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Continuous plankton records : zooplankton and net phytoplankton in the southern regions of the Middle Atlantic Bight

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CONTINUOUS PLANKTON RECORDS:
ZOOPLANKTON AND NET PHYTOPLANKTON IN THE SOUTHERN REGIONS
OF THE MIDDLE ATLANTIC BIGHT

By

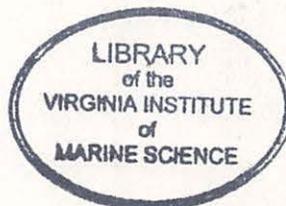
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ANNUAL REPORT SUBMITTED TO THE
NATIONAL MARINE FISHERIES SERVICE

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Contract #NA-79-FAC-00009



INTRODUCTION

The National Marine Fisheries Service (NMFS) Platform of Opportunity Program provides environmental and biological monitoring data for the Middle Atlantic Bight. Temperature (XBT), salinity (surface), and plankton (CPR) are monitored on a monthly basis along standard transects as defined by the Atlantic Environmental Group of NMFS. The standard transect for the southern Middle Atlantic Bight extends from the mouth of the Chesapeake Bay (20-fathom isobath) eastward to the Gulf-stream.

This study is part of a cooperative agreement between the MARMAP Program of the National Marine Fisheries Service, the U. S. Coast Guard, the Institute of Marine Environmental Research (IMER) of the United Kingdom and the Virginia Institute of Marine Science. The objectives of this survey include:

- 1) determine composition, abundance, and distribution of phytoplankton and zooplankton communities within two distinct water masses, shelf water and slope water;
- 2) identify seasonal and annual cycles in plankton dynamics, long term trends; and,
- 3) document spatial and temporal variations in the observed plankton dynamics in terms of timing and duration.

This report represents the conclusion of two year's analysis of the Chesapeake Route and is divided into three sections.

Part 1 provides a descriptive account of XBT, surface salinity and surface temperature analysis and a graphical presentation of XBT vertical sections along with the 1980 routes. Part 2 presents a monthly synopsis of the 1980 phytoplankton and zooplankton analysis. Part 3 is a comprehensive analysis of copepods using a composite five-year data base, 1974-1980 from the Chesapeake Route.

METHODS

Plankton samples were collected at a depth of 10 m along the defined transect (e.g. Fig. 1) by U. S. Coast Guard vessels towing Hardy Continuous Plankton Recorders (CPR). Three cubic meters of water were filtered every 10 m onto a continuously moving band of bolting silk (24 meshes per cm or $225 \mu \times 234 \mu$ aperture) through an opening of 1.61 cm^2 in the nose of the CPR. The entire bolt of silk corresponding to a transect was cut into segments equivalent to 10 m of tow, numbered and treated as a single sample.

Hourly expendable bathythermograph (XBT), surface temperature and surface salinity measurements were taken bracketing the CPR tow. Vertical profiles were contoured using the XBT data to determine the water column thermal structure through which the CPR was towed. The contoured vertical profile, surface temperature, surface salinity, and satellite imagery (AEG-modified NESS oceanographic analysis) were used to determine the water mass from which each CPR sample originated.

A detailed account of CPR phytoplankton and zooplankton analyses has been described in Hardy (1939) and Colebrook (1960) and is summarized here. Species of phytoplankton were enumerated as the number of occurrences per twenty fields ($.295 \text{ mm}$ diameter) regardless of density within a specified field. This value was then converted to number per liter (Hardy, 1939).

Zooplankton enumeration was categorized according to the size range of individual taxa. Those groups less than 2.0 mm

were subsampled; and each taxa counted as viewed within one complete staggered traverse of an individual silk. The area examined in this manner was equivalent to 1/49th of the entire 10 - nm silk. Number categories (Hardy, 1939) were used instead of actual counts. After the traverse examination, the number of organisms greater than 2.0 mm, present on the entire silk were enumerated by taxa. Number categories were used in this eyecount examination as well.

RESULTS AND DISCUSSION

Water Column Thermal Structure Across the Shelf and Slope East of Chesapeake Bay in 1980

During 1980, five expendable bathythermograph (XBT) transects were run over the continental shelf and slope east of the mouth of the Chesapeake Bay along 37°N. Contoured sections were drawn and analyzed for April, May, June, August and September. These data were correlated with the biological data obtained coincidentally using the Continuous Plankton Recorder (CPR) to identify and define water mass specific plankton assemblages. In addition special features of the water column thermal structure were monitored including: position of the shelf water-slope water front; eddies formed from the Gulf Stream, and variations in temperature and position of bottom water cold cell on the continental shelf. Position of the shelf water-slope water front was determined primarily through analysis of subsurface temperature gradients contoured as a vertical section. In addition surface temperature and surface salinity gradients along with AEG-modified National-Environmental Satellite Service (NESS) satellite imagery were used as supporting data.

FEBRUARY: Hourly surface temperature measurements were taken along an 89 n.m. CPR transect (Fig. 1), however XBT measurements were unsuccessful. Using only surface data the shelf water - slope water front was positioned seaward of Station 5

in the vicinity of 37°N 74° 35'W. Surface shelf water temperatures ranged from <3.0°C coastally to >9.0°C near the front. Slope water surface temperatures were more constantly fluctuating between 10-13°C.

APRIL: Thirteen XBT's were dropped along an 112 n.m. CPR transect (Fig. 2). Thermal subsurface analysis placed the shelf water - slope water front seaward of Station 5 near 36° 55'N 74° 20'W (Fig. 3) and was verified by the AEG-modified NESS analysis, 19-23 April. Subsurface water deeper than 20m was well mixed at 10°C over the continental shelf, while surface temperatures in the area had warmed to 11°C or greater. At this time the cold cell was not evident along the sampled shelf. Slope water surface temperatures ranged from greater than 12°C to less than 15°C. Upwelling of deep water between 150 - 400 m depth was noted along slope stations 7-9. Analysis of satellite imagery for this area revealed no eddy activity.

MAY: Seventeen XBT's were dropped along a 156 nm CPR transect (Fig. 4). The transect extended due northeast from the mouth of the Chesapeake Bay. According to XBT thermal analysis (Fig. 5), surface salinity determinations and the satellite analysis 4-7 May as modified by AEG, the transect ran parallel to the shelf water - slope water front but remained in shelf water. The first evidence of cold cell formation was noted by the presence of the characteristic "bubble-like structure" on the continental shelf at station 7-9. Temperatures ranged from less than 7°C to 9°C and the cell extended from a minimum

bottom depth of 30 m to a maximum of 80 m. The horizontal extent exceeded 40 nm. The structure was approximately 35 m thick at the center. Spring warming resulted in stratification of surface waters with nearshore temperatures exceeding 15°C. Surface temperatures between Station 8-15 remained constant, 10.7 - 11.8°C. Subsurface structure in this area was less stable evidenced by various isolated parcels of warm and cool water. This was probably due to the close proximity of the shelf - slope water front. Stations 15-17 exhibited much warmer surface temperatures (greater than 14°C), however surface salinity remained below 34 o/oo, thus shelf water. Again this was the result of the transect running parallel to the front through a very dynamic area.

JUNE: The CPR was towed 220 nm, and twelve XBT's were successfully dropped along the shoreward half of the transect (Fig. 6). The shelf - slope water front was positioned just seaward of Station 5 near 37° 01' N 74° 40'W (Fig. 7). Intense stratification over the shelf was observed where temperatures ranged from 8°C to greater than 20°C between the cold cell and surface waters respectively. The thermocline was strongest nearshore between 10-20 m depth. The cold cell structure was evident close to the shelfbreak, where temperatures ranged from 8°C in the core to 10°C along the boundary. The shoreward extension of the entire cell was not determined. However the 8°C core extended horizontally approximately 10 nm with a 25 m thick core. Thermal stratification was not as intense in slope water. Surface temperatures varied between 20°C-25°C.

A pronounced upwelling feature of small horizontal extent (10 nm) was observed seaward of the shelfbreak and another of greater horizontal extent seaward of station 10. According to AEG modified satellite imagery Eddy 79-K was located in close proximity to the northeast of the transect. Subsurface eddy or thermal inversions may have been responsible for the observed water column thermal structure.

JULY: The CPR was towed for 192 nm, however no physical data or hourly log positions were taken. The transect started to the north of the original transect area travelling east. Silks 1,3,5, and 7 were analyzed as shelf water according to AEG modified satellite analysis, 9 July and supported by biological data. Eddy 79-K was present on satellite imagery to the south of the transect.

AUGUST: Eight XBT's were dropped along the transect, unfortunately the CPR malfunctioned. There was a 51 nm gap between Station 4-5 seaward of the shelfbreak (Fig. 8). Based on the downwarping of the isotherms, the shelf - slope water front was positioned just seaward of station 4 near $36^{\circ} 59'N$ $74^{\circ} 20'W$ (Fig. 9).

The seasonal thermocline was strongest nearshore, 10-15 m deep. Surface temperatures across the shelf ranged from 26-27°C. The seaward edge of the cold cell was evident with bottom temperatures less than 10°C. Slope water surface temperatures exceeded 28°C. The transect re-entered shelf water as evidenced by the upwarping of isotherms near station 8 as the course changed northeast.

SEPTEMBER: Six XBT's were dropped along the transect, however the CPR malfunctioned (Fig. 10). The shelf water - slope water front was located between station 3-4, in the vicinity of $36^{\circ} 59'N$ $74^{\circ} 38'N$ (Fig. 11). The thermocline had intensified and deepened and was strongest nearshore between 22-30 m depth. The cold pool was still a prominent isolated structure with a $9^{\circ}C$ core. The cell extended from a minimum bottom depth of 45 m to a maximum of 85 m. The horizontal extent was lessened to approximately 12 nm and the core was 30 m thick at the center. The slope water seasonal thermocline was deeper and less intensified than that of adjacent shelf water. Surface temperatures at the seaward edge of the transect were greater than $24^{\circ}C$, 3° cooler than the surface temperatures observed in August.

1980 Plankton Analysis

Due to the poor success of CPR transects August through December and the infrequent entry into slope water in 1980, only the winter-spring shelf communities will be discussed. PHYTOPLANKTON: Phytoplankton standing stock was low in February 1980, typical of winter conditions. A large diatom Coscinodiscus spp. dominated the shelf community averaging 4.6/liter. Green algal mats were numerous in nearshore coastal areas only.

The major annual diatom spring bloom was not sampled in 1980 but was thought to have occurred during March. A dinoflagellate bloom was observed in May 1980 dominated by Ceratium tripos (16.7/lit), C. fusus (13.1/lit) and C. lineatum (4.8/lit). Dinoflagellate had begun to increase by April. Ceratium tripos dominated the shelf April phytoplankters but in much lower concentrations than May, approximately 3.1/lit.

Dinoflagellate abundance declined in June while diatoms increased. Rhizosolenia alata alata dominated both water mass assemblages averaging 4.6/liter and 3.1/liter in shelf and slope water, respectively. By July Rhizosolenia alata alata had increased to 5.2/liter in shelf water. Dinoflagellates also increased in July with Ceratium tripos and C. fusus stocks reaching 16.8/lit and 10.5/lit in shelf water.

COPEPODS ≤ 2.0 mm: Diversity, in terms of the absolute numbers of species encountered was lowest in February, typical of the seasonal cycle. Species number increased to a maximum in May and was similar to the average long-term value for May. Standing crop values followed a similar trend to that of diversity increasing from a minimum of $48/m^3$ in February to a maximum of $415/m^3$ in May. In each case the 1980 standing stock value was much lower than that of the long term average standing crop for that particular month. Both diversity and standing crop values decreased in June followed by an increase in July. The observed standing stock in July ($748/m^3$) was much higher than the recorded long term average for that month. The phytoplankton standing stock, both diatom and dinoflagellates, in 1980 was much higher than the long-term average or the 1979

value which may explain the pulse in zooplankton standing crop in 1980.

The early winter copepod community was dominated by adult Centropages typicus and Para-pseudocalanus spp. By early spring Clausocalanus sp replaced Para-pseudocalanus in importance with C. typicus still dominant ($76/m^3$). In May at the peak of the winter-spring assemblage Oithona sp and Calanus copepodites had increased and were frequently observed in moderate numbers ($20/m^3$). Centropages typicus ($65/m^3$) dominated inshore being replaced by Clausocalanus ($83/m^3$) seaward. As the winter spring community declined in June, Oithona dominated in the shelf assemblage. Adult C. typicus were absent however copepodites of Centropages were present in moderate numbers. The summer-fall community usually becomes established during July with the appearance of subtropical forms such as Oncaea, Corycaeus and the disappearance of cool water forms such as C. typicus and Oithona. However, July 1980 was anomalous not only in terms of absolute abundances but also the dominant plankters. A substantial peak in C. typicus was observed in July ($300/m^3$). Oithona and Clausoclanus also appeared in relatively high numbers.

The winter-spring assemblage was dominated by C. typicus, which was the only copepod observed within shelf water every month sampled. It constituted from 10-75% of the total standing crop throughout the sampling period. Previous studies also

also indicated dominance of shelf zooplankton by C. typicus based on frequency of occurrence year-round (Grant, 1979, Grice and Hart, 1962).

COPEPODS >2.0mm: Trends in diversity and absolute standing stock paralleled those of copepods < 2.0 mm. During winter the shelf copepod assemblage was comprised of Calanus finmarchicus, Metridia lucens, and Pleuromamma borealis. During peak abundances C. finmarchicus reached 2.5/m³. Canadacia armata appeared in low abundances (<1/m³) late in winter, early spring.

OTHER ZOOPLANKTERS: Chaetognaths were present every month sampled. They occurred sporadically in low abundances (<1/m³) during February, April, and May. Chaetognath abundances increased to 5/m³ for June and July.

Adult euphausiids appeared in low numbers in April. By May, very high numbers were recorded (>6/m³) mostly juveniles.

Zooplankton Analysis: Composite 5 Year Mean

Monthly sampling was initiated August 1974 and has been analyzed through August 1980. A total of 42 samples have been taken in shelf and 35 in slope water. The irregularity of the data is the result of conflicting Coast Guard operational priorities, ship breakdown, and equipment malfunction.

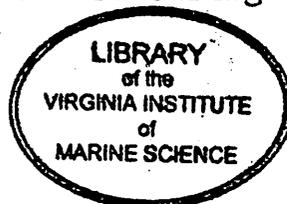
The actual months sampled and number of silks analyzed per water mass per month is shown in Table 1. An abundance value is the mean of all silks (three cubic meters filtered)

sampled that month in a particular water mass. A composite one year mean was established by averaging all January samples to give a mean long term January and so on for all months. This long term composite year will be used as a comparison for future sampling in terms of timing, duration and magnitude of phytoplankton and zooplankton community dynamics. In addition all subsequent samples will be incorporated into the composite year.

COPEPODS \leq 2.00 mm

The abundance of total copepods \leq 2.0 mm for a composite mean year is illustrated in Fig. 12a for both shelf and slope water. All standing stock values represent mean number of individuals per cubic meter of filtered sample. The mean number of species observed within a water mass will be used as an index of diversity. The diversity of copepods \leq 2.0 mm for a composite year is presented in Fig. 12b for each water mass. Of all zooplankton categories analyzed, copepods \leq 2.0 mm is the most abundant group numerically and is represented by the greatest number of species.

Two phases in diversity are exhibited in shelf water over an annual cycle (Fig. 12b). The number of species is characteristically low November through June, the winter-spring assemblage. Diversity increases abruptly in July and is maintained through the summer reaching a peak in October, characterizing the summer-fall assemblage. The number of species declines sharply in November decreasing to a minimum level



in February. Peak species diversity for the late winter period is noted in April, however this pulse is much less in terms of absolute number of species compared to the summer-fall pulse.

Slope water is characterized by two seasonal peaks in diversity, April and September. In each case there is a progressive increase January to April and June to September followed by an abrupt decline. The absolute number of species is similar for the winter-spring and summer-fall peaks.

In general the trends in diversity during the period of winter-spring are similar between water masses in terms of timing and duration. The observed absolute number of species however differ by almost two-fold between shelf and slope. In contrast the absolute number of species appear similar between water masses during the summer-fall period, while duration and timing differ. Diversity increases more rapidly and is sustained for a greater length of time in shelf than that observed for slope water. The early decline in the number of species within slope water may reflect a diminished food supply available in these waters.

Shelf water standing crop values (Fig. 12a) for copepods < 2.0 mm increase gradually through winter into March from the minimum abundance observed in January. Abundance increases abruptly three-fold from March ($151/m^3$) to April ($435/m^3$) and is maintained through May. The standing stock decreases in June

and fluctuates irratically through the summer. Very low values are observed in August followed by a five-fold increase in abundance by October. This fall peak is short-lived decreasing rapidly to low winter values ($141/m^3$). The shelf water spring and fall peaks are similar in terms of absolute abundance however, the spring pulse is of longer duration than the abrupt fall increase.

Analysis of slope water standing crop reveals two annual peaks, April and November. Abundance values increase progressively from a minimum in January to a peak in April ($479/m^3$) with a similar decline into June. Low numbers ($<109/m^3$) are maintained through the summer into October. A pulse in standing crop of one month's duration is observed in November $226/m^3$ declining to a low value again by December. The slope water spring pulse is much greater in terms of absolute abundance and is of longer duration than that observed for fall.

In general, shelf and slope standing crop values during winter-spring are similar. The slope pulse occurs earlier and is of longer duration than in shelf water. Total copepod abundance remains much higher in shelf than slope throughout the annual cycle. Standing crop in slope water remains quite low $35-100/m^3$ year-round except for a 3-month spring and 1-month fall increase. In contrast shelf water exceeds $100/m^3$ year-round except January. The summer-fall peak is numerically much smaller and a month later in slope than adjacent shelf waters.

Peaks in diversity coincide with peaks in abundance during spring for both water masses. Shelf diversity is much less than slope during the spring peak even though standing crop values are similar. In contrast shelf diversity equals slope diversity during the fall peak; but shelf standing stocks is 2x greater than slope.

The winter-spring assemblage in shelf water is characterized by adult Centropages typicus, Para-pseudocalanus spp., Oithona spp. and Clausocalanus spp. All of these are cool-water or ubiquitous forms. In slope water the community is characterized by the above species plus a few warm-water genera such as Oncaea and Corycaeus both of which are absent in shelf H₂O. In addition copepodites of larger copepods (>2.0 mm) comprise a significant portion of the slope community.

Centropages typicus dominates the winter-spring community in both water masses comprising an average of 58% of the total in shelf samples and 47% of the total in slope samples. Para-pseudocalanus is second comprising 26% of the slope total and 20% shelf.

The summer-fall assemblage in shelf water is characterized by high diversity and evenness, i.e. no one particular species dominates the standing crop. Clausocalanus, Oncaea and Corycaeus increase greatly in importance within shelf water. C. typicus occurs sporadically, however it can be found in great numbers upon occasion. In addition, tropical forms such as Farranula

sp., Centropages furcatus and Mecynocera clausi are observed in the shelf water summer-fall community, but only in the lowest abundances.

Slope water is also characterized by high diversity and evenness; however, the absolute standing crop present at any one time is very low. Cool-water forms such as C. typicus and Para-pseudocalanus spp. are absent in most cases, however sporadic occurrence in low numbers may be observed. Oncaea, Clausocalanus and Corycaeus predominate, comprising an average <20% each of the total. Occurrence of tropical forms is not infrequent and individual species such as C. furcatus may comprise 10% of the standing crop in a particular month.

Centropages typicus is the most frequently occurring copepod within shelf water year-round. In this study it is present in 38 of 43 months sampled (90%). Abundances range from 5 to 758/m³ in samples from November to May and 0 to 304/m³ June through October. Other studies using standard sampling gear indicate dominance of shelf zooplankton by C. typicus based on frequency of occurrence for areas in the southern regions of the Mid-Atlantic Bight (Grant, 1979, Grice and Hart, 1962).

Oncaea, Oithona and Clausocalanus were each observed in 60% of the slope samples, thus are the most frequently occurring species within slope water. However standing crop values observed for any one of these taxa was always <50/m³. C. typicus is present in slope water 19 of 35 sampled (54%),

however it is absent only once from January-May. It reaches max abundance in slope water of $154/m^3$ by May. Summer-fall abundance of C. typicus range from 0 to $21/m^3$.

ZOOPLANKTON ANALYSIS

Copepods >2.0 mm will be treated as a separate category due to the method of enumeration. All standing crop values are based on the number observed upon the entire silk, in contrast to the subsample method used for copepods ≤ 2.0 mm. In addition copepods > 2.0 mm are target prey of different predator species or different size of the same predator species feeding on copepods ≤ 2.0 mm. Thus categorial separation discussed above is supported by separation based on trophic function.

The mean number of species observed within a water mass in a particular month is used as an index of diversity for copepods > 2.0 mm (Fig. 12c). As with copepods ≤ 2.0 mm, diversity appears two-phase in shelf water. Low diversity is observed January to June followed by an abrupt increase in July. This high diversity is maintained through the summer into October, at which time the number of species declines sharply by November.

In slope water diversity is bimodal, also a characteristic of copepods ≤ 2.0 mm. There is a progressive increase from January to a peak in April followed by a decline in June.

The absolute number of species is much higher in slope water during winter-spring compared to the shelf water mass.

Slope diversity increases in July and maintains a high level through November with moderate monthly fluctuations. Absolute numbers are similar between the two water masses during the summer. In contrast, slope diversity is sustained longer and does not decline to winter values until January compared to the shelf decline in November.

The shelf winter-spring community is comprised of Calanus finmarchicus, Metridia lucens and Pleuromamma borealis. C. finmarchicus occurs in 50% of all the samples taken January to June reaching a maximum abundance of 2/m³ in April. Metridia lucens occurs in fluctuating numbers depending on the proximity of the shelf/slope front. Pleuromamma abundances also fluctuate due to diel migratory habits.

In slope water the winter-spring community is also dominated by the cool-water forms listed above. Sporadic occurrences of warm-water fauna such as Euchaeta marina and Undinula vulgaris in low abundances is observed in slope water. C. finmarchicus occurs less frequently (35% of all samples, January-June) in slope water but may occur in abundances equal to those observed in shelf water. Pleuromamma borealis is present in similar abundances in both water masses, dominating the communities in January and February.

The dichotomy between shelf winter-spring and summer-fall communities is more defined and evident for copepods

>2.0 mm. The cool-water forms dominant through May, occur very seldom and then in numbers $<1/m^3$ July-November. The summer-fall shelf community is dominated by Nannocalanus minor. Peak abundances reach $4/m^3$ in July and November. This is the greatest average abundance of any copepod > 2.0 mm observed in shelf water. Tropical forms such as Euchaeta marina and U. vulgaris also contribute significantly to the total shelf standing stock.

Nannocalanus minor is also an important component of slope summer-fall assemblage reaching a maximum abundance of $1/m^3$ in July and November. The total abundance of all copepods >2.0 mm is distributed evenly among the species. No one particular species dominates the community. Undinula vulgaris and Euchaeta marina occur more frequently and in greater numbers than observed in slope water during winter-spring and more than observed in shelf water summer-fall. Occurrence of many tropical forms such as Scolecithrix danae, Pleuromamma abdominalis, and species of Copilia and Sapphirina are noted regularly in low abundances.

ACKNOWLEDGEMENTS

Appreciation is extended to the staff of the U. S. Coast Guard Marine Services Branch, Atlantic area. We also thank the officers and crew of the USCG cutters Ingham, Taney, Cherokee and Reliance for their assistance in conducting this survey.

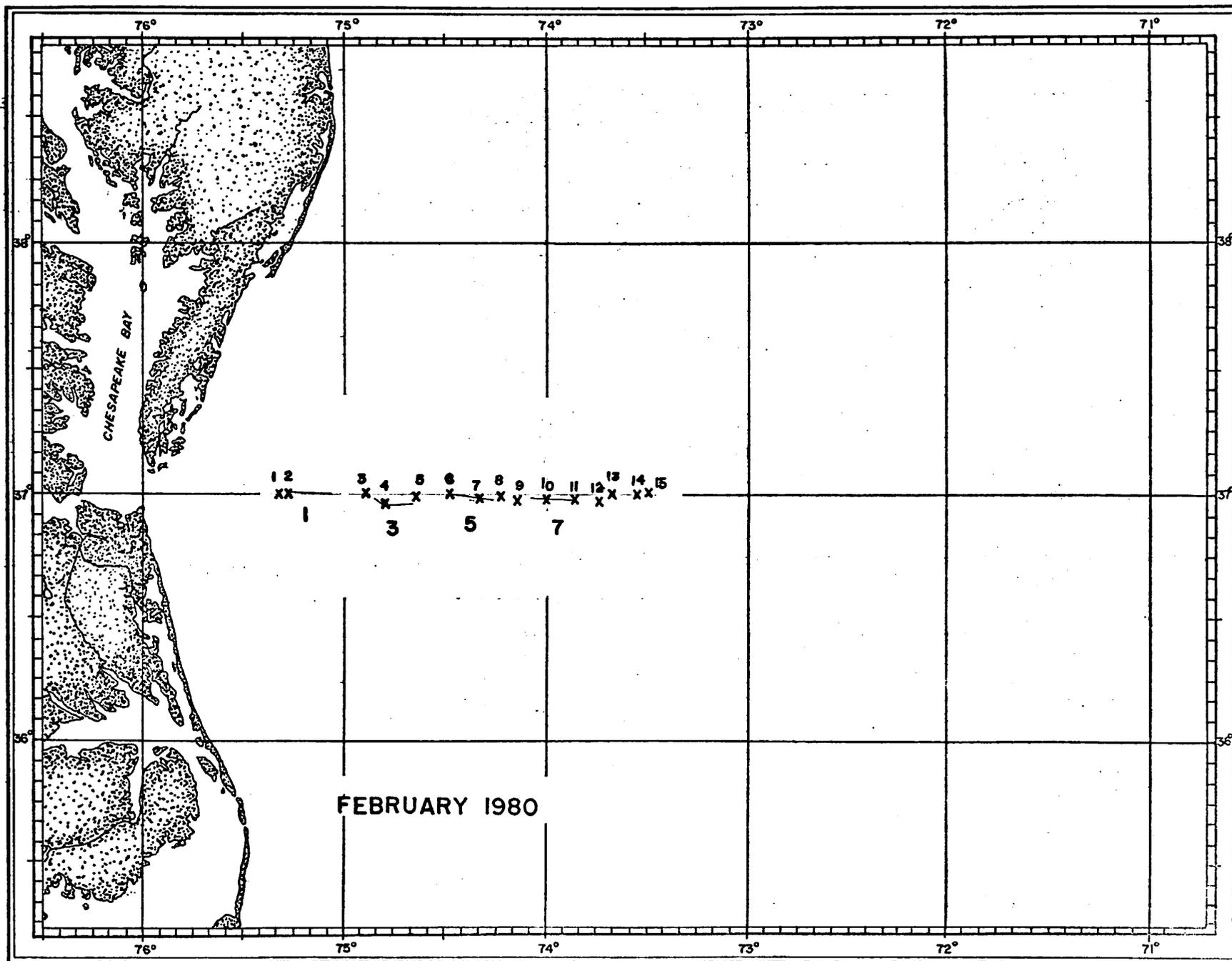


FIGURE 1. Transect positions of CPR samples and XBT/Surface Stations, February 1980. In this figure and the following: the X and small number above the transect correspond to XBT/Surface Stations and the horizontal (10-nm) bar and large number below the transect correspond to CPR blocks.

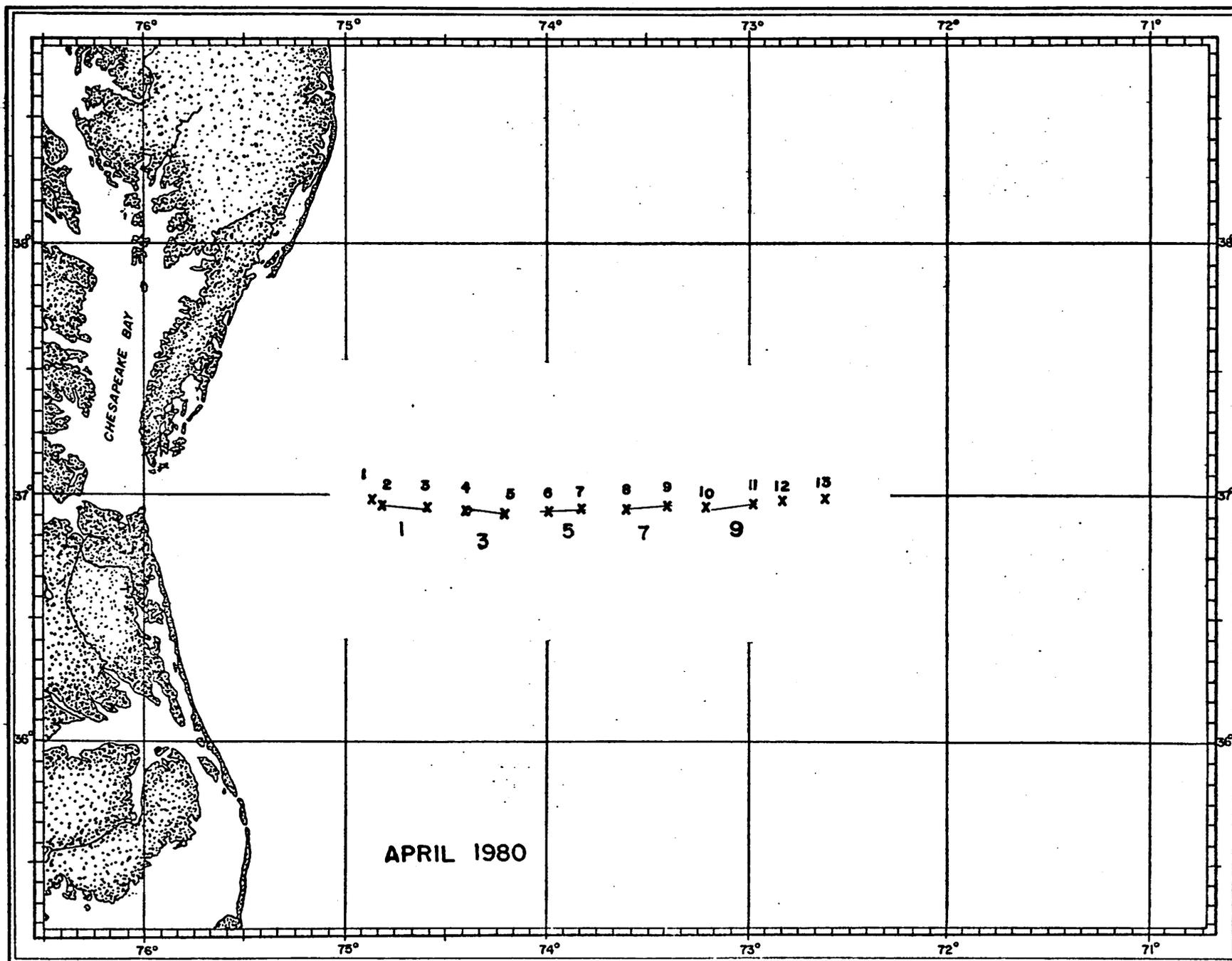


FIGURE 2. Transect positions of CPR samples and XBT/Surface Stations, April 1980.

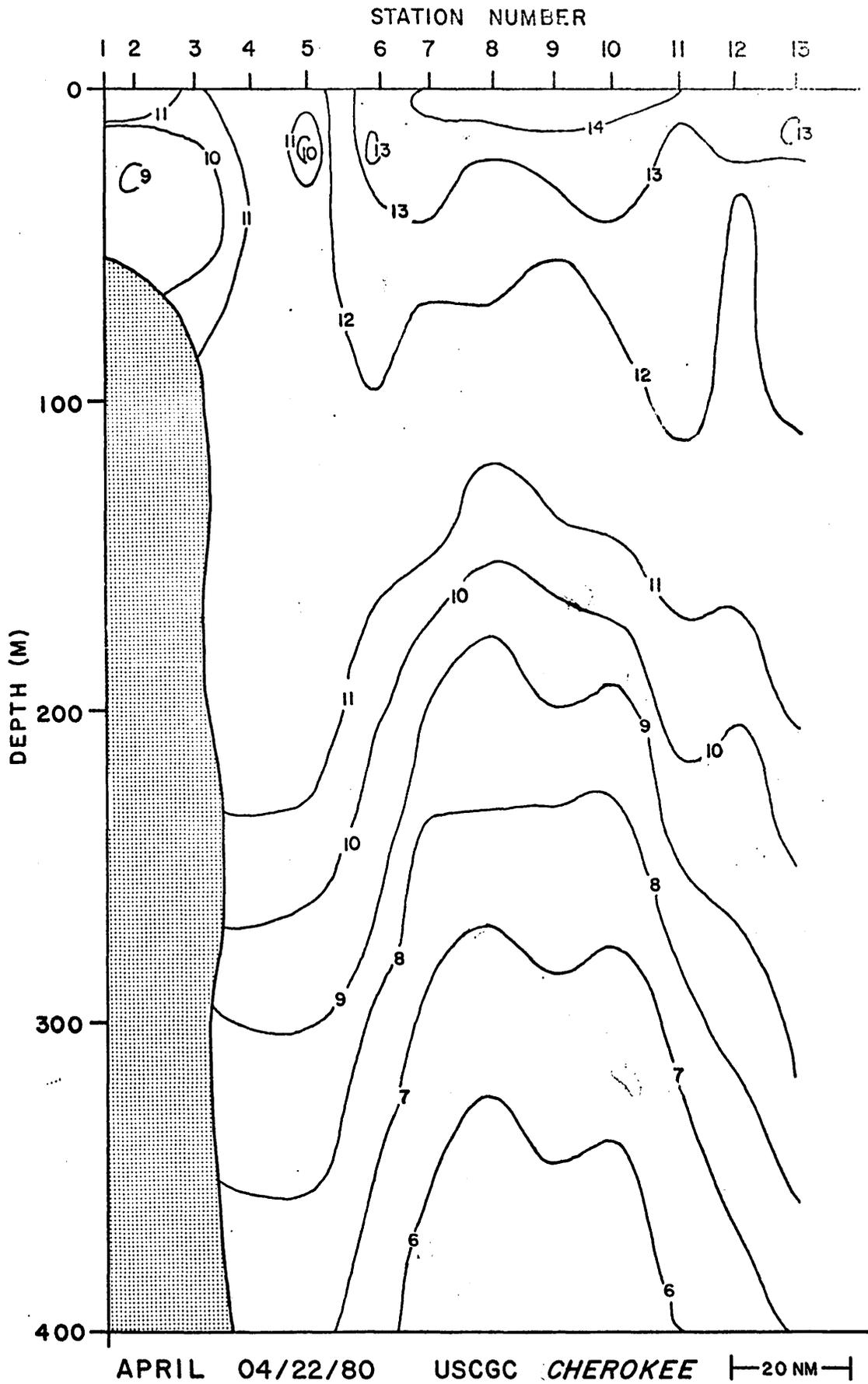


FIGURE 3. April vertical distribution of temperature (°C).

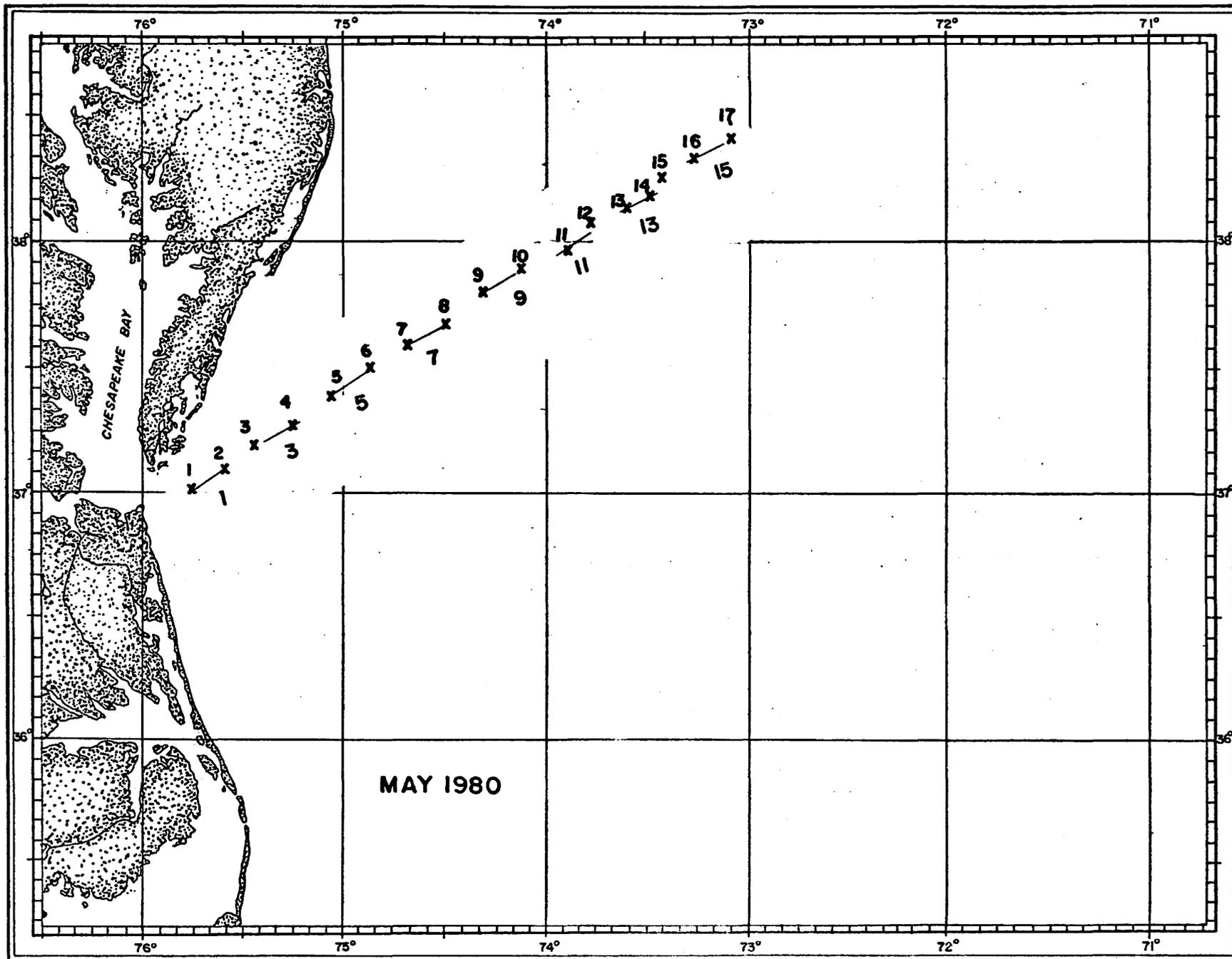


FIGURE 4. Transect positions of CPR samples and XBT/Surface Station, May 1980.

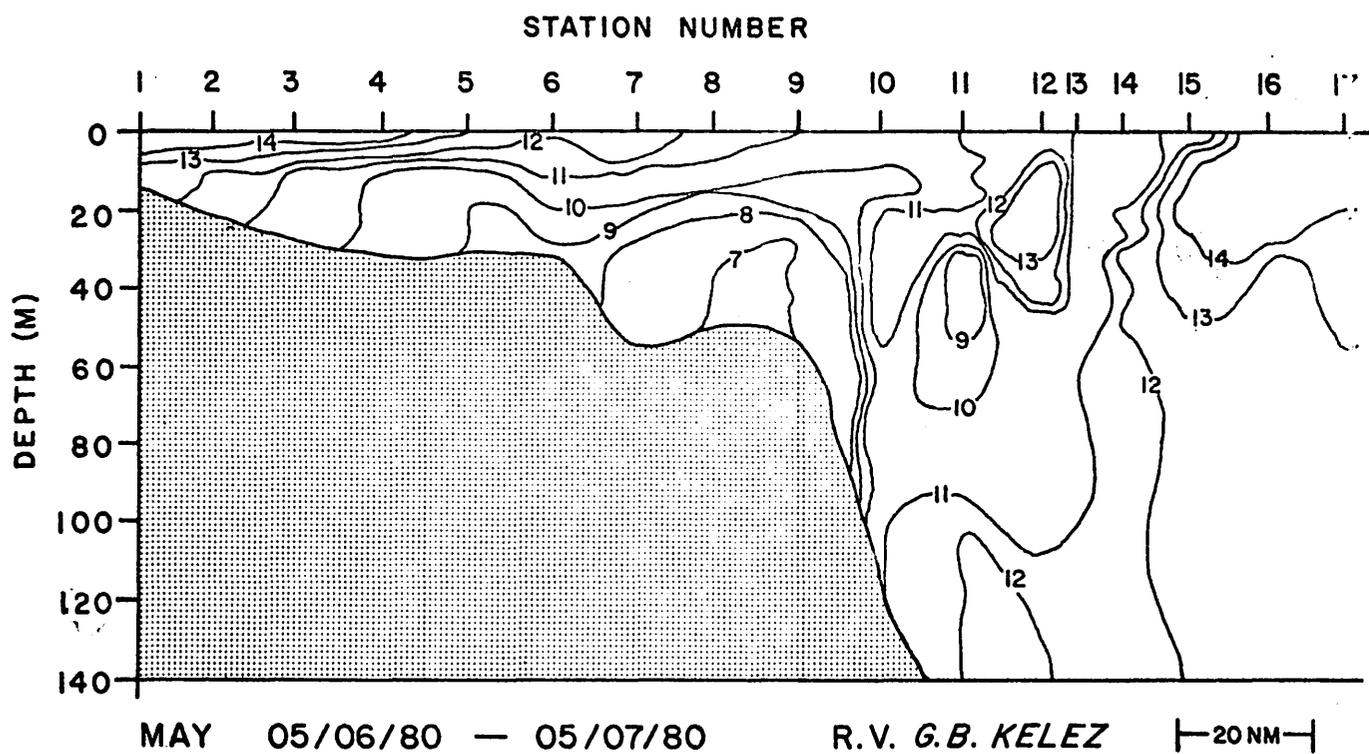


FIGURE 5. May vertical distribution of temperature ($^{\circ}\text{C}$).

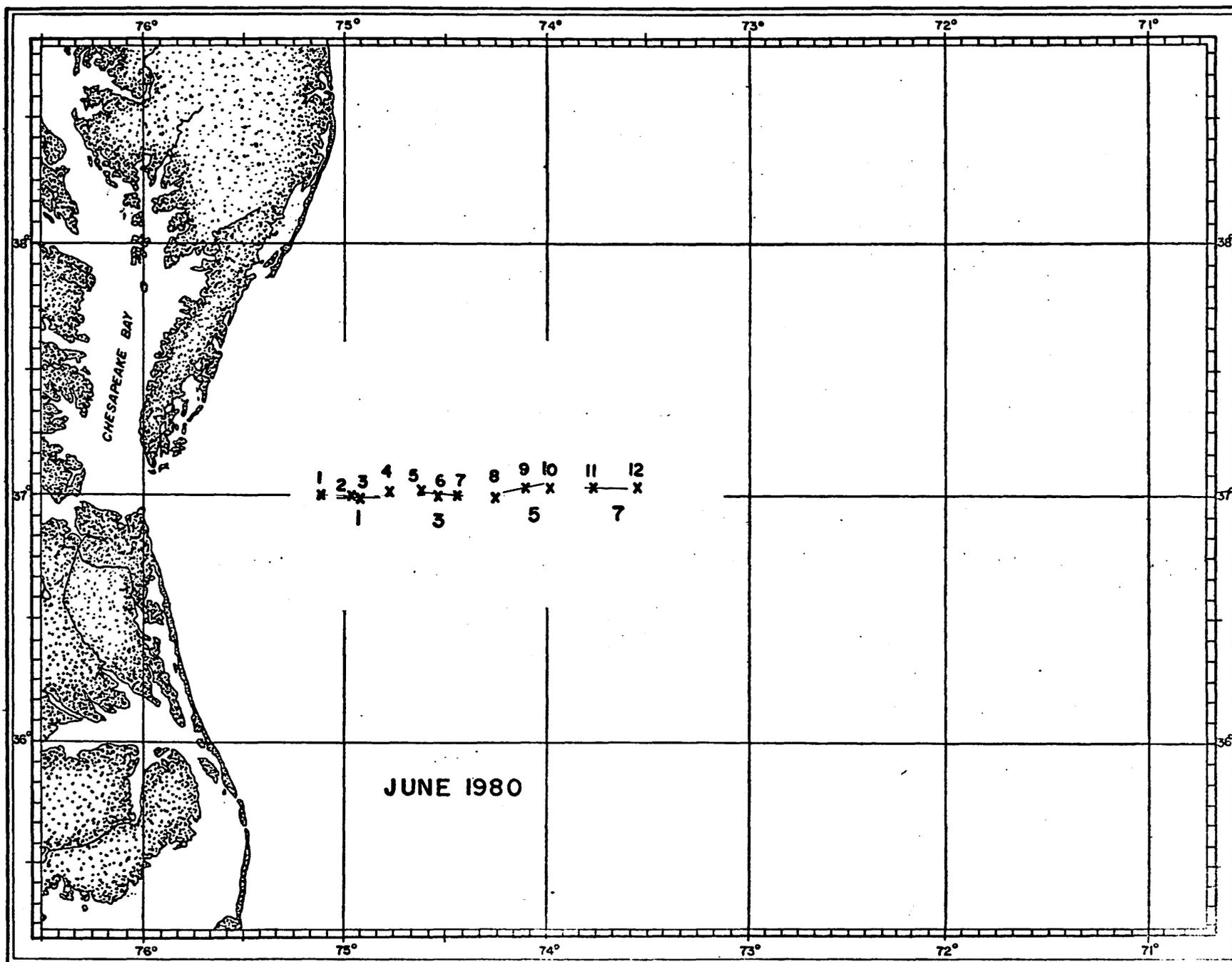


FIGURE 6. Transect positions of CPR samples and XBT/Surface Stations, June 1980.

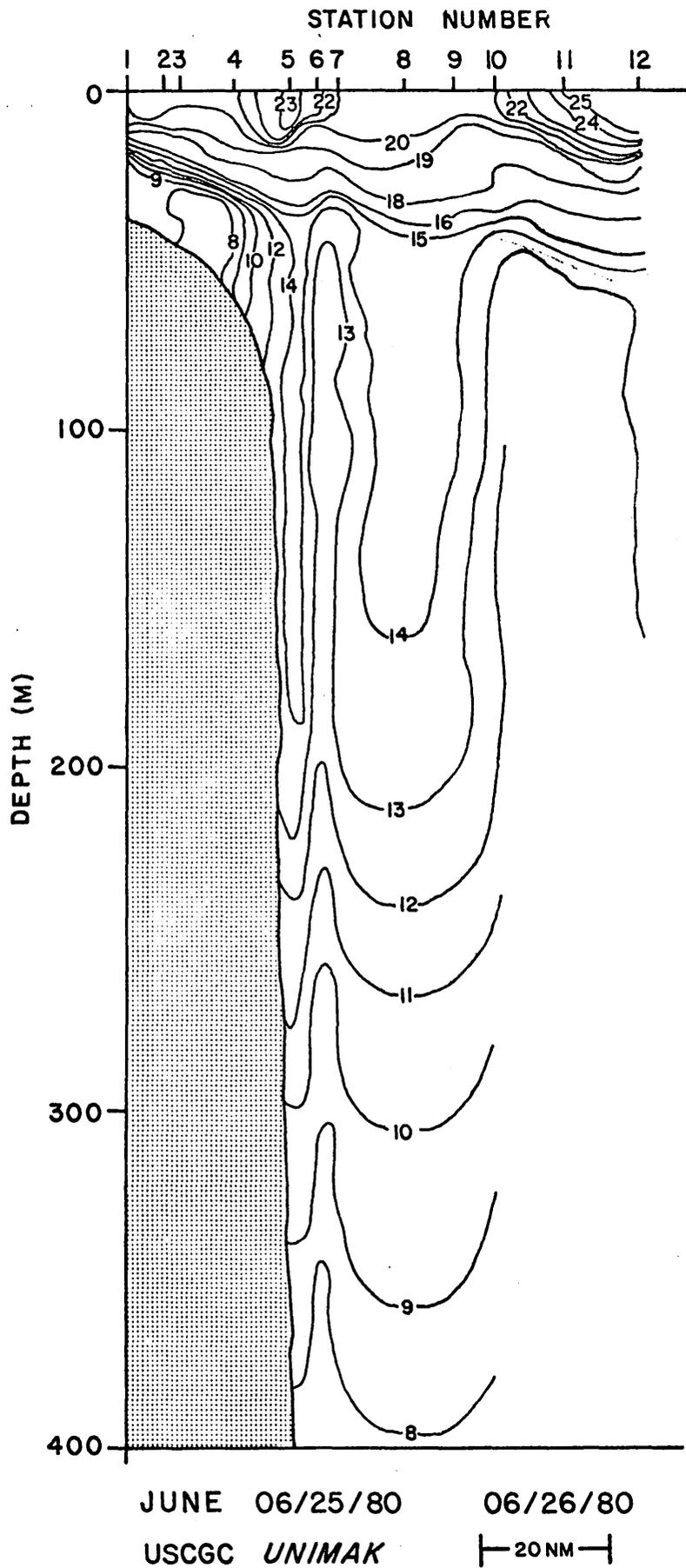


FIGURE 7. June vertical distribution of temperature (°C)

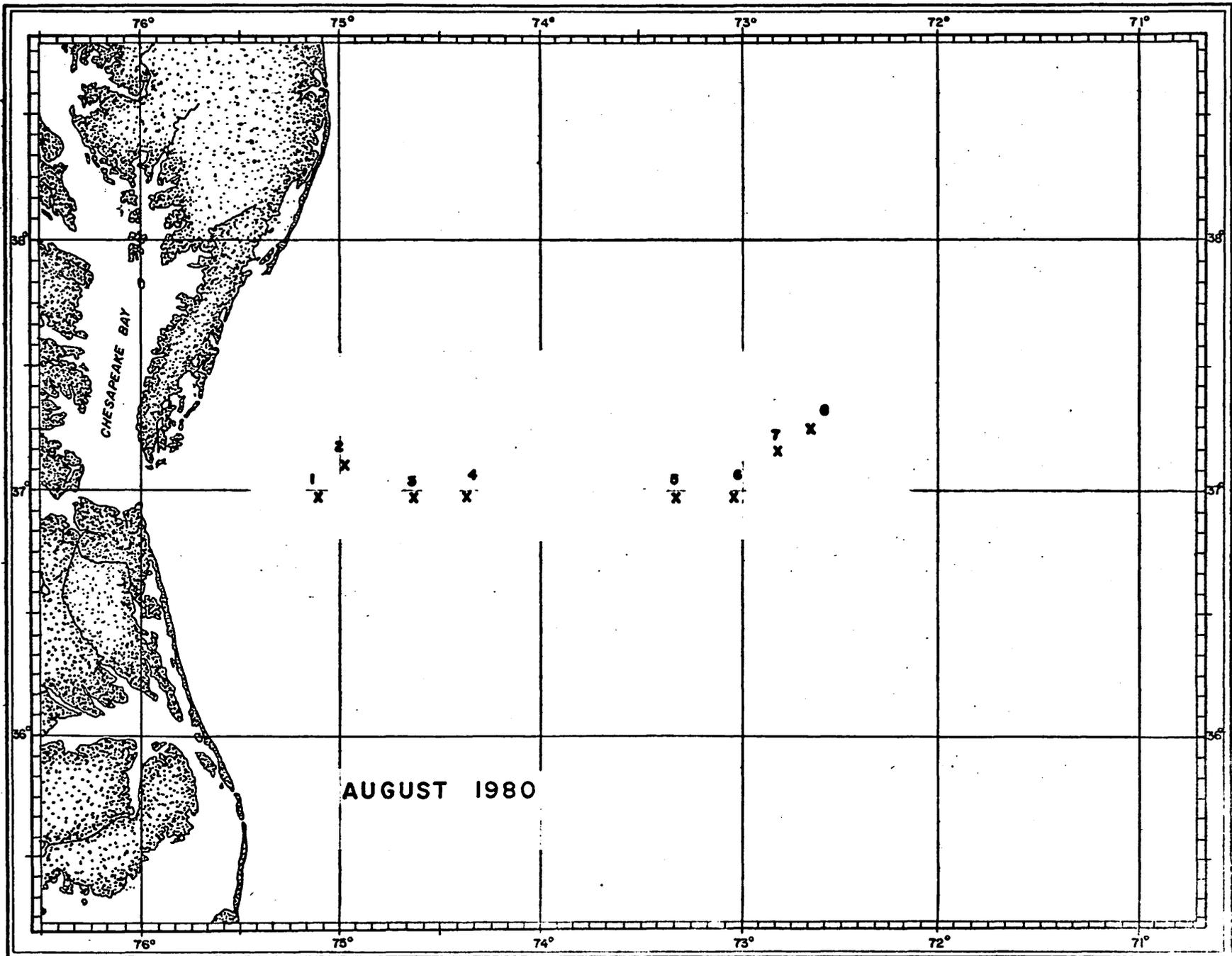
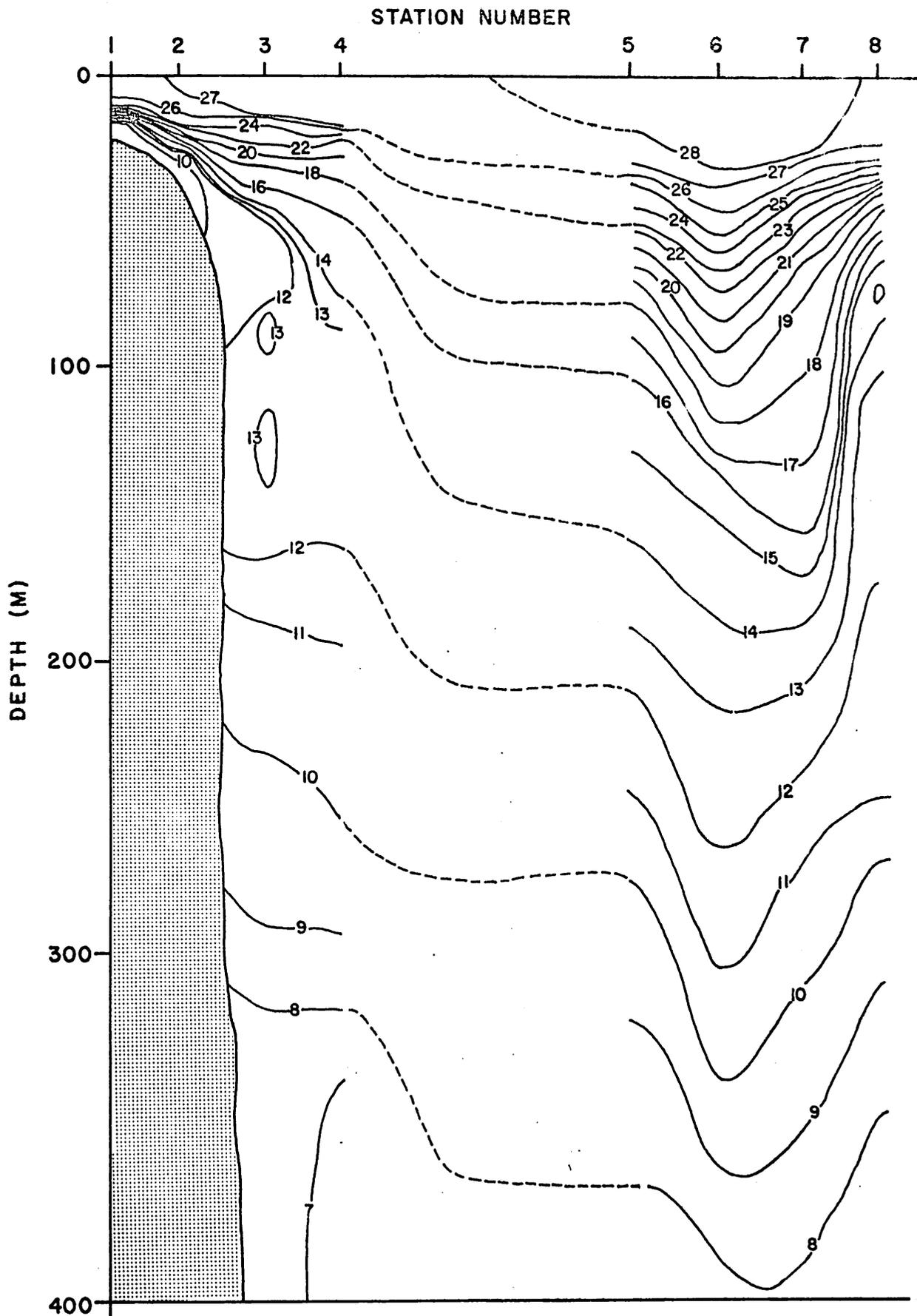


FIGURE 8. Transect positions of XBT/Surface Stations, August 1980.



AUGUST 08/04/80 — 08/05/80

USCGC *RELIANCE*

— 20 NM —

FIGURE 9. August vertical distribution of temperature (°C).

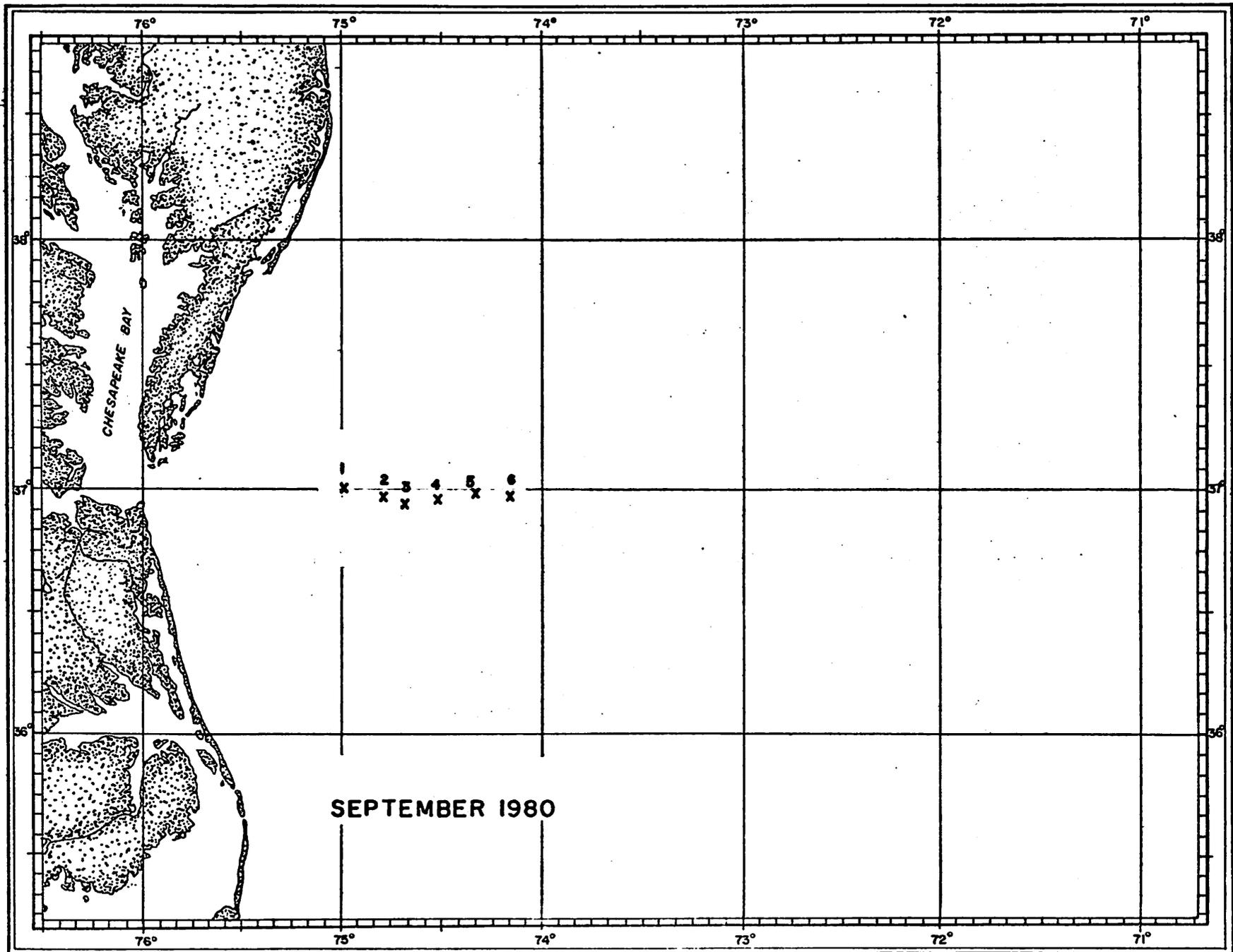


FIGURE 10. Transect positions of XBT/Surface Stations, September 1980.

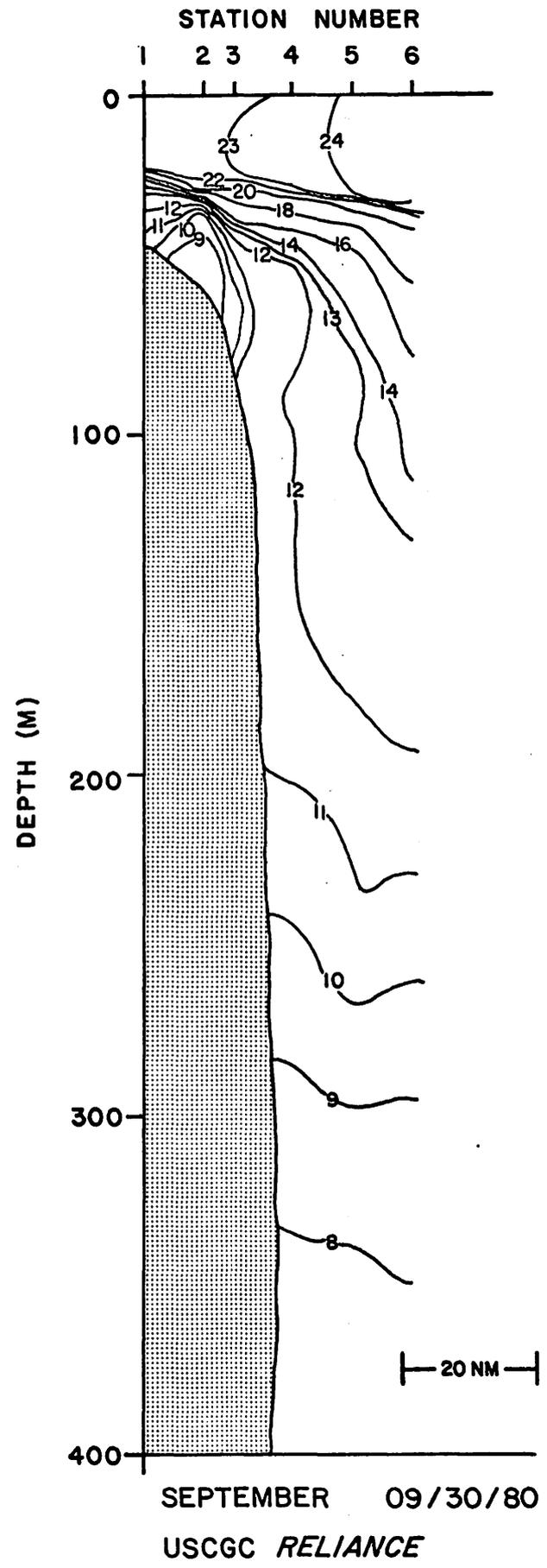


FIGURE 11. September vertical distribution of temperature ($^{\circ}$ C).

TABLE 1. Months sampled from August 1974-August 1980, MA Route. Number of CPR silks analyzed per water mass.

<u>Month</u>	<u>Year</u>	<u>MA</u>	<u>Shelf</u>	<u>Slope</u>
Aug	74	1	0	7
Oct	74	3	3	8
Nov	74	4	1	9
Jan	75	6	2	3
Feb	75	7	2	4
Mar	75	8	2	4
May	75	10	4	2
June	75	11	2	0
Aug	75	13	3	2
Sept	75	14	4	8
Nov	75	16	4	5
Dec	75	17	5	8
Jan	76	18	4	5
Feb	76	19	1	9
May	76	23	3	3
July	76	25	3	8
Oct	76	28	3	3
March	77	33	3	5
April	77	34	4	4
May	77	35	3	0
Aug	77	37	3	2

<u>Month</u>	<u>Year</u>	<u>MA</u>	<u>Shelf</u>	<u>Slope</u>
Oct	77	39	3	3
Nov	77	40	4	3
Dec	77	41	2	4
Jan	78	42	2	3
Apr	78	43	5	0
May	78	44	3	0
June	78	45	5	0
July	78	46	7	0
Aug	78	47	1	4
Sept	78	48	5	0
Nov	78	49	1	4
Jan	79	50	3	3
March	79	51	3	7
April	79	52	3	0
July	79	56	3	3
Aug	79	57	0	7
Sept	79	58	0	5
Oct	79	59	2	3
Nov	79	60	1	1
Feb	80	61	3	3
April	80	62	3	3
May	80	63	9	0
June	80	64	1	3
July	80	65	4	0

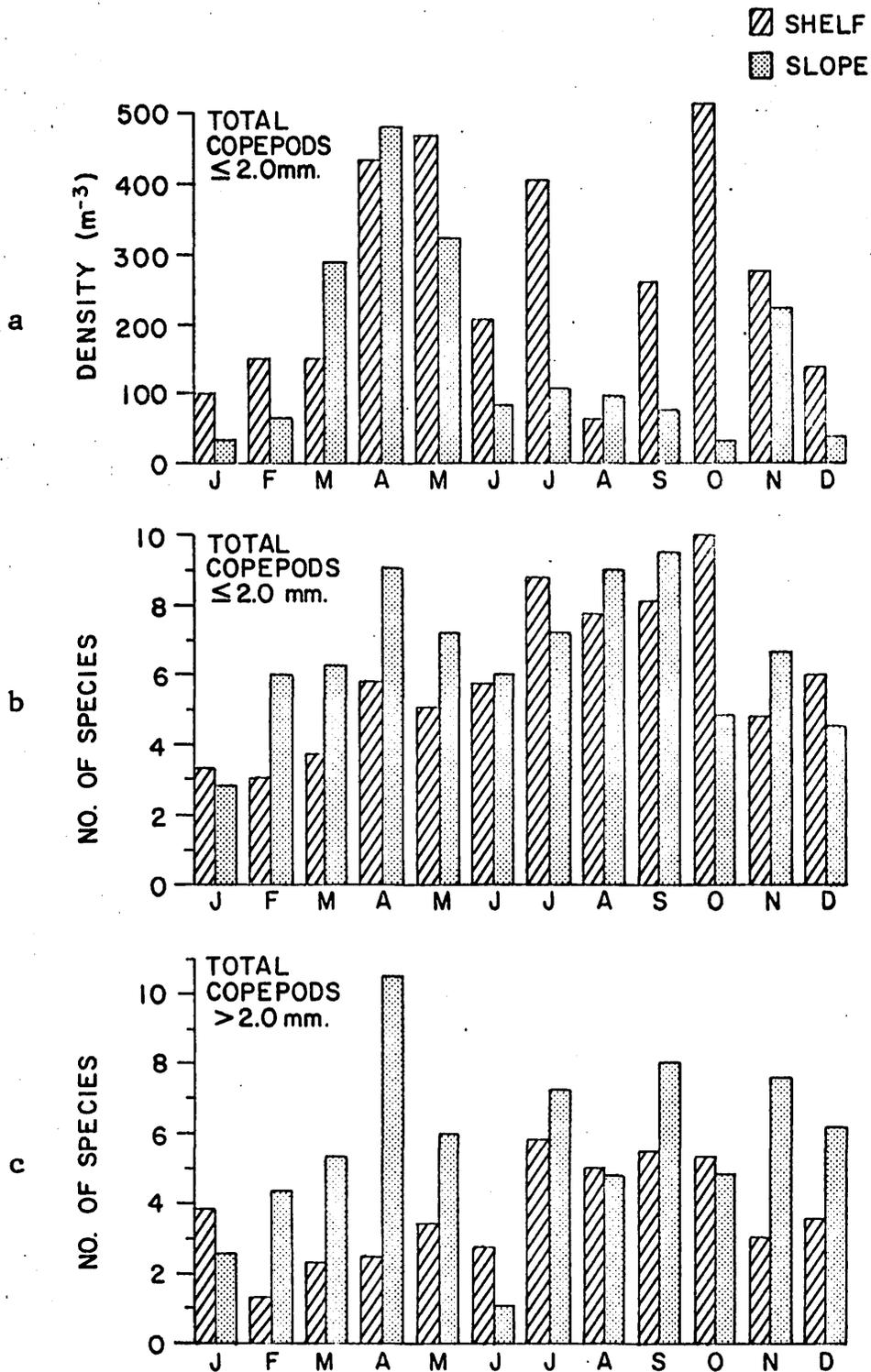


FIGURE 12. Five year composite mean annual cycle. Density of copepods $\leq 2.0mm$ (12a), number of species of copepods \leq (12b), and number of species of copepods $> 2.0mm$ (12c) by month for shelf and slope water.

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