387

ATLANTIC OCEANOGRAPHIC GROUP

St. Andrews, N. B.

#387

AN INCREASING ATLANTIC INFLUENCE IN HUDSON BAY

by

W. B. Bailey and H. B. Hachey

ATLANTIC OCEANOGRAPHIC GROUP
ST. ANDREWS, N. B.

An Increasing Atlantic Influence in Hudson Bay

by

W. B. Bailey and H. B. Hachey

Introduction

The waters of Hudson bay and Hudson strait are comparatively well known, and while considerable attention has been given to this area over the past quarter century, from the navigational point of view, little serious study has been given to the many and varied oceanographic problems of the area.

The first known attempt to determine oceanographic conditions in the Hudson bay region was made by Beauchemin in 1929 (Andersen 1931), while the first detailed examination was made by one of the authors (Hachey 1931) while officer in charge of the Hudson Bay Fisheries Expedition in 1930. The northern cruise of R.C.N. ships in 1948 provided an opportunity of making limited, but detailed oceanographic observations, which when compared with those made in 1930, allow for some interesting deductions on the increasing Atlantic influence in these areas.

The General Geography of Hudson Bay and Strait

Hudson bay, connected to the Arctic by Foxe channel, and to the Atlantic by Hudson strait, is a shallow flooding of the Great Continental Shelf surrounding the North Polar sea (Canada Year Book, 1947, p. 9). Constituting an inland sea, about 250,000 square miles in area, into which is poured the drainage water from 1,500,000

square miles of continent, Hudson bay has the character of an enormous estuarial basin. While soundings are too few to give a complete picture of the submarine physiography, the average depth of Hudson bay is about 70 fathoms (128 metres). The greatest charted depth of 141 fathoms (258 m.) is found in the centre of the bay and a deep water channel extends from this central depression to the greater depths of Hudson strait.

Hudson strait, 430 miles in length, connects Hudson bay with the Atlantic ocean. Width of the strait varies from 37 miles at the entrance to 120 miles near its western extremity, and the greatest charted depth is 481 fathoms (874 m.). The high, bold and broken coasts, the extremely irregular sea-floor, and the swift tidal currents combine to present what must be a mixing area of considerable extent, and must have an important role in determining the oceanographical features of the area.

The "Haida" Observations 1948

On the northern cruise of R.C.N. ships in 1948, the opportunity was provided of occupying a limited number of hydrographic stations from the H.M.C.S. "Haida". Eight stations were occupied in Hudson strait, five in early September and three in late September, while six stations were occupied in Hudson bay. The locations of all stations are shown in figure 1. In addition, the detailed vertical temperature distribution was obtained at 50 mile intervals from bathythermograms (Spilhaus 1938).

The Distribution of Temperature and Salinity in Hudson Strait

In early September the temperatures and salinities in section show Hudson strait to be an area of intense water movements

as indicated by the slope of the isotherms and isohalines in figures 2 and 3. The main body of water in Hudson strait, lying below the isotherm of 1.0°C. has salinities greater than 32.50 °/oo, and generally less than 34.00 °/oo. A large body of warm light surface water is pressed against the south side of Hudson strait as indicated by the slope of the isotherms and isohalines at stations 9H and 10H.

Surface warming to a temperature greater than 3.0°C. is indicated by the slope of the 2.0°C. isotherm on both sides of Hudson strait. The water in the centre has a temperature of approximately 2.0°C. In early September the surface waters are generally of temperatures greater than 3.5°C. and of salinities less than 32.00 °/oo.

Temperature and salinity sections taken in Hudson strait in late September are shown in figures 4 and 5. Comparatively strong temperature stratification of the upper 50 metres of water is located in the vicinity of station 25H, while strong vertical mixing is indicated by the downward slope of the isotherms between stations 26H and 27H. The warmest and coldest waters are found in the vicinity of station 25H with temperatures ranging from 3.5°C. to -0.6°C.

Further evidence of the great mixing taking place in Hudson strait is afforded by the salinity distribution shown in figure 5, which indicates a certain amount of homogeneity in the water mass. Salinities range from 32.50°/oo at the surface to 34.00 °/oo at 300 metres. The main portion of the water below 50 metres has temperatures less than 0.0°C. and salinities greater than 33.00 °/oo.

The main features of the waters of Hudson strait, shown particularly by the late September sections (figures 4 and 5) are:

(a) the decreasing stratification both as to temperature and salinity in the upper fifty metres from west to east;

(b) the vertical mixing, as shown by the comparative uniformity of temperatures and salinities in the eastern portion of the strait; and

(c) the increasing temperatures of the main body of water below fifty metres from west to east.

Temperature observations made with a bathythermograph at seven stations within the strait give detailed vertical temperature distribution as shown in figure 6. Station B47 would seem to mark the transition area, where the stratification in the upper fifty metres changes over to the more mixed columns found at B48 and B49.

Distribution of Temperature and Salinity in Hudson Bay

Temperatures and salinities in September 1948 are plotted in a section running southwest from Hudson strait to Churchill, in figures 7 and 8.

The main features of the waters in Hudson bay are: (1) the marked stratification of the upper 50 metres; (2) the main body of cold water below 50 metres with temperatures less than -1.0°C., (3) the isothermal nature of the surface layers to depths of 10 to 25 metres; (4) the low salinities in the surface layers.

The main body of water in Hudson bay has temperatures less than -1.0°C. and salinities greater than 32.50 °/oo. The lowest temperature of -1.6°C. and a high salinity of 33.50 °/oo are found

in the vicinity of station 15H.

On the surface, temperatures are greater than 6.8°C., with a high of 7.8°C. at station 18H. All salinities down to the 25 metre level are less than 31.00 °/oo. In the vicinity of stations 14H and 15H a body of water of salinities less than 29.30 °/oo is found.

Typical bathythermograph traces, running in succession from Hudson bay to the mouth of Hudson strait, are shown in figure 9. The waters of Hudson bay, as indicated by these traces, are shown to have a very marked transition between the surface waters which are warm and nearly isothermal, to the cold isothermal main body of water in the bay. On approaching Hudson strait the depth of the isothermal surface layer is seen to decrease and the main body of water seems perceptibly warmer. On passing through Hudson strait the increased temperature of the deep waters and the lowered temperature of the surface waters are indicative of vertical mixing, until at the mouth of Hudson strait all of the water to a depth of 150 metres has a uniform temperature of approximately 2.0°C. Thus a decrease of 5.0°C. in temperature at the surface and an increase of 2.8°C. at the 100 metre level are to be observed in the west to east passage through Hudson strait.

Temperature-Salinity Diagrams

On the basis of the observations made from "Haida" in September, 1948, the temperature and salinity relationships in Hudson strait are shown in figure 10. The diagram gives pre-eminence only to two characteristic water masses as follows:

(a) A-water exhibiting temperatures greater than 3.5°C. and salinities between 29.50 and 32.00 °/oo;

(b) B-water exhibiting temperatures between -0.8 and 0.1°C., and salinities between 32.90 and 33.80 °/oo.

The character of A-water, found at the surface, is greatly influenced by land drainage which causes a large variation in salinities. B-water, found below the fifty metre level, has the characteristics of Baffin Land current water (Smith, Soule and Mosby 1937) and is probably of the same characteristics as Foxe basin water. There are indications of the influence of water of the West Greenland current as indicated by salinities greater than 33.50 °/oo (Smith, Soule and Mosby 1937). All other water is a mixture of A-water and B-water.

The T-S diagram shows that the inner stations in Hudson strait (stations 11H and 12H) tend to be colder at greater depths than the outer stations 8H, 25H and 26H. The latter stations contain waters of the Baffin Land current, slightly modified, at greater depths, by the Greenland current, while the former stations contain waters from Foxe basin.

The temperature and salinity relationships in Hudson bay in 1948 are shown in figure 11. Two characteristic water masses are indicated as follows:

(a) C-water exhibiting temperatures greater than 4.0°C. and salinities less than 31.50 °/oo;

(b) D-water exhibiting temperatures between -0.5 and -1.5°C. and salinities between 32.00 and 33.50 °/oo.

C-water is of the surface layer which is largely influenced by land drainage and surface warming. D-water found below the fifty metre level is, probably in greater part, surface water that has cooled during the winter when the surface waters have salinities greater than 32.00 °/oo and has sunk to its own density level. In lesser part, D-water contains the higher salinities derived from water movements from Foxe channel or Hudson strait.

A Comparison of the Waters of Hudson Bay in 1930 and 1948

The temperature and salinity relationships in Hudson bay in 1930 (Hachey 1931) are shown in figure 12, and, in comparison with 1948 (figure 11), the characteristic D-water may be described as follows:

(a) 1930, exhibiting temperatures between -0.5 and -1.8°C. and salinities between 31.00 and 33.20 °/oo;

(b) 1948, exhibiting temperatures between -0.5 and -1.5°C. and salinities between 32.00 and 33.50 °/oo.

In addition it will be noted that salinities greater than 32.80 °/oo were found only at one station in 1930, and were found at all stations in 1948. The deeper waters were generally of lower temperatures in 1930 than in 1948.

Discussion

Observations in 1930 showed that below fifty metres the water temperatures were at least -1.8°C. with corresponding salinities from 31.50 to 33.17 °/oo (Hachey 1931). It was concluded that the waters below fifty metres were, for all purposes, dynamically dead, thus resulting in a cold, saline body of water which probably

undergoes very little change from season to season. The observations in 1948 would indicate that the waters of Hudson bay are not dynamically dead, but that there is a strong influence from the oceans through Foxe channel and Hudson strait. This is clearly indicated by the higher temperatures and salinities in 1948 as compared to 1930. In particular, the higher salinities are of greater significance, not only in indicating that replacement of the deeper waters does take place, but also in reflecting an increased Atlantic influence in the subarctic waters.

Increasing Atlantic influence in the Greenland area as indicated by increasing salinities, the retreat of the sea ice, the weakening of arctic water, important changes in marine fauna, including commercial fishes, and the marked reduction in the transportation of floe ice from east to west Greenland waters, has been discussed by various writers (Dunbar 1946). This increasing Atlantic influence would seem, on the basis of the comparatively higher salinities in the deeper waters in 1948, to be reflected in the Hudson bay area. Hudson bay would seem to offer an excellent area for studying phenomena associated with the pulsation of the Atlantic influence in the Subarctic. The opportunity to study the vagaries of arctic influence through observations of the water movements of ice and water from Foxe basin and channel is equally important.

<u>Summary</u>

I. The temperature and salinity distributions in a section running through Hudson strait are described for September, 1948, as having the main body of water of temperatures between 1.0 and -0.6°C. with salinities greater than

32.50 °/oo and generally less than 34.00 °/oo, while on the surface, temperatures greater than 3.5°C. and salinities less than 32.00 °/oo are found.

II. The main features of the waters of Hudson strait so shown by the sections are:

(a) the decreasing stratification both as to temperature and salinity in the upper fifty metres from west to east;

(b) the vertical mixing, as shown by the comparative uniformity of temperatures and salinities in the eastern portion of the strait, and

(c) the increasing temperatures of the main body of water below fifty metres from west to east.

III. The temperature and salinity distributions in section are described for Hudson bay in September 1948 as having:

(a) a marked stratification in the upper 50 metres,

(b) the main body of cold water below 50 metres with temperatures less than -1.0°C. and salinities from 32.50 to 33.50 °/oo, and

(c) a nearly isothermal surface layer to depths of 10 to 25 metres with temperatures as high as 7.8°C. and salinities as low as 29.30 °/oo.

IV. Typical bathythermograph traces taken in Hudson strait show a decreas of 5.0°C. in temperature on the surface, and an increase of 2.8°C. at the 100 metre level in the west to east passage through Hudson strait.

V. Temperature and salinity diagrams for Hudson bay and Hudson strait are discussed for September 1948 and show the waters to be derived from two different water masses in each case.

VI. The waters from Baffin Land current and from Foxe basin are shown to exhibit similar temperature and salinity characteristics.

VII. The observations in 1948 indicate that replacement of the deep waters of Hudson bay takes place on a large scale, the higher salinities observed, as compared to 1930, reflecting an increased Atlantic influence.

Acknowledgements

The observations discussed herein were made possible through the co-operation of the Defence Research Board of Canada, the Royal Canadian Navy, and the Canadian Joint Committee on Oceanography.

References

Andersen, F. Canadian Hydrographic Service 63rd Annual Report, Department of Marine and Fisheries, pp. 106-136, Ottawa, 1931.

Dunbar, M. S. The State of the West Greenland Current up to 1944. Journal of the Fisheries Research Board of Canada, VI (7) (460-471), 1946.

Hachey, H. B. The General Hydrography and Hydrodynamics of the Waters of the Hudson Bay Region. Contributions to Canadian Biology and Fisheries VII (9) (93-118), 1931.

Smith, E. H., F. M. Soule and Olav Mosby The "Marion and General Greene" Expedition to Davis Strait and Labrador Sea. Scientific results, physical oceanography. U. S. Coast Guard Bulletin, No. 19, Part 2, Washington, 1937.

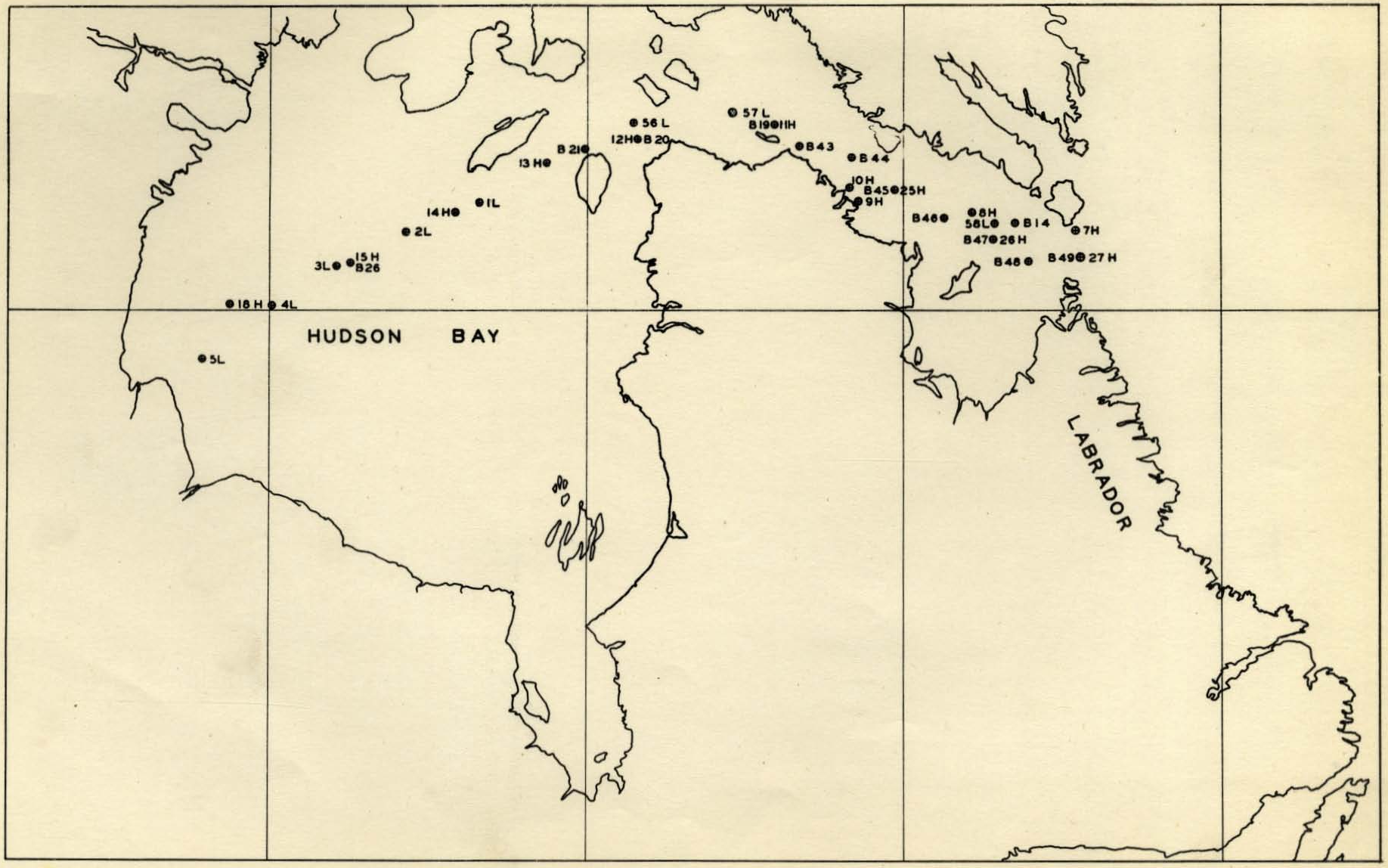

Fig. 1. Hudson Bay and Strait showing the locations of "Haida" stations and positions of bathythermograph observations, September, 1948, and "Loubyrne" stations in 1930

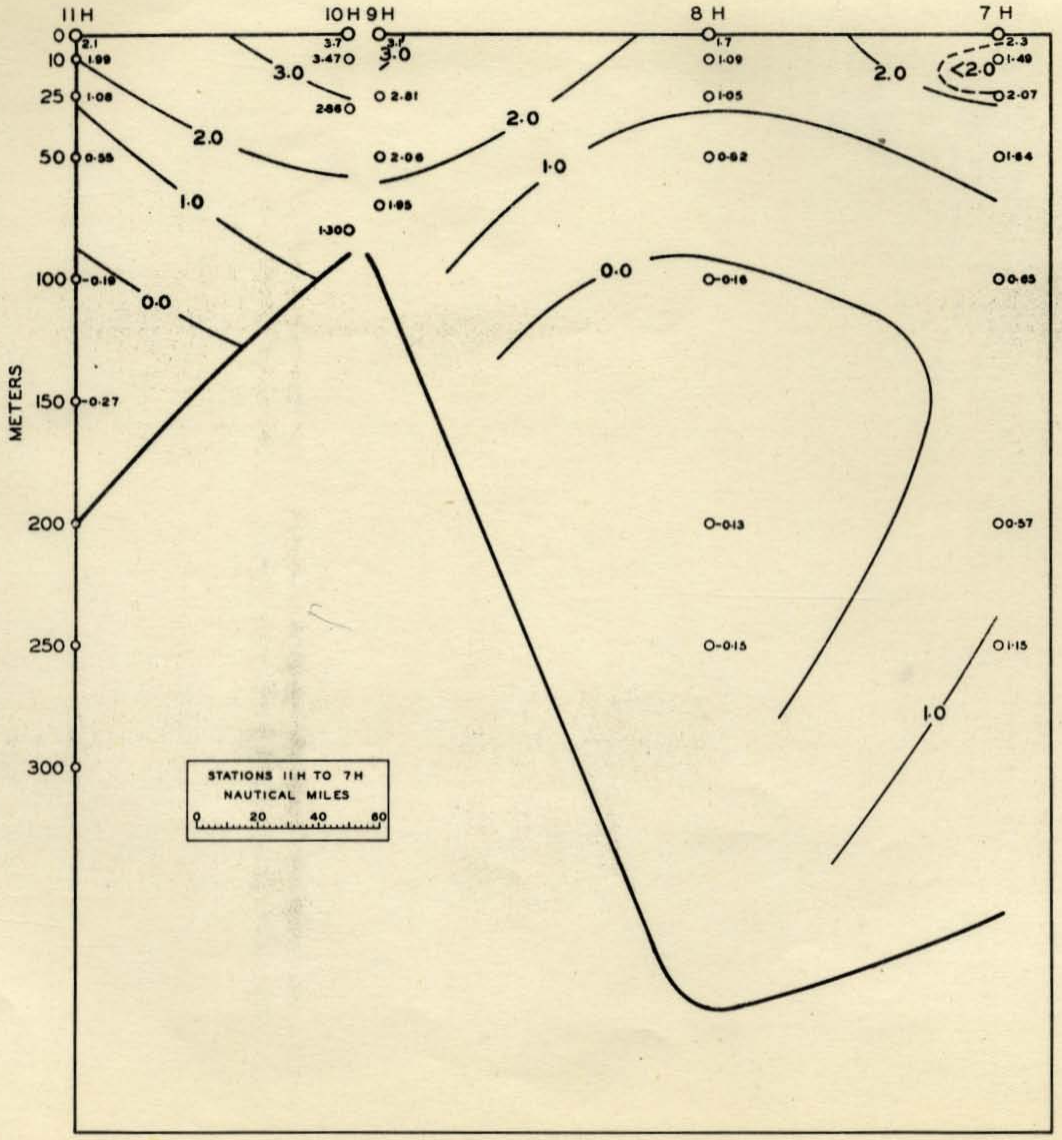

Fig. 2. Temperatures in section in Hudson Strait September 6-9, 1948.

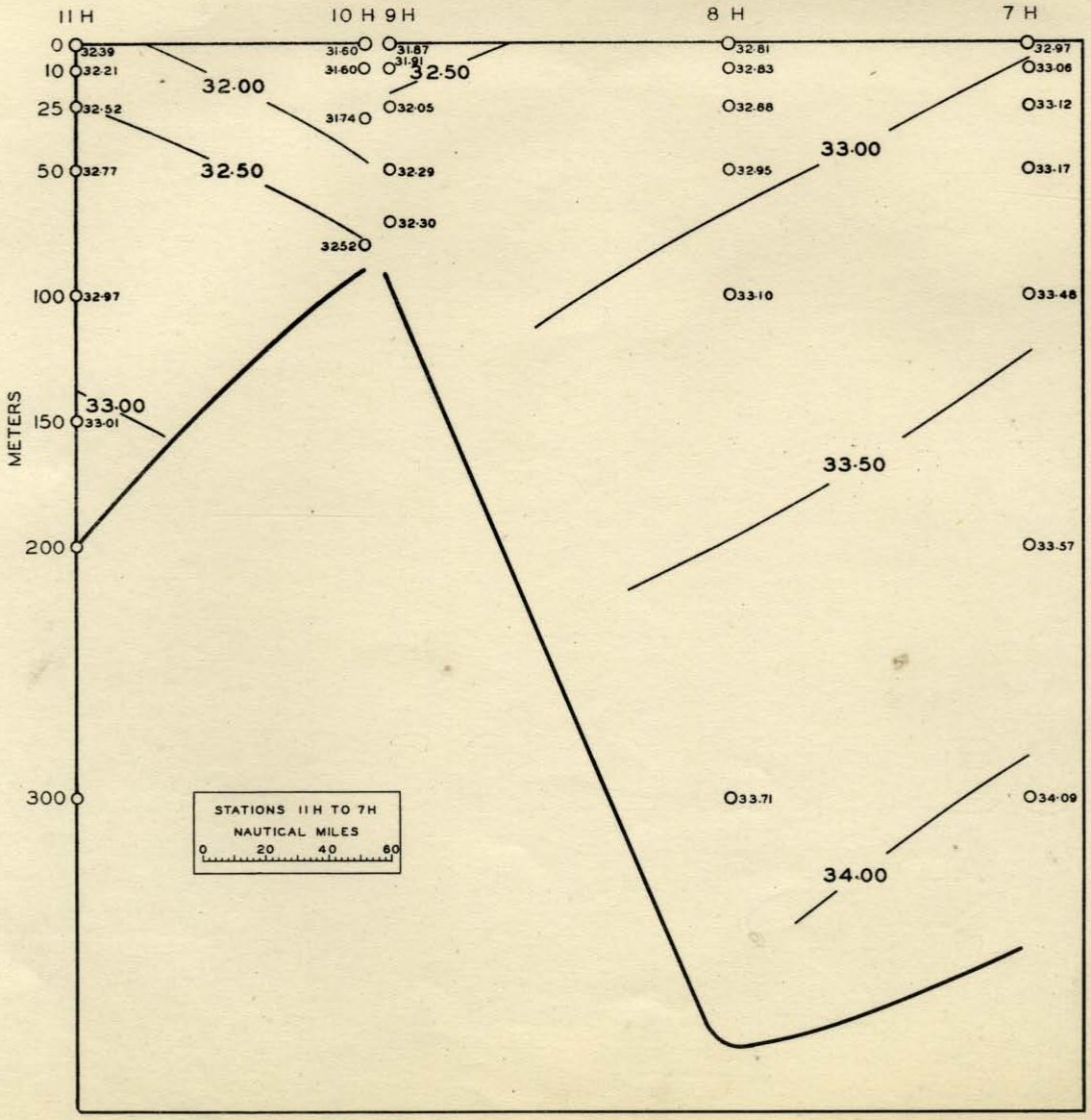

Fig. 3. Salinities in section in Hudson Strait September 6-9, 1948.

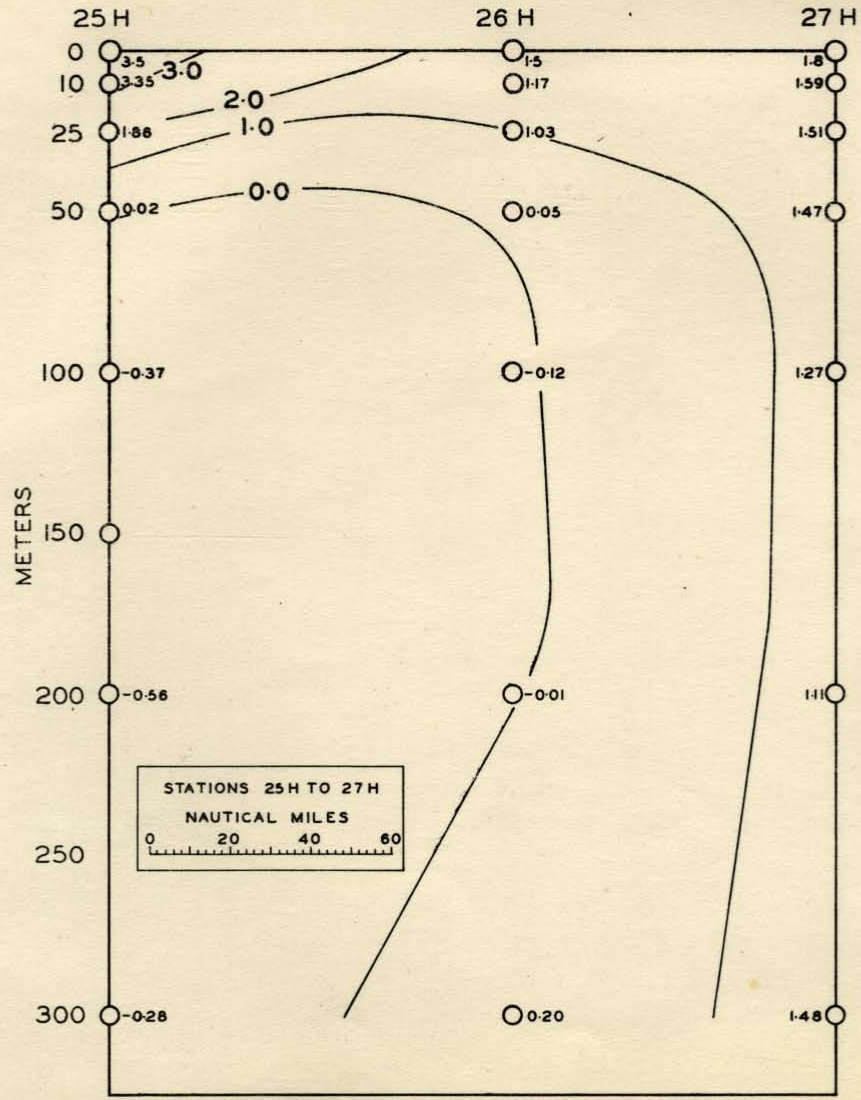

Fig. 4. Temperatures in section in Hudson Strait September 20-23, 1948.

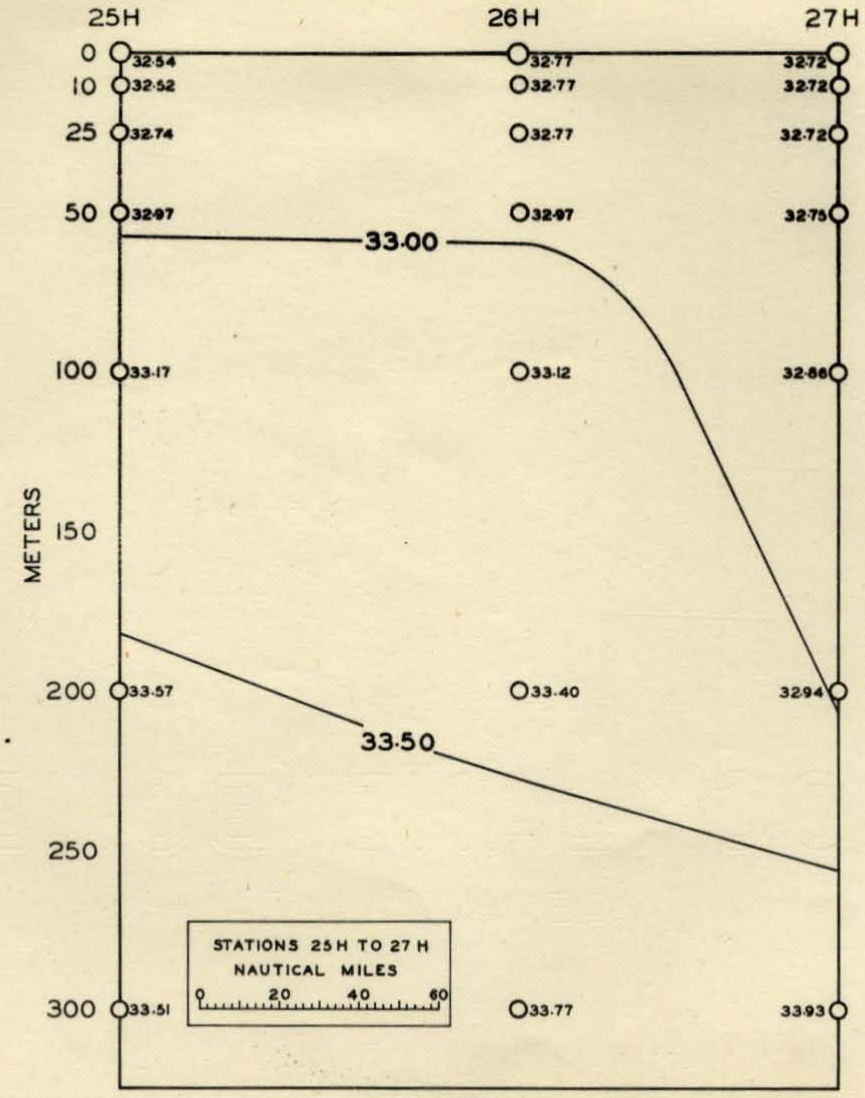

Fig. 5. Salinities in section in Hudson Strait September 20-23, 1948.

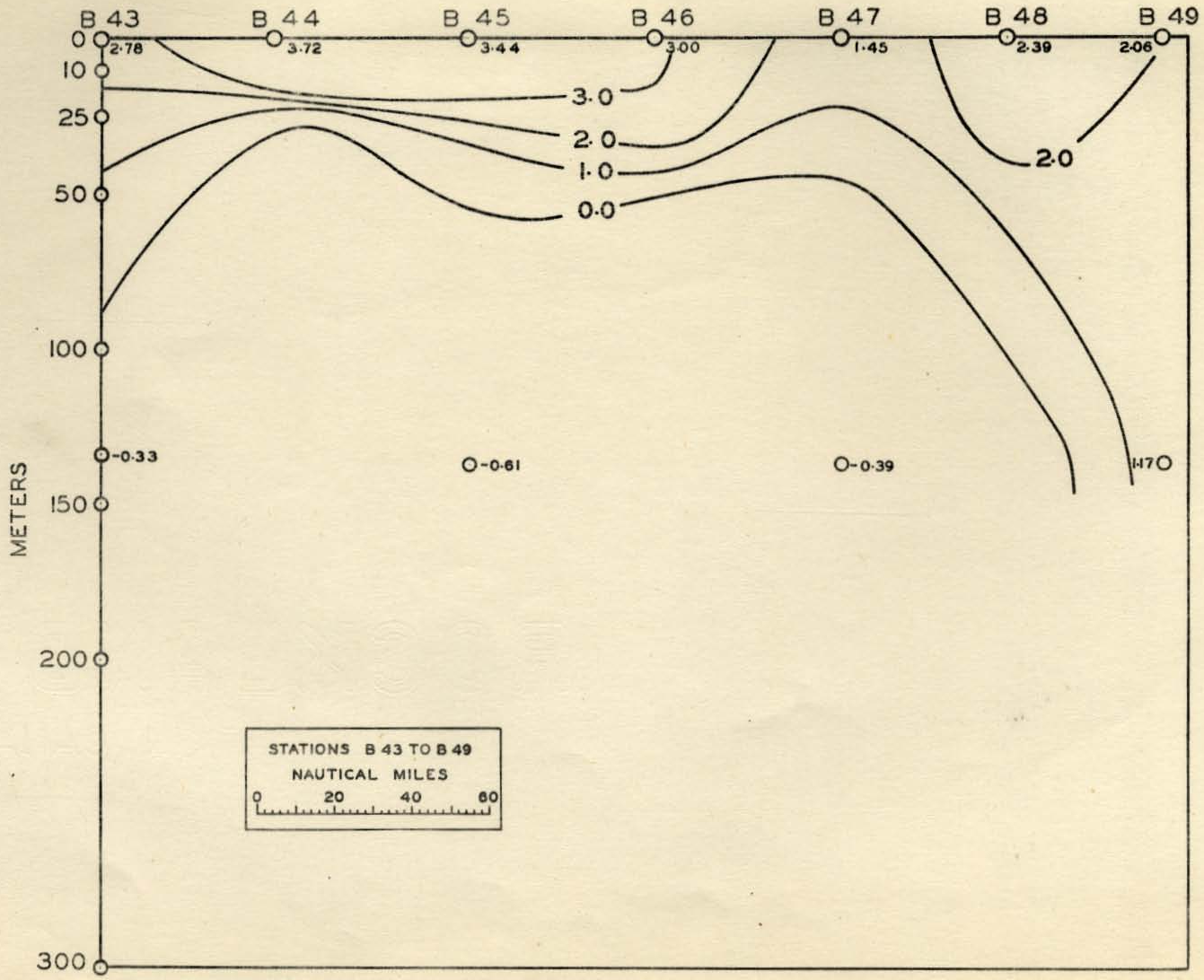

Fig. 6. Vertical temperature structure in Hudson Strait September, 1948.

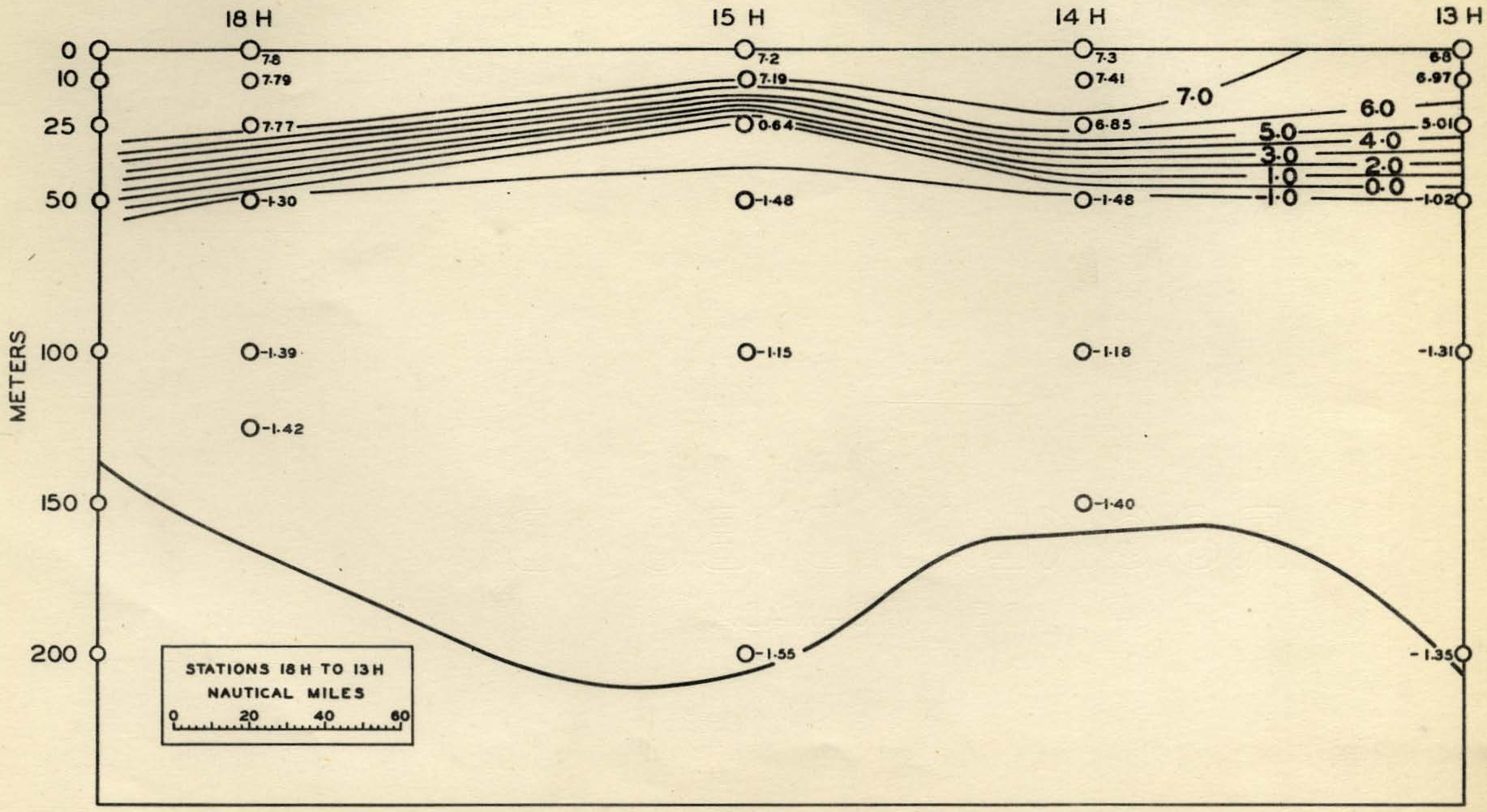

Fig. 7. Temperatures in section in Hudson Bay September 9-16, 1948.

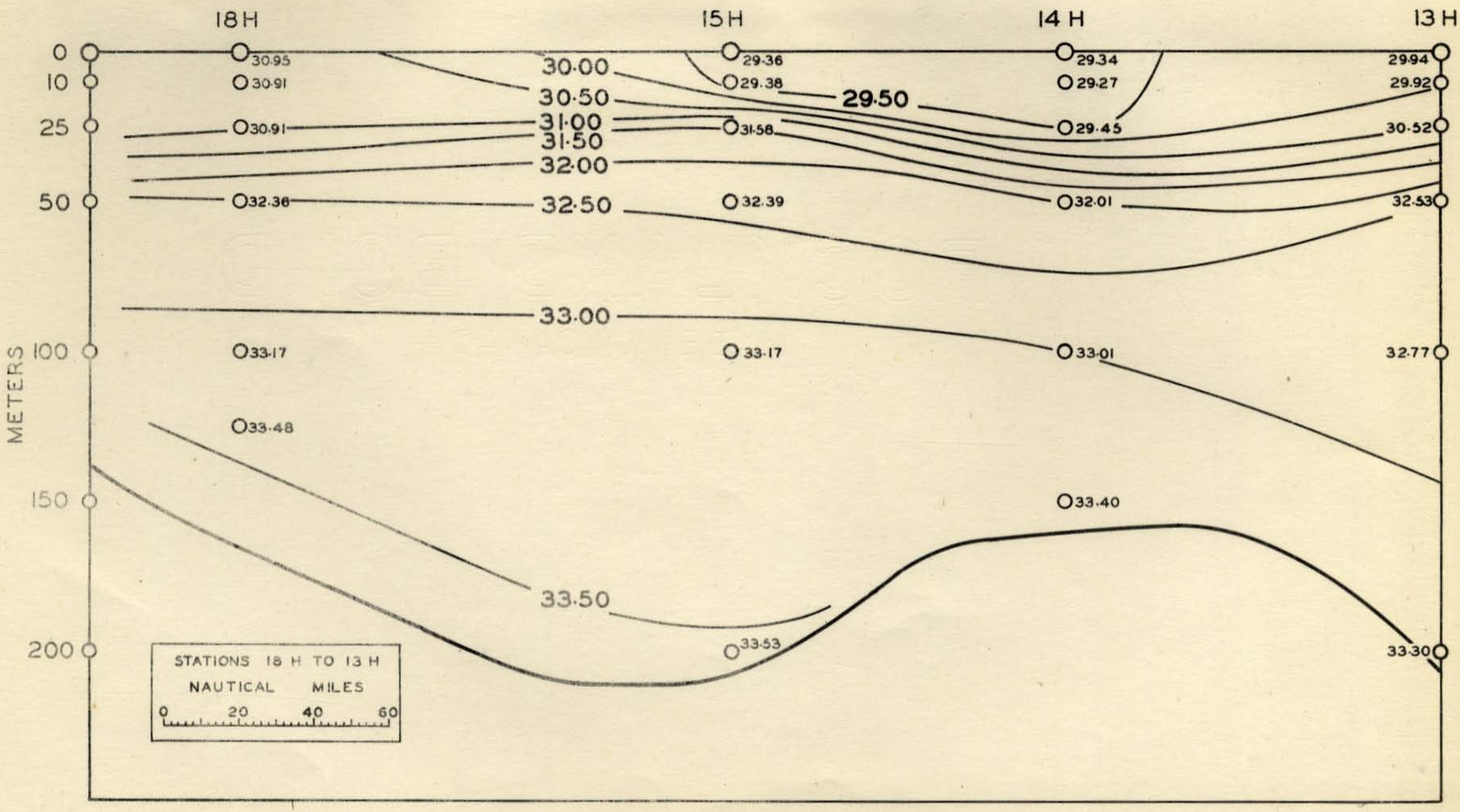

Fig. 8. Salinities in section in Hudson Bay September 9-16, 1948.

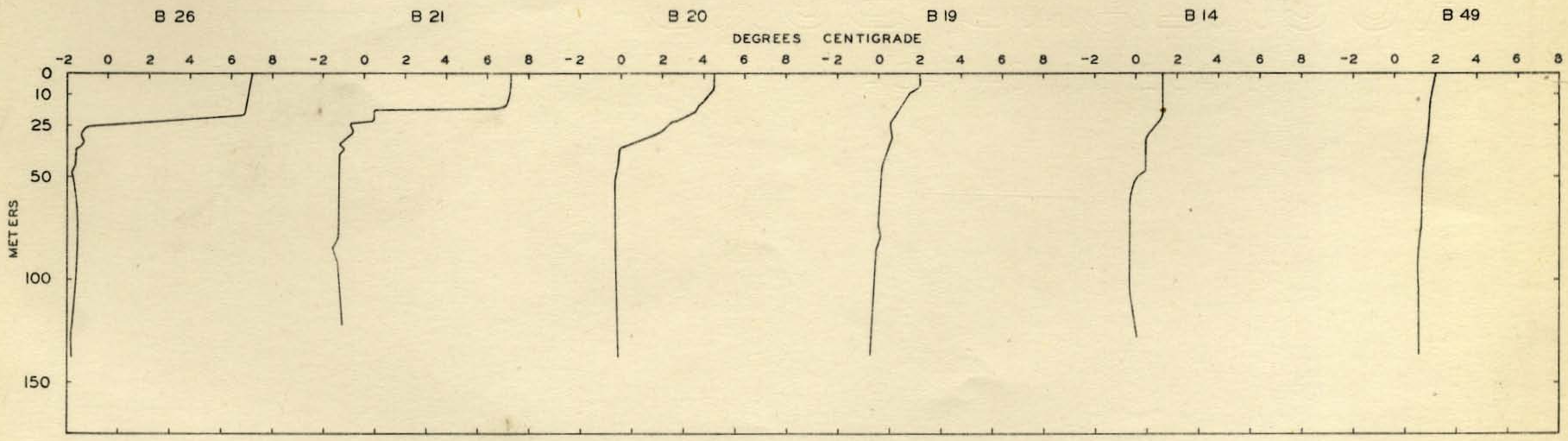

Fig. 9. Typical bathythermograph traces in Hudson Bay and Hudson Strait running in succession from Hudson Bay to the mouth of Hudson Strait.

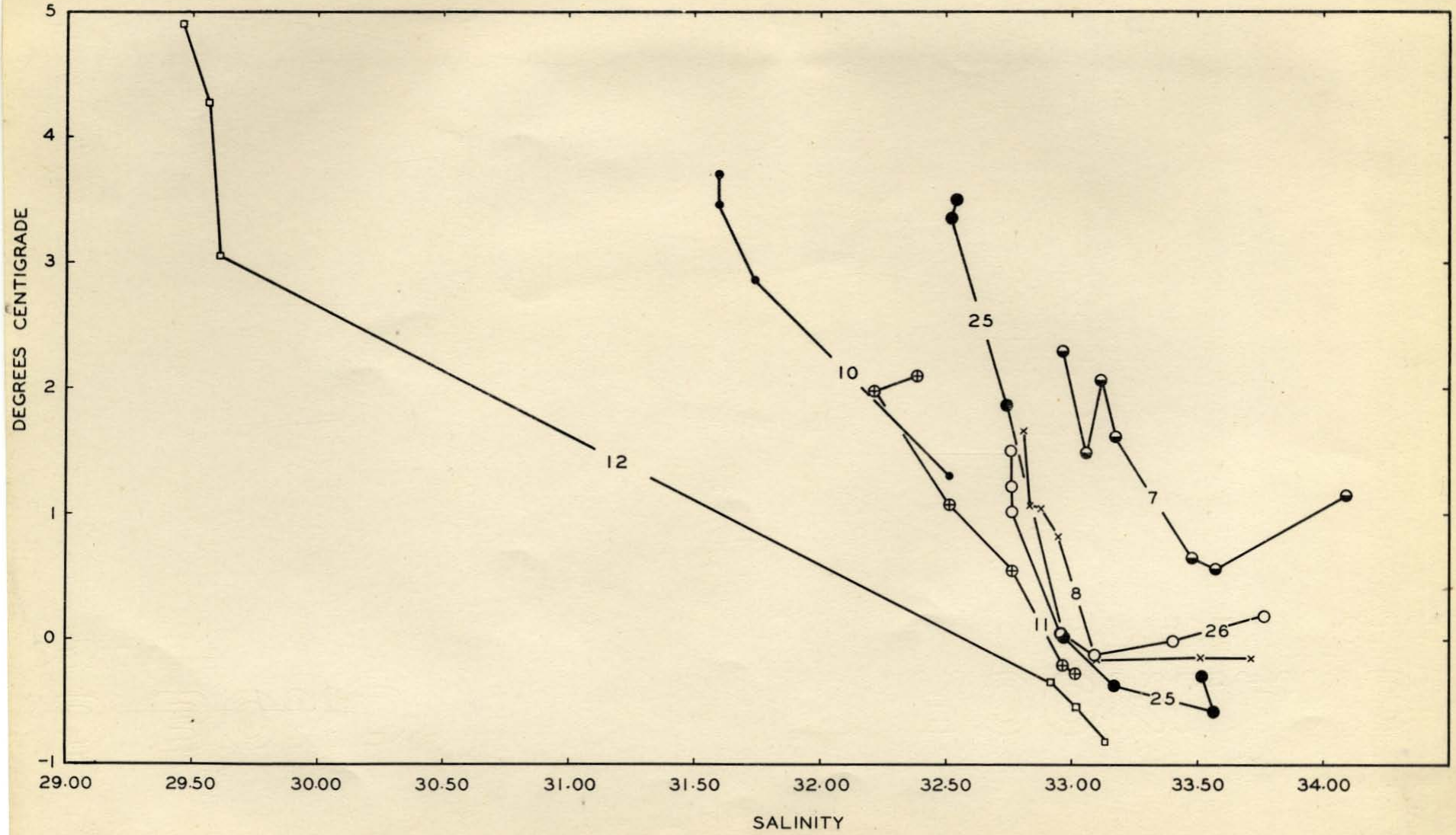

Fig. 10. Temperature-Salinity correlation curves for Hudson Strait in September, 1948.

Fig. 11. Temperature-Salinity correlation curves for Hudson Bay in September, 1948.

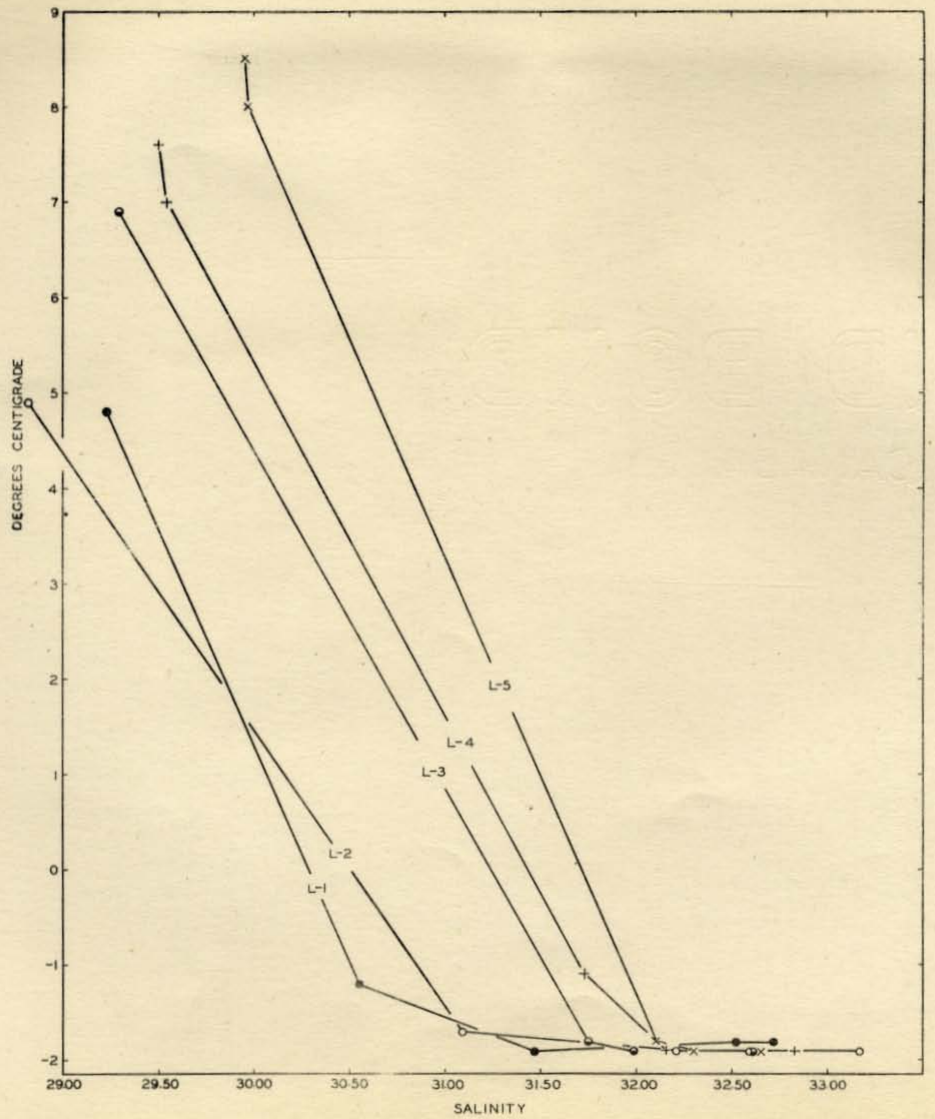

Fig. 12. Temperature-Salinity correlation curves in Hudson Bay for August, 1930.