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Surface and Bottom Temperatures, and Surface Salinities: Massachusetts to Cape Sable, N.S., and New York to the Gulf Stream, 1990

by

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Abstract

Monthly monitoring of surface and water column temperature, and surface salinity across the Gulf of Maine, and the Middle Atlantic Bight has been conducted for fourteen and fifteen years, respectively. Water temperature and salinity patterns observed in 1990 are compared to 1978 through 1987 means within a time-space matrix.

In both areas in 1990 sea surface temperatures were generally cooler than the ten-year (1978-1987) means at the beginning of the year and warmer than average from late summer to the end of the year. Surface salinities in the Gulf of Maine were generally above average and, in the Middle Atlantic Bight, were near average for the year. Botttom temperatures in both areas were typically cooler than average in January and warmer than normal for much of the remainder of the year, except over the central Gulf ledges and Crowell Basin areas where bottom temperatures were generally cooler than average from April through the end of the year. Significant departures in sea surface temperature and salinity in the Middle Atlantic Bight occurred beyond the shelf break from April through June when cooler and fresher shelf water moved well offshore of normal.

Introduction

Monitoring of water column and bottom temperatures, and surface salinities has been conducted by the Northeast Fisheries Center along monthly transects across the Gulf of Maine since 1977, and from New York towards Bermuda since 1976 (Figure 1). Merchant

and other ships of opportunity regularly pass along these transects and make the observations. Reports describing the water column and bottom temperature conditions along these two routes are prepared annually, and are summarized in Jossi and Benway (1990). This report presents surface temperature and salinity, and bottom temperature conditions along the Gulf of Maine and Middle Atlantic Bight transects during 1990 and describes their departures from average conditions for the ten-year period, 1978 through 1987.

Methods

For the Middle Atlantic Bight, sampling intervals averaged 22 km over the shelf, 11 km near the shelf break, and 22 km offshore of the shelf break. For the Gulf of Maine, sampling intervals averaged 22 km for the surface variables, and 44 km for bottom temperature along the entire route.

Approximately 50% of the surface temperatures for the Gulf of Maine, and over 90% for the Middle Atlantic Bight came from expendable bathythermograph (XBT) deployments. Bucket temperatures were taken for calibration purposes, for cases of XBT failure, and, in the Gulf of Maine, at locations between the XBT stations. This combination of sources resulted in the data reported here as "surface" temperature, actually representing temperature in the upper 2 meters of the water column.

Samples of surface water were taken from bucket samples for salinity determinations.

Bottom temperatures all came from those XBT casts which obtained valid data until reaching the ocean bottom. Depths for bottom temperatures were checked against the ships navigational charts at sea and from bottom impact marks on analog traces produced at the Narragansett facility.

During the cruises, XBT and synoptic meterological data were transmitted via Geostationary Operational Environmental Satellite (GOES) to the National Environmental Satellite, Data, and Information Service (NESDIS) in Washington D.C.

Along the Middle Atlantic Bight transect, shelf/slope frontal positions mentioned in this report were determined by using surface and water column temperature distributions, and a surface salinity indicator of $34.5^{\circ}/_{oo}$.

Methods for generating standardized time-space matrices are

described in Jossi and Smith (1989). Briefly, the method involved 1) deleting any samples outside of the transect polygon (Figure 1); 2) calculating the sample's standardized distance along the transect, termed reference distance; 3) calculating a uniform time-space grid using julian day and reference distance from all data in a single year to make a single year map; (4) generating a uniform time-space grid using all data over the base period to make a mean map; (5 producing an estimated standard deviation map for the transect's base period; (6) calculating the residuals of raw data for a single year from the mean map and gridding these residuals to make an anomly map; and 7) dividing the anomaly map by the standard deviation map to obtain a standardized anomaly map.

Results

Surface temperature and salinity, and bottom temperature data for the Middle Atlantic Bight and the Gulf of Maine transects are presented as contoured time-space plots (Figures 2-7). Portrayed are the conditions during 1990, and the departure of these conditions from the 1978 through 1987 means, in terms of algebraic anomalies (data units) and standardized anomalies (standard deviation units). Figure 8 illustrates the mean bottom depth at 5 km intervals of reference distance along each transect. Figure 9 shows water column temperature conditions, and surface salinities along the Middle Atlantic Bight transect during 13-14 June, 1990.

Discussion

Middle Atlantic Bight

Surface Temperature: Surface temperatures during the year ranged from 3.6 ° C in the nearshore in early January to 28.7 ° C offshore during mid-August (Figure 2). In 1990 annual minimum temperatures occurred over the entire transect in early January approximately 30 days earlier than normal. This seems related to abnormally cold air temperatures which occurred during December 1989. Air temperatures in December 1989 were the coldest of record over the northeast United States (NOAA, 1990a). Warmer than normal surface temperature conditions from early February to late April on the continental shelf followed unusually high air temperatures during the month of January (NOAA, 1990b). Departures from the 1978-1987 means, in excess of -2° C were noted from late April to

July, between the location of the shelf break and approximately 350 km reference distance. The vertical temperature section (Figure 9), indicates that this cool water condition was caused by offshore extensions (to about 275 km reference distance) of the strong thermal gradient zone at the surface associated with the shelf/slope front and of the sub-surfacre cold pool (water enclosed by the 10° C isotherm). From August to the end of the year, surface temperatures were generally above average. Overturn began in mid-August very near shore and was completed on the shelf by late October to early November. This was approximately 1 month earlier than usual.

Surface Salinity: Observed salinities in the Middle Atlantic Bight ranged from a low of 25.4°/$_{oo}$ nearshore in early February to a high of 36.4°/$_{oo}$ in water at the offshore end of the transect in late February (Figure 3). Below average salinities were observed in April to July beyond the shelf break and associated with the offshore extension of shelf water described above. Over most of the transect for the remainder of the year, salinities were generally near average.

Bottom Temperature: Bottom temperature conditions on the shelf and upper slope for 1990 are presented in Figure 4. The relationship between reference distance and bottom depth is portrayed in Figure 8. Colder than average conditions in January, and warmer than average in March and April reflect conditions observed at the surface during this period, as described above. Typically, warmest temperatures on the bottom occur with fall overturn. In 1990, fall overturn began nearshore in mid-August and, across the shelfwas about one month earlier than normal. This early initiation of fall overturn is considered to be responsible for the large positive anomaly in bottom temperatures over the inner half of the shelf in August and September.

Gulf of Maine

Surface Temperature: Minimum 1990 surface temperature of <2° C occurred on the Scotian Shelf from late January to mid March (Figure 5). Over the rest of the transect minima occurred in early March reaching <3° C in Massachusetts Bay. Maximum temperatures occurred in early August over all but the eastermost portion of the

transect. Temperatures in Massachusetts Bay exceeded 22° C. Near Cape Sable the maximum was > 11° C, during mid August to late September. Departures from the 1978-1987 means repeated a pattern seen in these data for each year since 1987. The winters have been colder than average and the springs to early falls have been hotter than average (with the central Gulf ledges being a partial exception).

Surface Salinity: The time-space distribution of surface salinity in 1990 (Figure 6) generally exhibits the pattern of the 1978-1987 means. However, with only minor exceptions the majority of the time-space area showed positive anomalies to an extent not seen during the term of record. The minimum salinity in Massachusetts Bay usually occurs from early May to late June. Minimum Massachusetts Bay salinities in 1990 were about $1^{o}/_{oo}$ above average, but the period of this minimum extended from late May to mid September. This extension resulted in negative salinity anomalies in Massachusetts Bay from mid August to mid September. The only other negative departures occurred on the Scotian Shelf in December.

Bottom Temperature: Minimum bottom temperatures in 1990 occurred on the Scotian Shelf (<2° C) from mid January to mid March and in Massachusetts Bay (<3° C) from mid February to the end of March (Figure 7). Temperatures reached greater than 11° C on the Scotian Shelf in August, a value usually seen only near the beginning of November in the 1978-1987 means. In the western Gulf the timing of bottom temperature maxima (September-October) matched the long-term mean, but its magnitude was 2° C above normal. January, over the western half of the transect, and January through March over the eastern portion had significantly below average temperatures. The area over the central Gulf ledges and western Crowell Basin was significantly cooler than average from June through the end of the year, and most of the Scotian Shelf was 1° C to 2° C below average during November and December.

Acknowledgements

Appreciation is extended to the officers and crews of the Oleander, Bermuda Container Lines; and of the Yankee Clipper, Claus Spect, Hamburg Germany; for their generous cooperation in the

continued succes of this program. Appreciation also is proffered to all the volunteers who have collected data aboard the Oleander. Special thanks are extended to the members of the National Ocean Service, Office of Marine Observations, for their continued support.

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Jossi, Jack W., and Robert L. Benway. 1990. Surface and bottom temperatures, and surface salinities: Massachusetts to Cape Sable, N.S., and New York to the Gulf Stream, 1990. NAFO SCR Doc. 90/27, Serial No. N1744, 17 p.

Jossi, Jack W., and Daniel E. Smith. 1989. Continuous plankton records: Massachusetts to Cape Sable, N.S., and New York to the Gulf Stream, 1988. NAFO SCR Doc. 89/59, Serial No. N1639, 19 p.

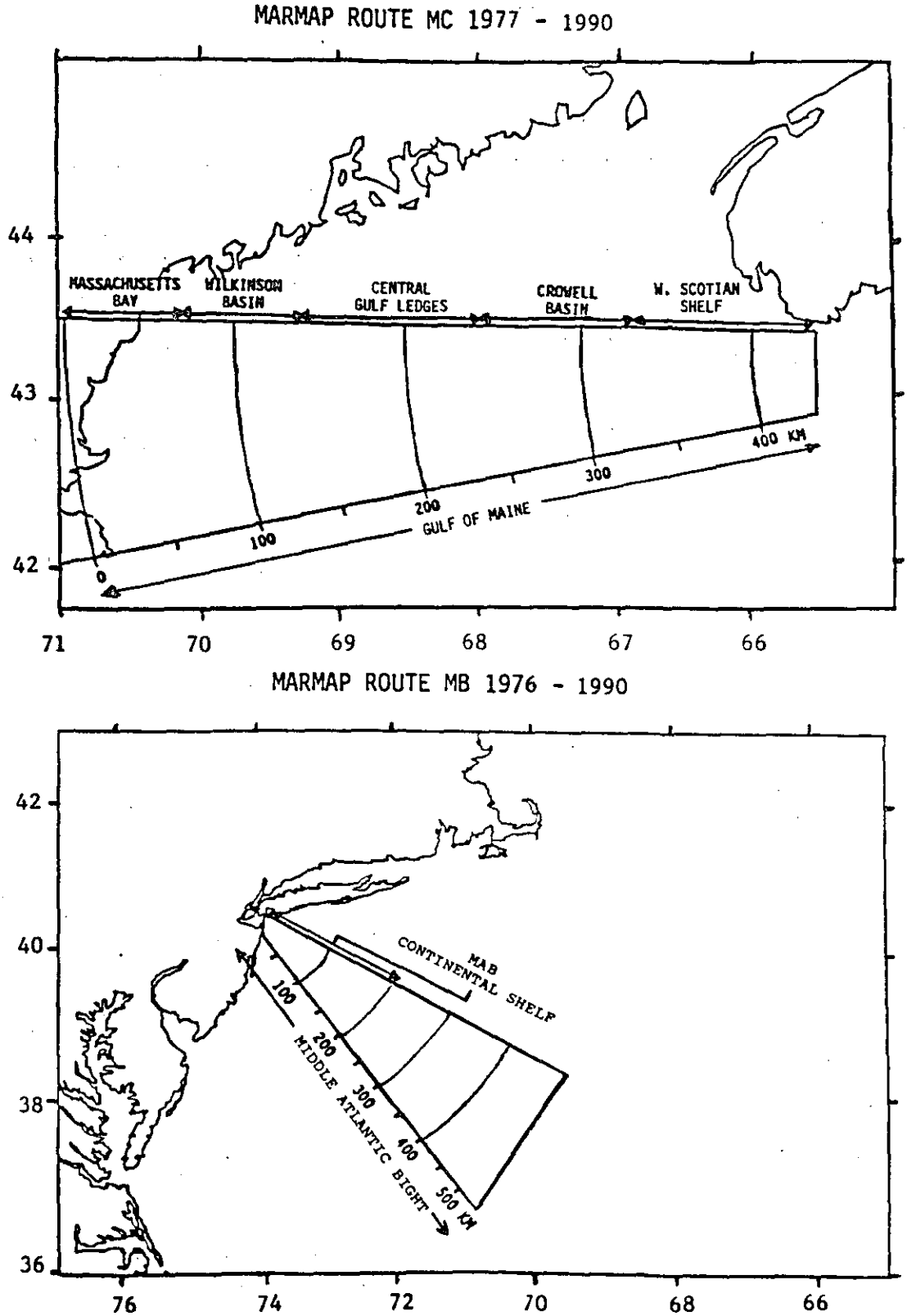

Figure 1. Gulf of Maine (MC) and Middle Atlantic Bight (MB) polygons within which monitoring transects occur, with years of temperature and salinity sampling, standard reference distances, and major subareas of the Northeast Continental Shelf ecosystem.

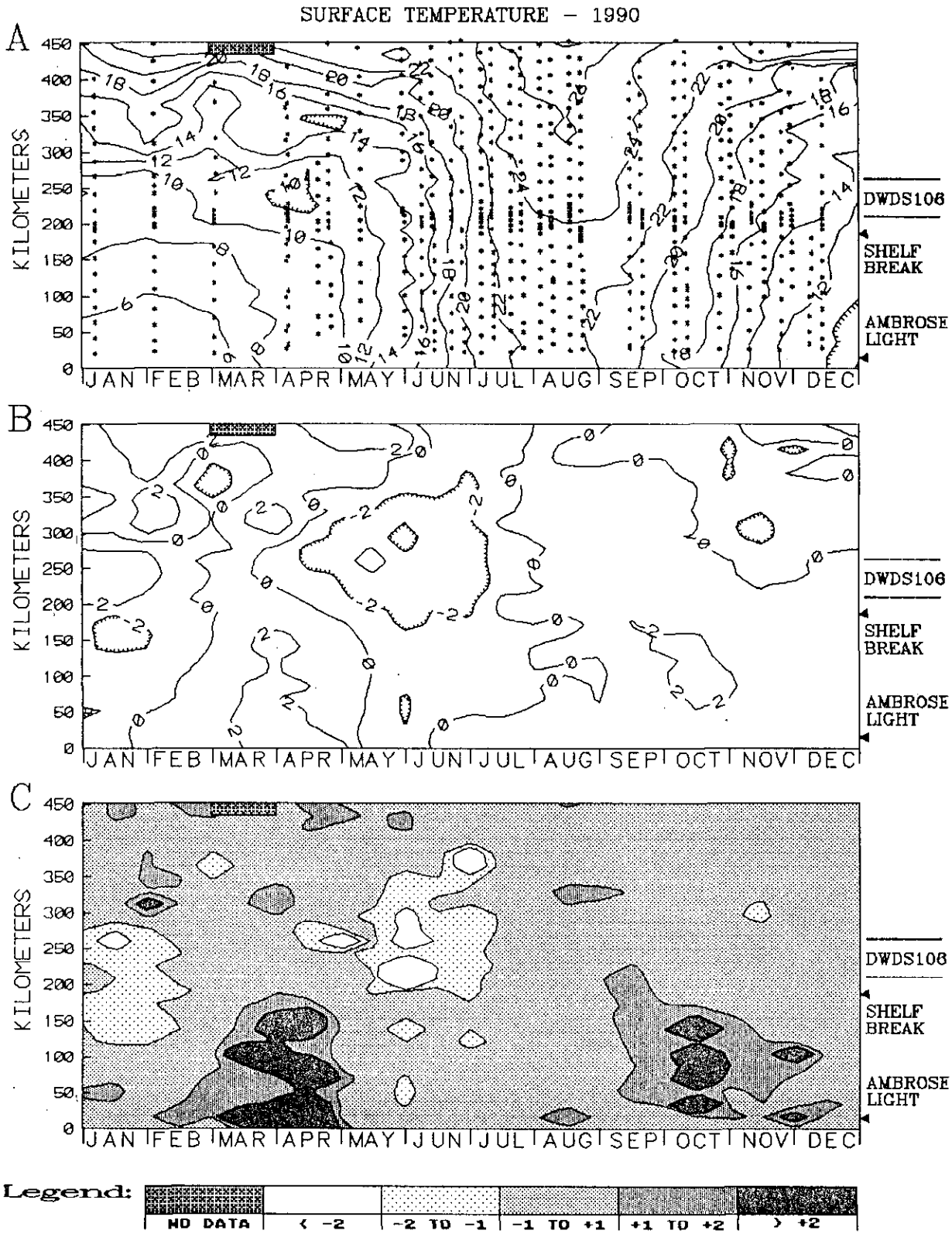

Figure 2. Surface temperature conditions along the Middle Atlantic Bight transect during 1990. A. Measured values (degrees centigrade) in time and space. Dots indicate sampling locations. B. Anomalies in time and space based on 1978 through 1987 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1987 means and variances. In panels A and B values decline on those sides of contour lines with hachures.

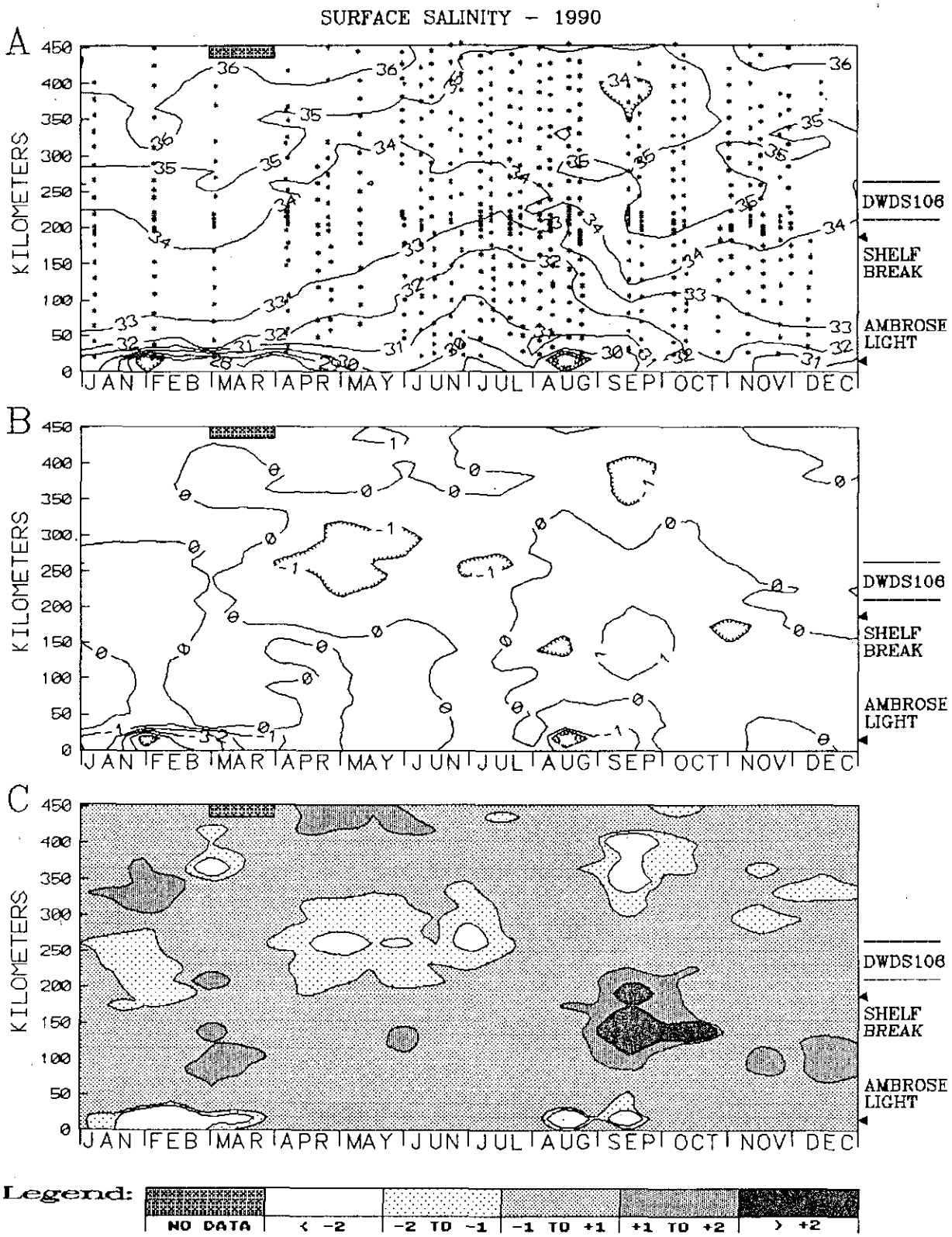

Figure 3. Surface salinity conditions along the Middle Atlantic Bight transect during 1990. A. Measured values (parts per thousand) in time and space. Dots indicate sampling locations. B. Anomalies in time and space based on 1978 through 1987 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1987 means and variances. In panels A and B values decline on those sides of contour lines with hachures.

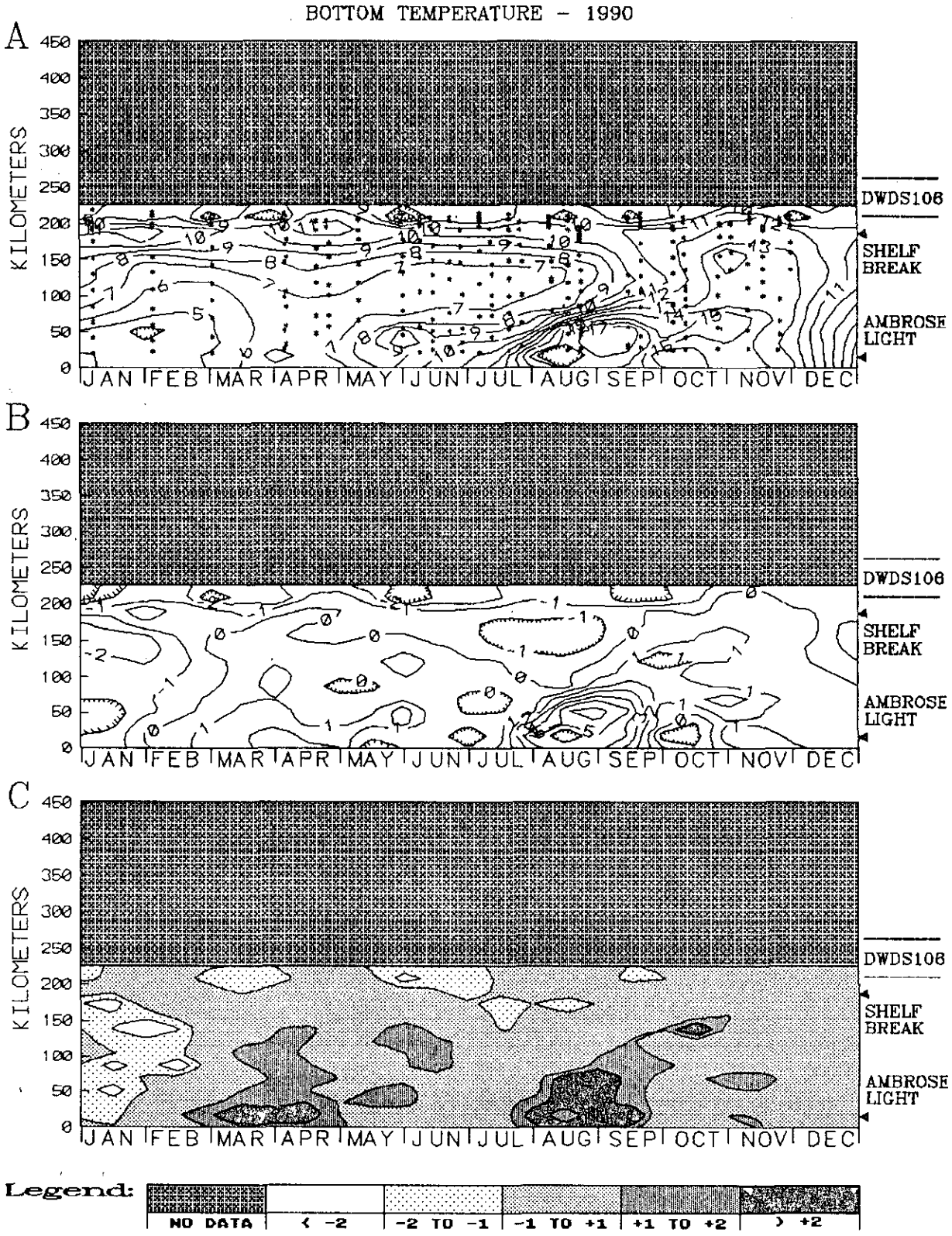

Figure 4. Bottom temperature conditions along the Middle Atlantic Bight transect during 1990. A. Measured values (degrees centigrade) in time and space. Dots indicate sampling locations. B. Anomalies in time and space based on 1978 through 1987 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1987 means and variances. In panels A and B values decline on those sides of contour lines with hachures.

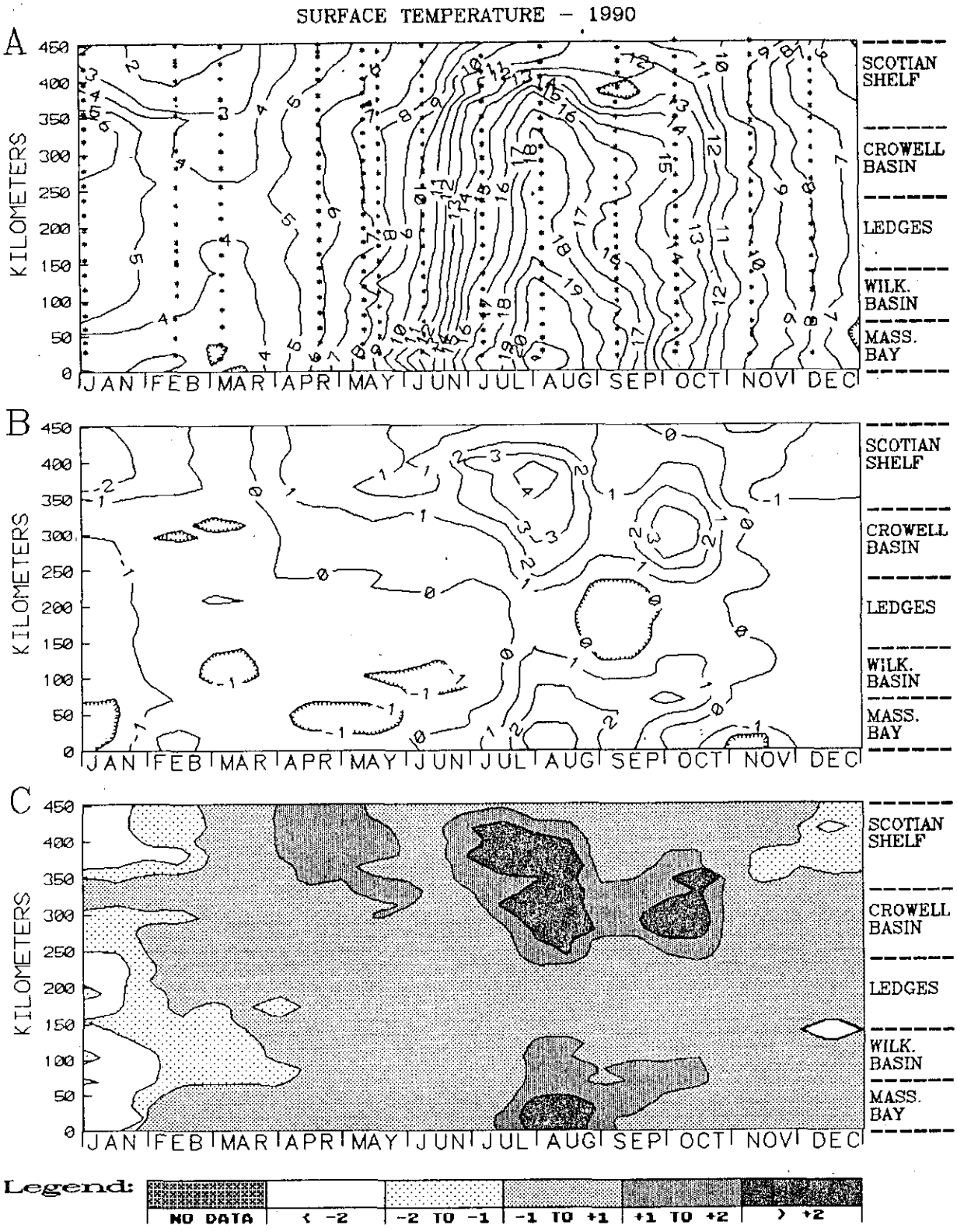

Figure 5. Surface temperature conditions along the Gulf of Maine transect during 1990. A. Measured values (degrees centigrade) in time and space. Dots indicate sampling locations. B. Anomalies in time and space based on 1978 through 1987 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1987 means and variances. In panels A and B values decline on those sides of contour lines with hachures.

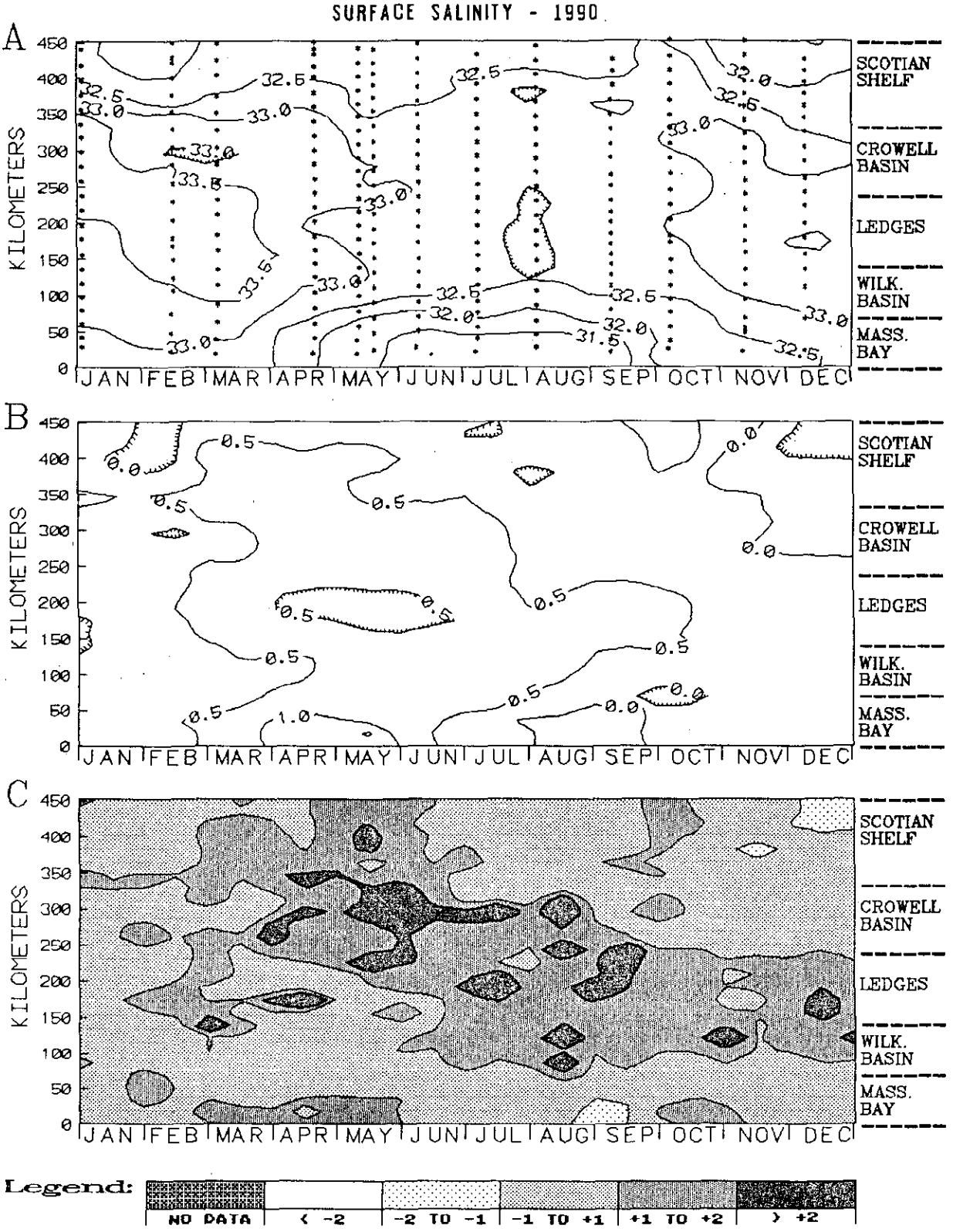

Figure 6. Surface salinity conditions along the Gulf of Maine transect during 1990. A. Measured values (parts per thousand) in time and space. Dots indicate sampling locations. B. Anomalies in time and space based on 1978 through 1987 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1987 means and variances. In panels A and B values decline on those sides of contour lines with hachures.

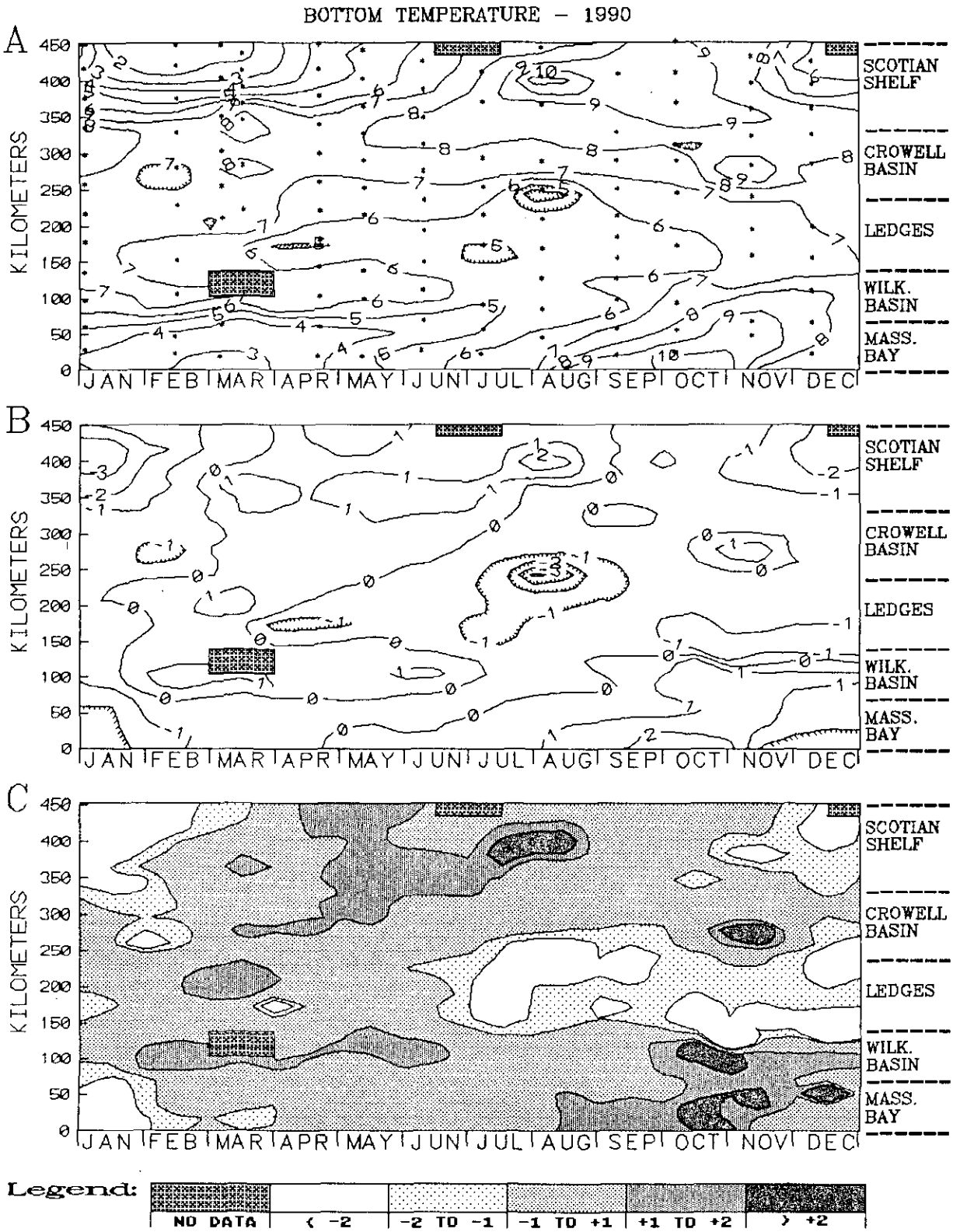

Figure 7. Bottom temperature conditions along the Gulf of Maine transect during 1990. A. Measured values (degrees centigrade) in time and space. Dots indicated sampling locations. B. Anomalies in time and space based on 1978 through 1987 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1987 means and variances. In panels A and B values decline on those sides of contour lines with hachures.

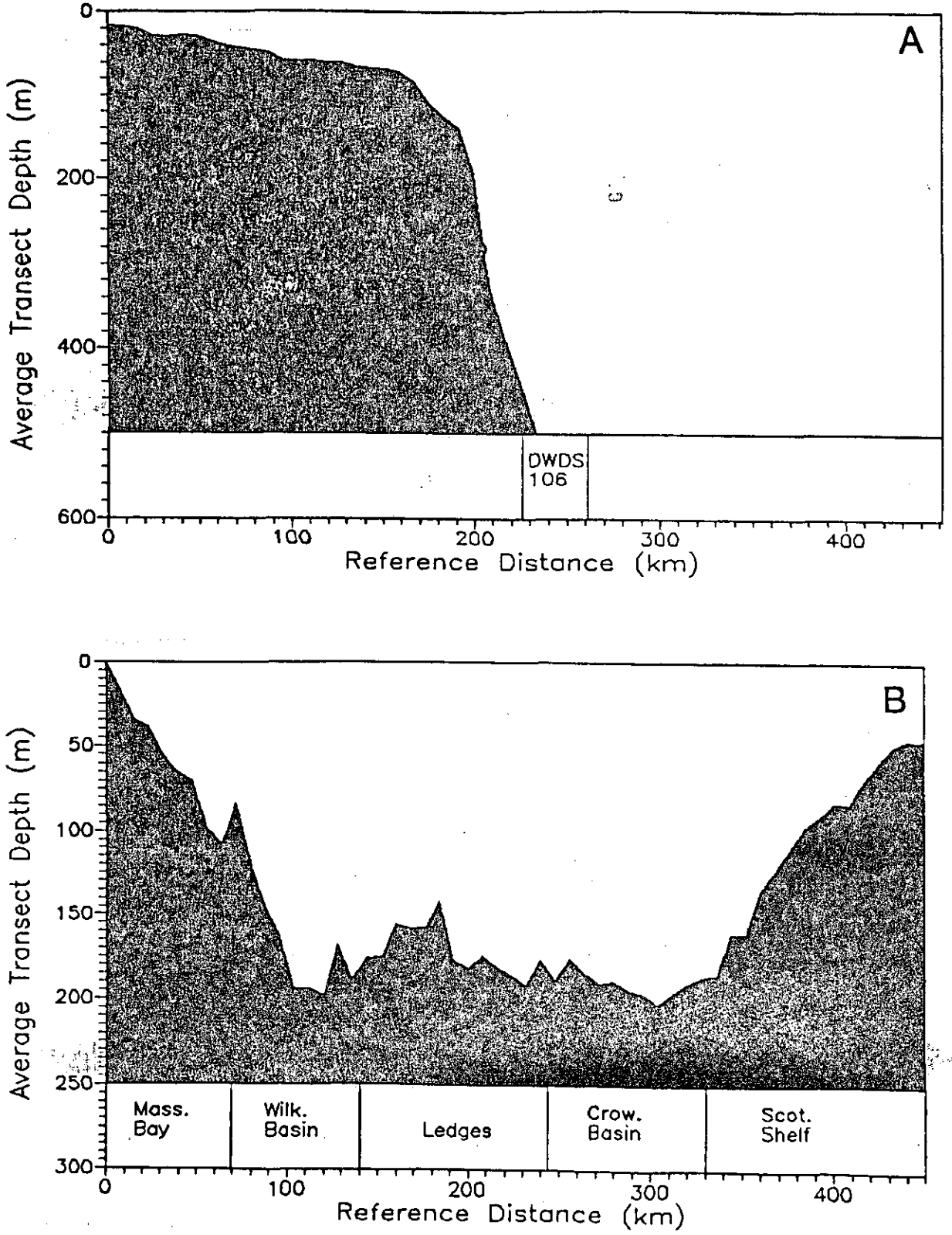

Figure 8. Mean bottom depth along the Middle Atlantic Bight (A), and the Gulf of Maine (B) transects based on monitoring survey data, 1978 through 1987.

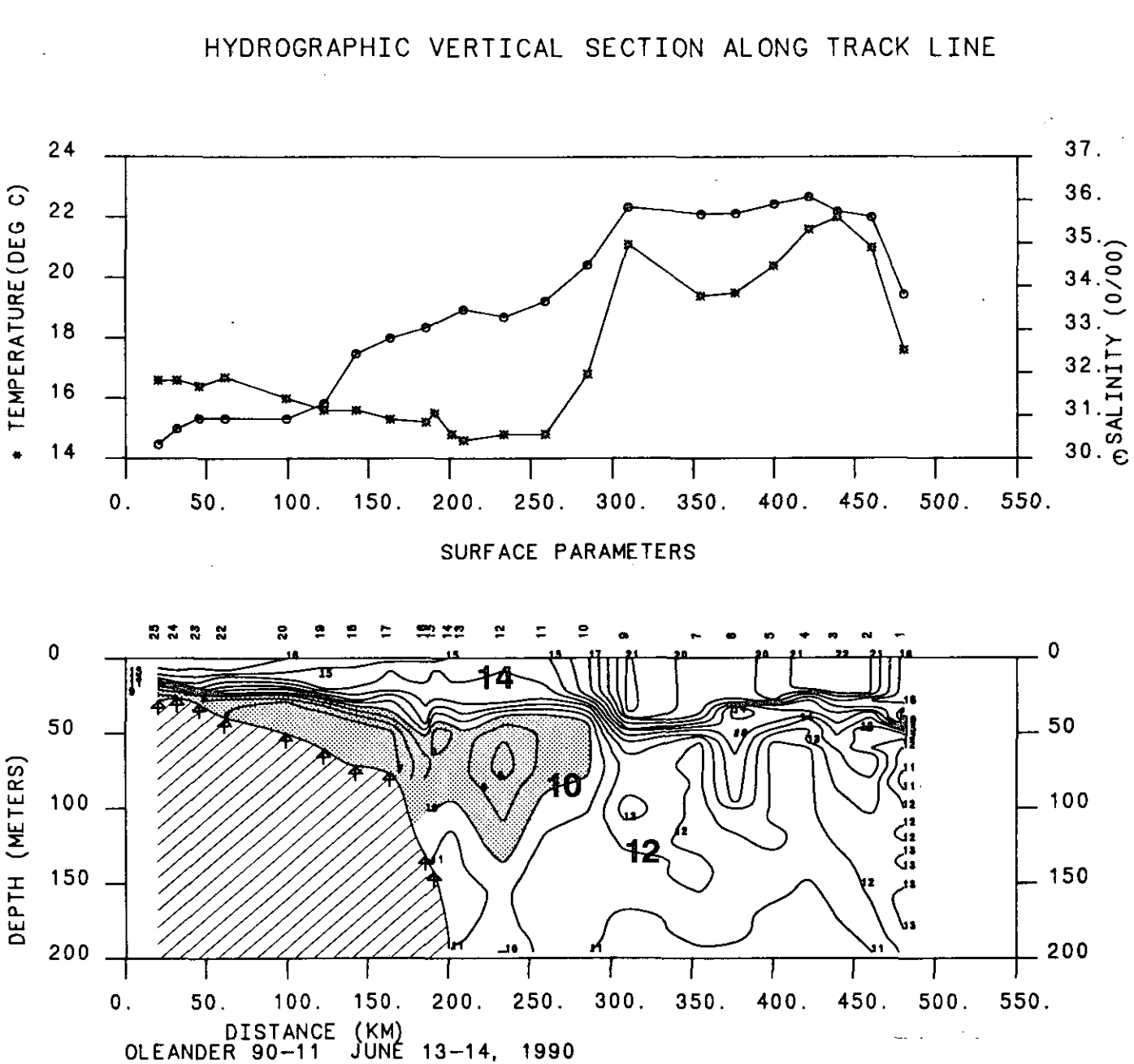

Figure 9. Water column thermal structure and surface salinity conditons along the Middle Atlantic Bight transect during 13-14 June, 1990.