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Bottom Temperatures on the Continental Shelf and Slope South of New England During 1984

by

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Annual summaries of bottom temperature have been prepared since 1974 following the procedure described by Chamberlin (1976) from expendable bathythermograph (XBT) data collected along transects across the continental shelf and slope south of New England on or near 71°00'W longitude (Fig.1). This report summarizes the data collected during 1984, especially the seasonal and non-seasonal changes in bottom temperature, and compares it to data collected from the same area since 1974 and to bottom temperatures averaged for 1974-1983.

During 1984, 16 XBT transects were collected (Table 1). For each transect a contoured vertical temperature section was drawn. To construct the annual summary diagram of bottom temperatures (Fig. 2B), the bottom temperatures recorded by the XBTs and intersects of isotherms with the bottom, determined from the contoured vertical sections, were plotted by depth and date, and contoured at 1°C intervals. To complete the bottom temperature diagram to shore, temperatures were determined from the following two records: daily observations acquired from the NOAA National Ocean Survey of tide station temperture (0m depth) at Newport, Rhode Island (41°30'N, 71°20'W); and data collected from a recording thermograph placed on the bottom at Brenton Tower (20m depth) in the mouth of Narragansett Bay (41°25'N, 71°25'W). Passage of the one warm core Gulf Stream ring (84-E) through slope water south of New England in 1984 is noted as a line of duration along the bottom of Figure 2B. The duration line starts when the western edge of the ring crossed the transect line and ends when the ring's northern edge passed south of 39°30'N.

The ring positions were determined from the warm core ring analyses for 1984 by Price (MS 1985).

For comparing bottom temperature conditions in 1984, annual summary diagrams of bottom temperature for each of the ten years, 1974-1983, were digitized at 10-m bottom depth, 10-day time increments, and averaged to derive a ten-year mean bottom temperature diagram (Fig. 2A). Differences between the bottom temperatures in 1984 and the ten-year means were calculated and contoured to depict the anomaly patterns of bottom temperature in 1984 (Fig. 2C).

Mean Annual Cycle

Based on the ten-year mean bottom temperature diagram (Fig. 2A), shelf water south of New England typically covers the bottom inshore of the 80-120m isobaths. At the surface near the 200-m isobath, a thermal gradient (front), separating the shelf water from the warmer offshore slope water, is usually visible in infrared satellite imagery. On the bottom, offshore and below shelf water and above cooler deep slope water, there is a slope water thermostad layer of relatively uniform, warm (11°->12°C) water. The thermostad layer is present at depths ranging from about 110 to 200m.

In the shelf water during winter, vertically homogeneous shelf water progressively cools from nearshore to offshore along the bottom to beyond the 100-m isobath, accompanied by deepening of the shelf-slope front and intensification of the frontal gradient. Mid-winter shelf bottom temperatures typically range from 2°C at the coast to 10°C at the shelf-slope front. Annual minimum bottom temperatures occur nearshore in early February and at the shelf water front in early April. Thermal stratification usually is apparent in the water column by early April and bottom temperatures begin rising over the inner shelf from vernal warming. Between the shelf-slope front and nearshore bottom water, the cold pool is found. From spring until autumn, the coolest water on the bottom across the shelf is found in the cold pool. From early April to early August, nearshore waters along the bottom (0-20m) warm at rates of 3°-4°C per month as the thermocline deepens and intensifies, whereas, along the axis of the cold pool (60-80m), bottom temperatures increase at a rate of about 1°C per month. From mid-April until mid-September, the shelf-slope front retreats shoreward along the bottom from a depth

of about 110m in April to near the 80-m isobath in September, and the cold pool diminishes in across-shelf width. As surface water begins cooling and mixing downward during fall, bottom temperatures at depths greater than 40m increase to the annual maximum, with 13°C water present to 150m bottom depth and 14°C water at cold pool depths in November. From December through the winter, cooling and vertical mixing produce vertically homogeneous shelf water which leads to rapidly decreasing bottom temperatures from nearshore to offshore.

In the upper slope water band at depths from about 110m to 200m, bottom temperatures typically range from 11°C to about 13°C, with maximum temperatures associated with fall overturn. Out to bottom depths of about 170m, annual minimum temperatures occur in April, associated with winter cooling of shelf water, but at greater depths, the annual minimum occurs during summer. From the ten years of records, bottom temperatures at the 200-m isobath have ranged from extremes of about 9°C to 13°C.

1984 Bottom Temperatures and Anomalies

In 1984, bottom temperatures (Fig. 2B) followed the ten-year mean annual cycle, but were generally warmer than normal (Fig. 3B). Winter bottom temperatures in the nearshore shelf waters were about 1°C warmer than normal until mid-March when bottom waters cooled to less than 4°C. By mid-May, nearshore bottom temperatures were near normal and remained near normal for the remainder of the year until December, when cooling was less rapid than in the ten-year mean conditions. In the waters of the mid- and outer-shelf, bottom temperatures were as much as 3°C above normal during February, associated with an onshore displacement of the shelf-slope front on the bottom, which lasted from mid-January until mid-March. By the end of April, the cold pool had become established and bottom temperatures and the development of the cold pool were fairly typical until its destruction from fall overturn in October. During fall overturn, and continuing until the last sampling in late November, bottom temperatures were above normal from 50 m to beyond 200m bottom depth. During November, water of greater 17°C was present on the bottom from the 70-m to greater than the 90-m isobaths, when bottom temperatures reached more than 4°C above normal. For the 1974-1983 data, only in 1977 and 1980 was water as warm as 17°C

present at mid-shelf or greater depths, and in both those years, the maximum depth of 17°C water was about 70m. During late April and early May at bottom depths of about 80 to 120m, the shelf-slope front shifted onshore and then was abruptly displaced offshore. With the shoreward displacement, warmer slope water invaded the outer shelf and, with the offshore displacement in early May, cooler shelf water replaced it. In September, with the passage of the weak remnants of warm core ring 34-E, water warmer than 13°C extended onto the bottom between about the 90-m and 130-m isobaths, resulting in bottom temperatures as much as 2°C above normal

In the upper slope water band in 1984, water warmer than 12°C was present throughout the year (Fig. 2B). Of the previous ten years, only in 1974 and 1975 did 12°C water remain through the year. During April bottom temperatures were more than 1°C warmer than normal (Fig.2C) because of the presence of water warmer than 12°C at that time. Typically, April is the time of year when less than 12°C water is present (Fig. 2A). During November, upper slope water on the bottom was more than 1°C warmer than the ten-year mean, associated with the warmer than normal conditions on the bottom of the outer shelf.

Discussion

During 1984, in comparison with ten-year averaged conditions (1974-1983), bottom temperatures south of New England were generally above normal for most of the year for nearshore waters. At mid-shelf depths (20-70m) bottom waters were cooler than normal for about half the year (principally during spring and summer), and warmer than normal for the other half of the year. Beyond the 70-m isobatn, bottom temperatures were above the ten-year means for about 90% of the year. Bottom waters in 1984 were particularly warmer than normal at bottom depths of about 70m to 90m in February and in late October-early November. During 1984, only one warm core ring passed through the slope water along the transect. For the ten years, 1974-1983, 3 to 4 rings per year were typical, with minimum of 3 during 4 of the years and a maximum of 7 in 1977.

References

CHAMBERLIN, J. L. 1976. Bottom temperatures on the continental shelf and slope south of New England during 1974. In Goulet, J. R., Jr. (compiler), The environment of the United States living marine resources, 1974 (p. 18-1 to 18-7), U.S. Dep. Comm., NOAA/ NMFS, MARMAP Contrib. 104.

Table 1. Temperature sections collected south of New England during 1984.

Section Number	Date	Vessel and Cruise Number	Coordinates Inshore	Coordinates Offshore
1	4 Jan	CGC "Vigilant" 84-01	41°10'N 70°57'W	39°51'N 71°00'W
2	9 Feb	CGC "Vigilant" 84-02	41°10'N 71°00'W	39°50'N 71°00'W
3	25 Feb	FV "Clearview IV" 84-01	40°48'N 71°02'W	39°46'N 71°01'W
4	4 Mar	FV "Bullwinkle" 84-05	40°31'N 70°50'W	40°02'N 70°49'W
5	22 Mar	RV "Oceanus" 84-01	41°10'N 70°55'W	40°30'N 70°55'W
6	28 Mar	RV "Oceanus" 84-02	41°09'N 70°52'W	39°50'N 70°55'W
7	18 Apr	RV "Oceanus" 84-03	41°10'N 70°55'W	40°10'N 70°55'W
8	25 Apr	RV "Oceanus" 84-04	40°37'N 70°55'W	39°50'N 70°56'W
9	1 May	RV "Oceanus" 84-05	40°41'N 70°55'W	39°54'N 70°53'W
10	4 Jun	RV"Cape Henlopen" 84-01	40°55'N 70°59'W	39°43'N 71°07'W
11	13 Jul	FV "Bullwinkle" 84-16	41°10'N 70°56'W	40°11'N 70°47'W
12	20 Aug	RV "Cape Henlopen" 84-02	41°00'N 70°59'W	39°52'N 70°58'W
13	13 Sep	FV "Bullwinkle" 84-24	40°31'N 70°55'W	40°15'N 70°45'W
14	8 Oct	CGC "Vigilant" 84-03	41°10'N 71°00'W	39°50'N 71°00'W
15	28 Oct	RV "Mt. Mitchell" 84-01	40°56'N 71°00'W	39°48'N 71°00'W
16	25 Nov	CGC "Vigilant" 84-04	41°10'N 71°00'W	39°50'N 71°00'W

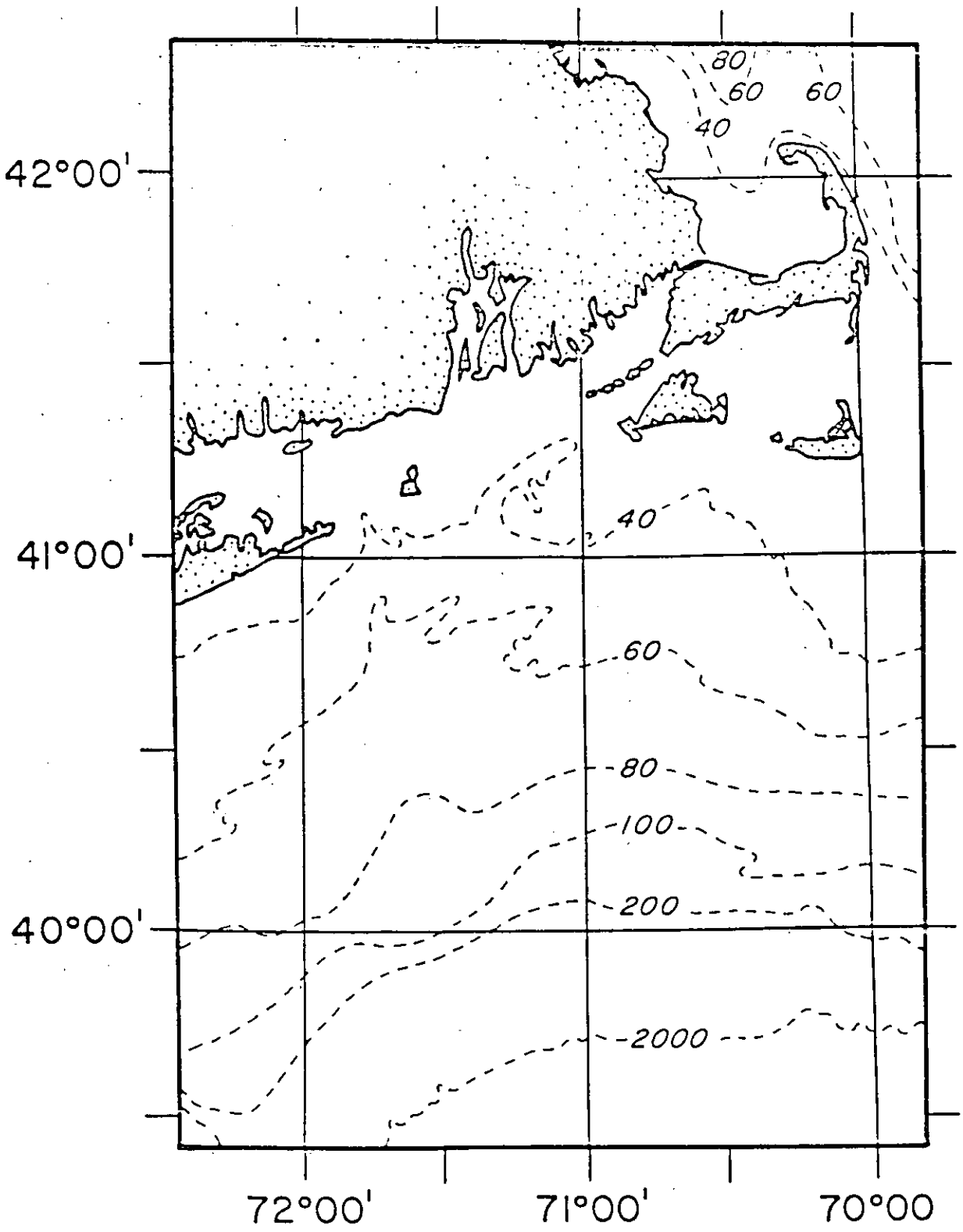

Figure 1. Location of 71°00'W transect south of New England. Depth contours in meters.

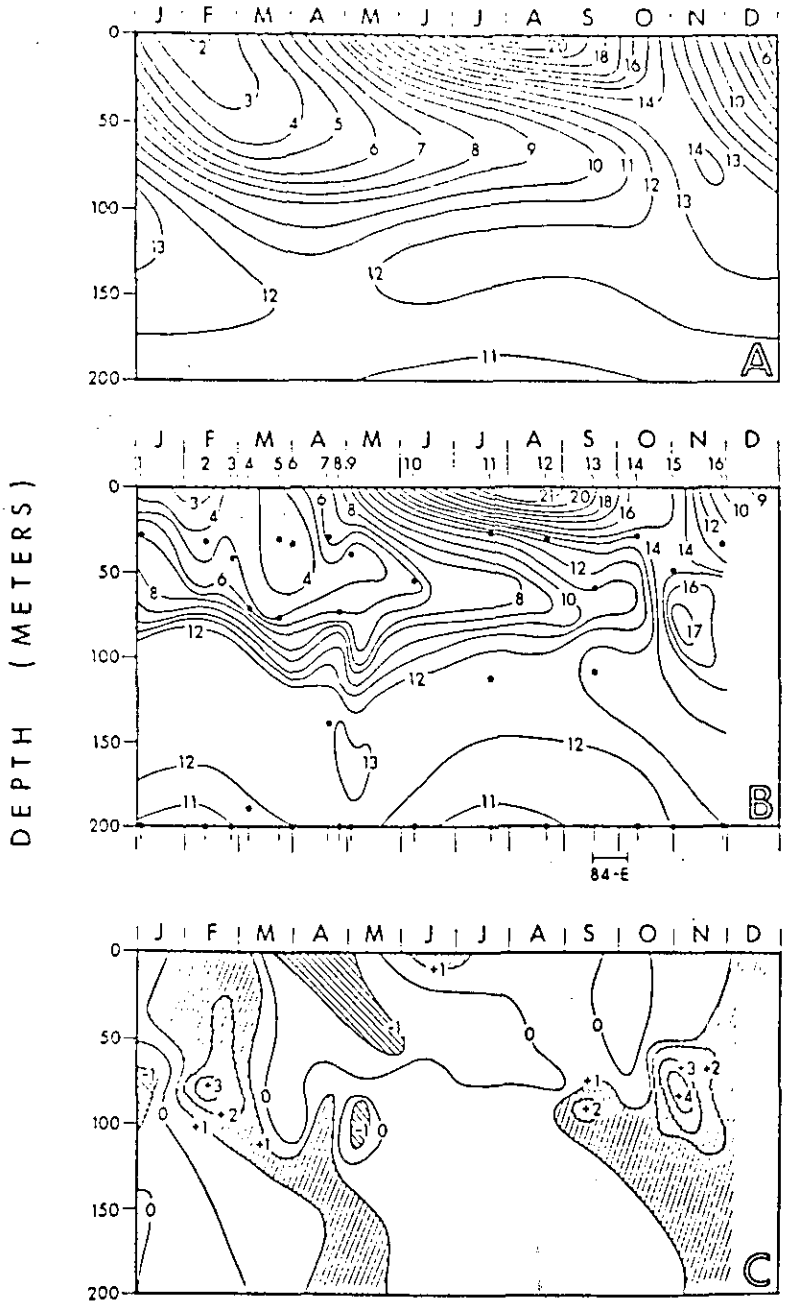

Fig. 2. Bottom temperature (°C) on the continental shelf and upper slope south of New England. (A) Ten-year (1974-1983) mean. (B) 1984 bottom temperatures. Vertical sections are numbered along the top (see Table). Heavy dots mark inshore and offshore limits for each section. Horizontal line at the bottom indicates duration of warm core ring passage south of New England. (C) Anomaly of 1984 bottom temperatures, referenced to ten-year mean, in °C. Hatching denotes anomalies in excess of 1°C.