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Surface and Bottom Temperatures, and Surface Salinities: New York to the Gulf Stream, Massachusetts to Cape Sable N.S. 1991

by

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Abstract

Monthly monitoring of surface and water column temperature, and surface salinity across the Middle Atlantic Bight and Gulf of Maine has been conducted for sixteen and fifteen years, respectively. Water temperature and salinity patterns observed in 1991 are compared to 1978 through 1991 means within a time-space matrix. Sea surface temperatures in the Middle Atlantic Bight during 1991 were generally warmer than the fourteen-year (1978-1991) means, averaging 1°C warmer for the year. In the Gulf of Maine January through April surface temperatures were near normal, May through September above normal, and the autumn cooler than average, especially over the western portion. Surface salinities in the Middle Atlantic Bight were near average for the year, with the exception of high values at Ambrose Light in February and March, and offshore in the fall. The Gulf of Maine surface salinities averaged 0.122‰ below baseline during 1991. Bottom temperatures in the Middle Atlantic Bight were warmer than average during January through April and for November and December, but cooler than the long-term mean conditions in September, amounting to 0.1°C below average for the entire transect during 1991. Over the Scotian Shelf in the Gulf of Maine, bottom temperatures were colder than normal from June to September, and generally warmer than average in the area of Massachusetts Bay at the time of fall overturn (October-November). For the Gulf of Maine transect as a whole, bottom temperatures were 0.3°C above the baseline in 1991.

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). Merchant and other ships of opportunity regularly pass along these transects and make the measurements. These measurements are made to monitor changes in the state of 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 are summarized in Jossi and Benway (1990). This report presents surface temperature and salinity, and bottom temperature conditions along the Middle Atlantic Bight and Gulf of Maine transects during 1991 and describes their departures from average conditions for the fourteen-year period, 1978 through 1991.

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.

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) in Washington D.C.

Methods for generating standardized time-space matrices are described in Benway *et al.* (Ms). 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 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 anomaly map; and 7) dividing the anomaly map by the standard deviation map to obtain a standardized anomaly map. Annual means and departures for geographical sections of the transects (Tables 1-6) were obtained by 1) subsetting geographical section values from the single-year map, the mean map, and the standard deviation map; 2) calculating the 1991 mean for the single-year subset; 3) calculating the 1978-1991 mean for the base period subset; 4) obtaining the 1991 anomaly by subtracting the base period from the 1991 subset; and 5) standardizing each anomaly value for 1991 by dividing it by appropriate standard deviation subset.

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. 2-7). Portrayed are the conditions during 1991, and the departure of these conditions from the 1978 through 1991 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.

Annual means and departures of these variables for geographical sections and for the transects as a whole are presented in Tables 1-6.

Discussion

Middle Atlantic Bight

Surface Temperature: Surface temperatures during the year ranged from less than 6°C in the nearshore waters in March to greater than 28°C offshore during mid-August (Fig. 2). In 1991 annual minimum temperatures occurred over the entire transect in March, slightly later than normal. Except for a cold event near Deep

Water Dumpsite 106 in February and another offshore in April, the transect was dominated by warmer than average temperatures during the first half of 1991. Offshore during late May and again in October and December, migration of the north wall of the Gulf Stream accounted for surface temperatures nearly 5°C warmer than normal. During December at the DWD 106 location, the passage of a warm core ring resulted in temperatures more than 4°C warmer than normal. Between these two events in the waters offshore of the shelf break, cooling occurred during late August. This was associated with the passage of Hurricane Bob and another warm core ring. Surface temperatures at the time of fall overturn, which occurred in mid-November, were about average. Surface temperatures for the year on the continental shelf averaged 1.1°C above the 1978-1991 baseline; those over the Dumpsite 106 were 0.4°C above average; and those for the transect as a whole were 1.0°C higher than the baseline (Table 1).

Surface Salinity: Salinities in the Middle Atlantic Bight ranged from a low of 25.0‰ nearshore in May to greater than 37.0‰ at the offshore end of the transect in October and November (Fig. 3). Above average salinities were detected in late January through March within the apex of the New York Bight. Inshore migration of the Gulf Stream during October through December was responsible for in the higher than normal surface salinity conditions. Over most of the transect for the rest of the year, salinities were generally near average. Surface salinity over the continental shelf averaged 0.033‰ above the 1978-1991 baseline; over the Dumpsite 0.130‰ below average; and for the transect as a whole 0.010‰ higher than average (Table 2).

Bottom Temperature: Bottom temperature conditions on the shelf and upper slope for 1991 are presented in Fig. 4. The relationship between bottom relief and reference distance is portrayed in Fig. 8A. Warmer than normal conditions prevailed over most of the shelf from January and continued through April until the onset of stratification. These warmer than normal bottom temperatures were associated with warmer than normal surface waters during that period. In September bottom temperatures were more than 1°C cooler than normal over most of the continental shelf. In 1991 fall overturn began in mid-November during which time bottom waters were generally warmer than average. Annual means of bottom temperature on the continental shelf averaged 0.6°C above the 1978-1991 baseline; at the dumpsite were 2.1°C below the baseline; and for the transect as a whole 0.1°C below average (Table 3).

Gulf of Maine

Surface Temperature: Surface temperatures ranged from 2.5°C on the Scotian Shelf end of the transect in late March to slightly higher than 20°C in Massachusetts Bay in August (Fig. 5). Warmer than average surface conditions in January over Massachusetts Bay coincided with the same warming period, though not to as great an extent, in the Middle Atlantic Bight. Across-transect positive anomalies occurred in late May and continued through mid-June. Positive anomalies persisted over Massachusetts Bay through August and into early September. Significant positive departures from the 1978-1991 means occurred over Crowell Basin during the period of early May to mid June. Negative departures occurred over Wilkinson Basin beginning in mid November into early December. This latter event occurred at the time of fall overturn. Annual means were higher than the baseline for all sections of the transect except the central Gulf ledges where temperatures were normal (Table 4). For the transect as a whole 1991 temperatures were 0.5°C above normal.

Surface Salinity: During 1991 salinities ranged from less than 30.00‰ in May in Massachusetts Bay to greater than 33.00‰ early in the year from Wilkinson Basin to half-way across Crowell Basin (Fig. 6). While salinities over most of the transect for approximately 83% of the time were near average, a notable negative departure occurred during the month of December over the entire transect west of the Scotian Shelf. Annual mean salinities were below the baseline for all sections of the transect (Table 5). For the transect as a whole salinities were 0.122‰ below average.

Bottom Temperatures: Annual minimum temperatures for the transect of less than 3°C occurred over the Scotian Shelf during March and April and this timing for the annual minimum appeared to be later than normal (Fig. 7). From June through August and extending over two thirds of the Scotian shelf, bottom temperatures were

more than 1°C cooler than average. This coincided with lower than normal surface salinity (Fig. 6) and warmer than normal surface temperature (Fig. 5). Maximum bottom temperatures, >10°C, occurred on the Scotian Shelf during the period mid-September to mid-October, and over Massachusetts Bay a month later. For reference, bottom relief along the transect is shown in Fig. 8B. Annual mean bottom temperatures were higher than the baseline for those sections of the transect west of the Scotian Shelf (Table 6). For the transect as a whole 1991 averaged 0.3°C above average.

Acknowledgements

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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.

Table 1. Surface Temperature Means and Departures during 1991 for sections of the Middle Atlantic Bight Transect.

SECTION	1991 MEAN (°C.)	1978-1991 MEAN (°C.)	1991 ANOMALY (°C.)	1991 ZSCORE (standard deviation)
Continental Shelf	14.7	13.6	+ 1.1	+ 0.92
DWDS 106	17.3	16.9	+ 0.4	+ 0.27
Entire Transect	17.5	16.5	+ 1.0	+ 0.65

Table 2. Surface Salinity Means and Departures during 1991 for sections of the Middle Atlantic Bight Transect.

SECTION	1991 MEAN (ppt.)	1978-1991 MEAN (ppt.)	1991 ANOMALY (ppt.)	1991 ZSCORE (standard deviation)
Continental Shelf	32.259	32.226	+0.033	+0.08
DWDS 106	34.349	34.479	-0.130	-0.11
Entire Transect	33.822	33.812	+0.010	+0.04

Table 3. Bottom Temperature Means and Departures during 1991 for sections of the Middle Atlantic Bight Transect.

SECTION	1991 MEAN (°C.)	1978-1991 MEAN (°C.)	1991 ANOMALY (°C.)	1991 ZSCORE (standard deviation)
Continental Shelf	9.9	9.3	+0.6	+0.60
DWDS 106	4.6	6.7	-2.1	-1.81
Entire Transect	8.8	8.9	-0.1	-0.02

Table 4. Surface Temperature Means and Departures during 1991 for sections of the Gulf of Maine Transect.

SECTION	1991 MEAN (°C.)	1978-1991 MEAN (°C.)	1991 ANOMALY (°C.)	1991 ZSCORE (standard deviation)
Massachusetts Bay	11.1	10.3	+ 0.8	+ 0.50
Wilkinson Basin	10.7	10.4	+ 0.3	+ 0.17
GOM Ledges	9.9	9.9	0.0	- 0.09
Crowell Basin	9.4	9.2	+ 0.2	+ 0.21
Scotian Shelf	7.6	7.3	+ 0.3	+ 0.15
Entire Transect	9.5	9.0	+ 0.5	+ 0.17

Table 5. Surface Salinity Means and Departures during 1991 for sections of the Gulf of Maine Transect.

SECTION	1991 MEAN (ppt.)	1978-1991 MEAN (ppt.)	1991 ANOMALY (ppt.)	1991 ZSCORE (standard deviation)
Massachusetts Bay	31.828	31.959	-0.131	-0.13
Wilkinson Basin	32.469	32.539	-0.070	-0.22
GOM Ledges	32.577	32.714	-0.137	-0.38
Crowell Basin	32.452	32.677	-0.225	-0.58
Scotian Shelf	32.004	32.239	-0.235	-0.54
Entire Transect	32.242	32.364	-0.122	-0.17

Table 6. Bottom Temperature Means and Departures during 1991 for sections of the Gulf of Maine Transect.

SECTION	1991 MEAN (°C.)	1978-1991 MEAN (°C.)	1991 ANOMALY (°C.)	1991 ZSCORE (standard deviation)
Massachusetts Bay	6.5	5.9	+0.6	+0.58
Wilkinson Basin	6.8	6.2	+0.6	+0.55
GOM Ledges	7.2	6.8	+0.4	+0.35
Crowell Basin	8.1	7.9	+0.2	+0.40
Scotian Shelf	6.6	6.9	-0.3	-0.37
Entire Transect	7.0	6.7	+0.3	+0.22

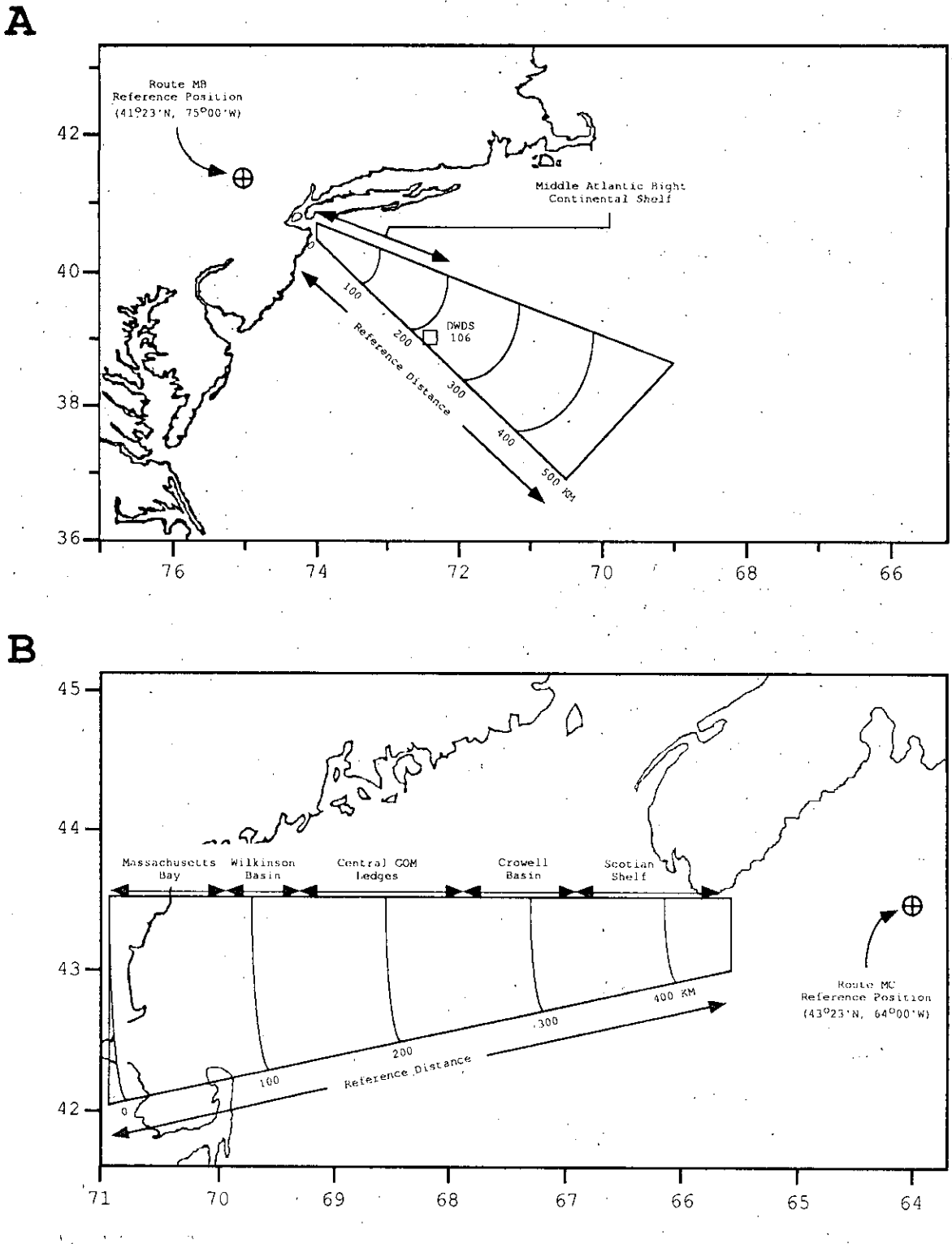

Figure 1. The (A) Middle Atlantic Bight - Route MB, and (B) Gulf of Maine - Route MC, Polygons, within which monitoring transects occurred, showing reference positions and distances, and major geophysical features through which sampling took place.

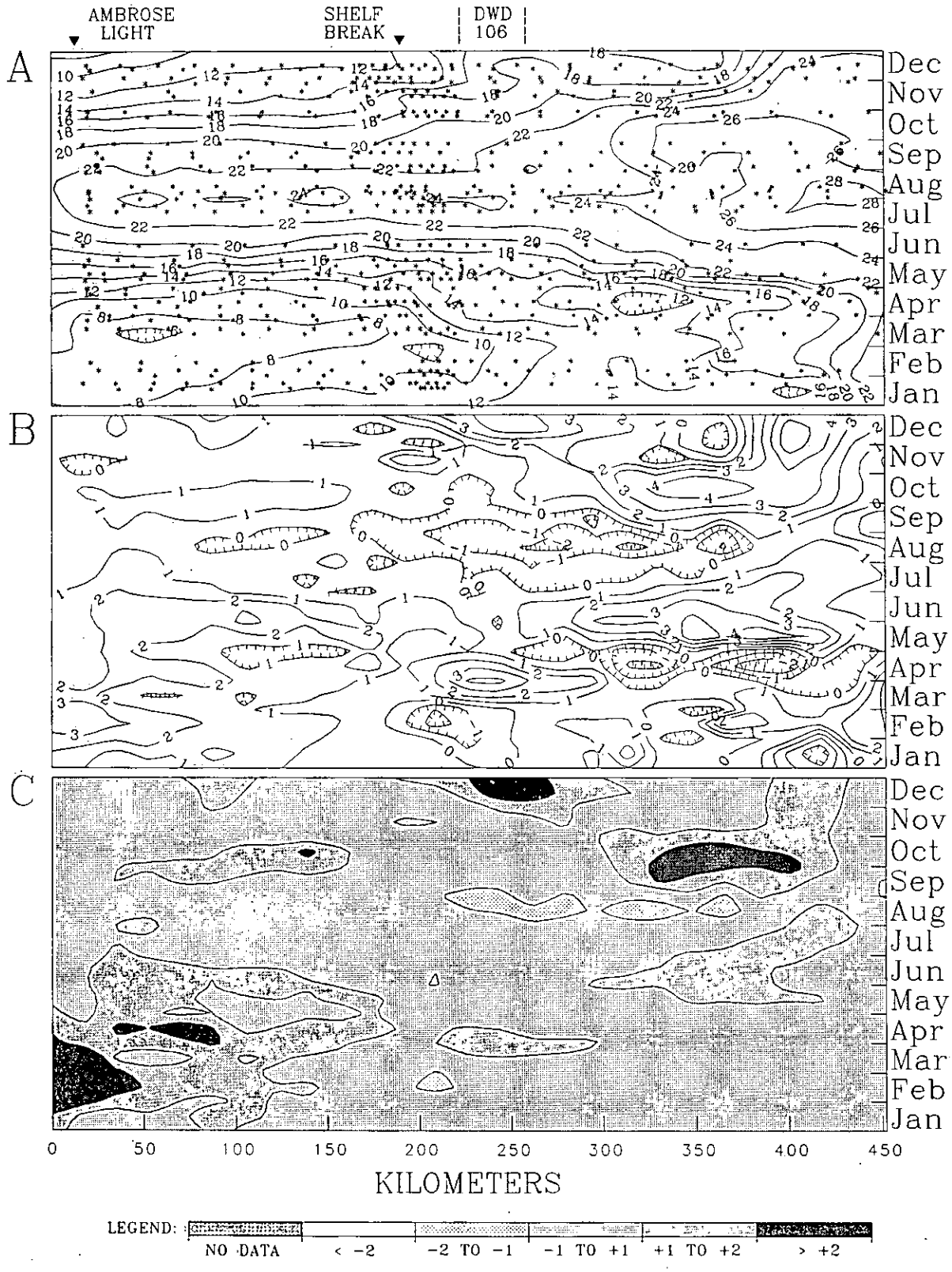

Figure 2. Surface temperature conditions along the Middle Atlantic Bight transect during 1991. A. Measured values (degrees centigrade) in time and space. Dots indicate sampling locations. B. Anomalies in time and space based on 1978 through 1991 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1991 means and variances. In panels A and B values decline on those sides of contour lines with hachures.

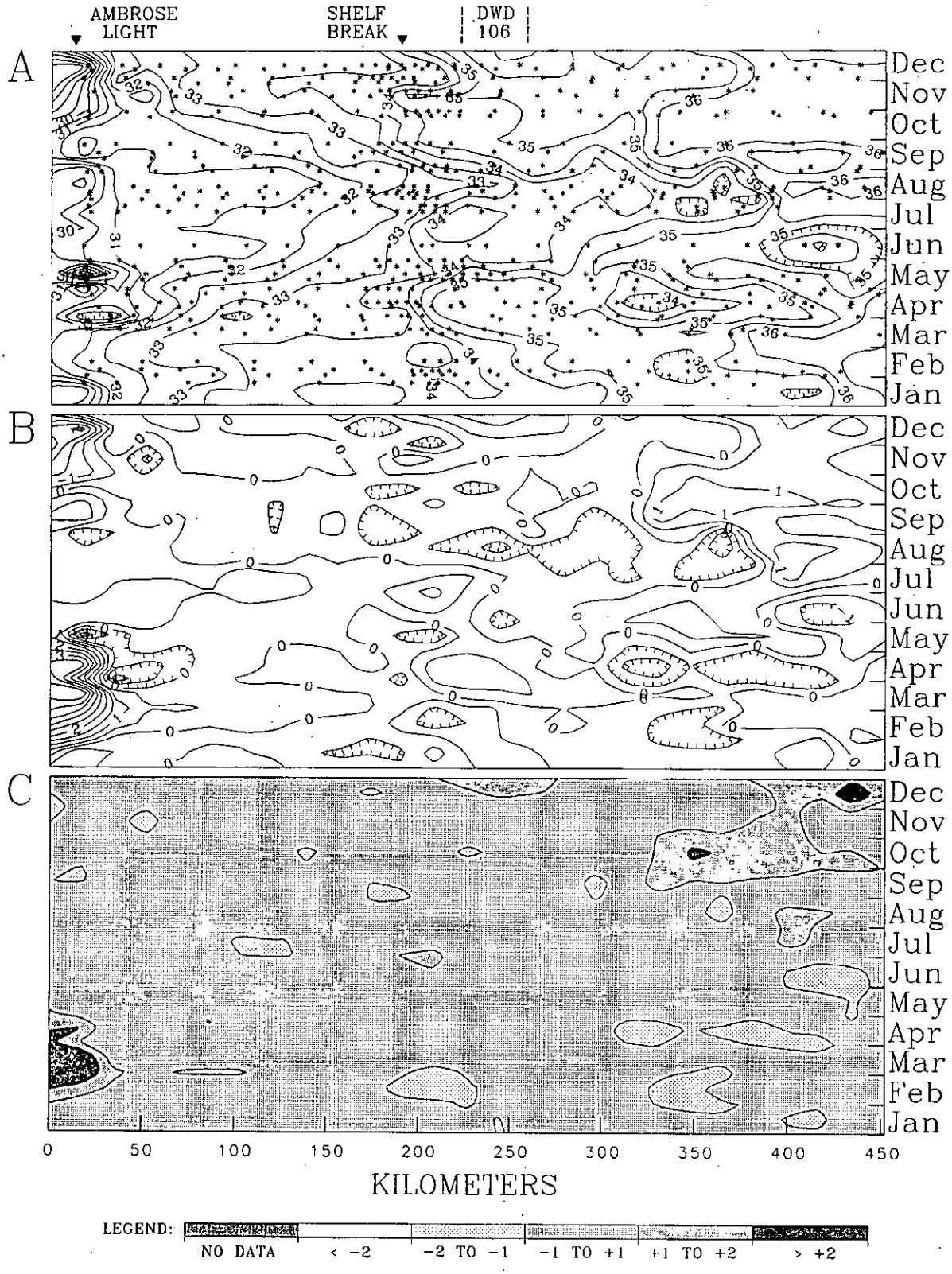

Figure 3. Surface salinity conditions along the Middle Atlantic Bight transect during 1991. A. Measured values (parts per thousand) in time and space. Dots indicate sampling locations. B. Anomalies in time and space based on 1978 through 1991 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1991 means and variances. In panels A and B values decline on those sides of contour lines with hachures.

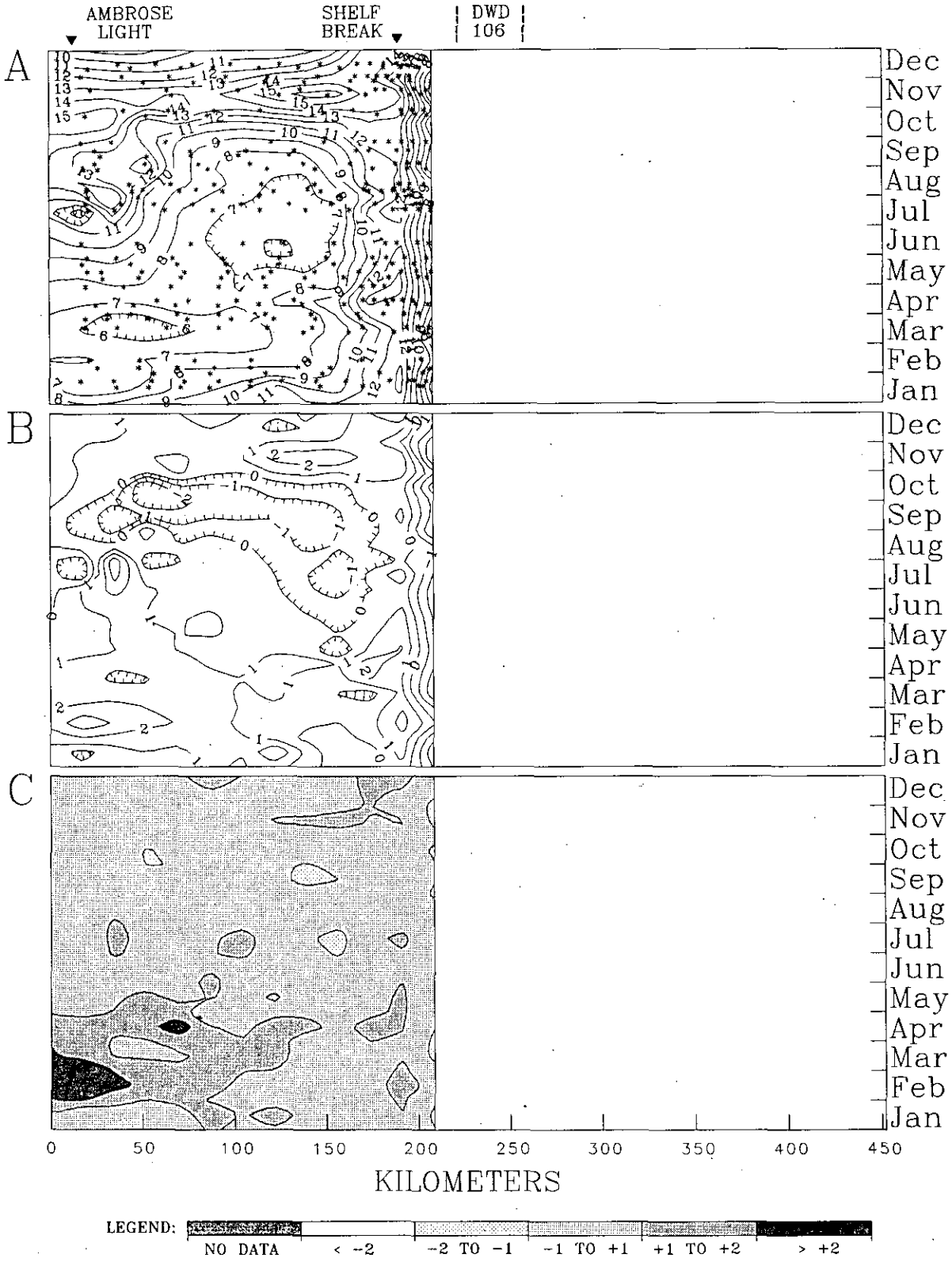

Figure 4. Bottom temperature conditions along the Middle Atlantic Bight transect during 1991. A. Measured values (degrees centigrade) in time and space. Dots indicate sampling locations. B. Anomalies in time and space based on 1978 through 1991 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1991 means and variances. In panels A and B values decline on those sides of contour lines with hachures.

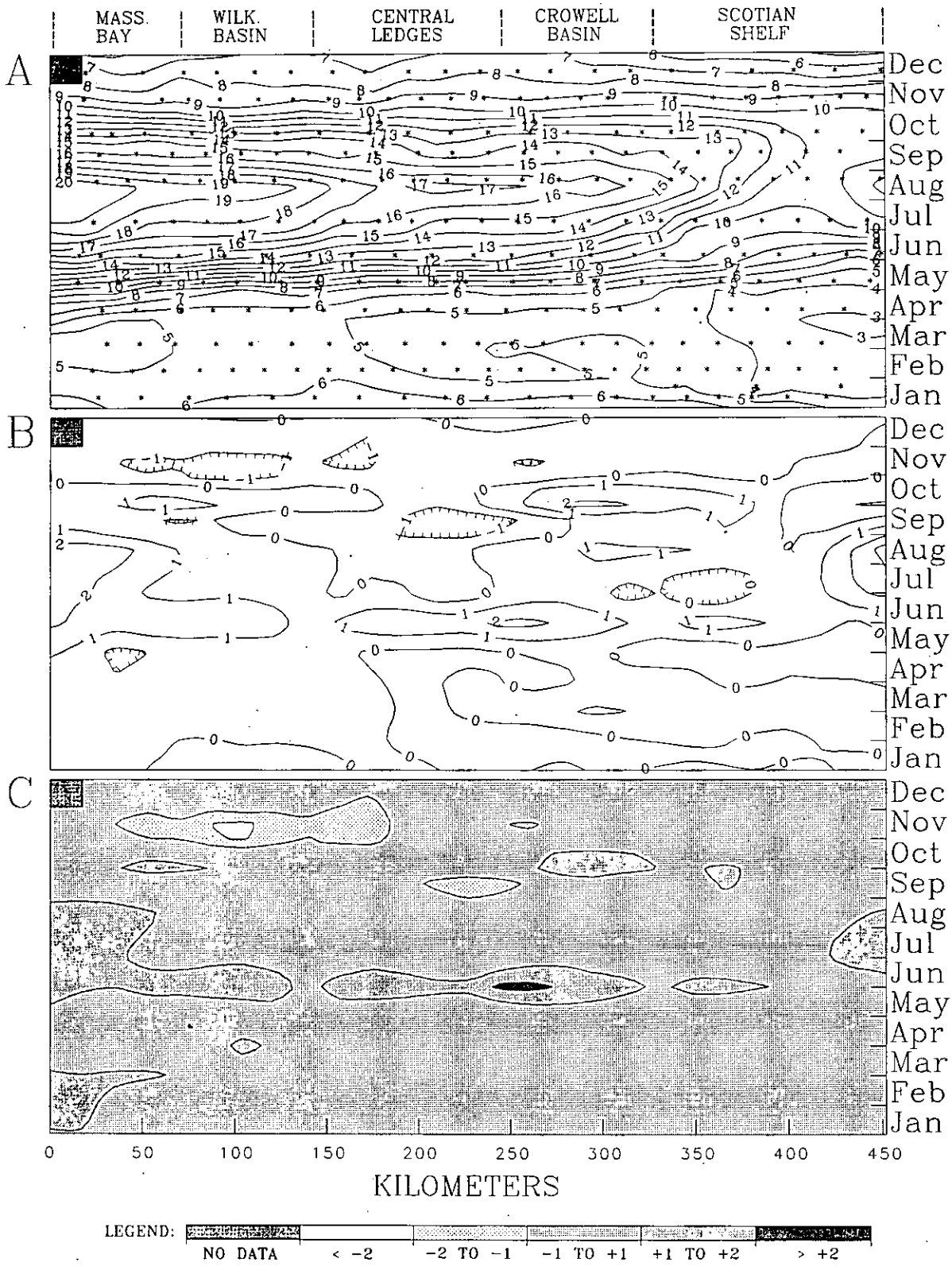

Figure 5. Surface temperature conditions along the Gulf of Maine transect during 1991. A. Measured values (degrees centigrade) in time and space. Dots indicate sampling locations. B. Anomalies in time and space based on 1978 through 1991 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1991 means and variances. In panels A and B values decline on those sides of contour lines with hachures.

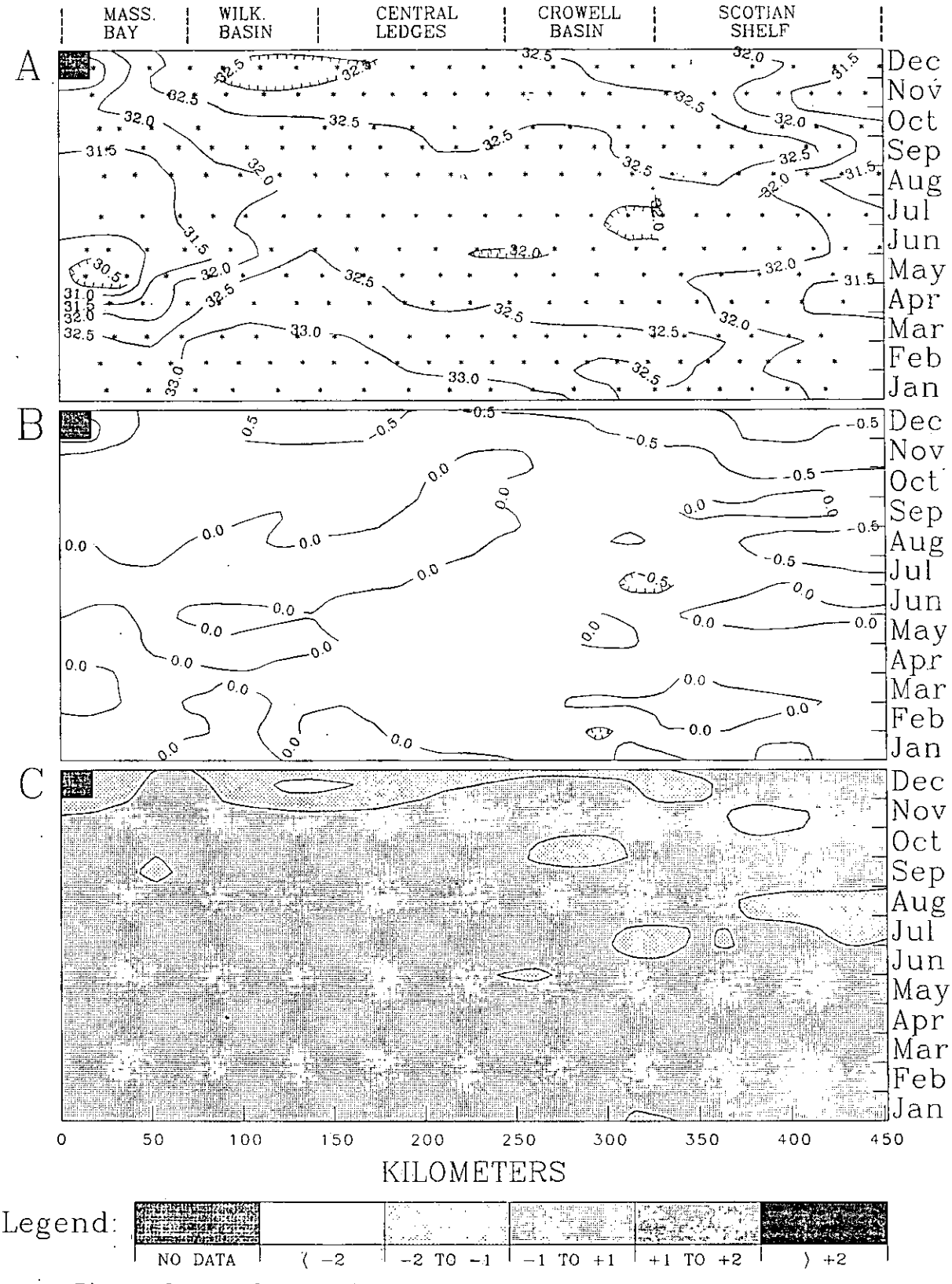

Figure 6. Surface salinity conditions along the Gulf of Maine transect during 1991. A. Measured values (parts per thousand) in time and space. Dots indicate sampling locations. B. Anomalies in time and space based on 1978 through 1991 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1991 means and variances. In panels A and B values decline on those sides of contour lines with hachures.

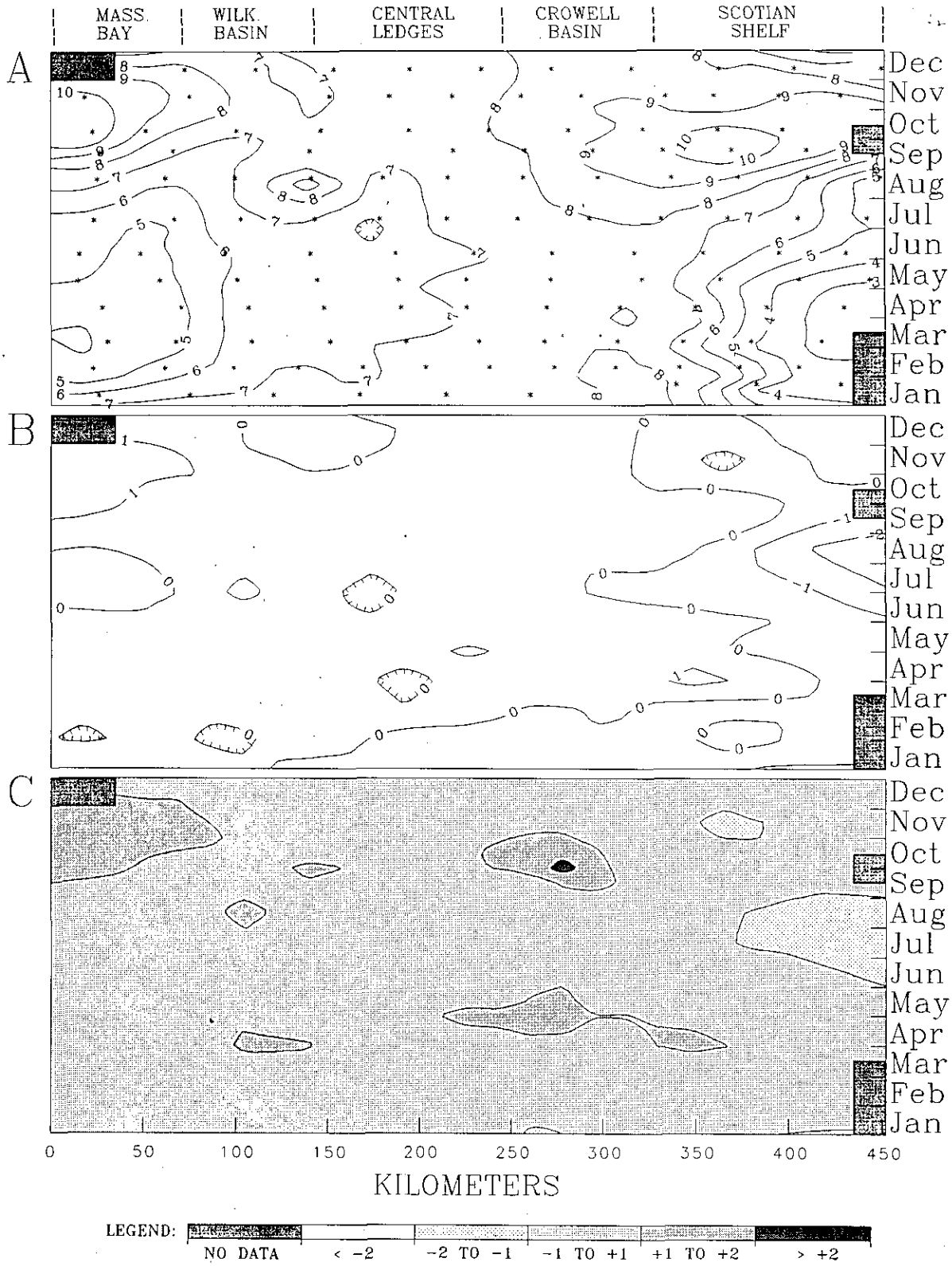

Figure 7. Bottom temperature conditions along the Gulf of Maine transect during 1991. A. Measured values (degrees centigrade) in time and space. Dots indicate sampling locations. B. Anomalies in time and space based on 1978 through 1991 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1991 means and variances. In panels A and B values decline on those sides of contour lines with hachures.

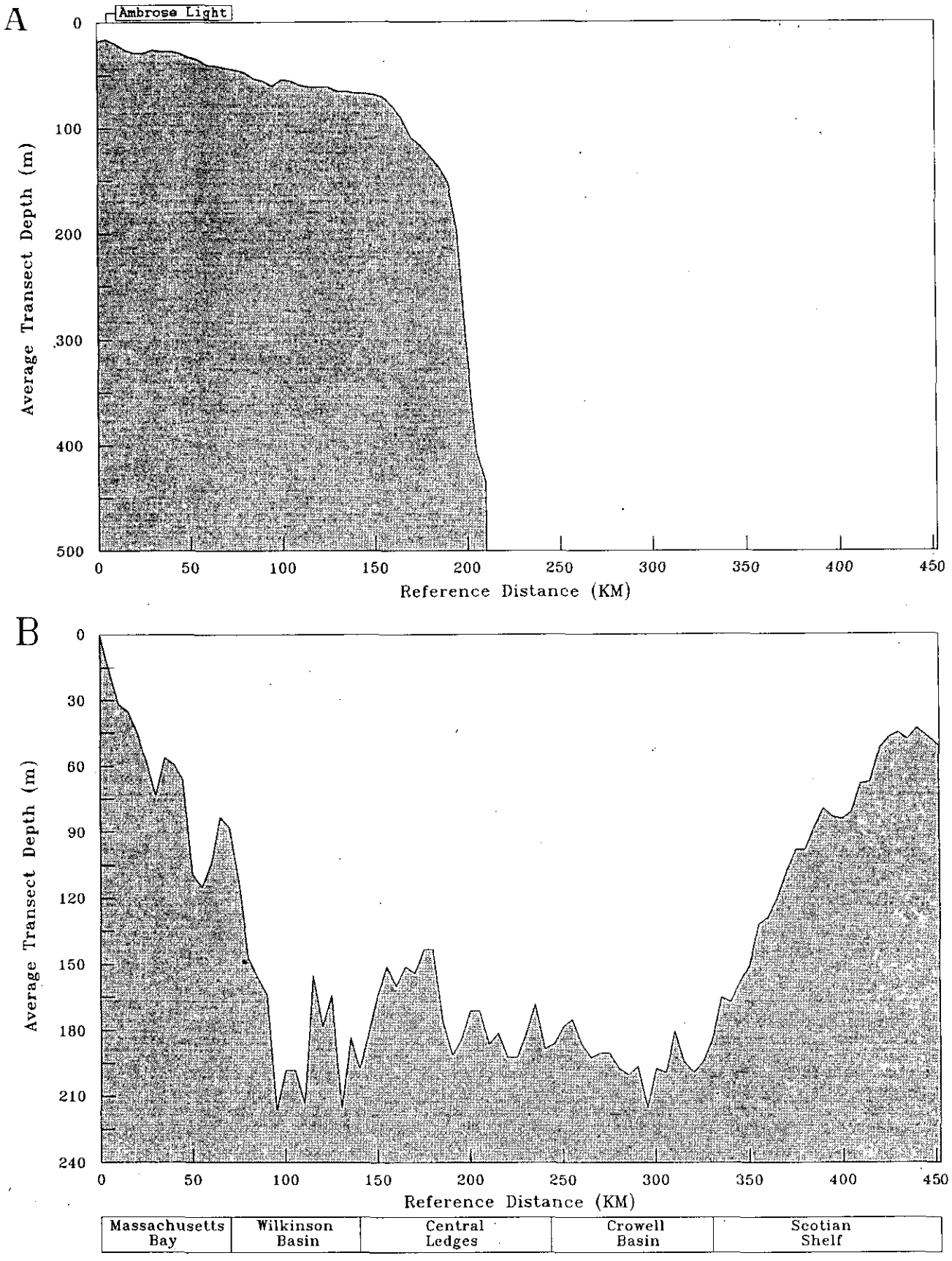

Figure 8. Mean bottom depth along the transects based on monitoring survey data, 1978 through 1991. A. Middle Atlantic Bight. B. Gulf of Maine.