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OCEANOGRAPHIC CONDITIONS IN THE STRAIT OF BELLE ISLE REGION IN 1955

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Oceanographic Conditions in the Strait of Belle Isle Region in 1955

by

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INTRODUCTION

The general oceanography of the Strait of Belle Isle region has been described in considerable detail by Huntsman, Bailey and Hachey (1954) from observations made during the Strait of Belle Isle Expedition of 1923.

Three main water types in and adjacent to the Strait of Belle Isle were described; that of the surface layer of the Gulf of St. Lawrence, that originating in the Arctic or sub-Arctic, and that of the Labrador Sea modified by the waters of the West Greenland Current.

Huntsman <u>et al</u> (1954) have demonstrated the existence, at times, of a progressive inward movement of waters of Arctic and sub-Arctic origin on the north side of the Strait of Belle Isle; a progressive outward movement of Gulf of St. Lawrence water on the south side; and a dominant outward flow of Gulf water. In the Esquiman Channel, they have demonstrated the existence of a strong northeasterly movement along the west coast of Newfoundland, and a somewhat weaker westerly movement along the Mecatina shore and entering Jacques Cartier Passage. While a dominant flow of water into the Gulf was not observed in 1923, there were indications that such a flow existed at times.

Within the period 1923-55, only scattered observations have been made in the region. However, in 1955, several series of observations were taken in June, September, and November. These allow for the comparison of synoptic conditions at different times of the year, as well as for a comparison of conditions between 1923 and 1955.

OBSERVATIONS IN 1955

The network of oceanographic stations occupied in 1955 are shown in Figure 1. In June 1955, four sections were occupied by H.M.C.S."Labrador" enroute to the Canadian Archipelago, and two sections were repeated in November on returning to base. In September, C.N.A.V."Sackville" occupied eight sections in the network while carrying out an extended survey of oceanographic conditions in Newfoundland waters.

A chart showing the general bottom configuration of the Strait of Belle Isle region is given in Figure 2. The shallower depths in the Strait of Belle Isle form a submarine boundary between the deeper water in the Esquiman Channel and those of the Labrador Sea.

The Esquiman Channel has three principal features: the Point Riche Gully, which embodies the deeper region along the Newfoundland coast; the Mecatina Bank, which stretches southwestward across the Channel and has depths as shallow as 36 metres; and the Mecatina Gully, which embodies the deep trough between the Mecatina Bank and the Quebec shore. All of these features of the bottom configuration are factors in determining the general circulation of the region, and the water types found there.

VERTICAL DISTRIBUTIONS OF TEMPERATURE, SALINITY AND DENSITY.

June 1955.

Figures 3 to 6 show the vertical distributions of temperature, salinity and density (σ_t) in the Esquiman Channel and in the Strait of Belle Isle as observed in June 1955. Where depths were sufficiently great, the water columns were characterized by three distinct water layers, mainly, the surface, intermediate cold, and deeper warmer water layers. The surface layer which varied in thickness from 25 to 50 metres from north to south, had the highest temperatures and the lowest salinities. At the surface, temperatures ranged from 2.2°C. in the Strait of Belle Isle, to 6.7°C. in the southern part of the Esquiman Channel. Salinities in the surface layer for the most part were quite uniform, and varied between 31.5 and 32.0‰. However, along the shores small pockets of lower salinity water were in evidence where stations were located near river mouths.

The intermediate cold water layer with temperatures less than 0.0°C. had minimum temperatures as low as -1.74°C. at station 2 in Section B. Salinities in the cold water layer were between 32.0 and 33.0‰. The thickness of this layer varied between 50 and 100 metres over the area, and was thinnest in the southern part of the area. Water with temperatures less than -1.0°C. was located at the eastern entrance to the Strait of Belle Isle at a depth of 50 metres, but none was found in the western entrance. In the northern part of Section B, a large body of less than -1.0°C. water filled the Mecatina Gully below a depth of 80 metres, while none was observed in the deeper, southern end. A small patch of this cold water reached Section A at 100 metres at station 11, along the north shore.

The deeper waters typified by the warmer temperatures and higher salinities (as high as 4.1°C. and 34.1‰) were found below 150 metres except at station 13 where mixing brought these waters to a depth of 75 metres. This water layer was found only in Section A and in the southern part of Section B.

The circulation of the water may be derived from the slopes of the isopycnals. They indicate a southwestward movement along the Quebec shore. In the Strait of Belle Isle, the two sections were occupied days apart. The earlier section (C) indicates outward movement of Gulf water through the Strait on the south side and an inward movement of Labrador water in on the north side. The outward movement appears to have been the greater of the two at that time. The later section (D) indicates that a westward movement dominated the section. This adds further evidence that a dominant westward flow does take place in the Strait of Belle Isle.

<u>September 1955.</u>

The vertical distributions of temperature, salinity and density (σ_t) for September, 1955 are given in Figures 7 to 14. Observations in the Belle Isle region in the late summer indicated that a general warming at all levels had taken place since June and that the salinity of the deeper water increased also. Surface temperatures in the southern part of the region were generally greater than 5.0°C. in the central part and less than 10.0°C. along the shores. In the Strait of Belle Isle, surface temperatures were between 4° and 5°C. except in Section G, between Belle Isle and Newfoundland, where temperatures were between 3°C. and 4°C. Outside of the Strait (Section F) surface temperatures decreased gradually from 5.1°C. inshore to 2.3°C. in the core of the Labrador Current. In Section H, running eastward from Cape Bauld, surface temperatures were less than 4.0°C. near the Strait and increased to 5.1°C. further offshore.

A marked decrease in the volume of the cold water layer from June in the southern sections and in the Strait of Belle Isle (Sections C and D) is clearly indicated. The minimum observed temperature was -1.17°C. at this time of the year in Section B, and no sub-zero water was present in Sections C, D, and E. The cold water layer was present, below the 100-metre level, in Section E between Belle Isle and Labrador. In Section H, the cold water layer can be seen pressed up against the coast and with a tongue-like distribution reaching offshore.

The deep waters in the Esquiman Channel had temperatures and salinities higher than 4.8°C. and 34.5‰ at a depth of about 275 metres. A comparison of Figures 3 and 7 shows that there was a very definite increase in the volume of the deeper waters from June to September. This increase in volume from spring to autumn was demonstrated by Lauzier and Bailey (1957).

The vertical distributions of density (σ_t) indicate that in the upper 100 metres, there is an overall movement southward along the Labrador coast, and southwestward through the Strait of Belle Isle and the Esquiman Channel into the Gulf of St. Lawrence. Below this level, there was a northeastward movement of the deeper waters in the Point Riche Gully.

November 1955.

The vertical distributions of temperature, salinity and density (σ_t) in November 1955, are illustrated in Figures 15 and 16. Both sections show the effects of vertical mixing as the result of autumnal cooling. The waters in the Strait were well mixed and showed only small variations both in temperature and salinity from top to bottom. Temperatures varied between 0.8°C. and 2.8°C. in different parts of the Strait. Corresponding salinities varied between 32.5 and 31.3‰.

The vertical distribution of density (σ_t) is not indicative of any strong movements because of the mixed nature of the waters. Section C indicates a general southward movement while in Section D, a bilateral movement is indicated, southwestward on the north side, northeastward on the south side.

HORIZONTAL DISTRIBUTIONS OF TEMPERATURE, SALINITY AND DENSITY.

June 1955.

Figures 17 to 19 show the horizontal distributions of temperature, salinity and density for June 1955. The charts for June indicate a warming of the waters from east to west through the Strait of Belle Isle. Temperatures at the surface ranged from 2.60°C. at the eastern end of the Strait to 6.70°C. at the southern end of Esquiman Channel.

At subsurface depths, the temperature distribution had the same general pattern as at the surface.

Down to 50 metres, salinities in the Esquiman Channel were slightly lower than those in the Strait of Belle Isle. The low salinity water was confined to both sides in the Esquiman Channel, but in the Strait of Belle Isle, the low salinity water was confined only to the north side.

From the horizontal distribution of density (σ_t), we may draw certain general conclusions regarding the general circulation. In June, the dynamic gradients were small and the only appreciable movement was along the north side of the Esquiman Channel, where a westward current was in evidence. In general, a weak westward movement through the area persisted with a very weak eastward movement along the west coast of Newfoundland.

<u>September 1955.</u>

Figures 20 to 22 show the horizontal distributions of temperature, salinity and density (σ_t) for September, 1955. The charts for September show a marked increase in the horizontal temperature structure over those for June. Surface temperatures along the shores of the Esquiman Channel were only slightly less than 10.0°C., while in the Strait, they were for the most part less than 5.0°C. and lower than 3.0°C. east of Belle Isle. The temperature distribution patterns at the various levels depicted were about the same. The most noteworthy features were the tongue of cool water with relatively high salinities that reached from the Strait to the southern end of the Channel, and the tongue of warm low salinity water protruding northward along the west coast of Newfoundland.

The general water movements in September are indicated by the horizontal distributions of density (σ_t). From the diagrams, the southward movement of Labrador water past Belle Isle, and the entrance of some of these waters into the Strait is indicated by the 25.0 isopycnal Most of the water flowing westward through the Strait of Belle Isle keeps to the north shore to enter the Gulf of St. Lawrence. Some of this water was recurved northward to flow along the northern edge of Mecatina Bank. On reaching the western end of the Strait of Belle Isle, some of the water was carried part way into the Strait along the south side, while the remainder was deflected southward to flow along the west coast of Newfoundland. From the distribution of properties, it appears that an eddy was formed at the western end of the Strait of Belle Isle. It is possible that its formation is due to the bottom configuration in this region.

TEMPERATURE-SALINITY RELATIONSHIPS

Temperature-salinity curves for the Strait of Belle Isle and adjacent areas for the early spring, late summer, autumn, and winter are illustrated in Figures 23 to 25. These T-S diagrams show the same major features of those given by Huntsman et al (1954). In addition, the above diagrams show the continuity of Labrador coastal water from the Labrador coast through the Strait of Belle Isle and into the Mecatina Gully. The waters in the Point Riche Gully were on the other hand typical of the Gulf of St. Lawrence, being influenced by movements through Cabot Strait.

The cold waters with temperatures less than -1.0°C. had differing salinities in different areas. In the Gulf of St. Lawrence, the cold-water layer had salinities less than 32.5‰ during its formation, as shown by the T-S curves in Figure 25. Outside of the Gulf, salinities were higher at the surface, and thus the cold water had salinities that are higher than 33.0‰. The presence of the high salinity cold water in the Gulf indicates its origin outside of the Gulf. Such cases are shown by the T-S curves for stations in the Mecatina Gully and they suggest that it is part of a cold water layer which has entered through the Strait of Belle Isle.

The T-S curve for station 52 clearly shows that the deep waters in the Labrador Current are a mixture of Deep Labrador Sea water and the cold water, whereas, the deep waters flowing through Cabot Strait and in the Gulf have characteristics of being mixtures of water found south of the continental shelf off the Laurentian Channel.

It is worthy of note that salinities in the Strait of Belle Isle were lower in September than in June. The apparent reason for this is that river discharges are low between October and May. The spring freshet does not occur until June and thus observations taken in early June were as yet unaffected by river water.

DISCUSSION

The results of the surveys made in 1955 in the Strait of Belle Isle region allow comparisons to be made with the results of 1923. A well developed southwestward movement existed during the September survey which showed the effect of a dominant westward flow on the oceanographic conditions in the Esquiman Channel. Although Dawson (1907) showed by current measurements that such a condition did exist, the surveys of 1923 (Huntsman et al, 1954) observed a "differential" movement between the two sides of the Strait and a dominant eastward movement.

The existence of an eddy in the Esquiman Channel was indicated by the results of drift bottle experiments carried out in August 1923 (Huntsman et al, 1954, p.225) in which 14 of 72 bottles set out were returned. However, the only direct evidence of its existence are the 1955 data. The eddy appears to develop with a westward movement along the north shore and when the eastward movement along the Newfoundland coast is relatively weak. The existence of the eddy appears to be due to the influence of the bottom configuration on the water movements. Data are insufficient to accurately establish the extent of the eddy or to indicate additional features that may exist in conjunction with it.

ACKNOWLEDGMENT

The co-operation of the Commanding Officer and Officers of H.M.C.S. "Labrador" and C.N.A.V. "Sackville" during the oceanographic cruises is gratefully acknowledged. The assistance of my colleagues of the Fisheries Research Board of Canada, Atlantic Oceanographic Group in the collection and analysis of the data is especially appreciated.

SUMMARY

1. Oceanographic data from the Strait of Belle Isle and the Esquiman Channel in June, September and November, 1955, indicate the seasonal trends of both temperatures and salinities in the several layers which constitute the water column in these localities.
2. The distributions of temperature, salinity, and density (σ_t) indicate that at the time of the June survey, there was a weak dominant flow westward through the area while during the September survey, there was a strong dominant westward flow.
3. The development of an eddy as a result of the dominant westward flow and the bottom configuration is illustrated from the results of the June and September 1955 surveys.
4. The observation of the oceanographic conditions attendant to a dominant westward flow and the development of an eddy are indicated as initial findings.

REFERENCES

Bailey, W. B. and H. B. Hachey, MS, 1951. Hydrographic features of the Strait of Belle Isle with a preface on the oceanography of the Strait of Belle Isle by A. G. Huntsman. Fish. Res. Bd. Canada, MS Rept. Biol. Sta., No. 422.

Dawson, W. B. 1907. The Currents in Belle Isle Strait. Dep't. Marine and Fisheries, Ottawa, 42 pp.

Dunbar, M. J. 1951. Eastern Arctic waters. Bull. Fish. Res. Bd. Canada, No. 88, 131 pp.

Huntsman, A. G., W. B. Bailey and H. B. Hachey, 1954. The general oceanography of the Strait of Belle Isle. J. Fish. Res. Bd. Canada, 11(3): 198-260.

Lauzier, L. and W. B. Bailey, 1957. Features of the deeper waters of the Gulf of St. Lawrence. Bull. Fish. Res. Bd. Canada, No. 111: 213-250.

Smith, E. H., F. M. Soule and O. Mosby, 1937. The "Marion" and "General Greene" Expedition, 1928-35. U.S.C.S. Bull. No. 19, Pt. 2, Washington, 259 pp.

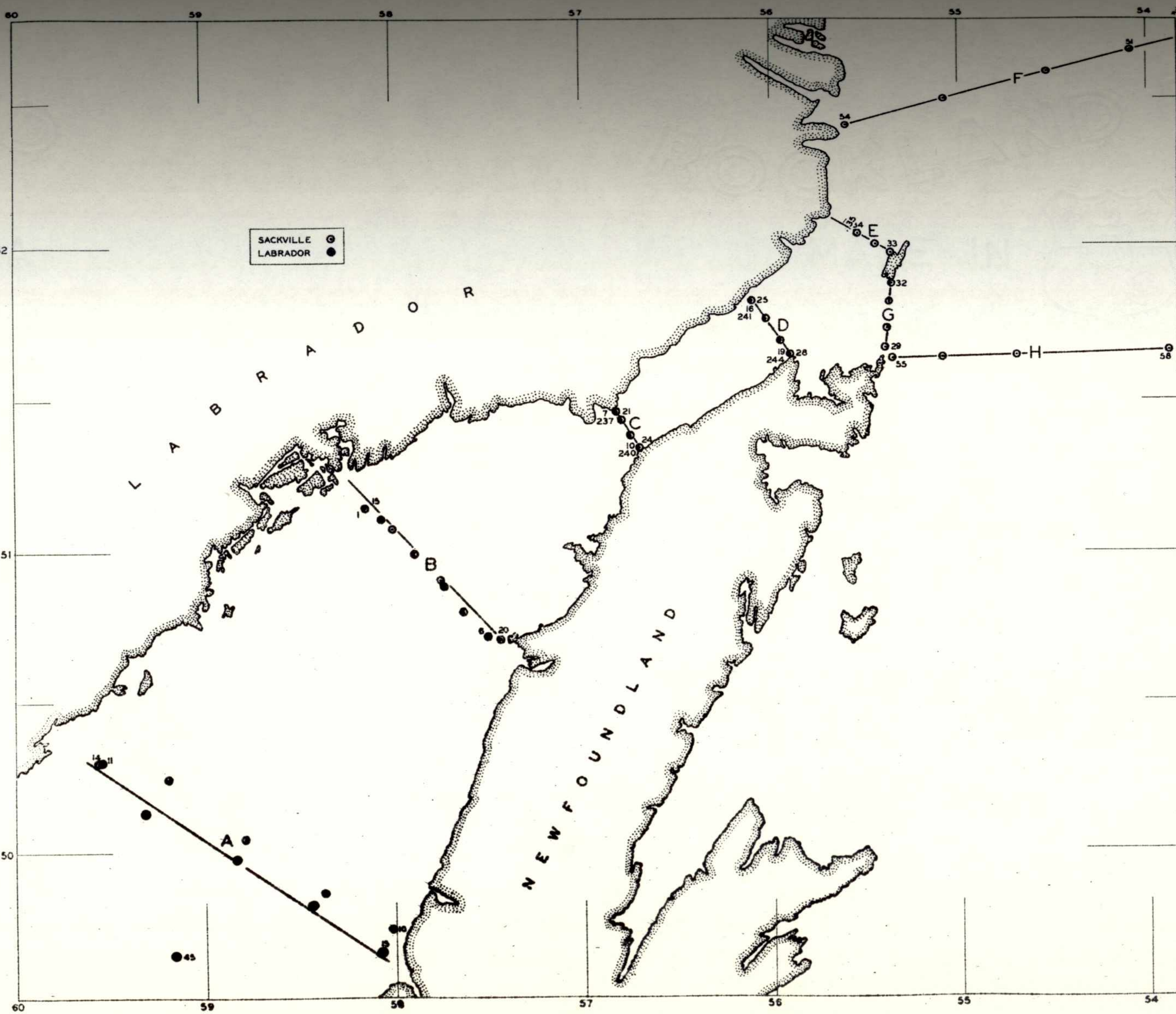

Fig. 1 The Strait of Belle Isle and its approaches showing the locations of stations occupied by H.M.C.S. "Labrador" and by C.N.A.V. "Sackville".

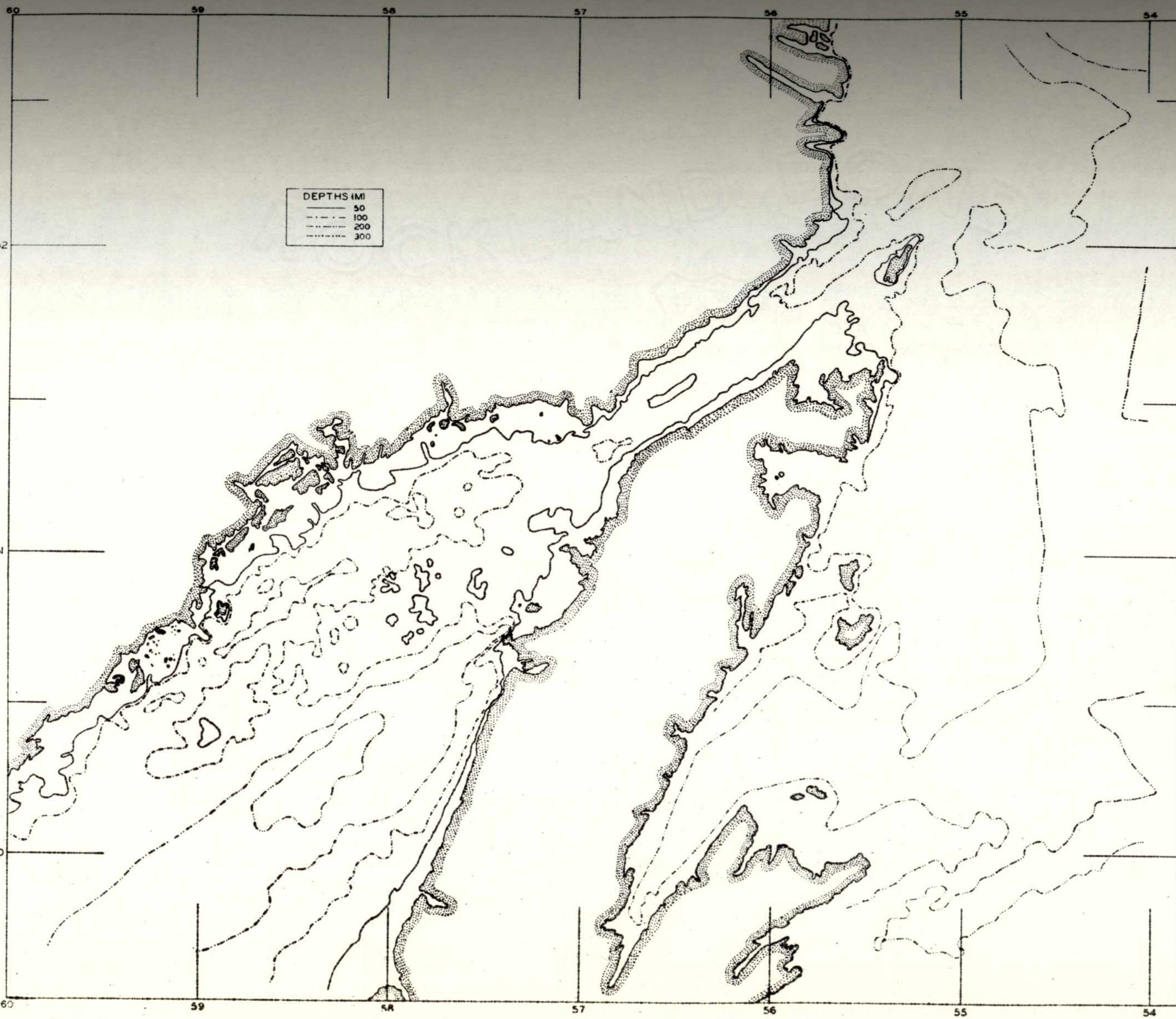

Fig. 2 **The Strait of Belle Isle and its approaches showing the bottom configuration.**

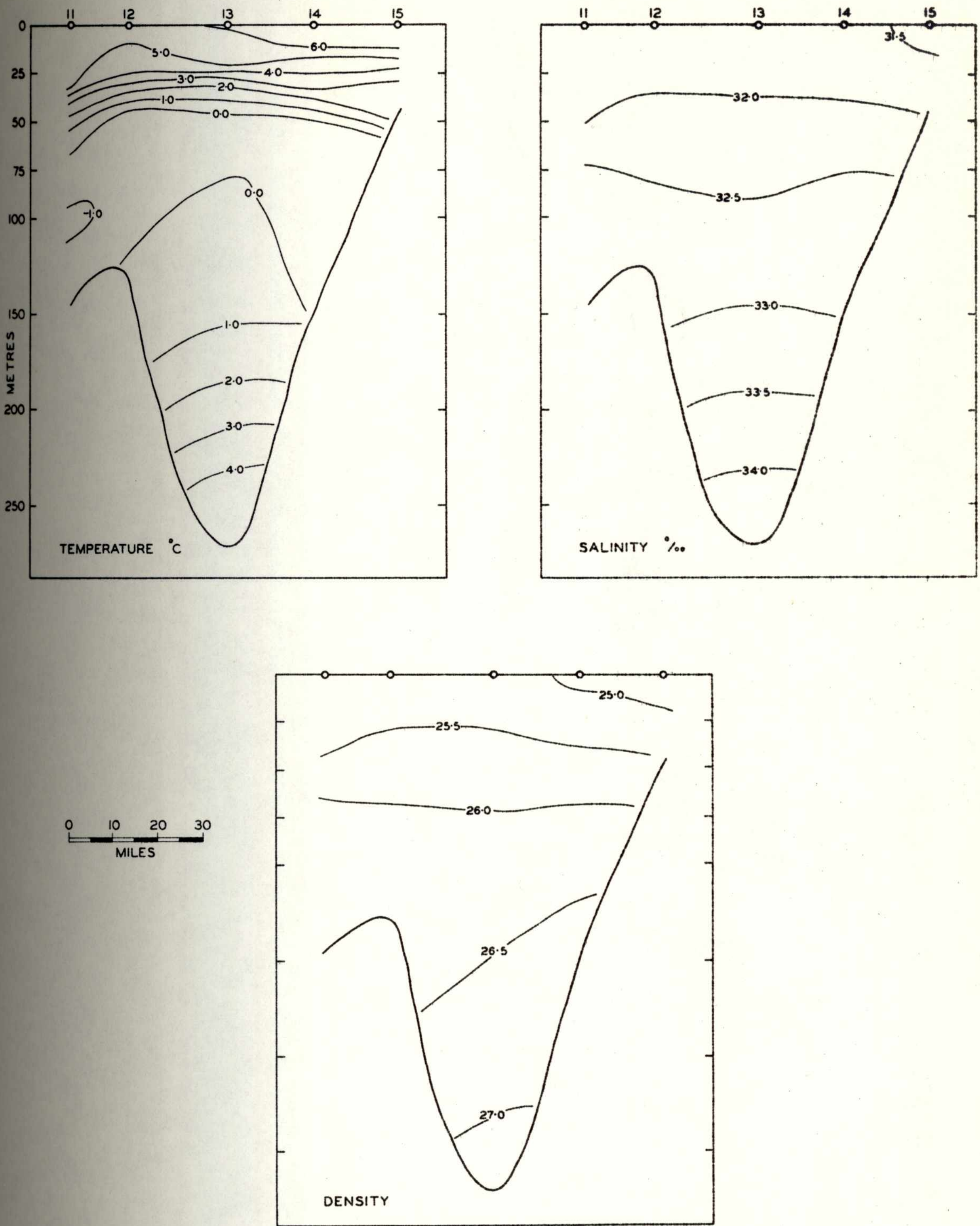

Fig. 3 Distribution of temperature, salinity and density in section A, -June 1955.

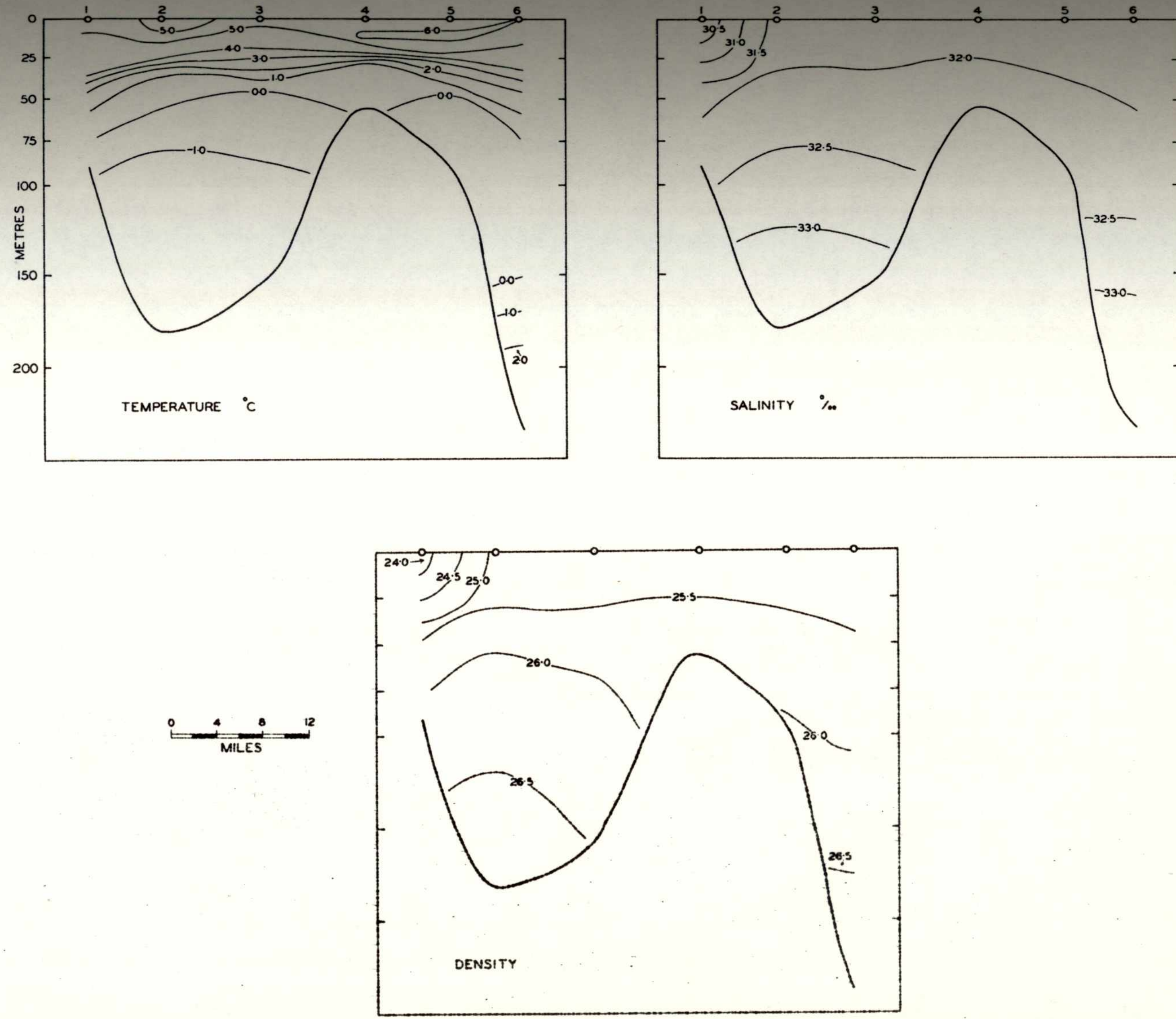

Fig. 4 Distribution of temperature, salinity and density in Section B, -June 1955.

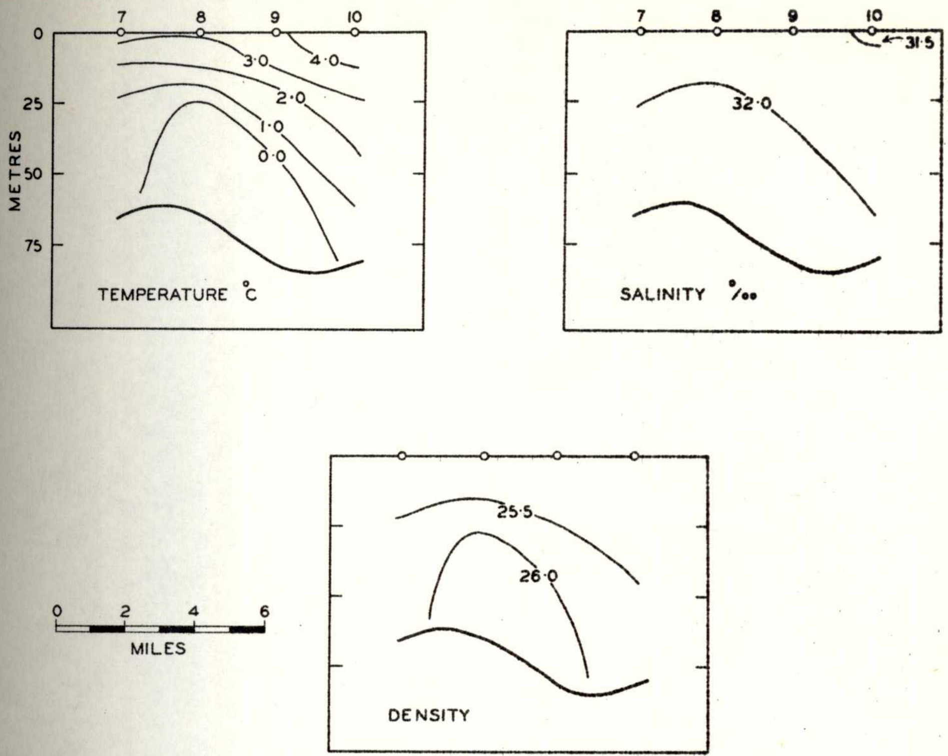

Fig. 5 Distribution of temperature, salinity and density in section C, -June 1955.

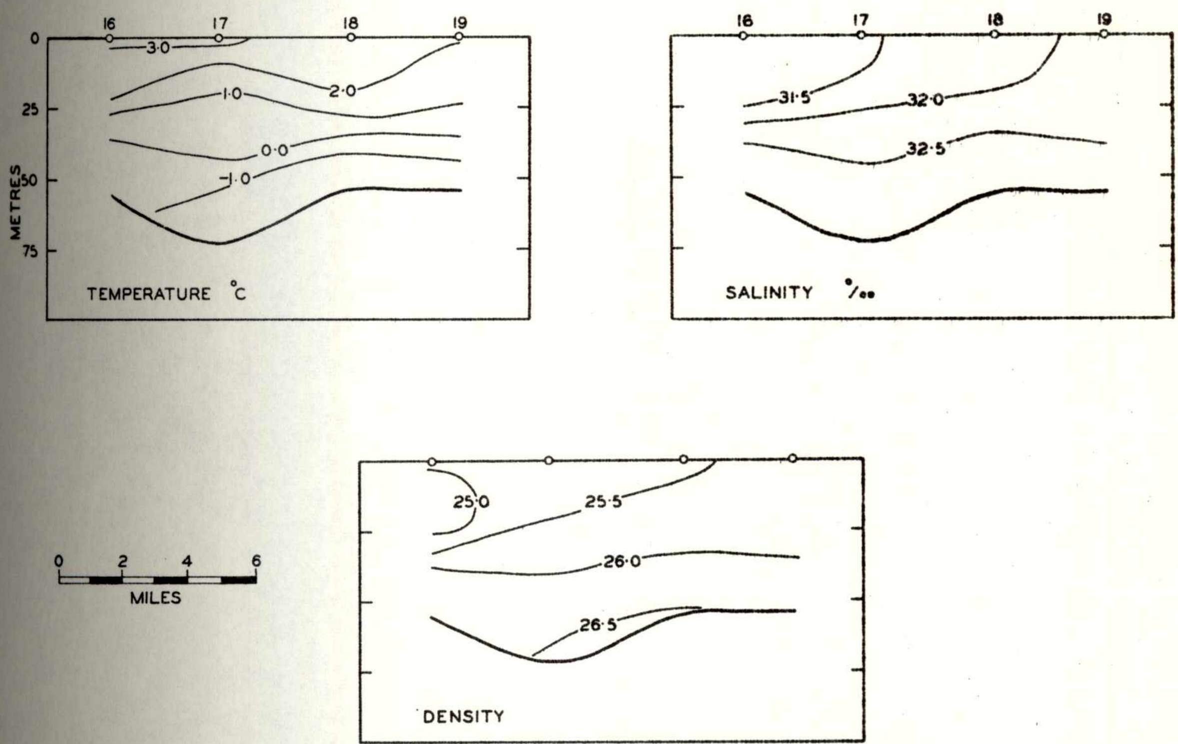

Fig. 6 Distribution of temperature, salinity and density in section D, -June 1955.

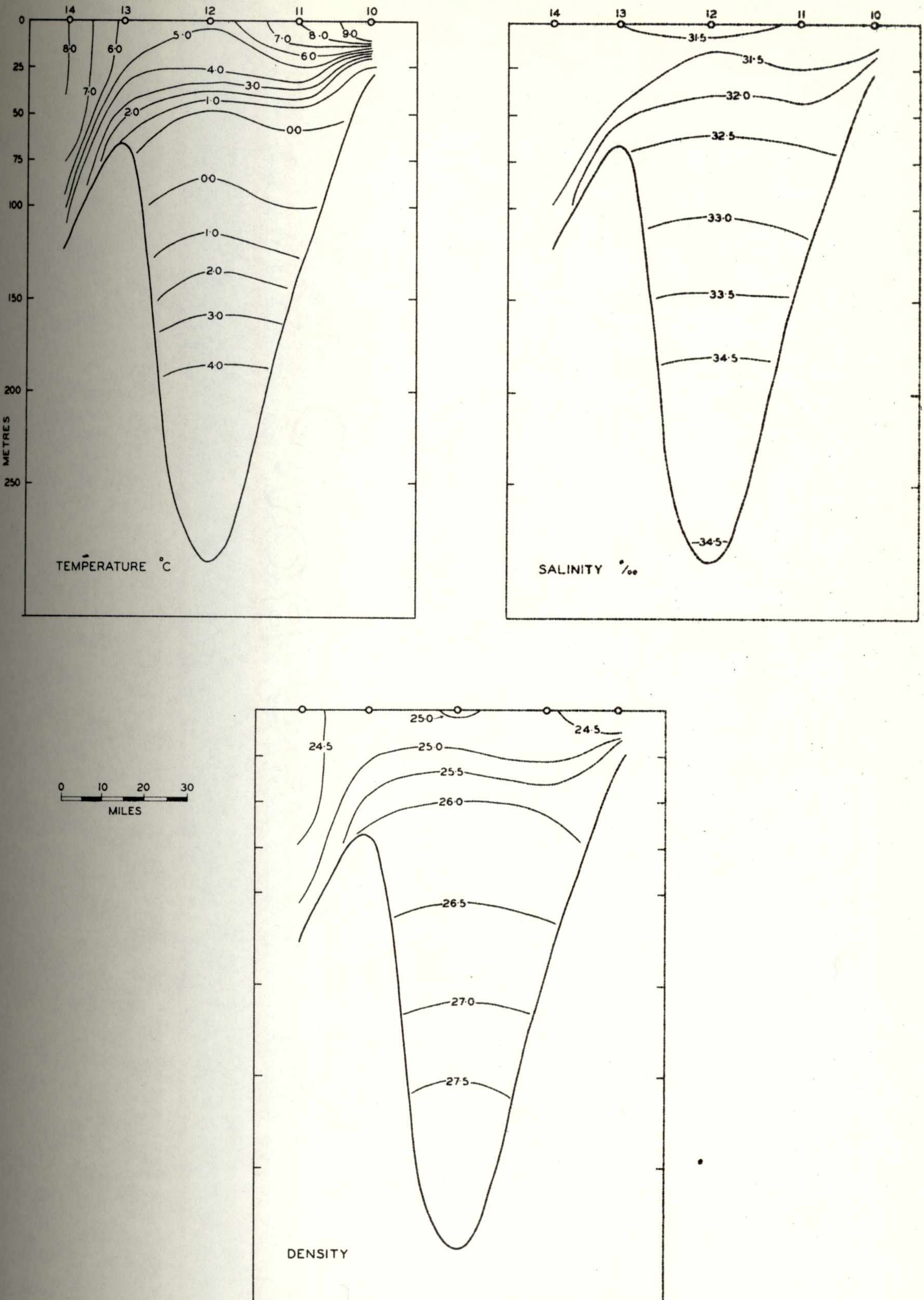

Fig. 7 Distribution of temperature, salinity and density in section A, -September 1955.

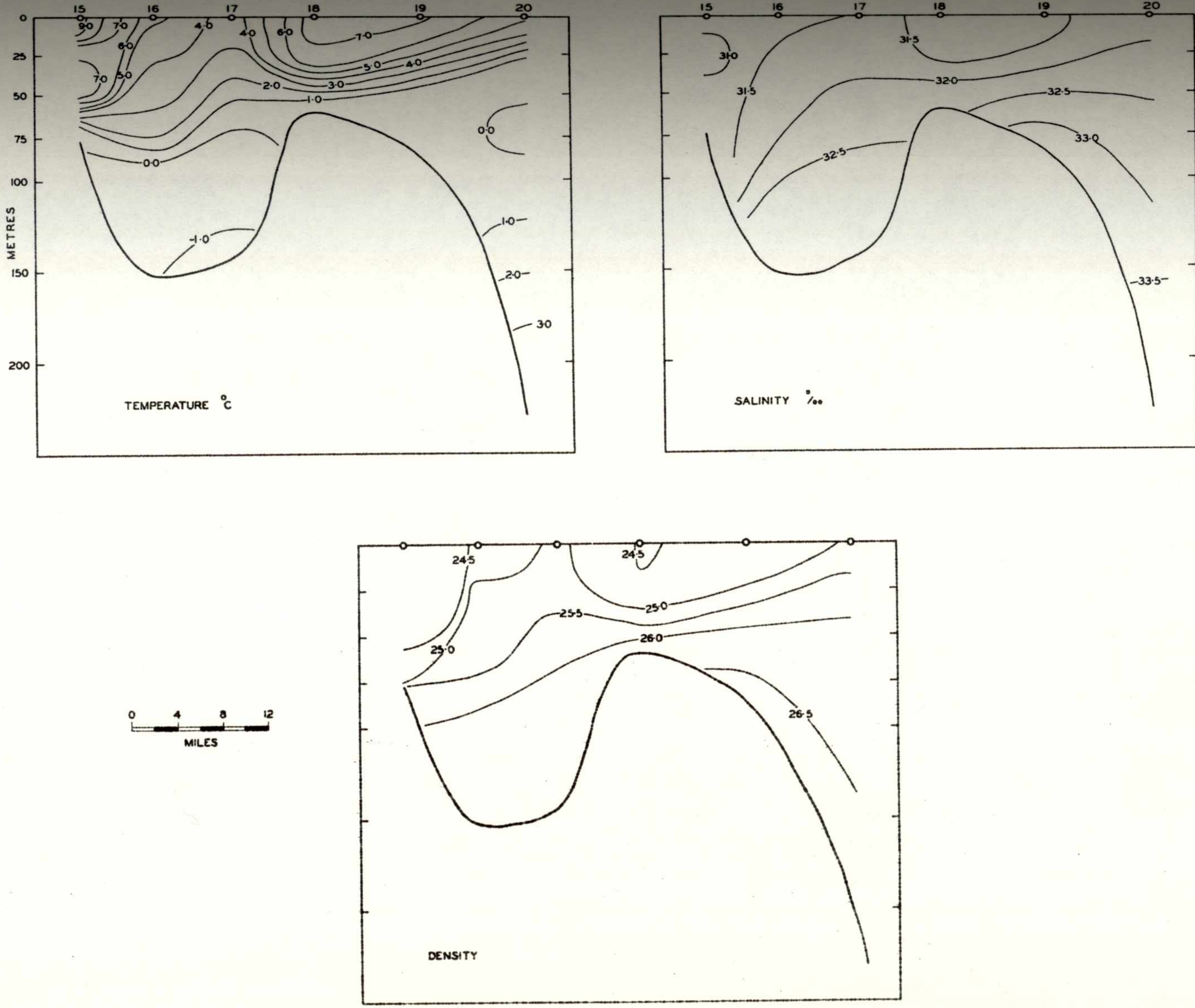

Fig. 8 Distribution of temperature, salinity and density in section B, -September, 1955.

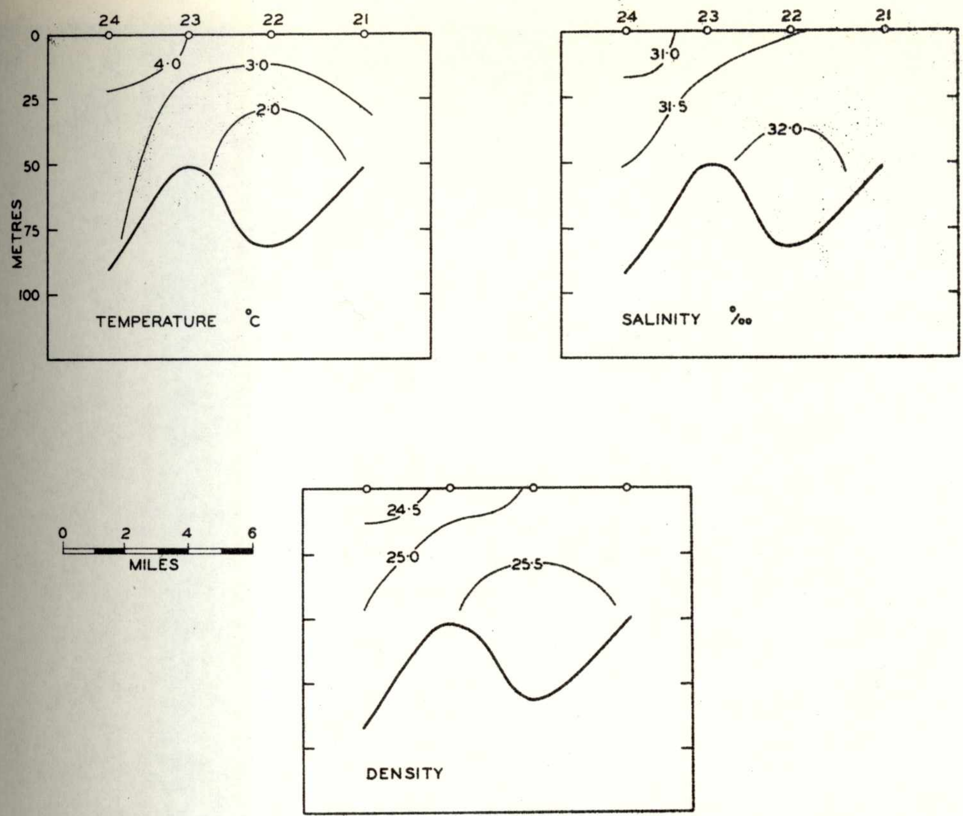

Fig 9 **Distribution of temperature, salinity and density in section C, -September 1955.**

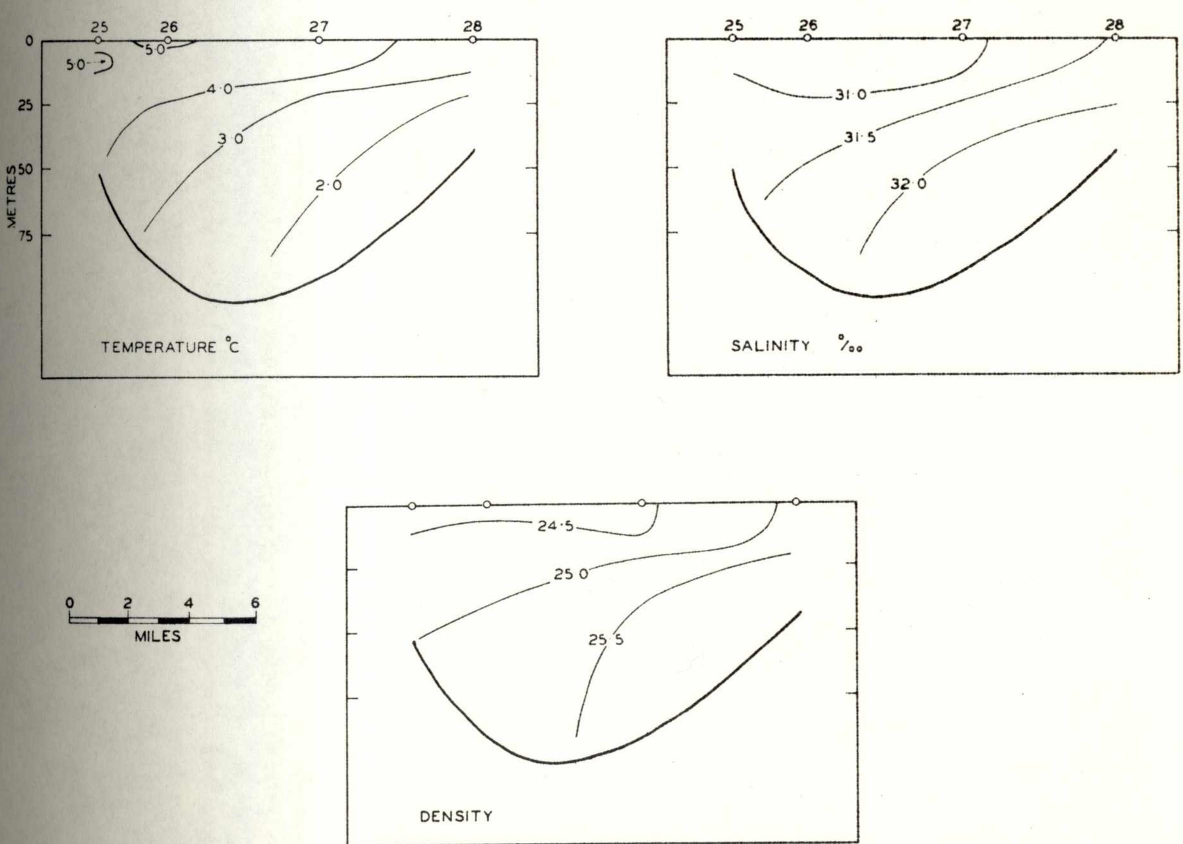

Fig 10 **Distribution of temperature, salinity and density in section D, -September 1955.**

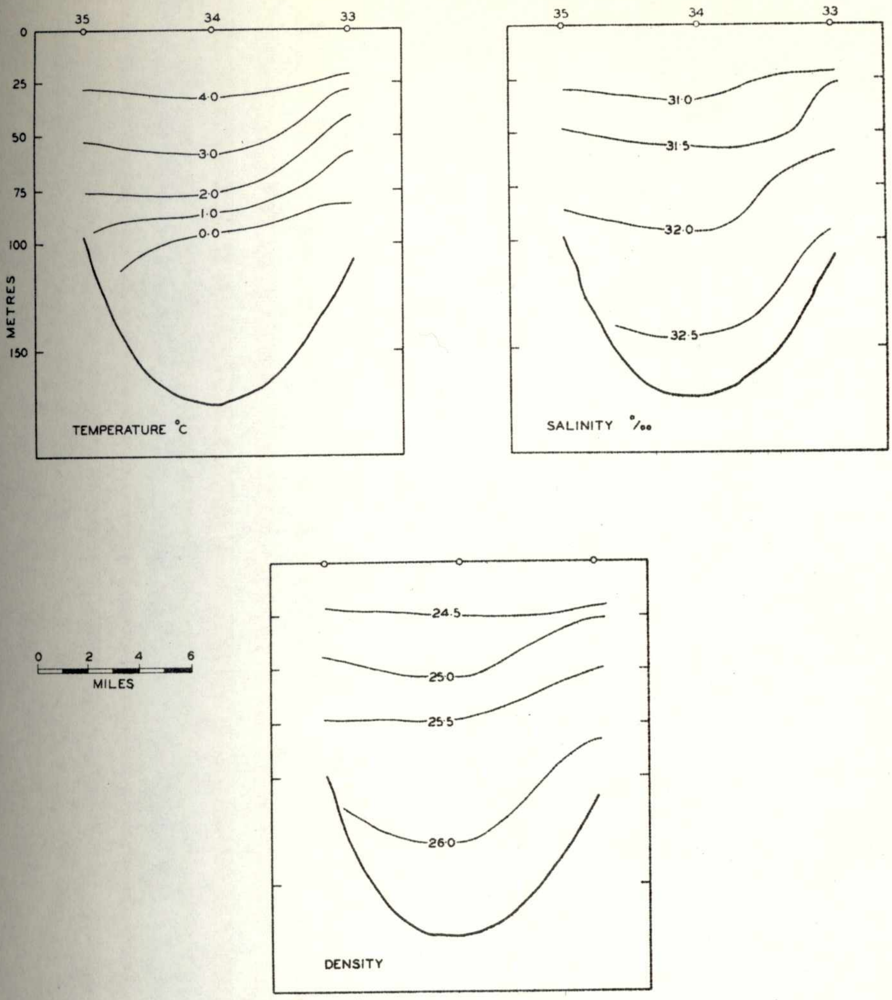

Fig. 11 Distribution of temperature, salinity and density in section E, -September 1955.

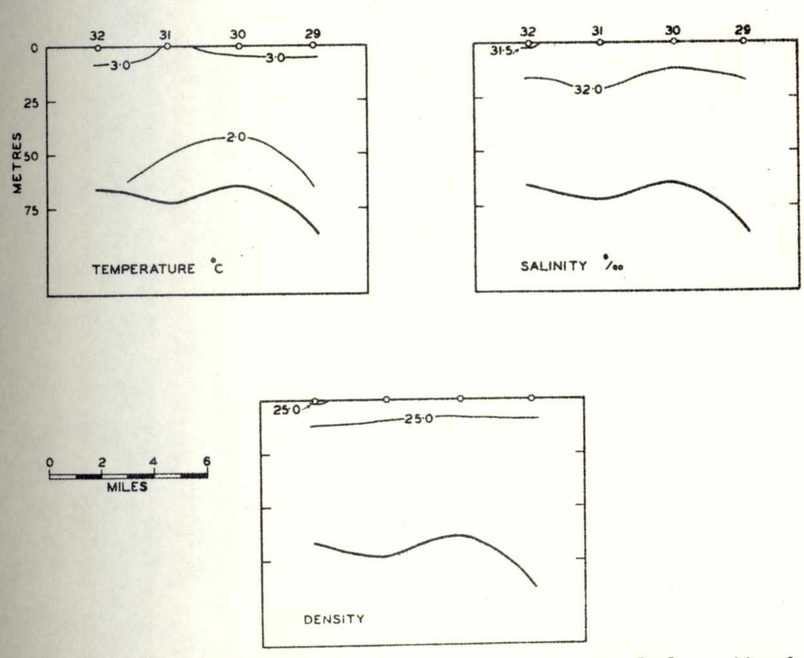

Fig. 12 Distribution of temperature, salinity and density in section G, -September 1955.

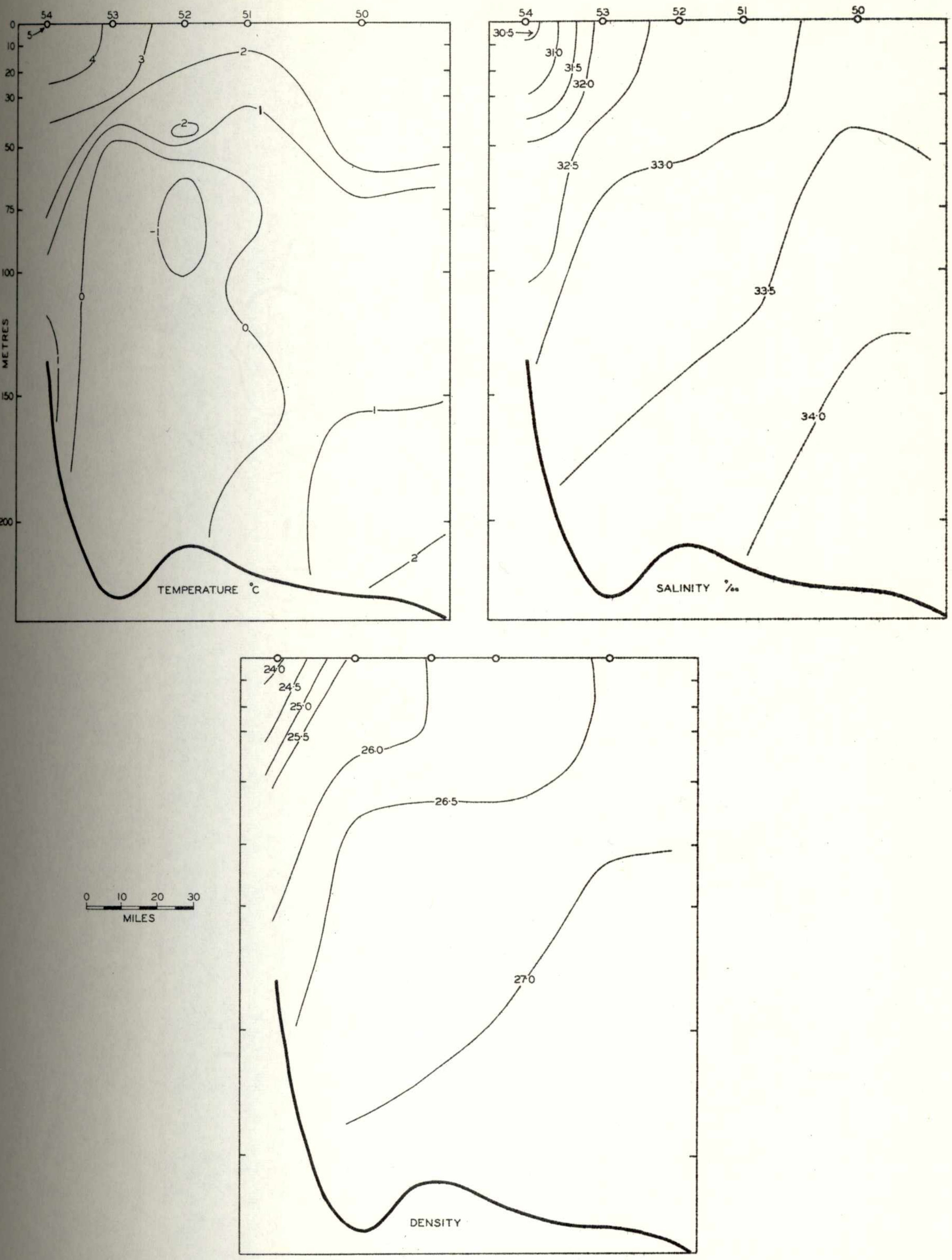

Fig. 13 **Distribution of temperature, salinity and density in section F, -September 1955.**

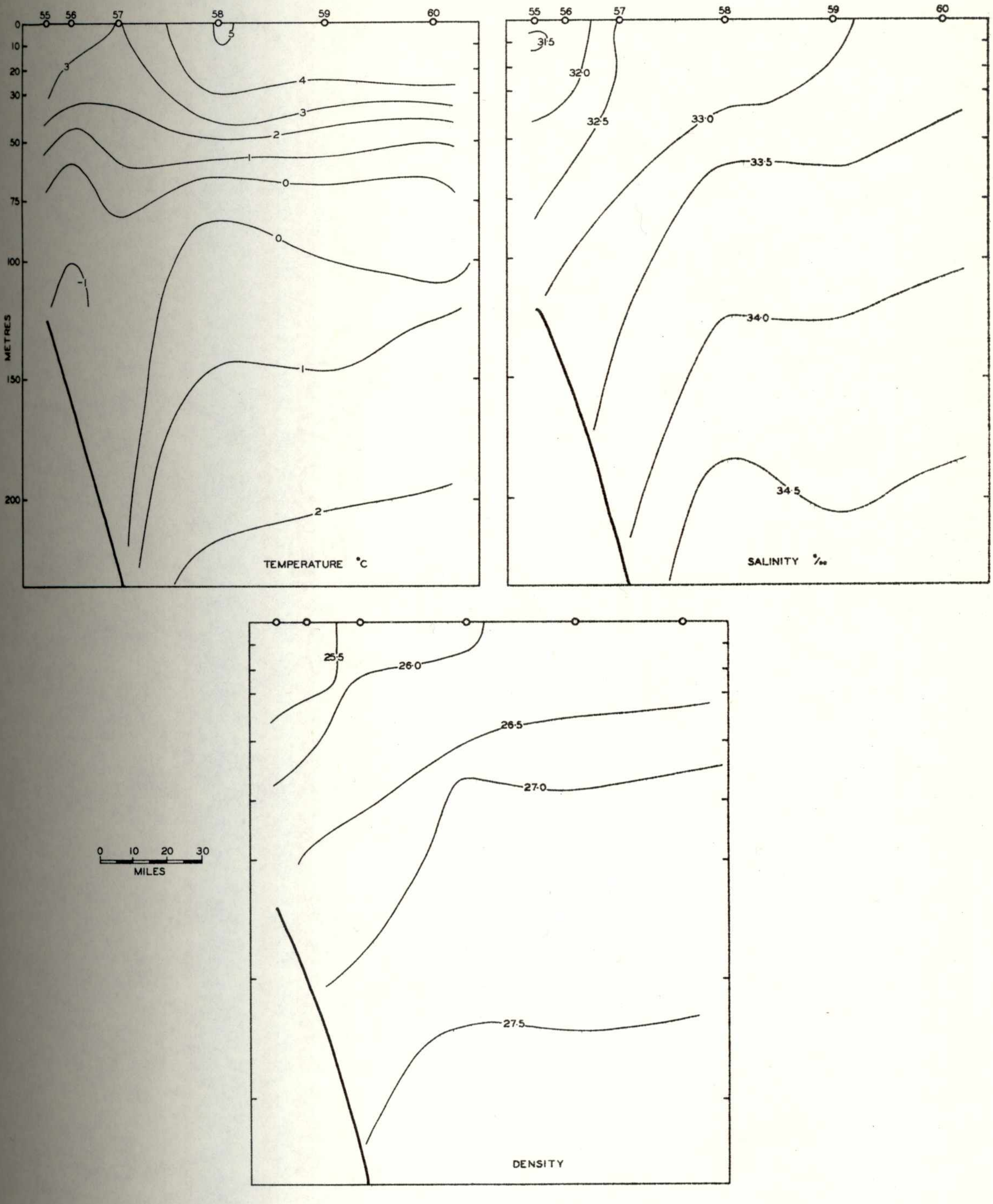

Fig. 14 Distribution of temperature, salinity and density in section H, -September 1955.

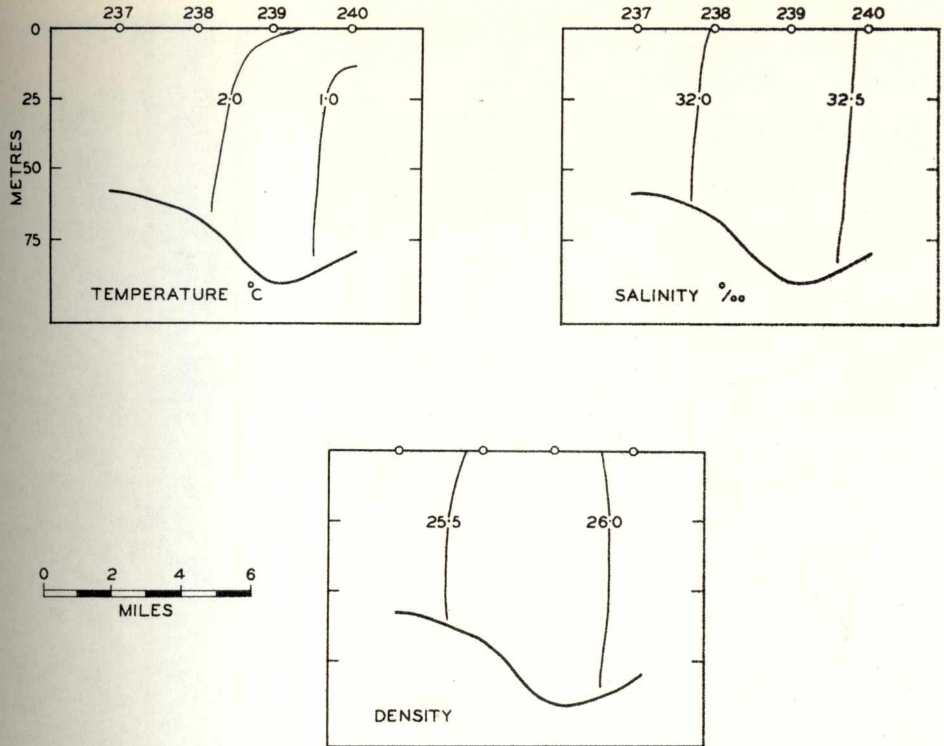

Fig. 15 Distribution of temperature,salinity and density in section C, -November 1955.

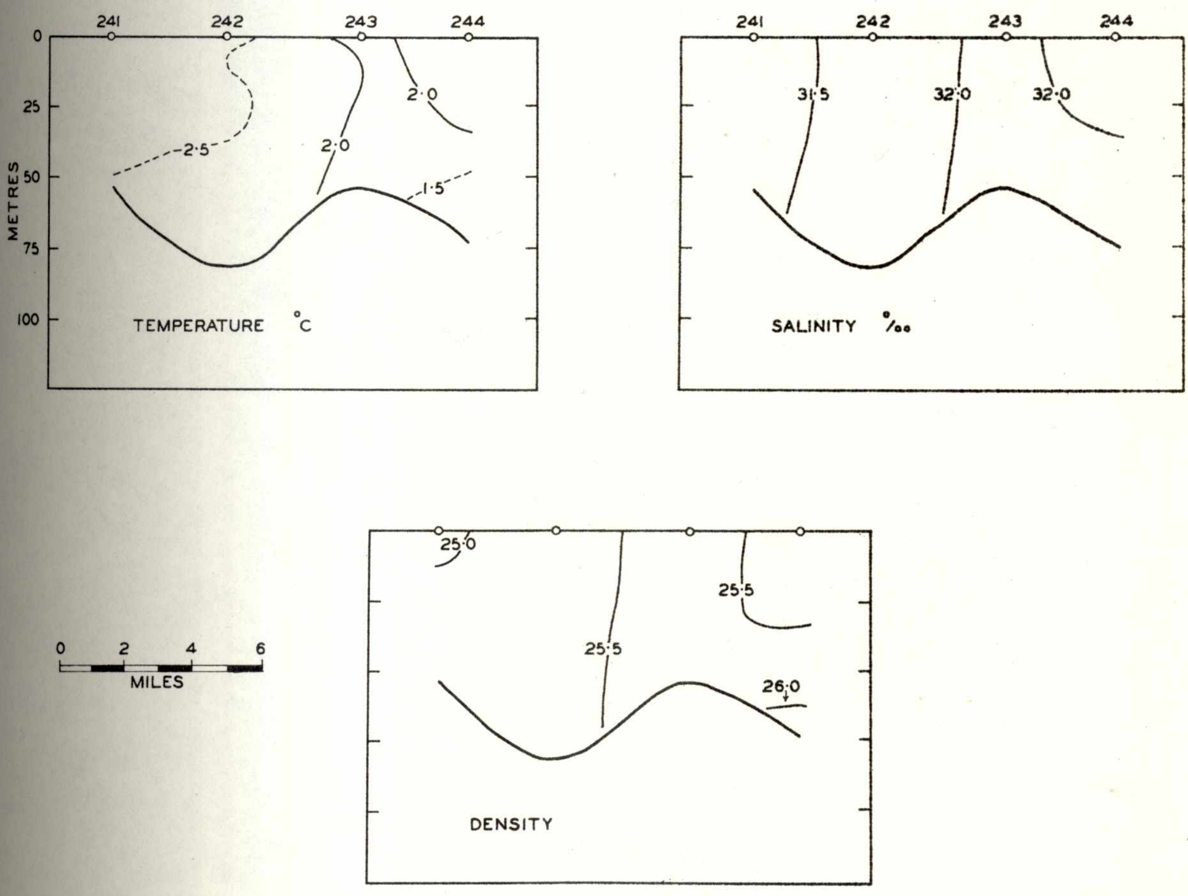

Fig. 16 Distribution of temperature, salinity and density in section D, -November 1955.

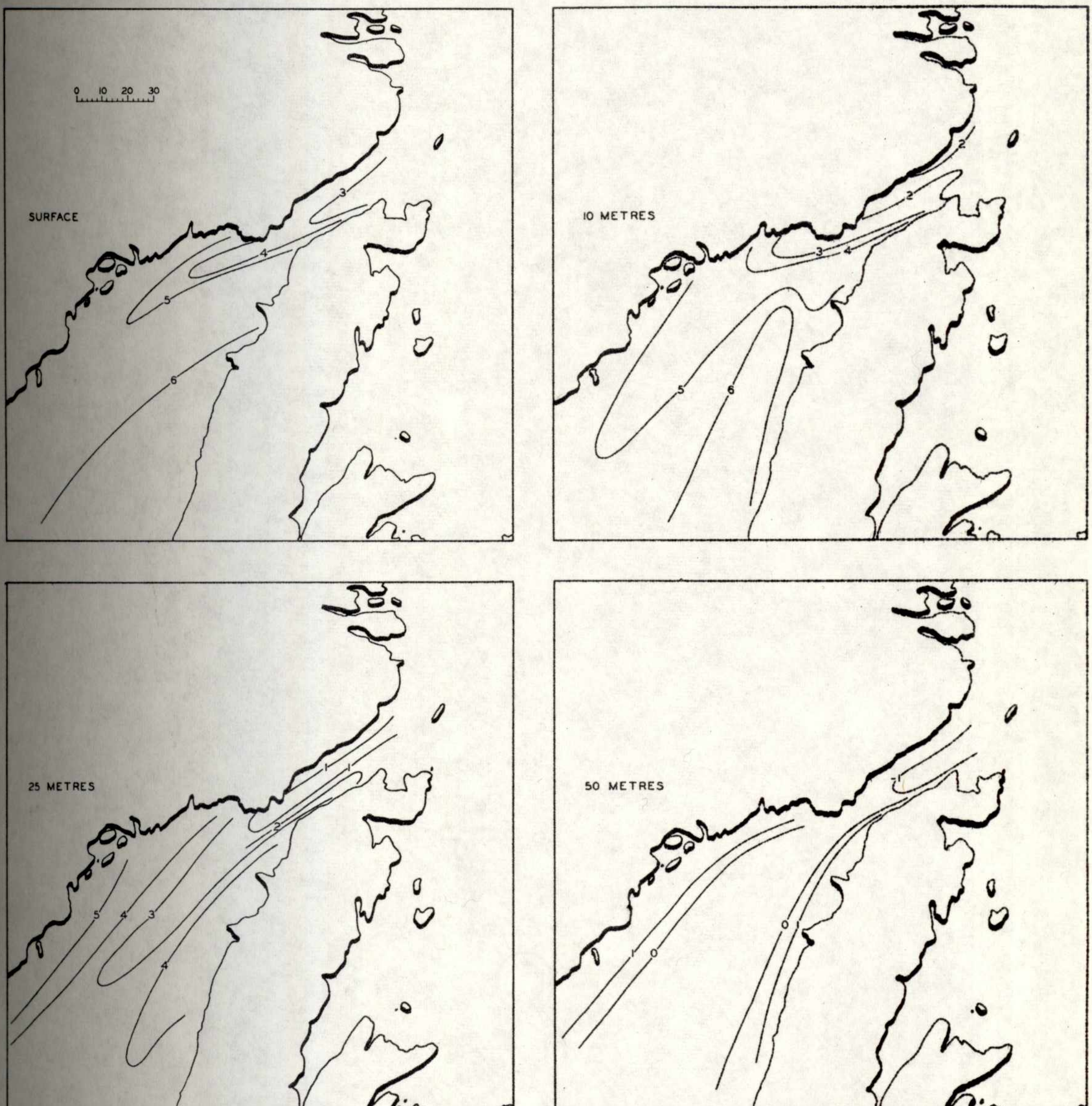

Fig. 17 Distribution of temperature - June 1955.

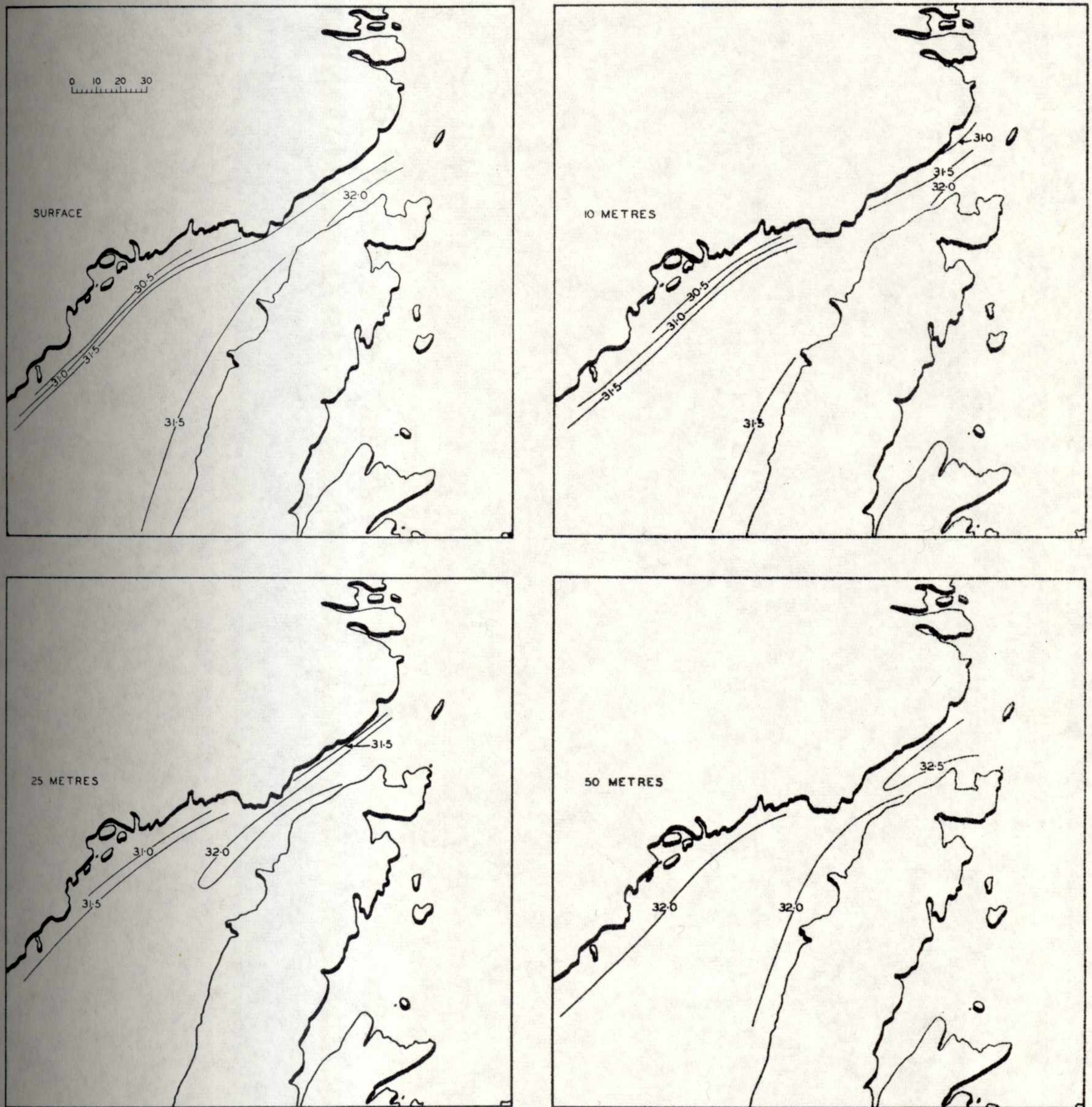

Fig. 18 Distribution of salinity - June 1955.

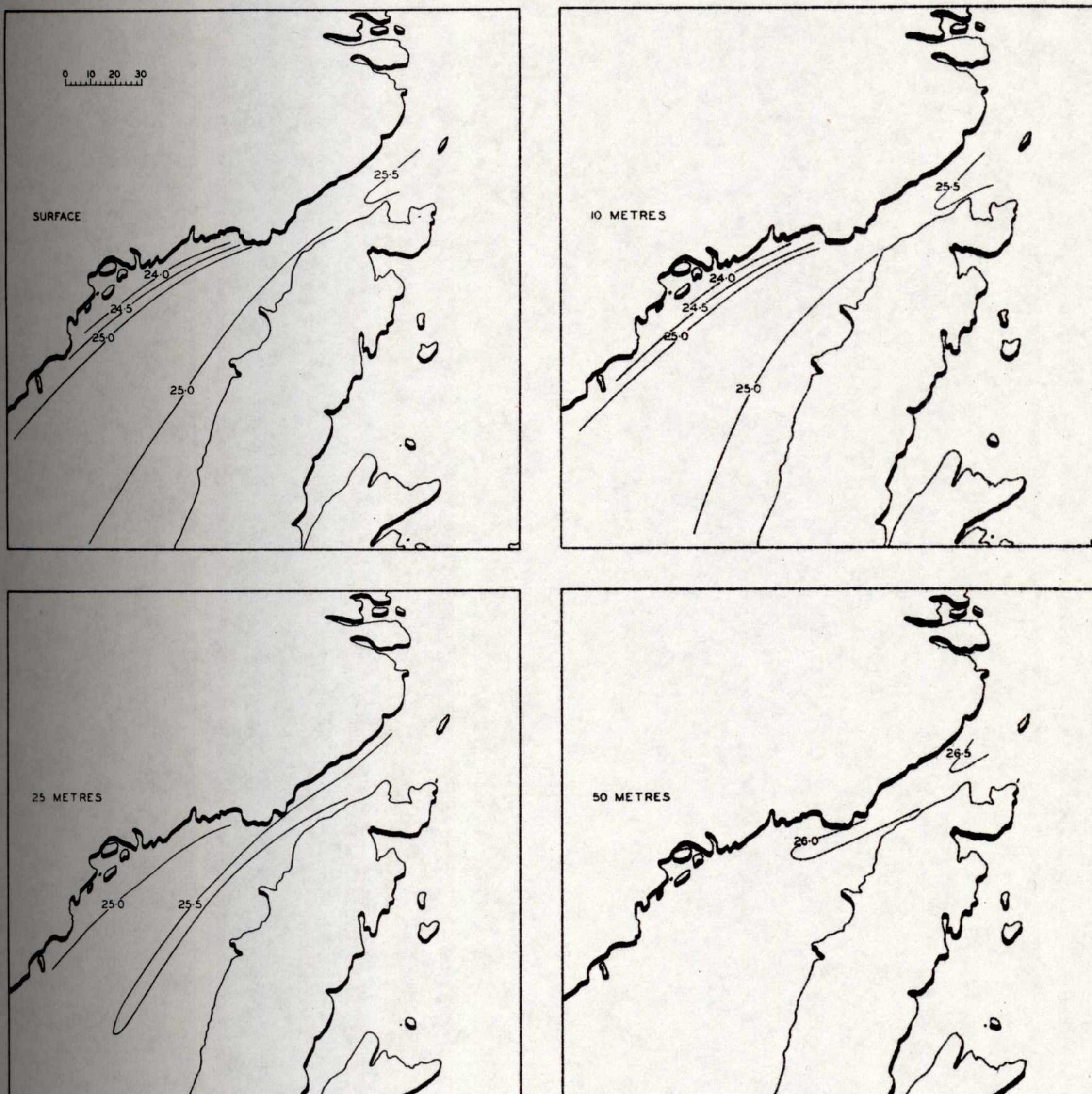

Fig. 19 Distribution of density (σ_t) - June 1955.

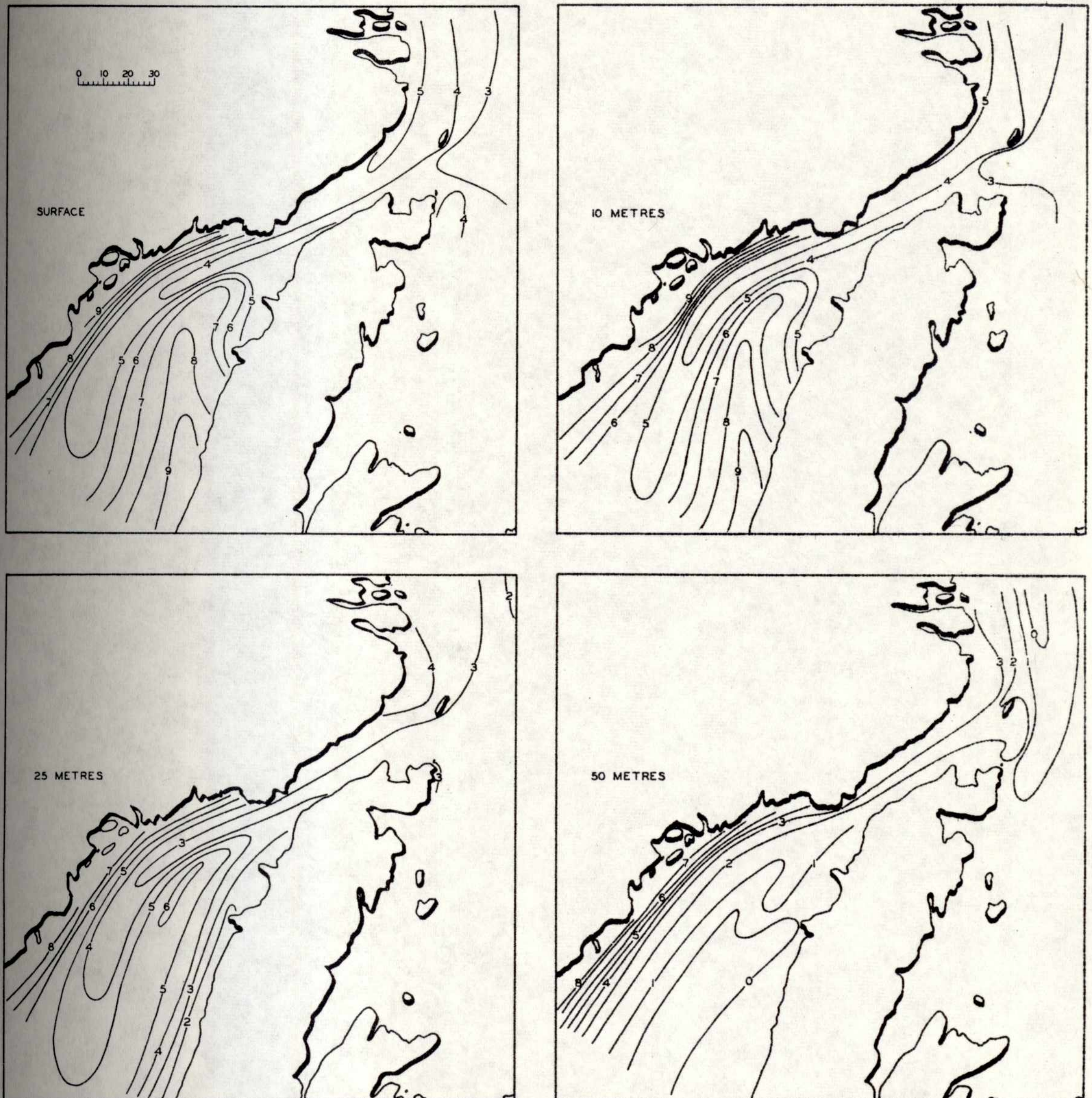

Fig. 20 Distribution of temperature - September 1955.

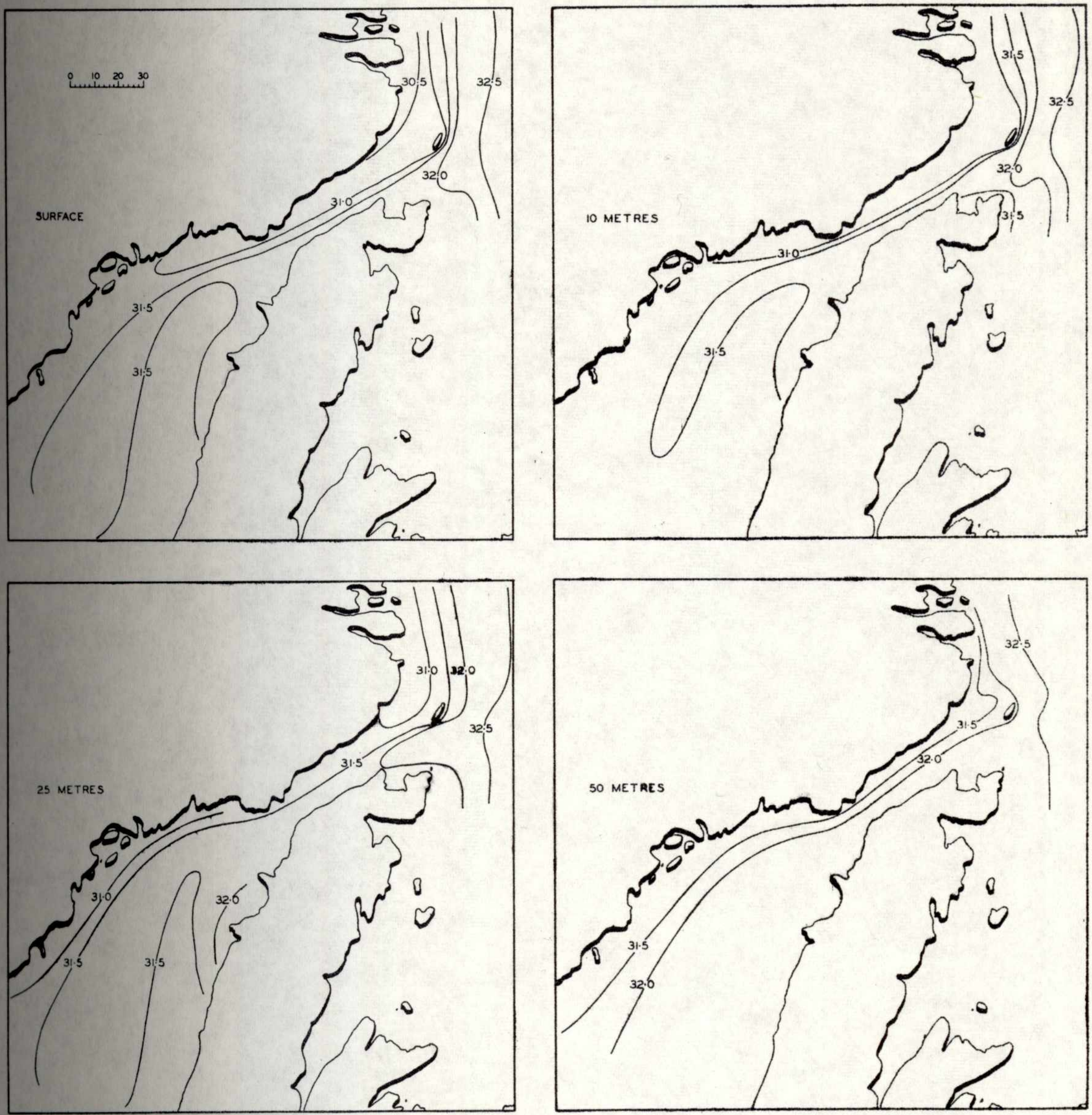

Fig. 21 Distribution of salinity - September 1955.

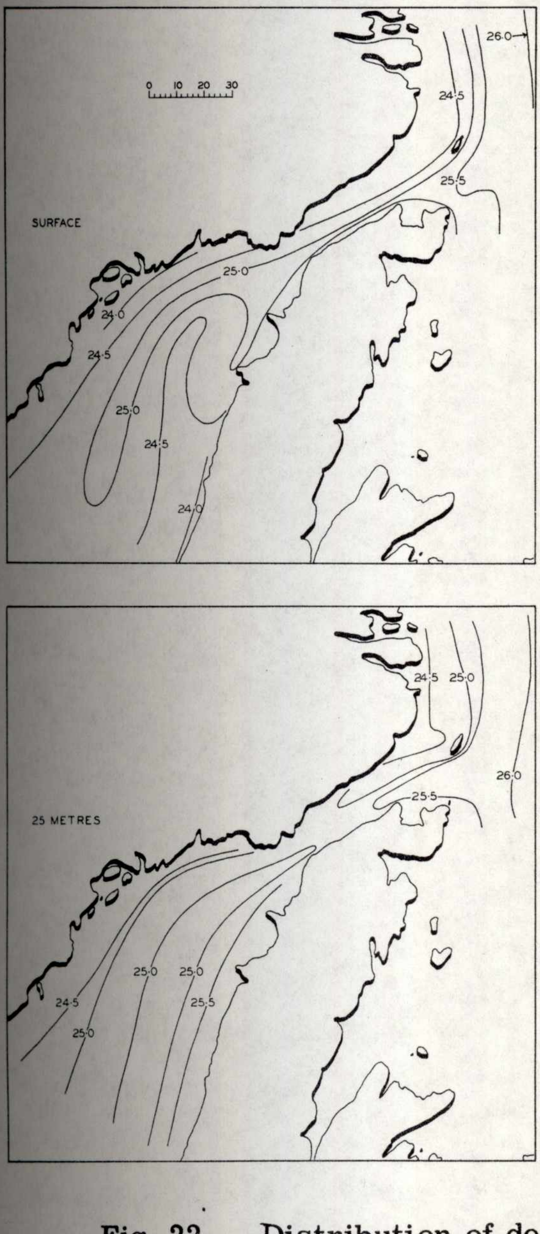

Fig. 22 Distribution of density (σ_t) - September 1955.

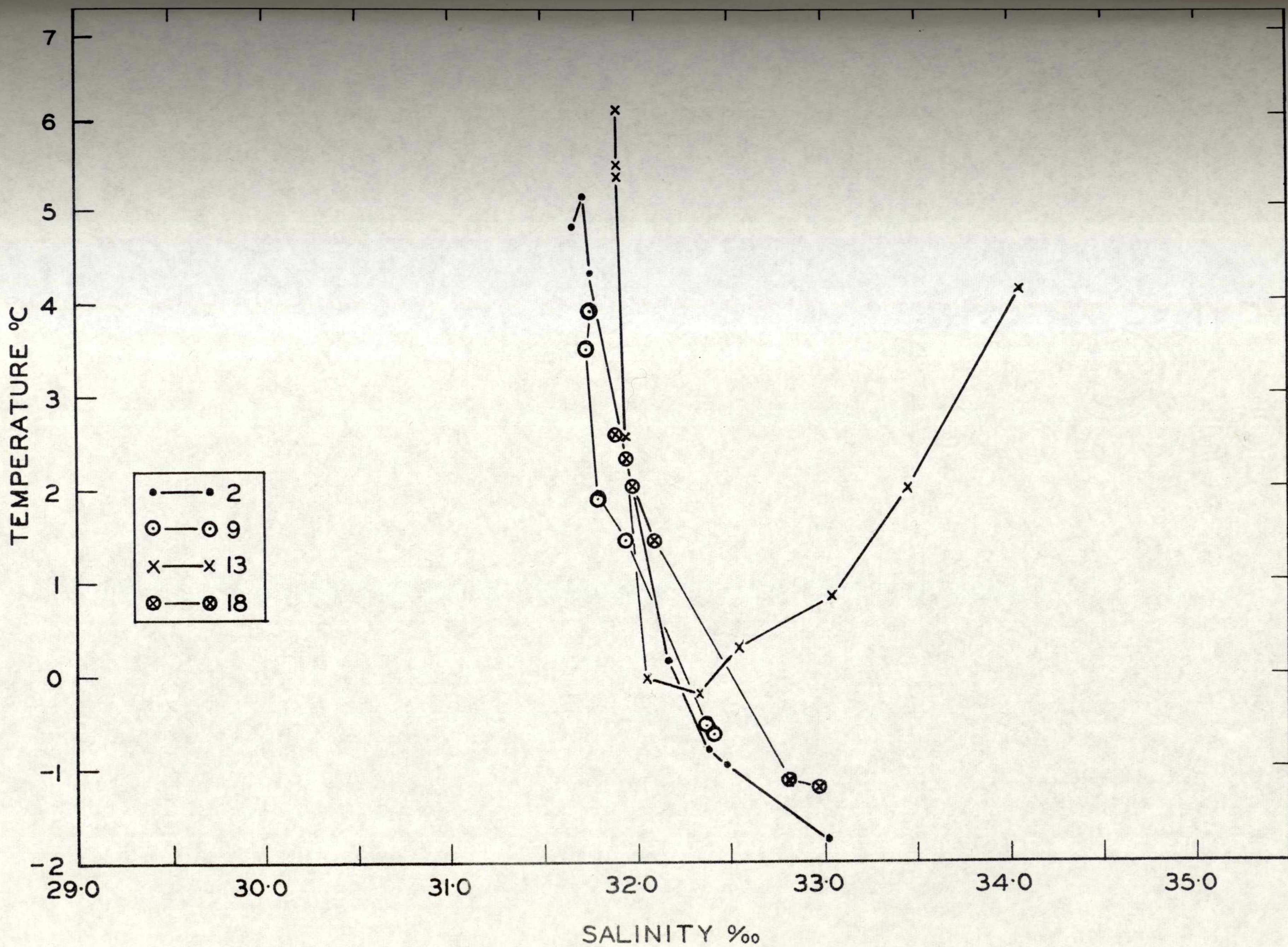

Fig. 23 Typical temperature-salinity correlation curves for the Strait

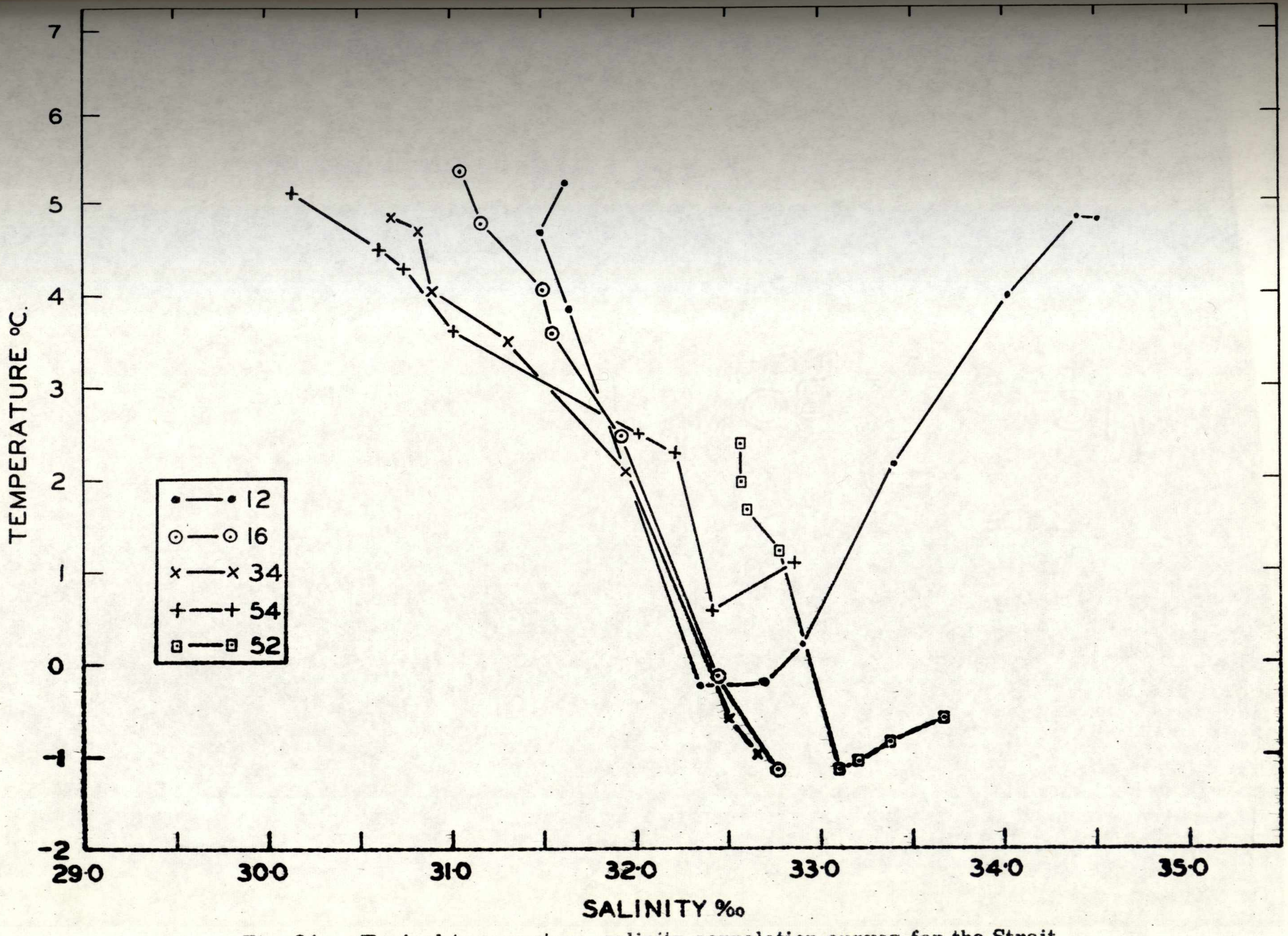

Fig. 24 Typical temperature-salinity correlation curves for the Strait of Belle Isle region in September 1955.

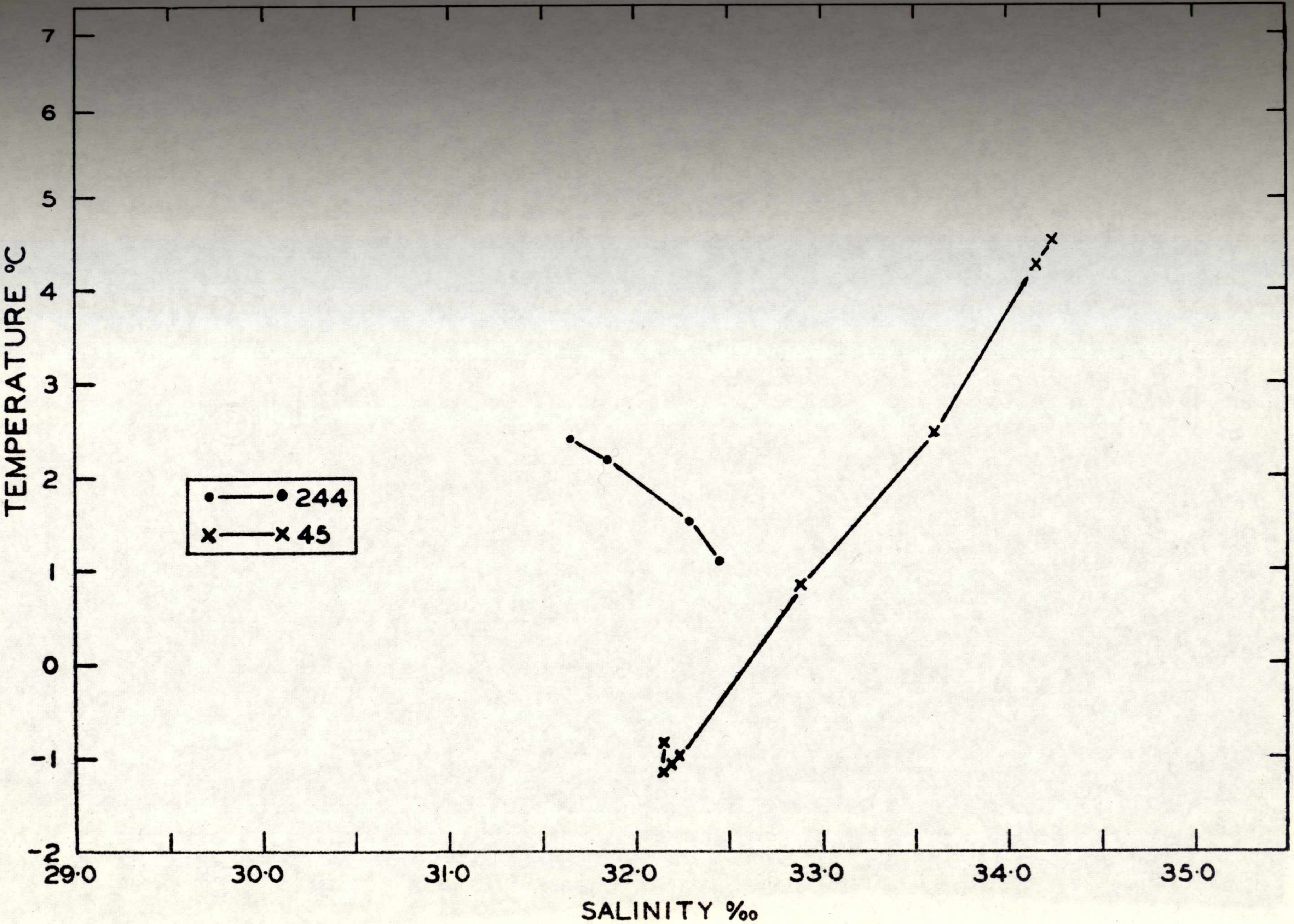

Fig. 25 Temperature-salinity correlation curves for the Strait of Belle Isle region in November 1955 and March 1956.