Northwest Atlantic Fisheries Organization

Serial No. N2678

NAFO SCR Doc. 96/11

SCIENTIFIC COUNCIL MEETING - JUNE 1996

Surface and Bottom Temperatures, and Surface Salinities: New York to the Gulf Stream, Massachusetts to Cape Sable N.S. 1995

by

Robert L. Benway[1], and Jack W. Jossi[1]

[1] Oceanography Branch, Northeast Fisheries Science Center, NOAA/NMFS, 28 Tarzwell Dr., Narragansett, RI 02882, USA

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 for twenty and nineteen years, respectively. Water temperature and salinity patterns observed in 1995 are compared to 1978 through 1992 means within a time-space matrix. Surface temperatures along both transects and averaged over all of 1995 were 0.5°C above the 1978-1992 mean. Annual mean bottom temperatures were 1.6°C warmer over the shelf portion of the MAB transect, and 0.4°C warmer along the GOM transect. No surface salinity samples were collected in the GOM for 1995 although thermal salinograph data were collected but are still undergoing calibration methodology. In the MAB, average 1995 surface salinity was 0.29 psu above the 15 year base period.

In the more detailed time-space sense surface temperatures over the outershelf of the MAB were significantly higher than average from January through mid-March, during July and August over the entire transect, and in October nearshore. Surface temperatures over most of the Gulf of Maine were significantly above average during September and October, reaching highly significant departures on the Scotian Shelf. Highly significant surface salinities occurred over the outer shelf of the MAB during the first half of 1995 and well offshore in July. Bottom temperatures over the MAB continental shelf were significantly warmer than average with highly significant departures nearshore in January and February, and over the mid-shelf in March and April. Over the Scotian Shelf in the GOM, bottom temperatures were colder than normal from January through early August. The central Gulf also was colder than average from March to May. Above average bottom temperatures prevailed over the remainder of the central and western GOM during the year, reaching highly significant departures, especially, over Crowell Basin.

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 1977 (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 1995 and describes their departures from average conditions for the fifteen-year period, 1978 through 1992.

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 effects the definition of the data reported here as "surface" temperature. What is 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 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 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 griding 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- 2) were obtained by 1) 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 the Gulf of Maine transects are presented as contoured time-space plots (Fig. 2-6). No surface salinity data however are presented for the Gulf of Maine. Portrayed are the conditions during 1995, and departure of these conditions from the 1978 through 1992 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 only the continental shelf (to approximately 200 km reference distance), because more offshore bottom depths exceed sampling depth of the expendable bathythermographs employed.

Discussion

Middle Atlantic Bight

Surface Temperature: Surface temperatures during 1995 ranged from less than 5°C in the near-shore waters in February and March to greater than 28°C at the extreme off-shore end of the transect during July and August (Fig. 2). In 1995 annual minimum temperatures occurred over the entire transect in February, approximately a month earlier than the 15-year base period. Particularly inshore, 1995 began with 2°C warmer than average temperatures a carryover from 1994's milder winter, but by year's end had returned to average conditions. During January and continuing through April, surface temperatures in general across the shelf, slope and offshore waters were as much as 4°C warmer than average. This above average condition recurred in late July through early September. These warm temperatures were driven by much higher than normal air temperatures throughout June and continuing into early October (National Climatic Data Center, 1995). Surface temperatures for the year for the transect as a whole were 0.5°C higher than the 1978-1992 means (Table 1).

Surface Salinity: Salinities in the Middle Atlantic Bight for 1995 ranged from a low of less than 30.0 psu near-shore in April to greater than 36.5 psu at the off-shore end of the transect for the entire year (Fig. 3). Salinity values during the Northeast river discharge periods showed a drop in runoff from previous years in the March, April time frame and was almost undetectable during the fall runoff period. Significantly higher than normal salinities occurred inshore ($> +4$ psu) and over the outer shelf ($> +2$ psu) between January and April. Similar departures were observed during the May June period off-shore of the shelf break ($> +2.5$ psu) due the persistence of a warm core ring; and during June, July and August in the off-shore waters ($> +1$ psu) as a result the migration shoreward of the Gulf Stream. Below average salinities were detected starting in December in the near-shore waters. Surface salinity in 1995 for the transect as a whole was 0.29 psu higher than average (Table 1).

Bottom Temperature: The relationship between bottom relief and reference distance is portrayed in Fig. 7a, showing that bottom depth was beyond sampling depth (500 m) seaward of about 210 km reference distance. Bottom temperatures ranged from less than 6°C from mid-March to mid-April in the nearshore to greater than 18°C also in the near-shore during October. Degradation of the stratified condition began during mid-September and was nearly completed on the shelf by November. This earlier than normal fall overturn produced above average bottom temperatures during this period. Near normal conditions were observed during late November through December over most of the inner shelf. Annual means of bottom temperature on the continental shelf averaged 1.6°C above the 1978-1992 baseline (Table 1).

Gulf of Maine

Surface Temperature: Surface temperatures ranged from less than 1.0°C on the Scotian Shelf end of the transect in early February into early March to higher than 21°C over Wilkinson Basin in July (Fig. 5). Significant positive anomalies occurred over much of the transect during September and October, exceeding the 1978-1992 mean by more than 1°C. Highly significant negative anomalies occurred over the Scotian Shelf January through March. Positive anomalies amounting to more than 1°C occurred over Wilkinson Basin, the central Gulf ledges, and Crowell Basin during July. For the transect as a whole, surface temperatures averaged 9.4°C, or 0.5°C warmer than 1978-1992 means (Table 2).

Bottom Temperatures: The relationship between bathymetry and reference distance is shown in Fig. 7b. Annual minimum temperatures for the transect of less than 1°C occurred over the Scotian Shelf during February, and of less than 5°C over Massachusetts Bay from March to May (Fig. 6). Maximum bottom temperatures occurred over the outer Scotian Shelf in November. Negative anomalies in excess of 1°C occurred from February thru April over the Central Gulf Ledges. Negative departures reaching in excess of 2°C and 2 standard deviations occurred over the Scotian Shelf from February to April. Warm water in Crowell Basin persisted from January through June with highly significant anomalies during that period. Annual mean

bottom temperatures exceeded the baseline temperature of 6.7°C for 1995 by 0.4°C (Table 2).

Acknowledgements

Appreciation is extended to the officers and crews of the C/V Oleander, Bermuda Container Lines, and the C/V Skogafoss, Skogaline Ltd, St. John, Antigua for their generous cooperation in the continued success 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 Ocean Observations, for their continued support.

References

Benway, R. L., J. W. Jossi, and K. P. Thomas. 1993. Variability of temperature and salinity in the Middle Atlantic Bight and Gulf of Maine 1978-1990. U.S. Department of Commerce, NOAA Technical Report, NMFS, 112, 108 p.

Sherman, K., M. Grosslein, D. Mountain, D. Busch, J. O'Reilly, and R. Theroux. 1988. The continental shelf ecosystem off the northeast coast of the United States. Chapter 9., pp. 279-337. In H. Postma and J.J. Zijlstra (Eds.) Ecosystems of the World 27--Continental Shelves. Elsevier, Amsterdam.

National Climatic Data Center. 1995. Local climatological data monthly summary. [Boston, Providence, and JFK Airport-June through October].

TABLE 1. Water temperature (°C) and surface salinity (psu) for the Middle Atlantic Bight transect.

	1995 MEAN	1978-1992 MEAN	1995 ANOMALY
Surface temperature	17.6	17.1	0.5
Bottom temperature	9.9	8.3	1.6
Surface salinity	34.32	34.03	0.29

TABLE 2. Water temperature (°C) and surface salinity (psu) for the Gulf of Maine transect.

	1995 MEAN	1978-1992 MEAN	1995 ANOMALY
Surface temperature	9.4	8.9	0.5
Bottom temperature	7.1	6.7	0.4
Surface salinity	No Samples Collected		

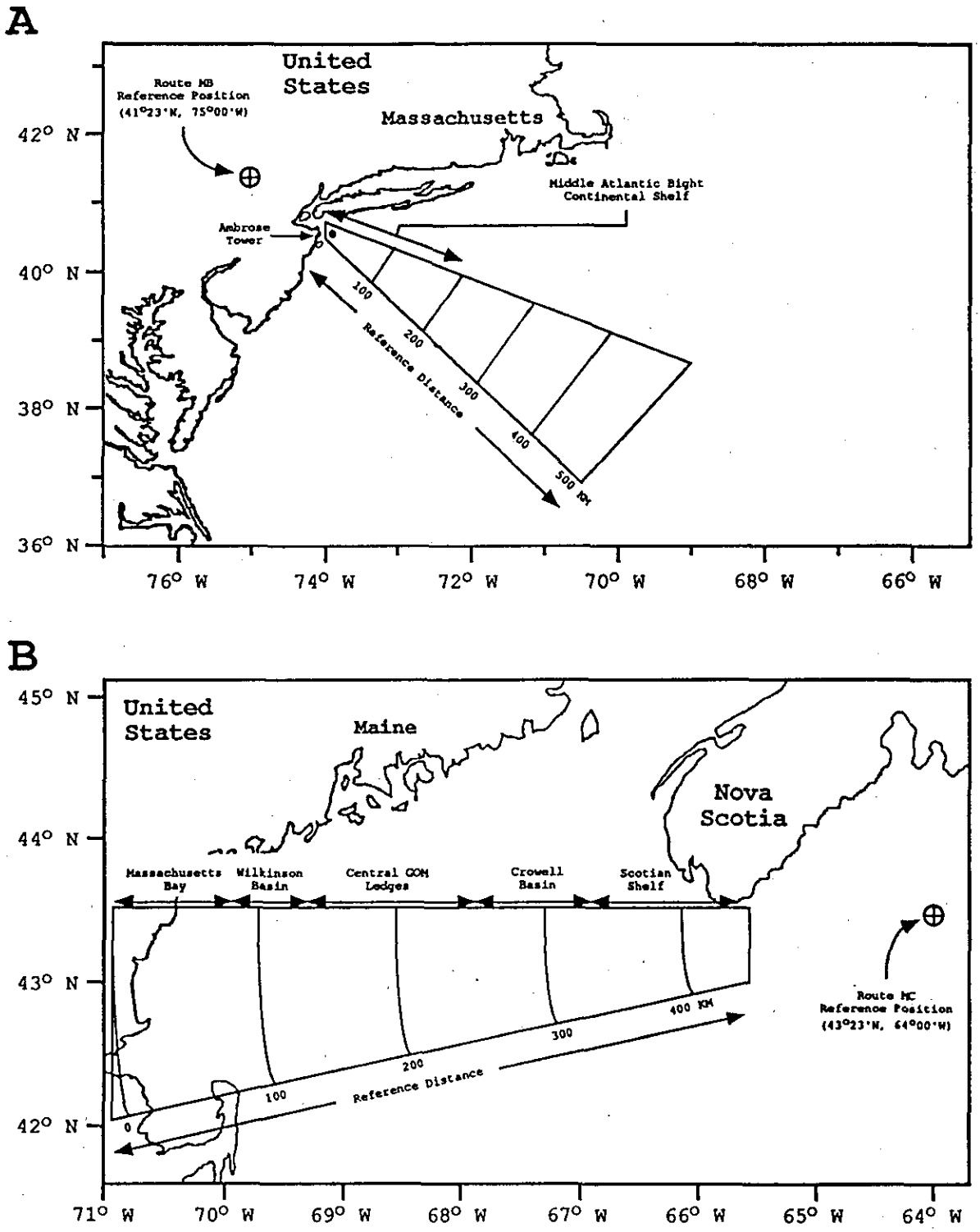

Fig. 1. The (A) Middle Atlantic Bight (MAB)-Route MB, and (B) Gulf of Maine (GOM)-route MC polygons, within which monitoring transects occurred, showing reference positions and distances, location of Ambrose Tower, and major geographical features through which all sampling took place.

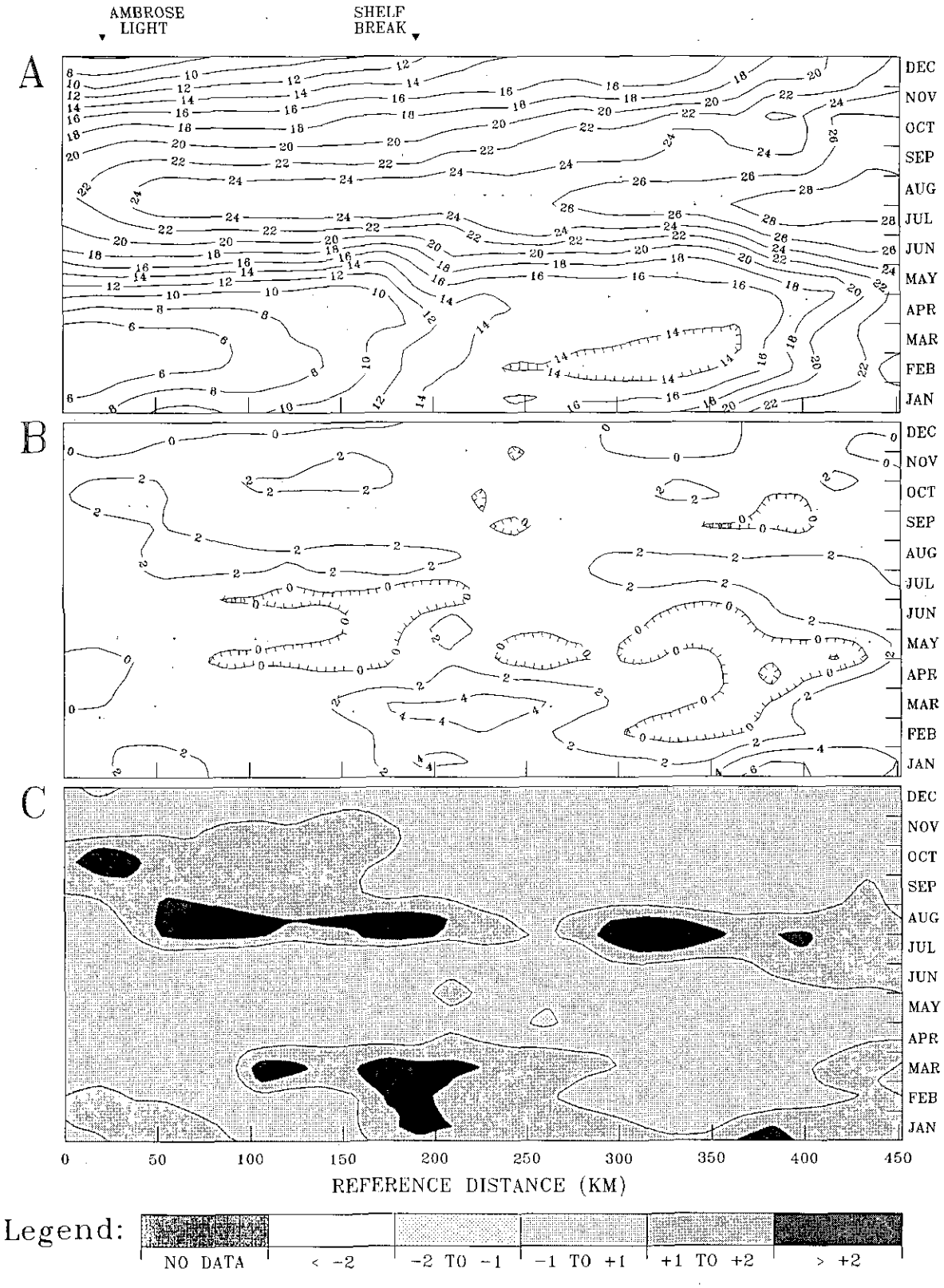

Fig. 2. Surface temperature conditions along the Middle Atlantic Bight transect during 1995. A. Measured values (degrees centigrade) in time and space. B. Anomalies in time and space based on 1978 through 1992 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1992 means and variances; scale given in legend. In panels A and B values decline on those sides of contour lines with hachures.

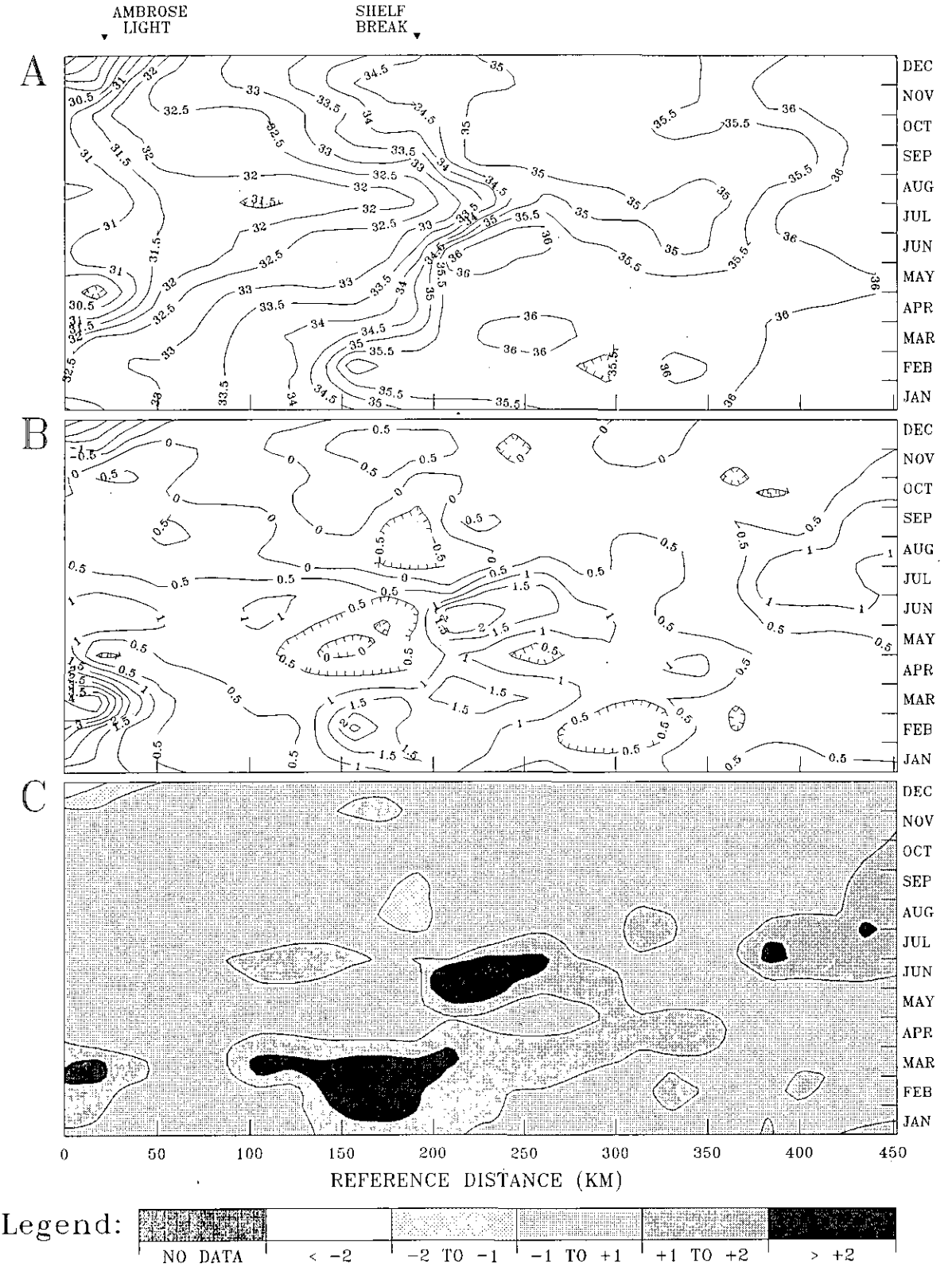

Fig. 3. Surface salinity conditions along the Middle Atlantic Bight transect during 1995. A. Measured values (practical salinity units) in time and space. B. Anomalies in time and space based on 1978 through 1992 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1992 means and variances; scale given in legend. In panels A and B values decline on those sides of contour lines with hachures.

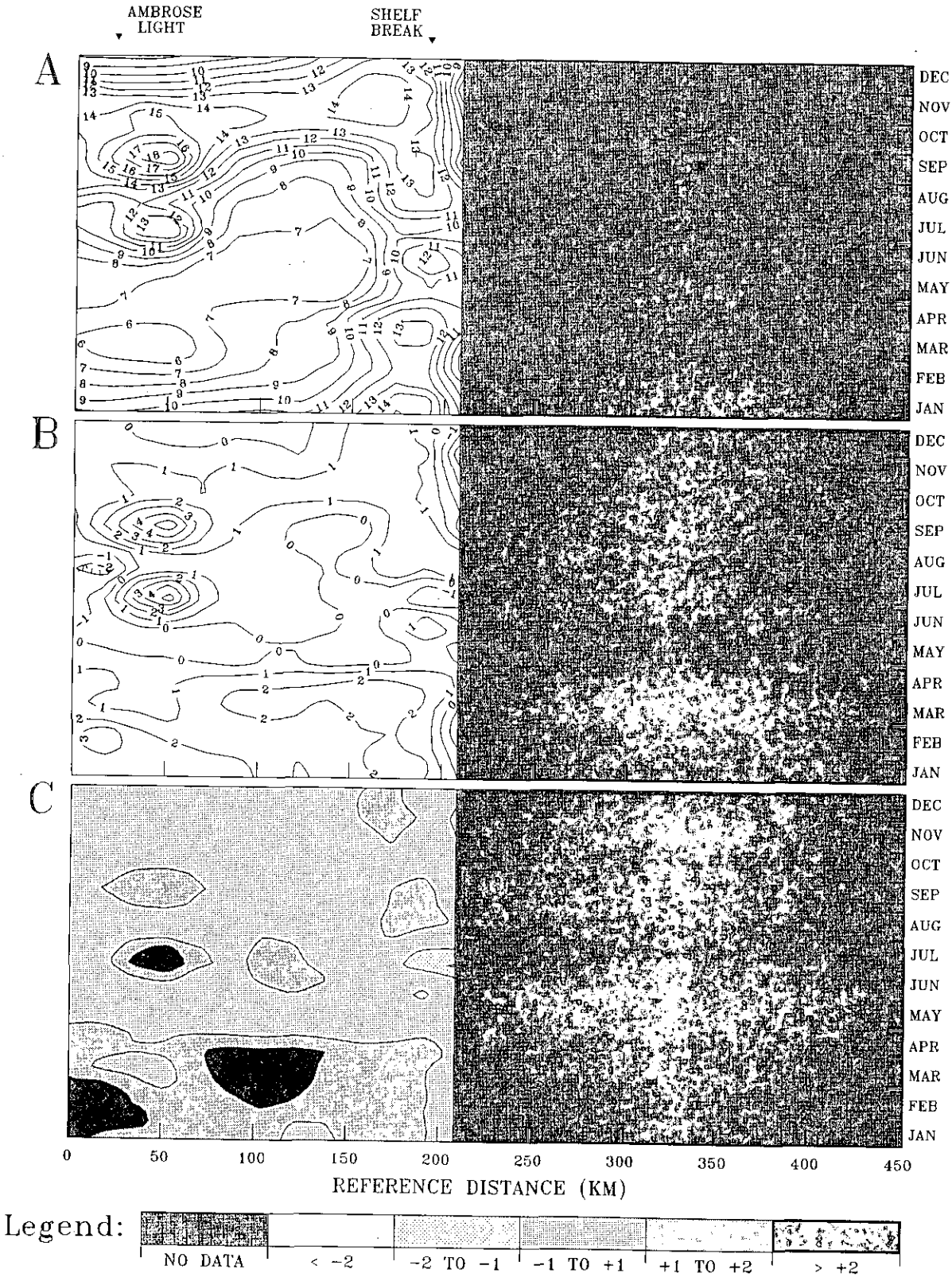

Fig. 4. Bottom temperature conditions along the Middle Atlantic Bight transect during 1995. A. Measured values (degrees centigrade) in time and space. B. Anomalies in time and space based on 1978 through 1992 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1992 means and variances; scale given in legend. In panels A and B values decline on those sides of contour lines with hachures.

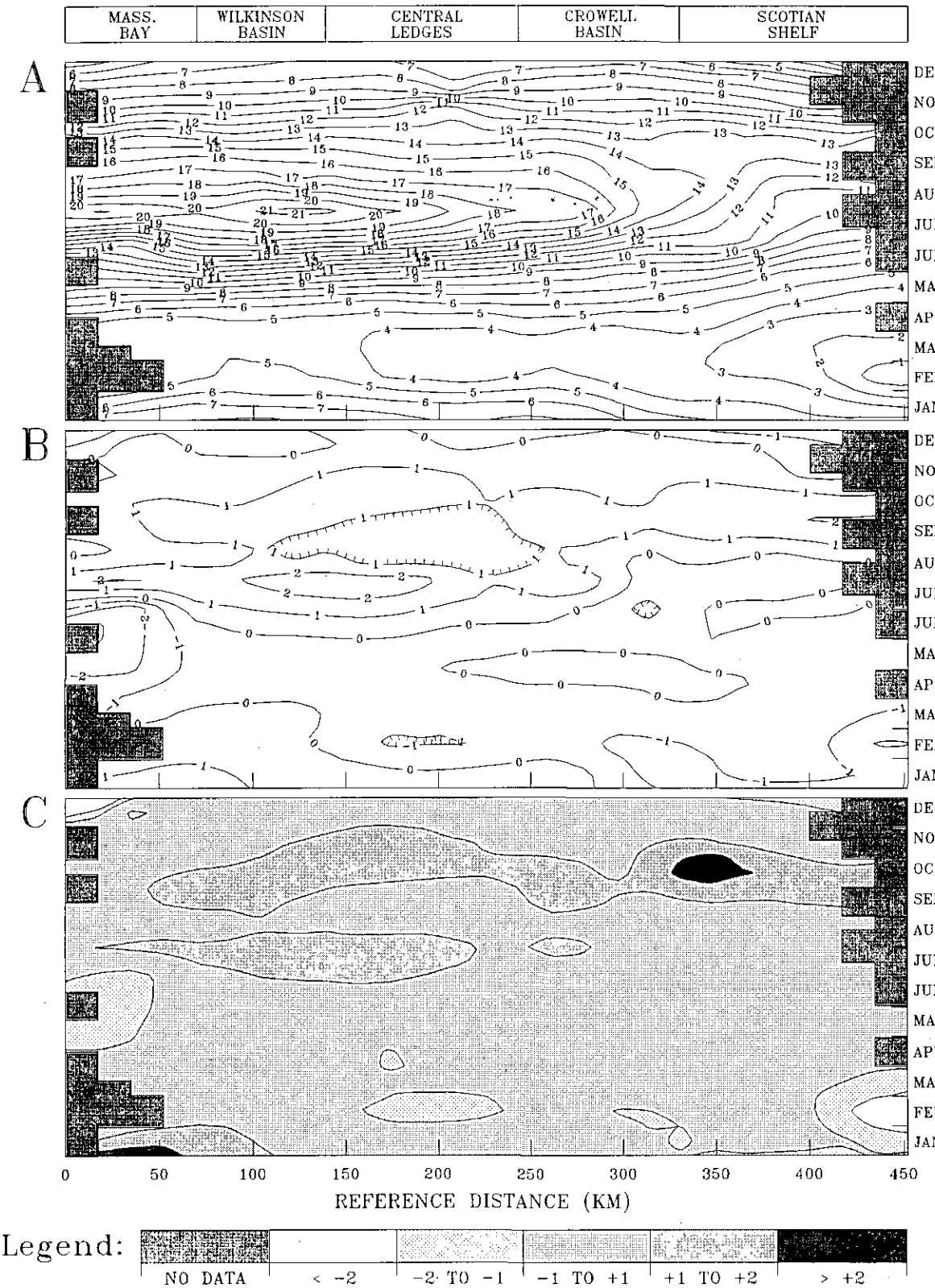

Fig. 5. Surface temperature conditions along the Gulf of Maine transect during 1995. A. Measured values (degrees centigrade) in time and space. B. Anomalies in time and space based on 1978 through 1992 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1992 means and variances; scale given in legend. In panels A and B values decline on those sides of contour lines with hachures.

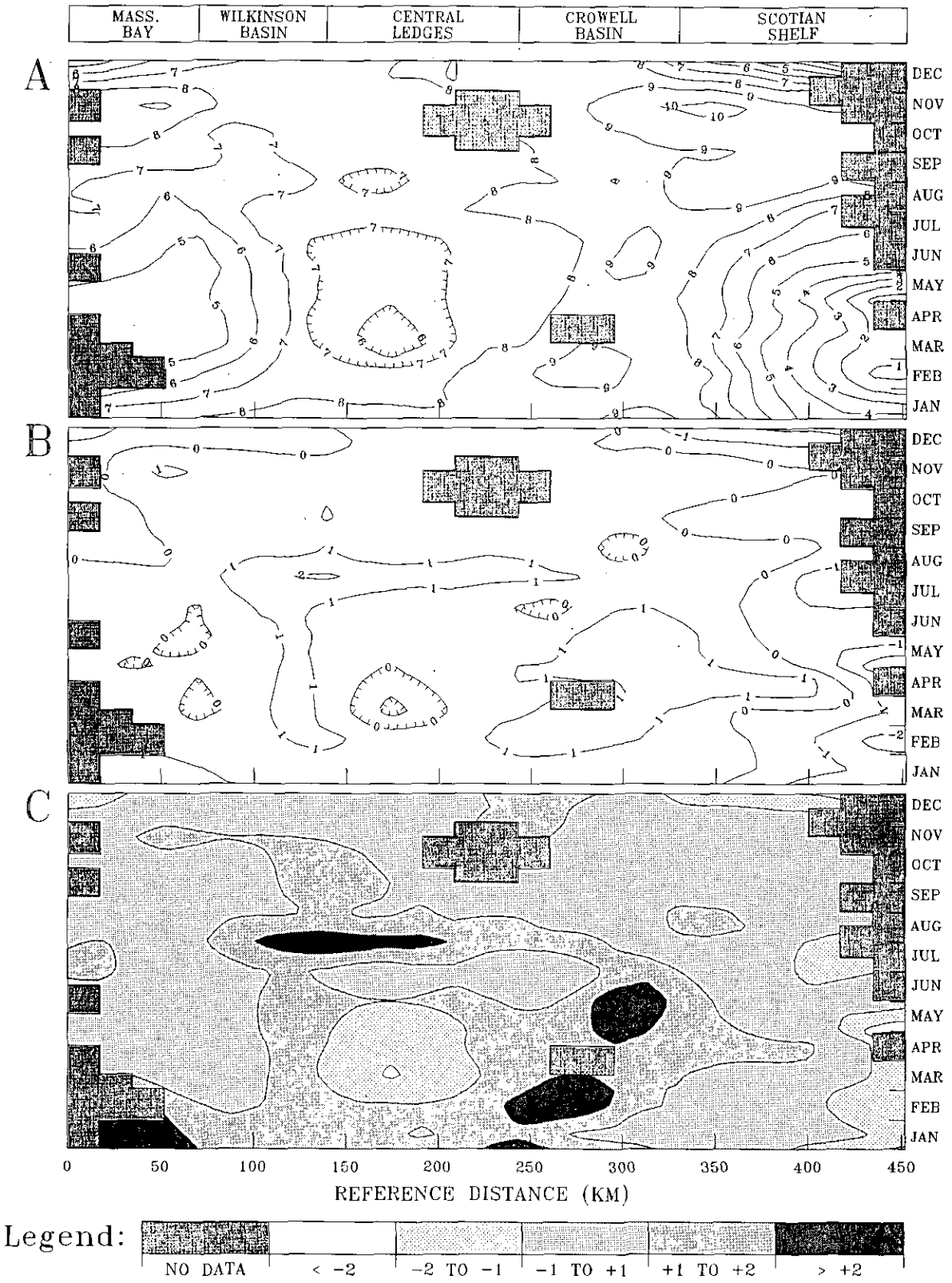

Fig. 6. Bottom temperature conditions along the Gulf of Maine transect during 1995. A. Measured values (degrees centigrade) in time and space. B. Anomalies in time and space based on 1978 through 1992 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1992 means and variances; scale given in legend. In panels A and B values decline on those sides of contour lines with hachures.

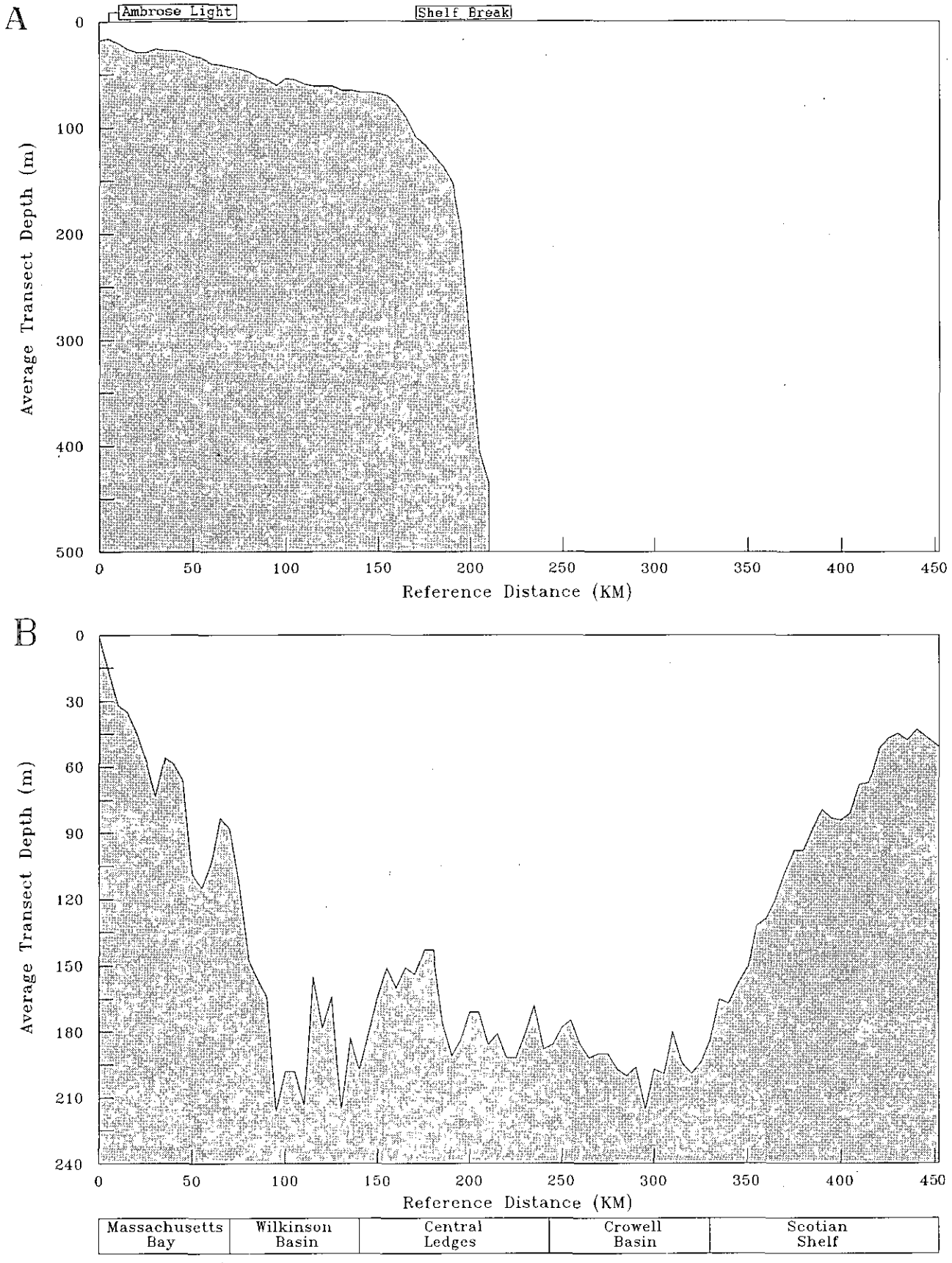

Fig. 7. Mean bottom depth along the transects based on monitoring survey data, 1978 through 1992. A. Middle Atlantic Bight. B. Gulf of Maine.