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TRINITY BAY, NEWFOUNDLAND SURVEY - SEPTEMBER 1956

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# Trinity Bay, Newfoundland Survey - September 1956

by

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## INTRODUCTION

Trinity Bay cuts deeply into the eastern coast of Newfoundland and, together with Placentia Bay, nearly severs the Avalon Peninsula from the rest of the Island. Trinity Bay (Fig. 1) has an overall length of some 50 miles, and for the most of its length, has an unusually uniform width of between eleven and twelve miles. It then widens near the mouth to 22 miles and narrows again to 15 miles at the mouth.

Depths within the Bay reach a maximum of 585 metres in a deep narrow trough in the central portion. The maximum depth across the mouth is nearly 310 metres. As indicated in Figure 1, an offshore ridge separates the deeps within the Bay from those on the edge of the Continental shelf. The maximum or sill depth of this ridge is about 236 metres and is found in the area about 25 miles northeast of the mouth of the Bay. The crown of the sill is indicated by the heavy dashed line.

### Topographic Features

Buddington (1939) in discussing the Pre-Cambrian rocks of southeast Newfoundland writes: "The results of glaciation expressed in the present topography point to the presence of local ice caps flowing into individual bays in a direction perpendicular

to the major outlines of the bays at each point, and hence controlled in a great degree by the gross features of the pre-glacial topography. The directions of ice movements are easily decipherable from the abundant striations, the stoss and lee sides of hills, and numerous boulder trains, which may be traced to their source.

Every bay indenting the coast of the Avalon Peninsula presents all the essential characteristics of a fiord, such as high, steep, straight, parallel walls, threshold across its mouth, and small insignificant streams entering its head. In Trinity Bay the inner, deepest position is over 1,100 feet deeper than the sill across the mouth. Where the relations are known, there is a remarkable parallelism between the strike of the major fault planes and the trend of the coastline, but the writer could find no evidence that faulting was directly responsible for the formation of the fiords. The faults and fractures controlling the lineaments of the bays are of ancient date - older than the peneplains and their influence on the present topography has been indirect. The formation of the sills across the mouths of the bays by deposits from currents is improbable, since this theory will not hold for the inland fiords of Gander Lake, Red Indian Lake, or Grand Lake, the latter with its deepest part not less than 988 feet below sea-level. In view of these conditions, glacial overdeepening of river valleys probably associated with some submergence followed by the invasion

of the sea, seems the best adapted explanation for these fiord bays."

Christie (1950) remarks that, in general, glacial action does not appear to have been strong in the Trinity Bay region, that both Smith and Random Sounds owe their configuration to faulting, and that all bays have been deepened by glacial erosion.

### General Circulation

The circulation of the waters in Trinity Bay is in a large measure controlled by the Labrador Current which flows past the mouth of the Bay, and by the sill across its mouth.

The Labrador Current may be divided into an inshore stream and an offshore stream. The inshore stream contains the greater volume of cold water and is confined to the continental shelf. The offshore stream which contains waters that are characteristic of the warmer West Greenland current flows over the continental slope (Smith, Soule and Mosby, 1937).

Smith, et al (1937) indicate that the Labrador current has an average velocity of 5 miles per day in a southeastward direction off the mouth of Trinity Bay. They also indicate that the current in this region can at times, attain similar speeds in the opposite direction as it did in the summer of 1933. The Newfoundland Pilot (1952 Edition p. 270) reports that within Trinity Bay after easterly winds, a strong current runs up the northwestern side into the Bay and, that fog hangs more over this side than on the southeastern side.

It would appear from the foregoing that the general circulation is cyclonic bringing the inshore waters of the Labrador Current into the Bay from the Cape Bonavista area, and that the waters are considerably influenced by the winds.

### Observations

The network of stations shown in Figure 2 was occupied between 27 and 29 September, 1956 by the C.N.A.V. "Sackville". Observations were made at standard serial depths to the bottom and they included temperature, water sample for salinity and plankton tows at every station, while bottom samples and dissolved oxygen content were taken at selected stations throughout the area. Horizontal and vertical plots of some of these observations are presented in this study.

Technical difficulties prevented the completion of the observational program further offshore, which is necessary to portray conditions both inside and outside of this basin. However, data taken in July 1956 by the Fisheries Research Board of Canada, Biological Station, St. John's, Newfoundland, on a line running northeastward from Cape Bonavista (Sta. 150) to the edge of the continental shelf, permits the presentation of some of the major oceanographic features related to Trinity Bay.

### VERTICAL DISTRIBUTION OF TEMPERATURE AND SALINITY

The vertical distribution of properties in representative sections are given in Figures 3 to 12.

In the latter part of September, the water column in Trinity

Bay had four important oceanographic features, namely:

(a) a well-mixed surface layer with temperatures ranging from  $8^{\circ}$  to  $10^{\circ}\text{C}$ . and with a salinity less than 32.0‰. The thickness of the surface layer varied from 30 metres at the head of the Bay to 20 metres in the offshore section.

(b) a well-developed thermocline about 30 to 50 metres thick in which the temperature changed 7 to 9 Centigrade degrees.

(c) a cold-water layer with temperatures less than  $-1.0^{\circ}\text{C}$ . extended well into the Bay from offshore. A minimum temperature of  $-1.52^{\circ}\text{C}$ . was observed at a depth of 100 metres at station 145 outside the Bay. Within the Bay, minimum temperatures were between  $-1.0^{\circ}$  and  $-1.14^{\circ}\text{C}$ . Salinities in the cold-water layer were between 32.7 and 33.3‰. The extremely low temperatures were generally associated with salinities of 33.0‰ with some freshening towards the head of the Bay.

(d) a deep-water layer was located below the cold-water layer. Temperatures were higher than  $0.0^{\circ}\text{C}$ . and salinities were above 33.5‰. In the deepest part of the Bay (500m.) temperatures were higher than  $1.0^{\circ}\text{C}$ . and salinities were greater than 34.0‰.

The waters found in the Trinity Bay region were typical of waters found in the Labrador Current at depths ranging between 100 and 250 metres as indicated by results of a survey of waters along the east coast of Newfoundland (Fig. 24).

The tongue-like distribution of waters in the Labrador

Current allows for the relatively wide range of depths of water with temperature and salinity characteristics of  $1.0^{\circ}\text{C}$ . and  $34.0\%$ . This water is formed through a mixture of the cold water ( $-1.5$ ,  $33.2\%$ ) and Labrador Sea Intermediate water ( $3.5^{\circ}$   $34.9\%$ ), (Smith, et al, 1937).

The exchange of waters below the sill in Trinity Bay may be expected to be renewed at fairly frequent intervals depending upon the relative strengths of the inshore and offshore parts of the Labrador Current. A decrease in the proportion of the cold or Arctic waters would bring about an increase in the warmer offshore waters in a given water column in the Trinity Bay region with the result that an exchange of waters below sill depth would likely take place.

#### HORIZONTAL DISTRIBUTION OF TEMPERATURE AND SALINITY

The horizontal distributions of temperature and salinity at depths of 0, 50, 100, 150 and 250 metres for the period September 27 to 29, 1956 are illustrated in Figures 13 to 33. Figures 13 and 14 showing the surface temperature and salinities indicate a fairly uniform distribution throughout the area. Both temperature and salinities increased from the mouth of the Bay towards the head.

At the 50 metre level, the distribution of temperature and salinity indicate a southeastward flow of Labrador Current water past the mouth of the Bay, a closed cyclonic circulation about

the inner Bay and a small clockwise eddy between the Labrador Current and the Bay circulation.

From 100 to 105 metres, the Labrador Current waters, shown by their characteristic low temperatures and high salinities, appear to make the circuit of the Bay, entering on the northwest side and leaving on the southeast side. The horizontal thermal and salinity gradients were relatively small and it is thus likely that the water movements were weak.

At the 250 metre level, the amount of data is sparse and no conclusions about the general circulation may be drawn.

#### TEMPERATURE-SALINITY CORRELATION CURVES

Figure 23 shows two T-S curves which are typical of those for the Trinity Bay region. The T-S curves for station 111 is representative of those for stations inside the Bay and the curves for station 152 are typical of those stations located outside the Bay.

The T-S curves show that the waters in the region are a mixture of three main water types as follows:

(a) surface waters with temperatures between  $8^{\circ}$  and  $10^{\circ}\text{C}$ . and salinities near 31.5‰.

(b) cold-water layer with temperatures less than  $-1.0^{\circ}\text{C}$ . and salinities between 32.7 and 33.3‰. A minimum temperature of  $-1.5^{\circ}\text{C}$ . is associated with a salinity of 33.0‰.

(c) deep water with temperatures higher than  $1.0^{\circ}\text{C}$ . and

salinities higher than 34.0‰.

The nature and origin of these water types was discussed earlier on page 4.

A noteworthy difference between the T-S curves is the extent of the cold-water layer. There was much less cold-water at station 111 than at station 152. The shape of the curve for station 111 indicates that the supply of the cold-water was considerably decreased from that at some earlier date and that vertical mixing had consumed it in the inner part of the Bay.

An inflow across the sill is indicated by the T-S characteristics of the waters at the sill and at the bottom of the basin. They are identical, and since the denser waters are at shallower depths offshore, the flow is towards the land.

#### DISCUSSION

From the foregoing descriptions, it is readily apparent that Trinity Bay and part of the region off its mouth, fulfills the description of a basin. The circulation of the waters is such that there is an inflow of waters from outside across the sill into the Bay. Vertical mixing alongshore prevents the deep waters in the basin from becoming stagnant. Since the sill depth is relatively great, the major portion of the waters in the Trinity Basin are in free exchange with the waters in the Labrador Current.

In general, the circulation of water in Trinity Basin appears to be slow and with only moderate exchanges taking place with

Labrador Current waters off the mouth of the Bay. In the deeper water, the exchanges across the sill are determined in a large measure upon the strength of the inshore portion of the Labrador Current, and to the extent of vertical mixing that takes place along the sides of the basin. If, for example, the Labrador Current is transporting a small volume of cold water, then the boundary between the cold-water layer and the Labrador Sea waters will be close to the shore, and, further offshore, when the Labrador Current flows in great strength. In addition, the thermal and the salinity boundaries between the cold water and the warm water are sharper when the Labrador Current is running stronger. Data taken in a section running northeastward from Cape Bonavista by the Fisheries Research Board, Biological Station, St. John's, Newfoundland, in July of 1955 and 1956, indicated that the major changes take place along the bottom at depths of 200 to 300 metres. The location of a given isotherm or isohaline at these depths may vary by 40 miles or more from one year to the next. These inshore-offshore movements likely cause considerable changes in the deep waters in Trinity Bay. The relationships of the waters in Trinity Bay with those in the Labrador current are illustrated in Figure 24. This diagram is a composite of data collected during the September cruise by "Sackville" and in July by "Investigator II" of the St. John's Station.

#### SUMMARY

1. The bottom configuration of Trinity Bay is such that it is,

oceanographically speaking, a basin with a sill depth of 236 metres and a maximum depth inside of 585 metres.

2. In September, the water column had four principal features, namely:

a) a well mixed surface layer 20 to 40 metres thick and with temperatures ranging between  $8^{\circ}$  and  $10^{\circ}\text{C}$ . and salinities near 31.5‰.

b) a well developed thermocline in which temperatures changed as much as 7.0 Centigrade degrees in a vertical distance of 30 metres.

c) a cold-water layer with temperatures less than  $-1.0^{\circ}\text{C}$ . and as low as  $-1.14^{\circ}\text{C}$ . and having salinities ranging from 32.7 to 33.3‰. This water is frequently known as Arctic or Polar water because of its low temperatures.

d) a deep water layer in which temperatures reach a maximum of  $1.1^{\circ}\text{C}$ . and salinities 34.1‰. This water is a mixture of the cold water layer (c) and Labrador Sea Intermediate water. In the Labrador Current, waters of these characteristics are found at depths ranging from 75 to 275 metres.

3. On the basis of temperature and salinity distributions, the circulation in the Trinity Bay region at the time of the September survey was composed of three parts, namely:

a) a southeastward movement of the Labrador Current past the mouth of the Bay,

b) an anti-clockwise movement in the inner part of the Bay and

c) a small clockwise eddy located between the two (a and b).

4. Waters at depths in excess of 500 metres within the Bay had similar T-S characteristics of water found near the 236 metre level at the sill.

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- Christie, A.M. 1950. Geology of Bonavista Map-Area, Newfoundland, Canada. Dept. Mines and Technical Surveys, Geological Survey of Canada, Paper 50-7, N. 40 pp.
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- Sverdrup, H.V., M.W. Johnson and R.H. Fleming, 1942. The Oceans, Prentice-Hall Inc., New York, 1087 pp.

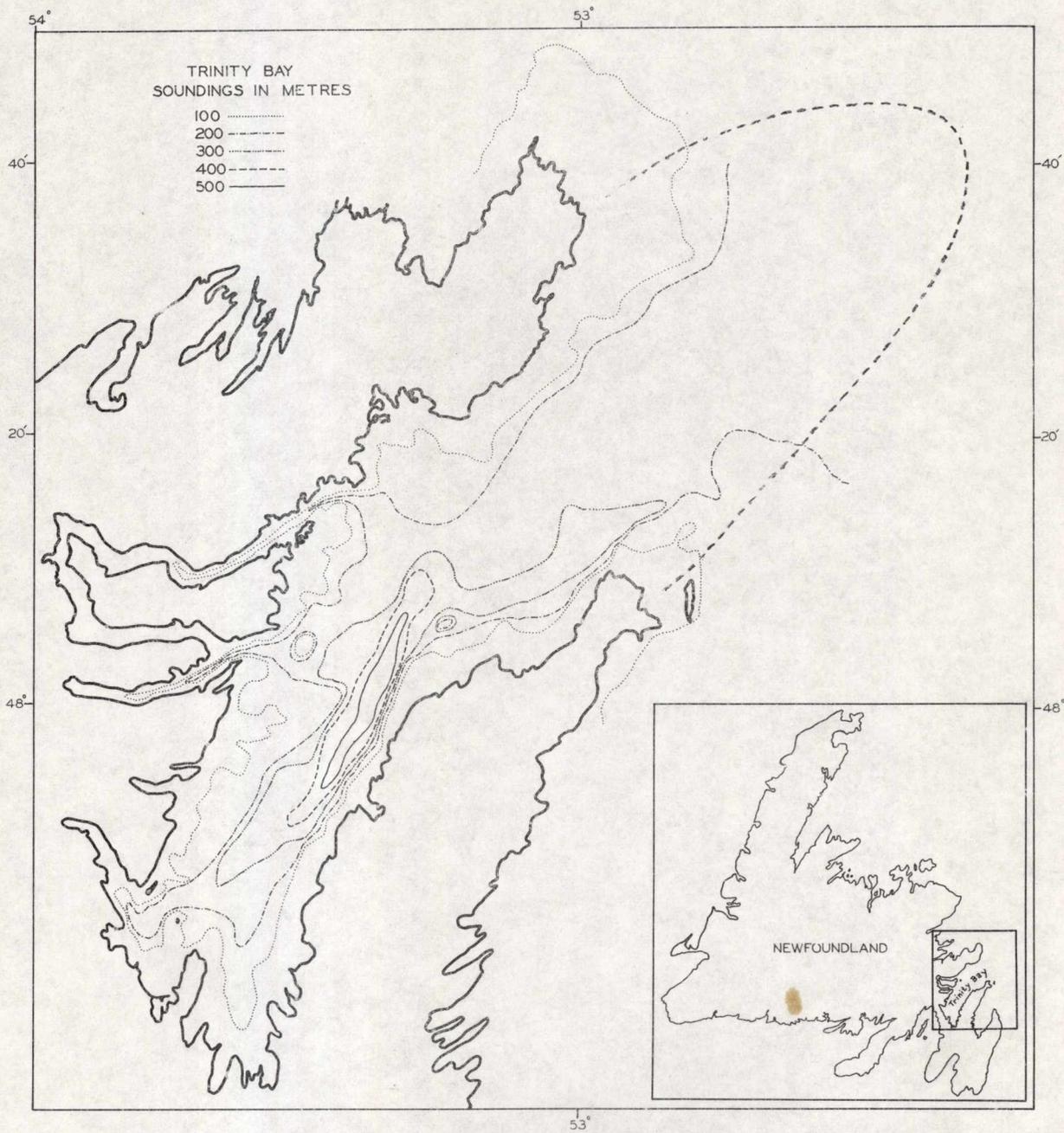


Fig. 1. Chart of Trinity Bay showing the general bottom configuration. Insert shows the location of the chart area.

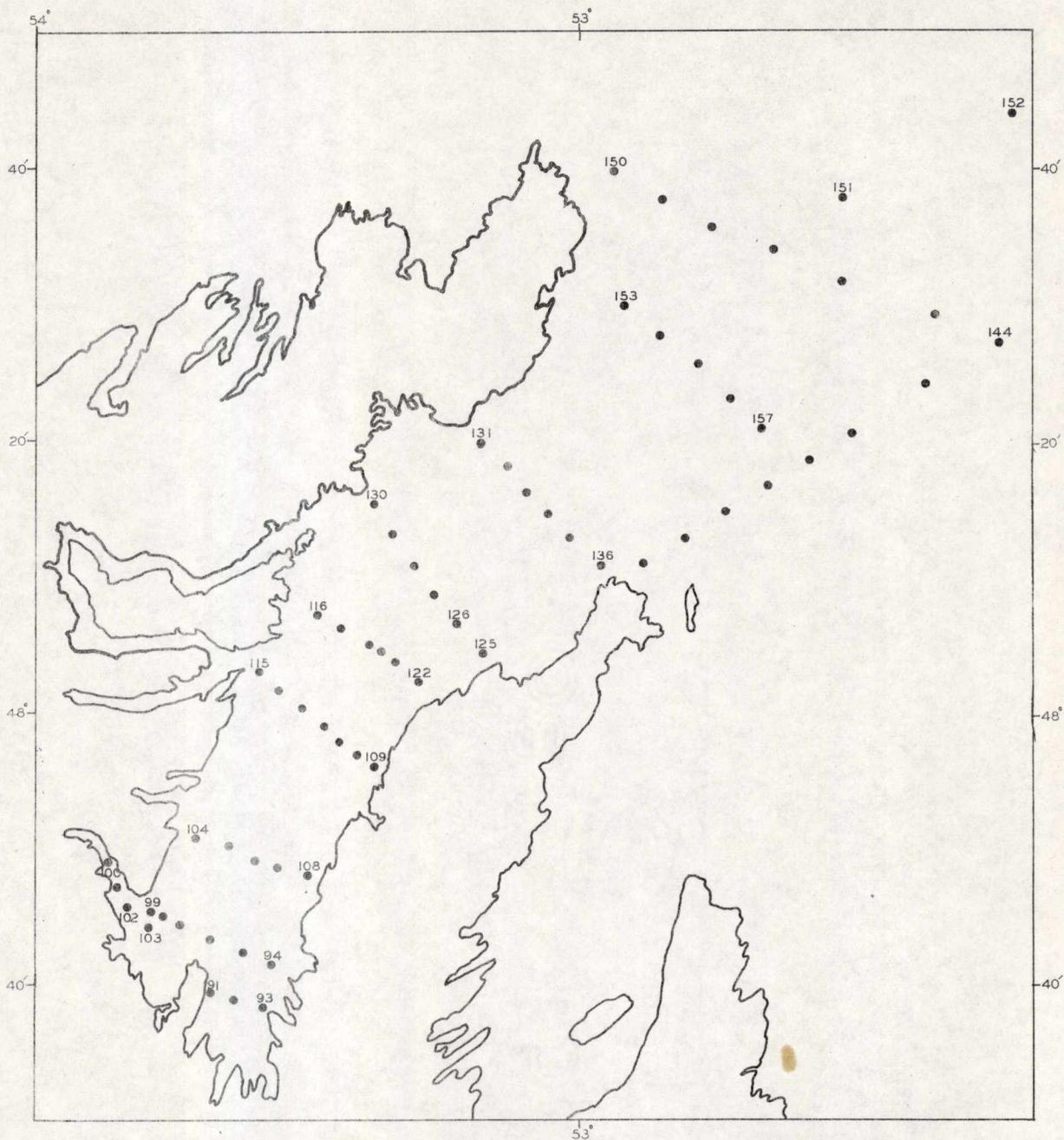


Fig. 2. Chart of Trinity Bay showing the locations of oceanographic stations occupied by C.N.A.V. "Sackville" between the 27th. and 29th. October, 1956.

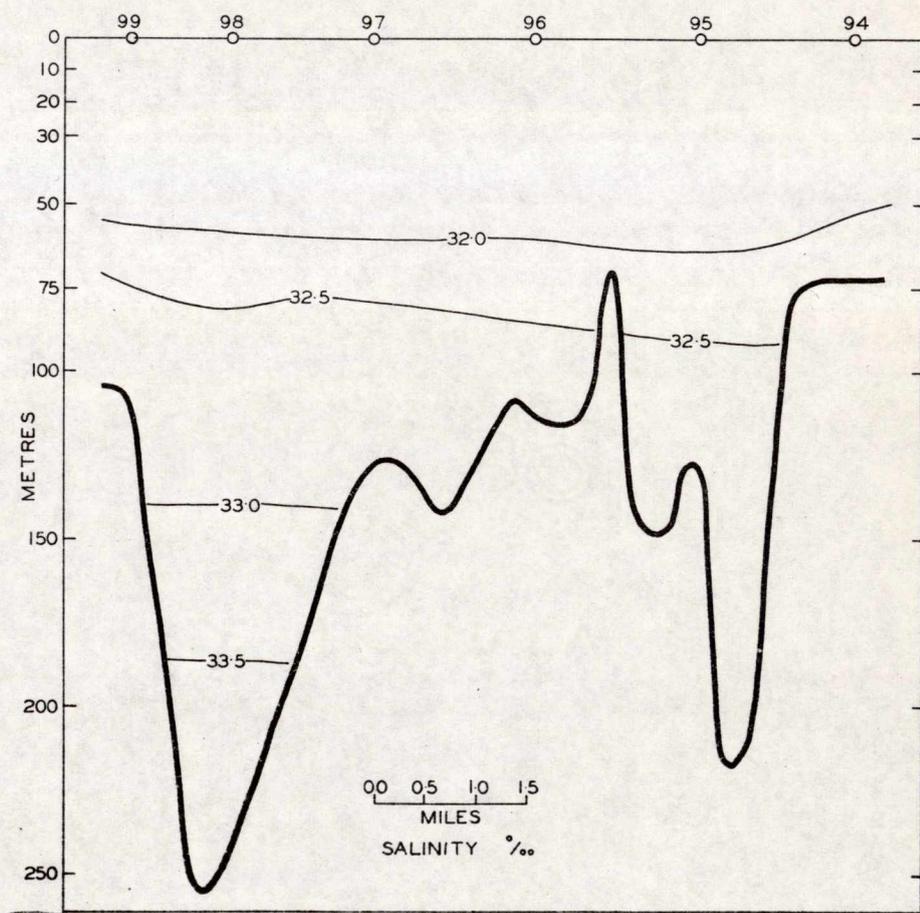
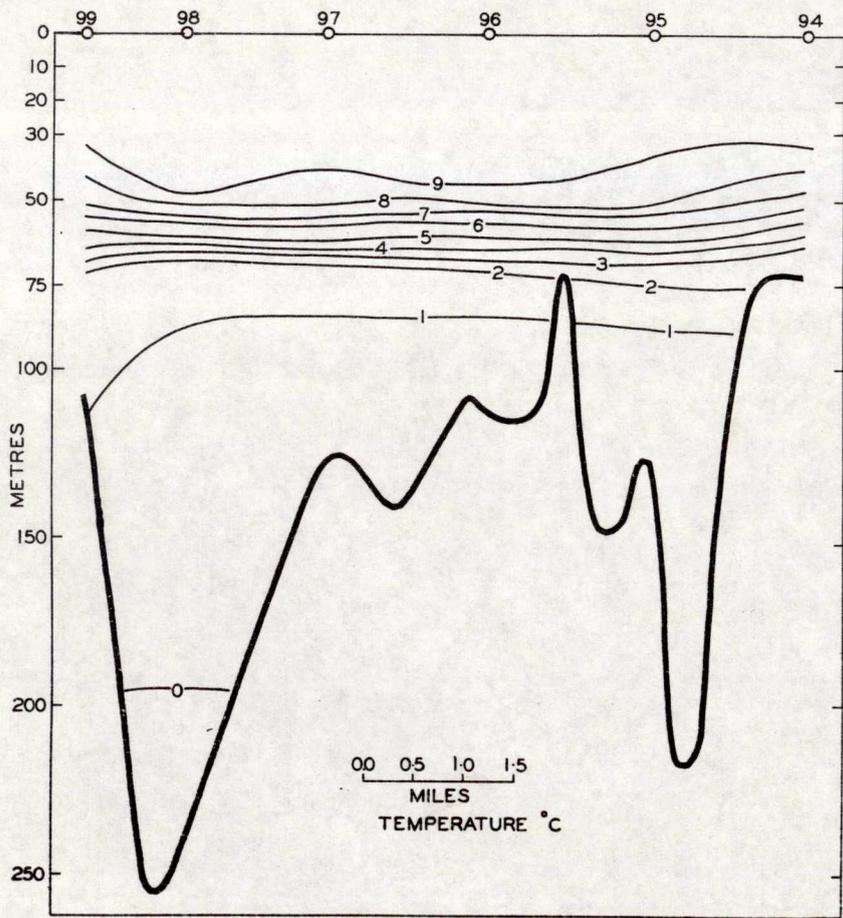


Fig. 3. Distribution of temperature and salinity in section between stations 99 and 94 in Trinity Bay.

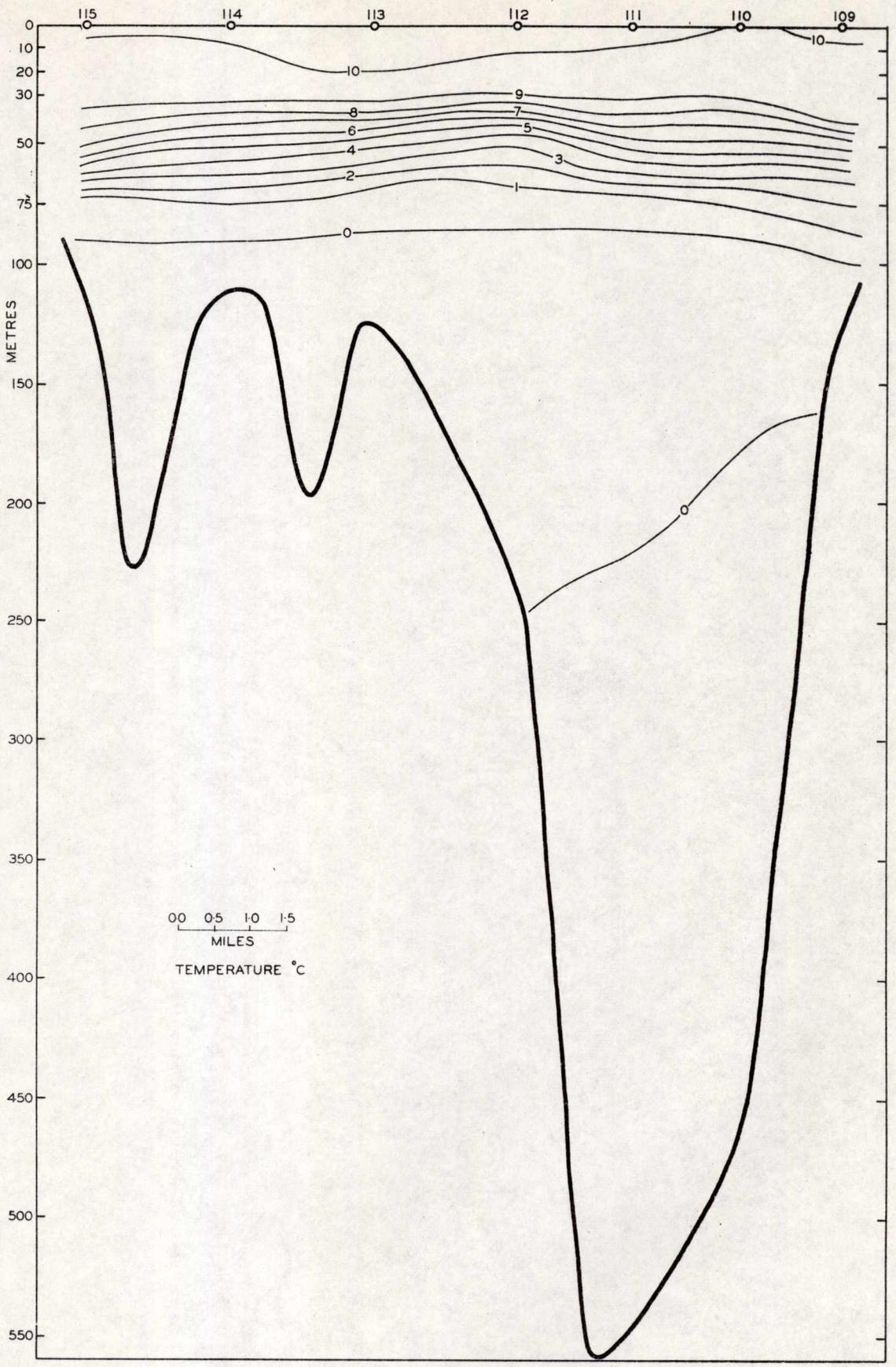


Fig. 4. Distribution of temperature in section between stations 115 and 109 in Trinity Bay.

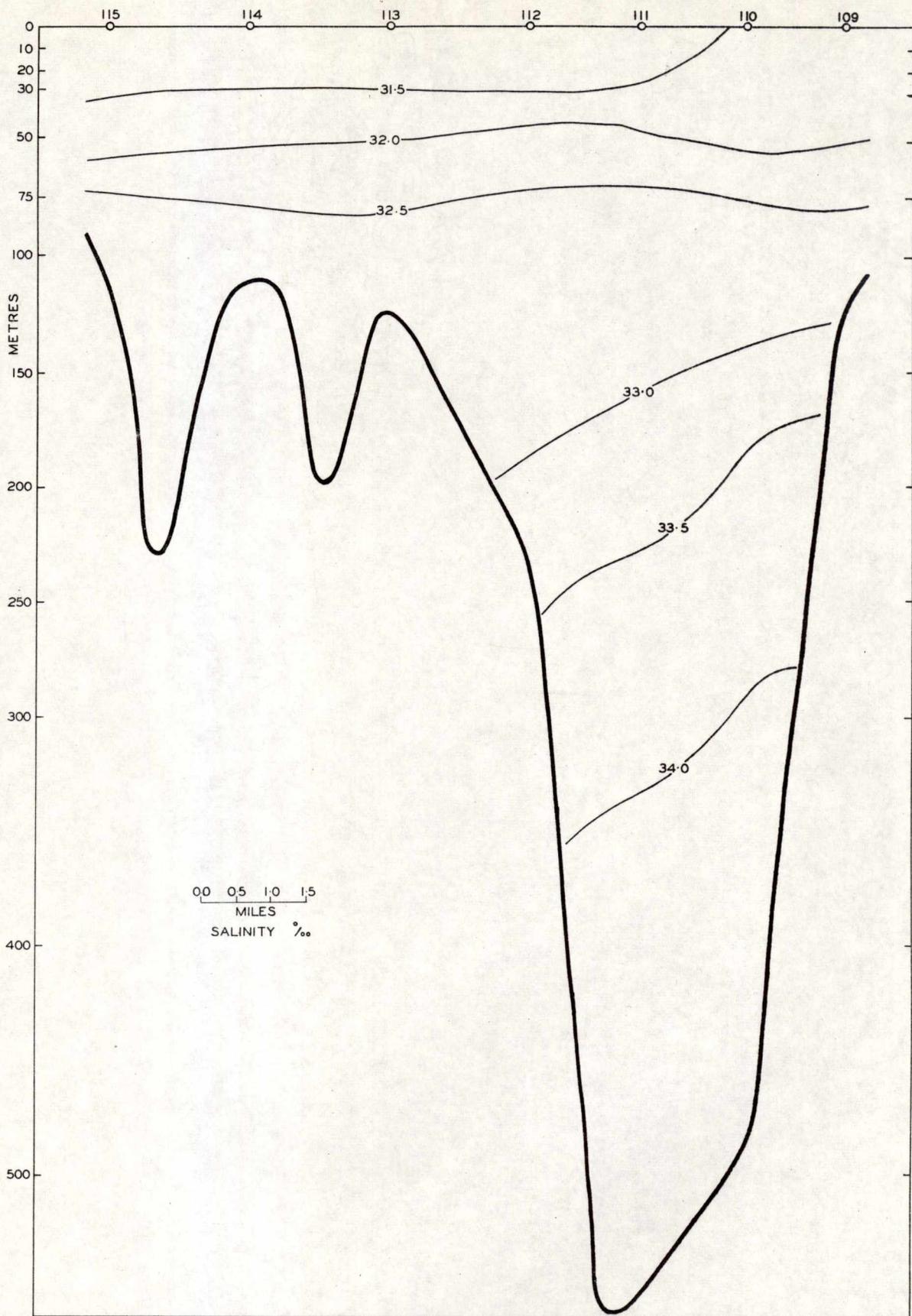


Fig. 5. Distribution of salinity in section between stations 115 and 109 in Trinity Bay.

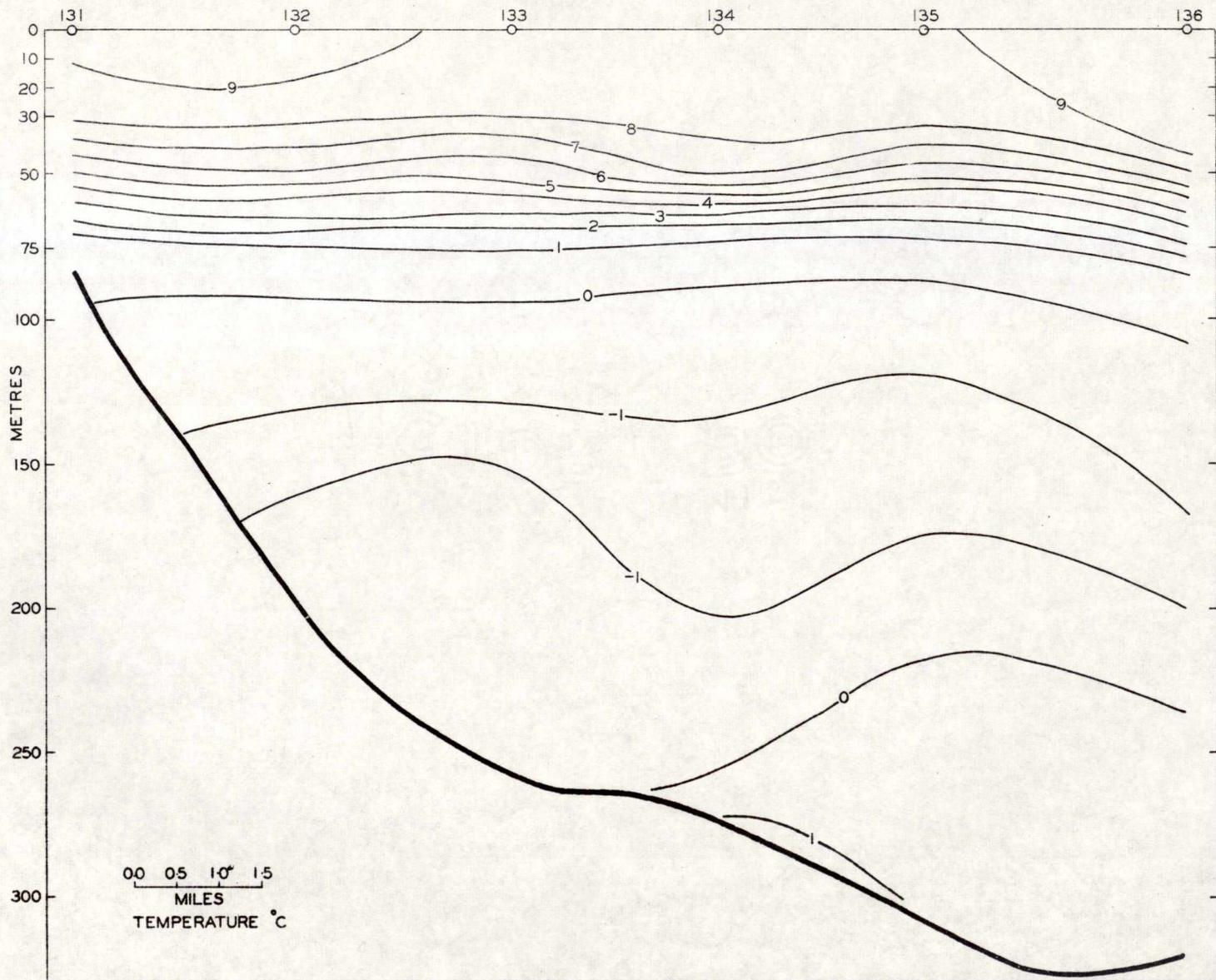


Fig. 6. Distribution of temperature in section between stations 131 and 136 in Trinity Bay.

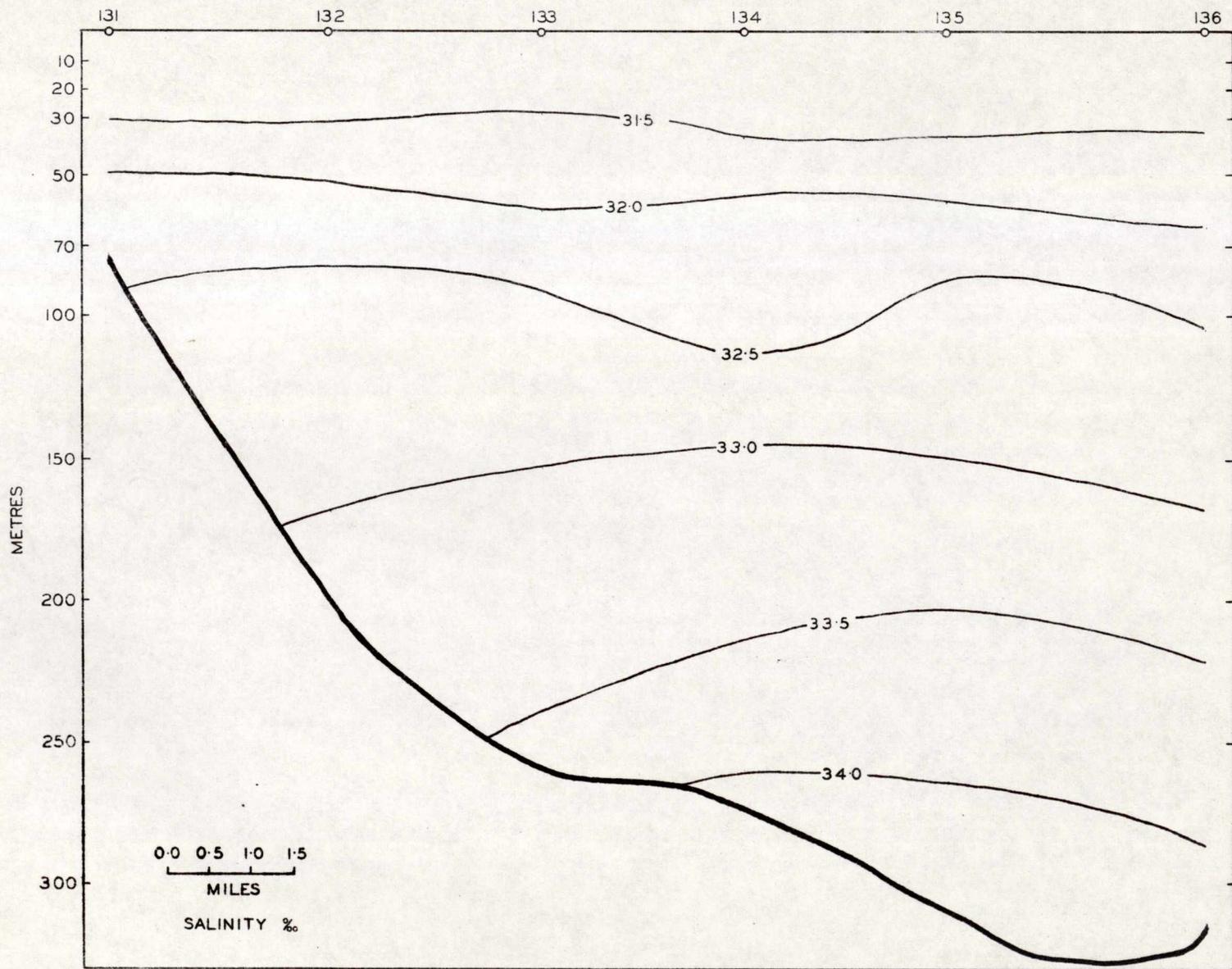


Fig. 7. Distribution of salinity in section between stations 131 and 136 in Trinity Bay.

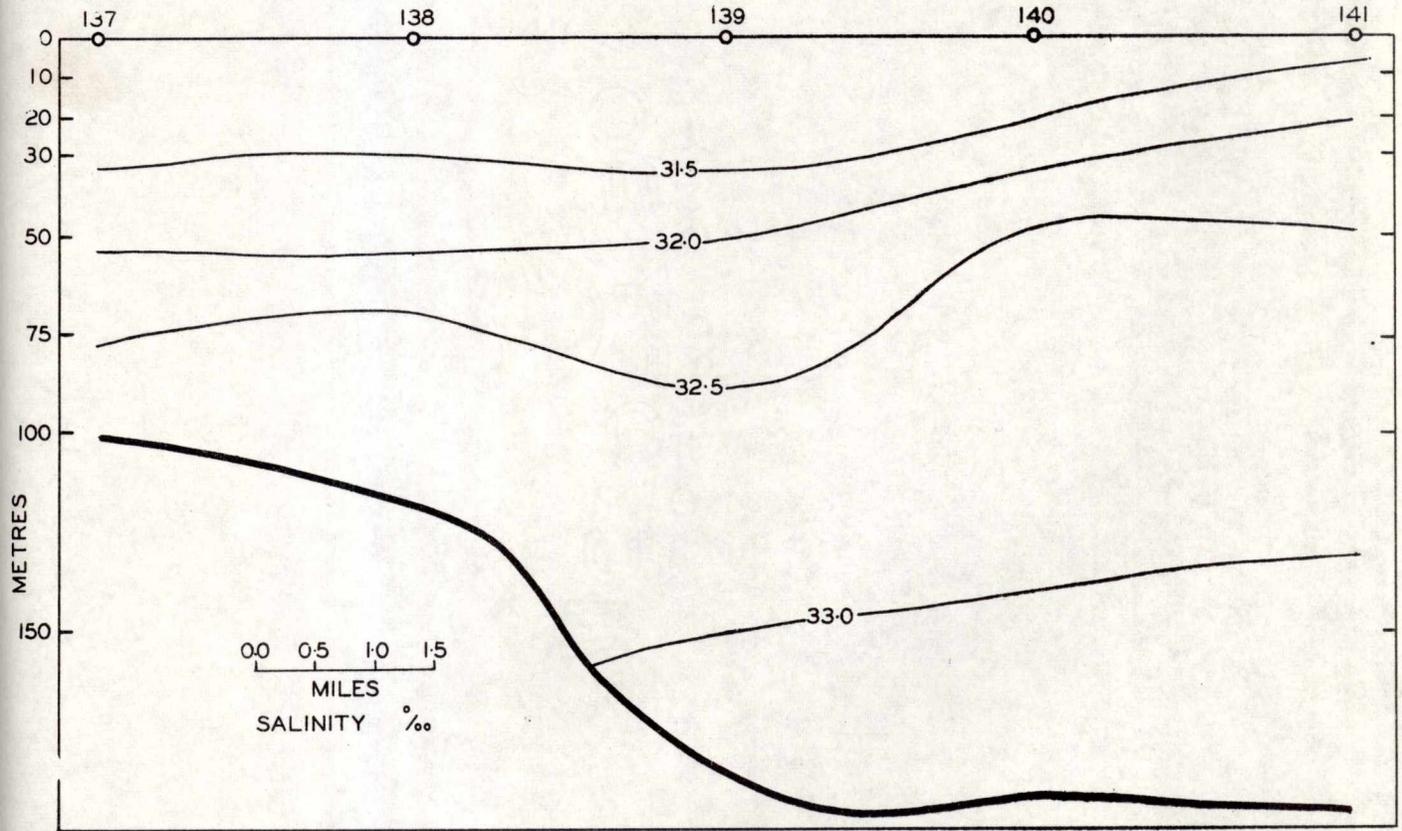
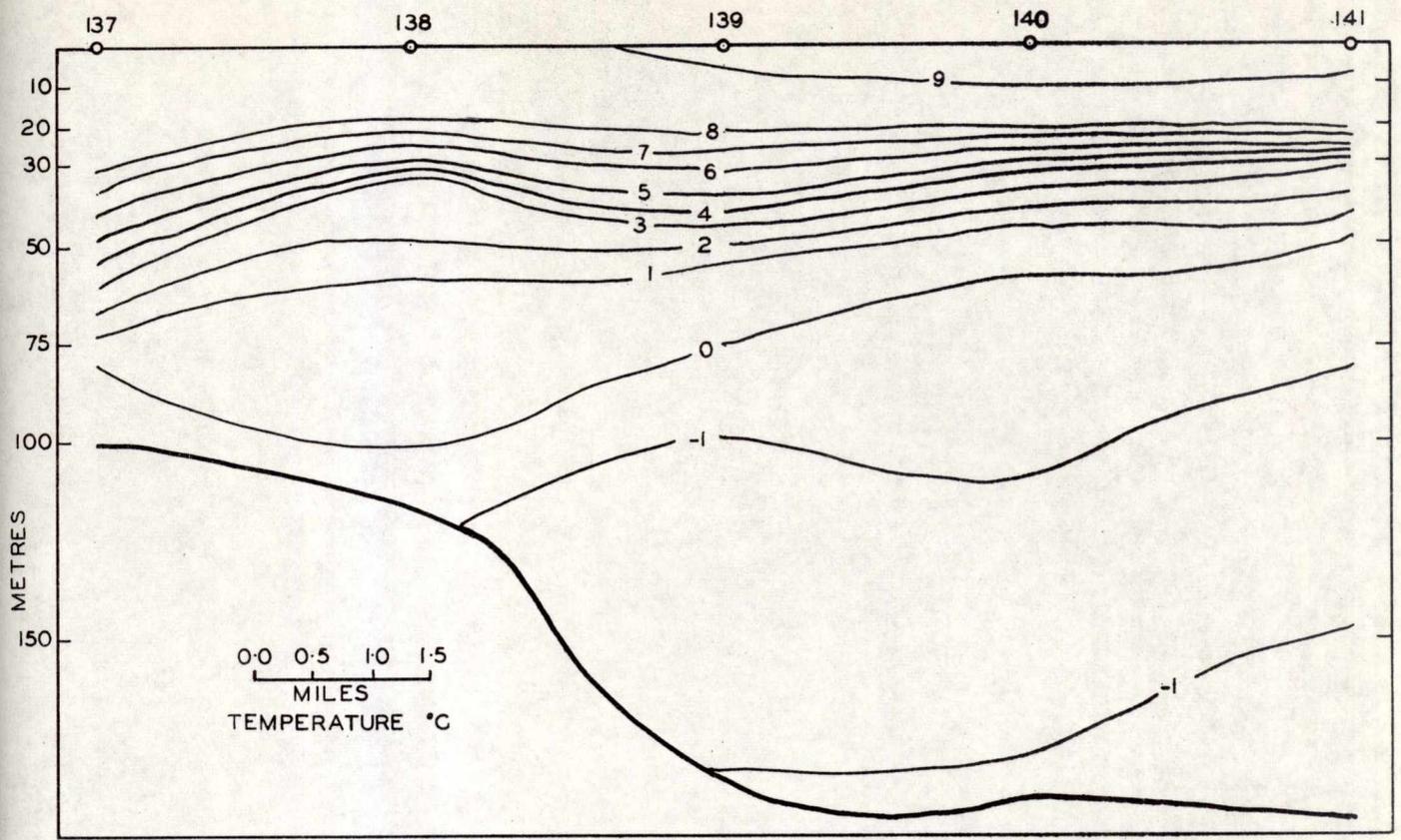


Fig. 8. Distribution of temperature and salinity in section between stations 137 and 141 in Trinity Bay.

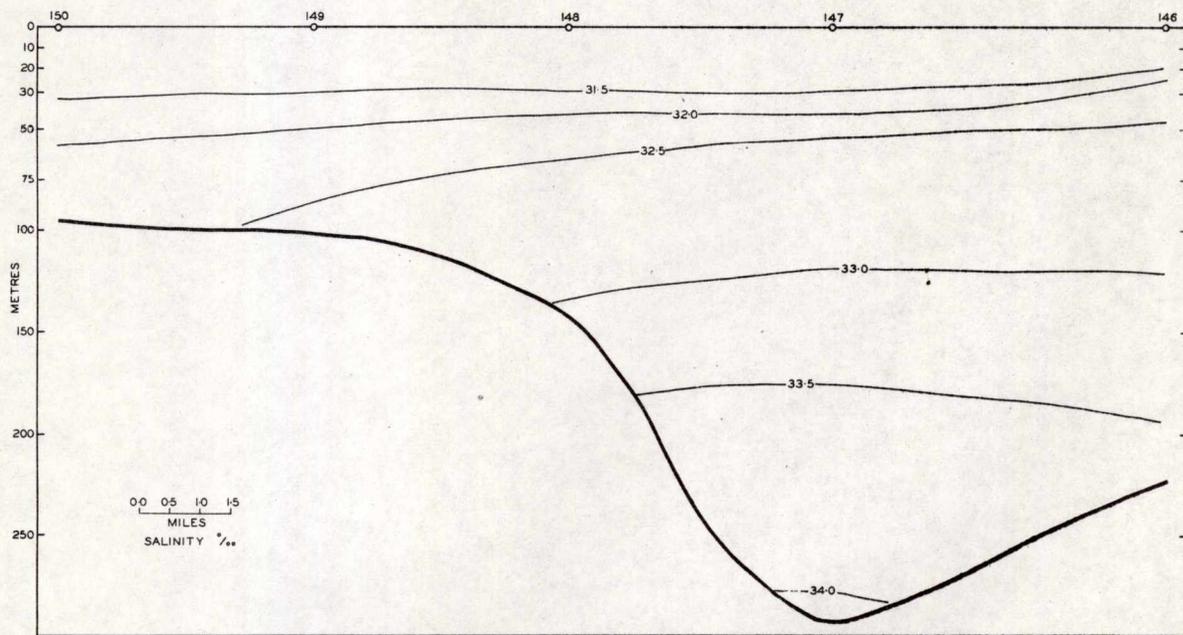
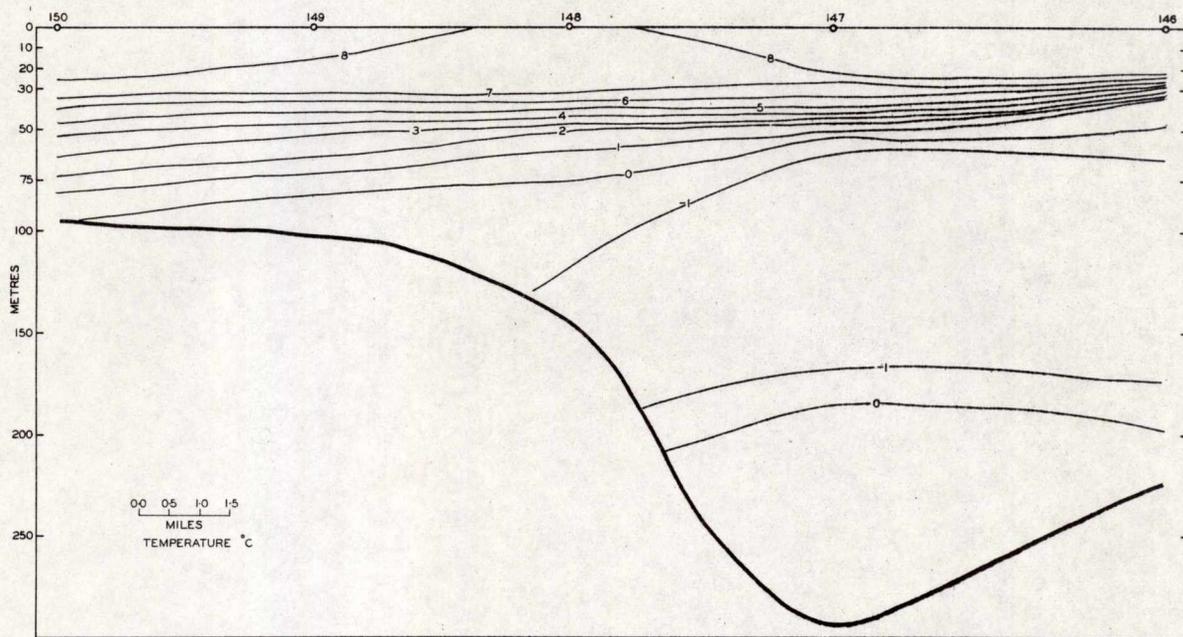


Fig. 9. Distribution of temperature and salinity in section between stations 150 and 146 in Trinity Bay.

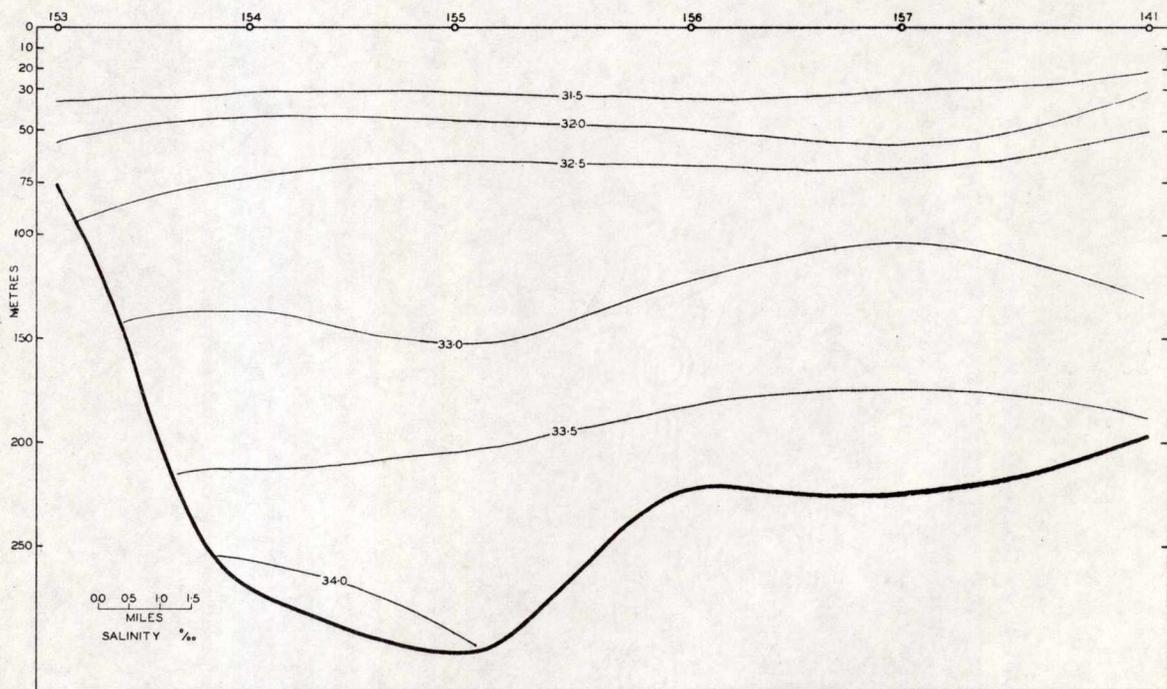
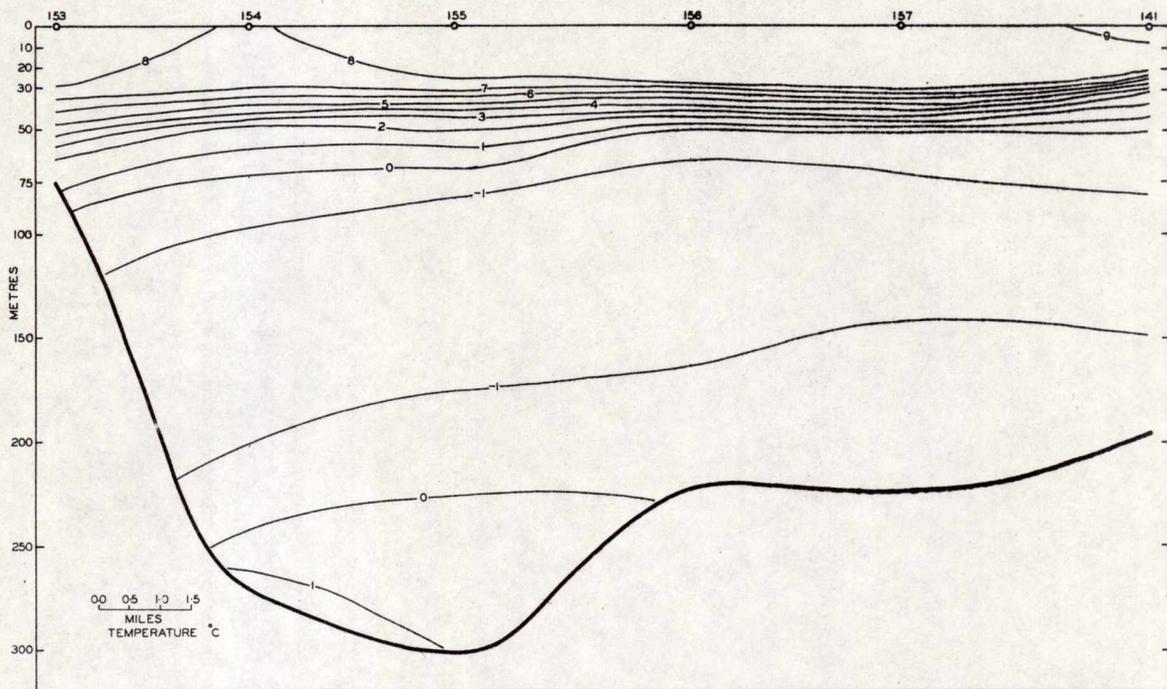


Fig. 10. Distribution of temperature and salinity in section between stations 153 and 141 in Trinity Bay.

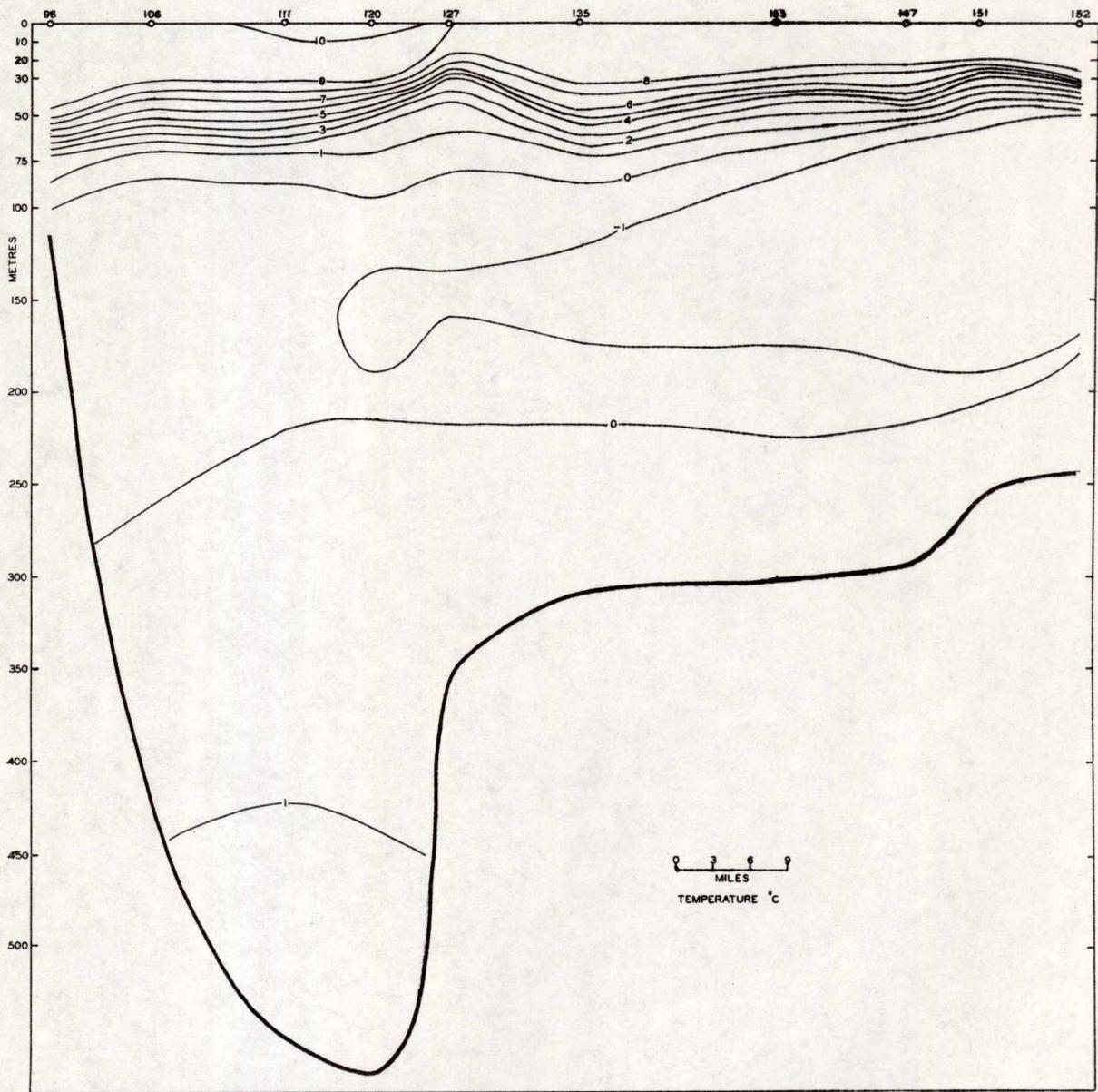


Fig. 11. Longitudinal distribution of temperature in Trinity Bay.

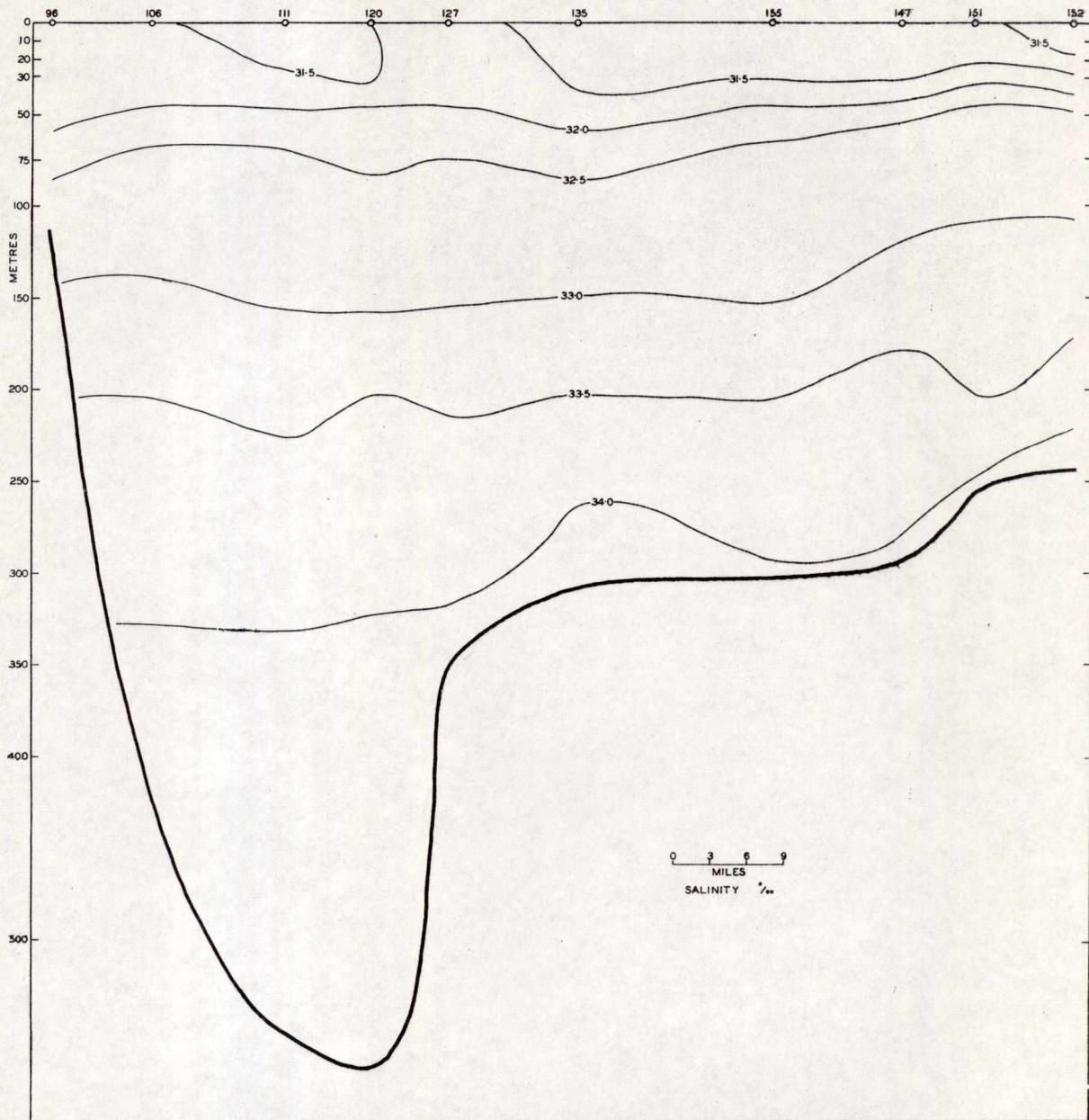


Fig. 12. Longitudinal distribution of salinity in Trinity Bay.

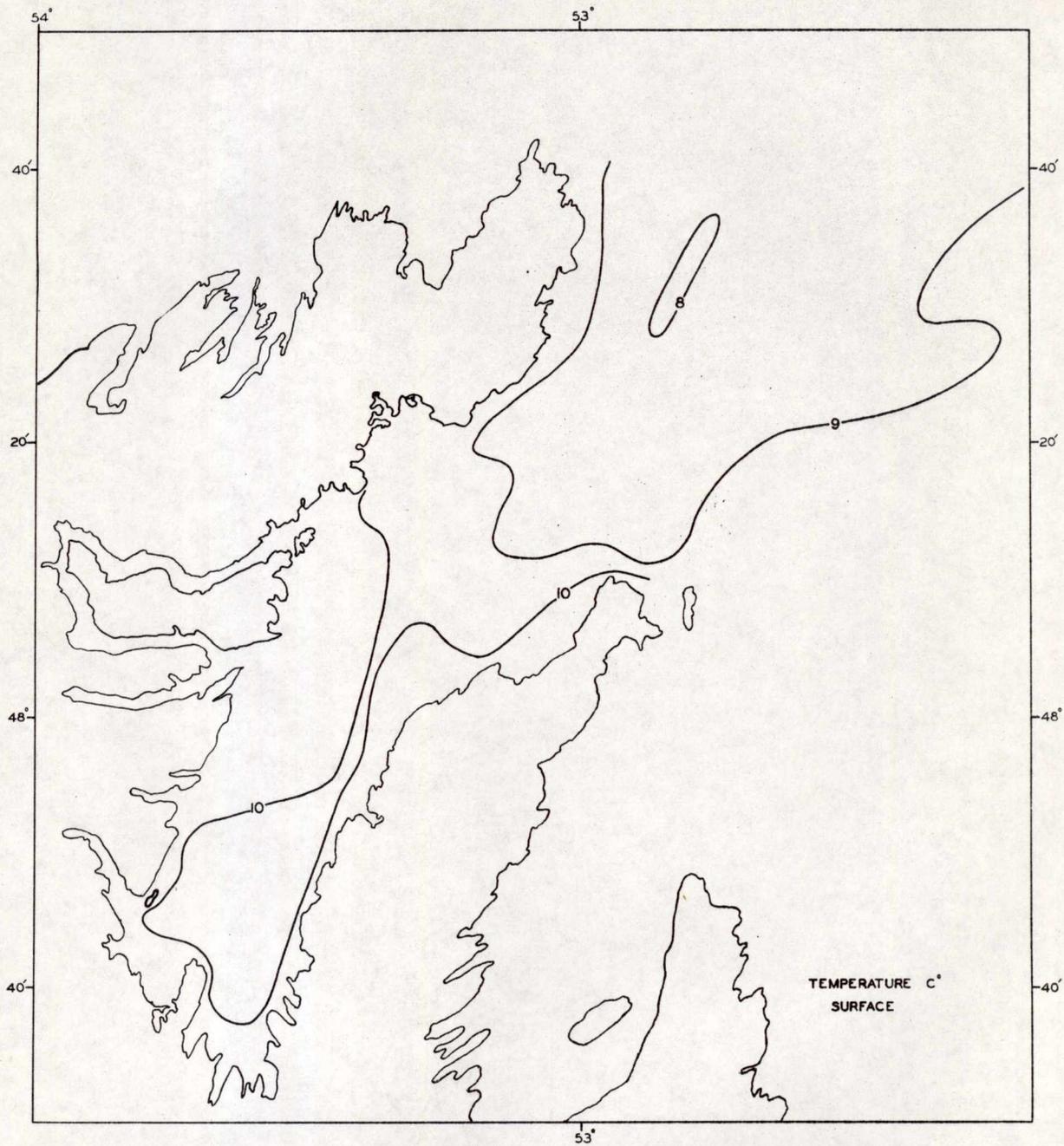


Fig. 13. Distribution of temperature at the surface, October 27 to 29, 1956.

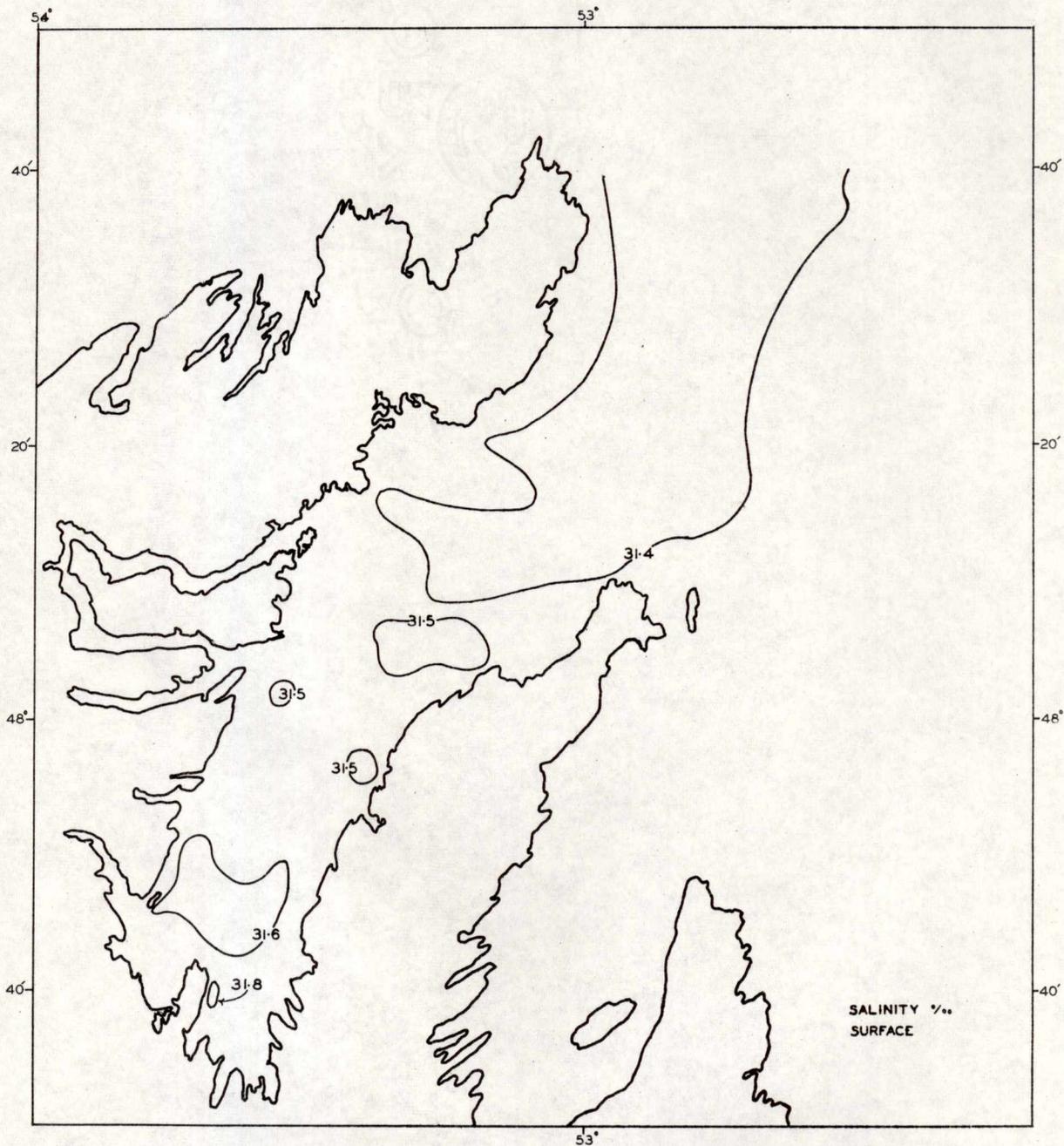


Fig. 14. Distribution of salinity at the surface, October 27 to 29, 1956.

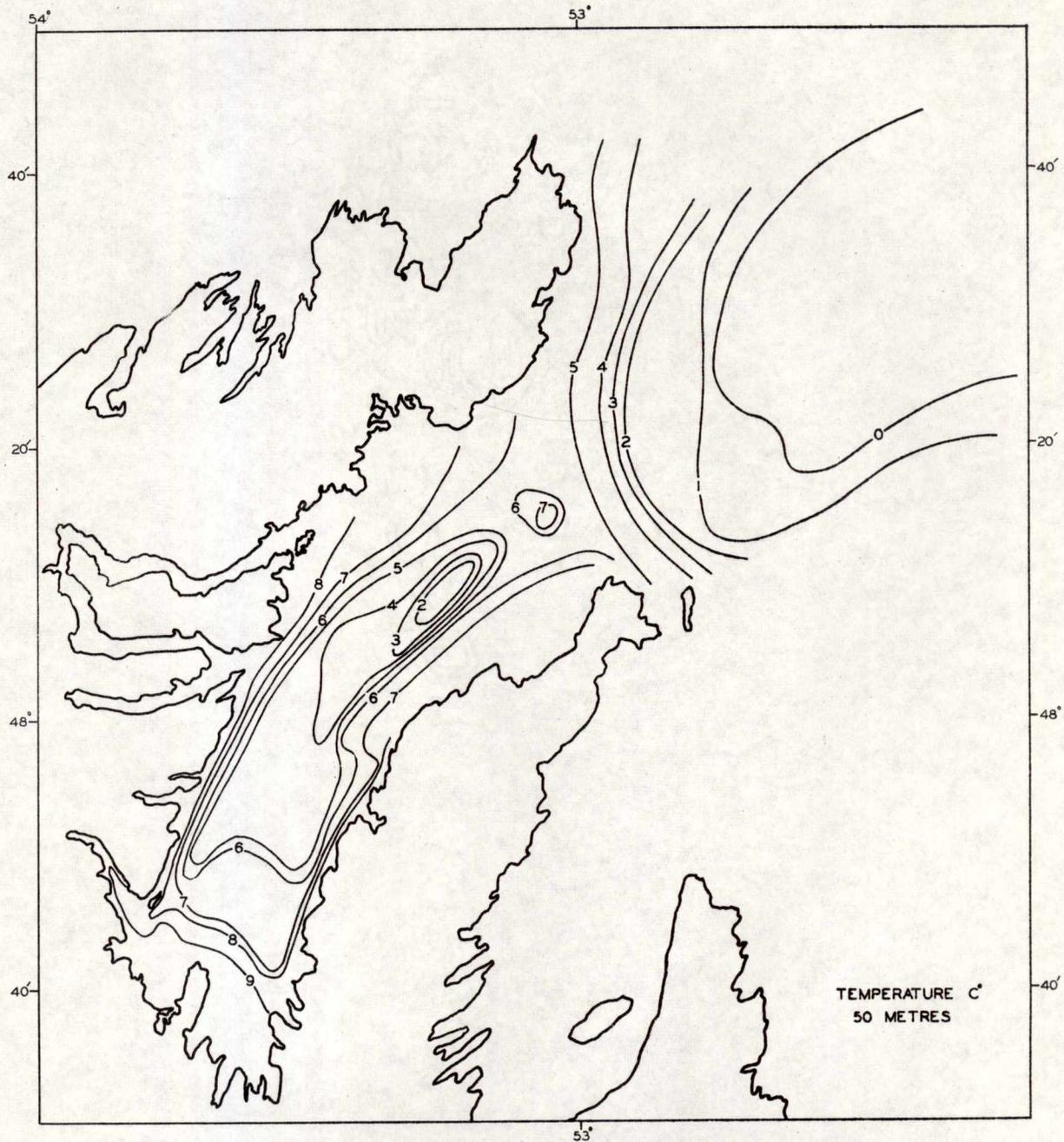


Fig. 15. Distribution of temperature at 50 metres, October 27 to 29, 1956.

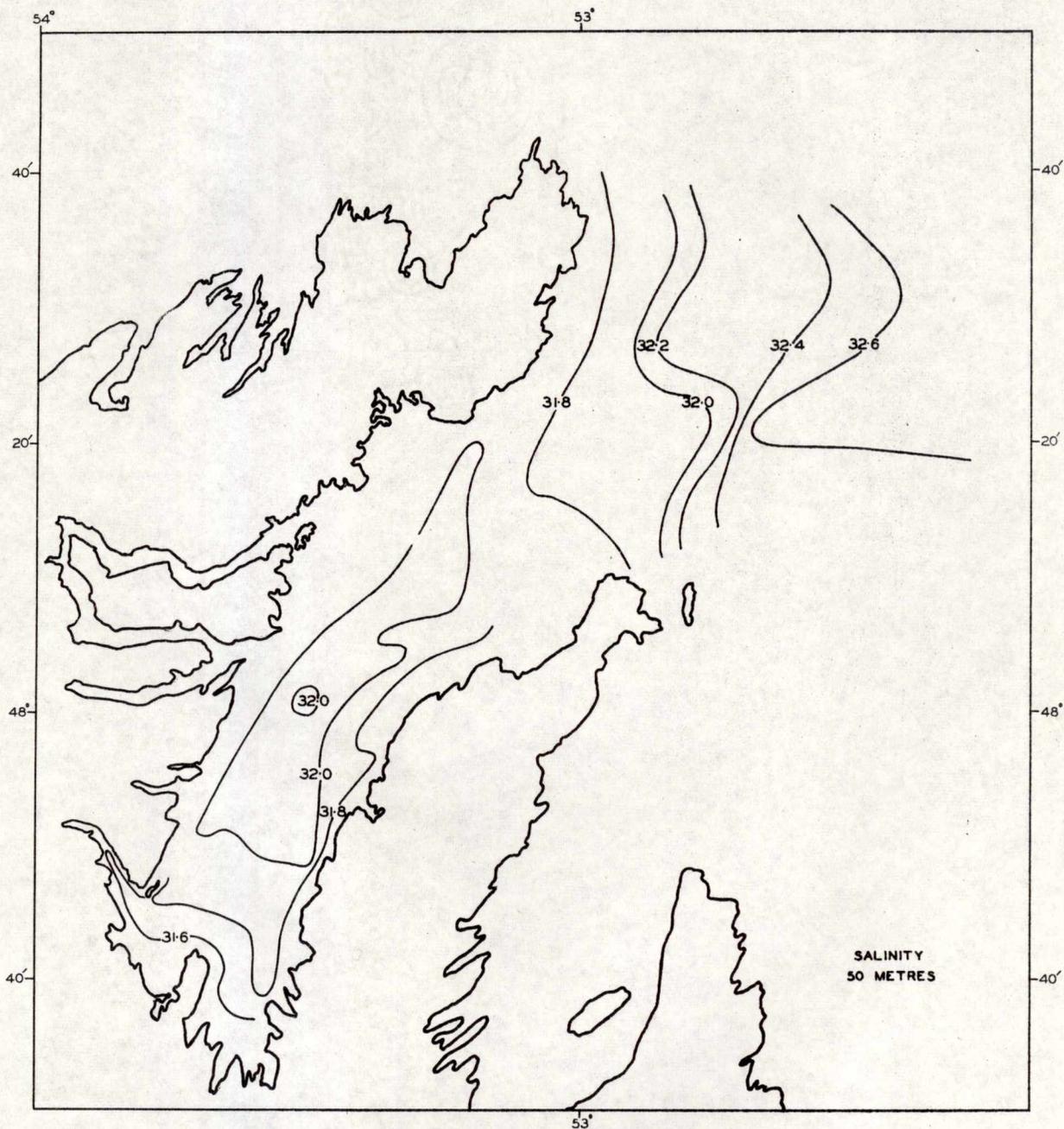


Fig. 16. Distribution of salinity at 50 metres, October 27 to 29, 1956.

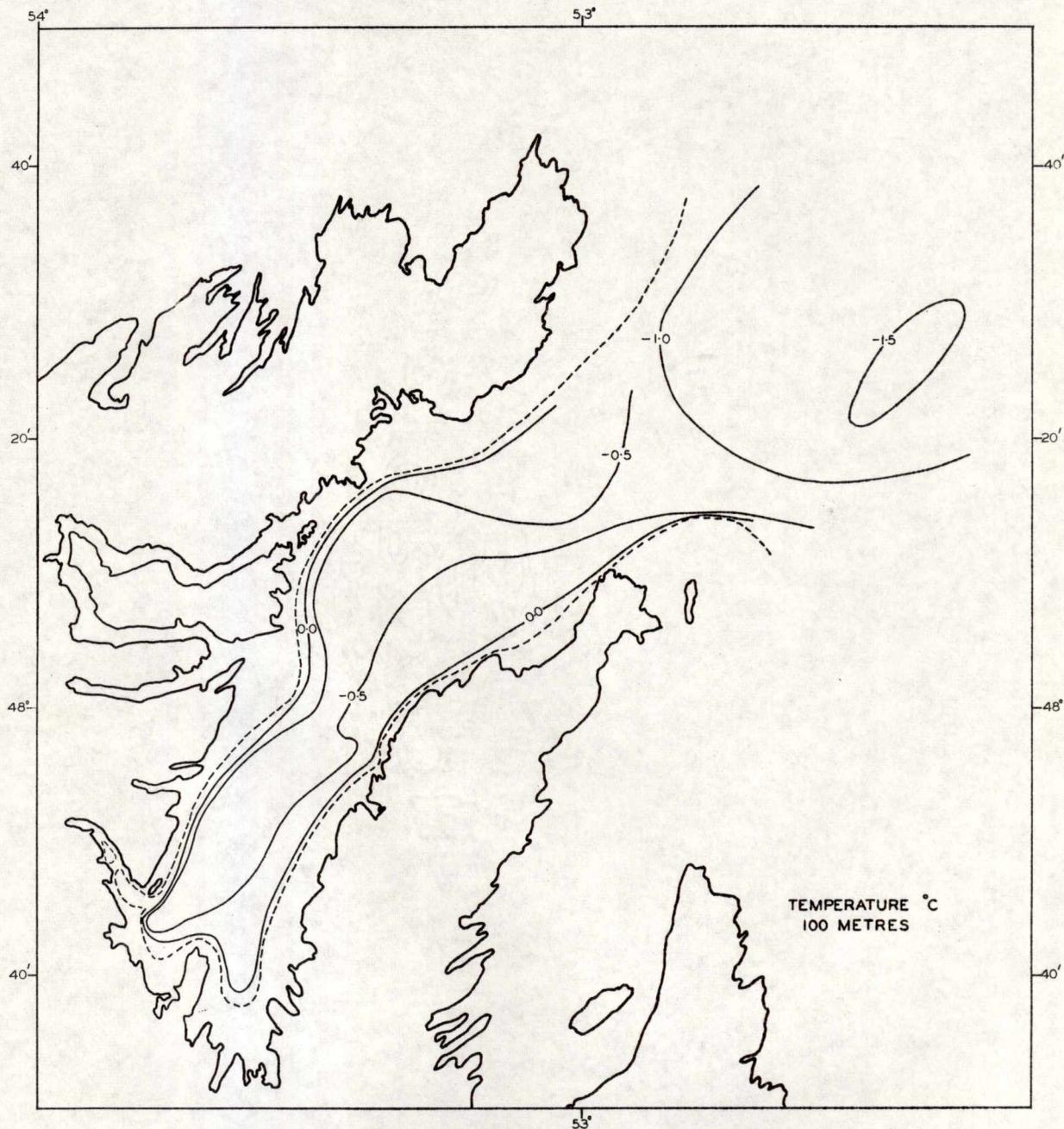


Fig. 17. Distribution of temperature at 100 metres, October 27 to 29, 1956.

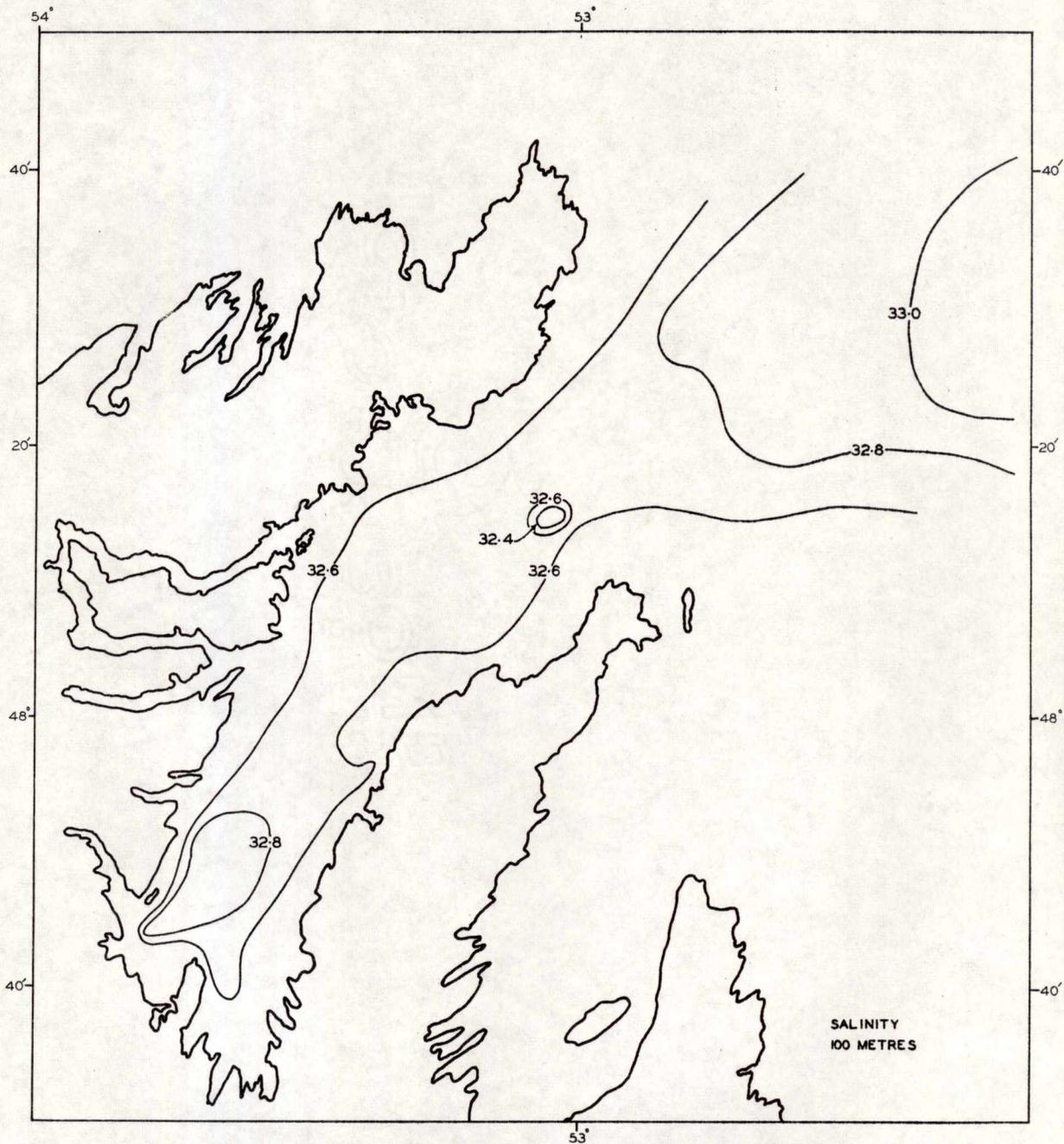


Fig. 18. Distribution of salinity at 100 metres, October 27 to 29, 1956.

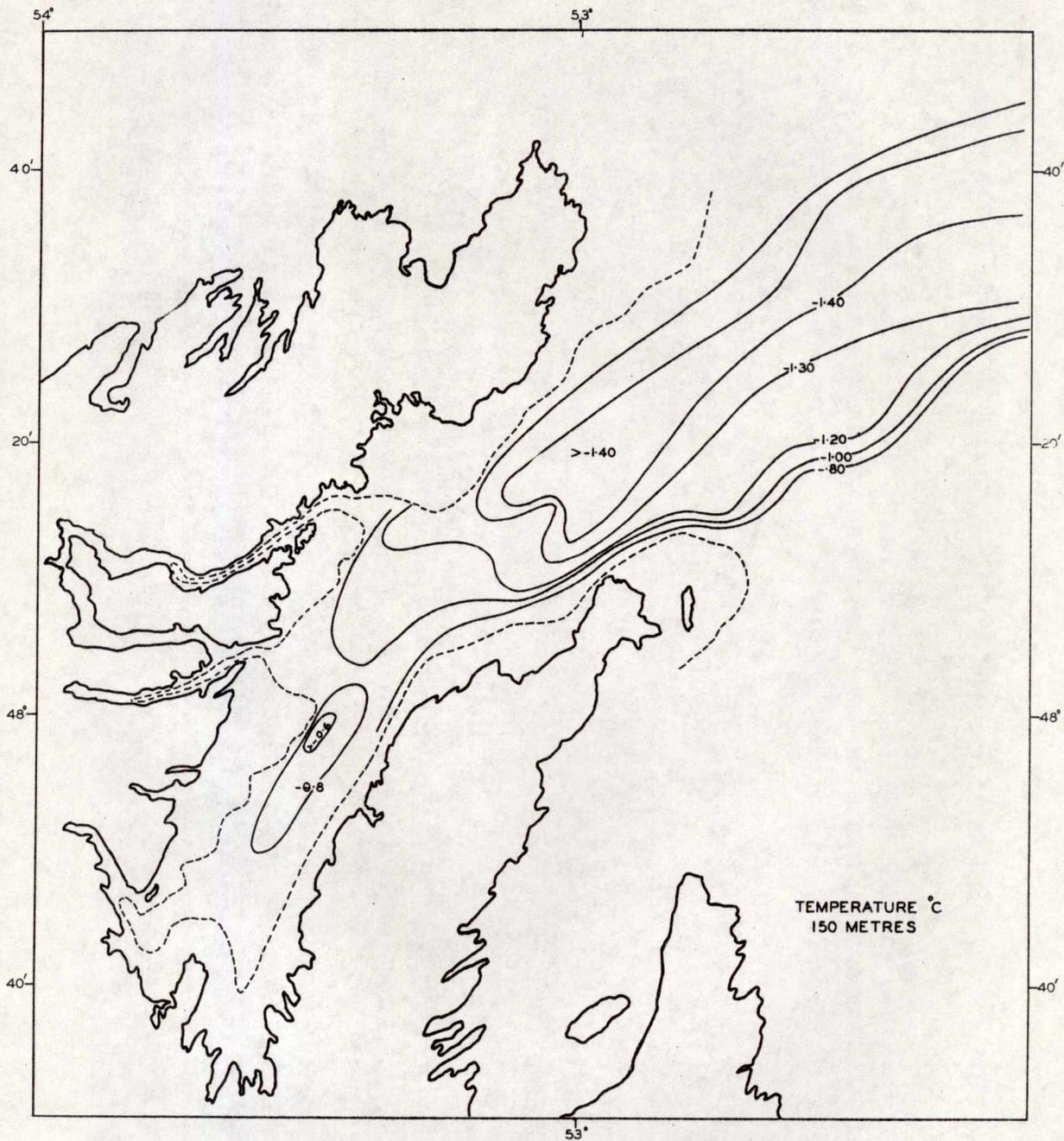


Fig. 19. Distribution of temperature at 150 metres, October 27 to 29, 1956.

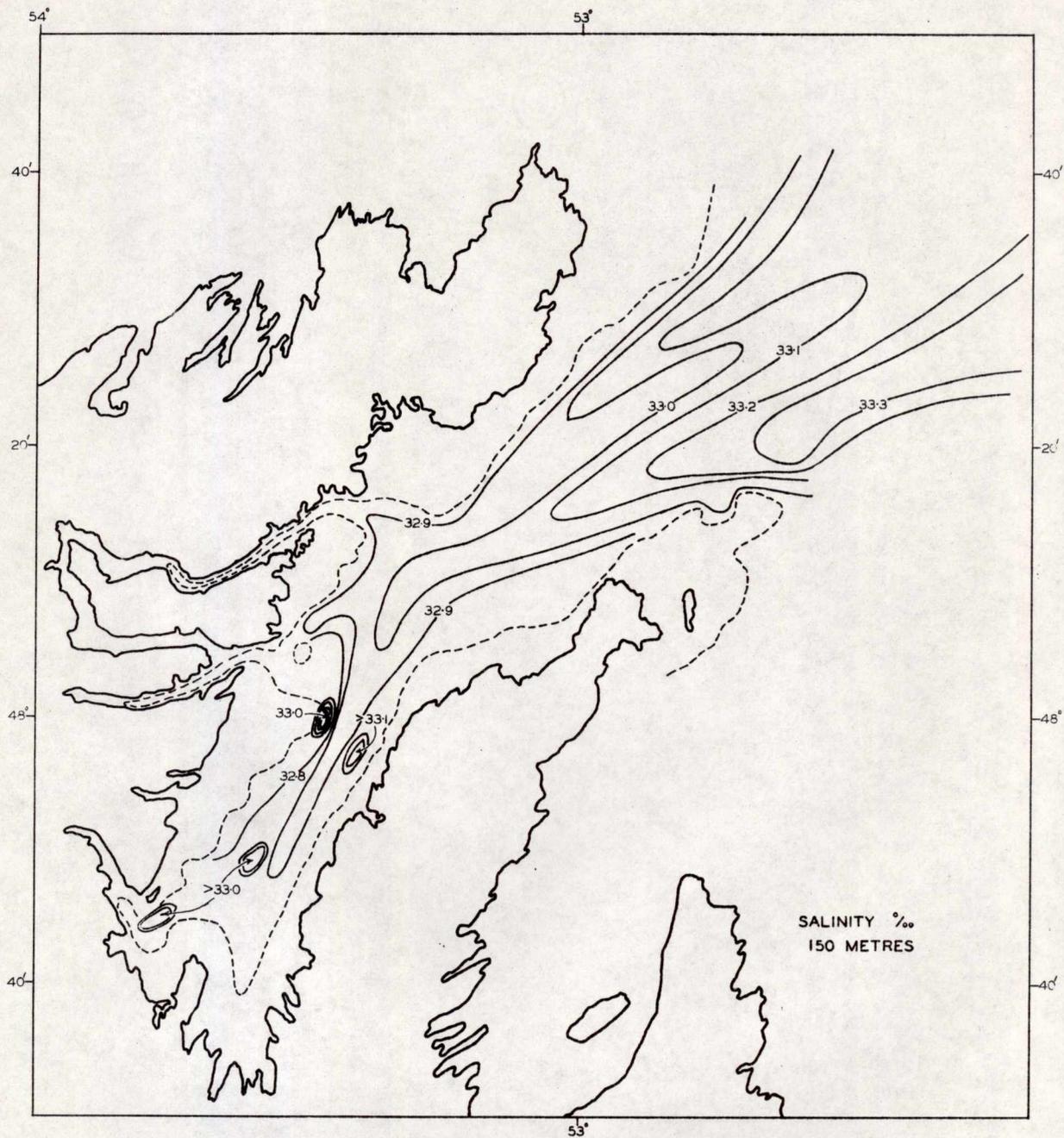


Fig. 20. Distribution of salinity at 150 metres, October 27 to 29, 1956

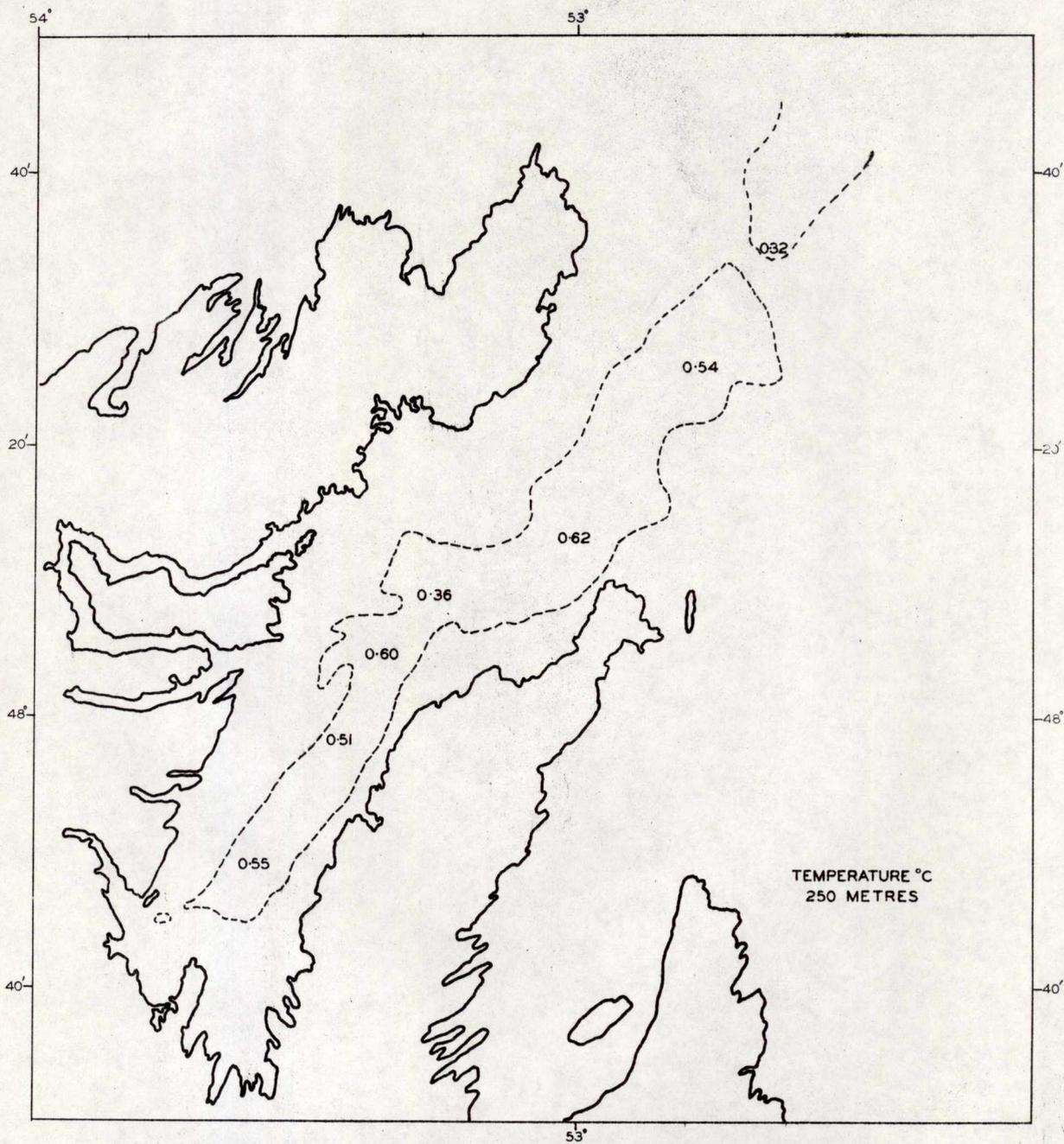


Fig. 21. Distribution of temperature at 250 metres, October 27 to 29, 1956.

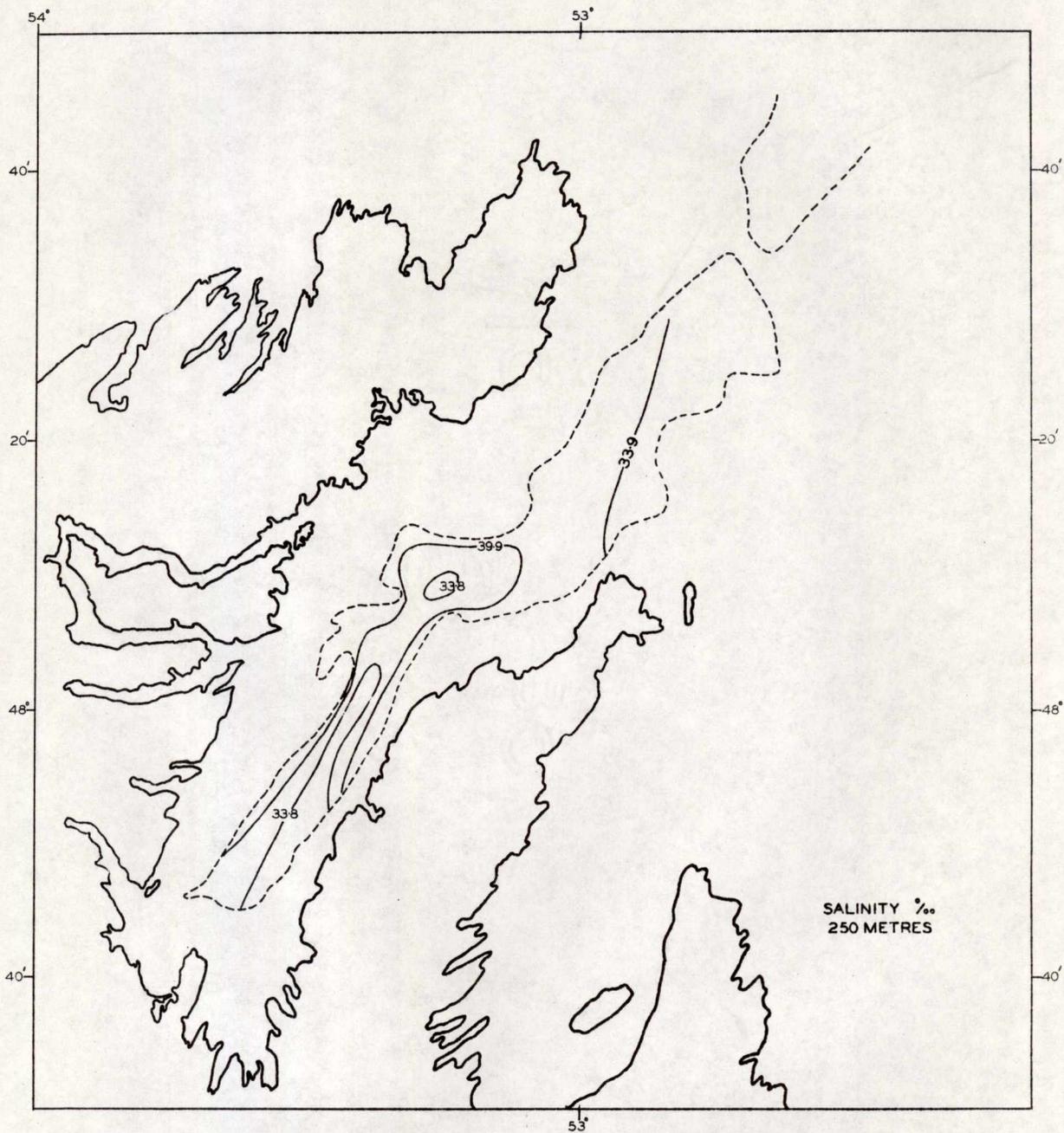


Fig. 22. Distribution of salinity at 250 metres, October 27 to 29, 1956.

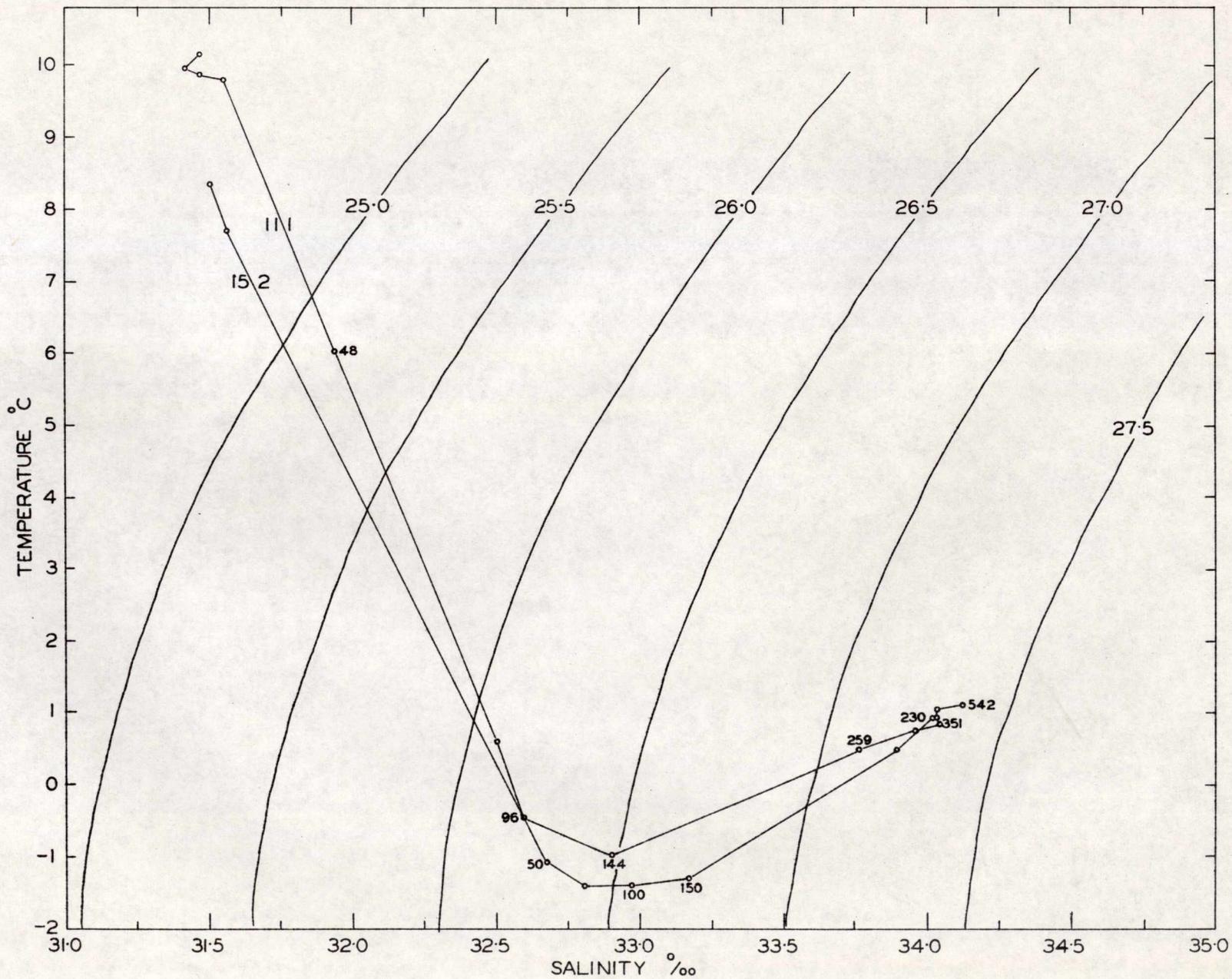


Fig. 23 Typical temperature-salinity correlation curves inside (111) and outside (152) Trinity Bay in late September 1956.

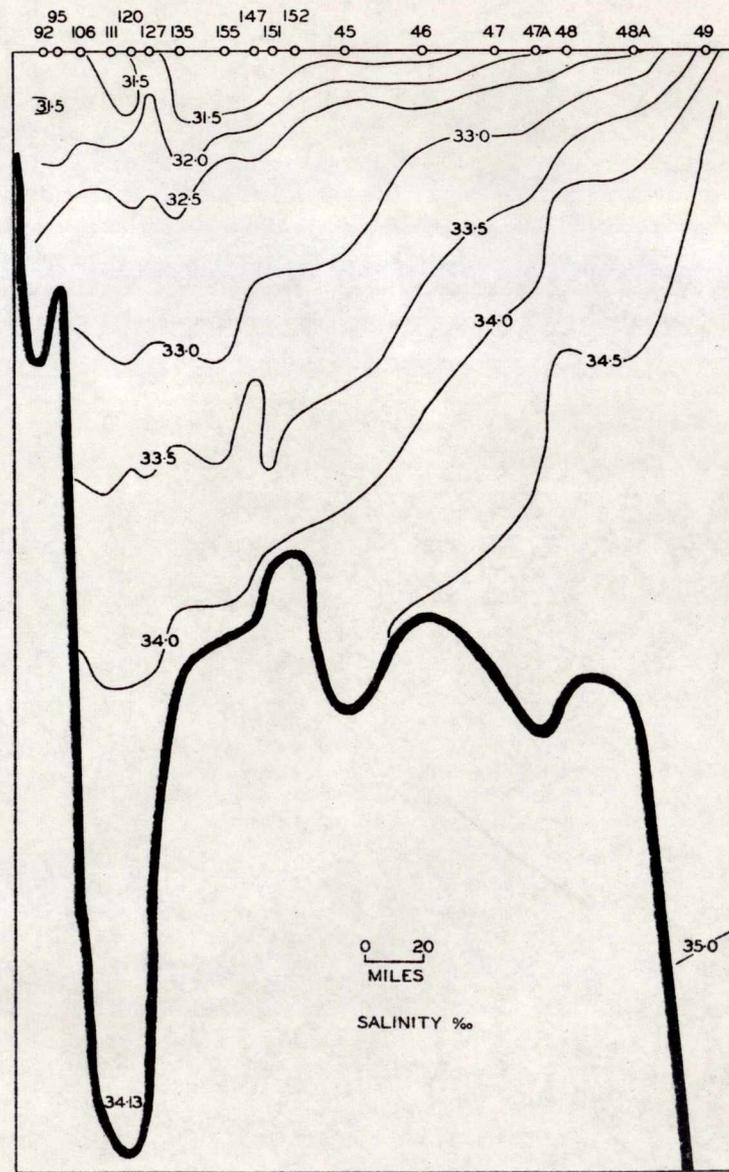
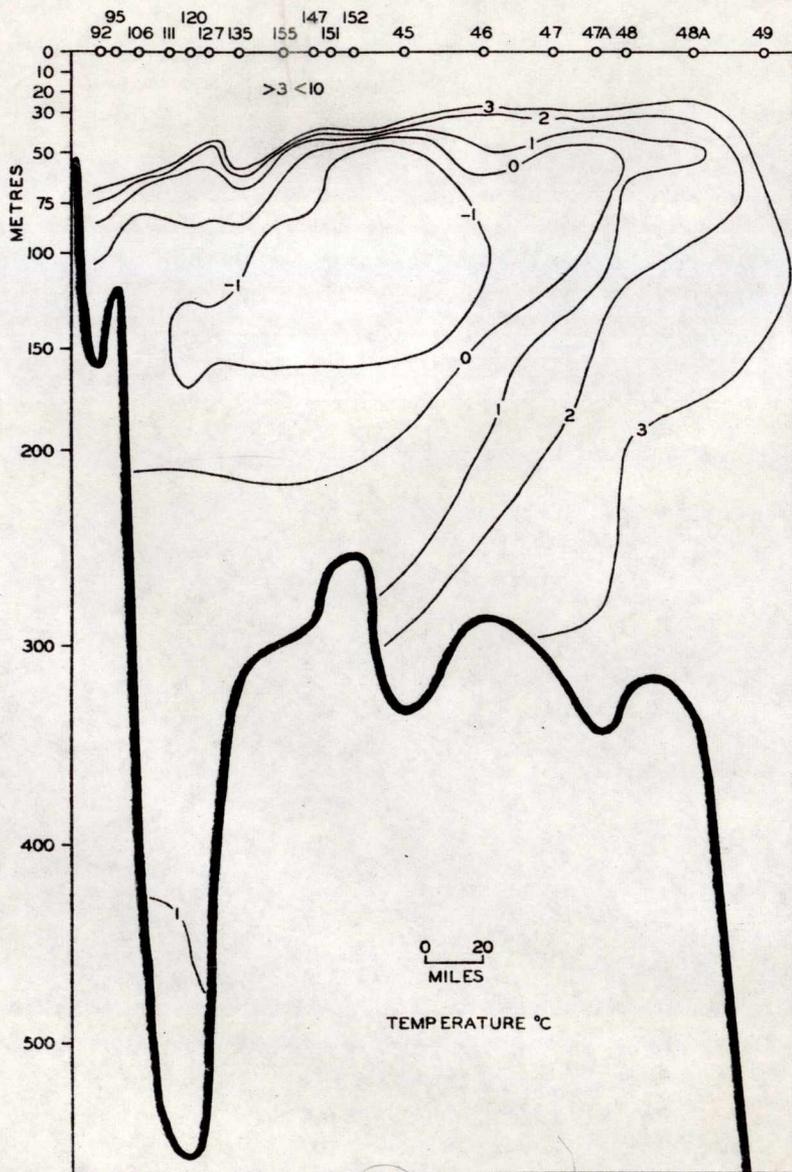


Fig. 24. Composite longitudinal distributions of temperature and salinity through Trinity Bay to the edge of the continental shelf.