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Water Column Thermal Structure Across the Shelf and Slope Southeast of Sandy Hook, New Jersey in 1988

by

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Abstract

Monitoring of shelf and upper slope water tmperature in the New York Bight continued in 1988 for the thirteenth year as part of the NEFC Ships of Opportunity Program (SOOP). Temperature-depth profiles were constructed from 13 expendable bathythermograph (XBT) transects extending from the entrance of New York Harbor through the 106-Mile Dump Site. From the XBT data, depictions of the water column temperature structure, bottom temperatures and sea surface temperature through the year have been derived. During 1988, water temperatures on the shelf and in the slope water followed the normal annual cycle, although they were generally cooler than usual. Continuing a pattern that began in 1985, bottom temperatures on the upper slope were warmer than normal by approximately 1°C. Abrupt changes in bottom temperature on the upper slope occurred during the passage of two warm core rings in the latter half of the year.

Introduction

Monitoring of water temperatures across the continental shelf and upper slope in the New York Bight continued in 1988 for the thirteenth year. Temperature-depth profiles were constructed from 13 expendable bathythermograph (XBT) transects extending from the entrance of New York Harbor, beginning at Ambrose Light, through the 106-Mile Dumpsite (DWDS-106), enroute to Bermuda

(Fig. 1). Information about the XBT cruises conducted and the oceanic features monitored in the New York Bight is presented in Table 1. The pattern of water temperatures through the year is shown in diagrams of water column temperature structure on the shelf (Fig. 2), bottom temperature on the shelf and upper slope (Fig. 3), and sea-surface temperature and anomalies along the transect (Fig. 4 and 5).

Methods

A "station-through-time" diagram (Fig. 2) was constructed by plotting the temperatures in the water column at a reference point 100km from the shore, for each cruise, on the date of the cruise. These plotted values were contoured, at 1°C intervals, through time for the year. The 100-km reference distance was selected for its mid-shelf location, a position in the cold pool not influenced by the Hudson Canyon.

A bottom temperature diagram (Fig. 3) was constructed following the method of Chamberlin (1977), by deriving bottom water temperatures from each contoured vertical section, plotting the temperatures against depth and date, and contouring at 1°C intervals. To extend the bottom temperature diagram to shore (0-m bottom depth), the records of daily observations of sea-surface temperature at Ambrose Tower (New York Harbor) were acquired from the NOAA Data Bouy Center.

A sea-surface temperature plot (Fig. 4) was constructed using sea-surface temperatures recorded on each monthly transect, plotting the temperatures on axes of time and distance from shore, and contouring at 2°C intervals. A sea surface temperature anomaly diagram (Fig. 5) was constructed by averaging sea surface temperatures for the six years, 1982-1987, and subtracting the averages from the values for 1988.

In the New York Bight two distinct water masses are present: shelf water and slope water. A thermal transition zone, the shelf/slope front (SSF) separates the inshore shelf water from the offshore slope water and is visible at the surface for most of the year in satellite imagery. The surface position of the SSF is generally over the 200-m isobath, while the bottom indicator, the intersection of the 10°C isotherm with the bottom, occurs at depths of 80-120 m (Wright, 1976). The 10°C isotherm has also been used by Cook (1985) to define the boundaries of the cold pool in the Middle Atlantic Bight. Following these methods, the location of the shoreward and offshore positions of the 10°C isotherm were determined from the vertical temperature sections and listed for each cruise in 1988 (Table 1) to estimate the depth range and presence of the cold pool and the position on the bottom of the SSF. Based on analysis of Gulf Stream warm core rings in 1988 by Fairfield and Sano (MS 1989), three rings were present along this transect during the year. In comparison, for the years 1977-1983 and in 1985-1987 an average of four rings were present each year with a maximum of five in 1982 and minimum of two in 1987. The year 1984 was unusual in that no warm core rings moved far enough to the south and west to enter the transect envelope (Fig. 1).

Shelf Water Events

In 1988, sea surface temperatures nearshore (top of Fig. 3) ranged from a minimum of about 3.2°C in mid-February to a maximum of over 22°C in early-August. Sea surface temperatures at mid-shelf ranged from less than 6°C in mid-March to greater than 21°C in late July and early August (Fig. 2), about 3° cooler than normal for summer, but reflecting the normal timing lag and temperature increase from nearshore to offshore.

Bottom Temperature Events

In 1988, "cold pool" water (< 10°C) lasted on the bottom until mid-November, more than a month later than usual (Fig.3). The extent on the bottom of water cooler than 5°C (a subjective way of estimating winter intensity) was about typical compared to previous years. In 1988, 5°C water lasted on the bottom until late March and extended to about the 50-m isobath on the bottom, which were typical conditions. With fall overturn, temperatures on the bottom were generally about 12°-13°C in November over most of mid- to outer shelf depths (50 - 100 m). The November bottom temperatures were about the same as those reported by Cook (1985) for the years 1977-1981, but about

2°C cooler than those found in 1982-1986 and 2°C warmer than the unusually cool conditions observed in 1987. On the upper slope, at depths of 100 m to 200 m, water temperatures exceeding 12°C persisted throughout the year, except for March and April, as was the case in 1987. Since 1977, water warmer than 12°C has remained on the upper slope for the entire year only twice, in 1985 and 1986. Of the three warm core rings crossing the transect line in 1988, only rings 88-C and 88-H seemed to come close enough to the shelf and upper slope to affect the bottom temperatures (Fig. 3). With ring 88-C, bottom temperatures on the upper slope at depths of about 200 m and greater decreased about 2°C during July and August, and 12°C water moved into shallower water on the bottom, shifting from about 175 m bottom depth in May to 110 m in August. In December, with the passage of ring 88-H, bottom temperatures at depths greater than 200 m increased 1°-2°C and ring water, of temperature greater than 15°C, came into contact with the bottom at about 175 m depth.

Sea Surface Temperature Events

During 1988, minimum sea-surface temperatures occurred in February on the shelf, but in March for the outer slope water, and the maximum was in August, across the full width of the transect (Fig. 4). Sea surface temperatures on the shelf ranged from about 4° to 23°C and off the shelf from 7° to greater than 27°C. Shelf water at the surface was typically 1°-2° cooler than the 6-year means throughout the year (Fig. 5). In the slope water (beyond the 200-m isobath), surface waters were about 2°-3°C cooler than average during the first half of the year and 1°-2°C cooler for the remainder of 1988. Large negative anomalies of more than 4°C cooler than average were present just offshore of the shelf break in February and May, resulting from offshore extensions of cool shelf water (Fig. 5).

Summary

In 1988, cold pool temperatures on the bottom at mid-shelf during summer were about 1° to 2°C cooler than observed in 1985-1987. At mid-shelf, the cold pool persisted for about a month longer than normal. For the fourth consecutive year, bottom temperatures along the upper slope remained above 12°C for all, or most of the year, which seems to continue a trend of warmer temperature on the bottom of the upper slope since 1977. Distinct changes in bottom temperatures on the outer shelf and upper slope accompanied the passage of two warm core rings during the latter half of the year. Sea-surface temperatures averaged 1° to 2°C cooler on the shelf and 1° to 3°C cooler in the offshore slope water.

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Table 1. Water column thermal structure in 1988.

Cruise No. M/V Oleander	Date	Depth range of the cold pool. Minimum-Maximum depth depth (m)	Bottom depth (m) of $10^{\circ}C$ isotherm SSF indicator	Rings present along transect
88-01	Jan 08	Isothermal	70	-
88-02	Feb 05	Isothermal	68	-
88-03	Mar 18	Isothermal	83	-
88-04	Apr 08	Isothermal	160	-
88-05	Apr 13	Isothermal	184	-
88-06	May 06	3-108	108	-
88-07	Jun 10	18-83	83	-
88-09	Jul 7-8	15-83	83	88-C
88-10	Aug 19-20	15-75	75	88-C
88-12	Sep 9-10	22-69	69	-
88-13	Oct 14	39-68	68	88-E
88-15	Nov 4	36-73	73	88-H
88-16	Dec 2-3	Isothermal	-	88-H

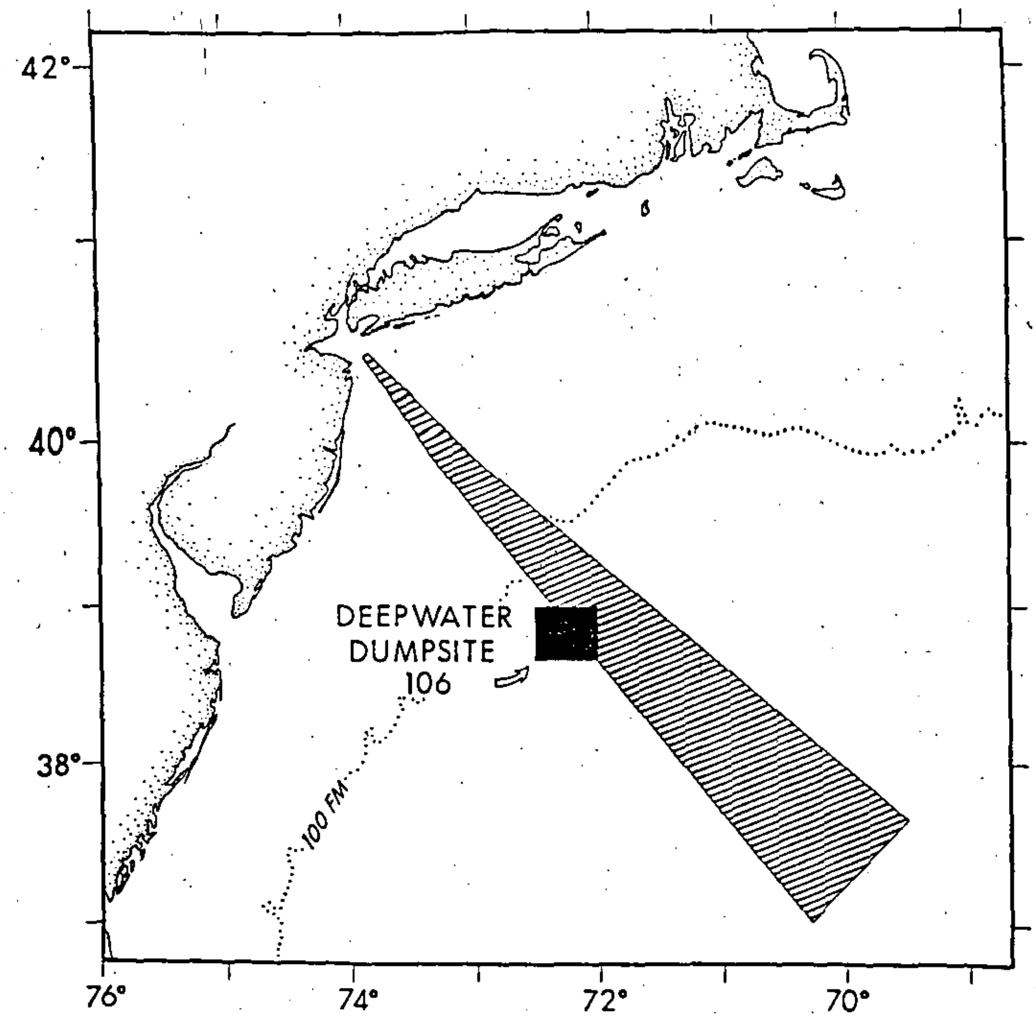

Figure 1. Envelope of 1988 transects in the New York Bight from the entrance of New York Harbor to beyond the 106 Dumpsite.

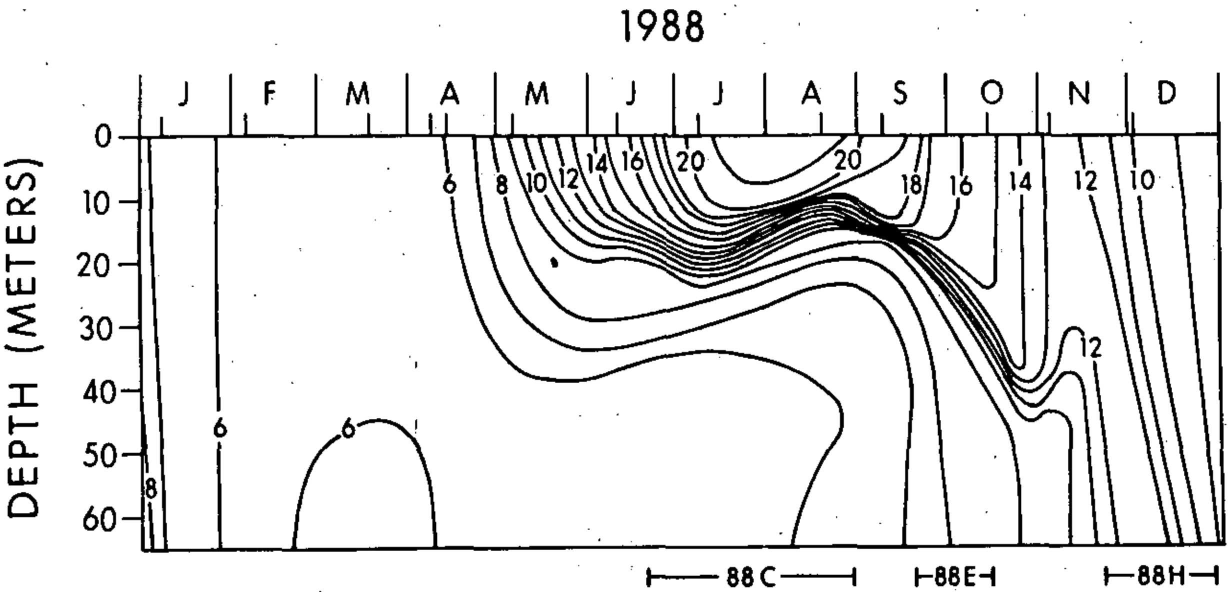

Figure 2. Station through-time diagram depicting seasonal water column temperatures (°C) at mid-shelf.

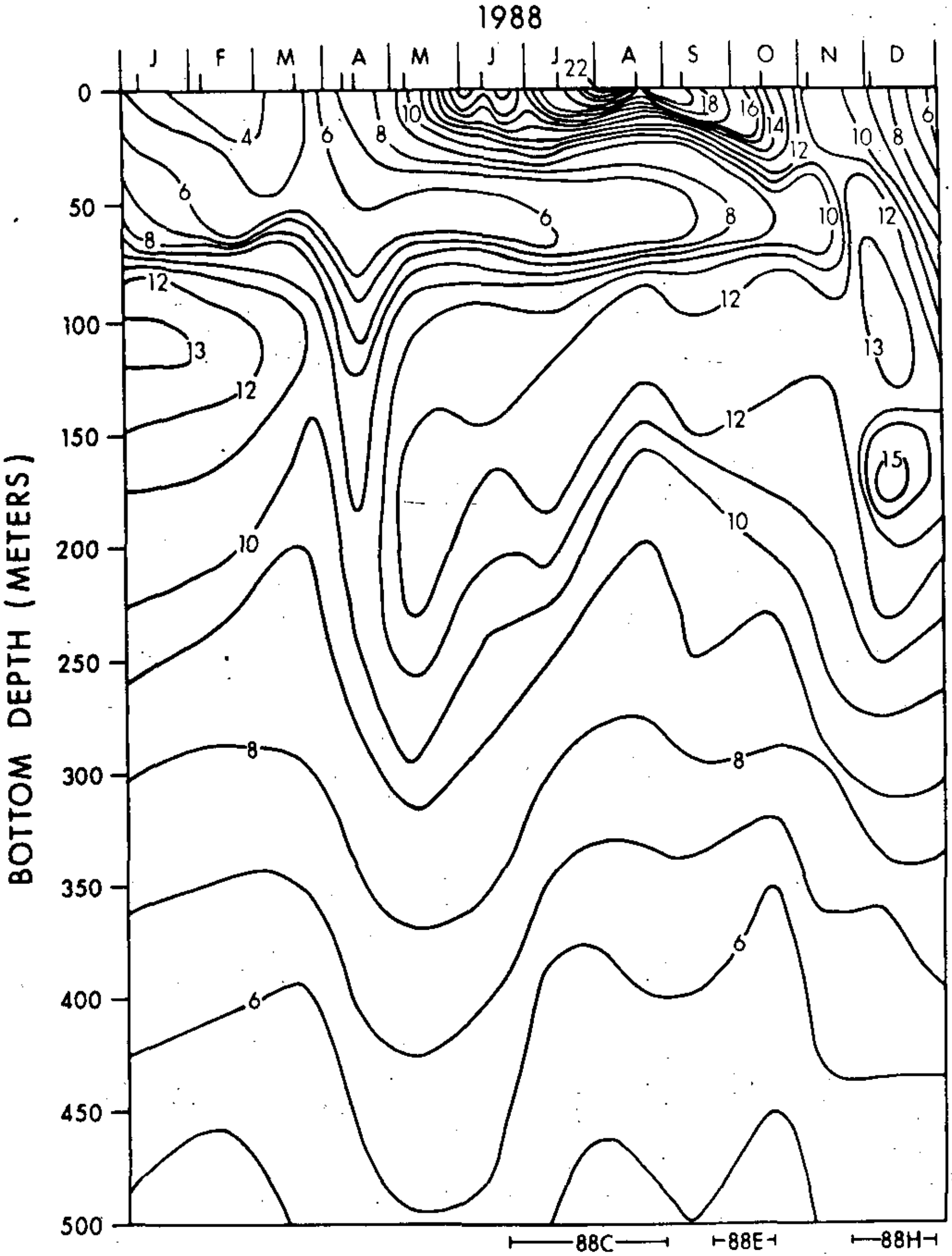

Figure 3. Bottom temperature diagram of the continental shelf and slope waters from New York harbor to the 106-Mile Dumpsite. Lines at the bottom indicate the duration of Gulf Stream warm core rings in the New York Bight area.

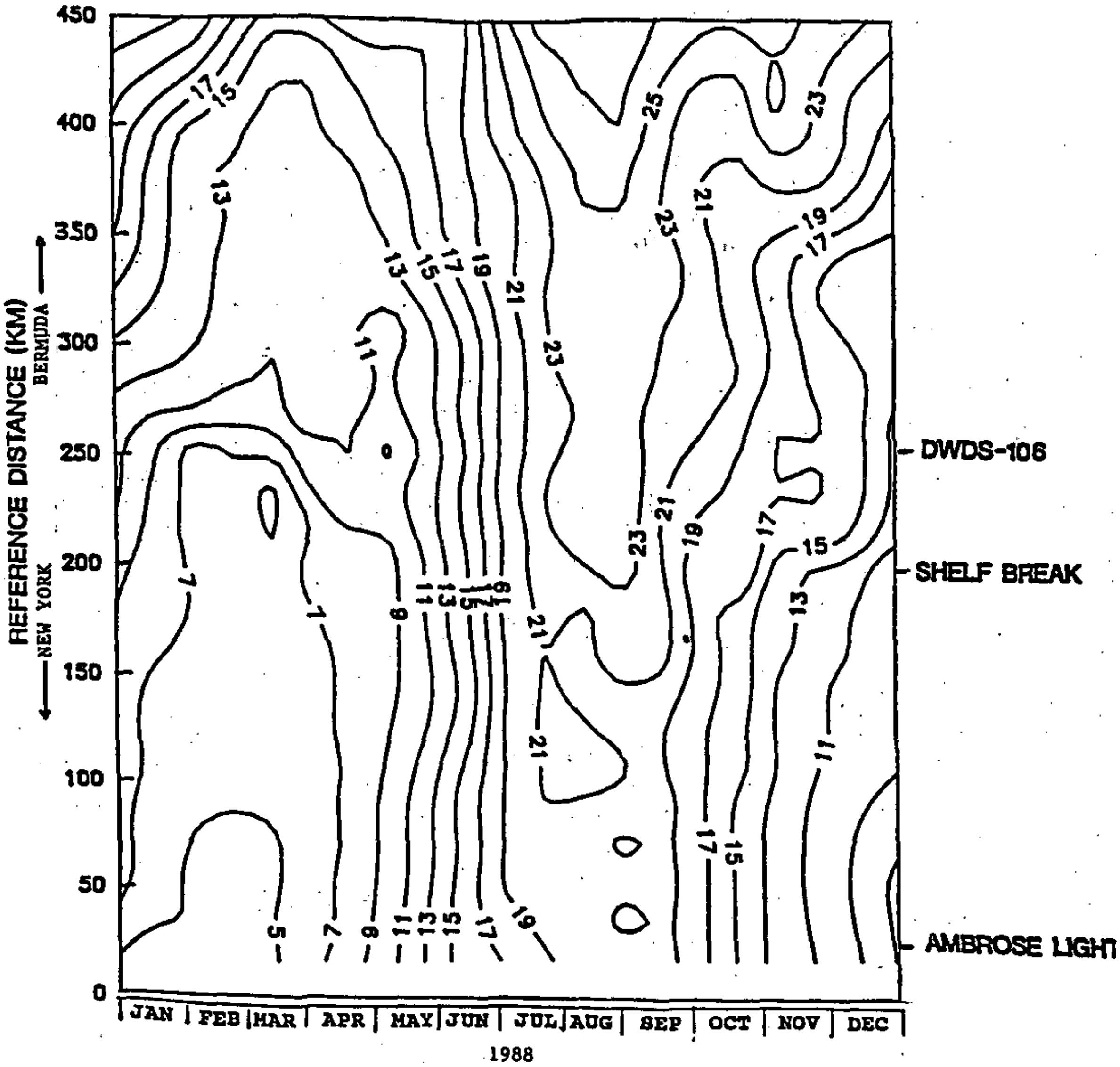

Figure 4. Sea surface temperature (°C) for 1988 along the transect (Fig.1). The shelf break position noted is the average location of the 200-m isobath along the transect.

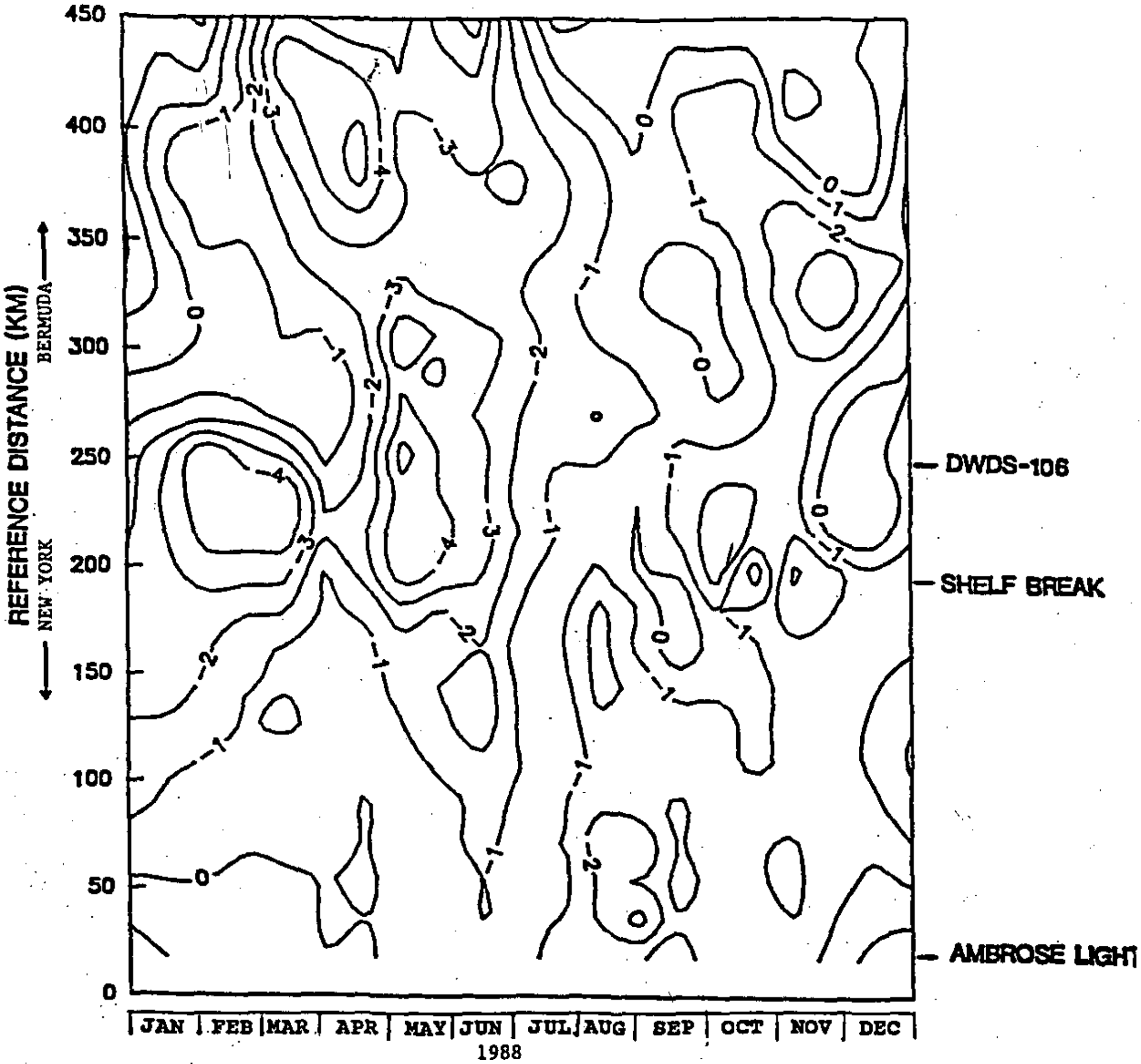

Figure 5. Sea surface temperature anomaly (°C) for 1988 along the transect (Fig. 1). Anomalies are departures from mean for 1982-1987. The shelf break position noted is the average location of the 200-m isobath along the transect.