Northeast Fisheries Science Center Reference Document 97-08

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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Region
Northeast Fisheries Science Center
Woods Hole, Massachusetts

June 1997

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This report may be cited as: Benway, R.L.; Jossi, J.W. 1997. Water column thermal structure in the Middle Atlantic Bight and Gulf of Maine for 1996. *Northeast Fish. Sci. Cent. Ref. Doc.* 97-08; 18 p. Available from: National Marine Fisheries Service, 166 Water St., Woods Hole, MA 02543-1026.

ABSTRACT

This report presents water-column temperature data collected in the Middle Atlantic Bight and Gulf of Maine for 1996, and extends a similar compilation for data collected during 1978-1992, 1993-1994 and 1995 of the Northeast Fisheries Service Ships of Opportunity Program (Benway *et al.* 1993a, 1995a). Data were collected by expendable bathythermographs deployed by merchant vessels during monthly transects within both bodies of water. Data are presented as contoured vertical sections. Methods of data collection, management, and portrayal are discussed.

INTRODUCTION

In 1970, the National Marine Fisheries Service (NMFS) and the Maritime Administration (MARAD) initiated a cooperative expendable bathythermograph (XBT) survey to identify and describe seasonal and year-to-year variations of temperature, salinity and circulation in major currents of the Gulf of Mexico and western North Atlantic. This survey, conducted in support of the NMFS's Marine Resources Monitoring, Assessment, and Prediction (MARMAP) Program, used merchant ships, cooperating in MARAD's Ship of Opportunity Program (SOOP), as inexpensive collection platforms, and relied on Kings Point Maritime Academy cadets to gather the XBT data.

In the mid-1970's, the continuous plankton recorder (CPR) survey (Glover 1967; Jossi *et al.* 1982), also using ships of opportunity, merged with the XBT survey. The combined surveys concentrated on water masses, circulation, and plankton of the Middle Atlantic Bight and Gulf of Maine, with particular interest in the continental shelf and slope waters.

This report portrays monthly water-column thermal conditions along MARMAP Routes MB (Middle Atlantic Bight) and MC (Gulf of Maine) for 1996. CPR data were also collected on the monthly cruises, but are not presented here, because of delays in data processing. Analyses of SOOP hydrographic data regarding long-term mean conditions and interannual variability in surface temperature, surface salinity, and bottom temperature are presented in Benway *et al.* (1993b). Additional analyses of the data collected in 1993 are presented in Benway *et al.*, 1994.

METHODS

STUDY AREA

Ship routes were selected in regions of interest to fisheries research to provide regular sampling and to allow the characterization of oceanographic conditions. Repeated coverage is important for comparative analyses, so ships with the most regular schedules were chosen whenever possible. The cooperating ships included research, commercial, and U.S. Coast Guard vessels outfitted with data sampling hardware and software from the National Marine Fisheries Service Narragansett (Rhode Island) Laboratory; The National Ocean Service Office of Ocean Observations, Washington D.C.; and the Environmental Research Laboratory, Atlantic Oceanographic and Meteorological Laboratory, Miami, Florida.

Track lines varied on different occupations of a route. This variability made it necessary to develop route polygons with shapes such that only variations along the long axis were considered significant relative to program goals (Figures 1a and 1b).

The Middle Atlantic Bight sampling originates at Ambrose Light (40°27.5'N, 73°49.6'W) and extends offshore 500 km (270 nm) towards Bermuda (Figure 1a). The route polygon is termed MARMAP Route MB, the corners of which are: 40°34'N, 74°00'W; 40°20'N, 74°00'W; 38°30'N, 69°00'W; and 34°44'N, 70°30'W. This route traverses waters of the continental shelf, continental slope and Gulf Stream.

The Gulf of Maine sampling extends from Boston, Massachusetts, on the western side, to Cape Sable, Nova Scotia on the eastern portion (Figure 1b), for approximately 452 km (244 nm). This route polygon is termed MARMAP Route MC, the corners of which are: 43°30'N, 71°00'W; 43°30'N, 65°37'W; 43°00'N, 65°37'W; and 42°00'N, 71°00'W. This route traverses waters of Massachusetts Bay, Wilkinson Basin, the central gulf ledges, Crowell Basin, southern Jordan Basin and western Scotian Shelf.

DATA AND SAMPLE PROCESSING

On all SOOP vessels, XBT and meteorological data were recorded and logged following the methods of Benway *et al.* (1993a). Temporal coverage by data type is shown in Tables 1 and 2. Middle Atlantic Bight SOOP vessels cast XBT's at 1-hr intervals (about each 26 km or 14 nm), whereas Gulf of Maine SOOP vessels dropped XBT's at 2-hr intervals (about each 44 km or 24 nm). In both regions, surface temperature was recorded hourly via bucket thermometer, and surface salinity was sampled whenever an XBT was deployed. In the Gulf of Maine, however, at the end of 1993 the C/V Yankee Clipper was replaced by the C/V Skogafoss and surface salinity sampling ceased. A thermosalinograph has been installed on the C/V Godafoss and is currently going through calibration.

Temperature and depth data collected aboard SOOP vessels were processed and quality controlled by personnel at the NMFS Narragansett Laboratory, following the methods in Benway *et al.* (1993a).

CPR data were collected and processed following the methods of Thomas (1992). In brief, CPR's were towed at a fixed depth of 10m. Seawater entering the front of the CPR was filtered through a mechanically driven belt of Swiss bolting silk with a wet mesh aperture of 225 microns x 234 microns. In the laboratory, the silk was divided into sections ("stations") corresponding to 10 nautical-mile segments (18.52 km) of a tow track. Geographic position and reference distance were calculated for each geometric center of each silk section, and successive silk sections were assigned sequential station numbers. Zooplankton and phytoplankton atlases are in preparation for both MB and MC Routes.

GENERATION OF CONTOURED VERTICAL SECTIONS

The method of generating contoured vertical sections, or grids, was designed at the NMFS Narragansett Laboratory to overcome problems associated with irregular sampling in time and space (Thomas 1992). Both XBT and bucket data from a single cruise were used to create a contoured grid of monthly, interpolated water-column temperatures.

All contoured sections of water-column temperatures (in degrees Celsius) have been constructed with route polygon reference distances (in kilometers) along the x-axis, and water-column depths along the y-axis. Grid intersections were chosen at intervals of 17.38 km distance and 10 m depth. A search was performed of the elliptical space (100km by 50m) around every grid intersection, and all raw data values within the search ellipses were fitted to the grid by interpolation, using inverse distance squared weighting. In the event of fewer than four raw data values within the search ellipse at a given grid intersection, no interpolation was performed, resulting in a blank region within the interpolated surface.

RESULTS

During 1996 the total number of cruises conducted was 15 for the Middle Atlantic Bight and 12 for the Gulf of Maine. Cruises are listed in Table 1 (Middle Atlantic Bight) and Table 2 (Gulf of Maine) along with information on the types of data collected on each cruise.

Portrayals of monthly water-column temperatures for the Middle Atlantic Bight are shown in Figures 2-7, and for the Gulf of Maine in Figures 8-11. Not included in these portrayals are the locations of concomitant CPR stations. In addition duplicate monthly XBT sampling also is not presented although listed in Tables 1 and 2.

Temperature data for any SOOP transect are available from the National Oceanographic Data Center (NODC) in a variety of forms. Requests for and inquiries about SOOP data held by NODC, as well as data products, should be directed to:

National Oceanographic Data Center
National Environmental Satellite, Data
and Information Service/NOAA
1825 Connecticut Ave., N.W.
Washington, DC 20235
U.S.A.

For information about CPR plankton collections, please contact:

Ecosystem Monitoring and Remote Sensing Investigation
Northeast Fisheries Science Center
National Marine Fisheries Service
28 Tarzwell Drive,
Narragansett, R.I. 02882
U.S.A.

ACKNOWLEDGEMENTS

Sincere appreciation is extended to the officers and crews of the *C/V Oleander*, *C/V Skogafoss* and *C/V Godafoss* for their generous cooperation in this program, the success of which is dependent on them. Appreciation is also proffered to all the individuals who have volunteered to collect SOOP data, especially aboard the *C/V Oleander*. Special thanks is extended to the National Ocean Service, Office of Ocean Observations, and to the National Weather Service, Eastern Region Headquarters for their continued support.

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Jossi, J.W., D. E. Smith, G. A. White. 1982. Continuous plankton records: the sampling program of the U.S. National Marine Fisheries Service. *Ann. Biol. 38: 66-68.*

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TABLE 1

List of all MARMAP Ships of Opportunity Program (SOOP) cruises through the Route MB (Middle Atlantic Bight) polygon from the C/V Oleander (OL) during 1996. An "X" indicates collection of a particular data type (XBT = expendable bathythermograph drop; SST = sea surface temperature (bucket); SSS = sea surface salinity (bucket) sample; CPR = continuous plankton record. Cruises with * are presented as verticle sections in this report.

CRUISE	*DATE*	*XBT*	*SST*	*SSS*	*CPR*
1996					
OL9601*	7 Feb 1996	X	X	X	X
OL9602*	2 Mar 1996	X	X	X	X
OL9603	12 Apr 1996	-	X	X	X
OL9604*	19 Apr 1996	X	X	X	-
OL9605*	3 May 1996	X	X	X	X
OL9606*	8 Jun 1996	X	X	X	X
OL9607*	20 Jul 1996	X	X	X	-
OL9608*	23 Jul 1996	X	X	X	X
OL9609*	8 Aug 1996	X	X	X	X
OL9610	20 Sep 1996	-	X	X	X
OL9611*	4 Oct 1996	X	X	X	X
OL9612*	23 Oct 1996	X	X	X	-
OL9613*	1 Nov 1996	X	X	X	X
OL9614*	6 Dec 1996	X	X	X	-
OL9615	14 Dec 1996	-	X	X	X

TABLE 2

List of all MARMAP Ships of Opportunity Program (SOOP) cruises through the Route MC (Gulf of Maine) polygon from the C/V Skogafoss (SK) and Godafoss (GD) during 1996. An "X" indicates collection of a particular data type (XBT = expendable bathythermograph drop; SST = sea surface temperature (bucket); SSS = sea surface salinity (bucket) sample; CPR = continuous plankton record. Cruises with * are presented as verticle sections in this report.

CRUISE	*DATE*	*XBT*	*SST*	*SSS*	*CPR*
1996					
SK9601*	13 Jan 1996	X	X	X	X
SK9602*	11 Feb 1996	X	X	X	X
SK9603*	11 Mar 1996	X	X	X	X
SK9604*	6 Apr 1996	X	X	X	X
GD9601*	19 May 1996	X	X	X	X
GD9602*	16 Jun 1996	X	X	X	X
GD9603*	16 Jul 1996	X	X	X	X
GD9604*	7 Sep 1996	X	X	X	X
GD9605	5 Oct 1996	-	X	X	X
GD9606*	4 Nov 1996	X	X	X	X
GD9607*	30 Nov 1996	X	X	X	X
GD9608*	29 Dec 1996	X	X	X	-

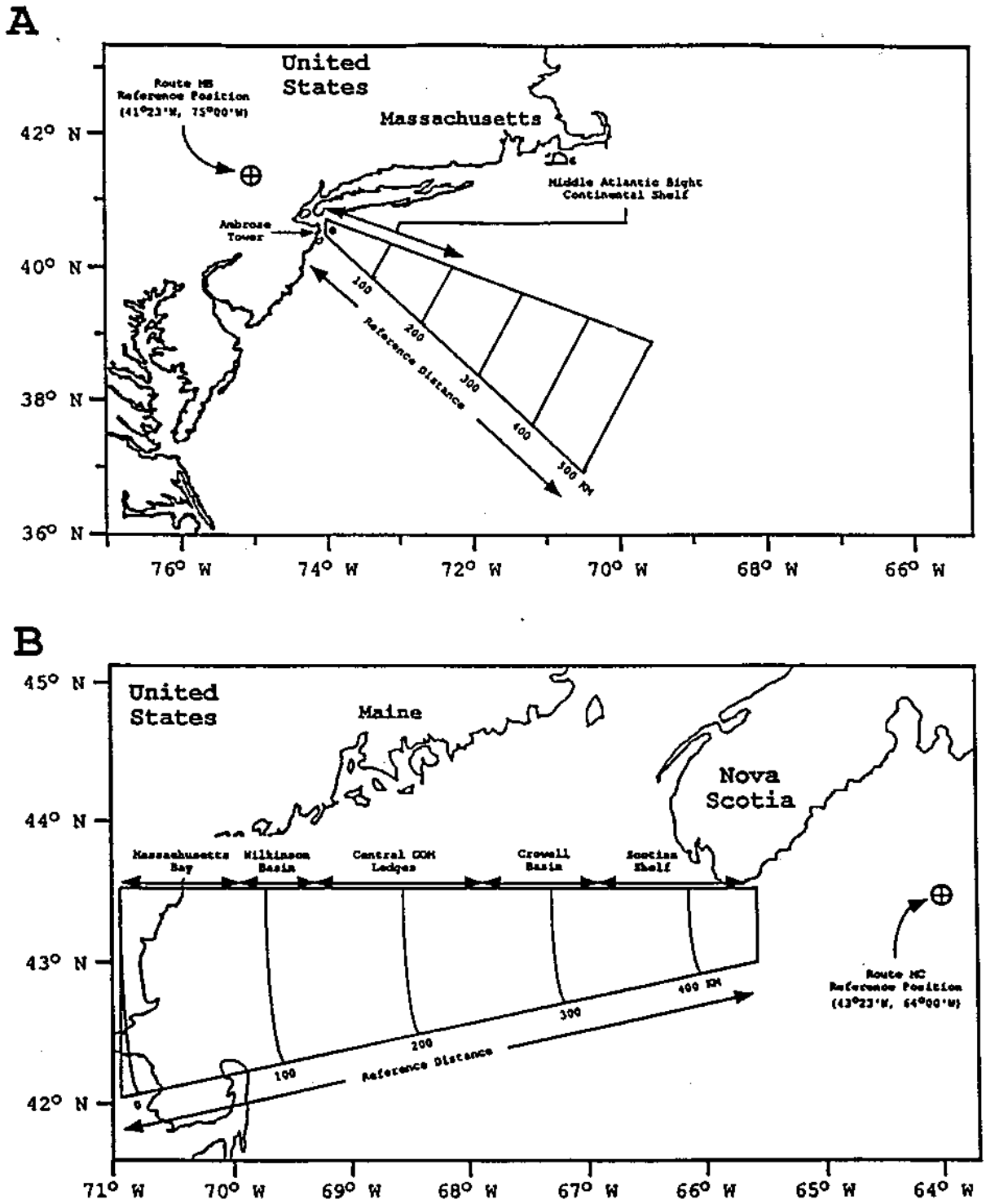

Figure 1. The (A) Middle Atlantic Bight (MAB)-Route MB, and (B) Gulf of Maine (GOM)-Route MC polygons, within which monitoring transects occured, showing reference positions and distances, location of Ambrose tower, and major geographical features through which all sampling took place.

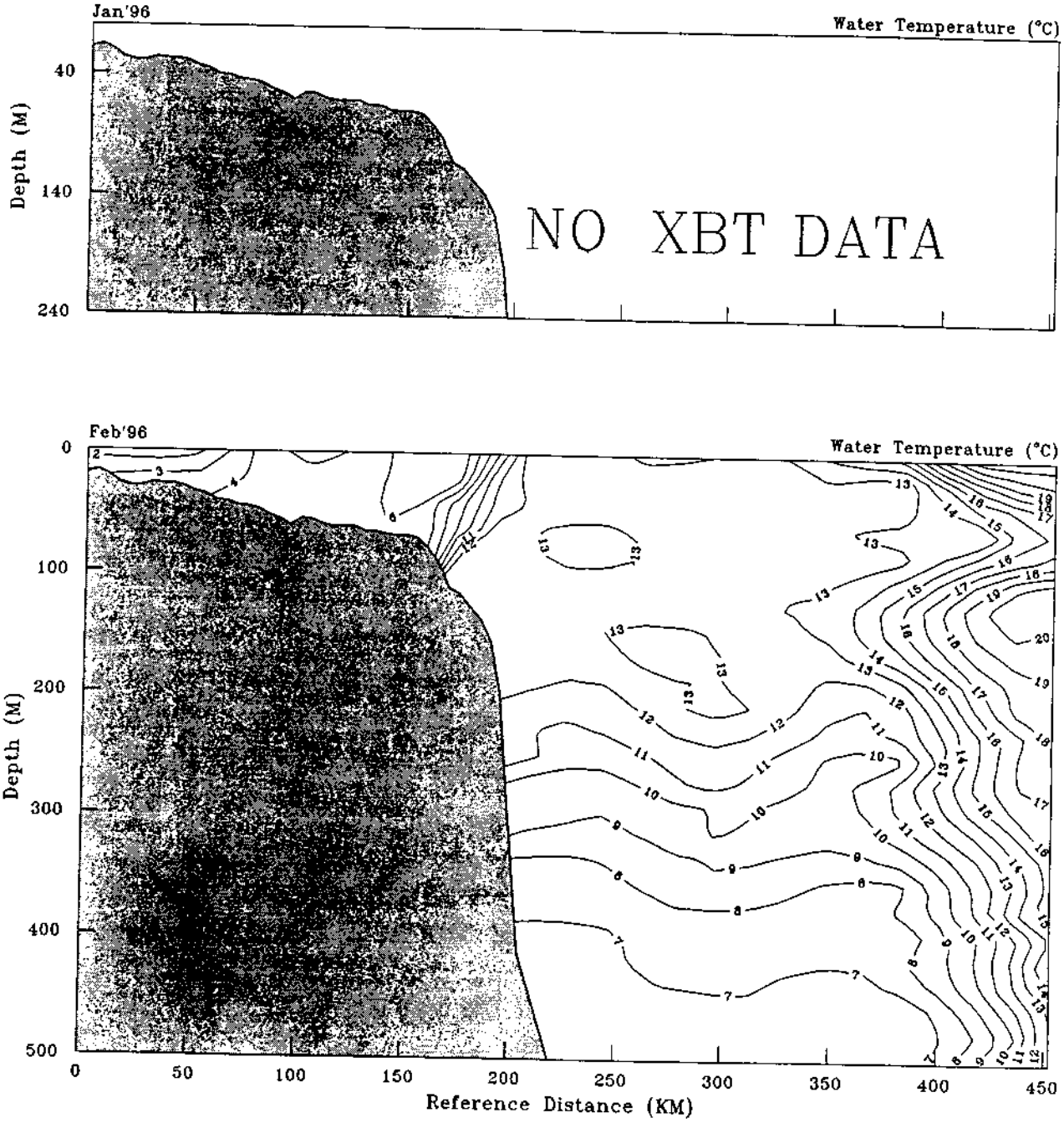

Figure 2. Water-column thermal structure (degrees Celsius) along the Middle Atlantic Bight transect during January and February 1996.

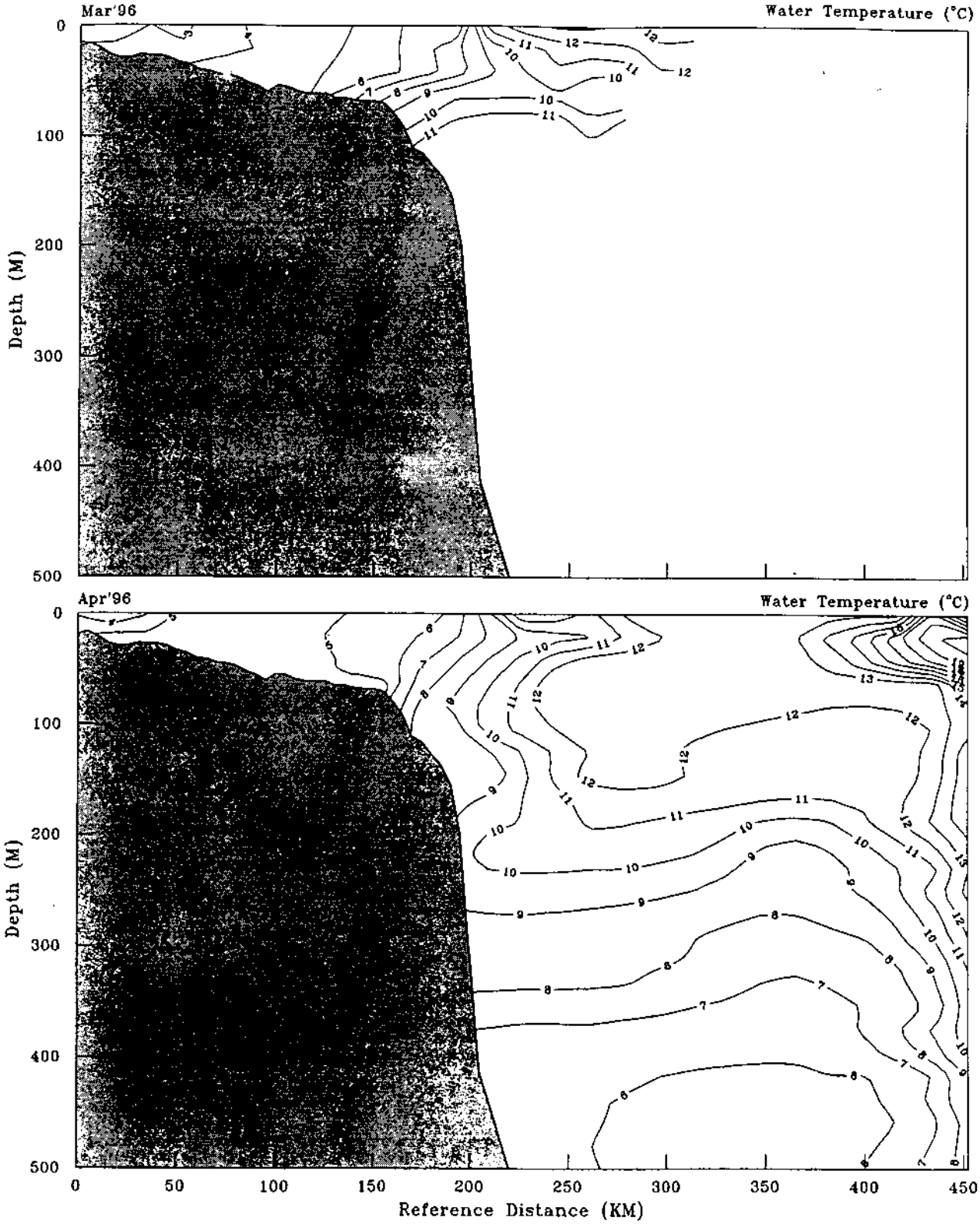

Figure 3. Water-column thermal structure (degrees Celsius) along the Middle Atlantic Bight transect during March and April 1996.

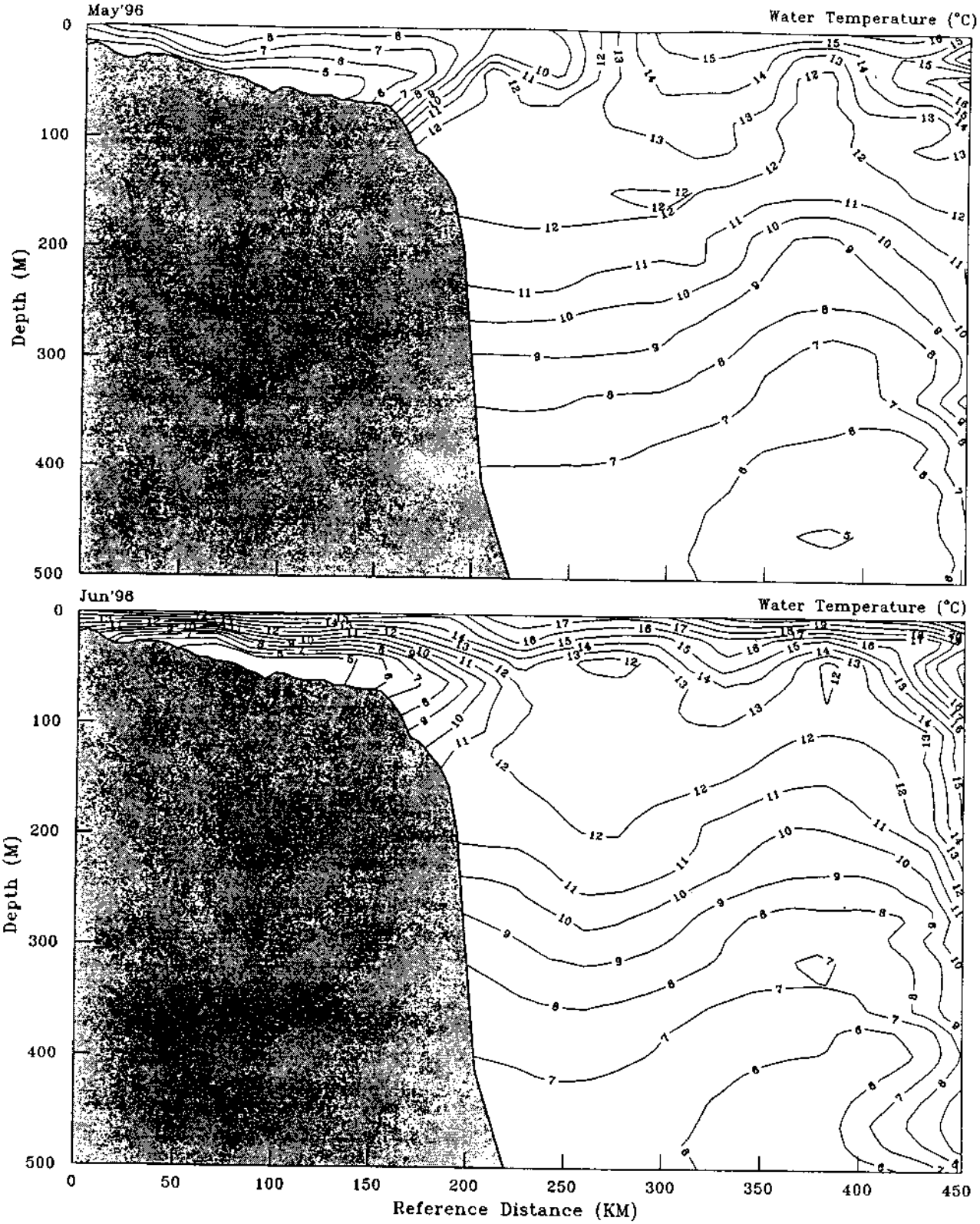

Figure 4. Water-column thermal structure (degrees Celsius) along the Middle Atlantic Bight transect during May and June 1996.

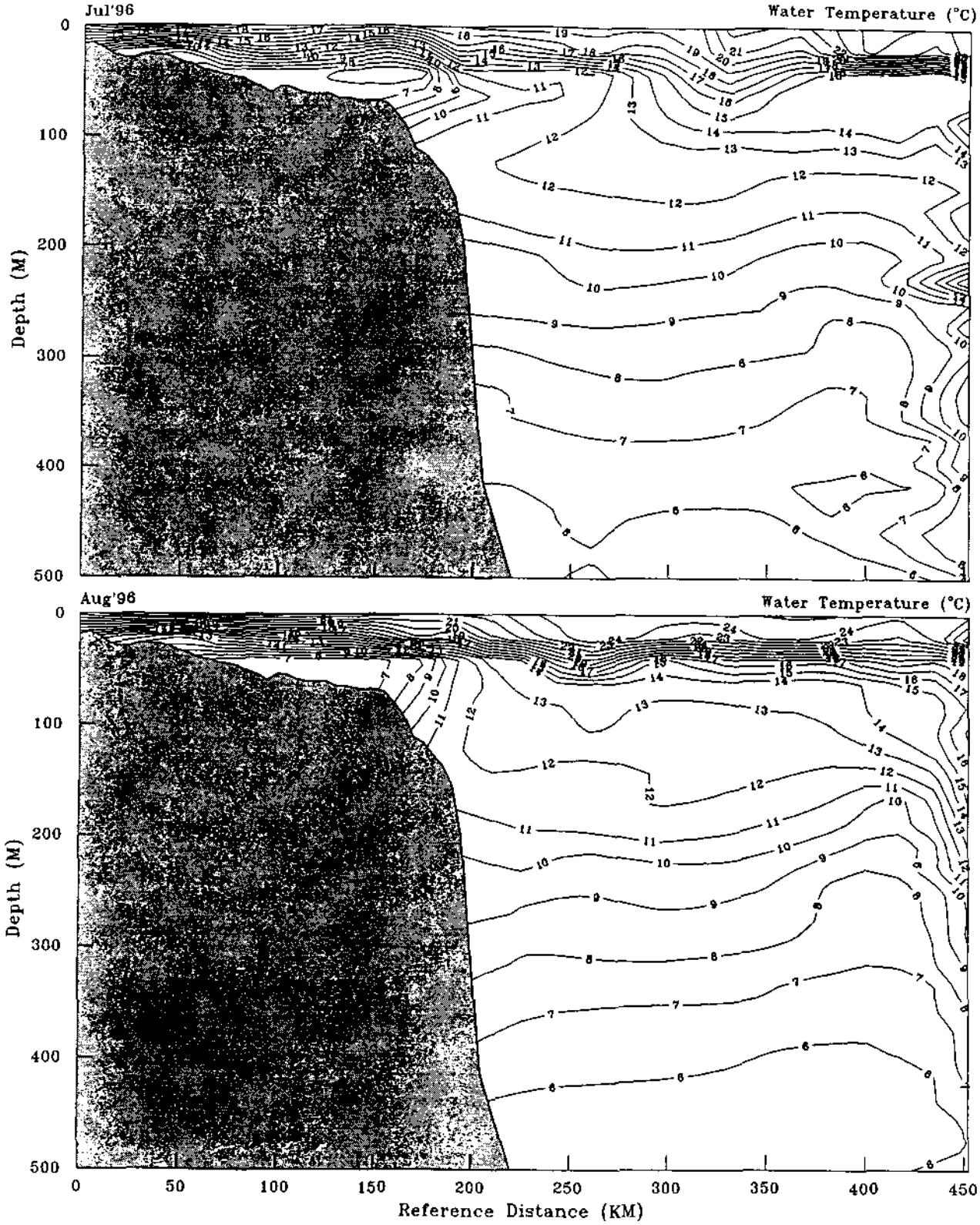

Figure 5. Water-column thermal structure (degrees Celsius) along the Middle Atlantic Bight transect during July and August 1996.

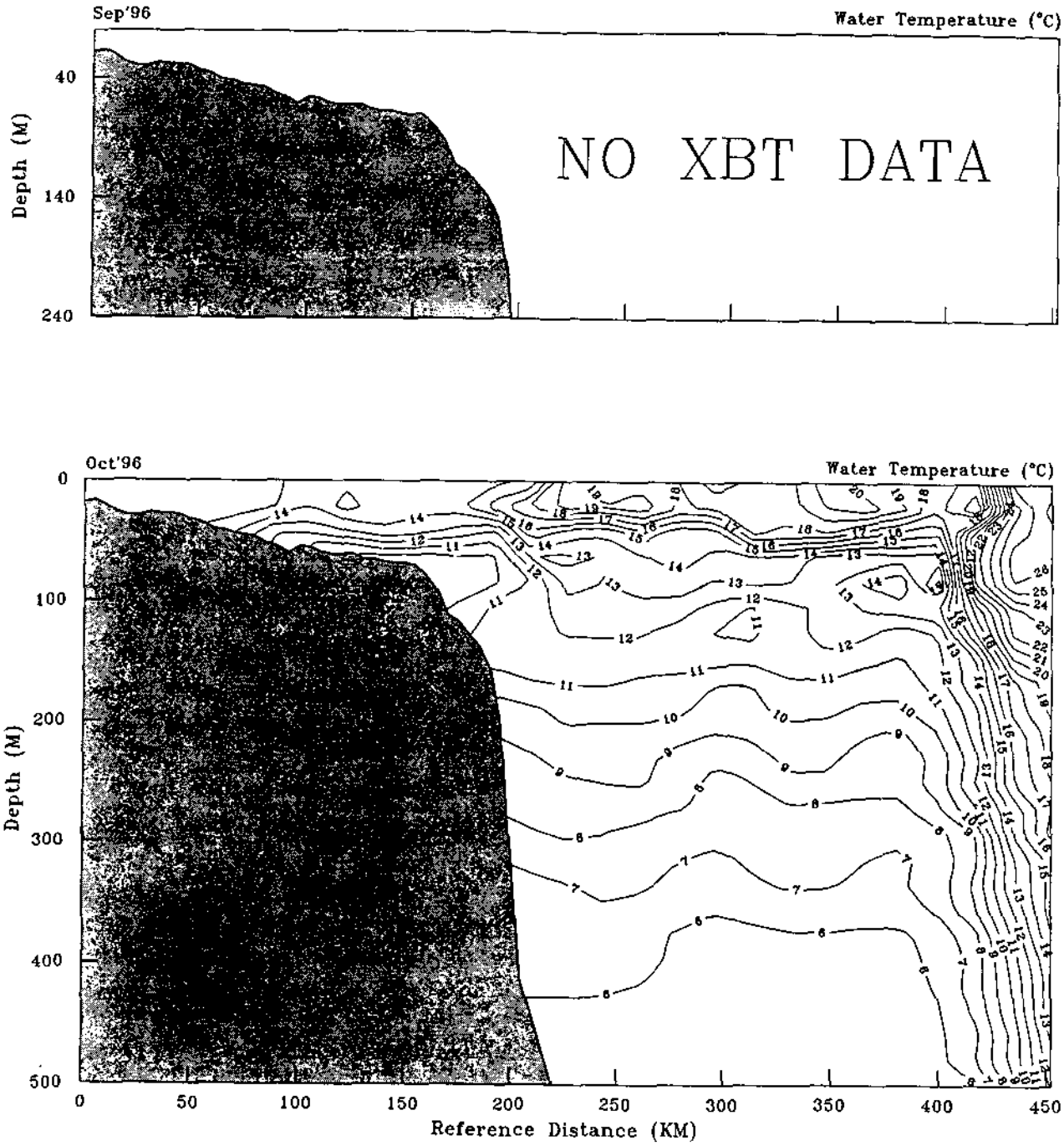

Figure 6. Water-column thermal structure (degrees Celsius) along the Middle Atlantic Bight transect during September and October 1996.

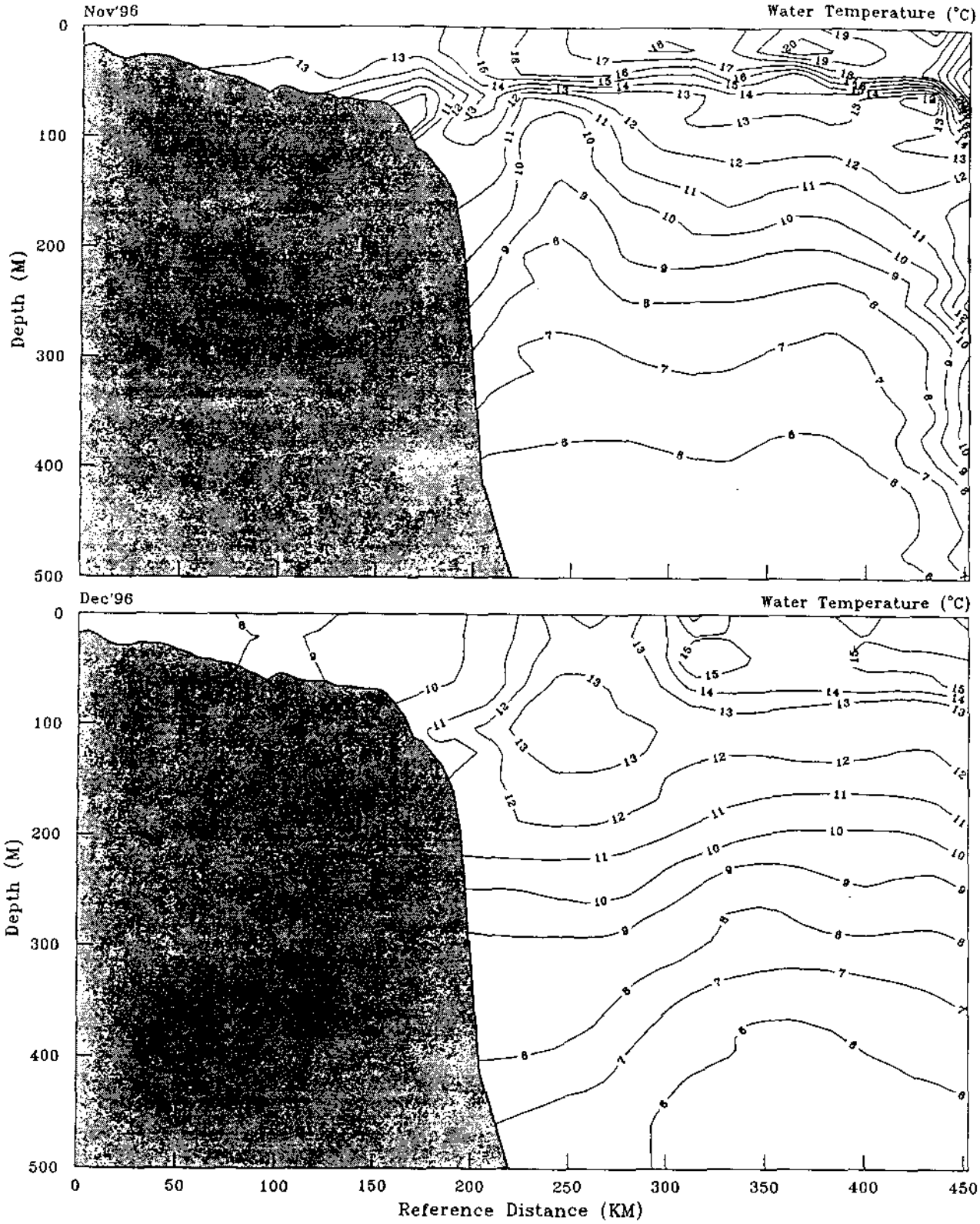

Figure 7. Water-column thermal structure (degrees Celsius) along the Middle Atlantic Bight transect during November and December 1996.

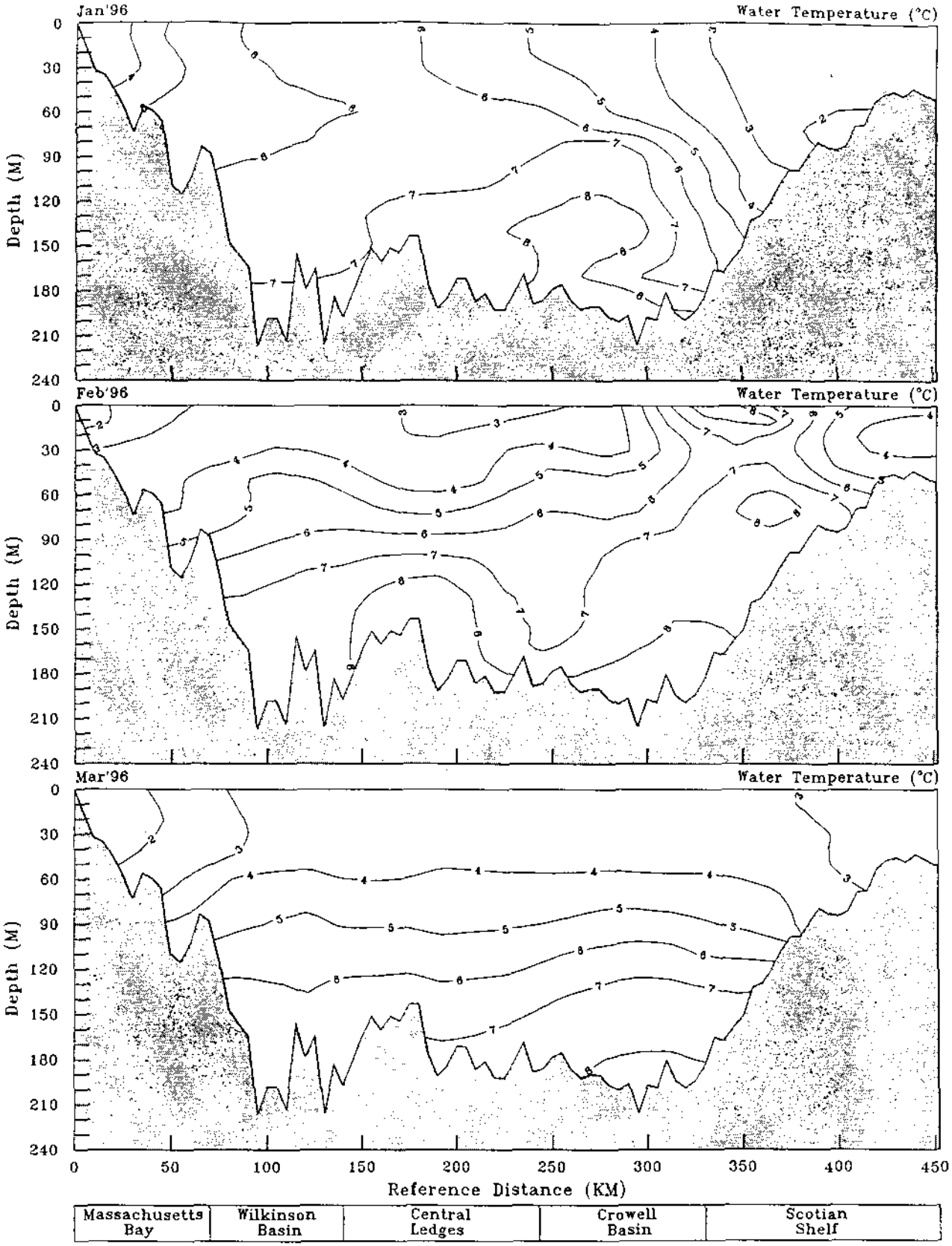

Figure 8. Water-column thermal structure (degrees Celsius) along the Gulf of Maine transect during January, February, and March 1996.

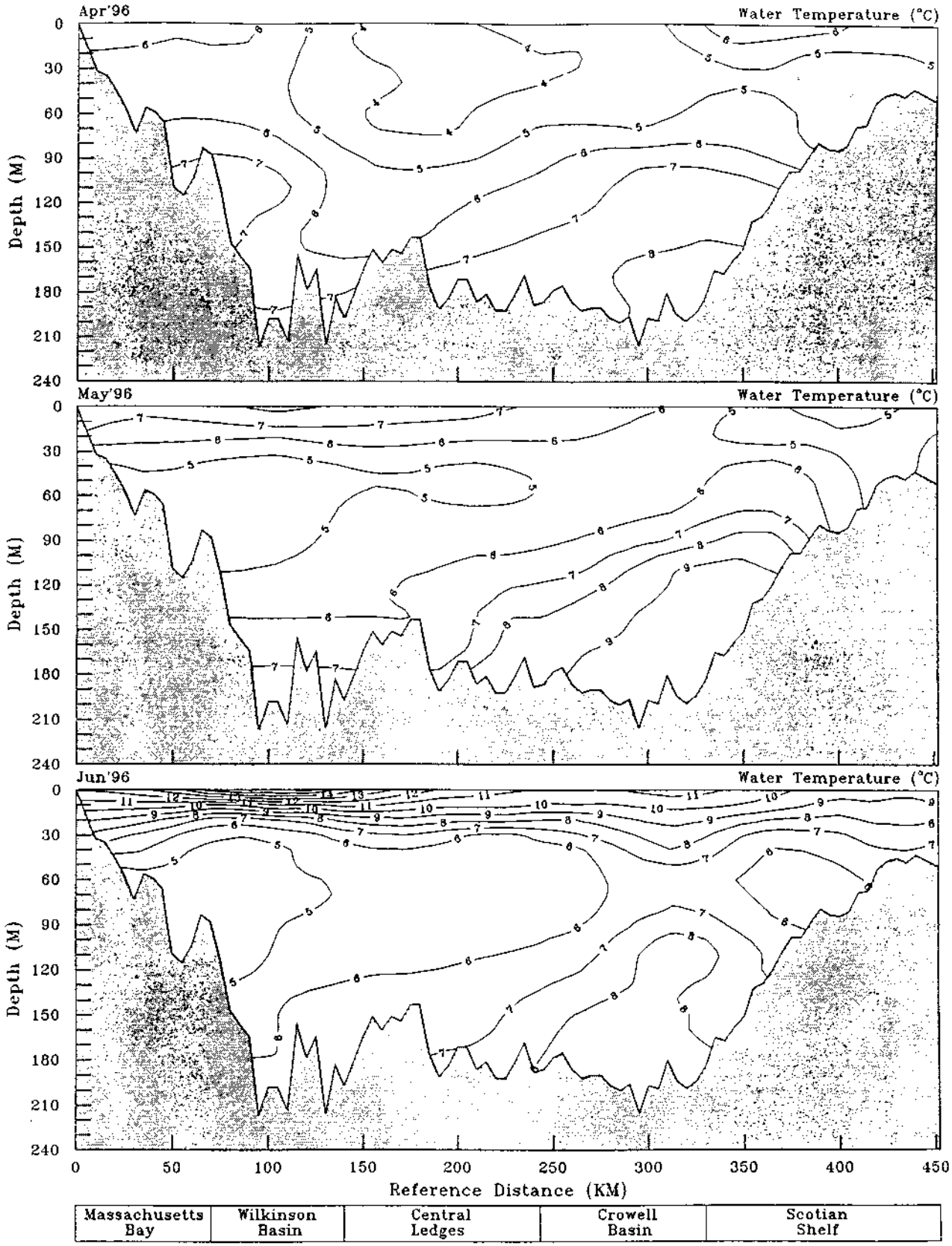

Figure 9. Water-column thermal structure (degrees Celsius) along the Gulf of Maine transect during April, May, and June 1996.

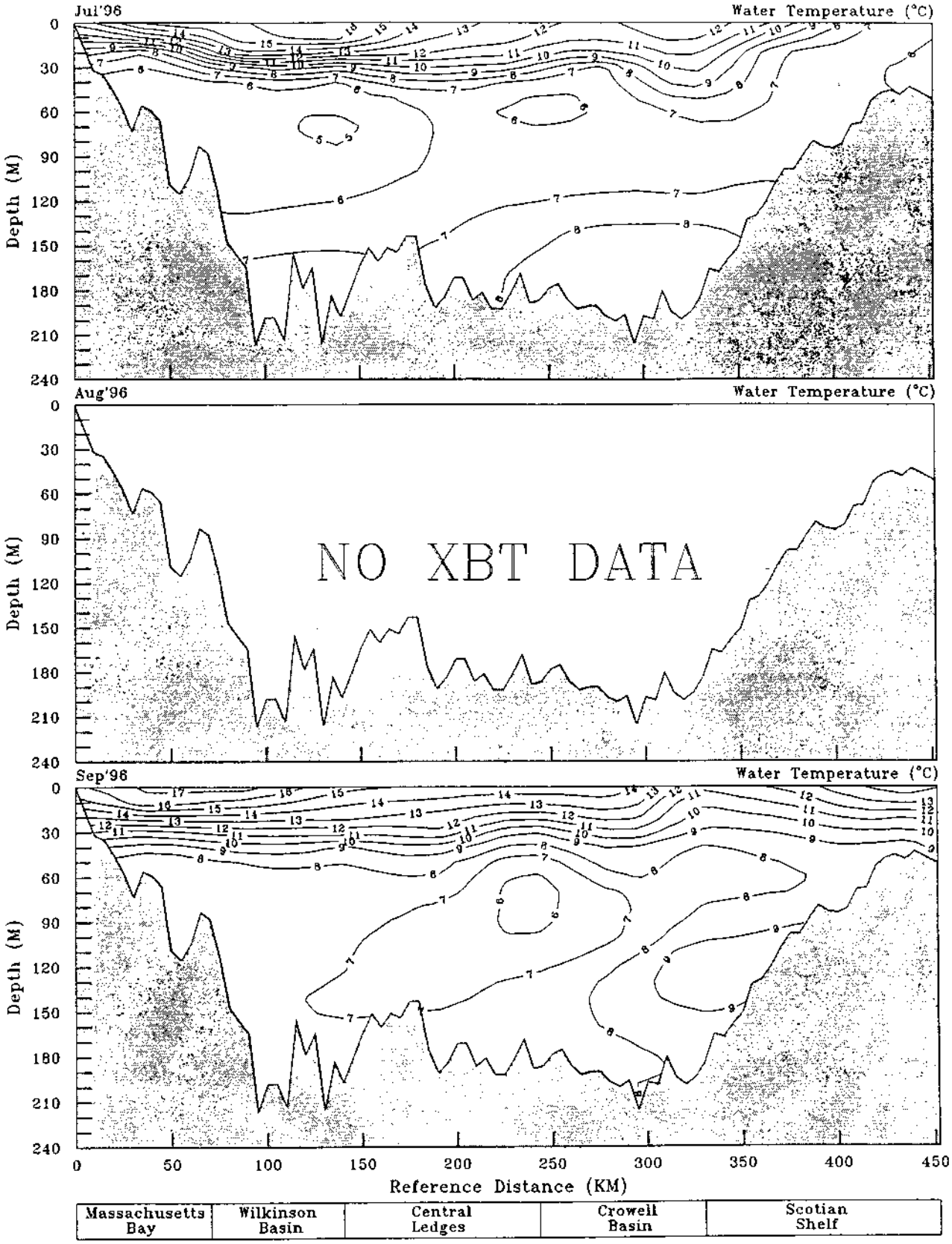

Figure 10. Water-column thermal structure (degrees Celsius) along the Gulf of Maine transect during July, August, and September 1996.

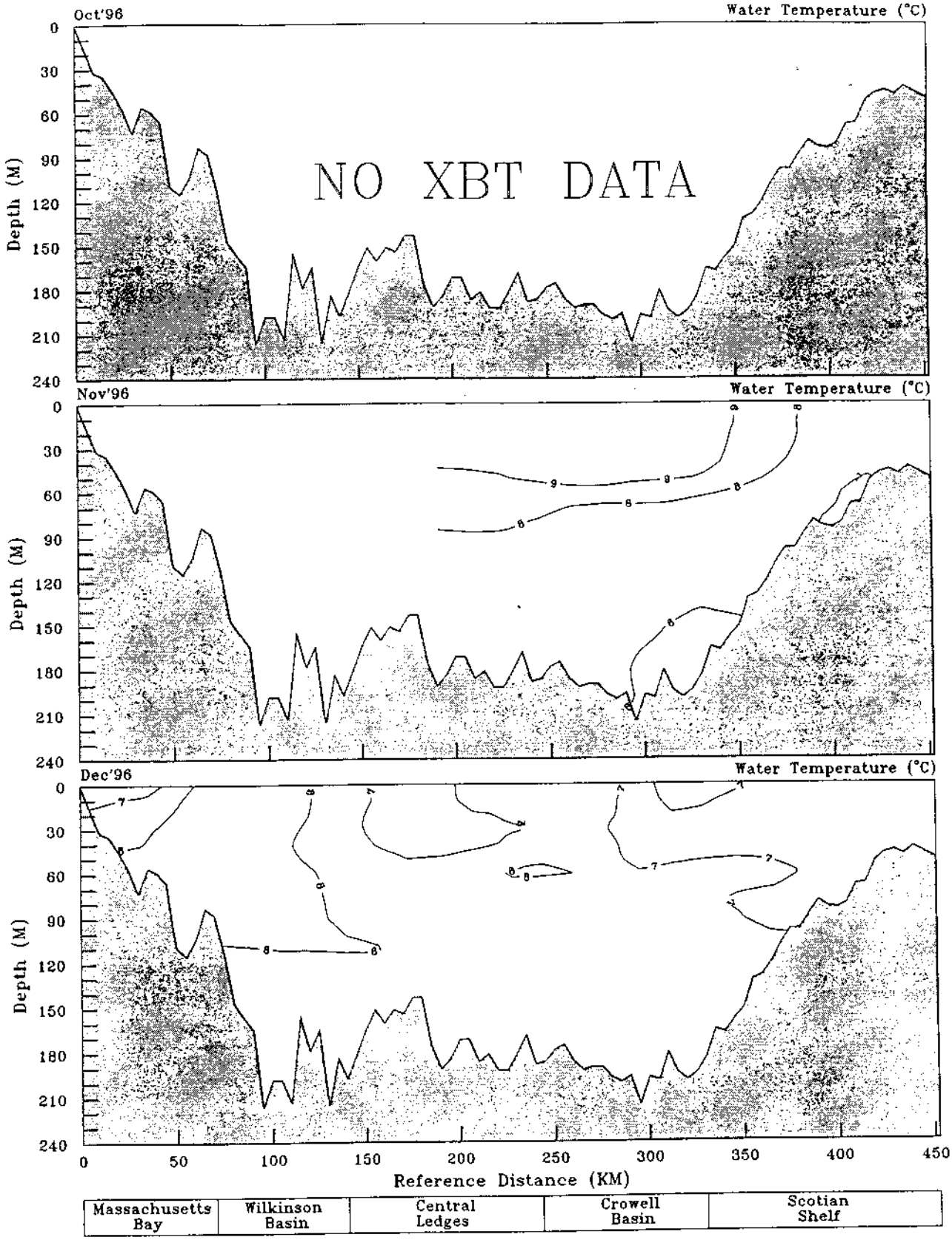

Figure 11. Water-column thermal structure (degrees Celsius) along the Gulf of Maine transect during October, November, and December 1996.

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