NOAA Technical Report NMFS SSRF-700

Expendable Bathythermograph Observations from the NMFS/MARAD Ship of Opportunity Program for 1973

STEVEN K. COOK

SEATTLE, WA
JUNE 1976

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Expendable Bathythermograph Observations from the NMFS/MARAD Ship of Opportunity Program for 1973

STEVEN K. COOK[1]

ABSTRACT

Results of the third year of operation of the NMFS/MARAD Ship of Opportunity Program are presented in the form of vertical distributions of sea surface temperature and salinity. Included are descriptive analyses of the most dynamic transects showing the Caribbean/Yucatan/Loop/Florida Current regimes, the Gulf Stream, associated eddies, and the bottom cell of cold water off the U.S. east coast. Operational and data management procedures also are discussed.

INTRODUCTION

In midyear of 1970 a cooperative expendable bathythermograph (XBT) program was initiated between the National Marine Fisheries Service (NMFS) and the Maritime Administration (MARAD) of the U.S. Department of Commerce. The program, conducted in support of the Marine Resources Monitoring Assessment and Prediction Program of NMFS, involved the use of Maritime Cadets from Kings Point Maritime Academy to collect XBT data on board merchant ships operating along the east and Gulf coasts of the United States. The objective of this cooperative program was to identify and describe seasonal and year-to-year variations of temperature and circulation in the major current regimes of the eastern tropical Atlantic, Caribbean Sea, Gulf of Mexico, and western North Atlantic, utilizing merchant ships as relatively inexpensive platforms for the collection of data. The program objective has been modified recently to eliminate the tropical Atlantic and most of the Caribbean, concentrating on the western North Atlantic and Gulf of Mexico.

AREAS OF STUDY

Ship routes were selected to obtain regular sampling in the most dynamic areas of the Gulf of Mexico and western North Atlantic. The features of principal interest were the Yucatan Current, Gulf Loop Current, Florida Current, Gulf Stream, Shelf Water-Slope Water front, and a cold water cell in the Middle Atlantic Bight.

DATA ACQUISITION AND PROCESSING

Subsurface temperature data were obtained by use of Sippican XBT systems. At the same time surface water samples were collected with bucket thermometer units for later analysis to determine salinity. The surface water samples were analyzed on shore using a Beckman inductive salinometer calibrated with standard (Copenhagen) water at least once every 30 samples. The XBT traces were submitted to the National Oceanographic Data Center (NODC) where they were digitized, key punched, and quality controlled. Finally, these processed data were listed in printout form and machine plotted. The plots produced by NODC were essentially camera ready and needed little hand correcting. The few corrections necessary were made by discarding anomalous XBT observations that could not be supported by other associated data such as sea surface temperature or other nearby XBT observations. Consequently a vertical section plot may have one or two missing observations resulting from the deletion of inaccurate subsurface data.

All data collected were archived by the NODC and are available to interested persons through the NODC, Washington, D.C. 20235. Approximately 146 additional XBT observations and associated surface data were archived at the NODC, but not discussed in this report. The observations were too scattered in time and space to be formed into meaningful transects.

Further details concerning the acquisition or processing of data from the cruises considered here can be obtained from the author.

DISCUSSION

This third year of operation of the NMFS/MARAD Ship of Opportunity Program (SOOP) was highlighted by a major program change. Instead of transoceanic XBT transects consisting of 4-6 observations per day, a more intense coverage over a smaller geographical area (hourly observations for the first 24 h after leaving port and the last 24 h before reentering port) was initiated. This has made possible the monitoring of portions of the Shelf Water-Slope Water front, North Wall of the Gulf Stream, Gulf Loop Current, and associated eddies.

The SOOP effort for 1973 consisted of a total of 15 cruises, 7 sailing from New Orleans and 8 from New York. Twenty-three transects of subsurface temperature data and associated surface data were obtained. A total of 357 XBT's were launched; of these, 211 (60%) were considered of sufficient quality to be incorporated into the transects presented in this report. Participation of midshipmen as data collectors does not allow for year-round coverage,

[1]Atlantic Environmental Group, National Marine Fisheries Service, NOAA, R.R. 7A, Box 522-A, Narragansett, RI 02882.

because of the transition period in January-February, when one group of cadets goes back to school and a new group begins sea duty.

TRANSECT ANALYSIS

Gulf of Mexico

Over the years there have been several descriptions of the Yucatan/Loop/Florida Current regimes, but many ambiguities still exist. For purposes of this report, I have used the criteria of Nowlin and McLellan (1967) for describing the Loop Current as that water within the Gulf of Mexico that has just passed through the Yucatan Channel and has not yet exited through the Straits of Florida (usually about midway between Cuba and the western Florida Keys). The current flow into the Gulf of Mexico between the western tip of Cuba and the Yucatan Peninsula was referred to as the Yucatan Current and the current flow upstream from there (into the Caribbean Sea) was referred to as the Caribbean Current.

Loop Current.—The Loop Current showed up on transects conducted in January, February, April, August, October, and November (Figs. 1-6). The downward slope (southward) of the isotherms, such as between stations 16 and 17 in Figure 1 for January, indicated the approximate position of the Loop Current as it passed from the Yucatan Channel into the Gulf of Mexico. About a month later the Loop Current was transected again near the Yucatan Channel as shown by the slope of the isotherms between stations 7 and 8 in Figure 2.

In April (Fig. 3), the Loop Current was found between stations 5 and 6. A comparison of Figures 1, 2, and 3 shows the Loop Current extending further into the Gulf of Mexico, from its January position at approximately lat. 23°N to approximately lat. 24°N in February and to lat. 25°N in April. This northward migration was consistent with previous observations of the behavior of this current (Boisvert 1967).

The complex temperature structure of the section made in August (Fig. 4) requires a close examination of the data to discern the difference between Yucatan Current, Loop Current, and an associated eddy. At this time, I feel the Yucatan/Loop Current system was transected four times.

Following the temperature structure from south to north, the downward tilting of the isotherms between stations 29 and 28 indicated the normal westward flow of the Caribbean Current just prior to entering the Yucatan Channel. The upward tilting of the isotherms between stations 26 and 23 indicated an eastward flow (into the page in the vertical section), and the downward tilt of the isotherms between stations 20 and 19 indicated a westward flow. Finally, the structure between stations 16 and 12 indicated eastward flow, apparently the northernmost crossing of the Loop Current. The configuration of the isotherms between stations 10 and 1 suggest the presence of a warm core eddy and are discussed in the following section.

Another possibility was that the flow pattern through the Yucatan Channel had diverged and become multiaxial as suggested by Cochrane[2] in 1963, with more eastward divergence flowing around Cuba and into the Straits of Florida; and the western axis looping through the Gulf between stations 16 and 12 at about lat. 25°N.

In later crossings the Loop Current appeared to recede from the Gulf. In October it was crossed at about lat. 24°N (Fig. 5, stations 16-21) and in November at about lat. 22°N (Fig. 6, stations 14-16).

Eddies.—Eddy structures were detected in the northeastern Gulf of Mexico on transects conducted in January, February, August, and October (Figs. 1, 2, 4, 5). In January (Fig. 1) the temperature structure between stations 17 and 21 showed some evidence of a weak anticyclonic eddy with a diameter of approximately 125 nautical miles.

In February (Fig. 2), the doming effect of the isotherms between stations 1 and 7 suggested the existence of a warm core anticyclonic eddy, possibly a recrossing of the same eddy seen the previous month. Unfortunately, the lack of XBT observations to the north of station 1 prevent the positive identification of this structure as a remnant anticyclonic eddy.

In August (Fig. 4), the temperature structure found between stations 10 and 1 was an indication of a warm core, anticyclonic eddy that has possibly broken off from the main flow of the Loop Current. This was consistent with past observations of Loop Current activity (Leipper 1970). The width of the eddy at this crossing was about 125 nautical miles and extended to depths of greater than 700 m.

In October (Fig. 5), another warm core, anticyclonic eddy was transected. The transect crossed through the eddy between stations 5 and 11 (approximately 125 nautical miles) and the eddy extended to a depth of greater than 750 m.

Caribbean Current.—The Caribbean Current, described by Boisvert (1967) as one of the most persistent and well defined of the major currents, is broad and relatively slow moving. It was seen in the SOOP transects south of the Yucatan Channel as a northward declination of isotherms. Utilizing this characteristic, we found the Caribbean Current in February, April, August, and November (Figs. 2, 3, 4, 6).

In February (Fig. 2), the Caribbean Current was crossed between stations 13 and 22. Temperature structure between stations 19 and 21 indicated an area of possible counterflow.

In April (Fig. 3), the Caribbean Current was again indicated by the general upward incline of the isotherms between stations 9 and 15.

In August (Fig. 4), the upward incline of the isotherms between stations 28 and 29 indicated the westward flow of the Caribbean Current just prior to entering the Yucatan Channel.

In November (Fig. 6), an indication of the Caribbean Current appears between stations 16 and 20.

Western North Atlantic

Features described in the western North Atlantic include the North Wall of the Gulf Stream, Shelf Water-Slope Water front, bottom cold cell, and eddies formed by the Gulf Stream. Temperature sections obtained on four New York to Bermuda sections made during May, June, and November (Figs. 7-10) show some of these features.

Gulf Stream.—Using the criterion of 15°C at 200-m depth (Worthington 1964) to indicate the North Wall of the Gulf

[2]Cochrane, J. D. 1963. Yucatan Current. Texas A&M College, Department of Oceanography and Meteorology, Ref. 63-18A. Unpubl. rep., 25 p. Atlantic Environmental Group, National Marine Fisheries Service, NOAA, Narragansett, RI 02882.

Stream, we found four crossings of the North Wall in May, June, and November (Figs. 7-10).

In mid-May (Fig. 7), the North Wall was indicated just to the east of station 13 (approximately lat. 37°00'N, long. 69°00'W). Unfortunately, there are not enough observations to completely describe the crossing.

In June (Fig. 8), just the opposite occurred. Observations were made from the east right up to the North Wall, discontinued for about 130 nautical miles, then recommenced. A crossing of the North Wall is detectable, but not well defined, between stations 19 and 18 (approximately lat. 37°15'N, long. 69°30'W). The November section (Fig. 9) shows the North Wall of the Gulf Stream between stations 15 and 16 (lat. 37°30'N, long. 71°00'W). In the transect made 4 days later (Fig. 10) the North Wall of the Gulf Stream showed up at station 10 (lat. 38°00'N, long. 71°00'W).

Cold Cell.—The cold cell, sometimes referred to as winter water (water less than 8°C), has been described by Ketchum and Corwin (1964) and Whitcomb (1970). This feature was transected on four occasions (Figs. 7, 8, 9, 10). These four crossings show how the cold cell degenerates throughout the summer. The first crossing in May (Fig. 7) shows a cold cell with a temperature range of 6°-8°C until finally in the last of November (Fig. 10) the cell structure is barely detectable and has warmed to 14°C.

In May (Fig. 7), a cell of bottom water extended 80 nautical miles offshore to a maximum depth of 75 m, with a temperature range of 6°-8°C. In June (Fig. 8), the cold cell of bottom water was still evident, although by this time the cell had begun to warm and extend out to the shelf break.

The November section (Fig. 9) shows still a further warming and decay of the cold cell. The extent of the cold cell had decreased to less than 60 nautical miles and warmed to a range of 12°-14°C.

The second November section (Fig. 10) showed the cold cell had eroded to less than 30 nautical miles extent and warmed to 14°C.

Shelf Water-Slope Water Front.—The Shelf Water-Slope Water front was transected in May just to the east of station 5 (Fig. 7), indicated by a thermal change from 10° to 17°C in about 18 nautical miles. Low sea surface salinities and temperatures out to station 5 also indicated the extent of the shelf water.

In June (Fig. 8), the front appeared between stations 25 and 24. At this time there was less sea surface temperature change to indicate the front, instead the most pronounced surface signature of the front was in the form of the strong surface salinity gradient changing slope and sign at station 23.

The November section (Fig. 9), shows that the Shelf Water-Slope Water front had no expression in either surface temperature or salinity, but a weak temperature gradient between stations 7 and 8, at about 50-m depth, suggests that the front might have been present there.

In the transect made 4 days later (Fig. 10), a definite surface signature of the shelf water was apparent in both sea surface salinity and temperature. The Shelf Water-Slope Water front did not show up in the subsurface data on this transect, but surface salinities of less than 34‰ readily identify the shelf water region.

ACKNOWLEDGMENTS

Appreciation is extended to the Maritime Academy Training representatives in New York and New Orleans, M. Chicurel and D. Thompson, respectively. Their diligent efforts to place midshipmen on board ships that were scheduled to traverse preselected oceanic areas were instrumental to the success of this program. In addition, thanks are extended to the Moore McCormack Lines and Grace Prudential Lines of New York and the Delta Steamship Company and Lykes Brothers of New Orleans.

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FIGURES

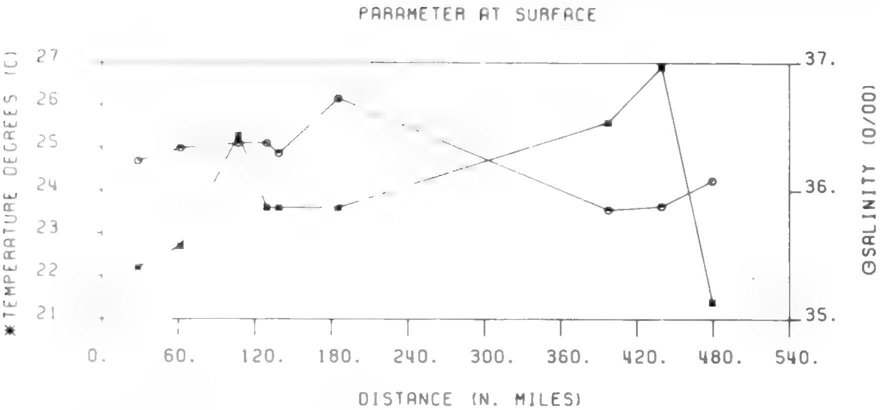
The figures are grouped by geographical location and time. They consist of two vertical sections of temperature, a plot of surface temperature and salinity versus distance along the transect, and a locator chart.

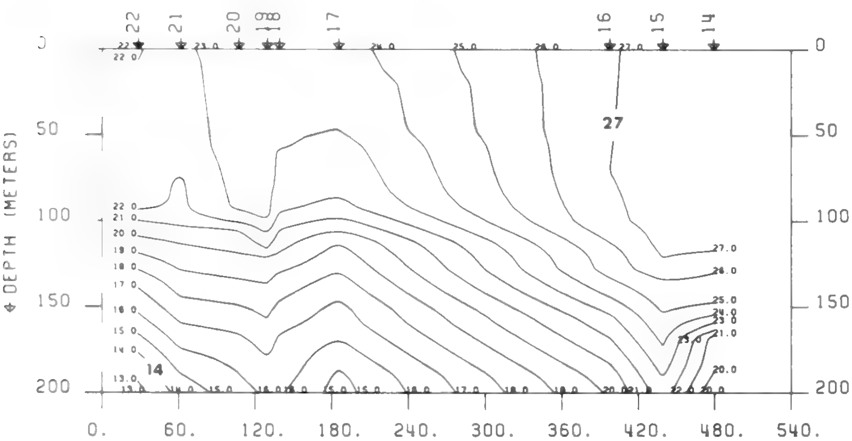
GULF OF MEXICO TRANSECTS

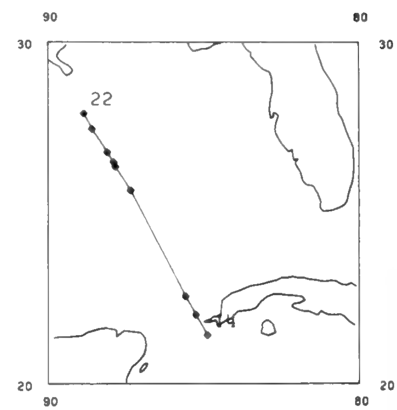
Figures	Vessels	Date
1	*Delta Argentina*	1- 2 Jan. 1973
2	*Gulf Shipper*	12-15 Feb. 1973
3	*Gulf Shipper*	20-24 Apr. 1973
4	*Gulf Trader*	1- 2 Aug. 1973
5	*Gulf Trader*	14-15 Oct. 1973
6	*Delta Norte*	3- 5 Nov. 1973

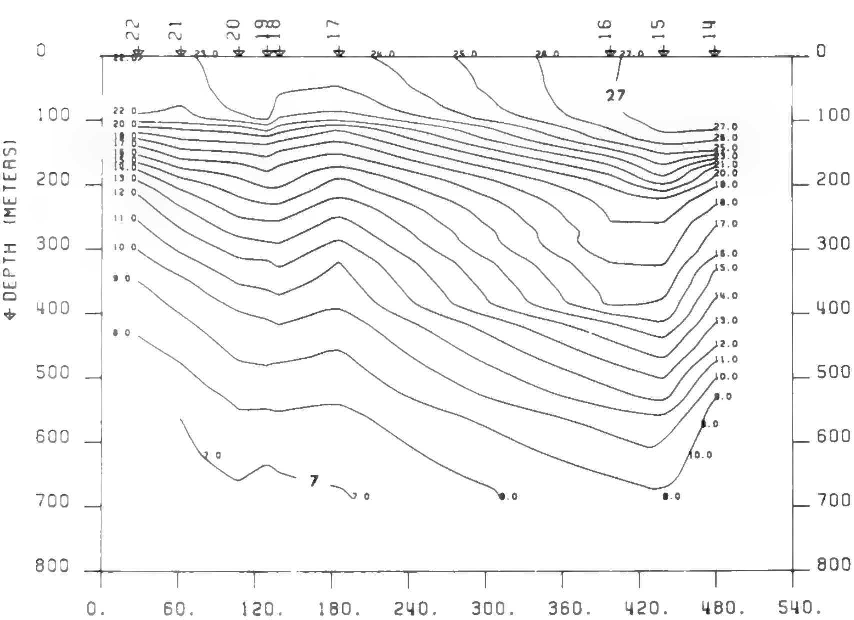
WESTERN ATLANTIC TRANSECTS

7	*Mormac Argo*	12-13 May 1973
8	*Mormac Argo*	17-18 Jun. 1973
9	*Mormac Rigel*	1 Nov. 1973
10	*Mormac Argo*	5 Nov. 1973



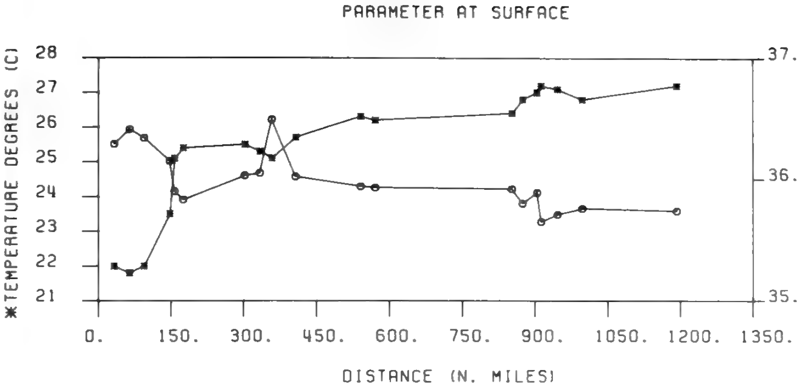


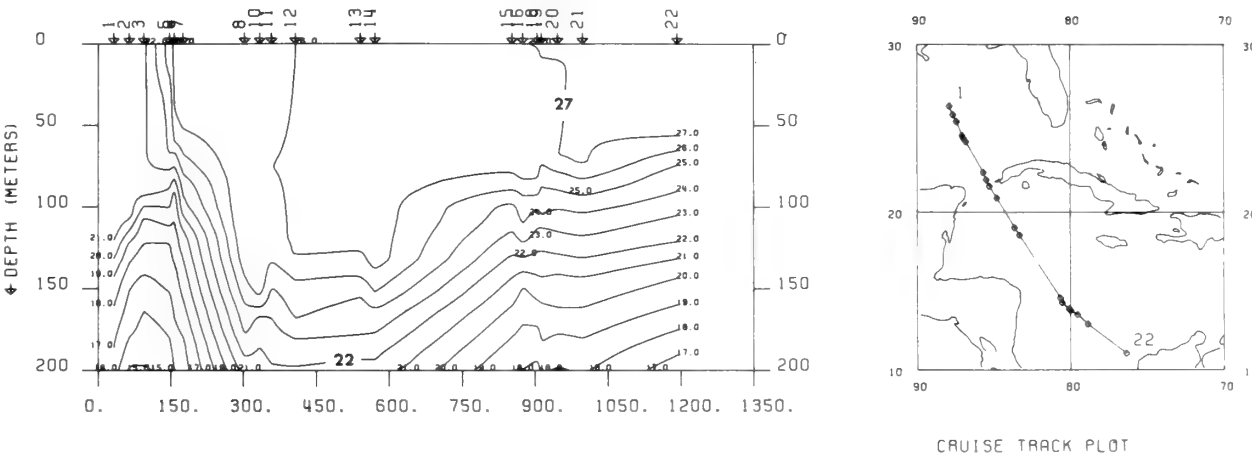


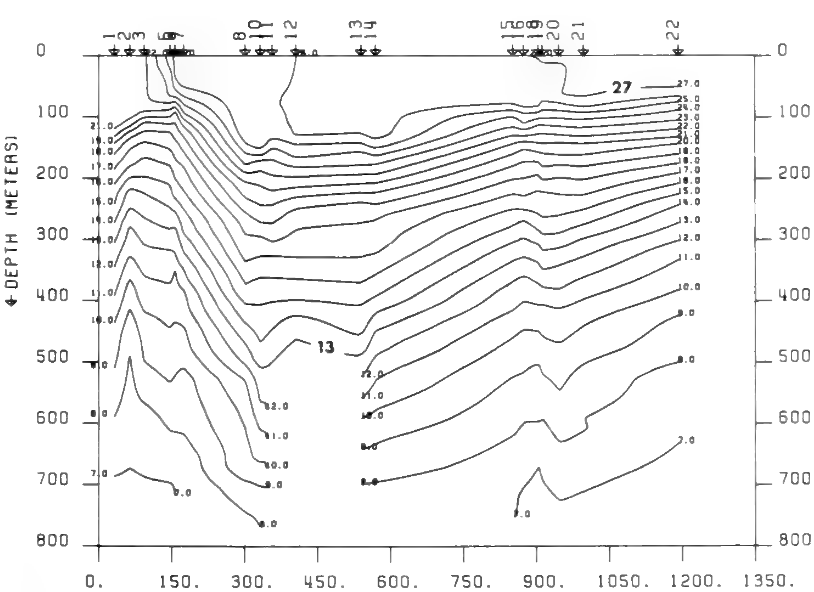


Horizontal distribution of sea surface temperature (°C) and sea surface salinity (‰), and vertical distribution of temperature (°C) in the upper 200 and 800 m.

Figure 1.—*Delta Argentina*, 7211, stations 14-22, 1-2 January 1973.

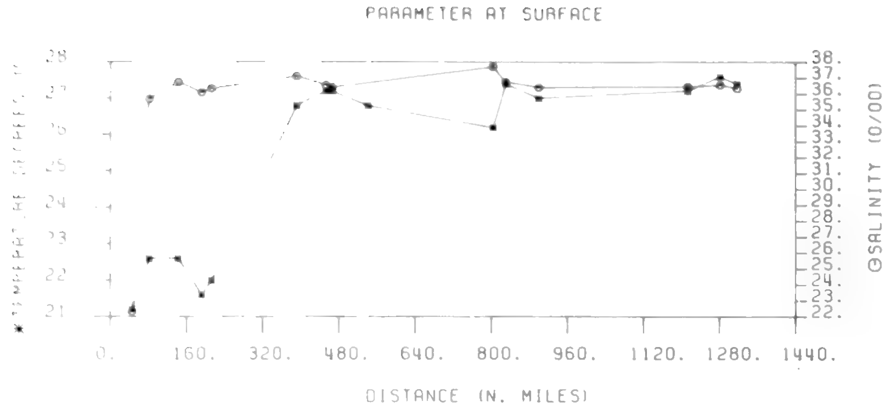


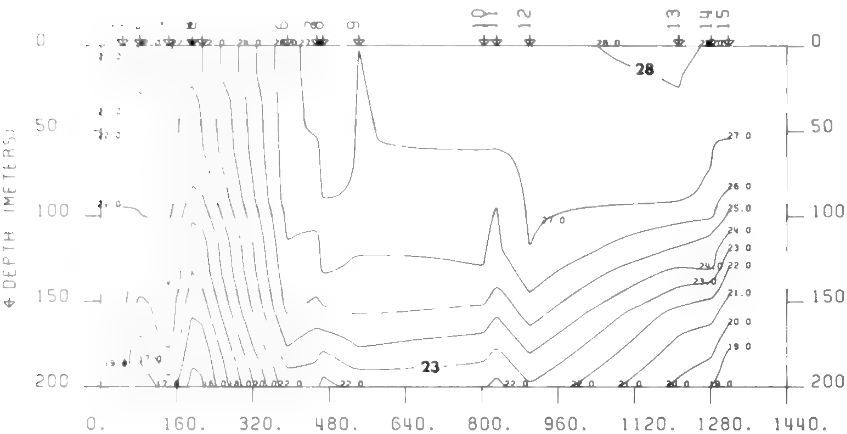


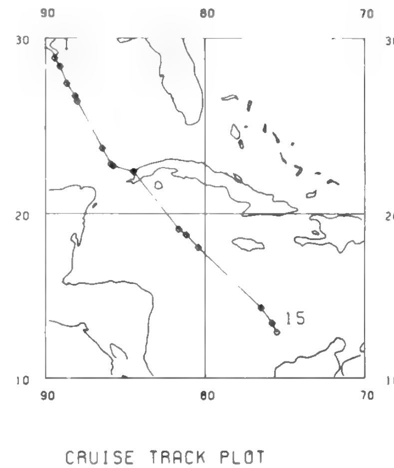


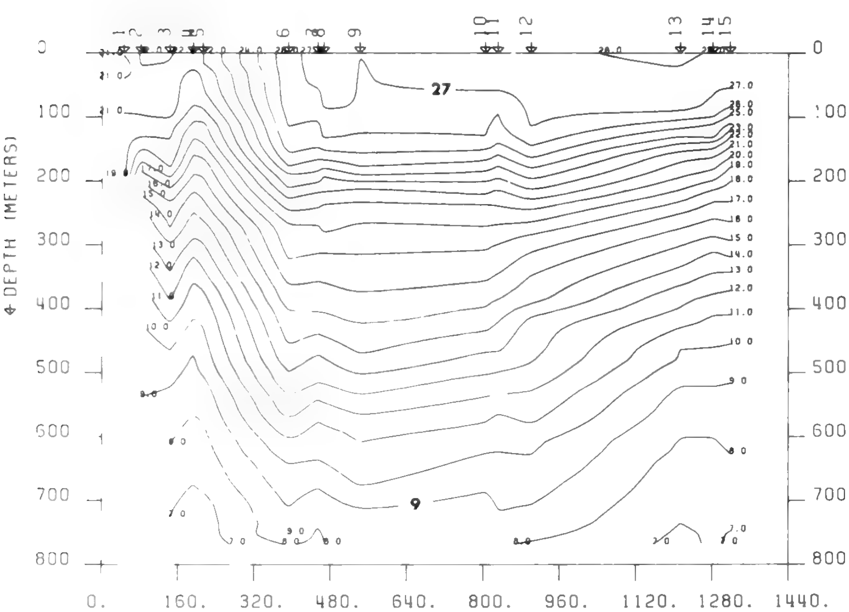
Horizontal distribution of sea surface temperature (°C) and sea surface salinity (‰), and vertical distribution of temperature (°C) in the upper 200 and 800 m.

Figure 2.—*Gulf Shipper*, 7302, stations 1-22, 12-15 February 1973.



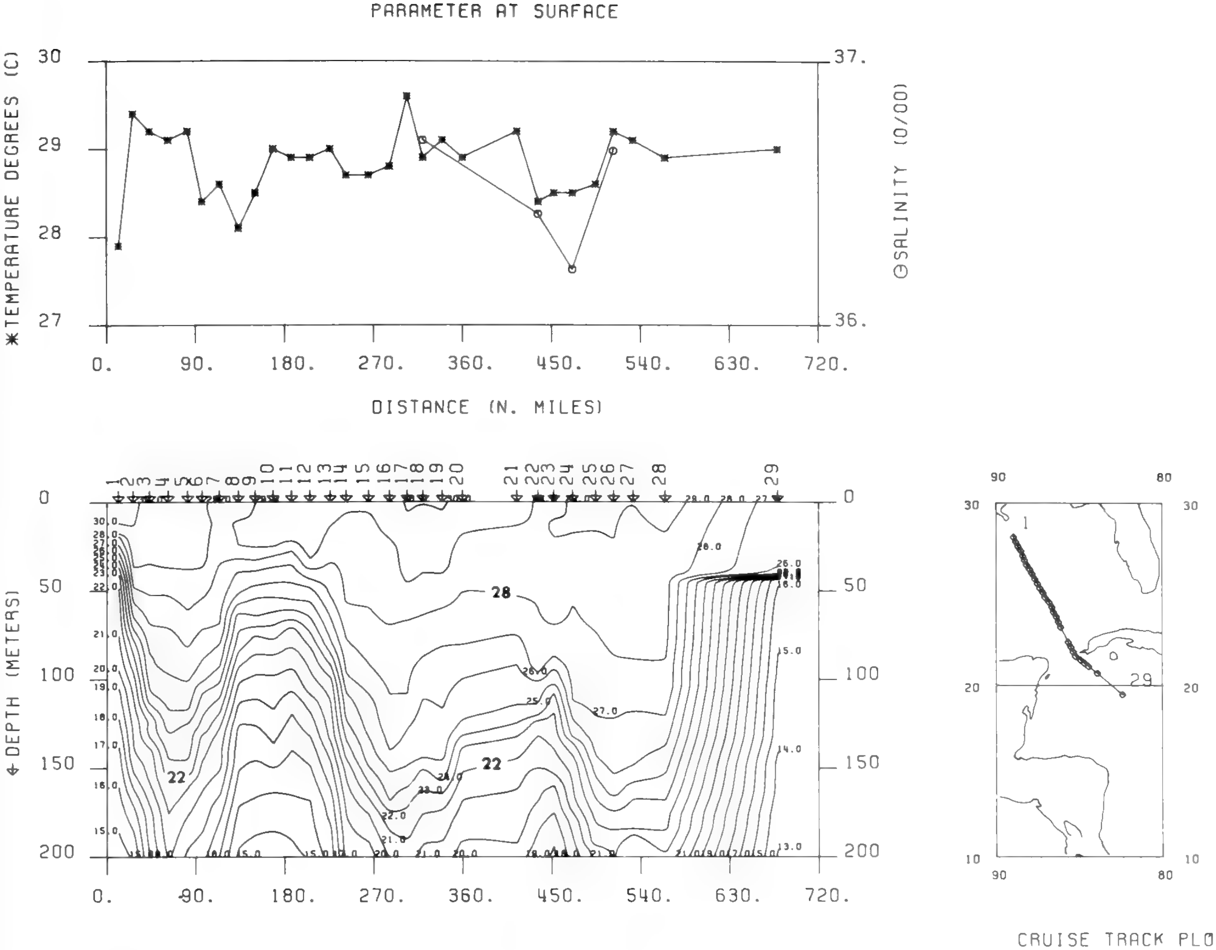


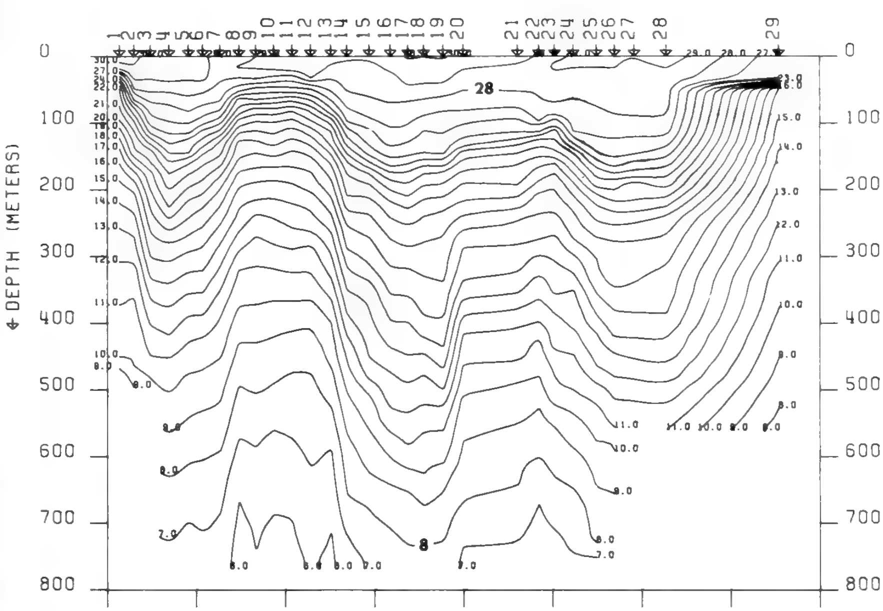




Horizontal distribution of sea surface temperature (°C) and sea surface salinity (‰), and vertical distribution of temperature (°C) in the upper 200 and 800 m.

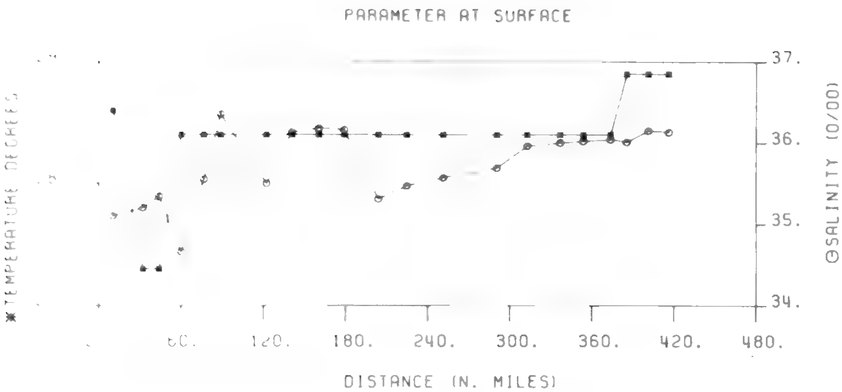
Figure 3.—*Gulf Shipper*, **7304, stations 1-15, 20-24 April 1973.**

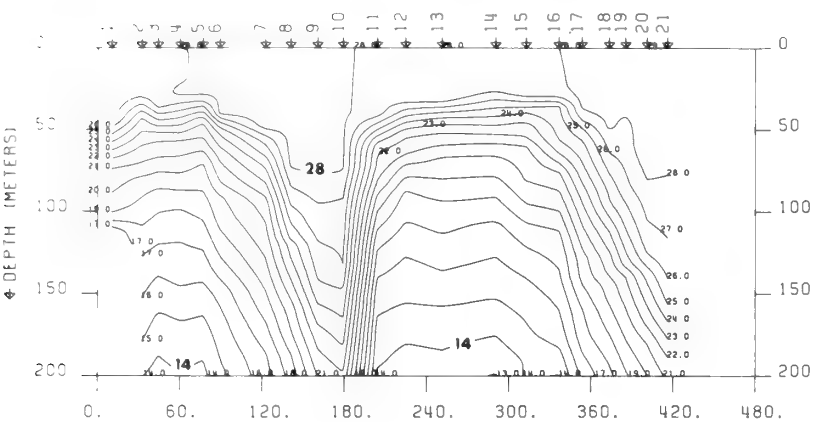


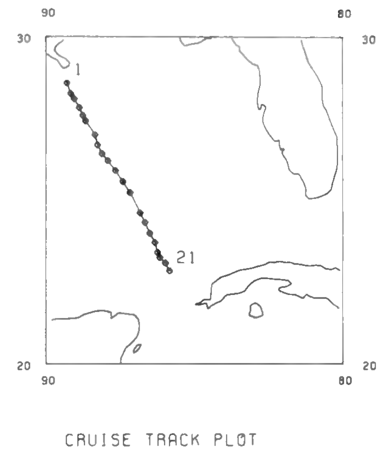


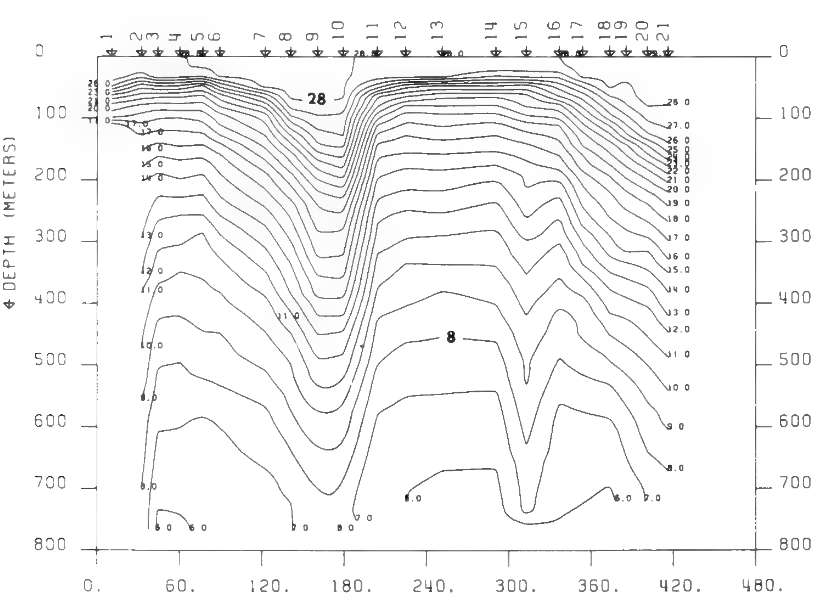
Horizontal distribution of sea surface temperature (°C) and sea surface salinity (‰), and vertical distribution temperature (°C) in the upper 200 and 800 m.

Figure 4.—*Gulf Trader*, 7308, stations 1-29, 1-2 August 1973.



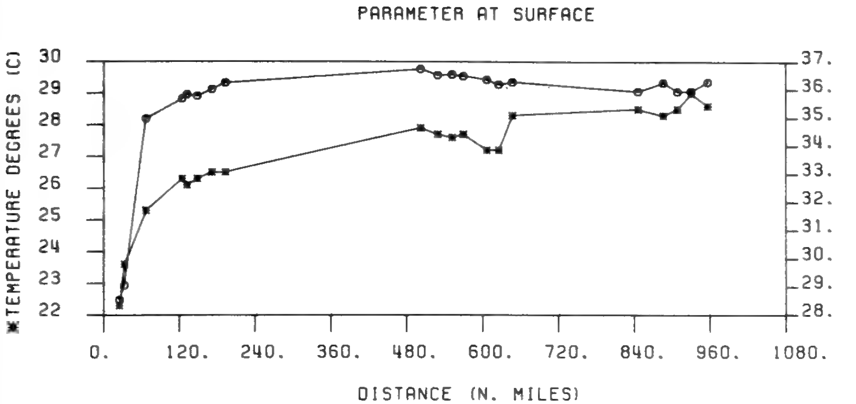


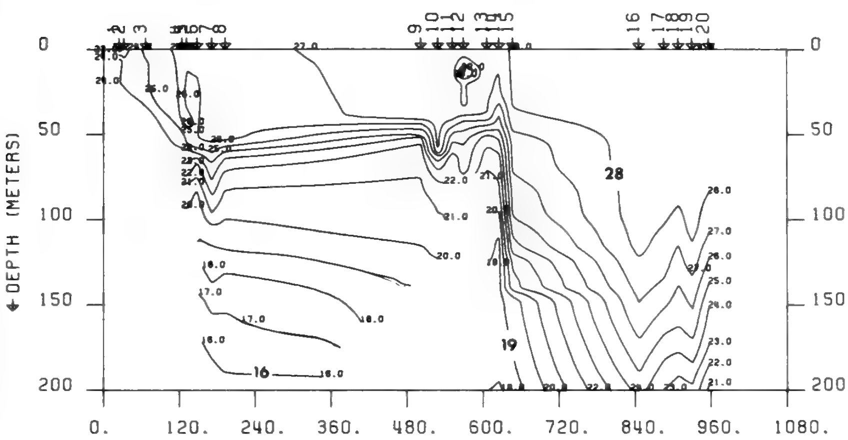


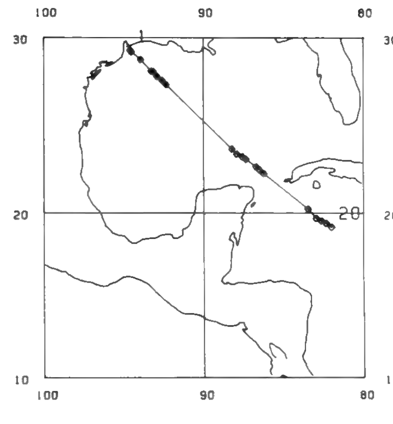


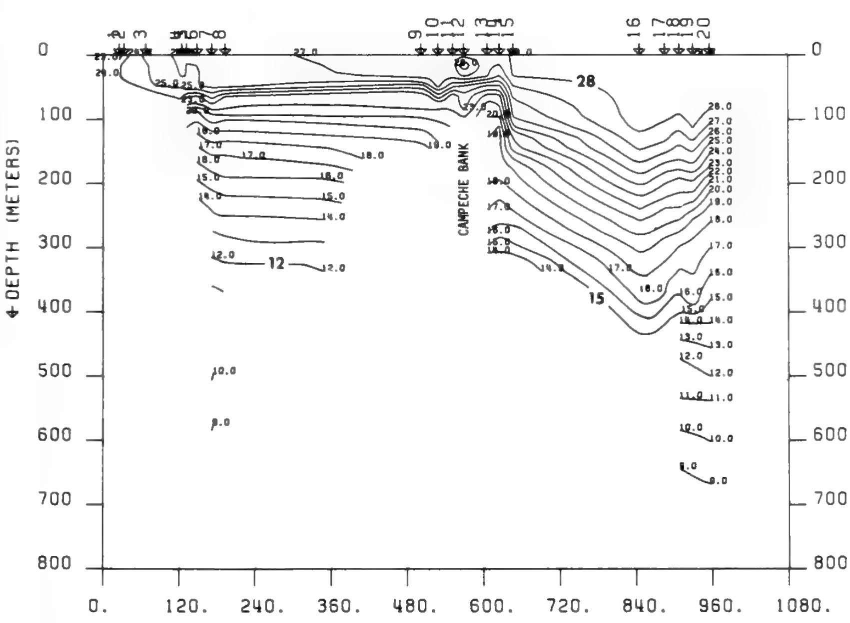
Horizontal distribution of sea surface temperature (°C) and sea surface salinity (‰), and vertical distribution of temperature (°C) in the upper 200 and 800 m.

Figure 5.—***Gulf Trader*, 7310, stations 1-21, 14-15 October 1973.**



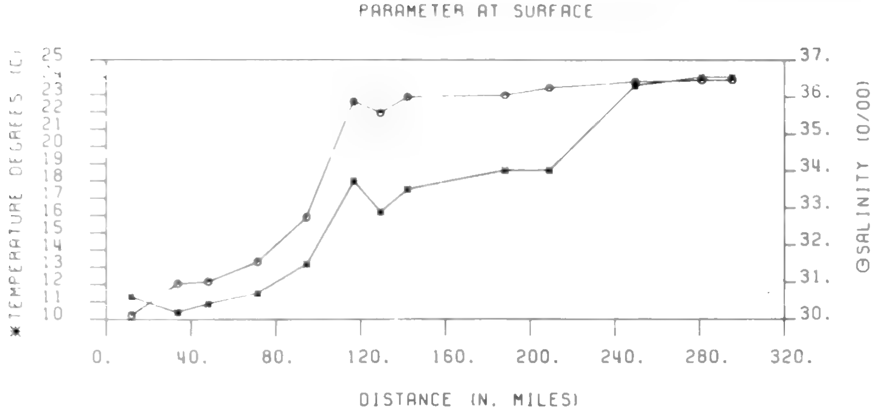


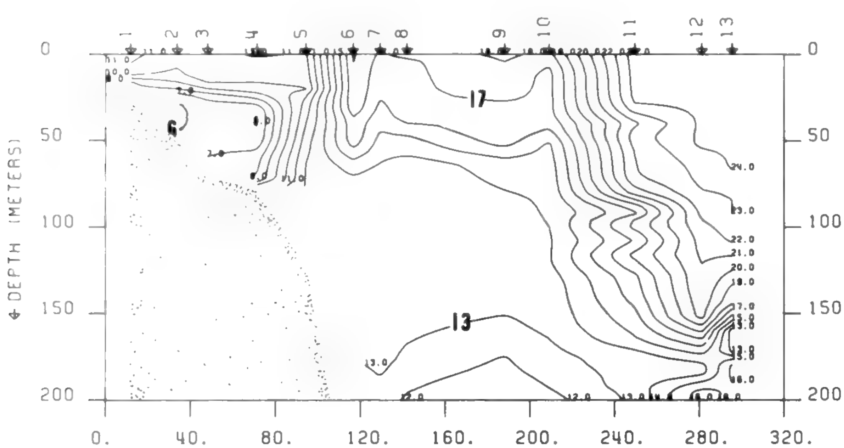


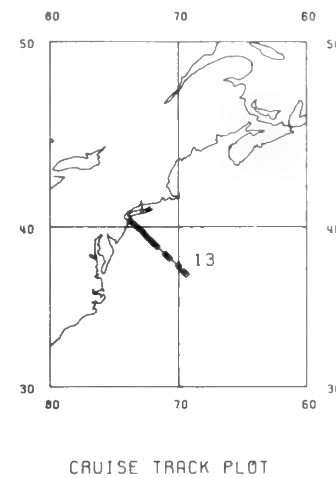


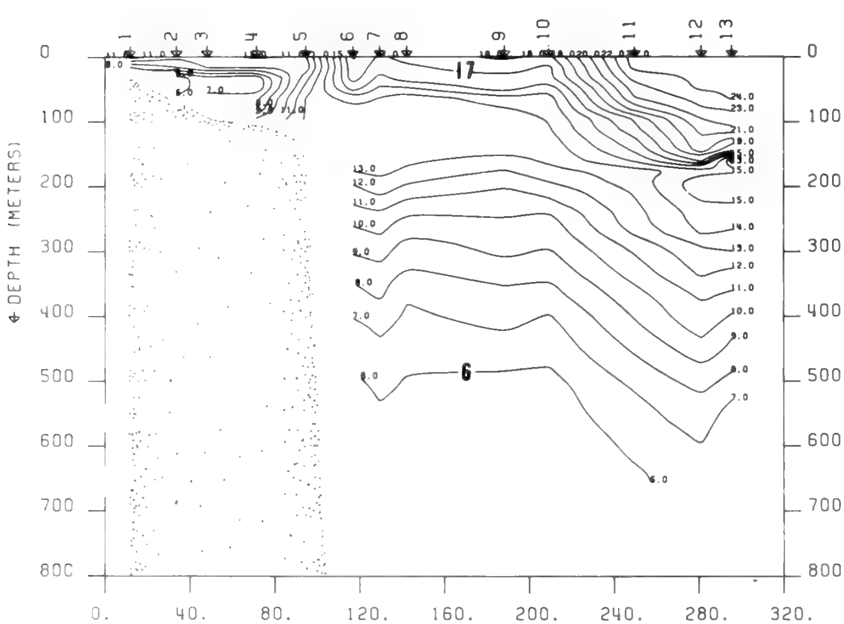
Horizontal distribution of sea surface temperature (°C) and sea surface salinity (‰), and vertical distribution of temperature (°C) in the upper 200 and 800 m.

Figure 6.—*Delta Norte*, 7311, stations 1-20, 3-5 November 1973.



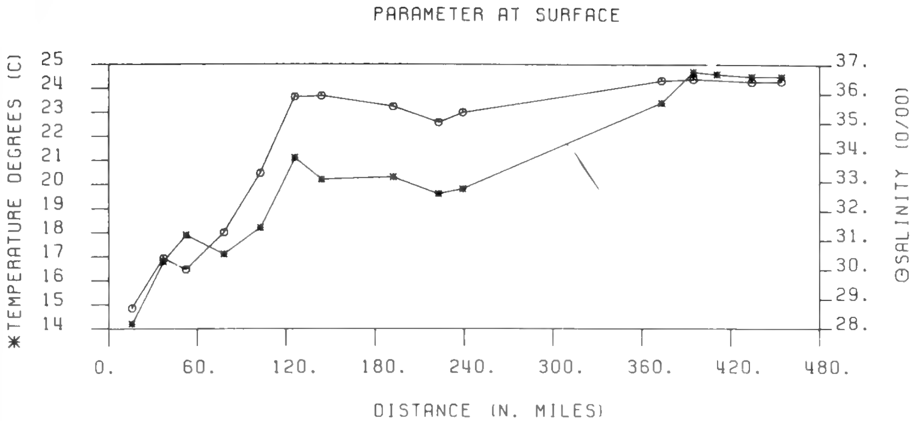


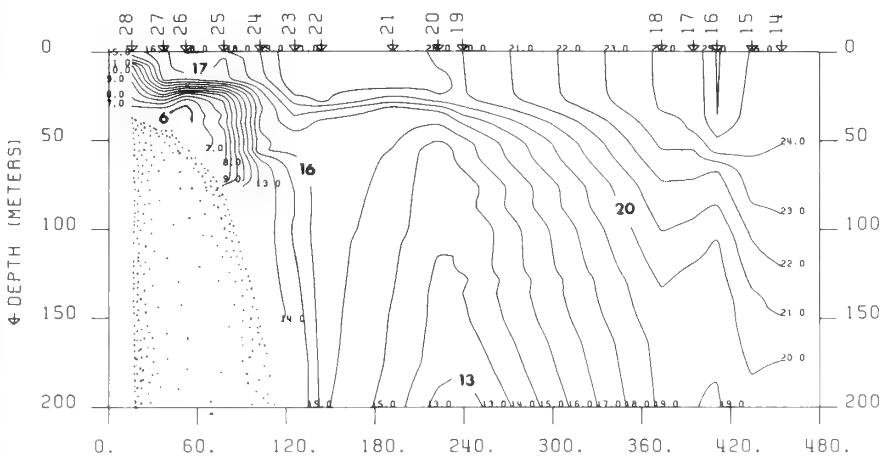


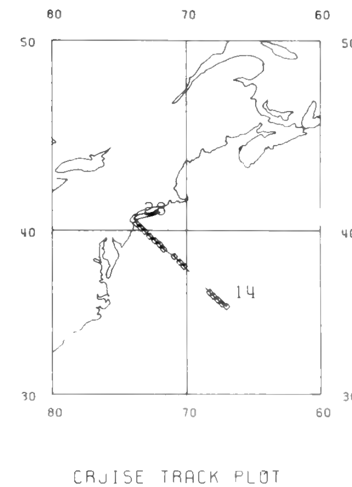


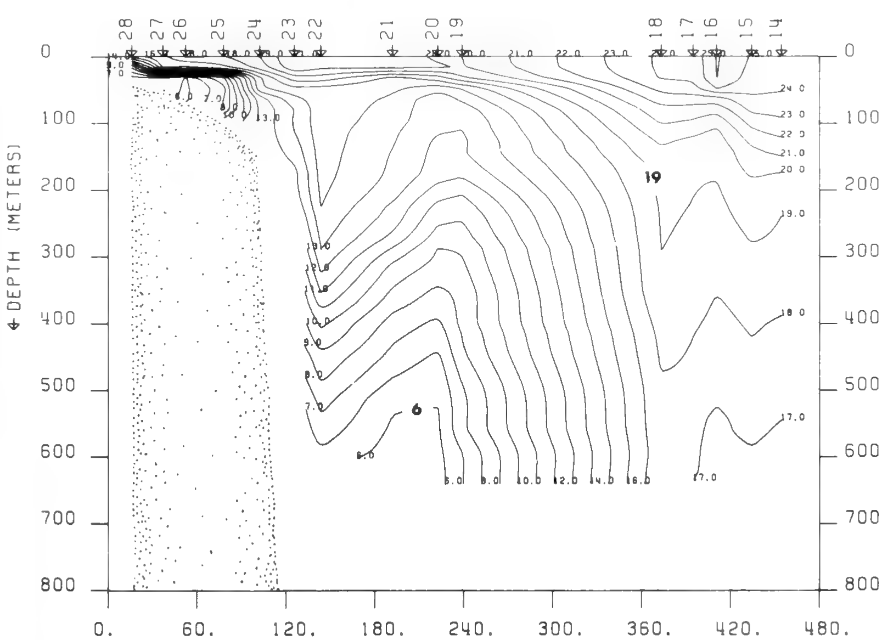
Horizontal distribution of sea surface temperature (°C) and sea surface salinity (‰), and vertical distribution of temperature (°C) in the upper 200 and 800 m.

Figure 7.—*Mormac Argo*, **7305, stations 1-13, 12-13 May 1973.**



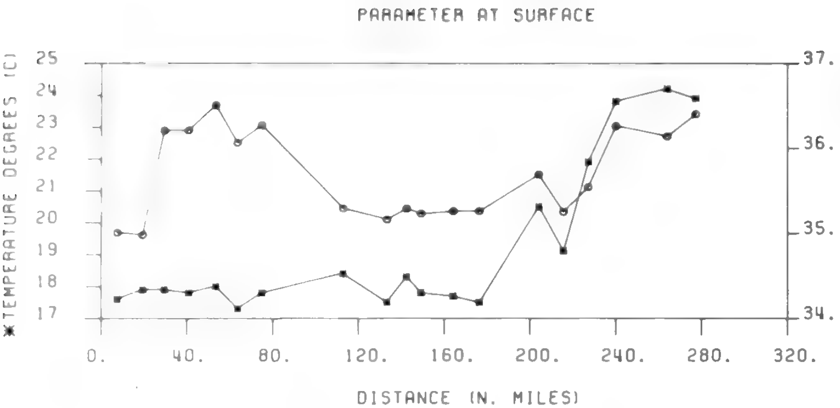


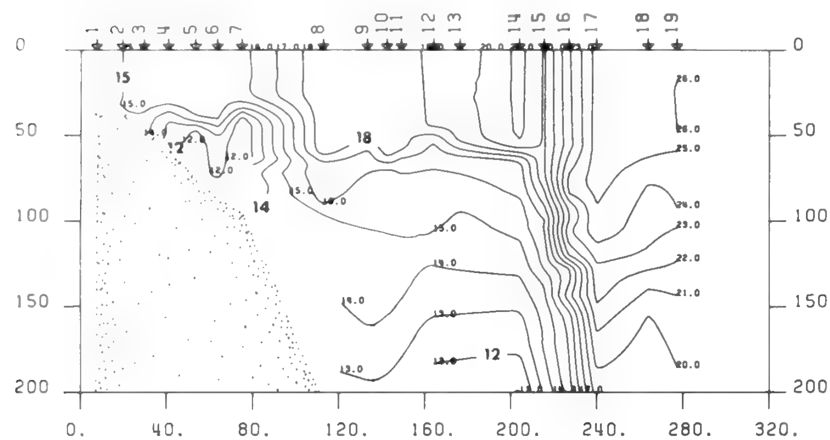


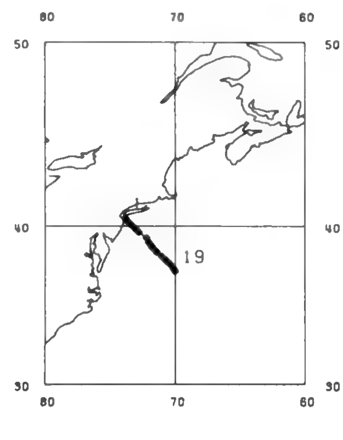


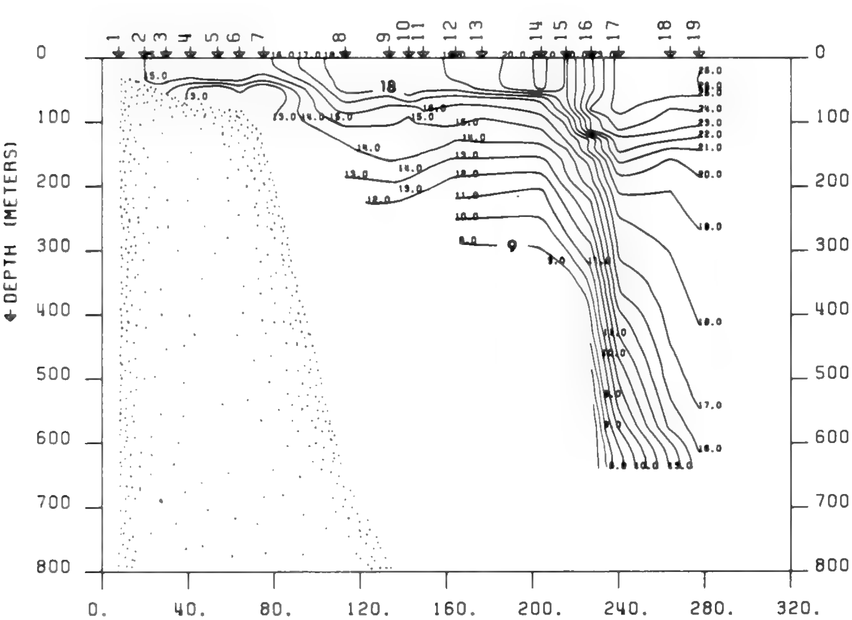
Horizontal distribution of sea surface temperature (°C), and sea surface salinity (‰), and vertical distribution of temperature (°C) in the upper 200 and 800 m.

Figure 8.—*Mormac Argo*, 7305, stations 28-14, 17-18 June 1973.



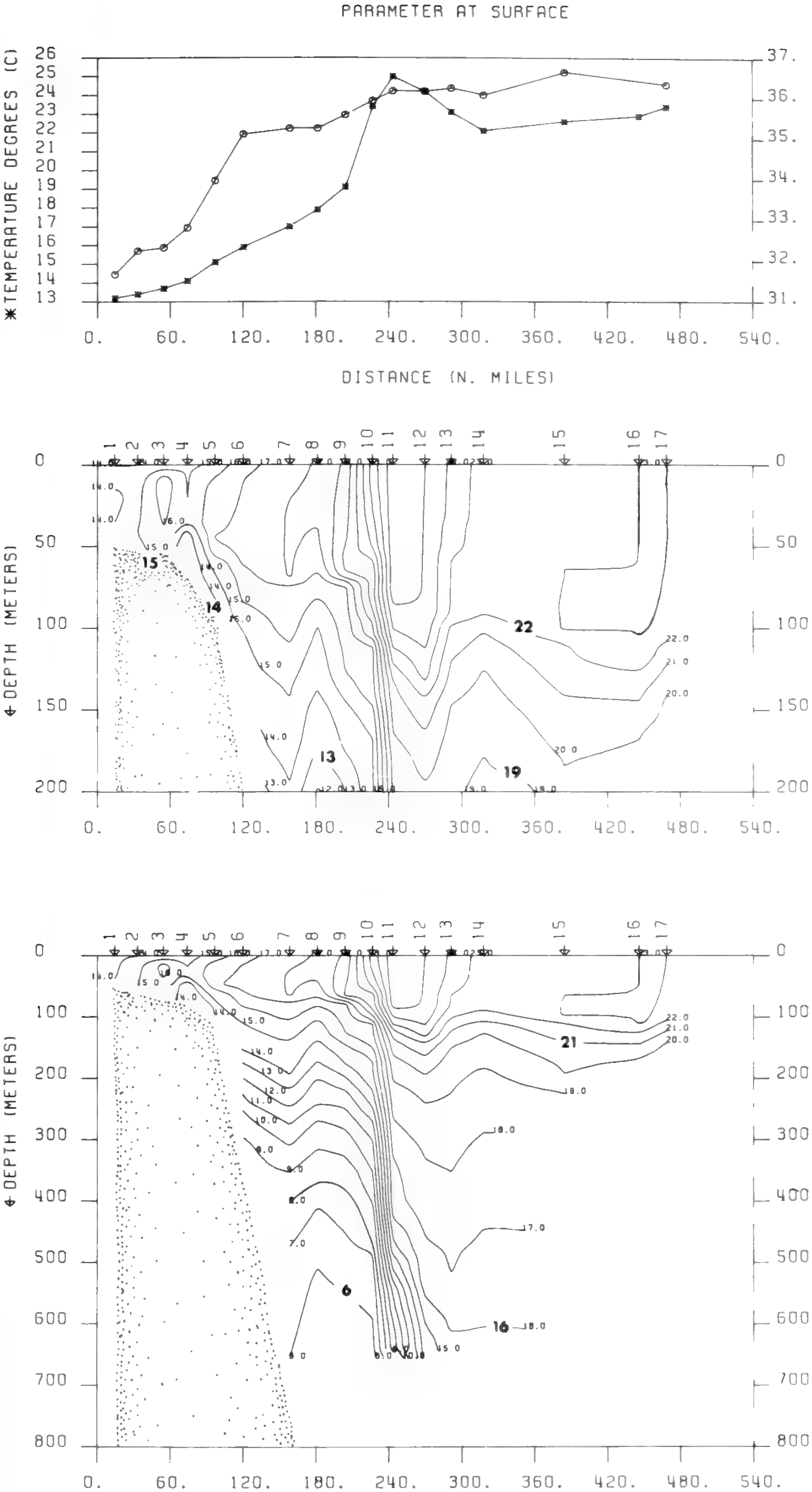


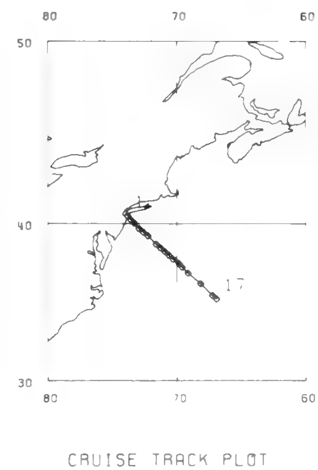




Horizontal distribution of sea surface temperature (°C) and sea surface salinity (‰), and vertical distribution of temperature (°C) in the upper 200 and 800 m.

Figure 9.—*Mormac Rigel*, 7311, stations 1-19, 1 November 1973.





Horizontal distribution of sea surface temperature (°C) and sea surface salinity (‰), and vertical distribution of temperature (°C) in the upper 200 and 800 m.

Figure 10.—*Mormac Argo*, 7311, stations 1-17, 5 November 1973.

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