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Surface and Bottom Temperatures, and Surface Salinities: New York to Gulf Stream, Massachusetts to Cape Sable, N.S., 1992

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 seventeen and sixteen years, respectively. Water temperature and salinity patterns observed in 1992 are compared to 1978 through 1991 means within a time-space matrix. Sea surface temperatures in the Middle Atlantic Bight during 1992 were generally cooler than the fourteen-year (1978-1991) means, averaging 0.5° C cooler for the year. In the Gulf of Maine January through May surface temperatures were colder than normal, June above normal in the near-shore off Boston, and the autumn cooler than average, especially over the eastern portion. For all of 1992 surface temperatures averaged 0.6° C below the baseline for the entire transect; 1.1° C below over the central Gulf ledges. Surface salinities in the Middle Atlantic Bight were about 0.7 psu (practical salinity units) above average for the year, due to high values at Ambrose Light in late January and through late March, again in July and August, and at the shelf break during June and July. Gulf of Maine surface salinities averaged 0.4 psu below baseline during 1992. Bottom temperatures in the Middle Atlantic Bight were cooler than average during April and May and for September and October, but warmer than long-term mean conditions in June averaging to 0.3° C cooler for the entire transect during 1992. Over the Scotian Shelf in the Gulf of Maine, bottom temperatures were colder than normal from April through November, and generally warmer than average in the area of Massachusetts Bay during late April through May. For the Gulf of Maine transect as a whole, bottom temperatures were 0.1° C below the baseline in 1992.

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 (Figure 1a) and across the Gulf of Maine since 1977 (Figure 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 and Gulf of Maine transects during 1992 and describes their departures from average conditions for the fourteen-year period, 1978 through 1991.

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 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 resulted 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 XBT stations. This combination of sources resulted in the data reported here as "surface" temperature, although it actually represents 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 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) 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 (Figure 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 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 1992 mean for the single-year subset; 3) calculating the 1978-1991 mean for the base period subset; 4) obtaining the 1992 anomaly by subtracting the base period from the 1992 subset; and 5) standardizing each anomaly value for 1992 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 (Figures 2-7). Portrayed are the conditions during 1992, and 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 February and March to greater than 26° C offshore during mid-August through late September (Figure 2). In 1992 annual minimum temperatures occurred over the entire transect in February and March, approximately one month earlier than normal. A cold event in the shelf break region of the transect area was noted beginning in early February and lasting until late March. Later than usual warming during early June on the mid-shelf region and late August in the offshore waters accounted for the year's greatest departure from the 14 year mean. Offshore during January, shoreward migration of the north wall of the Gulf Stream accounted for surface temperatures slightly over 4° C warmer than the 14 year mean. Also during early January at the DWD 106

location, the passage of a warm core ring resulted in temperatures more than 4° C warmer than normal. Surface temperatures at the time of fall overturn, which occurred between the mid-November and mid-December cruises, were about average. Surface temperatures for the year on the continental shelf averaged 0.8° C below the 1978-1991 baseline; those over the Dumpsite 106 were 1.1° C below average; and those for the transect as a whole were 0.5° C lower than the baseline (Table 1).

Surface Salinity: Salinities in the Middle Atlantic Bight for 1992 ranged from a low of 27.5 psu nearshore in May to greater than 36.5 psu at the offshore end of the transect from January through May, and again in late December (Figure 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 January to late February, and early April to early June was responsible for the higher than normal surface salinities observed. Offshore migration of the Gulf Stream was responsible for the observed lower salinity water during late September and into November at a reference distance of 350 to 450km. Passage of a warm core ring from mid-May through early August accounted for higher than normal surface salinity at the shelf break. In addition, higher than usual salinities were observed in the near-shore during mid-July into late August apparently due to coastal upwelling. Surface salinity in 1992 over the continental shelf averaged 0.04 psu below the 1978-1991 baseline; over the Dumpsite 1.95 psu below average; and for the transect as a whole 0.72 psu higher than average (Table 2).

Bottom Temperature: Bottom temperatures on the shelf and upper slope for 1992 are presented in Figure 4. The relationship between bottom relief and reference distance is portrayed in Figure 8a. Warmer than normal conditions prevailed during early January due to late fall overturn in 1991. Shifts seaward over the mid-shelf by the cold pool accounted for cooler than normal temperatures during mid-April to mid-May. Warmer than normal bottom temperatures observed during July were associated with the passage of a warm core ring pushing warm water up the Hudson Canyon to the apex of the New York Bight. In 1992 fall overturn began in the near-shore in mid-October while bottom waters were of average temperatures. Cooler than normal conditions were observed during early August into mid-October from 75 to 175km reference distance due to later than usual fall overturn in the mid-shelf region. Annual means of bottom temperature on the continental shelf averaged 0.3° C below the 1978-1991 baseline (Table 3).

Gulf of Maine

Surface Temperature: Surface temperatures ranged from less than 2.0° C on

the Scotian Shelf end of the transect in late February into early April to slightly higher than 19° C in Massachusetts Bay in July (Figure 5). Across-transect negative anomalies occurred from late January through early May. Positive anomalies occurred over Massachusetts Bay in late June and into July. Significant negative departures from the 1978-1991 means occurred from Wilkinson Basin to Crowell Basin during the period March to late May. Significant negative anomalies also occurred over Massachusetts Bay from late August through September. Negative anomalies during this same time also occurred over the central Gulf ledges and Crowell Basin area of the transect, although not of as great a magnitude. Significant across-transect negative anomalies occurred during the fall overturn period from late November through mid-December. Annual means were lower than the baseline for all sections of the transect (Table 4) and, for the transect as a whole, amounting to 0.6° C below the 1978-1991 mean.

Surface Salinity: During 1992 salinities ranged from less than 30.0 psu in May in Massachusetts Bay to greater than 32.5 psu early in the year from Wilkinson Basin to half-way across the central Gulf ledges (Fig. 6). Salinities over most of the transect and for approximately 72% of the time were well below average. Significant negative departures occurred during the months of October and December over the Massachusetts Bay end of the transect, in August over Wilkinson Basin, and in December over the central ledges. Annual mean salinities were below the baseline for all sections of the transect (Table 5). For the transect as a whole the 1992 salinities were 0.36 psu below average.

Bottom Temperatures: Annual minimum temperatures for the transect of less than 2° C occurred over the Scotian Shelf during mid-February through early May. The timing for the annual minimum appeared to be earlier and significantly longer-lasting than normal (Fig. 7). From June through August and extending over the eastern half of the Scotian Shelf, bottom temperatures were more than 2° C cooler than average, departing by more than 3° C over portions of the shelf. Maximum bottom temperatures of 9° C occurred on the Scotian Shelf during the period early August to mid-November, and over Massachusetts Bay in early October. Significantly higher than average bottom temperatures occurred in Wilkinson Basin during the period early April through the end of July. For reference, bottom relief along the transect is shown in Figure 8b. Annual mean bottom temperatures were lower than the baseline for Massachesetts Bay and the Scotian Shelf sections of the transect, and above average over the central sections (Table 6). For the transect as a whole 1992 bottom temperatures averaged 0.1° C below average.

Acknowledgements

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References

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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 1992 for the Sections of the Middle Atlantic Bight Transect.

SECTION	1992 MEAN (^{0}C)	1978-1991 MEAN (^{0}C)	1992 ANOMALY (^{0}C)	1992 STANDARDIZED ANOMALY (standard deviation)
Continental Shelf	12.8	13.6	-0.8	-0.45
DWDS 106	15.8	16.9	-1.1	-0.70
Entire Transect	16.0	16.5	-0.5	-0.40

Table 2. Surface Salinity Means and Departures during 1992 for Sections of the Middle Atlantic Bight Transect.

SECTION	1992 MEAN (psu)	1978-1991 MEAN (psu)	1992 ANOMALY (psu)	1992 STANDARDIZED ANOMALY (standard deviation)
Continental Shelf	32.19	32.23	-0.04	-0.15
DWDS 106	32.53	34.48	-1.95	-0.33
Entire Transect	34.53	33.81	+0.72	+0.05

Table 3. Bottom Temperature Means and Departures during 1992 for the Middle Atlantic Bight Transect.

SECTION	1992 MEAN (°C)	1978-1991 MEAN (°C)	1992 ANOMALY (°C)	1992 STANDARDIZED ANOMALY (standard deviation)
Continental Shelf	9.0	9.3	-0.3	-0.18

Table 4. Surface Temperature Means and Departures during 1992 for Sections of the Gulf of Maine Transect.

SECTION	1992 MEAN (°C)	1978-1991 MEAN (°C)	1992 ANOMALY (°C)	1992 STANDARDIZED ANOMALY (standard deviation)
Massachusetts Bay	9.8	10.3	-0.5	-0.76
Wilkinson Basin	9.5	10.4	-0.9	-0.94
Central Ledges	8.8	9.9	-1.1	-1.16
Crowell Basin	8.2	9.2	-1.0	-0.84
Scotian Shelf	6.8	7.3	-0.5	-0.53
Entire Transect	8.4	9.0	-0.6	-0.83

Table 5. Surface Salinity Means and Departures during 1992 for Sections of the Gulf of Maine Transect.

SECTION	1992 MEAN (ppt)	1978-1991 MEAN (ppt)	1992 ANOMALY (ppt)	1992 STANDARDIZED ANOMALY (standard deviation)
Massachusetts Bay	31.64	31.96	-0.32	-0.95
Wilkinson Basin	32.17	32.54	-0.37	-1.19
Central Ledges	32.21	32.71	-0.51	-1.49
Crowell Basin	32.16	32.68	-0.52	-1.38
Scotian Shelf	31.89	32.24	-0.35	-0.86
Entire Transect	32.00	32.36	-0.36	-1.15

Table 6. Bottom Temperature Means and Departures during 1992 for Sections of the Gulf of Maine Transect.

SECTION	1992 MEAN (°C)	1978-1991 MEAN (°C)	1992 ANOMALY (°C)	1992 STANDARDIZED ANOMALY (standard deviation)
Massachusetts Bay	5.7	5.9	-0.2	-0.42
Wilkinson Basin	6.4	6.2	+0.2	+0.31
Central Ledges	6.9	6.8	+0.1	+0.25
Crowell Basin	8.1	7.9	+0.2	+0.35
Scotian Shelf	6.0	6.9	-0.9	-1.02
Entire Transect	6.6	6.7	-0.1	-0.18

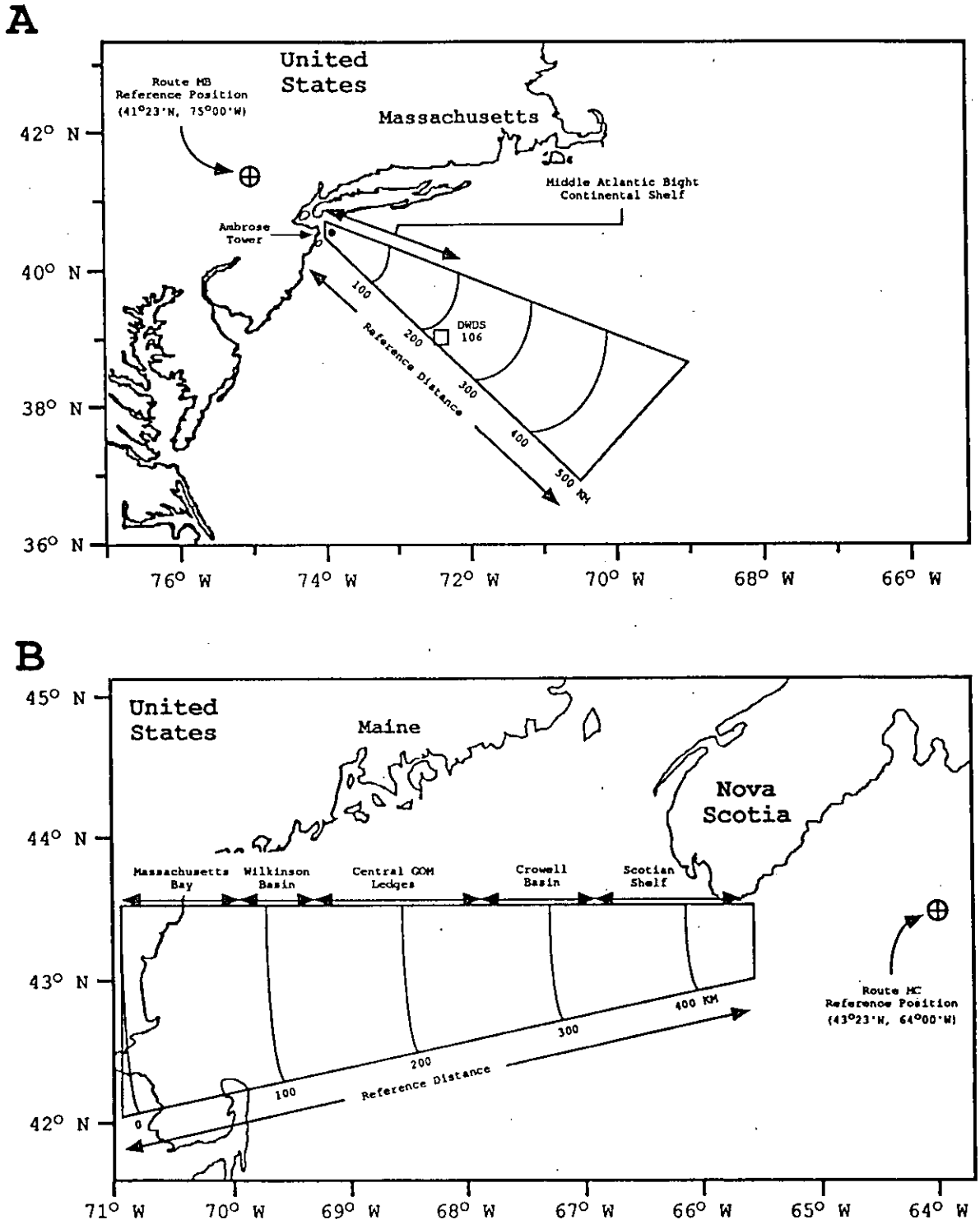

Figure 1. The (**A**) Middle Atlantic Bight - Route MB, and (**B**) Gulf of Maine - Route MC polygons, within which monitoring transects occurred, showing reference positions and distances, location of the Deep Water Dumpsite 106 (DWD 106), location of Ambrose Tower, and major geographical features through which all sampling took place.

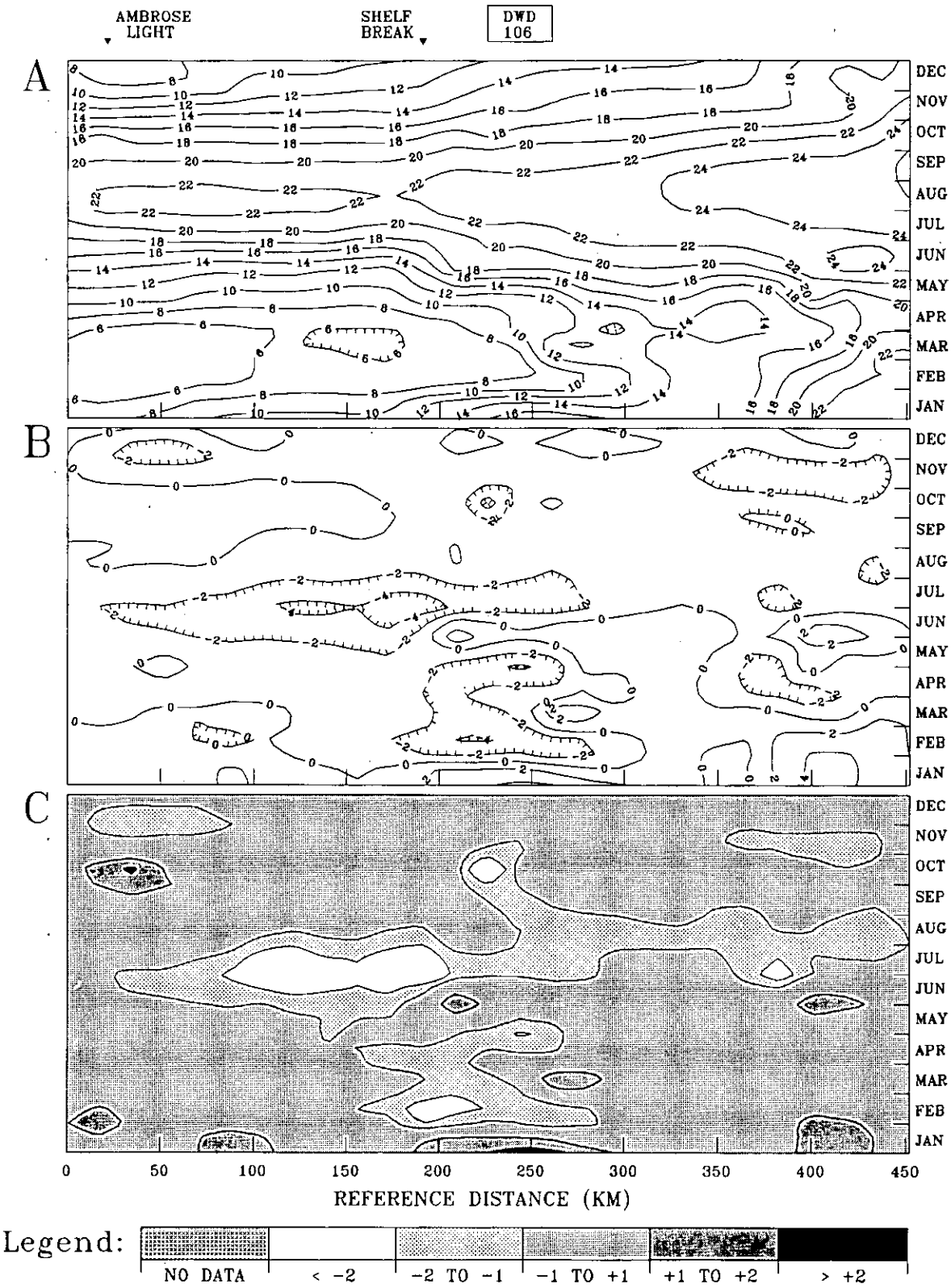

Figure 2. Surface temperature conditions along the Middle Atlantic Bight transect during 1992. A. Measured values (degrees centigrade) in time and space. B. Anomalies in time and space based on 1978 through 1991 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1991 means and variances; scale given in legend. In panels A and B values decline on those sides of contour lines with hachures.

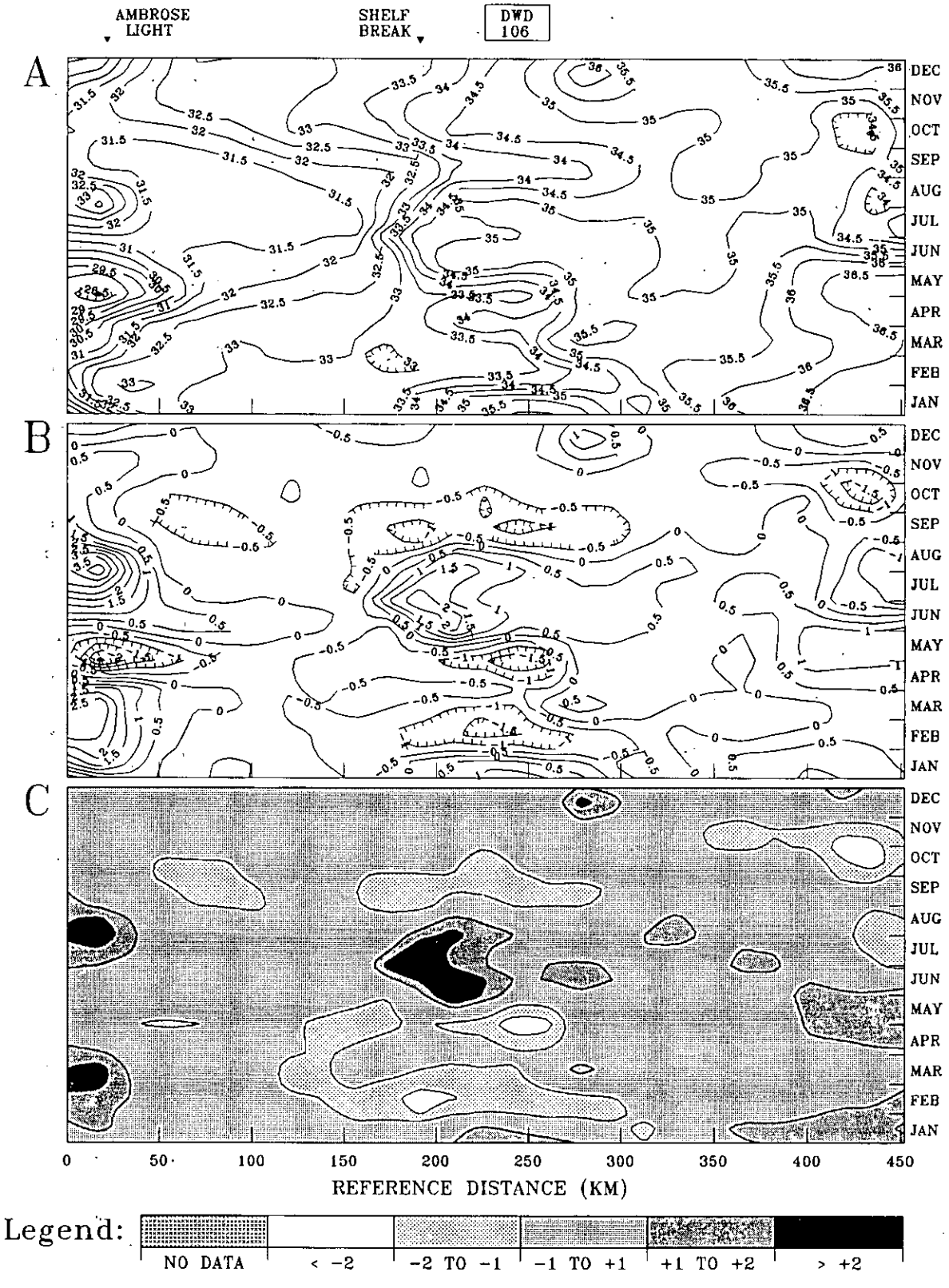

Figure 3. Surface salinity conditions along the Middle Atlantic Bight transect during 1992. A. Measured values (practical salinity units) in time and space. B. Anomalies in time and space based on 1978 through 1991 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1991 means and variances; scale given in legend. In panels A and B values decline on those sides of contour lines with hachures.

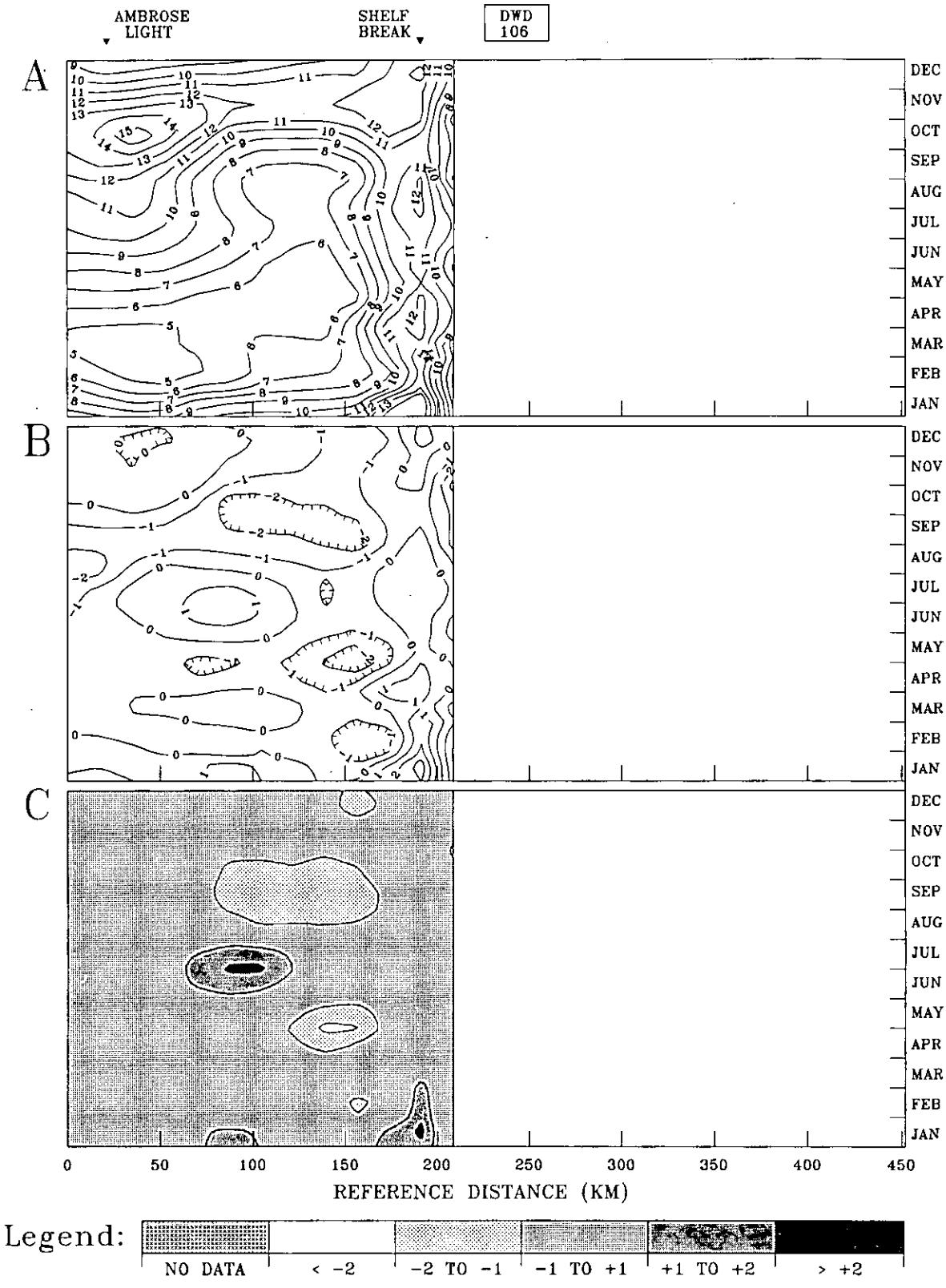

Figure 4. Bottom temperature conditions along the Middle Atlantic Bight transect during 1992. A. Measured values (degrees centigrade) in time and space. B. Anomalies in time and space based on 1978 through 1991 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1991 means and variances; scale given in legend. In panels A and B values decline on those sides of contour lines with hachures.

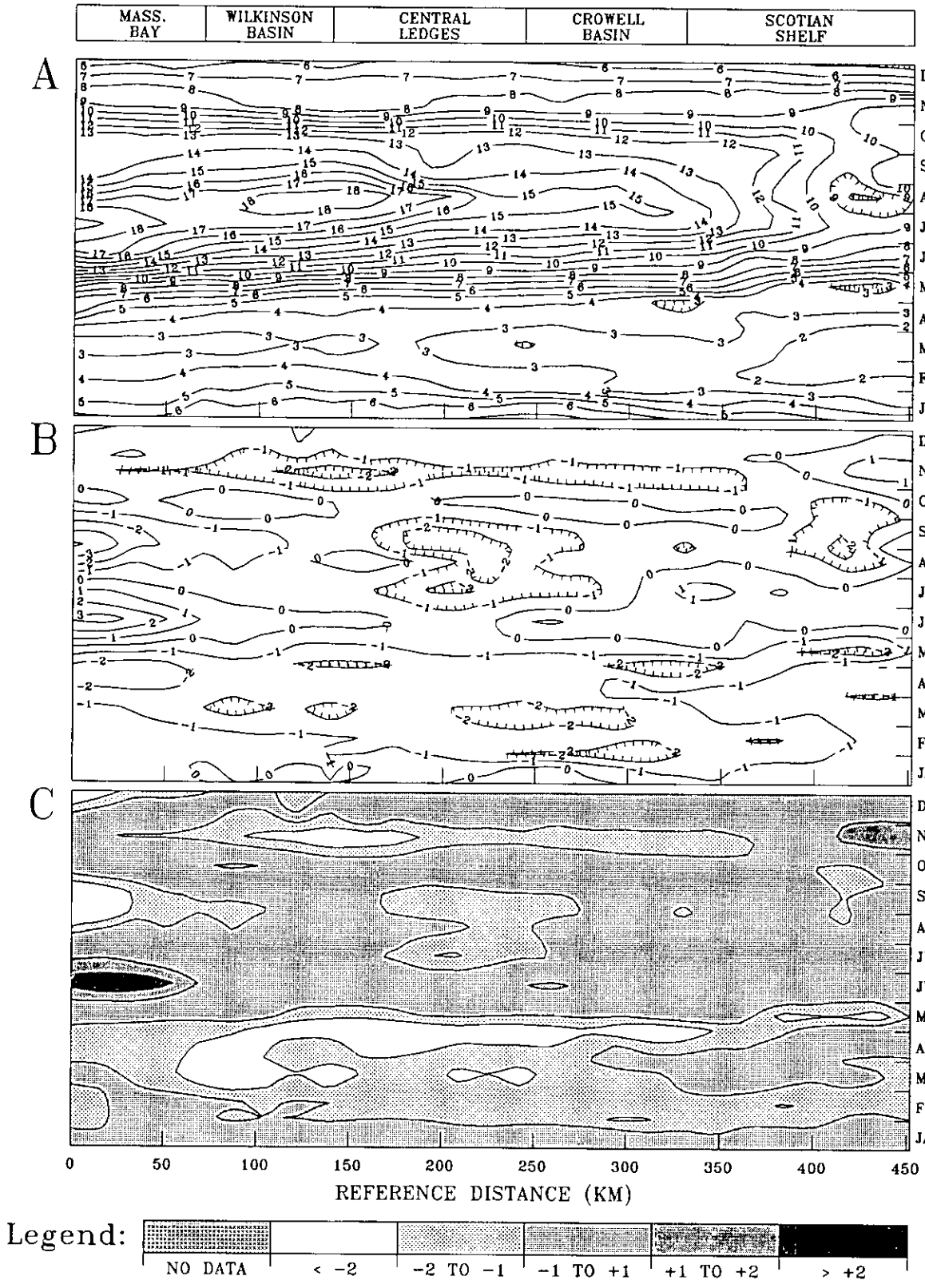

Figure 5. Surface temperature conditions along the Gulf of Maine transect during 1992. A. Measured values (degrees centigrade) in time and space. B. Anomalies in time and space based on 1978 through 1991 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1991 means and variances; scale given in legend. In panels A and B values decline on those sides of contour lines with hachures.

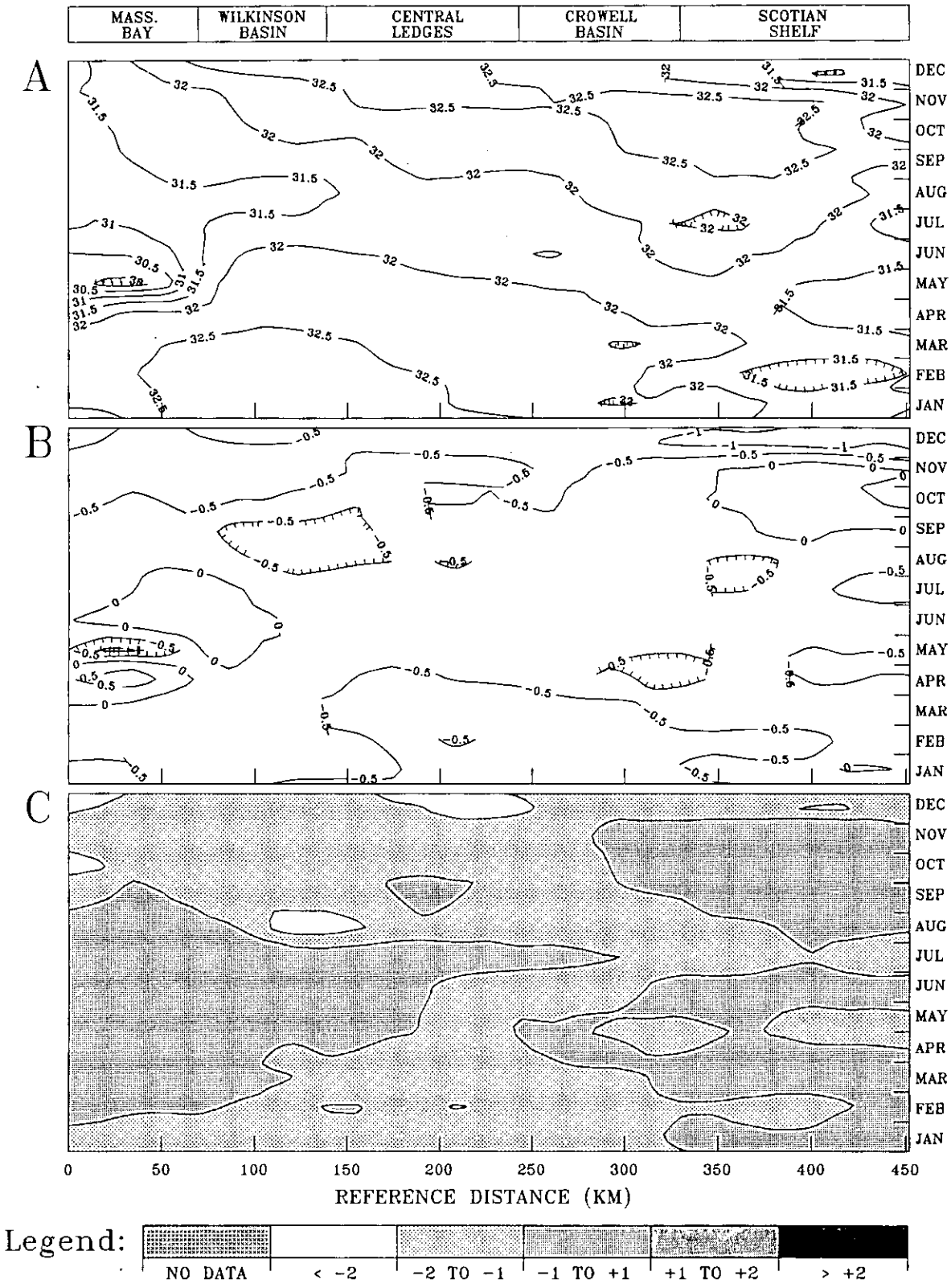

Figure 6. Surface salinity conditions along the Gulf of Maine transect during 1992. A. Measured values (practical salinity units) in time and space. B. Anomalies in time and space based on 1978 through 1991 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1991 means and variances; scale given in legend. In panels A and B values decline on those sides of contour lines with hachures.

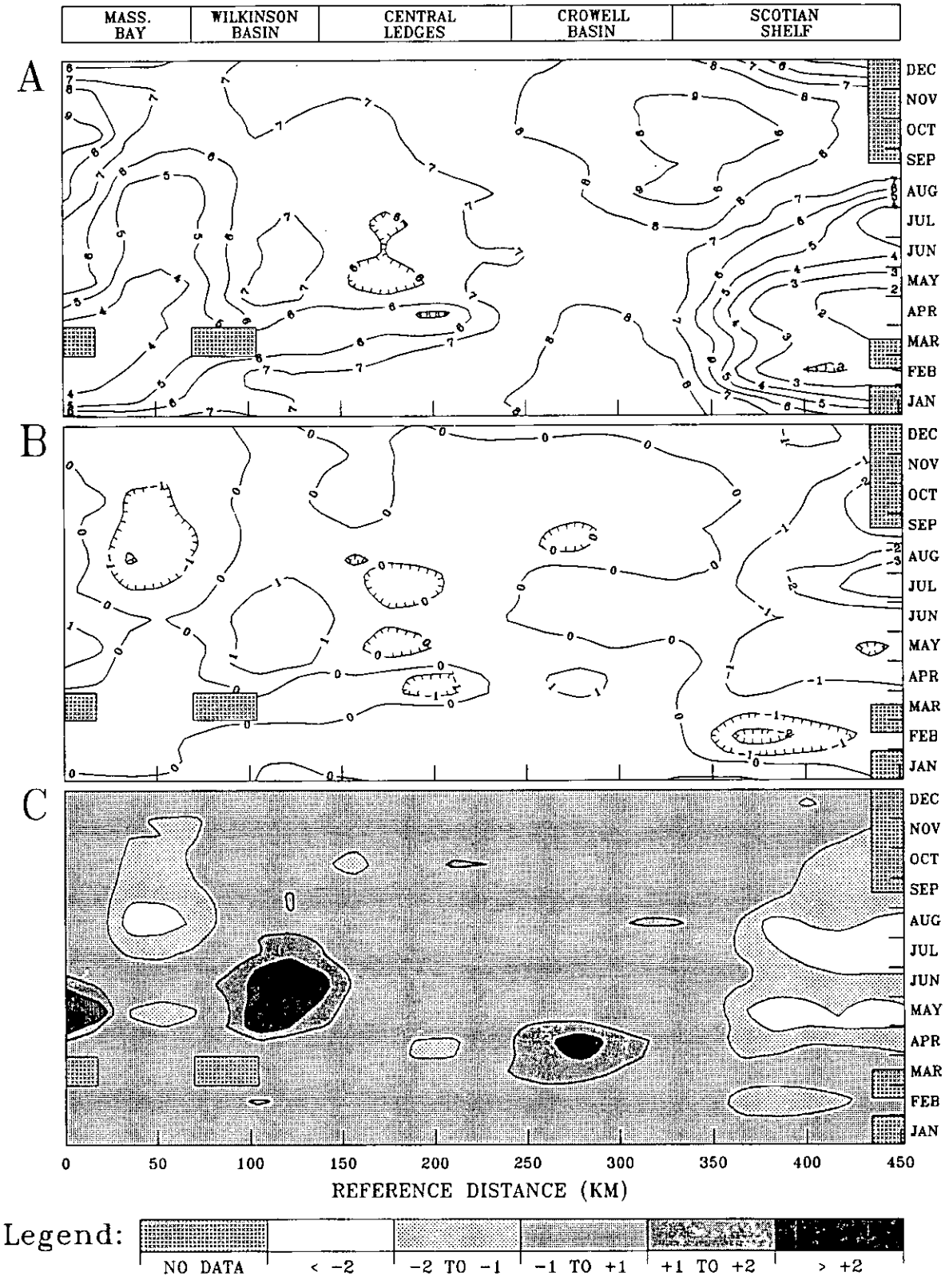

Figure 7. Bottom temperature conditions along the Gulf of Maine transect during 1992. A. Measured values (degrees centigrade) in time and space. B. Anomalies in time and space based on 1978 through 1991 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1991 means and variances; scale given in legend. In panels A and B values decline on those sides of contour lines with hachures.

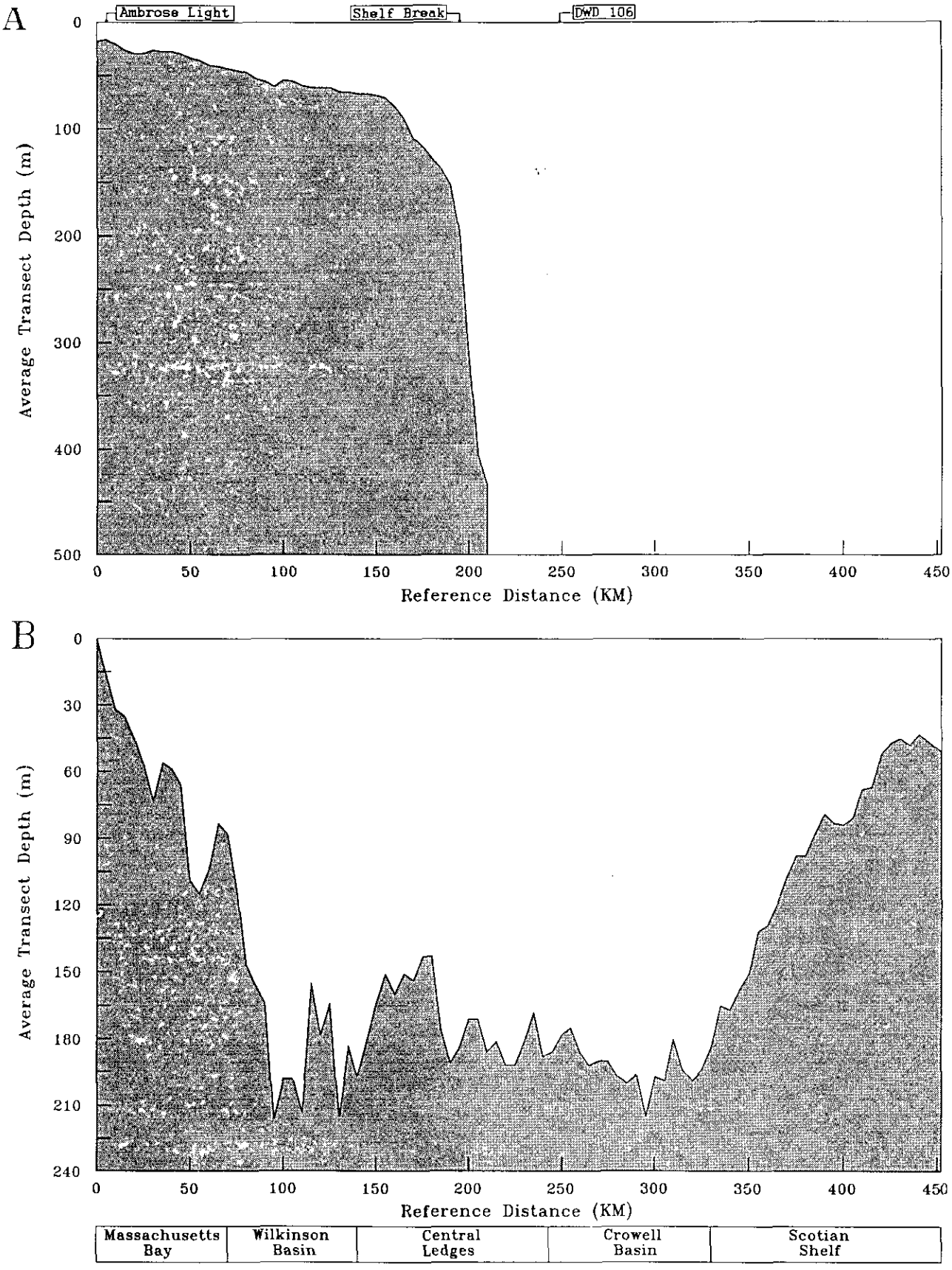

Figure 8. Mean bottom depth along the transects based on monitoring survey data, 1978 through 1991. A. Middle Atlantic Bight. B. Gulf of Maine.