Northwest Atlantic Fisheries Organization

Serial No. N497

NAFO SCR Doc. 82/VI/9

SCIENTIFIC COUNCIL MEETING - JUNE 1982

Bottom Temperatures on the Continental Shelf and Slope South of New England during 1981

by

R. W. Crist

Atlantic Environmental Group, National Marine Fisheries Service, NOAA
RR 7, South Ferry Road, Narragansett, Rhode Island 02882

Annual summaries of bottom temperature have been prepared since 1974 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 1981, especially the seasonal and non-seasonal changes in bottom temperature and compares it to data collected from the same area since 1974.

During 1981, 19 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. 2), the intersects of isotherms with the bottom, determined from the contoured vertical sections, were plotted by depth and date, and contoured at 1°C intervals. In addition, data collected from a recording thermograph placed on the bottom at Brenton Tower in the mouth of Narragansett Bay (41°25'N 71°25'W) in 20 m was included on the plot of bottom temperature. Passages of warm core Gulf Stream rings through the slope water south of New England are noted as lines of duration along the bottom of figure 2. Each duration line starts when the western edge of a ring crosses a cruise track and ends when the ring's northern or northeastern edge passes south of 39°30'N. The line durations are based on the ring analysis for 1981 by Fitzgerald and Chamberlin (MS 1982).

Shelf water south of New England generally occurs on the bottom inshore of the 80-120 m isobath. 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 except in the warmest part of the year. 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 (10-12°C) water at depths ranging from about 100 to 200 m.

Shelf Water

Vertically homogeneous shelf water progressively cools from nearshore to offshore along the bottom to beyond the 100 m isobath. Mid-winter shelf bottom temperatures typically range from near 0°C nearshore to 10°C at the shelf-slope front (Fig. 3).

In 1981 the cooling season was poorly documented, no XBT transects having been obtained south of New England from mid-January until mid-March. In 1977 and 1979, the annual minimum bottom temperatures were recorded across the shelf from mid-February to early March. In other years since 1974, these minimums were observed in shallow shelf water in February, but not until April in the deeper shelf water. During 1981, the coldest bottom temperature recorded at 20 m (Brenton Tower) was 0.5°C in late February. Shelf water temperatures on the bottom inshore of 60 m began to increase in mid-March, but at depths greater than 80 m temperature continued to decrease to an annual minimum in May, when bottom temperature between 120-130 m (depths typically occupied by slope water) decreased briefly to below 10°C.

Early signs of thermal stratification were observed in mid-April (Fig. 4), and by the end of May the seasonal thermocline developed in depths from 10 to 30 m. Bottom temperatures recorded at 20 m during May increased 5°C as surface warmed water mixed downward.

Offshore of where the thermocline intersects bottom, below the thermocline, and shoreward of the shelf-slope front, a 30-40 m thick isothermal lens of relatively cool water rests on the bottom. This feature, referred to as the cold pool, develops where heating from the surface and offshore is minimized. Bottom temperatures in the cold pool generally increase more gradually than elsewhere on the shelf during the warming months, so that the coldest water on the shelf is found there in summer and early fall (Fig. 5).

In June, the shelf-slope front retreated shoreward along the bottom to near the 70 m isobath. As the shelf water was replaced by slope water during this retreat, bottom temperatures between 80-100 m increased rapidly from about 5.5°C to over 12°C. Nearshore, between 20 m and 40 m, bottom temperature increased 5°C during June and July as the thermocline deepened and intensified. In June, bottom temperatures at 60 m increased about 1°C, a typical rate of cold pool warming.

At the end of July, bottom temperatures across the mid-shelf increased unusually fast in the area normally occupied by the cold pool, resulting in diminution of the pool and bottom temperatures 2-3°C above those observed there in other years since 1974. This increase may have resulted from an interruption or slowing of the normal westward alongshore drift, allowing warmer water from nearshore and offshore to invade the mid-shelf region. In early August, however, bottom temperatures between 40 m and 100 m decreased to near normal (9°C-10°C), suggesting that the alongshore drift near the bottom was reestablished.

The annual maximum surface temperature recorded was 22.5°C in late July when the bottom temperature at 20 m was 17°C. The maximum bottom temperature recorded at 20 m was 18.9°C in September as surface water continued mixing downward.

In September, the shelf-slope front shifted seaward along the bottom to about 120 m; offshore of normal, but similar to September 1978. As in 1978, the deepening of the front coincided with passage of a warm core Gulf Stream ring. Shelf water is frequently observed in satellite imagery entrained offshore around the eastern side of the anticyclonic Gulf Stream rings at the surface.

As the surface water began cooling and mixing downward during fall overturn, bottom temperatures between 40 and 80 m increased to their annual maximum. The warmest mid-shelf temperature recorded was 13.5°C at 50 m on October 27 (Fig. 6). In other years since 1974, the fall maximum has been upwards of 14°C, except in 1977 and 1980 when it reached 17°C. At the time of maximum shelf bottom temperatures, the thermal gradient separating shelf and slope water is lost.

Nearly uniform bottom temperatures developed across the shelf during the overturn and persisted through November. In December, the nearshore rate of cooling increased so that bottom temperatures between 20 and 30 m decreased 4°C.

Slope Water

Maximum bottom temperatures in the area of the warm upper slope water ranged from about 10.5°C (mid-April to the end of May) to 13°C (January and August). In the cold winter years, 1977 and 1978, maximum bottom temperatures in the warm slope water fell below 11°C for 2 and 4 months respectively. In other years since 1974, the recorded maximum has always been warmer than 11°C and in 1976 was warmer than 12°C through the year.

The observed annual maximum slope bottom temperature was 13.2°C in January between 95 m and 125 m, appearing to be either a remnant of the 1980 fall overturn or the result of passage of warm core ring 80-H. The bottom slope water was observed to reach 13°C again only in August for a brief period during the passage of warm core ring 81-C.

Three warm core Gulf Stream rings passed through the slope water south of New England in 1981 with a cumulative duration of nearly 3.5 months. Three or four rings have passed the transect every year since 1974, except in 1977 when seven rings were recorded with a cumulative duration of over 6 months. Warm core rings frequently cause maximum bottom temperatures on the slope to increase to 13°C. In February 1975, the bottom temperature at 120 m increased briefly to >17°C while a ring passed to the south.

The deep slope water bottom temperatures were cooler than normal as evidenced by the persistence of water <6°C on the bottom in 350 to 400 m after May. Since 1974 when our record began, 1978 was the only other year in which bottom temperatures at depths <400 m were below 6°C for this long.

References

FITZGERALD, JAYNE L., and J. LOCKWOOD CHAMBERLIN. MS 1982. Anticyclonic warm core Gulf Stream rings off the northeastern United States during 1981. NAFO SCR Doc. 82/VI/10.

Table 1. Temperature sections collected south of New England during 1981

	Ship	Cruise -	Date	Inshore Coordinates	Offshore Coordinates
1	"Endeavor"	81-01	Jan 10	41°10'N 71°00'W	39°50'N 71°00'W
2	"Delaware II"	81-01	Jan 19	41°08'N 70°58'W	40°03'N 71°00'W
3	"Unimak"	81-01	Mar 19	41°09'N 71°00'W	39°50'N 71°00'W
4	"Oceanus"	81-01	Apr 6	40°54'N 71°03'W	39°37'N 71°36'W
5	"Delaware II"	81-02	Apr 15	40°21'N 70°56'W	40°00'N 71°00'W
6	"Oceanus"	81-02	May 29	41°10'N 71°00'W	39°32'N 70°59'W
7	"Oceanus"	81-03	Jun 22	41°08'N 70°59'W	39°49'N 71°00'W
8	"Superhorse"	81-03	Jun 29	41°07'N 71°00'W	39°45'N 71°00'W
9	"Oceanus"	81-04	Jul 3	40°57'N 71°00'W	39°50'N 70°59'W
10	"Endeavor"	81-02	Jul 16	41°10'N 71°00'W	39°50'N 71°00'W
11	"Superhorse"	81-04	Jul 28	41°10'N 71°00'W	39°45'N 71°00'W
12	"Superhorse"	81-05	Aug 19	41°10'N 71°00'W	39°45'N 71°00'W
13	"STVOR"	81-01	Sep 7	40°39'N 70°58'W	40°00'N 70°38'W
14	"Delaware II"	81-06	Oct 5	41°20'N 70°57'W	40°00'N 71°00'W
15	"Albatross IV"	81-12	Oct 12	40°22'N 71°00'W	40°05'N 70°59'W
16	"Oceanus"	81-05	Oct 27	41°10'N 71°00'W	39°36'N 71°00'W
17	"Oceanus"	81-06	Nov 23	41°10'N 71°00'W	39°35'N 71°00'W
18	"Oceanus"	81-07	Dec 11	41°10'N 70°51'W	40°00'N 70°31'W
19	"Albatross IV"	81-14	Dec 21	40°20'N 71°21'W	39°59'N 70°40'W

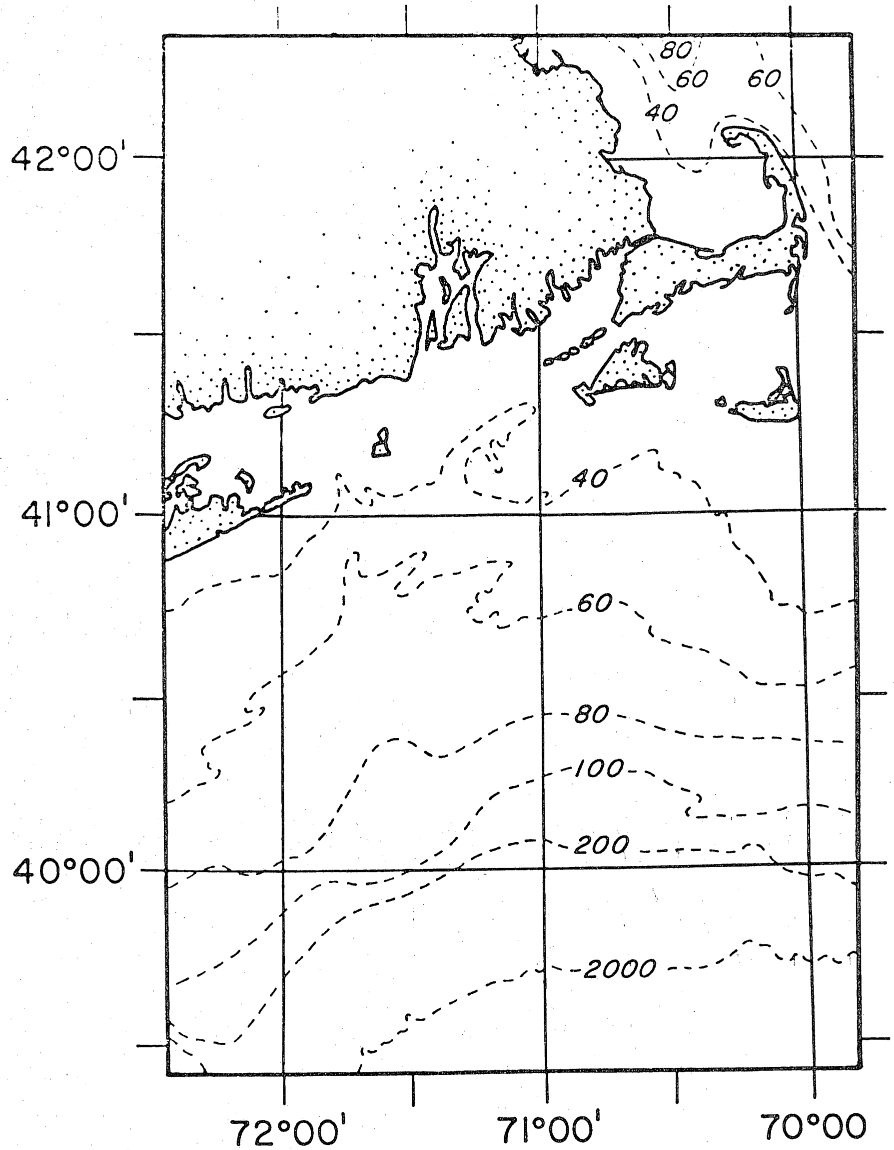

Figure 1. Location of 71°00'W transect south of New England. Depth contours in meters.

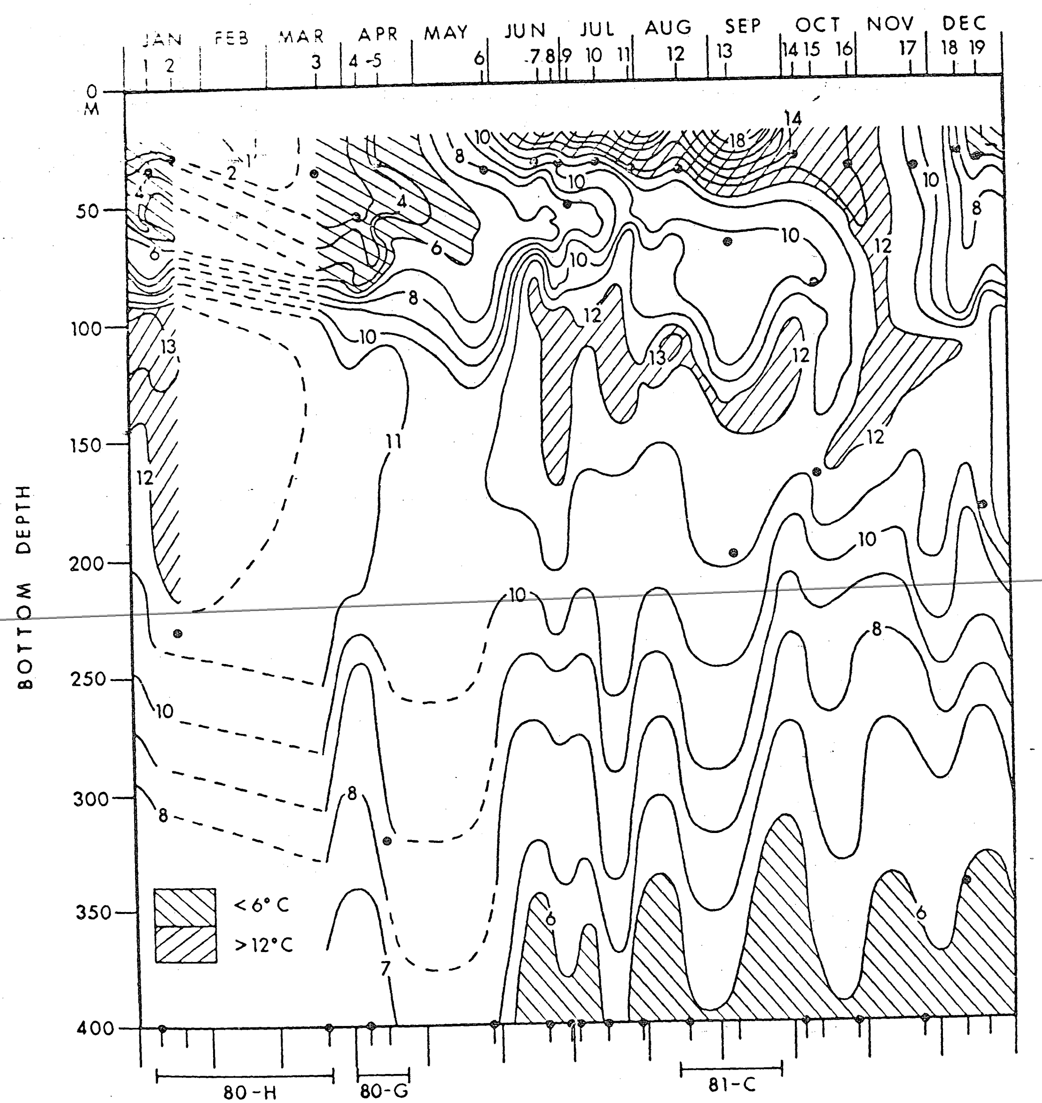

Figure 2. Bottom temperatures on the continental shelf and slope south of New England during 1981. Vertical sections are numbered along the top (see Table 1). Heavy dots mark inshore and offshore limits for each section. Horizontal lines at the bottom indicate duration of warm core ring passages south of New England.

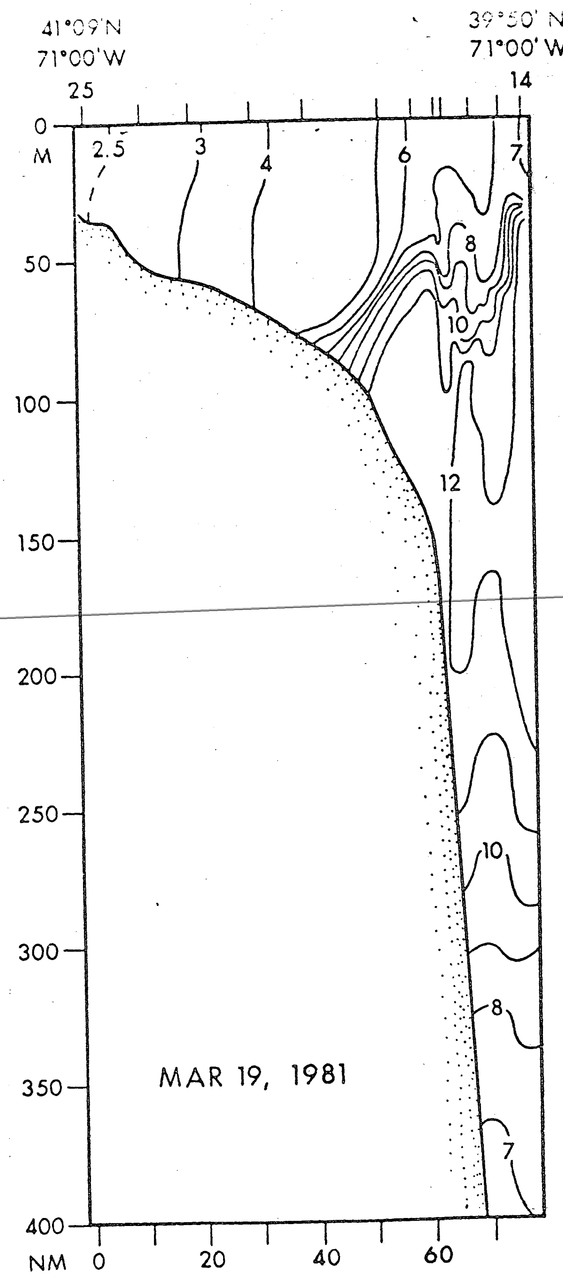

Figure 3. Section 3 contoured at 1°C interval.

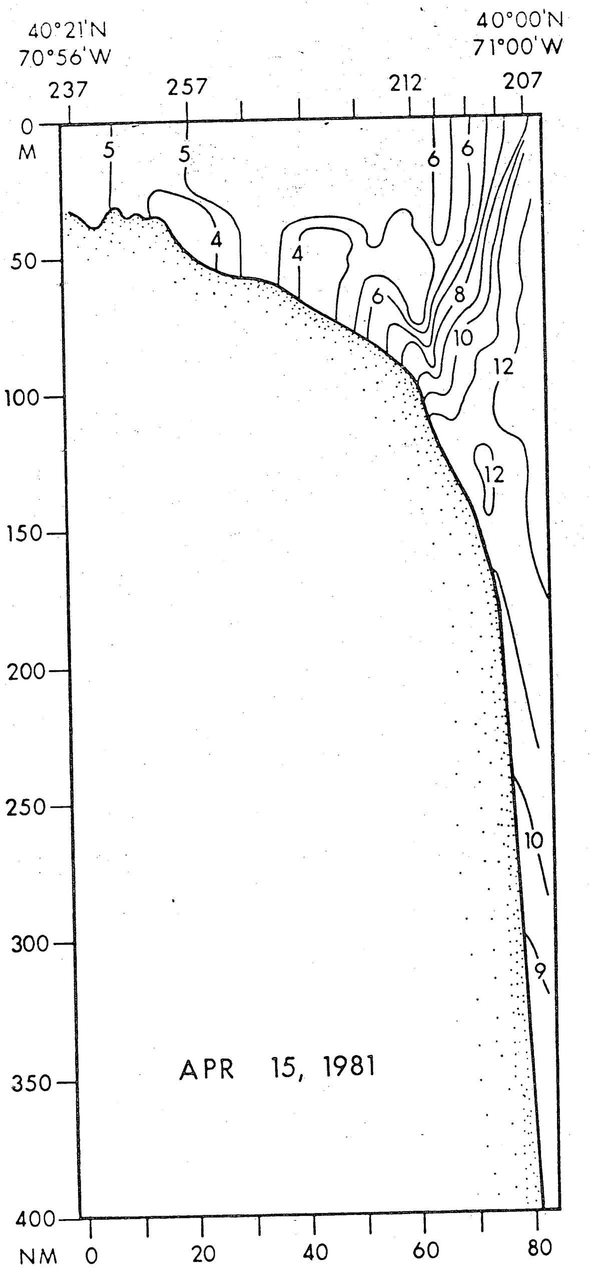

Figure 4. Section 5 contoured at 1°C interval.

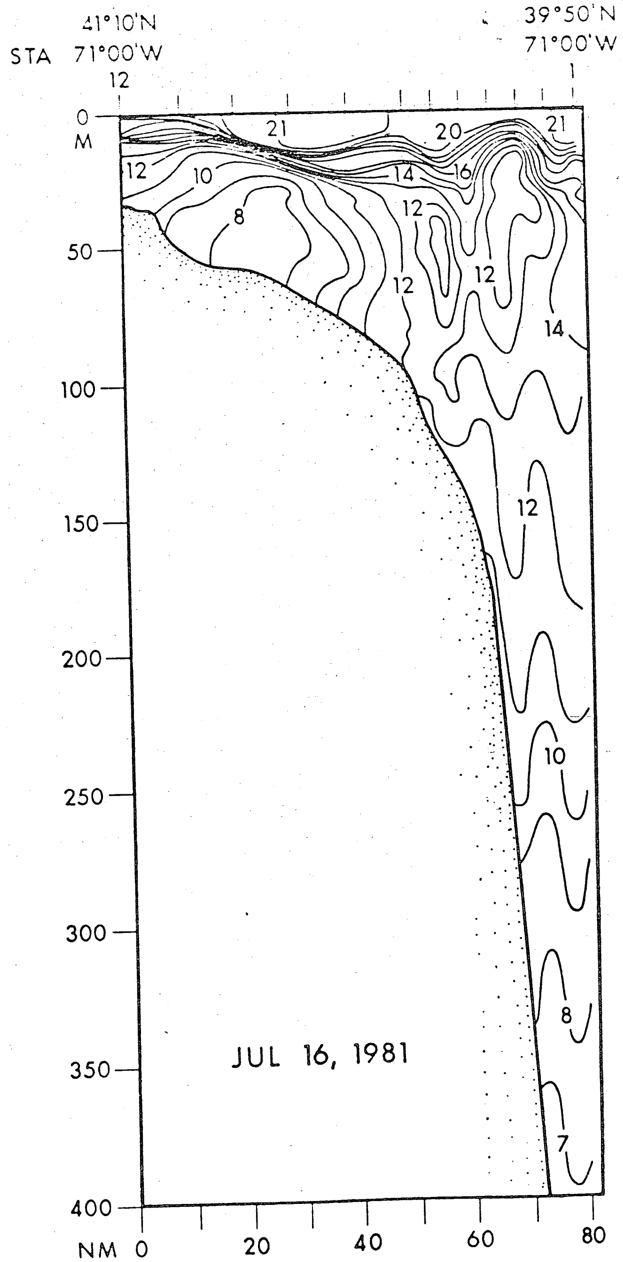

Figure 5. Section 10 contoured at 1°C interval.

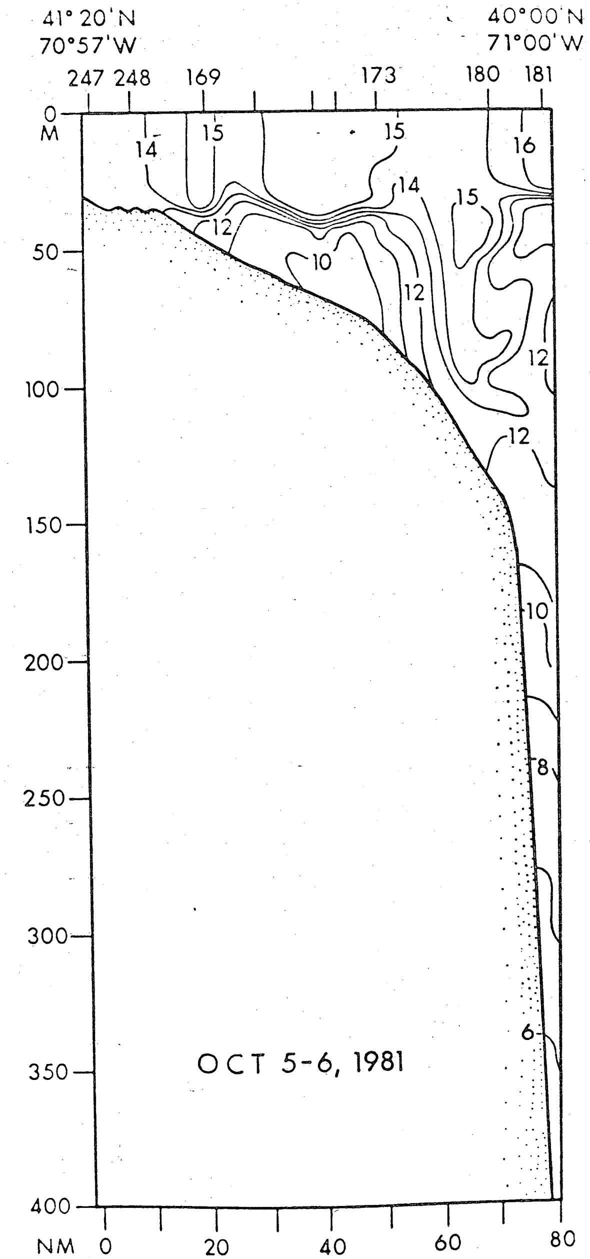

Figure 6. Section 14 contoured at 1°C interval.