International Commission for the Northwest Atlantic Fisheries

Serial No. 5457

ICNAF Res. Doc. 79/VI/95

Annual Meeting - June 1979

Bottom Temperatures on the Continental Shelf and Slope South of New England During 1978

by

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Vertical temperature sections and annual summaries of bottom temperature have been produced yearly since 1974 from expendable bathythermograph data collected along transects on the continental shelf and slope south of New England on or near 71°00'W. This report, the second to appear in Annales Biologiques, summarizes the data collected during 1978 -- especially the seasonal and transient variability of bottom temperatures on the shelf and upper slope -- and includes comparison with the previous 4 years.

During 1978, 21 temperature transects were obtained (table 1). For each transect a vertical temperature section was constructed. A section locator chart is provided (fig. 1). To construct the bottom temperature diagram (fig. 2), the intersects of isotherms with the bottom, determined from the vertical sections, were plotted by depth and date, and then contoured at 1°C intervals. In addition to data from the 1978 sections, data from the last 1977 section (22 December) and the first 1979 section (14 January) were used in preparing the diagram.

Passages of warm core Gulf Stream eddies, in a generally westward direction through the slope water south of New England, are represented by the lines at the bottom of figure 2. The line durations are based on an eddy analysis for 1978 by Celone and Chamberlin (in this volume). Each line starts when an eddy intersects a cruise track and ends when the eddy passes south of 39°30'N.

The shelf water south of New England extends from shore to a transition zone, the shelf/slope water front, which is visible at the surface during most of the year in satellite thermal infrared imagery. At the bottom the front is identified by the 10°C isotherm, except during fall when shelf water at the bottom rises above 10°C to its annual maximum and becomes thermetrically indistinct from slope water. Shelf water, however, can always be identified by salinities less than 35.0 ppt. The front most frequently intersects bottom at depths between 80 and 120 m, and slants seaward to the surface (Wright 1976).

A warm band of slope water rests on the bottom beneath the shelf/slope water front and above the colder deep slope water. Mid depth of the warm band is at an average depth of about 150 m. The presence of warm core eddies in the slope water region is usually evidenced by warm anomalies on the bottom in the depth range of the warm slope water and sometimes penetrating shoreward into the area ordinarily occupied by shelf water.

Abnormally cold weather prevailed over the northeast coast of the United States for the second consecutive winter, with temperatures averaging about 2°C below normal from December 1977 through February 1978. The previous winter of 1976-77 was 2° to 3°C below normal. Two consecutive comparably cold winters have not occurred since 1903-04 and 1904-05 (Wagner 1978).

SHELF WATER EVENTS

Winter cooling of the shelf water was well established at the beginning of January (fig. 2), but was interrupted at depths greater than 80 m by the presence of water associated with a warm core Gulf Stream eddy (77-D) which persisted south of New England until mid-February (fig. 3). The lowest bottom temperatures observed during the year were in late February and early March when water colder than 2°C extended to 60 m depth. Winter bottom temperatures at depths less than 50 m were similar to those recorded in 1977 but from 1° to 3°C cooler than those observed in 1974-1976.

In February bottom water cooling progressed seaward following the passage of eddy 77-D. The deepening of the shelf/slope water front at the bottom during March and April was accompanied by an unusual offshore extension of shelf water at the surface (Chamberlin 1978). South of New England in mid-April, shelf water extended approximately 158 km seaward of its normal limit at the surface, as defined by Wright (1976), and reached depths averaging 80 m (Hilland, in this volume).

The front was deepest on the bottom from late April through early May (fig. 4). The maximum depth recorded, about 155 m, was similar to that recorded in 1977, but the duration of the deepening was greater in 1978 than in the previous year, when passage of a warm core eddy caused a shoreward migration of the front and interrupted cooling near the shelf edge. During the period from 1974-1976 the shelf/slope water front rarely, and only briefly, reached bottom depths below 120 m.

At the end of March, bottom temperatures at depths less than 90 m tended to warm, and at depths less than 60 m rapid spring warming set in during late April. The bottom position of the shelf/slope front moved inshore during May, becoming established in normal depths between 80 and 100 m by the end of the month.

The first sign of thermal stratification was in mid-April (fig. 4) and progressive surface warming in May (fig. 5) insulated the "cold core" bottom water from atmospheric warming. During the late spring and through the summer, the cold core gradually warmed at a rate of about 0.8°C/month, but minimum temperatures in the core remained 1°-2°C cooler than measured in any of the previous four years. However, bottom temperatures inshore of the cold core, in less than 40 m, were similar to those observed in the other years.

Temporary deepening of the shelf/slope front to 120 m on the bottom in mid-July (compare figs. 2, 6, and 7) may have been caused by offshore entrainment of shelf water by eddy 77-A. In August, following passage of the eddy, the front returned to depths between 80 and 100 m.

As the bottom water in the cold core continued to warm through September and October, the temperature difference between shelf and slope water became nearly indistinct. A remnant of cold core water, <10°C on the bottom at depths around 80 m, was observed in October (fig. 8). From late October to mid-November, as the surface layer cooled and mixed to greater depths, the bottom temperatures warmed rapidly to an annual maximum of about 14°C, and the water column became nearly isothermal, to depths of 70 m. This fall overturn, in 1978, was accompanied by an intrusion of eddy water from 77-D, which in late November injected >15°C water onto the shelf to the 60 m isobath (fig. 9).

The onset of fall overturn occurred later in 1978 than in the previous four years. Thus, bottom temperatures between 50 and 100 m during September and October were from 1° to 4°C cooler than those observed in the other years. When the overturn did occur, however, warming on the bottom was apparently rapid, resulting in occurrence of the annual maximum at about the same time as recorded in other years.

Following the overturn, winter cooling proceeded rapidly to the end of the year, at bottom depths less than 60 m. Deeper than 60 meters, warm slope water apparently persisted on the bottom.

SLOPE WATER EVENTS

In 1978 bottom temperatures in the warm slope water ranged from above 15°C, when eddies were present, to below 11°C during most of the period from March through mid-June. The highest temperature recorded on the bottom in the warm band during the last five years was greater than 17°C while an eddy was present in 1975. The lowest temperatures recorded in the area of warm slope water contact was 9.5°C in February 1977 during a period of record cold weather.

The warming influence of Gulf Stream eddies in the slope water region is apparent in figure 2. They commonly bring 12°-15°C water to the bottom, and usually cause detectable warming down to depths greater than 400 m. Each eddy present south of New England during 1978 produced the familiar pattern of warming.

The cooling brought about by two consecutive cold winters appears to have significantly affected slope water bottom temperatures. In 1978, observed maximum temperatures in the slope water warm band were below 11°C for ten months from February to November. During the previous 4 years the longest period of such cold temperatures in the warm slope water mass was 6 or 7 months during 1977. Although each of these two years started with record cold weather, comparing them in regard to slope water temperatures is complicated by the fact that 1978 was a year when few warm core eddies passed south of New England, whereas 1977 was a year of numerous eddies (Crist and Chamberlin 1979). Throughout the 10 months in 1978 when the warm slope water was below normal, temperatures warmer than 11°C were observed on the bottom only during part of February, following the passage of eddy 77-D, and in August, following the passage of 78-A. The brief occurrence of 12°C water on the bottom at 200 m in February may have been a remnant from the prior passage of eddy 77-D, or a remnant of the previous year's warming of the slope water. In 1974 and 1976, maximum temperatures recorded in the warm band were all above 12°C, and in 1975 and 1977, were above 12°C during at least half of the year. When present during these years, the 12°C warm band reached depths of 180-220 m. The possibility that the recent cold winters may have moderately cooled the deep slope water is suggested by the occurrence of water colder than 6°C, at depths below 350 m, for a longer period during 1978 than recorded in any of the previous 4 years.

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Table 1. List of temperature sections obtained off southern New England during 1977.

Section Number	Date	Ship/Cruise Number
1*	31 January	Univ. Rhode Island R/V 'Endeavor' EN-18
2	22-24 February	NOAA R/V 'Albatross IV' 78-02
3	10 March	NOAA R/V 'Delaware II' 7802
4	4 April	Univ. Rhode Island R/V 'Endeavor' EN-20
5*	18 April	WHOI R/V 'Oceanus' OC-43
6	5-6 May	Univ. Rhode Island R/V 'Endeavor' EN-21
7*	12 May	USSR R/V 'Argus' 78-04
8	26 May	Univ. Rhode Island R/V 'Endeavor' EN-21
9	11-12 June	M/V 'Jennie and Jackie' 7801
10	27 June	WHOI R/V 'Oceanus' OC-48
11*	10 July	WHOI R/V 'Oceanus' OC-48
12*	21 July	Texas A & M R/V 'Gyre' 7866
13	31 July	M/V 'Jennie and Jackie' 7802
14	17-18 August	NOAA R/V 'Delaware II' 7805
15	20-21 August	NOAA R/V 'Albatross IV' 7810
16	29 September	NOAA R/V 'Delaware II' 7806
17*	20-21 October	Univ. Rhode Island R/V 'Endeavor' EN-30
18	11 November	Univ. Rhode Island R/V 'Endeavor' EN-30
19	21 November	NOAA R/V 'Delaware II' 7806
20*	29 November	USSR R/V 'Belogorsk' 7804
21	9 December	NOAA R/V 'Albatross IV' 7815

*Sections illustrated in this report.

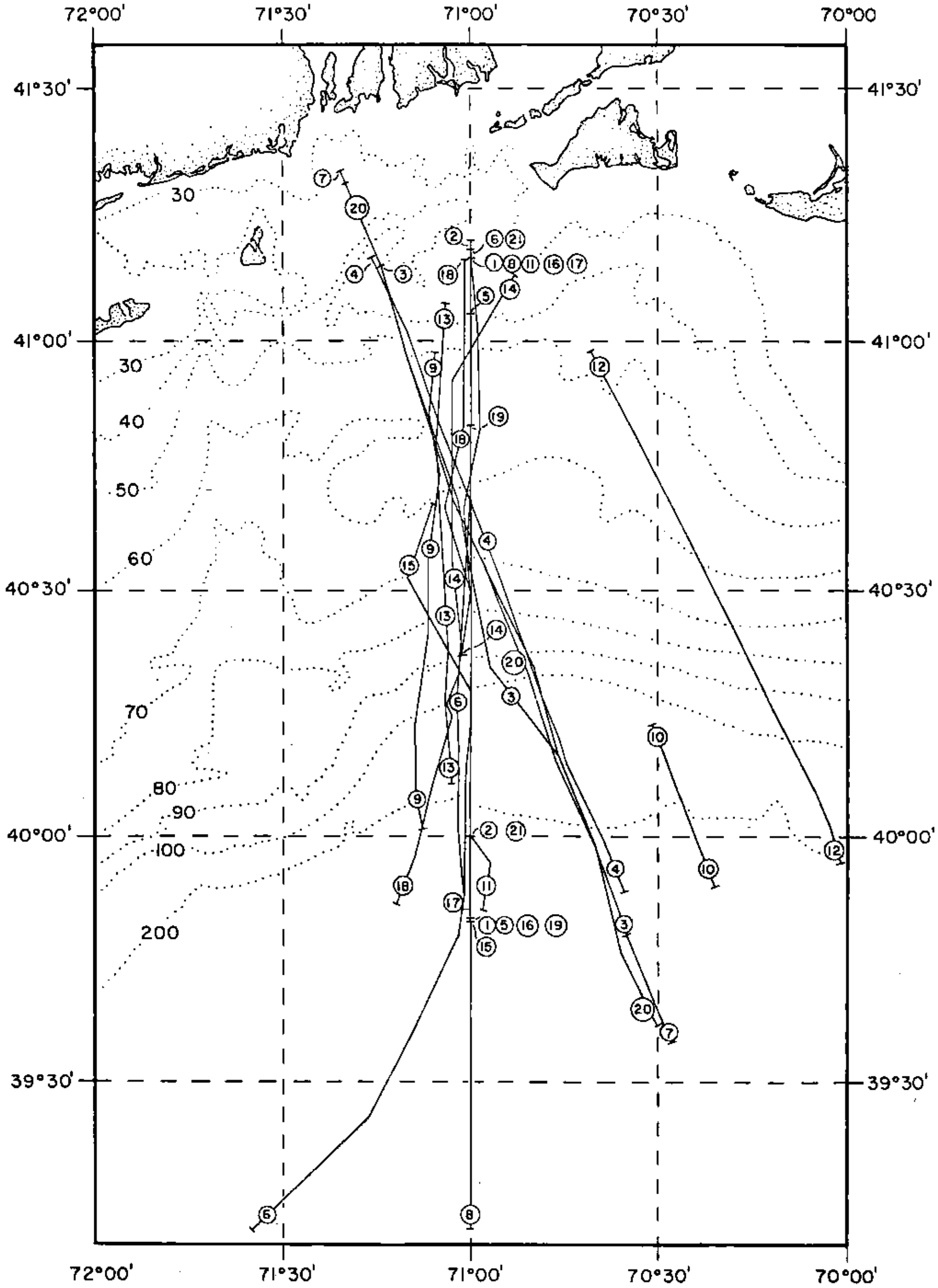

Fig. 1. Cruise lines along which vertical temperature sections were collected. Sections are numbered chronologically. Dates and sources of data are given in table 1. Depth contours in meters.

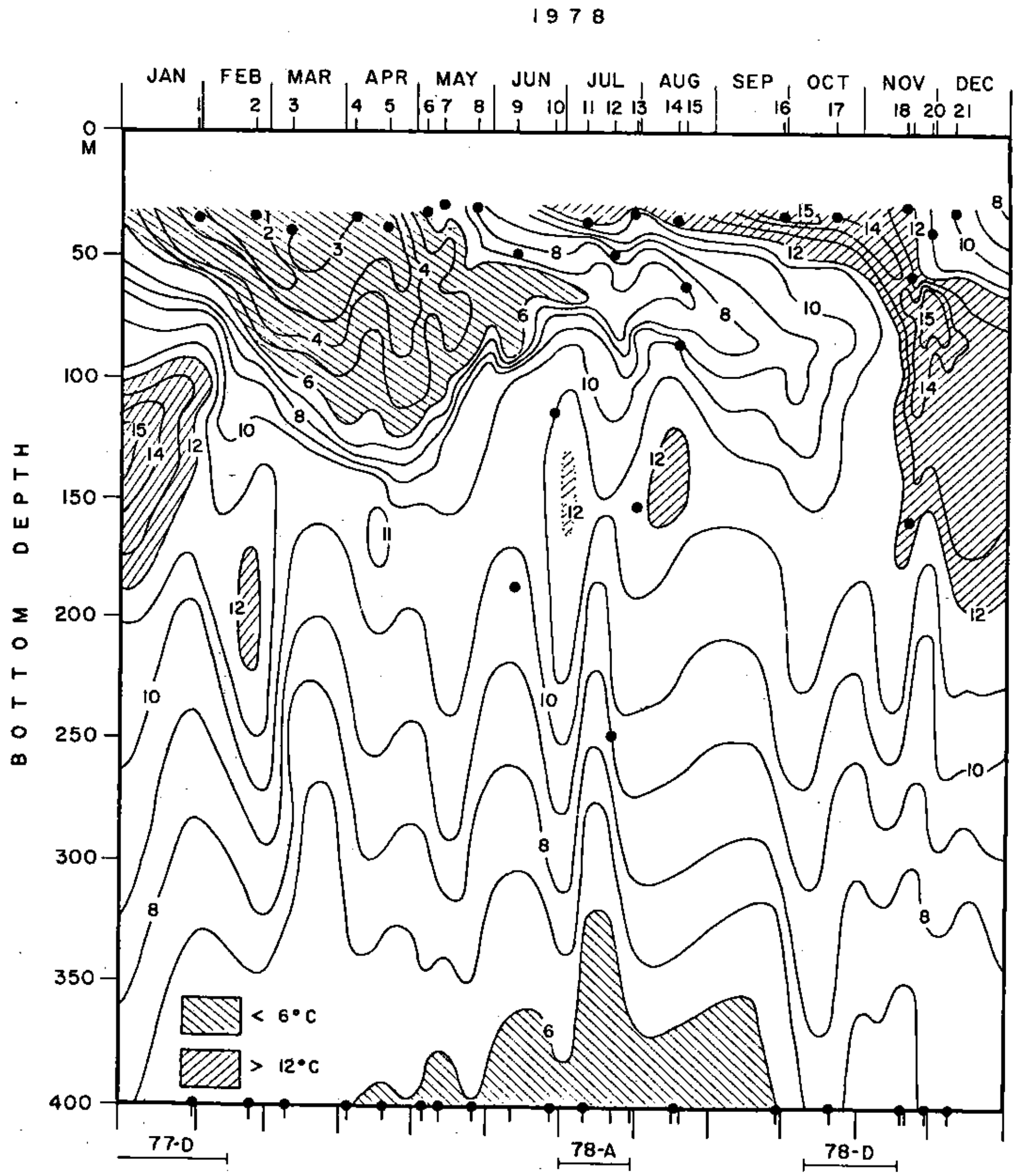

Fig. 2. Bottom temperatures on the continental shelf and slope south of New England during 1978. Vertical sections are numbered along the top (see table 1). Heavy dots mark inshore and offshore depth limits for each section. Horizontal lines at bottom indicate duration of warm core Gulf Stream eddy passages south of New England.

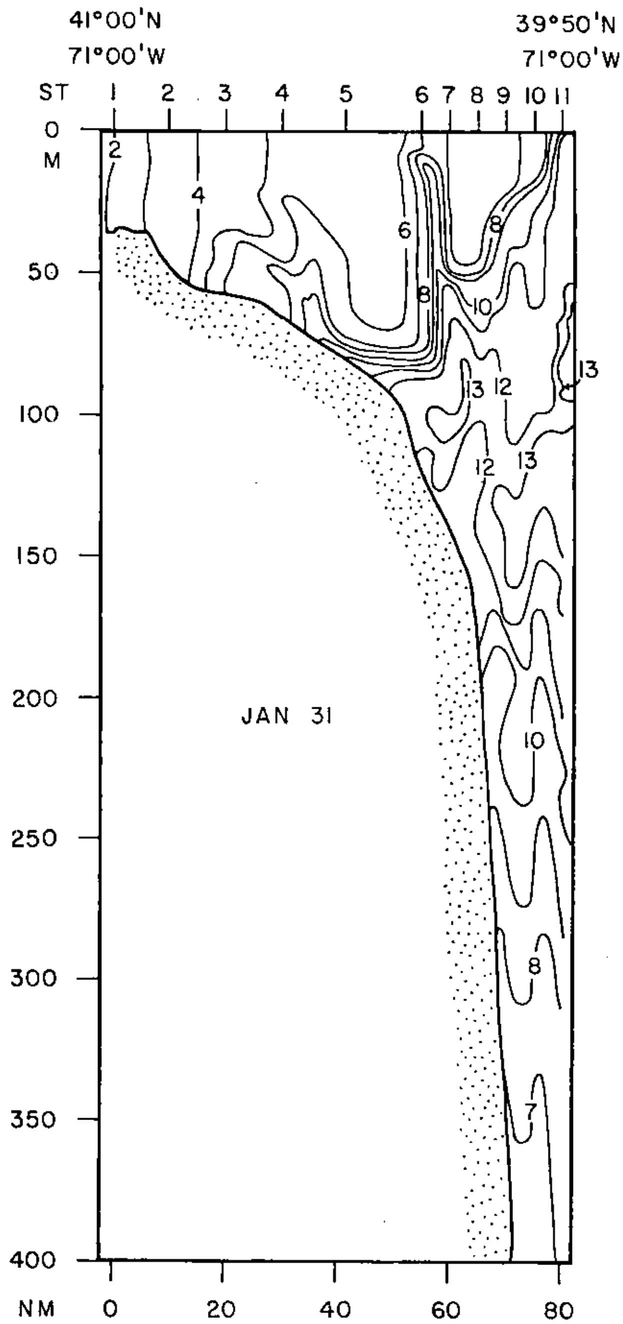

Fig. 3. Section 1. Legend for this and subsequent figures: solid line contours are at 1°C intervals, dashed line contours are at 0.5°C intervals. Station numbers appear at top of figure, and distance scale at bottom of figure.

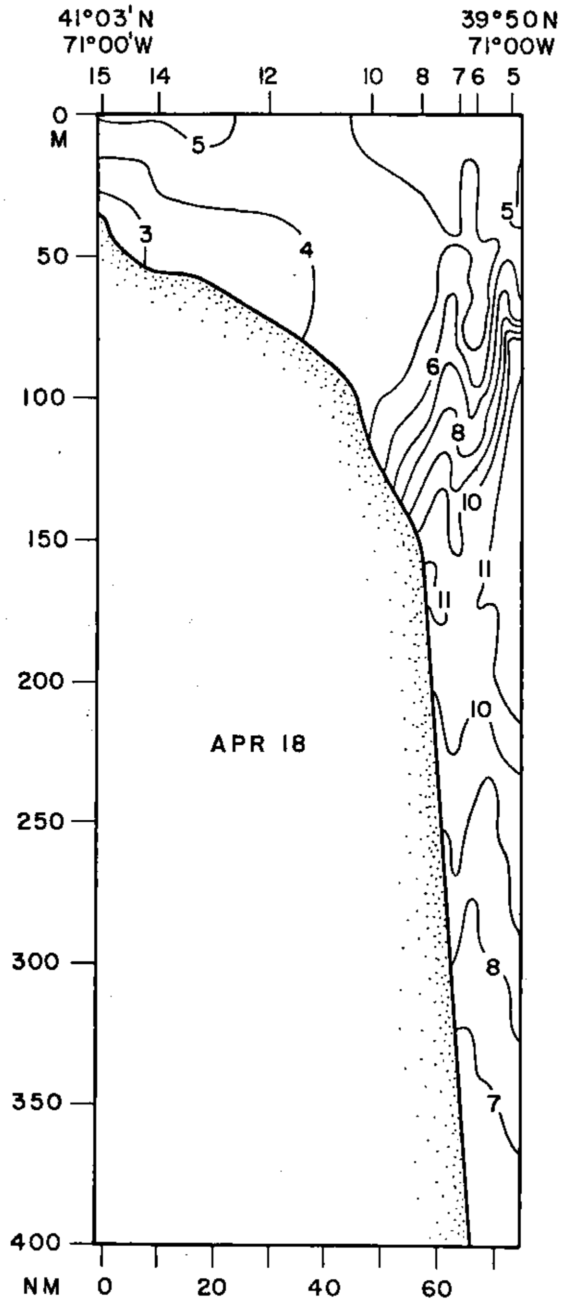

Fig. 4. Section 5

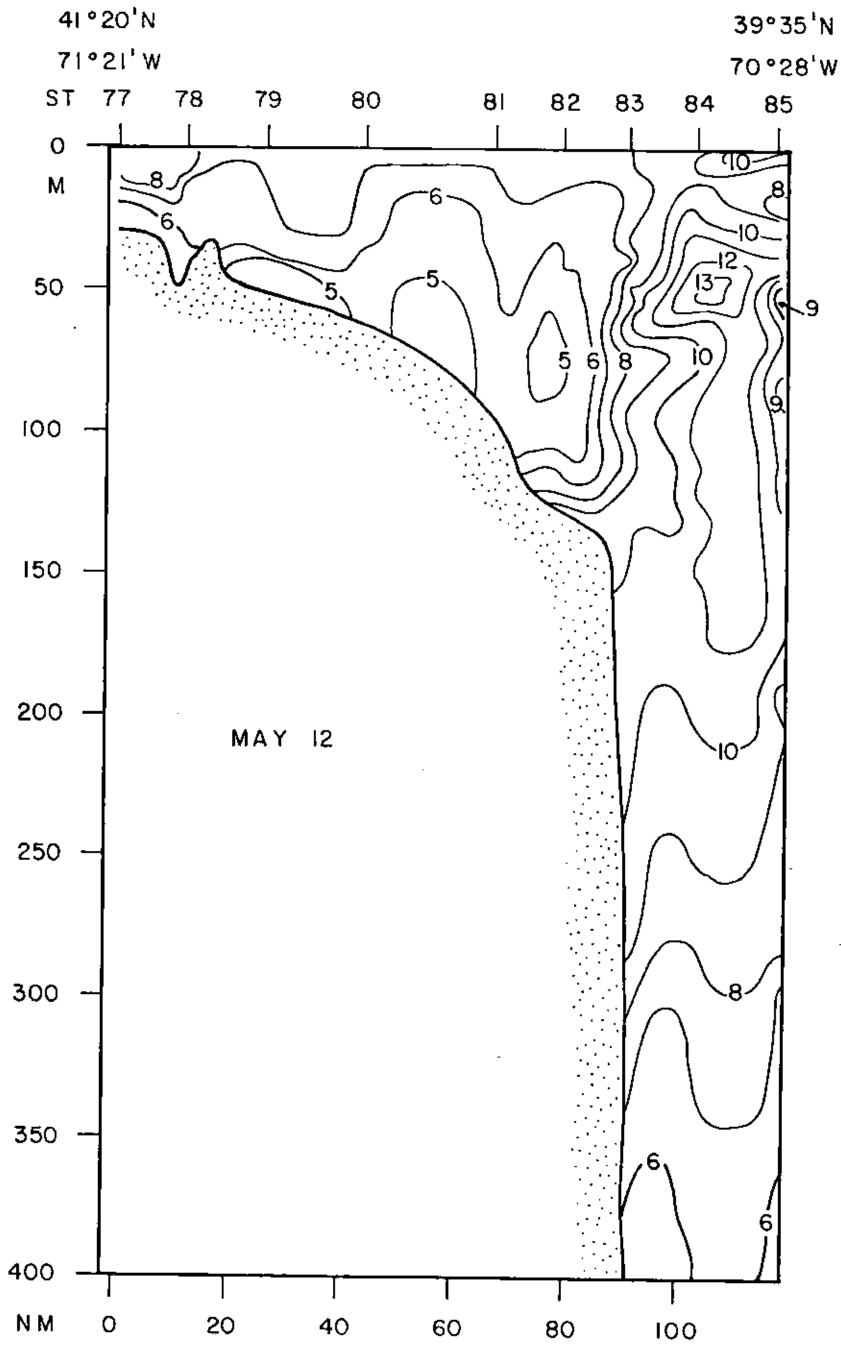

Fig. 5. Section 7

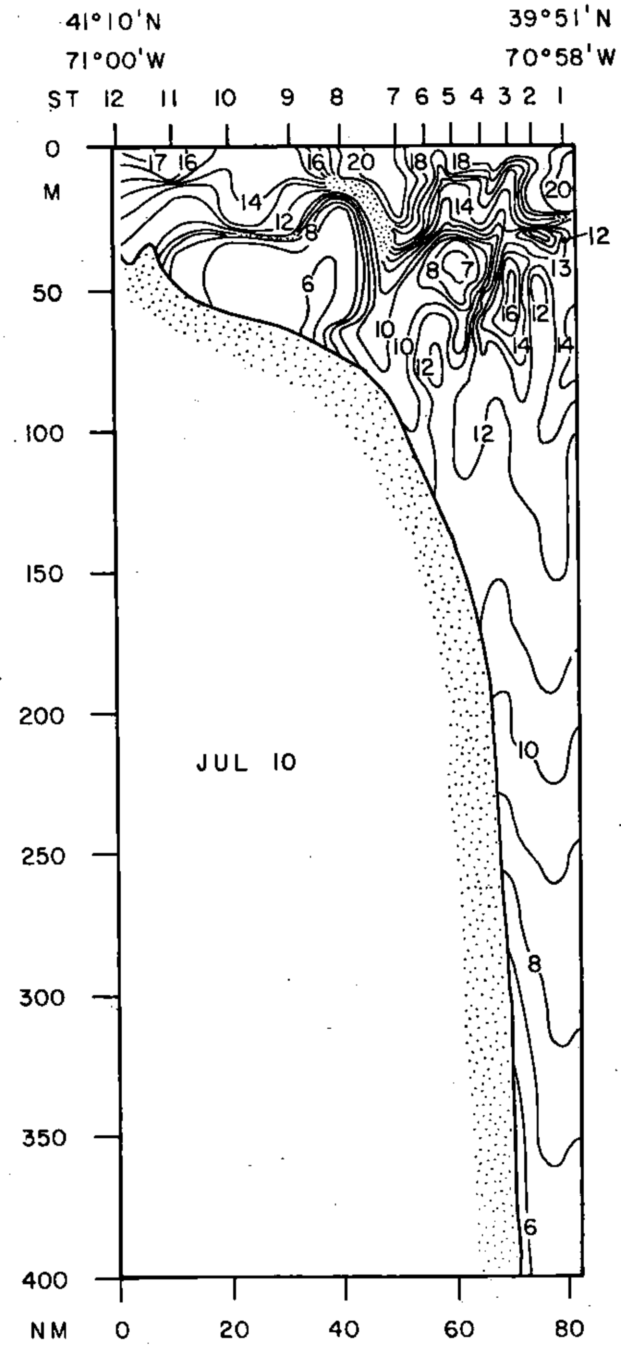

Fig. 6. Section 11

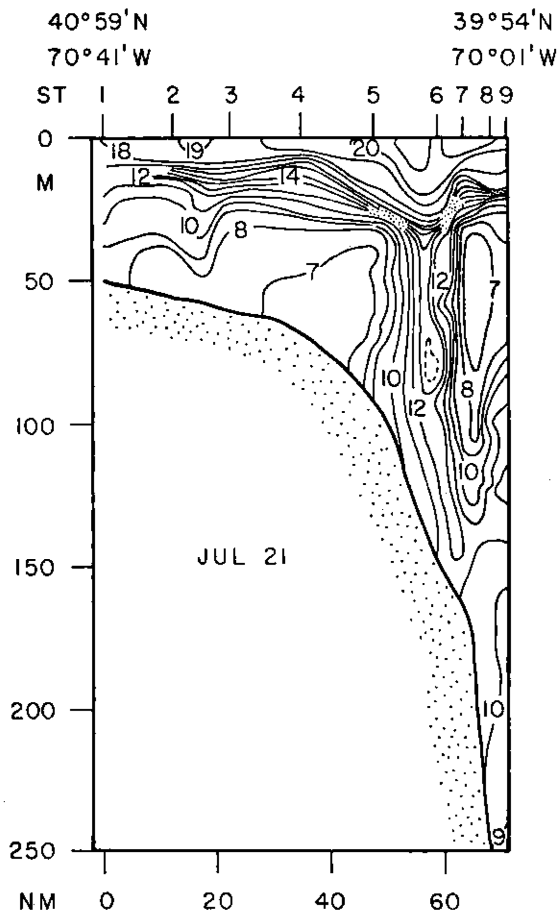

Fig. 7. Section 12

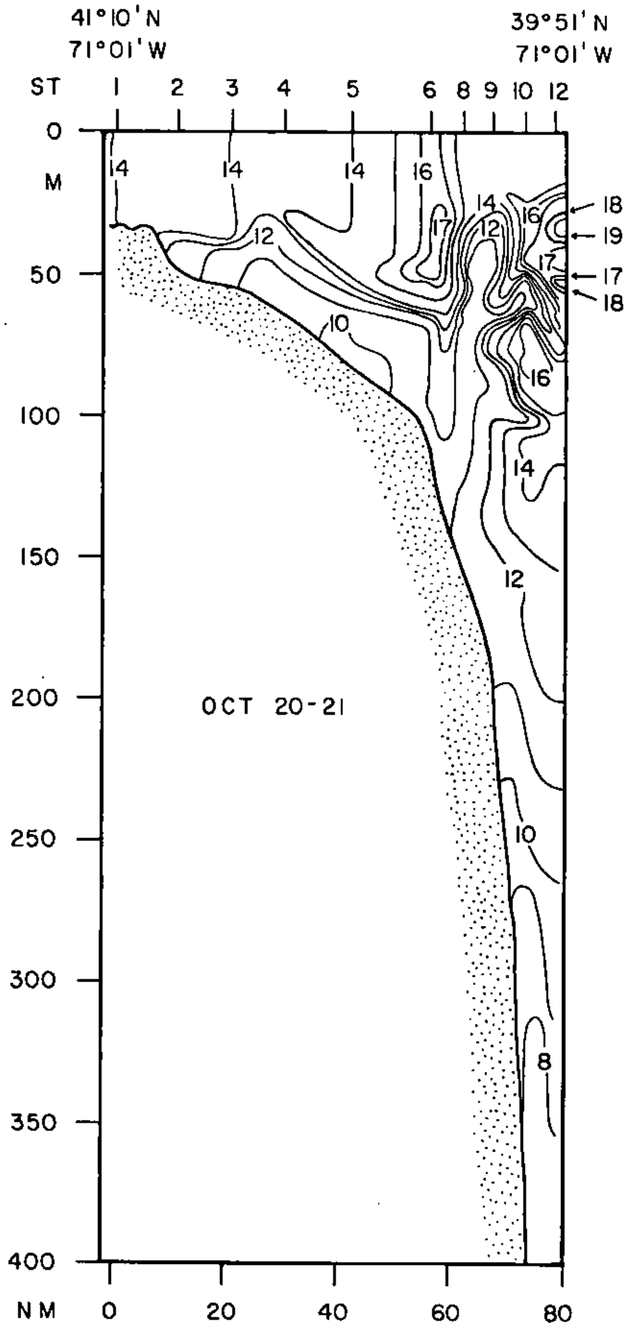

Fig. 8. Section 17

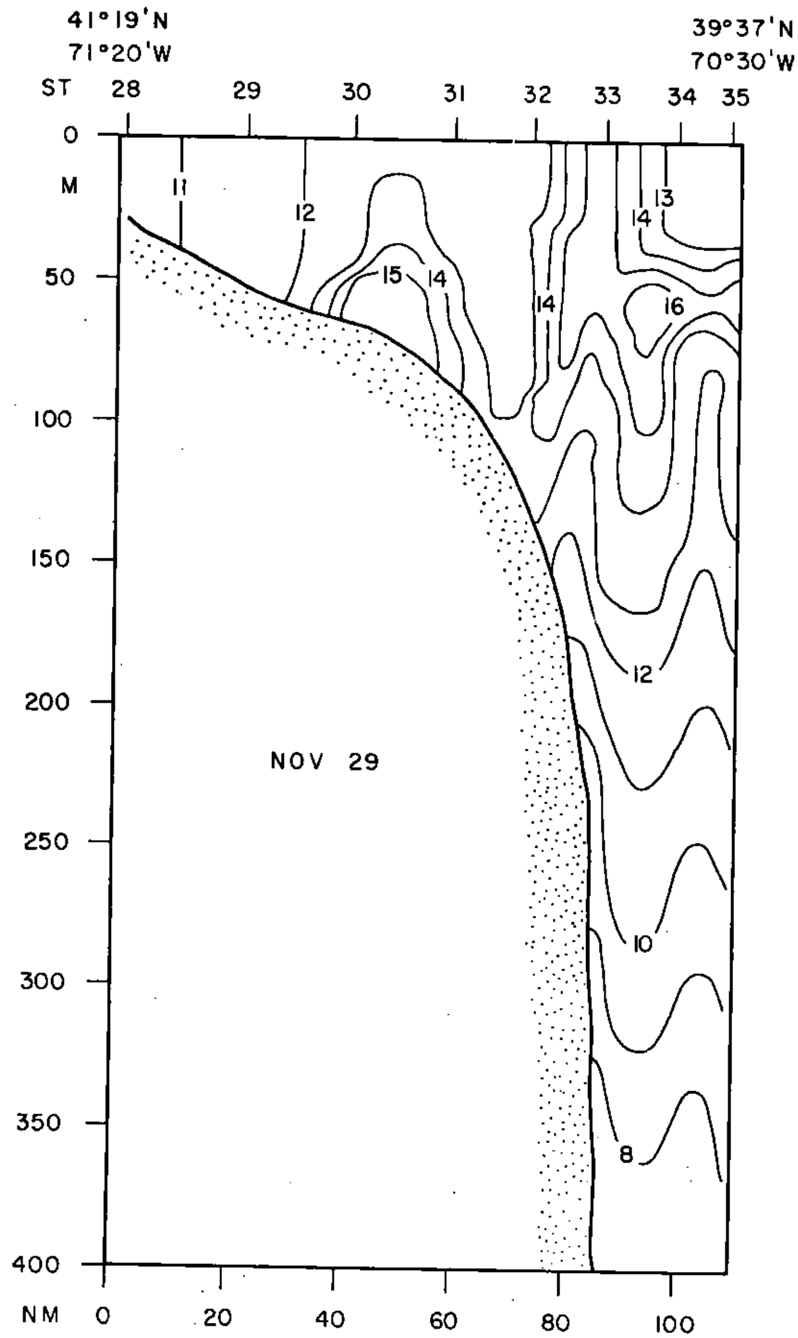

Fig. 9. Section 20