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Surface and Bottom Temperatures, and Surface Salinities: New York to the Gulf Stream, Massachusetts to Cape Sable N.S. 1993

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 eighteen and seventeen years, respectively. Water temperature and salinity patterns observed in 1993 are compared to 1978 through 1992 means within a time-space matrix. Averaged for the year surface and bottom temperatures and surface salinities in 1993 were all below the 1978-1992 means along monitoring transects in both the Middle Atlantic Bight and Gulf of Maine. In the Middle Atlantic Bight, surface temperatures were 1.4°C cooler, bottom temperatures 0.4°C cooler and surface salinity 0.46 psu (practical salinity units) below the 1978-1992 means. In the Gulf of Maine, surface and bottom temperatures were 0.3°C cooler and surface salinities 0.45 psu less than the 1978-1992 means. Generally, in both areas negative anomalies were more prevalent during the first half of the year.

Bottom temperatures in the Middle Atlantic Bight were cooler than average over much of the inner-shelf in 1993. Values were warmer than long-term mean conditions in June offshore. Over the Scotian Shelf in the Gulf of Maine, bottom temperatures were colder than normal from February through April, and generally colder than average in the area of Massachusetts Bay during January through August. Warmer than average waters in Crowell Basin occurred in June.

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 and Gulf of Maine transects during 1993 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 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 approximately the upper 2 m 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 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 standardized anomaly map; 2) calculating the 1993 mean for the single-year raw value subset; 3) calculating the 1978-1992 mean for the base period subset; 4) obtaining the 1993 anomaly by subtracting the base period from the 1993 subset; and 5) calculating the 1993 mean for the single year, standardized anomaly 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 1993, 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 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 4°C in the nearshore waters in February and March to greater than 26°C at the extreme offshore end of the transect during mid-August through late October (Fig. 2). In 1993 annual minimum temperatures occurred over the entire transect in March, at about the same time as in the 15-year base period. During February through April, surface temperatures in general across the entire transect were cooler than average. This below average condition persisted over much of the transect throughout the rest of the year most notably in the nearshore from late May through August, and then again in late September through mid-November. Surface temperatures for the year on the continental shelf averaged 0.3°C below the 1978-1992 baseline; those over the Dumpsite 106 were 1.1°C below average; and those for the transect as a whole were 1.4°C lower than the baseline (Table 1).

Surface Salinity: Salinities in the Middle Atlantic Bight for 1993 ranged from a low of less than 27.5 psu nearshore in May to greater than 36.0 psu at the offshore end of the transect from January and February, and again in October through December (Fig. 3). Above average salinities were detected in July and September in the waters offshore of the shelf break due to the passage of warm core rings. Below average salinities occurred from January to June in both the nearshore and the offshore. Lower than average conditions were noted again across transect during late October through early December. Surface salinity in 1993 over the continental shelf averaged 0.32 psu below the 1978-1992 baseline; over the Dumpsite, .15 psu below average; and for the transect as a whole 0.46 psu lower than average (Table 2).

Bottom Temperature: Bottom temperatures on the shelf and upper slope for 1993 are presented in Fig. 4. The relationship between bottom relief and reference distance is portrayed in Fig. 8a, showing that bottom depth was beyond sampling depth (500 m) seaward of about 210 km reference distance. Bottom temperatures ranged from less than 3°C during March nearshore to greater than 16°C also in the nearshore during September. Below average bottom temperatures during the first half of 1993 are a continuation of 1992 conditions (Benway *et al*, 1993). In 1993 fall overturn began in the nearshore in mid-September while

bottom waters temperatures were near normal. Much cooler than normal conditions were observed during October from 75 to 175 km reference distance due to later than usual fall overturn in the mid-shelf region. Annual means of bottom temperature on the continental shelf averaged 0.4°C below the 1978-1992 baseline (Table 3).

Gulf of Maine

Surface Temperature: Surface temperatures ranged from less than 1.0°C on the Scotian Shelf end of the transect in late February into early April to higher than 18°C over much of the western Gulf in August and early September (Fig. 5). Negative anomalies occurred over Massachusetts Bay and western Wilkinson Basin from the beginning of the year through March. These exceeded 2 standard deviations below the 1978-1992 means. Negative anomalies of similar magnitude occurred over the Scotian Shelf in March. Over much of the Gulf in June and July, surface temperatures were in excess of 1°C below average. Positive anomalies amounting to more than 1°C occurred over the central Gulf ledges, Crowell Basin and the Scotian Shelf in September. In May positive anomalies were seen over most of the transect. These were higher than average by as much as than 2°C and 2 standard deviations on the Scotian Shelf. Annual means were lower than the baseline for all sections of the transect, with Wilkinson Basin showing the largest negative annual departure of 0.4°C (Table 4). For the transect as a whole, surface temperatures averaged 0.3°C below the 1978-1992 baseline.

Surface Salinity: During 1993 salinities ranged from less than 29.5 psu in May in Massachusetts Bay to greater than 33.0 psu in Wilkinson Basin during February and the Scotian Shelf in September (Fig. 6). Salinities over most of the transect through September were below average. Significant negative departures occurred in January over Massachusetts Bay and the central Gulf ledges and over the eastern and western ends of the transect in September and in July and August, respectively. Annual mean salinities were below the baseline for all sections of the transect, with maximum negative departures over the central Gulf (Table 5). For the transect as a whole the 1993 salinities were 0.46 psu below average. No salinity samples were collected after September due to the change over to a different ship for data collection in October.

Bottom Temperatures: The relationship between bathymetry and reference distance is shown in figure 8b. Annual minimum temperatures for the transect of less than 1°C occurred over the Scotian Shelf during March, and of less than 2°C over parts of Massachusetts Bay during the same time. Maximum bottom temperatures occurred over the outer Scotian Shelf in October (Fig. 7). Negative anomalies in excess of 1°C occurred from February through June in Massachusetts Bay and western Wilkinson Basin, reaching significance in the latter area in May. Negative departures exceeding 2°C and 2 standard deviations occurred over the Scotian Shelf in March. Warm water in Crowell Basin persisted through most of the year with significant anomalies in June. Annual mean bottom temperatures were lower than the baseline for all sections of the transect except Crowell Basin which was 0.4°C above the baseline during 1993 (Table 6). By contrast Massachusetts Bay averaged 1.2°C below the baseline for 1993.

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 1993 for the Sections of the Middle Atlantic Bight Transect.

SECTION	1993 MEAN (°C)	1978-1992 MEAN (°C)	1993 ANOMALY (°C)	1993 STANDARDIZED ANOMALY (standard deviation)
Continental Shelf	13.8	13.5	-0.3	-0.32
DWDS 106	15.8	16.9	-1.1	-0.66
Entire Transect	15.7	17.1	-1.4	-0.46

Table 2. Surface Salinity Means and Departures during 1993 for Sections of the Middle Atlantic Bight Transect.

SECTION	1993 MEAN (psu)	1978-1992 MEAN (psu)	1993 ANOMALY (psu)	1993 STANDARDIZED ANOMALY (standard deviation)
Continental Shelf	31.88	32.20	-0.32	-0.49
DWDS 106	34.55	34.69	-0.15	-0.40
Entire Transect	33.57	34.03	-0.46	-0.38

Table 3. Bottom Temperature Means and Departures during 1993 for a Section of the Middle Atlantic Bight Transect.

SECTION	1993 MEAN (°C)	1978-1992 MEAN (°C)	1993 ANOMALY (°C)	1993 STANDARDIZED ANOMALY (standard deviation)
Continental Shelf	8.9	9.3	-0.4	-0.58

Table 4. Surface Temperature Means and Departures during 1993 for Sections of the Gulf of Maine Transect.

SECTION	1993 MEAN (°C)	1978-1992 MEAN (°C)	1993 ANOMALY (°C)	1993 STANDARDIZED ANOMALY (standard deviation)
Massachusetts Bay	10.0	10.3	-0.3	-0.10
Wilkinson Basin	9.9	10.3	-0.4	-0.43
GOM Ledges	9.6	9.8	-0.2	-0.21
Crowell Basin	8.9	9.1	-0.2	-0.04
Scotian Shelf	7.0	7.3	-0.3	-0.22
Entire Transect	8.9	9.1	-0.3	-0.34

Table 5. Surface Salinity Means and Departures during 1993 for Sections of the Gulf of Maine Transect.

SECTION	1993 MEAN (psu)	1978-1992 MEAN (psu)	1993 ANOMALY (psu)	1993 STANDARDIZED ANOMALY (standard deviation)
Massachusetts Bay	31.48	31.94	-0.46	-0.55
Wilkinson Basin	32.12	32.52	-0.40	-0.82
GOM Ledges	32.16	32.69	-0.53	-1.15
Crowell Basin	32.13	32.65	-0.52	-1.13
Scotian Shelf	31.84	32.22	-0.38	-0.86
Entire Transect	31.93	32.39	-0.46	-0.92

Table 6. Bottom Temperature Means and Departures during 1993 for Sections of the Gulf of Maine Transect.

SECTION	1993 MEAN (°C)	1978-1992 MEAN (°C)	1993 ANOMALY (°C)	1993 STANDARDIZED ANOMALY (standard deviation)
Massachusetts Bay	4.6	5.8	-1.2	-1.00
Wilkinson Basin	6.0	6.3	-0.3	-0.37
GOM Ledges	6.7	6.8	-0.1	-0.07
Crowell Basin	8.3	7.9	+0.4	+0.56
Scotian Shelf	6.4	6.8	-0.4	-0.23
Entire Transect	6.5	6.8	-0.3	-0.18

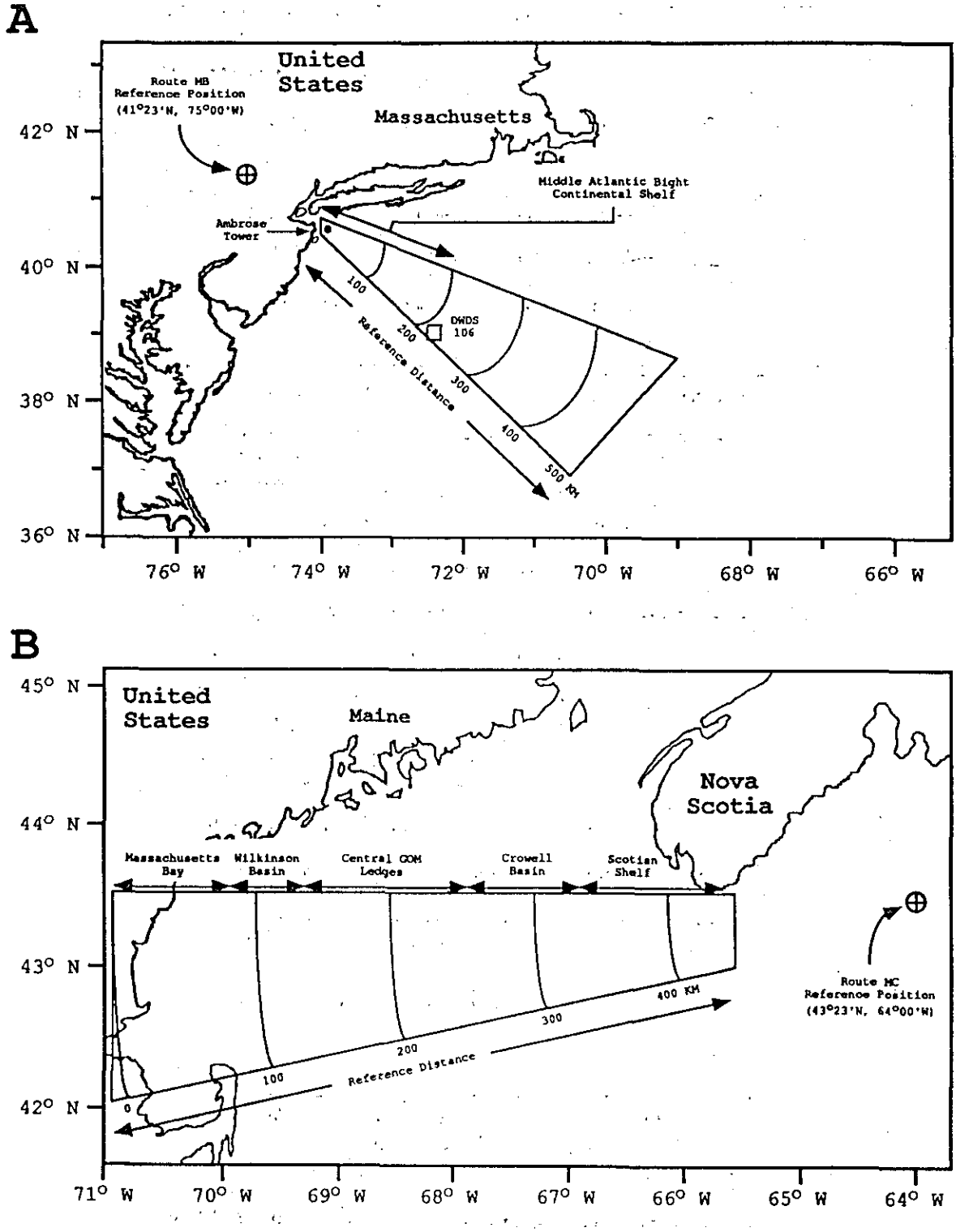

Figure 1. The (A) Middle Atlantic Bight (MAB)-Route MB, and (B) Gulf of Maine (GOM)-route MC polygons, within which monitoring transects occurred, showing reference positions and distances, location of the 106 mile dumpsite (DWS-106), location of Ambrose Tower, and major geographical features through which all sampling took place.

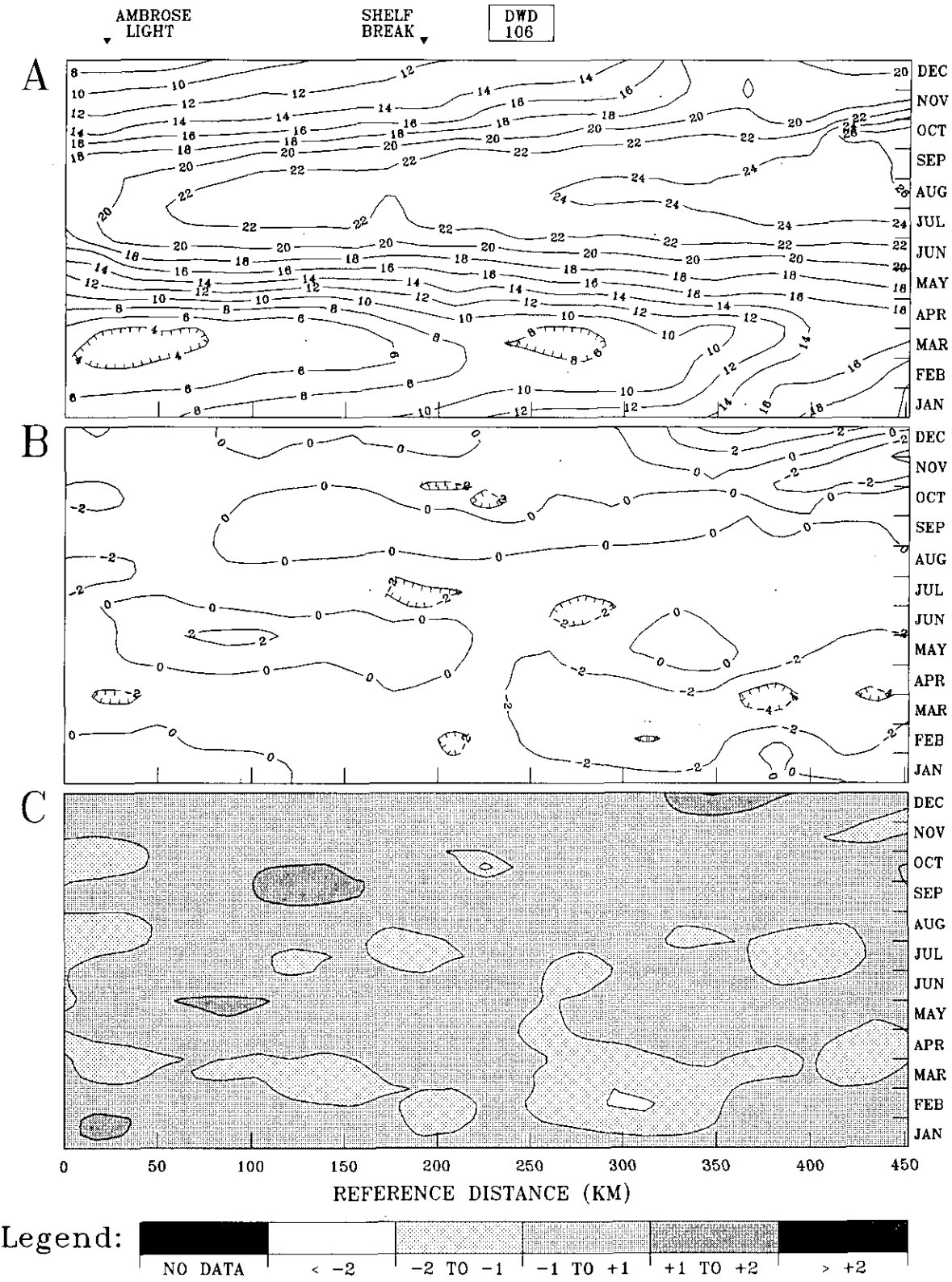

Figure 2. Surface temperature conditions along the Middle Atlantic Bight transect during 1993. A. Measured values (degrees centigrade) in time and space. B. Anomalies in time and space based on 1978 through 1992 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1992 means and variances; scale given in legend. In panels A and B values decline on those sides of contour lines with hachures.

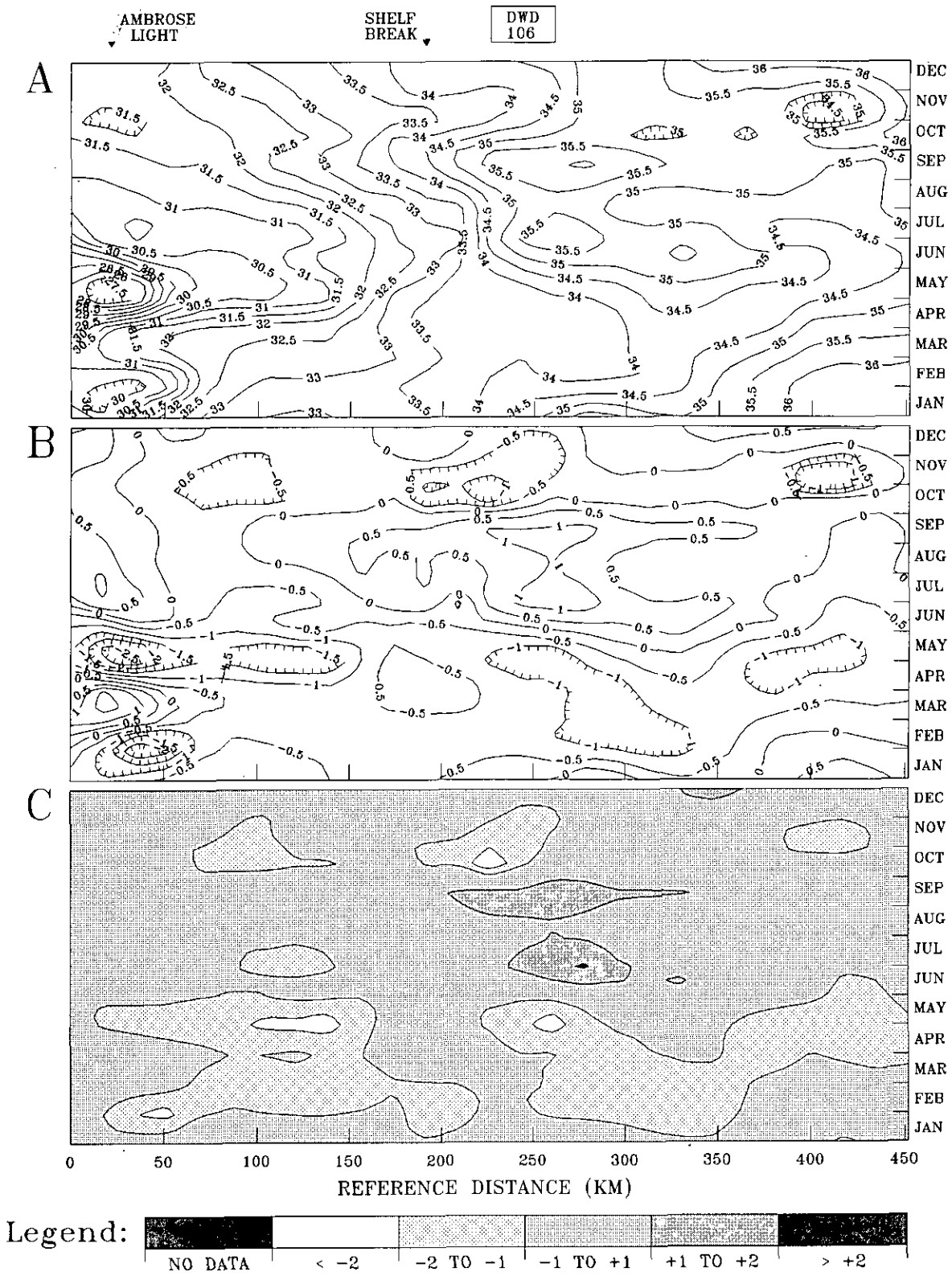

Figure 3. Surface salinity conditions along the Middle Atlantic Bight transect during 1993. A. Measured values (practical salinity units) in time and space. B. Anomalies in time and space based on 1978 through 1992 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1992 means and variances; scale given in legend. In panels A and B values decline on those sides of contour lines with hachures.

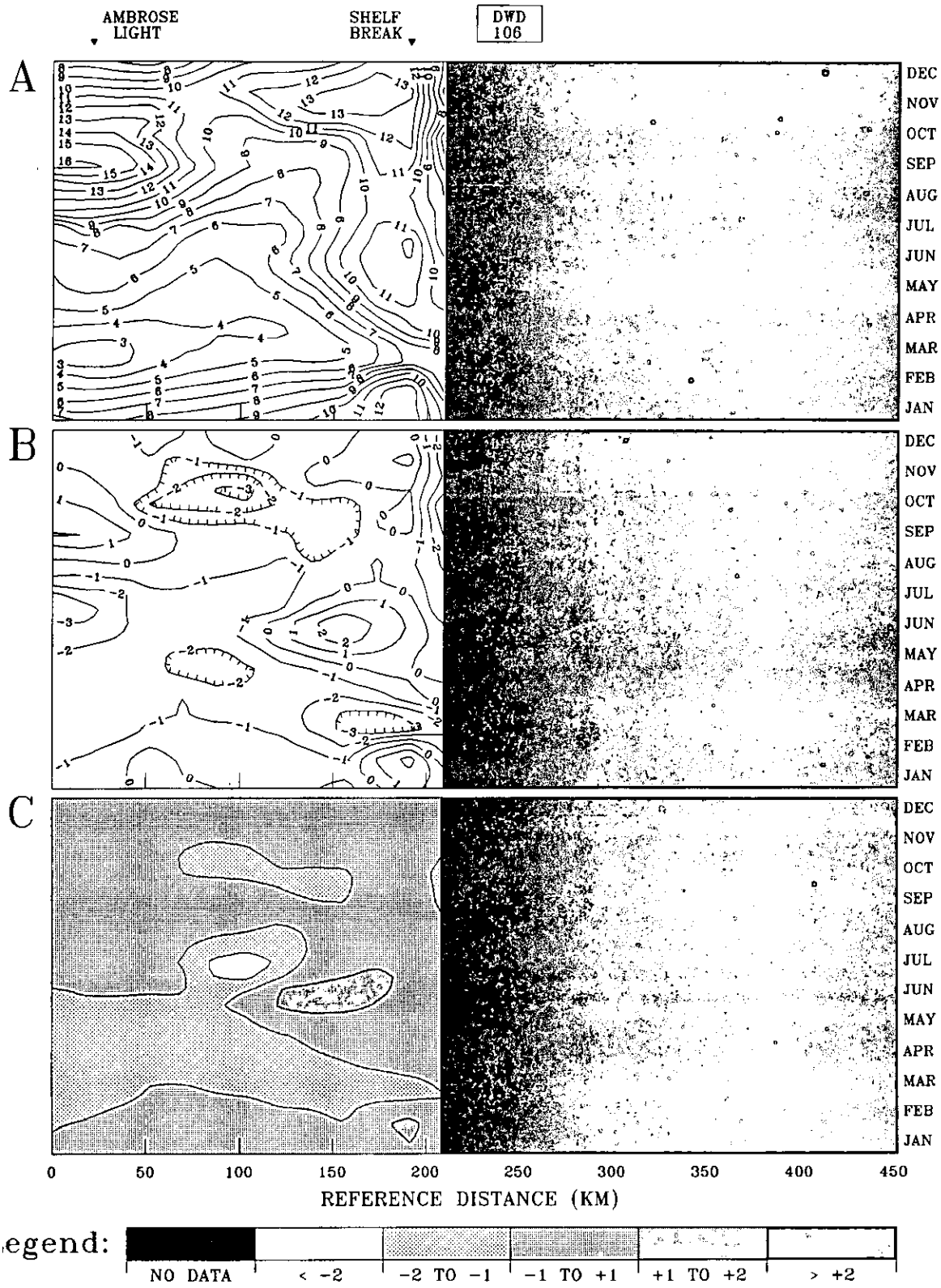

Figure 4. Bottom temperature conditions along the Middle Atlantic Bight transect during 1993. A. Measured values (degrees centigrade) in time and space. B. Anomalies in time and space based on 1978 through 1992 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1992 means and variances; scale given in legend. In panels A and B values decline on those sides of contour lines with hachures.

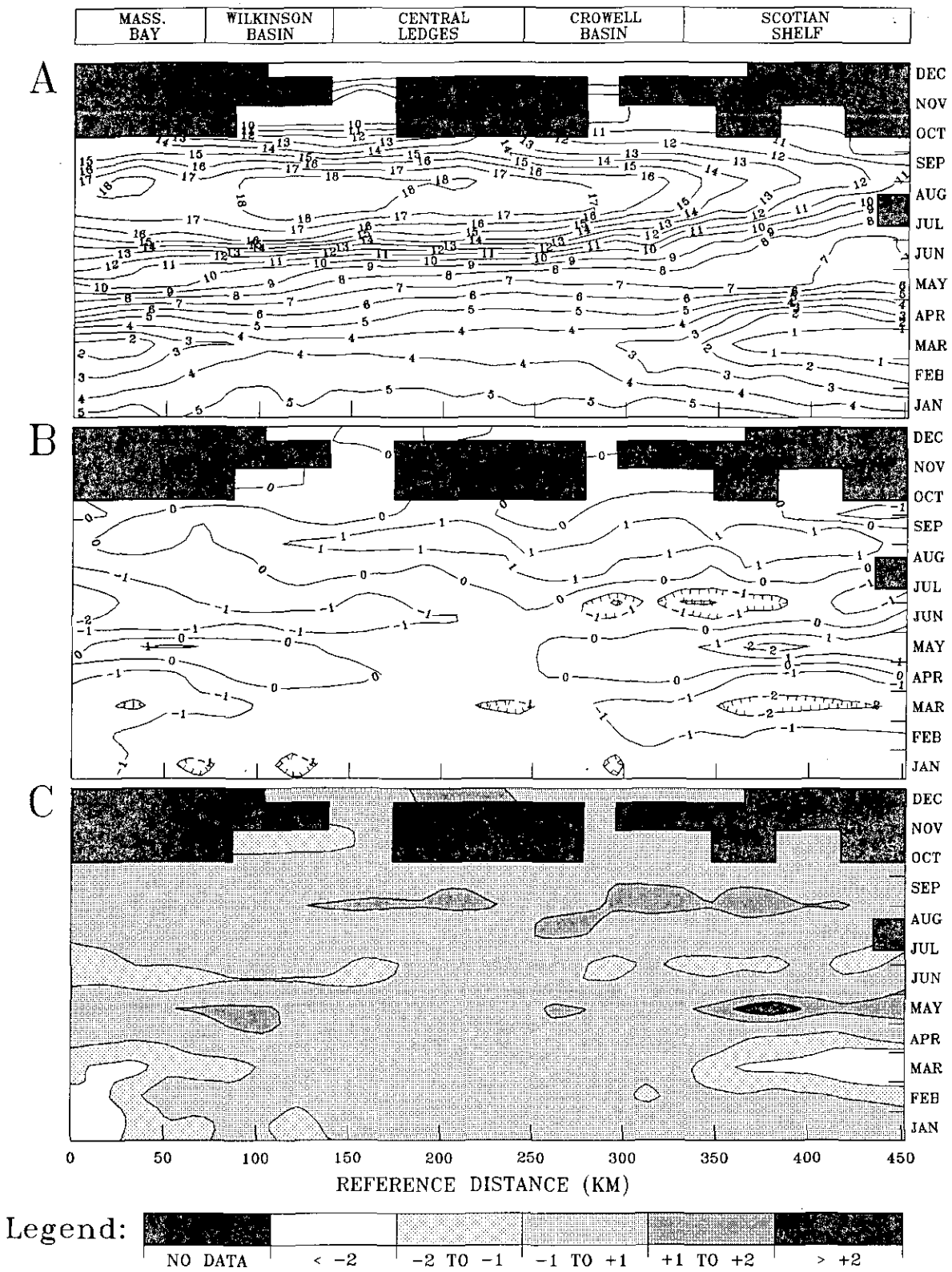

Figure 5. Surface temperature conditions along the Gulf of Maine transect during 1993. A. Measured values (degrees centigrade) in time and space. B. Anomalies in time and space based on 1978 through 1992 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1992 means and variances; scale given in legend.. In panels A and B values decline on those sides of contour lines with hachures.

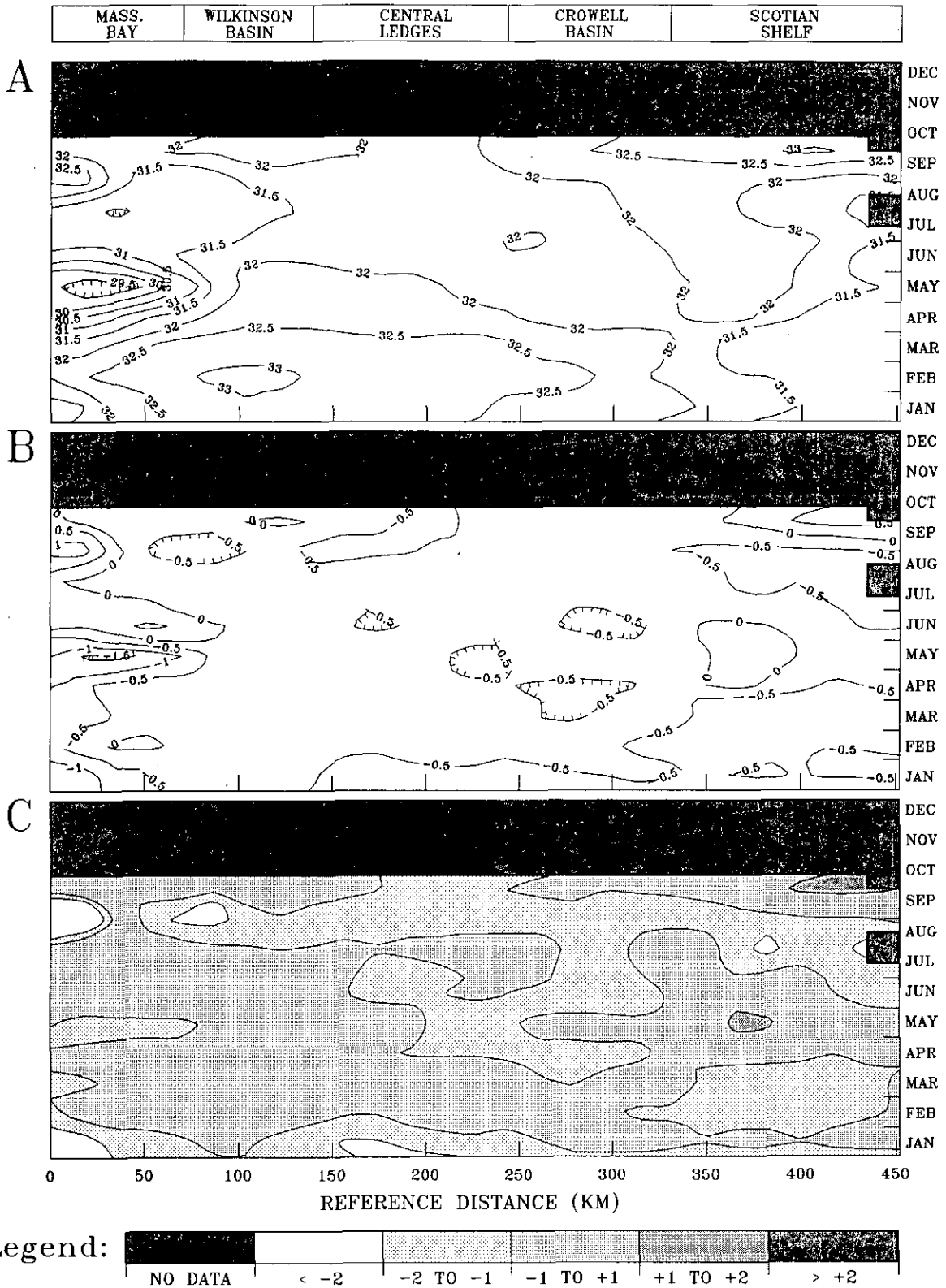

Figure 6. Surface salinity conditions along the Gulf of Maine transect during 1993. A. Measured values (practical salinity units) in time and space. B. Anomalies in time and space based on 1978 through 1992 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1992 means and variances; scale given in legend. In panels A and B values decline on those sides of contour lines with hachures.

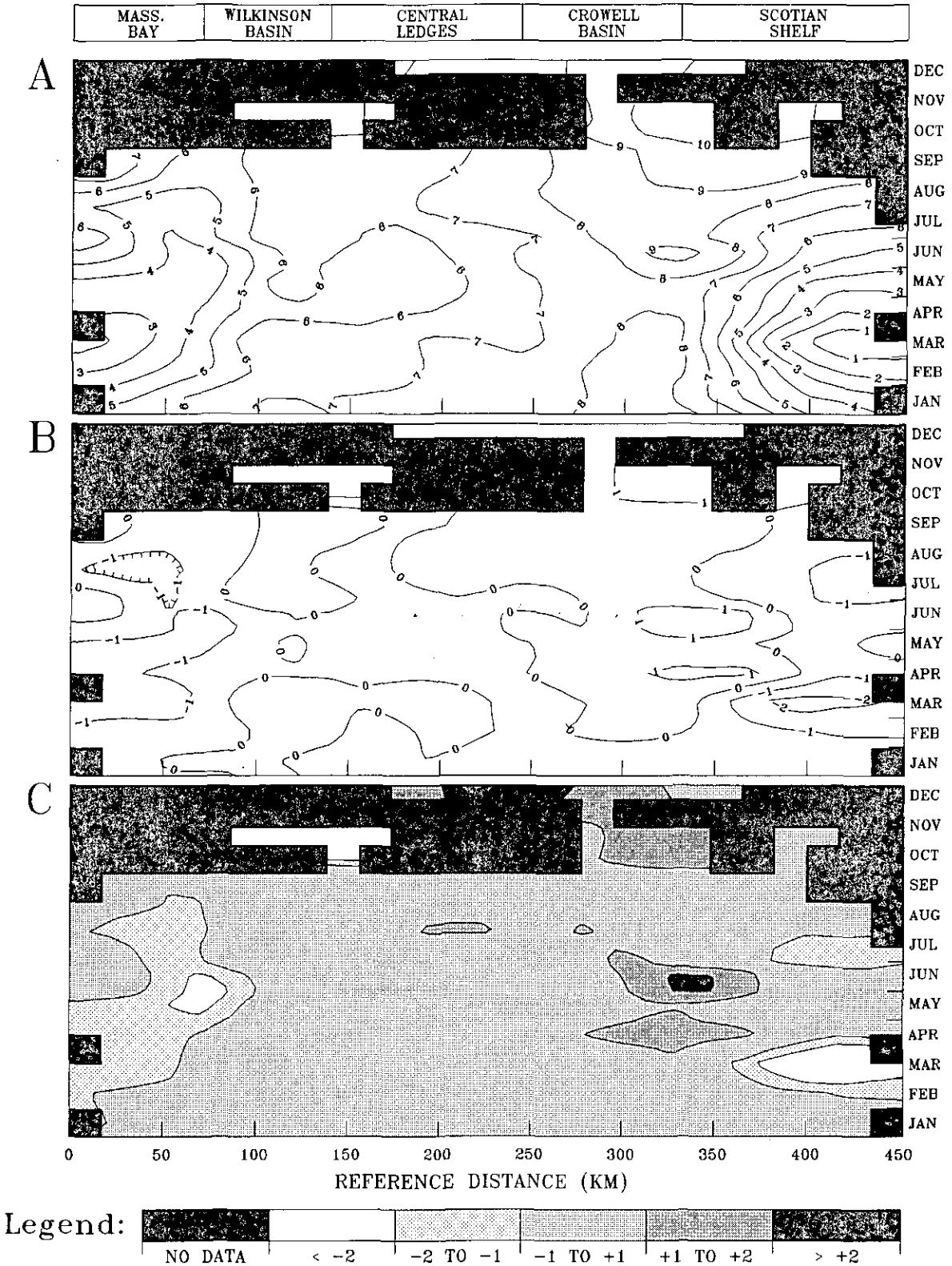

Figure 7. Bottom temperature conditions along the Gulf of Maine transect during 1993. A. Measured values (degrees centigrade) in time and space. B. Anomalies in time and space based on 1978 through 1992 means. C. Standardized anomalies (standard deviations) in time and space based on 1978 through 1992 means and variances; scale given in legend. In panels A and B values decline on those sides of contour lines with hachures.

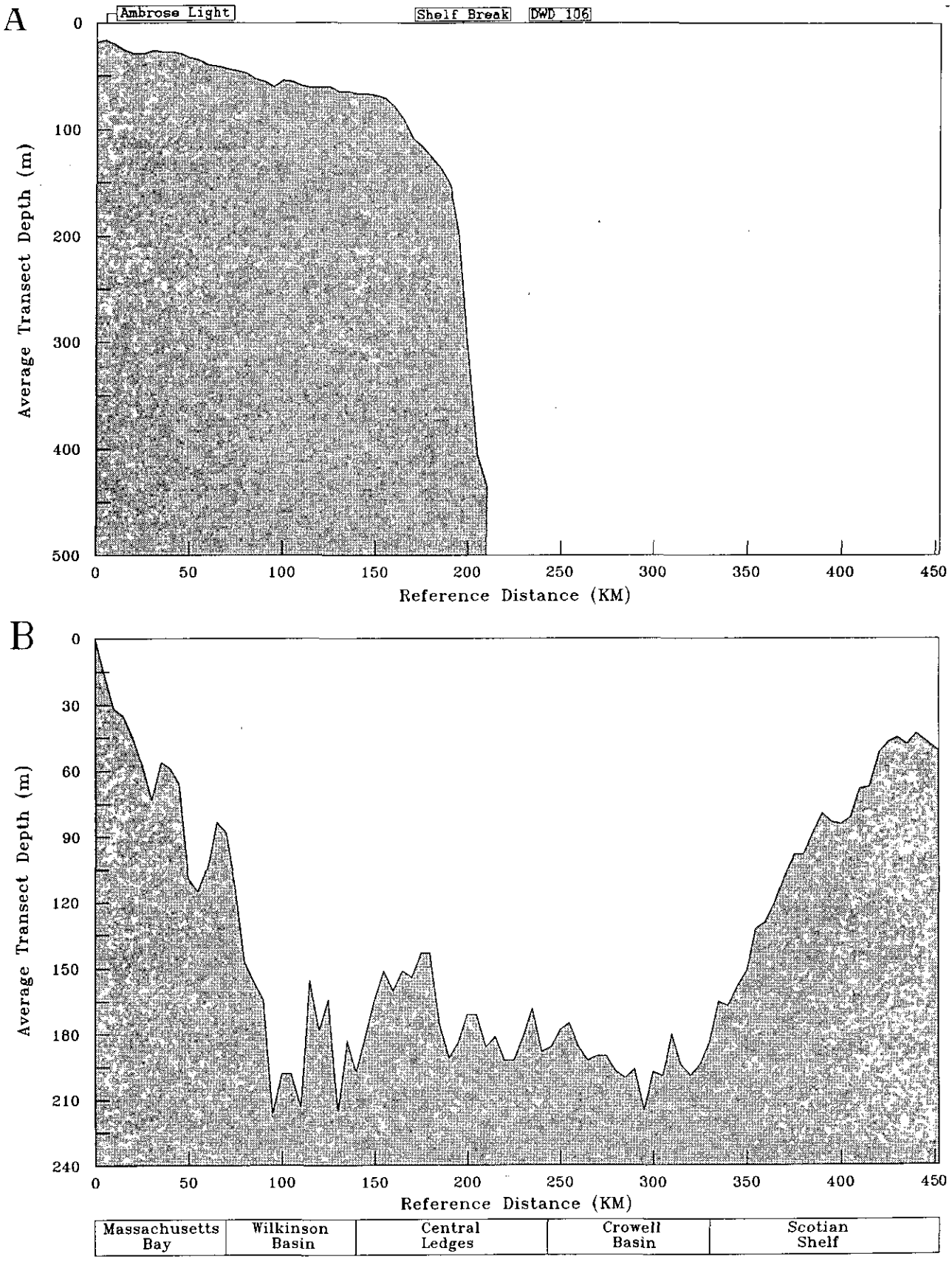

Figure 8. Mean bottom depth along the transects based on monitoring survey data, 1978 through 1991. A. Middle Atlantic Bight. B. Gulf of Maine.