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Surface and Bottom Temperatures and Surface Salinities: New York to the Gulf Stream, Massachusetts to Cape Sable N.S. 1997

by

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Abstract

Monthly monitoring of surface and water column temperature, and surface salinity across the Middle Atlantic Bight (MAB) and Gulf of Maine (GOM) has been conducted since 1976 and 1978, respectively. Presented are the temporal and spatial patterns of these features in 1997 and their comparisons to a 1978-92 mean. Surface temperatures averaged over all of 1997 and over the entire transects averaged -1.6°C for the MAB and -0.1°C for the GOM than the 1978-1992 means. Similarly averaged bottom temperatures were -0.4°C over the shelf portion of the MAB transect, and +0.6°C along the GOM transect. In the more detailed time-space sense, MAB surface temperatures were significantly lower than average 1) at the shelf/slope boundary during January and February, 2) in the offshore from February through September, 3) over the outer shelf and slope during late April through June, and 4) over the inner-shelf in August through September. Negative departures of surface salinity in the MAB occurred over the shelf through July with a distribution that ranged from 25 km to beyond 452 km reference distance. MAB surface salinities were -0.76 PSU as compared to the 1978-92 mean. MAB bottom temperatures were above average over the shelf to a reference distance of 210 km from January through March. A similar event was observed from June to mid-July but to a lesser magnitude.

GOM surface temperatures were slightly above the baseline from late May through early August over Wilkinson Basin and extending eastward to Crowell Basin. An additional positive anomaly was observed during late August into October in the Crowell Basin area. GOM surface conditions when compared to mean values were -0.1°C, only slightly cooler than average. GOM bottom temperatures were cooler than normal during January in the Central ledges and Crowell Basin. Positive anomalies occurred over the Scotian Shelf during this same period. Positive anomalies were observed from mid-April ranging in location from the Scotian Shelf region and extending westward to Wilkinson Basin through October.

Introduction

Monitoring of water column and bottom temperatures, and surface salinities has been conducted by the Northeast Fisheries Science Center along monthly transects from New York towards Bermuda since 1976 (Fig. 1a) and across the Gulf of Maine since 1978 (Fig. 1b). Measurements are made from merchant and other ships of opportunity, which regularly pass along these transects. The objective is to monitor changes in the U.S. Northeast Shelf Ecosystem in relation to possible effects on the long-term sustainability of fishery yields of the system (Sherman *et al*, 1988). Reports describing the water column and bottom temperature conditions along these two routes are prepared annually, and were summarized through 1990 in Benway *et al.* (1993). This report presents surface temperature and salinity, and bottom temperature conditions along the Middle Atlantic Bight transect and surface and bottom temperature conditions along the Gulf of Maine transect during 1997, and describes their departures from average conditions for the fifteen-year period, 1978-92.

Methods

In 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. In the Gulf of Maine, sampling intervals averaged 44 km along the entire transect.

All of the surface temperatures for the Gulf of Maine and over 90% for the Middle Atlantic Bight resulted from expendable bathythermograph (XBT) deployments. Bucket temperatures were taken for calibration purposes, and for cases of XBT failure. This combination of sources affects the definition of the data reported here as "surface" temperature. Actually represented are temperatures in approximately 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 ship's navigational charts at sea, and from bottom impact marks on analog traces.

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

Methods for generating standardized time-space matrices are described in Benway et al. (1993). Briefly, the method involved (1) deleting any samples outside of the transect polygon (Fig. 1A and 1B); 2) calculating each 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 annual map; 5) producing an estimated standard deviation map for the transect's base period; 6) calculating residuals of raw data for a single year from the mean map and gridding these residuals to make an anomaly map; and 7) dividing the anomaly map by the standard deviation map to obtain a standardized anomaly map. Annual means and departures for the transects (Tables 1 and 2) were obtained by averaging values from the single-year map, the anomaly map, and the mean map.

Results

Surface temperature and salinity, and bottom temperature data for the Middle Atlantic Bight and surface and bottom temperature data for the Gulf of Maine transects are presented as contoured time-space plots (Fig. 2-6). Portrayed are the conditions during 1996, and departure of these conditions from the 1978-92 means, in terms of algebraic anomalies (data units) and standardized anomalies (standard deviation units). Figure 7 illustrates the mean bottom depth at 5 km intervals of reference distance along each transect.

Annual means and departures of these variables along the transects are presented in Tables 1 and 2. Bottom temperatures in the Middle Atlantic Bight (Table 1) are averaged over the continental shelf to a limit of approximately 200 km reference distance, because bottom depths farther offshore exceed sampling depth of the expendable bathythermographs employed.

Discussion

Middle Atlantic Bight

Surface Temperature: Surface temperatures during 1997 ranged from less than 6°C in the near-shore waters in February to slightly more than 24°C at the extreme off-shore end of the transect during June through late August (Fig. 2). Annual minimum temperatures occurred over the entire transect in February and March, which is about average within 15-year base period. Slightly warmer surface water was observed in the near shore during mid-January through February. This is unusual in that a more typical melt water cold signal generally occurs during this winter/spring transitional period. From the mid-shelf area and extending eastward during the period late March through June, colder than average surface temperatures were observed. Exhibited were surface temperatures in excess of 2°C, and isolated cases exceeding 6°C below average. This condition was repeated when cold surface water was observed during mid-July in the offshore continuing into September, and in the nearshore

during the same period. Surface temperatures for the year for the transect as a whole were 1.6°C colder than the 1978-92 means (Table 1). Surface temperature conditions calculated for the shelf region only were -0.4°C for 1997. This represents a slightly below average year.

Surface Salinity: Surface salinities along the MAB transect during 1997 were slightly negative as a whole (Fig. 3). Surface water over the offshore portion of the transect during January and continuing into July was more than 2 PSU below the 1978-92 baseline. Significant negative anomalies occurred during January and February over the shelf, and March through June over the shelf and slope. It appeared that the annual melt water discharge magnitude signal normally seen in the near shore during late February and into March was absent. During the winter of 1996/97 frozen precipitation (snow) for this region was well below normal (National Climatic Data Center 1997). In addition the secondary signal of river discharge generally seen in late August and through September was weaker than normal. May salinities off Ambrose Light declined to <28.5 PSU, slightly below average. The entire shelf was 0.63 PSU below average (Table 1). Calculations done for the transect as a whole for 1997 stood at 0.76 PSU below average. Below average low salinity water was observed in the offshore end of the transect during November and December reaching a minimum of < 34.5 PSU.

Bottom Temperature: The relationship between bathymetry and reference distance is shown in Fig. 7a. Bottom temperatures ranged from less than 6°C from January to late-March on the most of shelf to greater than 14°C over the outer shelf during November (Fig. 4). Based on water column data, the annual fall overturn began during October and was nearly completed on the shelf by late November. The "Cold Pool," described by Cook (1985) as bottom water less than 10°C, which normally is confined to the inner 160 km of the transect, was present over the entire sampled area between March and late September. Significantly positive anomalies occurred over the shelf from January through March and over much of the shelf in June. These coincided with warmer than normal air temperatures beginning in December 1996 (National Climatic Data Center, 1997). Annual means of bottom temperature on the continental shelf averaged 0.4°C above the 1978-92 baseline (Table 1).

Gulf of Maine

Surface Temperature: Surface temperatures ranged from less than 3°C over the Scotian Shelf during late March and into April to greater than 19°C in the region of the Wilkinson Basin and central Gulf Ledges during late July and into August (Fig. 5). Positive anomalies occurred from Wilkinson Basin out to Crowell Basin from late May into August with a continuation into October over Crowell Basin. These follow the higher than normal air temperature weather pattern for the New England area mentioned above (National Climatic Data Center 1996). For the transect as a whole, surface temperatures averaged 9.0°C, or 0.1°C warmer than 1978-1992 means (Table 2).

Bottom Temperatures: The relationship between bathymetry and reference distance is shown in Fig. 7B. Annual minimum bottom temperatures for the transect of less than 5°C occurred over the central Gulf ledges during the April-May period. Equally low temperatures also were observed in the March-April period at the Scotian Shelf or eastern end of the transect (Fig. 6). Maximum bottom temperatures occurred in the Crowell Basin region during March and again for a more extended period in May through August. Positive anomalies reaching in excess of 2°C occurred over the Scotian Shelf beginning in January and continued through February. Additional warmer than normal conditions were observed from May in Crowell Basin, expanding into the central Gulf ledges region, and expanded westward farther to include Wilkinson Basin from July through the October period. For the transect as a whole, bottom temperatures in the Gulf of Maine decreased from the base line temperatures of 6.8°C by -0.6°C (Table 2).

Acknowledgments

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Table 1. Water temperatures (^{o}C) and surface salinities (PSU) for the Middle Atlantic Bight transect.

	1997 MEAN	1978-1992 MEAN	1997 ANOMALY
Surface temperature	15.5	17.1	-1.6
Continental Shelf Portion	13.0	13.4	-0.4
Bottom temperature	9.7	9.3	0.4
Surface salinity	33.27	34.03	-0.76
Continental Shelf Portion	31.57	32.20	-0.63

Table 2. Water temperatures (^{o}C) and surface salinities (PSU) for the Gulf of Maine transect.

	1997 MEAN	1978-1992 MEAN	1997 ANOMALY
Surface temperature	9.0	9.1	-0.1
Bottom temperature	6.2	6.8	-0.6

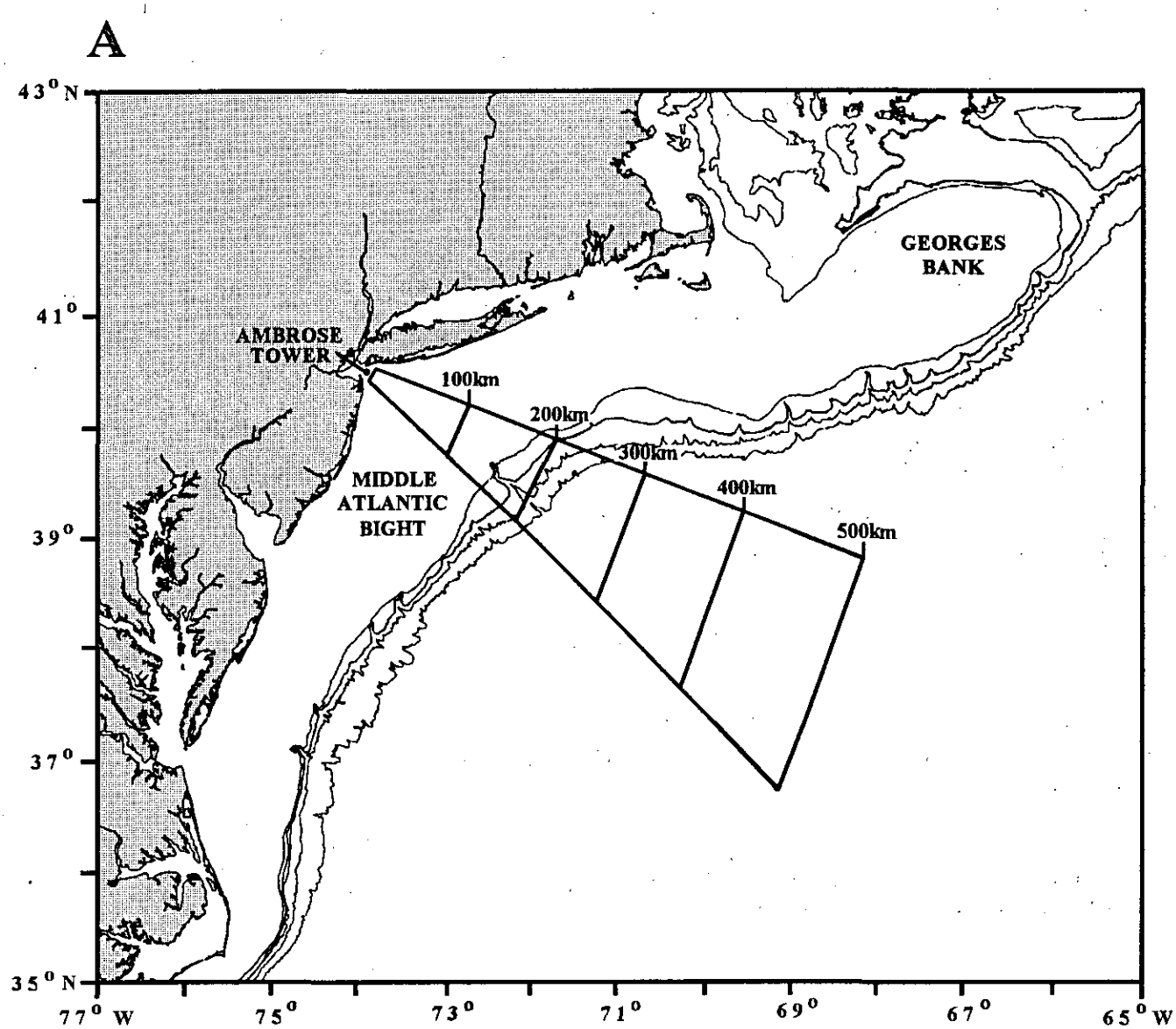


Fig. 1A. The Middle Atlantic Bight - Route MB polygon within which monitoring transects occurred, showing reference distances, location of Ambrose Tower, and major geographical features.

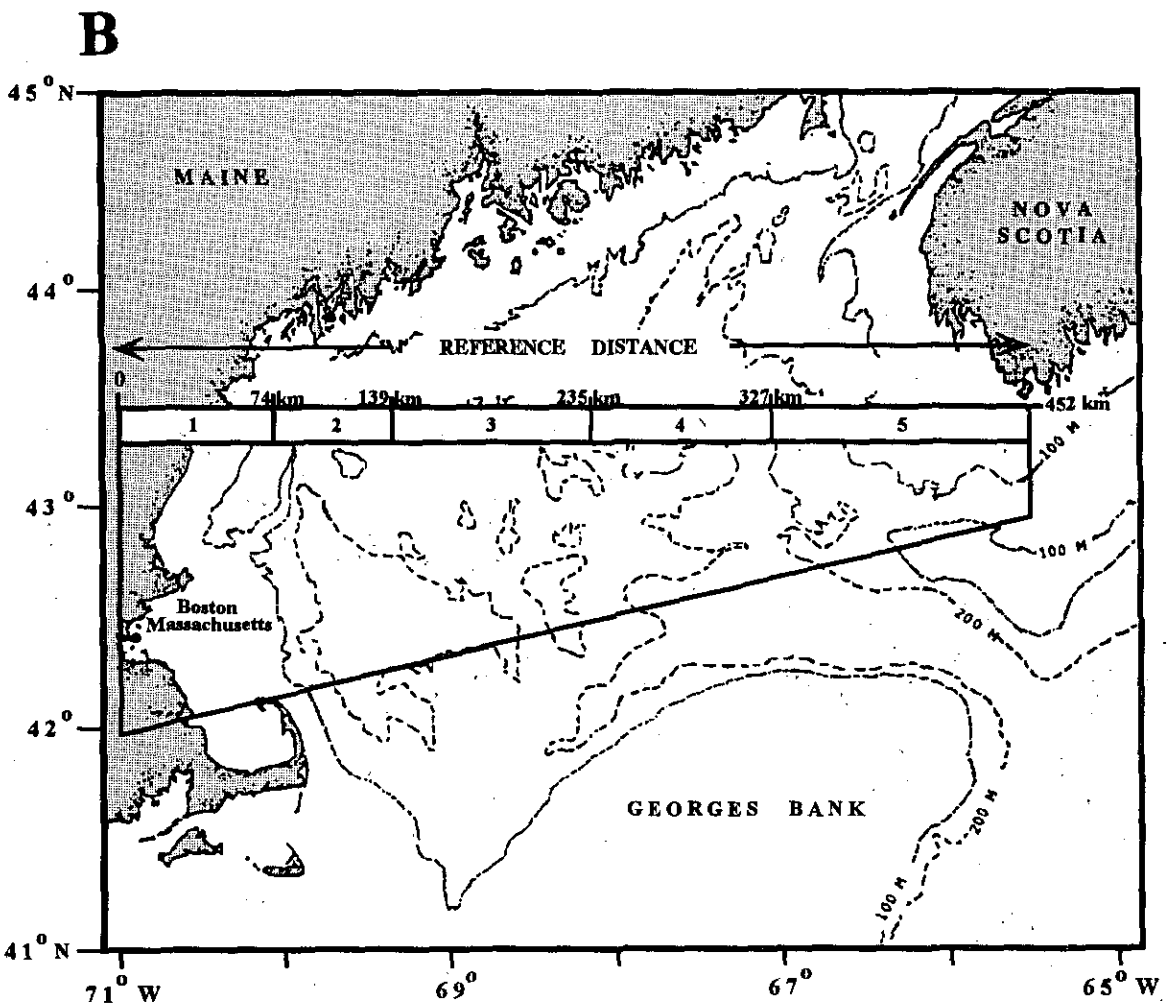


Fig. 1B. The Gulf of Maine - route MC polygon, within which monitoring transects occurred, showing reference distances of the following: 1 = Massachusetts Bay, 2 = Wilikinson Basin, 3 = central Gulf ledges, 4 = Crowell Basin, 5 = Scotian Shelf, and major geographical features.

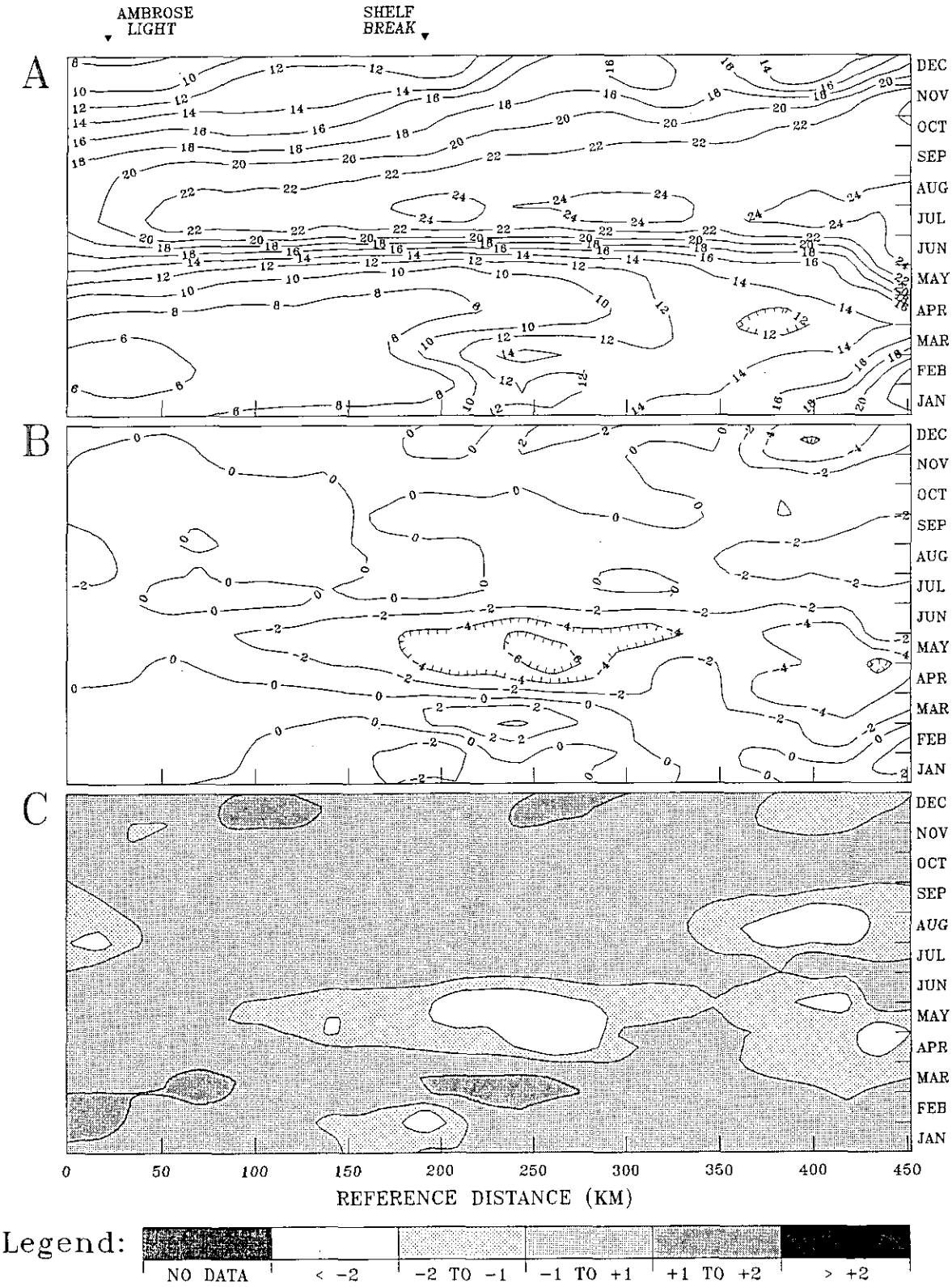


Fig. 2. Surface temperature conditions along the Middle Atlantic Bight transect during 1997. A. Measured values (degrees centigrade) in time and space. B. Anomalies in time and space based on 1978 through 1992 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1992 means and variances; scale given in legend. In panels A and B values decline on those sides of contour lines with hachures.

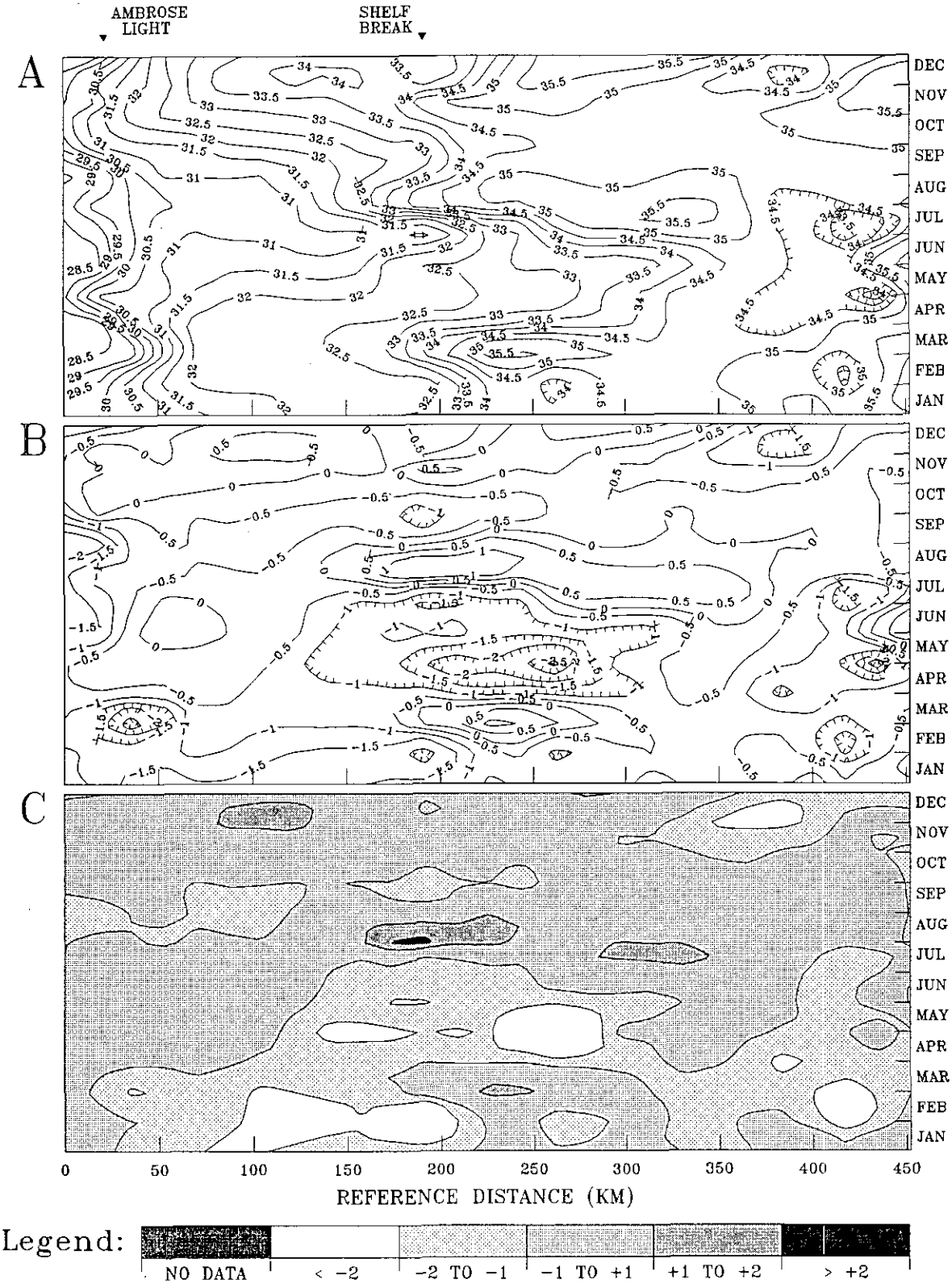


Fig. 3. Surface salinity conditions along the Middle Atlantic Bight transect during 1997. A. Measured values (practical salinity units) in time and space. B. Anomalies in time and space based on 1978 through 1992 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1992 means and variances; scale given in legend. In panels A and B values decline on those sides of contour lines with hachures.

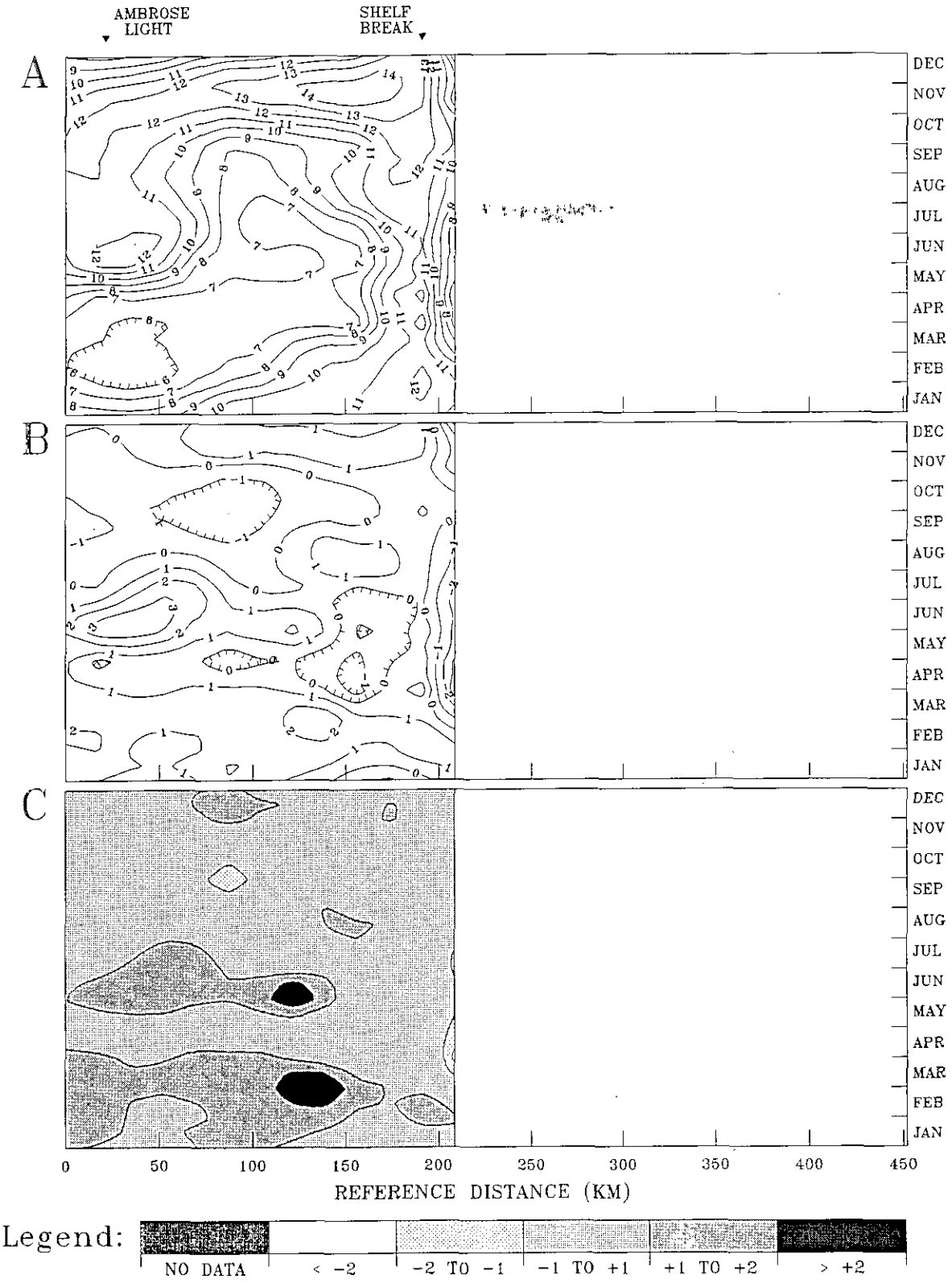


Fig. 4. Bottom temperature conditions along the Middle Atlantic Bight transect during 1997. A. Measured values (degrees centigrade) in time and space. B. Anomalies in time and space based on 1978 through 1992 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1992 means and variances; scale given in legend. In panels A and B values decline on those sides of contour lines with hachures.

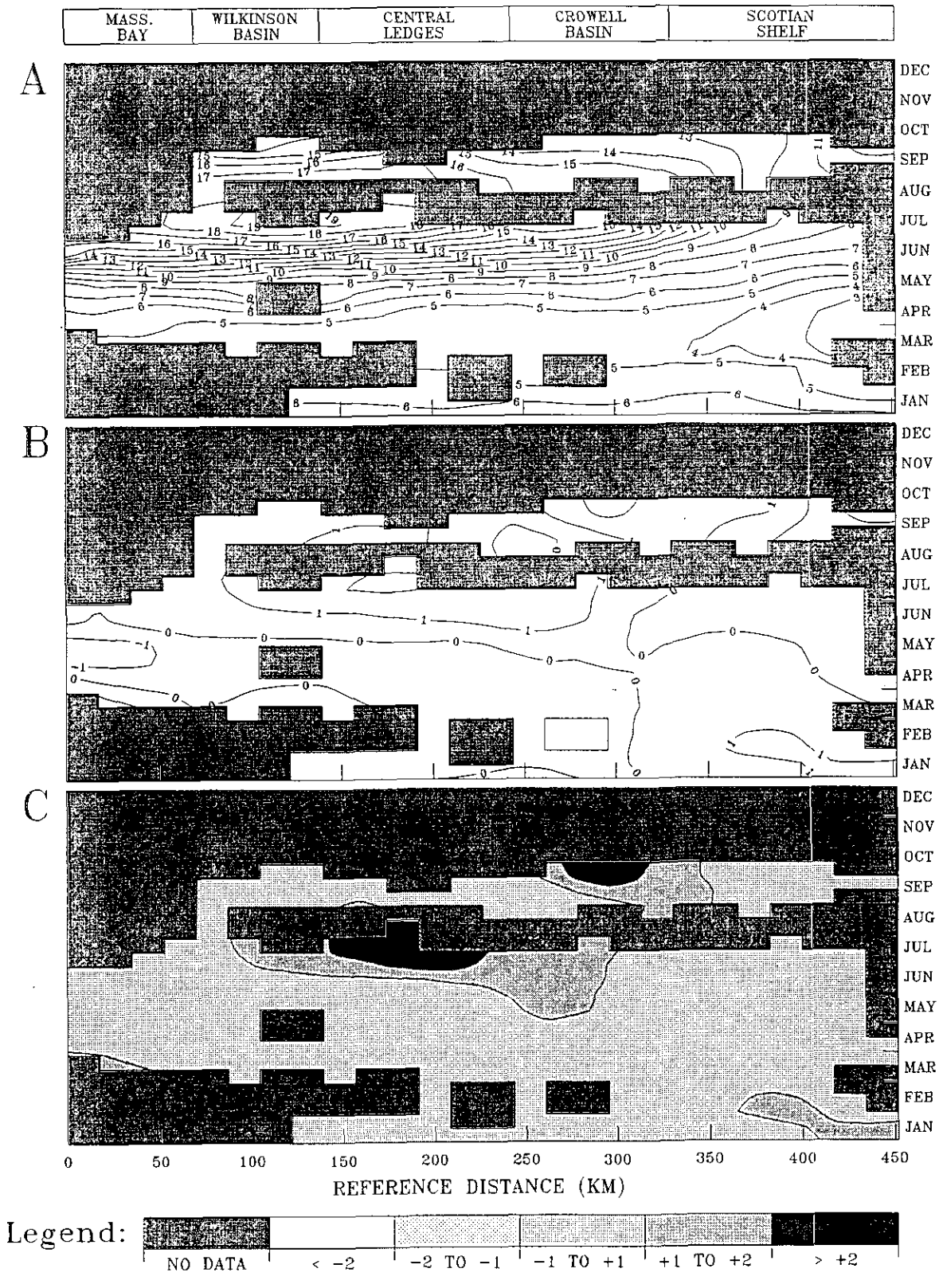
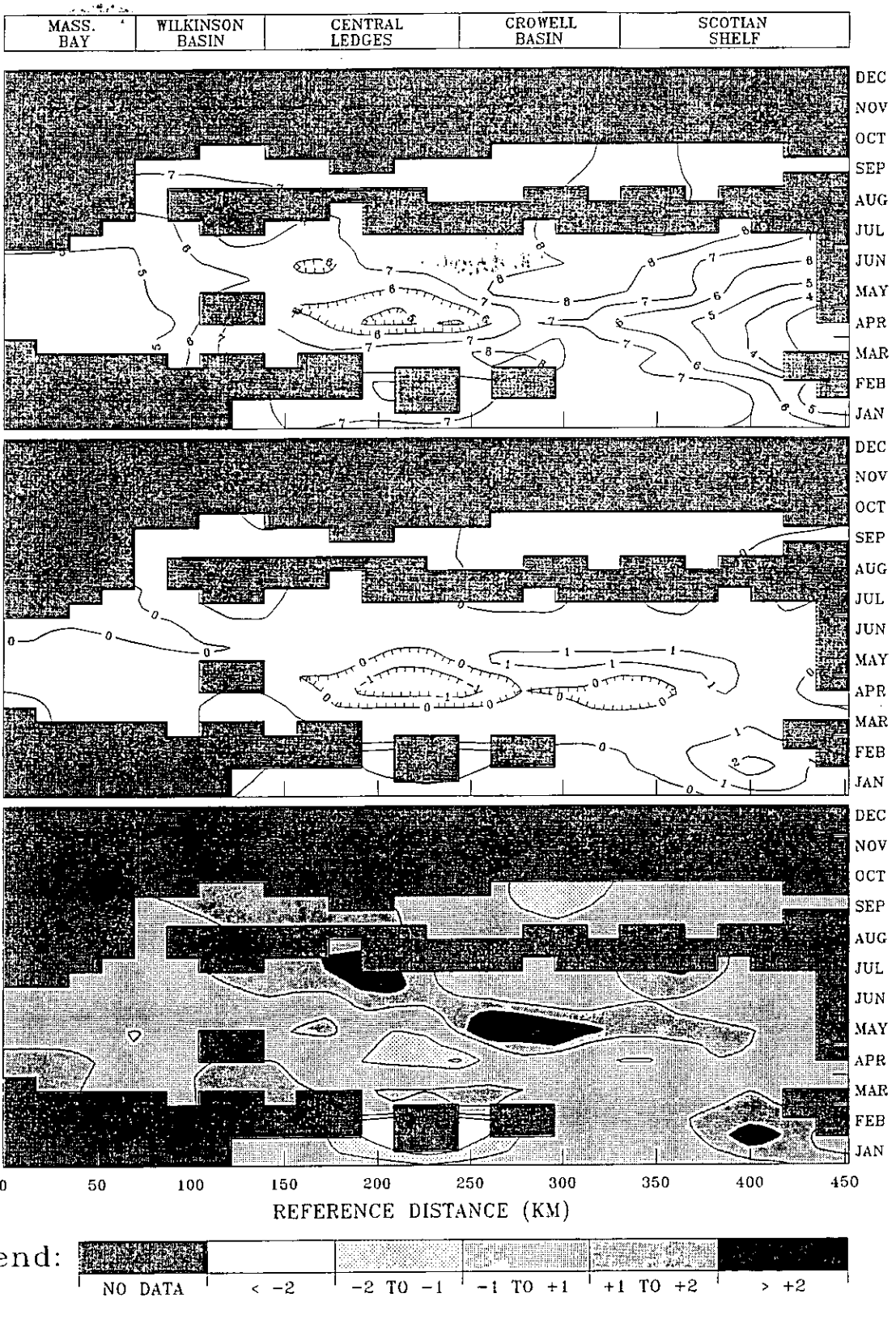


Fig. 5. Surface temperature conditions along the Gulf of Maine transect during 1997. A. Measured values (degrees centigrade) in time and space. B. Anomalies in time and space based on 1978 through 1992 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1992 means and variances; scale given in legend. In panels A and B values decline on those sides of contour lines with hachures.



Bottom Temperature conditions along the Gulf of Maine transect during 1997. A. Measured values (degrees centigrade) in time and space. B. Anomalies in time and space based on 1978 through 1992 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1992 means and variances; scale given in legend. In panels A and B values decline on those sides of contour lines with hachures.

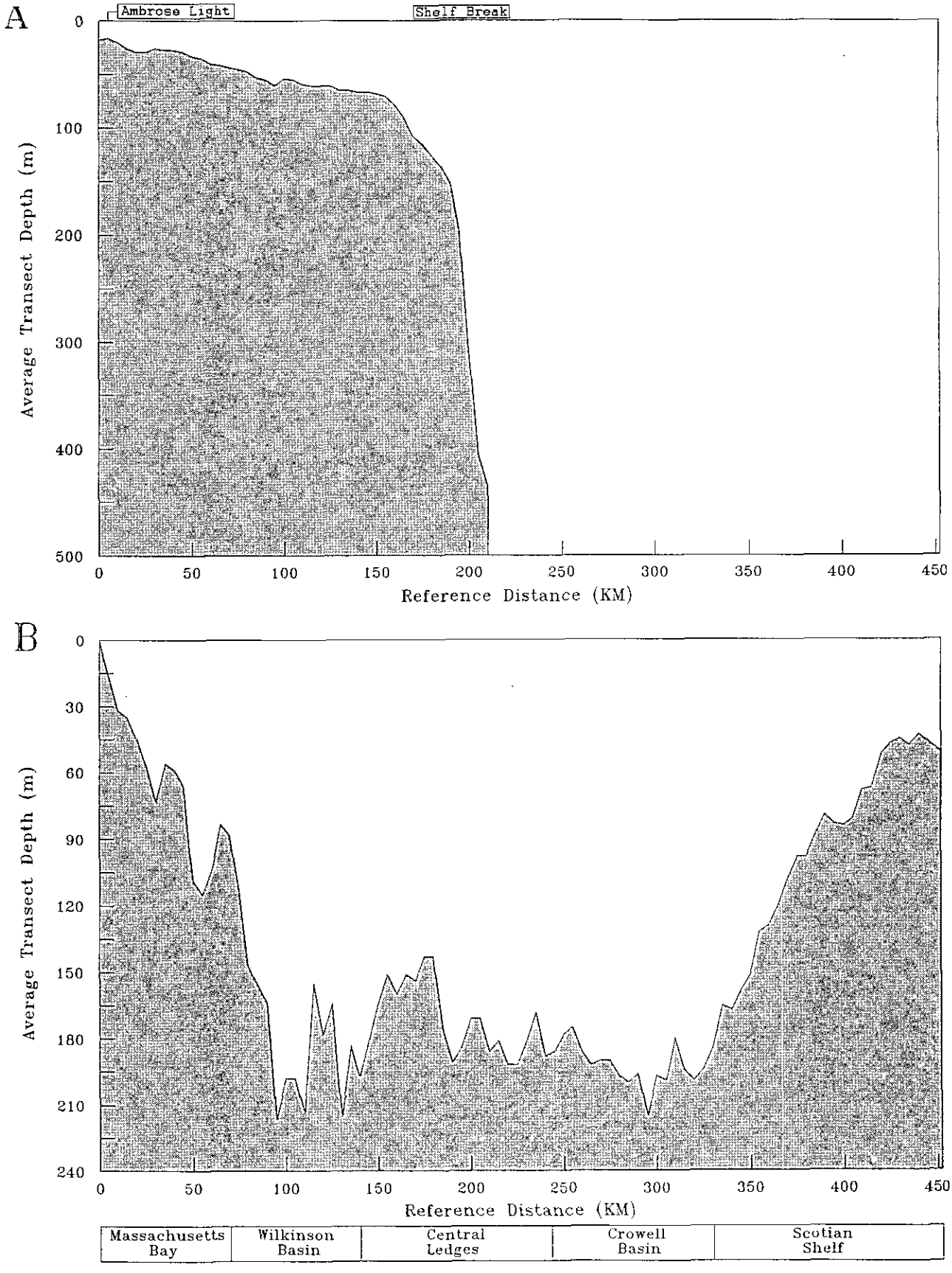


Fig. 7. Mean bottom depth along the transects based on monitoring survey data, 1978 through 1992. A. Middle Atlantic Bight. B. Gulf of Maine.