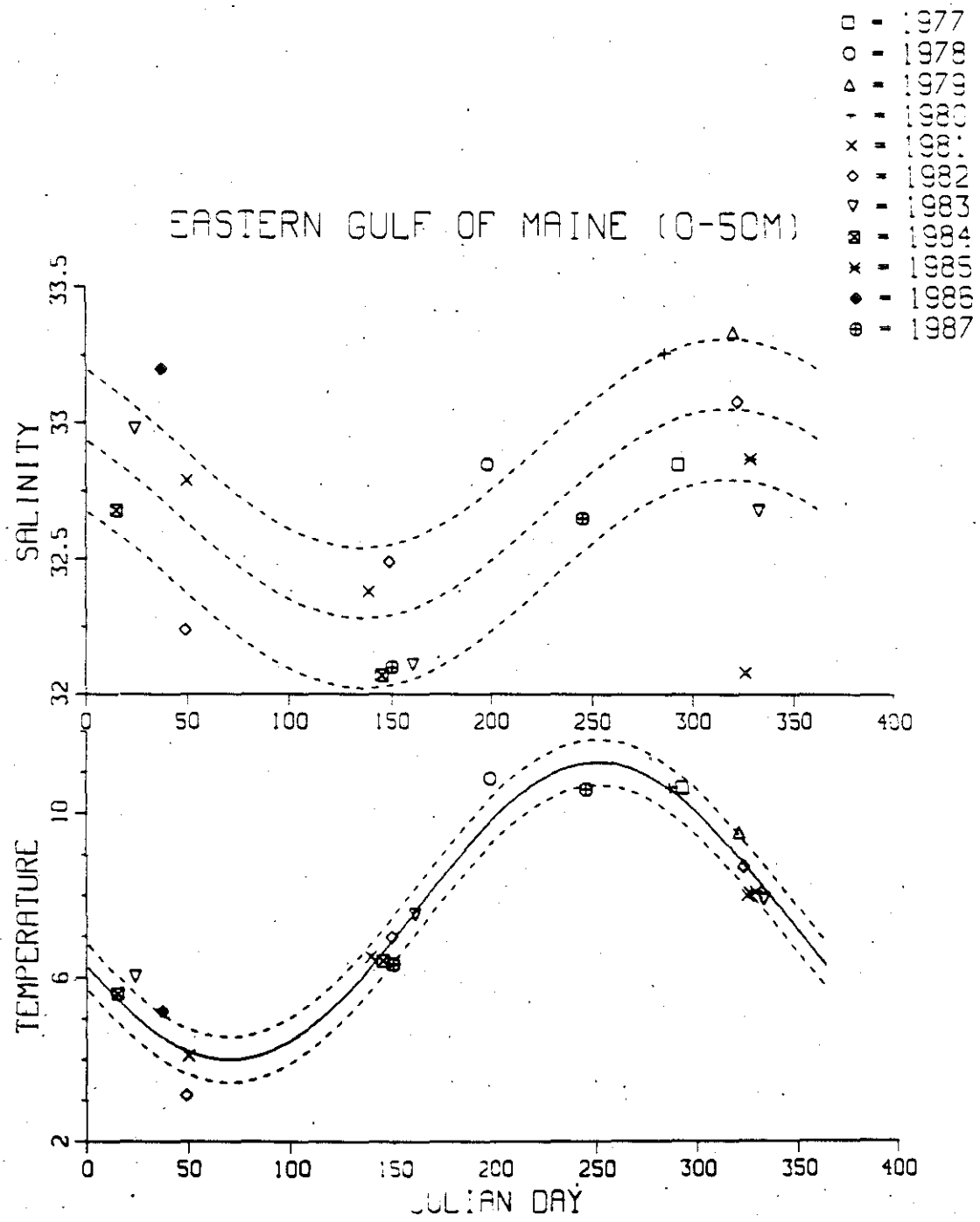


Figure 253. Mean values of temperature and salinity for the surface layer (0-50 m) in the eastern sector of the Gulf of Maine (1977-1987).

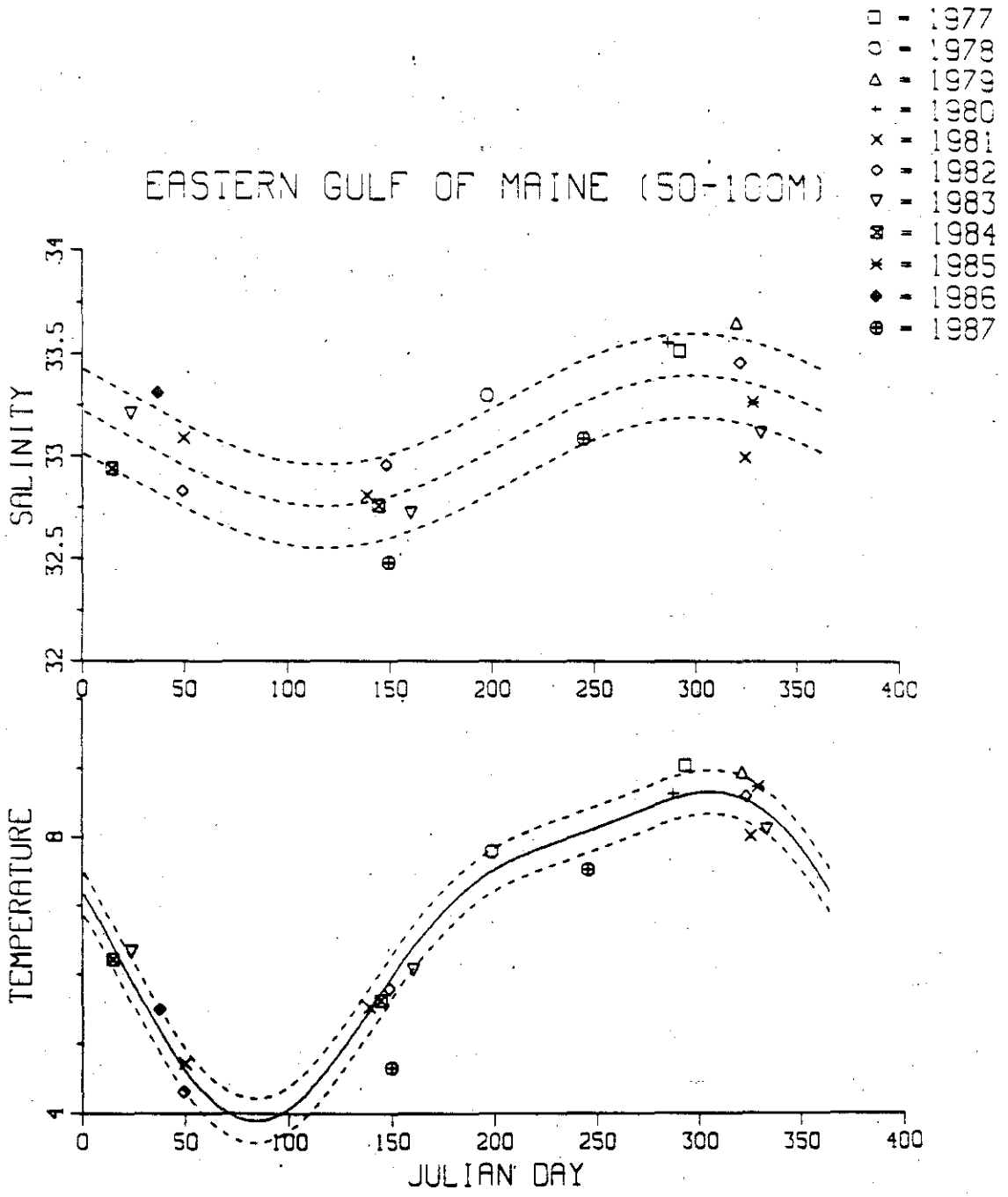


Figure 254. Mean values of temperature and salinity for the subsurface layer (50-100 m) in the eastern sector of the Gulf of Maine.

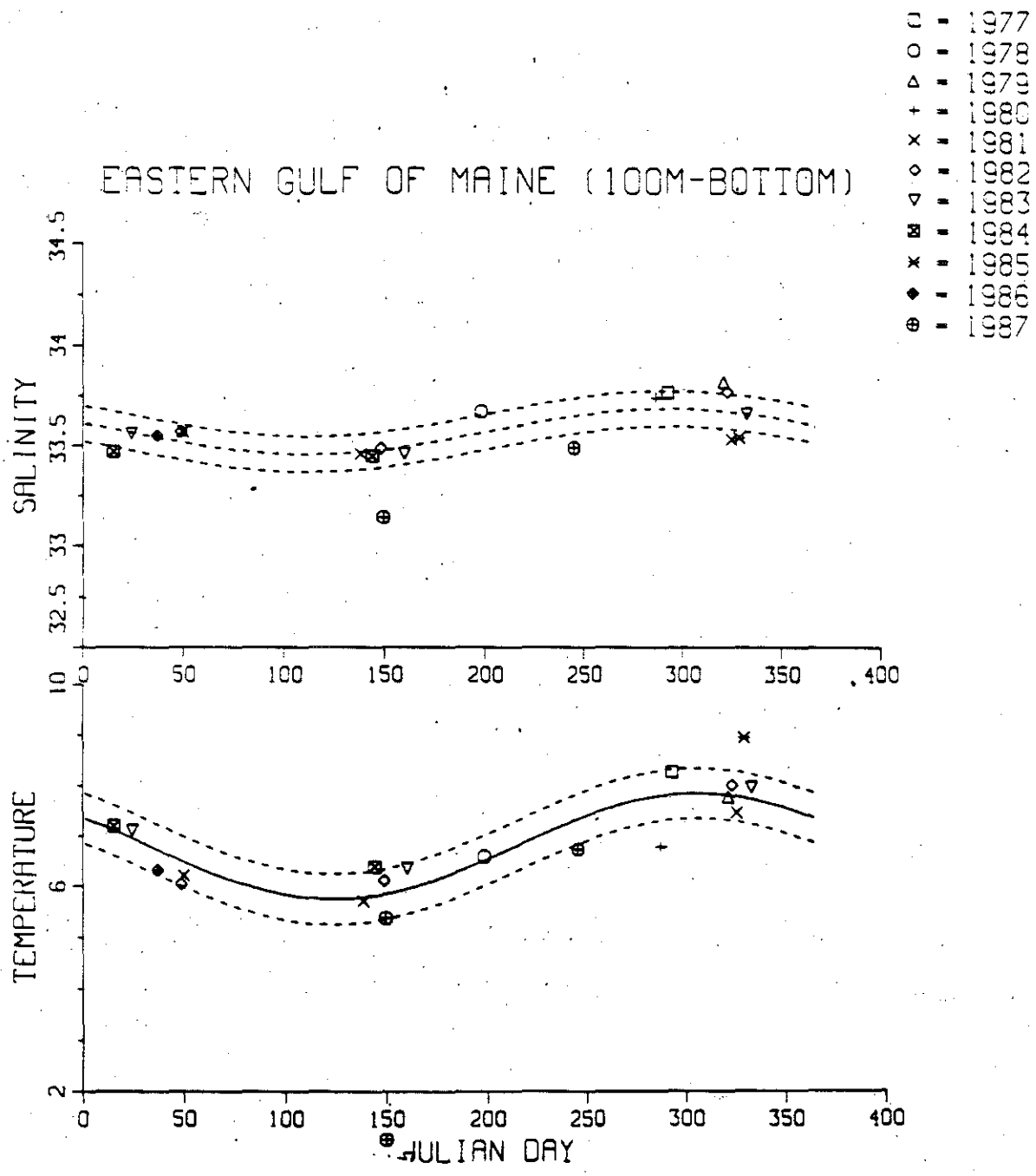


Figure 255. Mean values of temperature and salinity for the bottom layer (>100 m) in the western sector of the Gulf of Maine.

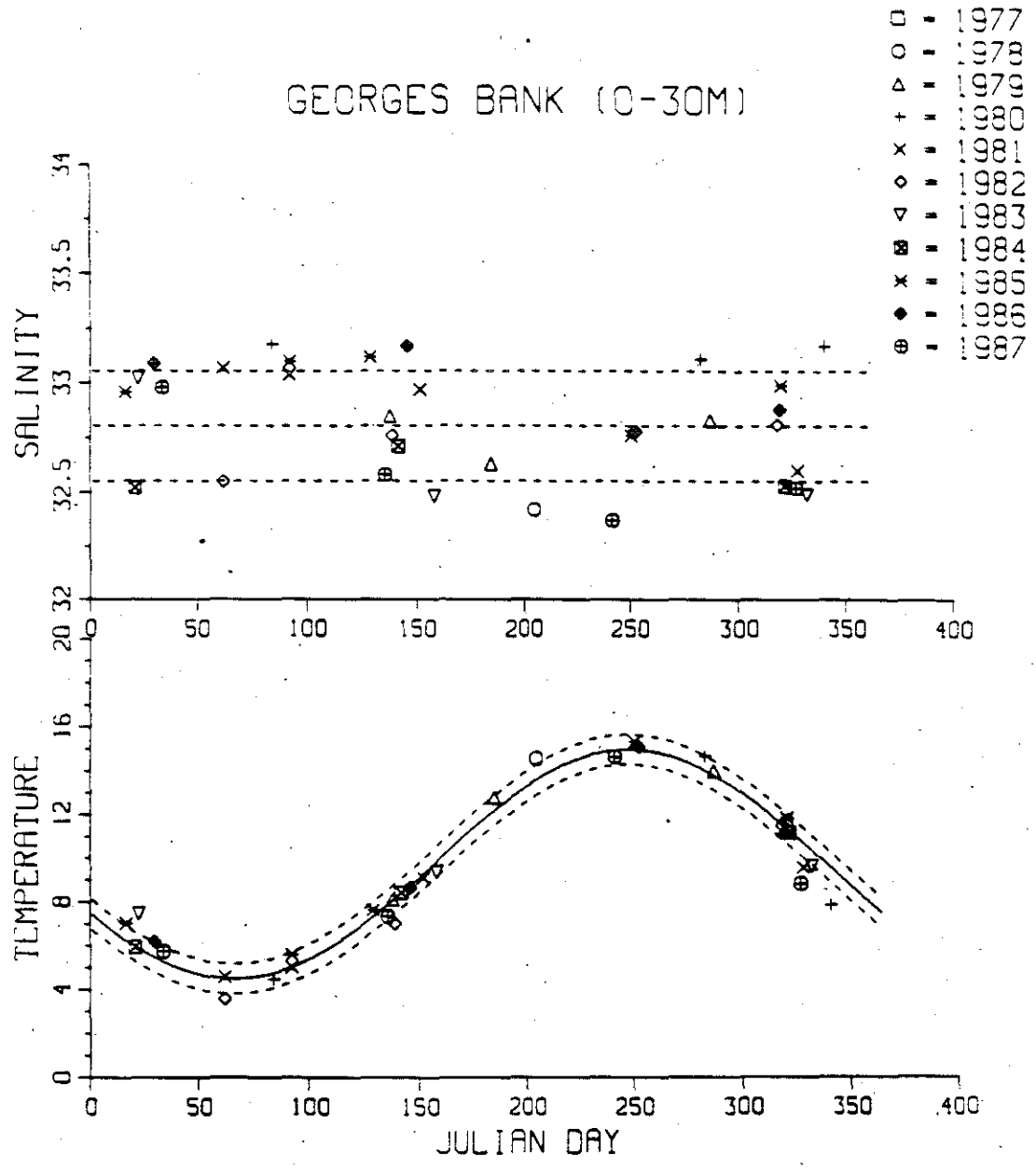


Figure 256. Mean values of temperature and salinity for the surface layer (0-30 m) on Georges Bank (1977-1987).

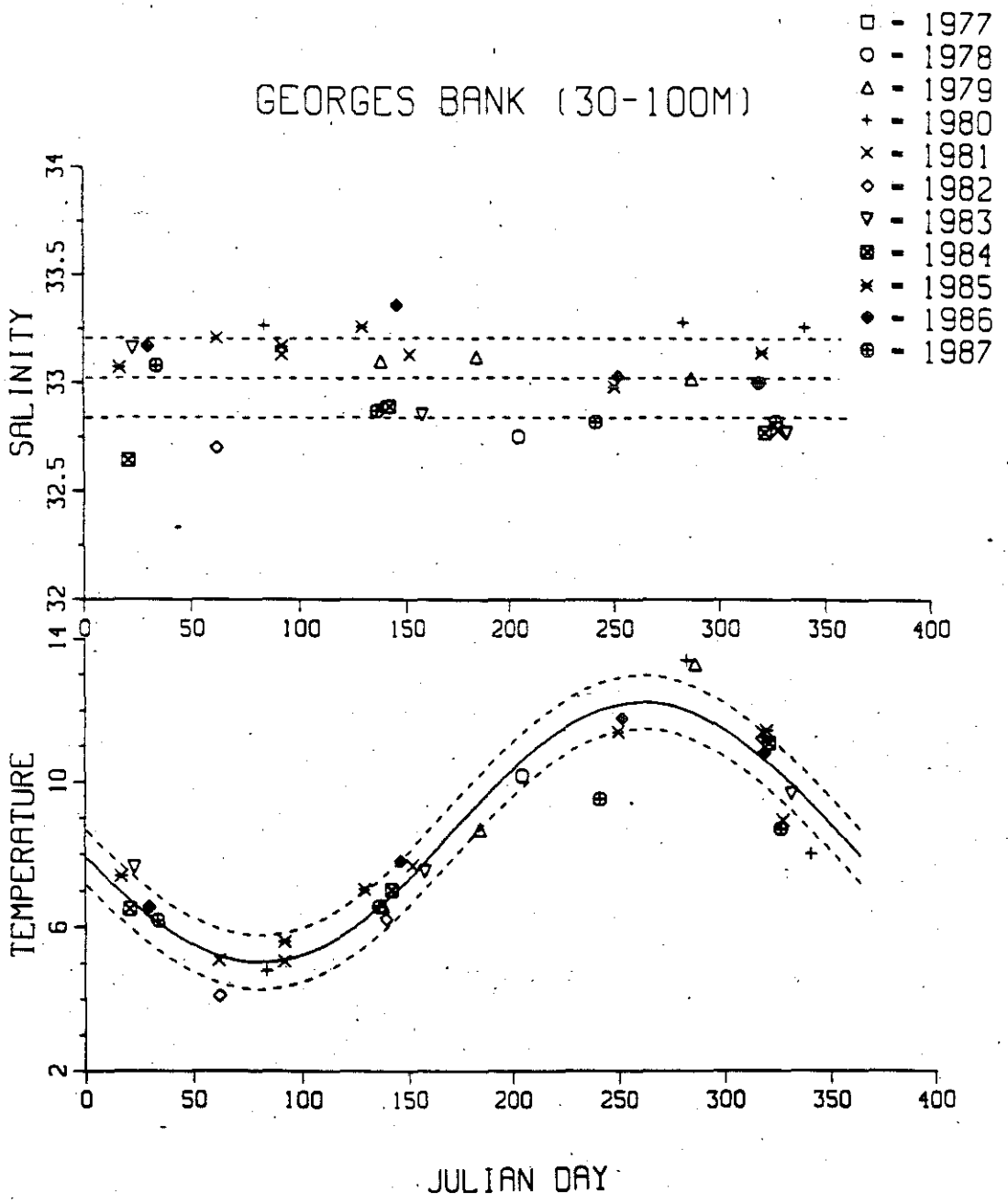


Figure 257. Mean values of temperature and salinity for the subsurface layer (30-100 m) on Georges Bank (1977-1987).

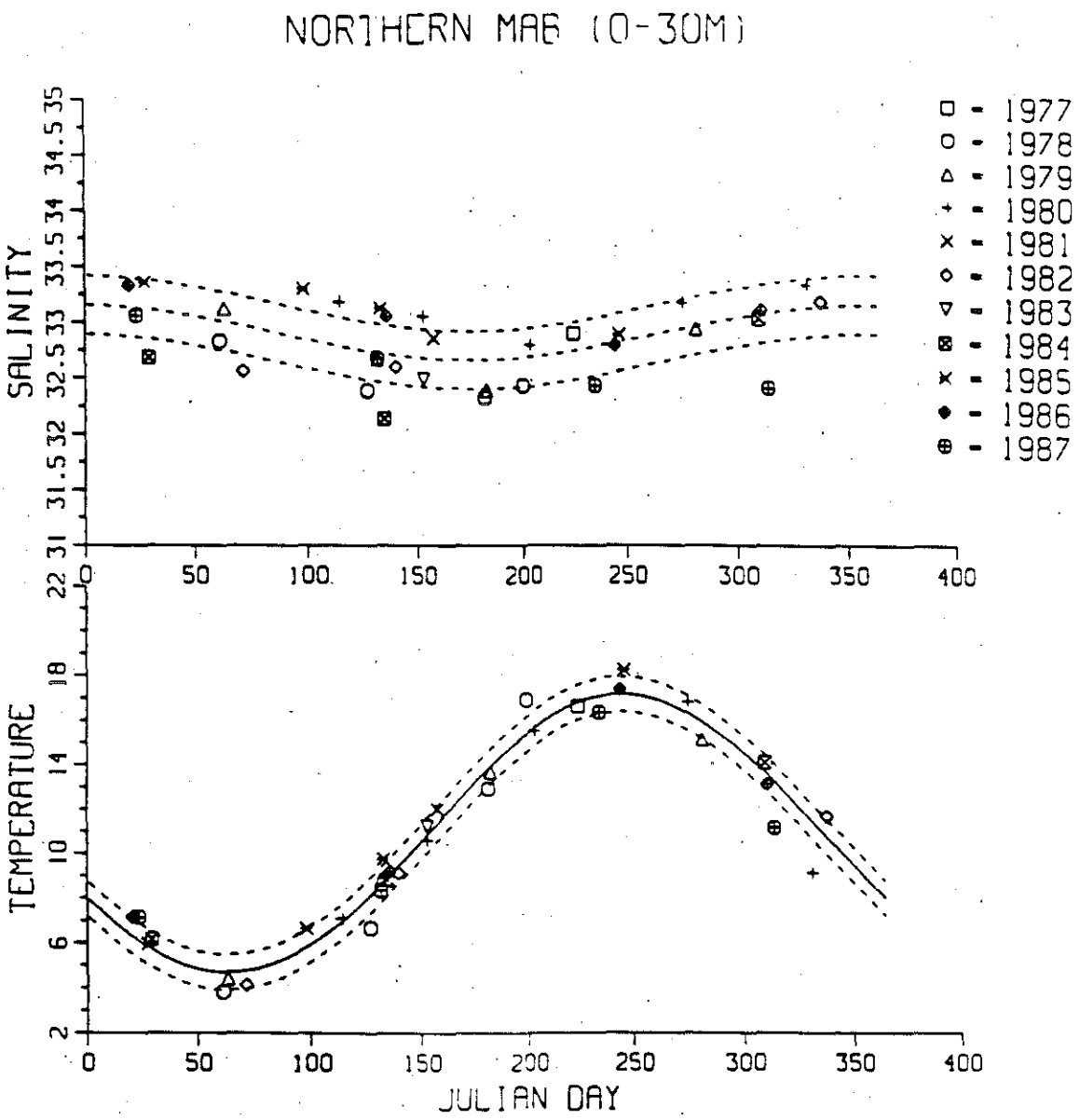


Figure 258. Mean values of temperature and salinity for the surface layer (0-30 m) in the northern sector of the Middle Atlantic Bight.

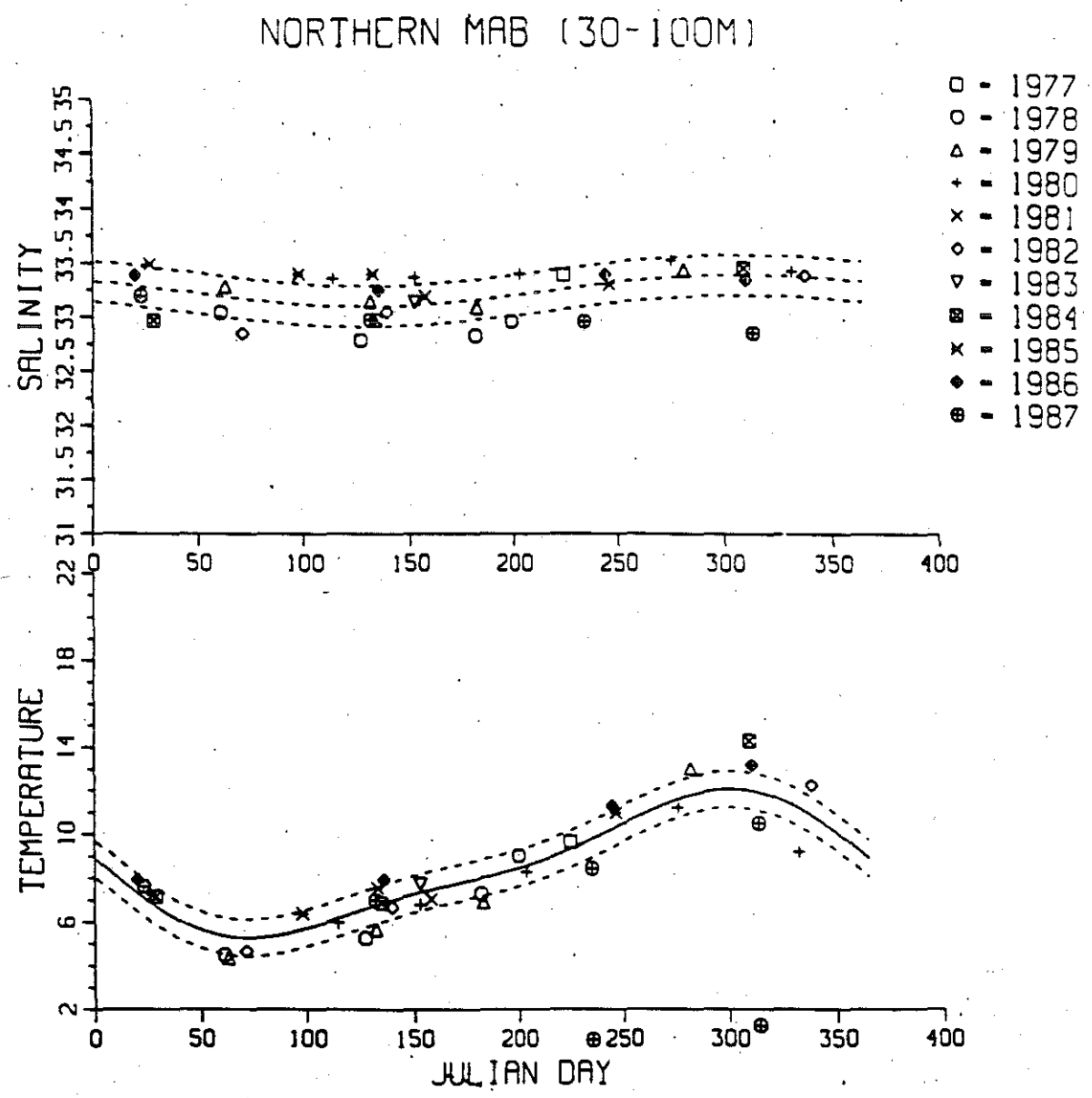


Figure 259. Mean values of temperature and salinity for the subsurface layer (30-100 m) in the northern sector of the Middle Atlantic Bight.

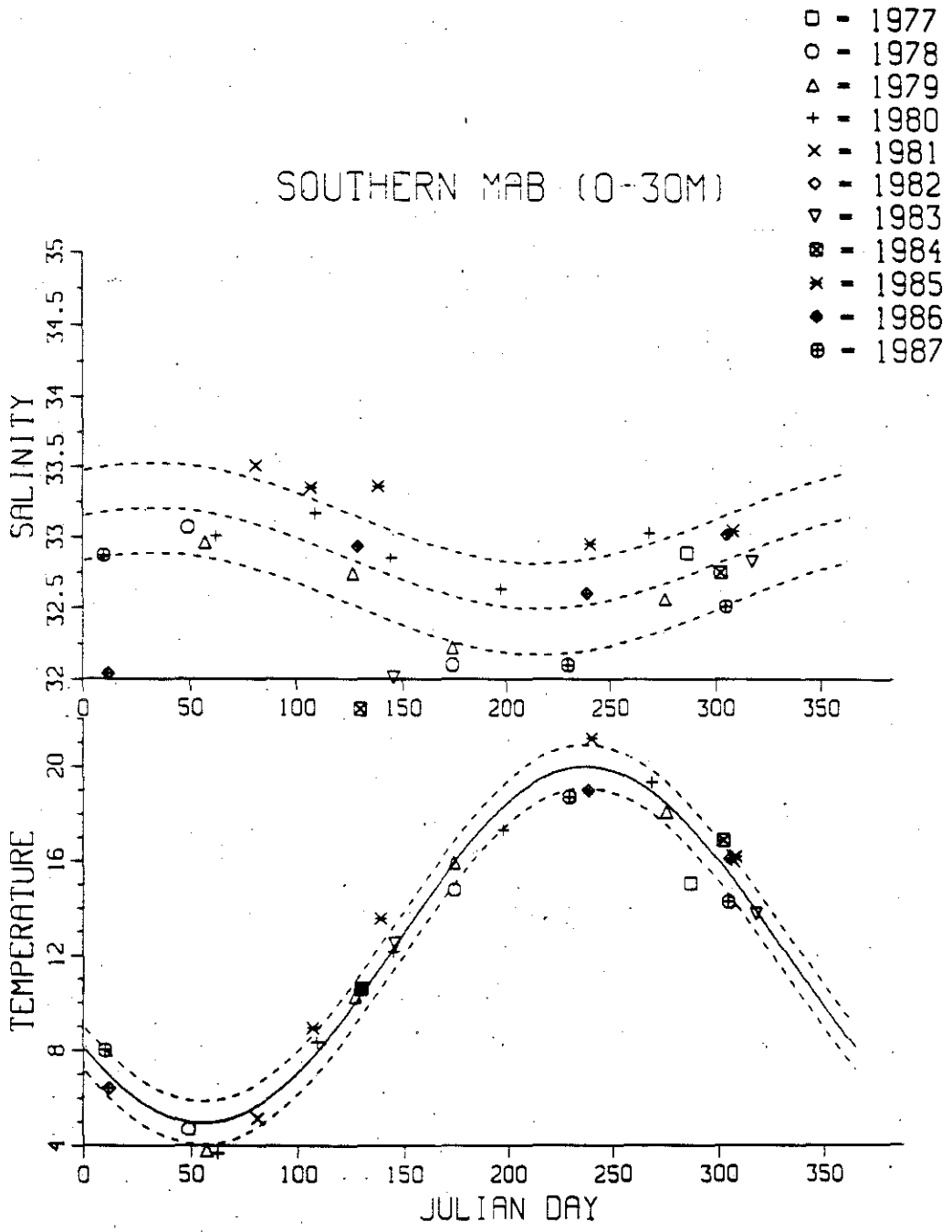


Figure 260. Mean values of temperature and salinity for the surface layer (0-30 m) in the southern sector of the Middle Atlantic Bight.

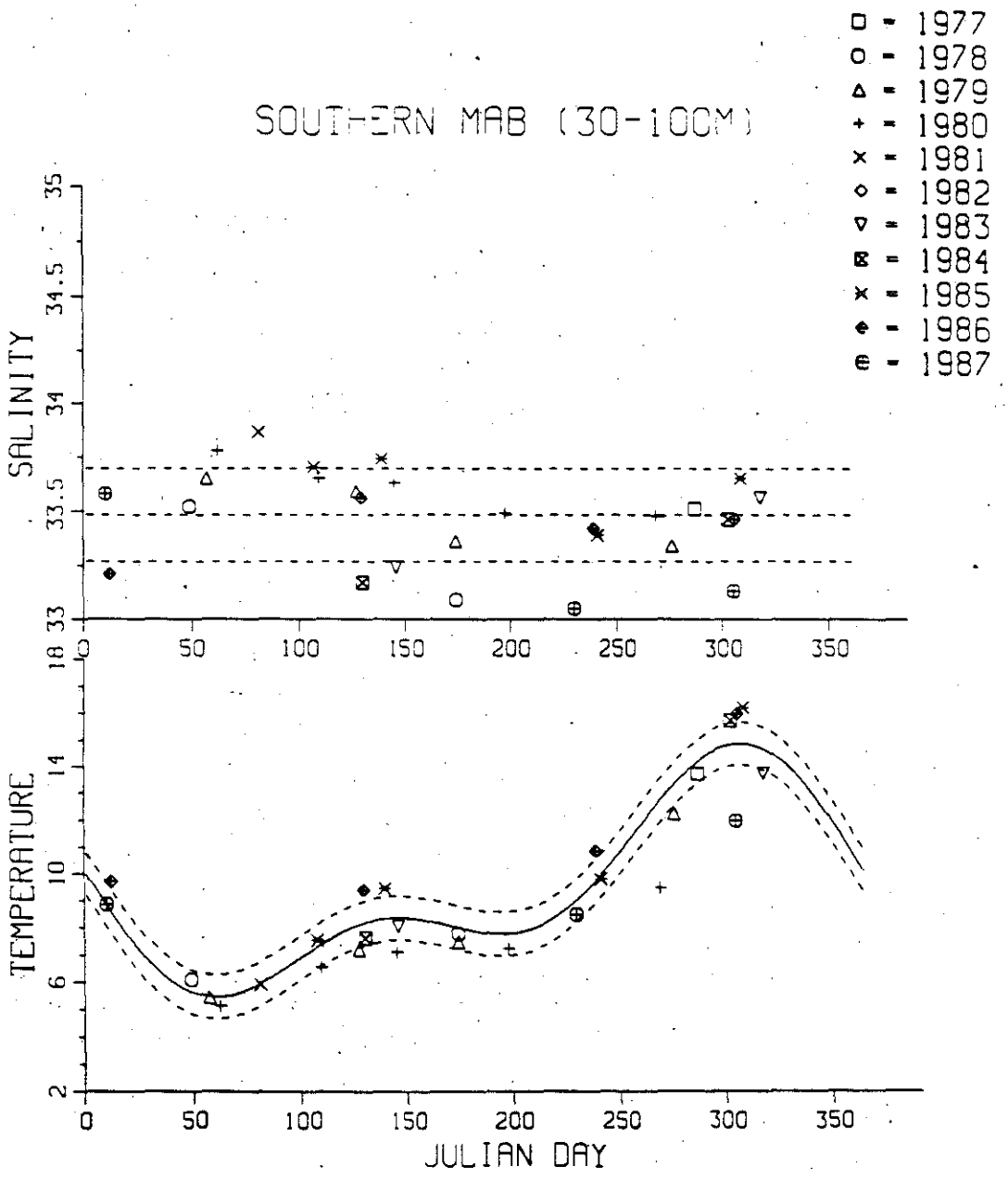


Figure 261. Mean values of temperature and salinity for the subsurface layer (30-100 m) in the southern sector of the Middle Atlantic Bight.