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AN OCEANOGRAPHIC STUDY OF PRINCE REGENT INLET, THE GULF OF BOOTHIA AND ADJACENT WATERS

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by

A. E. Collin

INTRODUCTION

In the summer of 1956 H.M.C.S. "Labrador" carried out her third oceanographic survey in the eastern Canadian Arctic. The work commenced in Hudson Strait and continued northward through Foxe Basin to Lancaster Sound. On this cruise, "Labrador" steamed over 19,000 miles in Hudson Strait, Foxe Basin, Gulf of Boothia, Barrow Strait, and Lancaster Sound.

The 1956 scientific survey was arranged to complement the work carried out in previous cruises and also to undertake the initial hydrographic and oceanographic investigations of the unsurveyed areas, Gulf of Boothia and Prince Regent Inlet.

This report considers only the northern sector of the cruise; the remaining areas of operation, Foxe Basin and Hudson Strait, are being treated separately with the 1955 survey of these waters.

The discovery and exploration of Lancaster Sound and the waterways leading into the Canadian Arctic have been a gradual undertaking since the seventeenth century.

The discovery of Baffin Bay and Lancaster Sound by Baffin in 1616 remained in question for nearly 200 years, until the existence of the Bay north of Davis Strait was confirmed by Sir James Ross in

1818. Stimulated by the skepticism of several of Ross's officers, an expedition was organized in 1819, under the command of Lieutenant W. E. Parry, to further investigate the western inlet which Ross had reported. Parry succeeded in entering Lancaster Sound and exploring Barrow Strait and Viscount Melville Sound. During this voyage, subsurface water temperatures were recorded in the Canadian Eastern Arctic (Parry, 1821). Parry's optimistic reports of a passageway to the west resulted in his command of a second expedition into Lancaster Sound and Prince Regent Inlet in 1824.

The triumphant return of Parry's latter expedition led to the formation of a second Arctic expedition under the command of Sir John Ross in 1829. This expedition contributed additional knowledge to the geography of Prince Regent Inlet and the Gulf of Boothia. However, Ross failed to recognize Bellot Strait which remained undiscovered until 1851.

As a result of the explorations of Parry and Ross, the existence of the Northwest Passage was firmly established. Consequently, the Franklin expedition of 1845 was planned as the final endeavour which would complete the charting and navigation of the Passage from east to west. With the tragic fate of Sir John Franklin and his men, the expedition fell far short of its high expectations. However, it did stimulate a concentrated search of this region for the missing ships. Franklin search expeditions culminated in the first transit of the Northwest Passage by Sir R. J. M'Clure in 1853 and the discovery of the Franklin remains by Sir F. L. M'Clintock in 1857. The explorations succeeded in completing the geography of the waterways leading into Lancaster Sound.

One of the first scientific investigations in the Archipelago was under the command of Sir Allen Young in 1857. The party explored Boothia Peninsula and Somerset Island in the vicinity of the Magnetic Pole and obtained water temperatures and soundings in Prince Regent Inlet and Lancaster Sound (Dunbar, 1951). After this expedition no major organized exploration was attempted until O. N. Sverdrup led a privately endowed scientific expedition into Jones Sound in 1902 (The Second Norwegian Arctic Expedition, 1907). This survey was followed by a Canadian geological study in Lancaster Sound by A. P. Low in the "Neptune", 1904, and continued by J. E. Bernier in command of the C.G.S. "Arctic" from 1906 to 1925 (Taylor, 1955). During this period Bernier made substantial contributions to the knowledge of the area south of Lancaster Sound in the vicinity of Prince Regent Inlet and Bernier Bay (Tremblay, 1921).

The first large scale oceanographic investigation of Davis Strait and Baffin Bay was conducted by the Danish "Godthaab" Expedition in 1928. One hundred and fifty stations were occupied, including a line consisting of seven stations across the entrance to Lancaster Sound (Riis-Carstensen, 1936).

Recently, Arctic exploration and reconnaissance has expanded through the combined efforts of the United States and Canadian governments seeking more thorough and precise information in the high latitude regions. In 1947, Task Force 68, U.S.S. "Edisto", set up the Resolute Bay weather station and resupplied other stations in the Eastern Arctic. The following year Task Force 80 consisting of U.S.S. "Edisto" and U.S.C.G.C. "Eastwind" performed the duty of supplying the eastern weather bases and also claimed the honours of reaching the farthest north for ships under their own power in the vicinity of Cape Sheridan, north Ellesmere Island. Task Force 80 returned to the Atlantic by way of Lancaster Sound, Prince Regent Inlet and Fury and Hecla Strait, thus becoming the first ships to transit an inland waterway from Lancaster Sound to Hudson Strait (Arctic Circular Vol. 1, No. 8, 1948).

During the summer of 1950, "Edisto" conducted an ice reconnaissance and oceanographic survey in Baffin Bay, Kane Basin, and Davis Strait. Two stations were taken in Lancaster Sound and one in Barrow Strait. In 1952, "Edisto" in company with U.S.S. "Atka" continued the oceanographic investigation of Baffin Bay and the eastern Canadian Arctic. The following year "Atka" continued the work in Davis Strait and Baffin Bay. Although this cruise did not enter into the waters of the Canadian Archipelago, one station was occupied in the eastern end of Lancaster Sound (Oceanographic Observations, Arctic Waters, 1954).

In August 1954, H.M.C.S. "Labrador" made her historic voyage through the Northwest Passage and obtained subsurface water temperatures and other oceanographic data through the entire length of the Passage. Ninety-six oceanographic stations were occupied in the Arctic during August and September, including sections across Lancaster Sound, Barrow Strait, and Wellington Channel (Bailey, 1957). In 1956 "Labrador" continued the oceanographic investigations in Fury and Hecla Strait, Gulf of Boothia, Prince Regent Inlet, and Lancaster Sound (Fig. 1). The investigations north of Fury and Hecla Strait consisted of 44 oceanographic stations with plankton sampling, ice observations, and a collection of bottom sediments (Fig. 2).

PHYSICAL OCEANOGRAPHY

Coastline

The inner passages from Lancaster Sound to the entrance of Hudson Bay form a continuous waterway 650 miles in length. The route leads from Lancaster Sound through Prince Regent Inlet, the Gulf of Boothia, Fury and Hecla Strait, and Foxe Basin to Hudson Strait (Fig. 1).

The structure of this whole region is described as a formation of horizontal Palaeozoic and Mesozoic strata overlapping the northern margin of the Canadian Shield (Nordenskjold and Mecking, 1928).

The south coast of Devon Island is formed of two distinct geological formations. The Archean eastern part of the island is blanketed with a thick cover from which numerous glaciers debauch into Lancaster Sound. The Palaeozoic western section forms a plateau landscape which is characterized by a rolling ice free surface and deep vertical erosional gorges in the coastal cliffs.

For the most part the entire south coast of Devon Island consists of steep cliffs rising directly from the sea to heights of 1200 feet (Greenaway and Colthorpe, 1948).

The south coast of Cornwallis Island presents a rolling, terraced landscape, which slopes up from the sea in steps of disintegrated rock.

The north coast of Baffin Island is cut by two deep bays, Admiralty Inlet and Navy Board Inlet, which form the Borden and Brodeur Peninsulas. These northern peninsulas are composed of Silurian limestone and present a landscape similar to that found along the eastern shore of Foxe Basin. The steep northern coastline of Baffin Island is cut by many deep fiords and gullies. The harsh terrain continues through the eastern and northern section of Brodeur Peninsula, but gradually alters to a low rolling plateau in the vicinity of Prince Regent Inlet (Greenaway and Colthorpe, 1948; Tremblay, 1921).

The north coast of Somerset Island presents a similar castellated appearance typical of the Devon and North Baffin shorelines. In the northern part of this island, the coastal elevation is approximately 1000 feet, while to the south, the coast is considerably lower.

Bellot Strait is a narrow fiord-like passage approximately a mile wide and 19 miles long. The sides of the Strait are steep and bold with surrounding elevations of 1500 to 1600 feet. Seen from the air, Bellot Strait appears to be one of a similar series of parallel grooves which cross the Isthmus both on the north and south sides of the Strait.

The east coast of Boothia Peninsula is characterized by a large number of small islands and bays. The coast south of Bellot Strait is composed of limestone cliffs considerably lower than those encountered north of Bellot Strait on Somerset Island.

The low and uniform northwestern coast of Baffin Island, including the southern coast of Brodeur Peninsula, forms the eastern shore of the Gulf of Boothia. The southern part of the Gulf of Boothia terminates in Committee Bay. The most southerly outlet from the Gulf of Boothia is Fury and Hecla Strait. The structure of Fury and Hecla Strait is similar to the fiords of the Barren Grounds. The Strait, however, extends from Foxe Basin to the Gulf of Boothia while other fiords, such as Repulse Bay, Lyon Inlet, and Walker Bay terminate inland.

Bottom Topography

From the western end of Fury and Hecla Strait, through the Gulf of Boothia and Prince Regent Inlet, the sea floor deepens gently towards the north at approximately a half fathom per mile (Fig. 3). At the northern entrance of Prince Regent Inlet there is an elevation of the sea floor which extends almost across the Inlet from the western side. A 200 fathom channel enters the Inlet along the eastern side.

The slope of the bottom of the Lancaster Sound trough from Resolute Bay in Barrow Strait to the eastern end of the Sound shows a very gradual drop from a depth of 80 fathoms at the western end to 450 fathoms off Bylot Island. Further east the main channel curves sharply southward and drops rapidly to nearly 600 fathoms. The eastward gradient through Barrow Strait and Lancaster Sound is approximately three fathoms per mile. However, off the east coast of Bylot Island, the slope increases to approximately seven fathoms per mile.

The configuration of the valleys which form Lancaster Sound, Barrow Strait, Prince Regent Inlet, and the Gulf of Boothia shows the effect of glacial action. Cross-sections through the troughs show the characteristic glacial "U" shape with relatively steep sides and rounded bottom. Toward the south, in Prince Regent Inlet, the characteristic "U" shaped troughs give way to a relatively shallow basin-like formation.

Climate

The Gulf of Boothia and Lancaster Sound area lie well within the boundaries of the tundra climatic classification. This climatic region, represented by the Koppen symbol "ET", is a transitional band lying between the subarctic climate to the south and the ice cap zone to the north (Finch and Trewartha, 1949). The accepted boundaries of the tundra climate are the 32°F. and 50°F. isotherms for the average mean temperature of the warmest month. In Canada, these boundaries include the entire Arctic Archipelago except for small eastern areas of permanent snow cover or ice cap.

In the Lancaster Sound region, the Arctic Bay weather station is the only location having weather records over the last ten years. The description of weather conditions is based upon the climatic summaries for this station.

In Lancaster Sound, the only months having average mean temperatures above freezing are June, July and August with temperatures of 36, 44 and 42°F. respectively. The average maximum temperature is 62°F., and the highest temperature on record is 75°F. (Rae, 1951). The other nine months of the year have daily mean temperatures below freezing varying from 30°F. in September to -27°F. in February. The average temperature is -48°F., and the lowest recorded temperature at Arctic Bay is -57°F.

Sixty-five percent of the total annual average precipitation, 6.8 inches, falls in the form of snow. A measurable snow fall is recorded for all months of the year. The three months which have the heaviest snowfall are May, September and October. The minimum snowfall of 0.1 inches occurs in July. The mean annual rainfall, 2.4 inches, falls during the period May to September. The highest mean monthly rainfall, 1.3 inches, occurs in August.

The predominant winter wind is from the northwest at an average speed of 10 m.p.h. In summer, however, wind direction is more variable, but generally it appears from either the southeast or northwest quadrants (Rae, 1951).

PHYSICAL OCEANOGRAPHY

Ice Conditions

Ice conditions in Prince Regent Inlet, Gulf of Boothia, and Committee Bay are not well known owing to the relative unimportance of the area from the point of sea navigation and also because most of the observations have been based on occasional voyages in the area and infrequent aircraft flights.

In 1823 Parry encountered heavy winter ice in Fury and Hecla Strait which blocked his passage westward (Parry, 1824). In September, 1956, Fury and Hecla Strait was free of ice except for light concentrations of 1-3 tenths winter ice. Committee Bay was full of winter and polar ice of 8-10 tenths coverage. Presumably much of the heavier ice from Prince Regent Inlet and the Gulf of Boothia moves south to Committee Bay in the summer, keeping this area almost permanently ice bound the year round.

West of Fury and Hecla Strait, "Labrador" encountered heavy polar ice of 7-10 tenths concentration, extending across the mouth of Committee Bay and as far north as Crown Prince Frederik Island. The ice was extremely heavy, varying in thickness from 15-25 feet and closely bound with new ice 4-8 inches thick. Very little winter ice was encountered further north in the Gulf of Boothia (Fig. 4).

North of the Committee Bay ice boundary, a wide band of young ice from 1 to 4 inches thick extended across the Gulf of Boothia and along the eastern shore of Prince Regent Inlet. Between the new ice and the western shore of the Gulf, light concentrations of well-weathered winter ice were encountered as far north as Bellot Strait. North of Bellot Strait, the winter ice remnants decreased and young ice was only sighted at one station on the eastern shore. Greenaway and Colthorpe have reported that, contrary to the information regarding ice conditions in the Inlet mentioned in the British Admiralty Arctic Pilot, Vol. III, the ice in Prince Regent Inlet tends to pack more along the east coast than the west (Greenaway and Colthorpe, 1948). This same condition was encountered by "Labrador" in 1956.

Light concentrations of winter ice fragments were observed extending in both directions along the south shore of Barrow Strait and Lancaster Sound. On no occasion was dirty ice, similar to that encountered in Foxe Basin, found west of Fury and Hecla Strait (Campbell and Collin, MS 1957).

A more general picture of ice conditions can be obtained from the prognostic ice forecasts of the United States Navy Hydrographic Office. These reports are based on what has been known of the ice conditions, and conditions observed by ships and aircraft, as well as oceanographic data. Close checks are kept on the reliability of the reports and in this way, the monthly ice forecasts are remarkably good.

Generally by mid-August the ice in the Gulf of Boothia and Prince Regent Inlet is broken, but of 8-10 tenths concentration. In Lancaster Sound and Barrow Strait, the ice usually moves out by July and decreases in concentration from July to the middle of August. In mid-August, however, ice concentrations in Lancaster Sound may increase with the influx of ice from M'Clure and Barrow Straits. Ice from Wellington Channel may also contribute to the congestion in Lancaster Sound in August. However, Lancaster Sound is generally open as far as Resolute from the end of August until mid-September.

The 1956 prognostic chart for mid-July indicated heavier ice concentrations for the western end of Lancaster Sound and Prince Regent Inlet than were forecast for the two previous years. These conditions did not occur because a rapid exit of ice took place in the latter part of July and the first half of August, resulting in the opening of Lancaster Sound, Wellington Channel, and Prince Regent Inlet by mid-August, 1956.

The only significant difference between the September 1956 prognostic chart and the chart prepared from the cruise data (Fig. 4) is found in the position of the new ice in the Gulf of Boothia. The young ice was forecast to form as a belt extending along the western shore of the Gulf and to continue across Committee Bay at the latitude of Fury and Hecla Strait. Contrary to this prediction the new ice was found to extend across Committee Bay and along the eastern shore of the Gulf of Boothia as far north as 72°30'N. It seems improbable that this condition resulted from the wind, because the predominant wind from September 20 to the end of the month was from the north and east.

Surface Temperature

The stations in the Gulf of Boothia, Prince Regent Inlet, and Lancaster Sound were occupied during a period of 14 days from September 17 to September 30, 1956 (Fig. 2). Throughout this time the weather was generally fair and the wind moderate.

The average surface water temperature throughout Lancaster Sound and Prince Regent Inlet and Barrow Strait was -1.4°C. There was no significant temperature difference between Prince Regent Inlet and the Gulf of Boothia. Temperatures of -1.6°C. on the eastern side of the Gulf of Boothia were the lowest. Cold water conditions were encountered off Prince Leopold Island and in Committee Bay (Fig. 5). Average surface temperature from the northern end of Prince Regent Inlet to Fury and Hecla Strait was -1.4°C. with a maximum variation of only six-tenths of a degree.

Where there was a significant change of temperature across the Gulf of Boothia the coldest water was found on the eastern side. This cold water was found in an eddy south of Bellot Strait and also in the outflow of water from Prince Regent Inlet to Lancaster Sound. In the Gulf of Boothia, both the surface isotherms and isohalines show a concentric pattern, the formation of which is believed to be related to the melting of ice in Committee Bay during the summer months (Figs. 5 and 6). Temperatures of -1.1 to -1.4°C. were found along the western side of the Gulf and these water conditions were probably related to the discharge of water from Bellot Strait.

In Barrow Strait the average surface temperature was -1.7°C. The lowest observed temperature was -1.8°C. In 1954, the average surface temperature in this area was 0.15°C. and in 1952 "Edisto" reported average surface temperatures of 0.00°C.

In Lancaster Sound the average surface water temperature reported by the "Godthaab" Expedition in August, 1928, was 1.27°C. (Riis-Carstensen, 1936). The highest temperature, 3.39°C., appeared in the northern half of the channel, while a low of 0.57°C. was found on the southern side. In 1950, U.S.S. "Edisto" occupied a number of stations in the same area and found a mean surface temperature of

2.9°C. where the "Godthaab" had previously located the warm water. A similar temperature condition was found in 1954 by "Labrador" with a maximum of 2.5°C. (Bailey, 1957).

In 1956 the thermal conditions were much different. Average surface temperatures for the same locality had dropped to -1.4°C. with a minimum of -1.7°C. and maximum of -1.1°C. The change in thermal conditions is extreme and probably the result of the normal seasonal change of temperature coupled with the greater wind activity in September and October. It is noted that in September, there is an average decrease of thirteen degrees centigrade in air temperatures. This decrease represents over one-third the annual air temperature range (Rae, 1951).

Wind direction for the two "Labrador" cruises is also quite different. In 1954 the predominant winds were from the west at 8 knots, while in 1956 the wind was from the northeast quarter at an average speed of 18 knots. The deterioration of the summer weather state to early winter conditions in September is normal, but what is remarkable is a suspected rapid readjustment of surface conditions and currents during this period.

Surface Salinity

The surface salinity in Barrow Strait and Lancaster Sound ranges from 31.00 ‰ in the vicinity of Resolute Bay to 33.00 ‰ in the eastern end of Lancaster Sound. These values indicate an increase of salinity over the results of the "Labrador" cruise in 1954. At that time the average surface salinity at Resolute was 30.66‰, and in the eastern end of Lancaster Sound, 30.68‰. In

1928, the average surface salinity at the eastern entrance of Lancaster Sound, reported by the "Godthaab" expedition, was 31.00‰. (Riis-Carstensen, 1936). Minimum and maximum surface salinities were 26.94 and 32.18‰ in August, 1943, and 32.16 and 33.01‰ in September, 1956 respectively. These observations reveal an increase in salinity from the results of the "Godthaab" expedition. Part of the increase may indicate a long term change of salinity, but it is believed to be more likely related to the time of survey in relation to the period of ice melting in August.

In Prince Regent Inlet and the Gulf of Boothia, the surface temperature and salinity distributions are similar (Figs. 5 and 6). The lowest salinities in the area occurred in the southwestern section of the Gulf of Boothia. Here the average surface salinity was less than 29.00‰. An eddy of low-salinity water extended northward from Committee Bay to the Gulf of Boothia. This formation of low-salinity cold water can be traced to the ice reservoir of Committee Bay.

A region of relatively high surface salinity, 30.50‰ extended along the central axis of Prince Regent Inlet. A southward continuation of this formation of high-salinity water appeared along the eastern shore of the Gulf of Boothia (Fig. 6).

At the eastern entrance of Bellot Strait, the surface isohalines appear as tongue-like formations with an average value of 30.06‰. The high values of the salinity in this region are anomalous for the area and probably arise from turbulent mixing with deep waters in the Strait.

The average surface salinity decreases from north to south through Prince Regent Inlet and the Gulf of Boothia. In Prince Regent Inlet, the average surface salinity was 30.26‰, and at Bellot Strait 30.06‰. The Gulf of Boothia surface salinity was distinctly lower at approximately 29.00‰. At several stations in the southern end of the Gulf, lower surface salinity values of 28.73‰ were found in the proximity of heavy ice concentrations.

The main oceanographic features indicated by the surface distributions of temperature and salinity are the influence of Committee Bay and Bellot Strait. In the summer, Committee Bay is a source of cold low-salinity water which pushes northward into the Gulf of Boothia. Bellot Strait appears to emphasize the discontinuous nature of the water as it periodically introduces "mixed" waters into the area with the flooding tide and removes water on the ebbing tide.

Vertical Distribution of Temperature and Salinity

Two sections (Figs. 7 and 8) were occupied in Lancaster Sound and one in Barrow Strait (Fig. 9). The maximum sampling depth was 580 metres at station 189 in the eastern end of the Sound, while the minimum depth was 75 metres at station 181 in Barrow Strait.

A cold surface layer was found at the northeastern end of Lancaster Sound, and within the upper 10 metres the average temperature and salinity was -1.30°C., and 32.60‰, respectively (Fig.7). The lowest surface temperature (-1.70°C.) and the highest surface salinity (33.01‰) were found off the Devon Island coast. From 10 to 50 metres, temperatures increased gradually to a maximum of -0.20°C. at 50 metres on the southern side of the Sound, while on the northern side, there was no evidence of this comparatively warm layer. Salinities ranged from 32.50 to 33.00‰ at the eastern end of Lancaster Sound (Fig. 7), but at the western end of the Sound, salinities varied from 31.00 to 32.00‰ (Fig.8). In both sections, a marked change of slope is evident at these depths on the northern side of the Strait, while in the central and eastern portions of the sections, the isohalines are almost horizontal (Figs. 7 and 8).

Between 50 and 200 metres, temperatures were found to decrease to a minimum of -1.40°C., while at greater depths, temperatures increased to 0.75°C. at the bottom.

At 50 metres depth, a salinity of 33.00‰ extended across the Sound, while below this depth, it increased at a uniform rate to a maximum of 34.47‰ at 580 metres (Fig. 7). The isohalines and isotherms have an anticlinal form indicative of a reversal in current direction. The distribution of the isopleths of temperature and salinity and the slope of the isopycnal surfaces indicate a fairly extensive westward flow along the north shore, while on the south side of the Strait, the current is easterly.

At the western section in Lancaster Sound (Fig. 8), similar distributions of properties as observed in the eastern section persisted, with only slight changes in the depth and slope of the isopleths.

The surface layer of temperatures between -1.40°C. and -1.60°C. and an average salinity of 31.50‰, extended to a depth of 30 metres on the southern side of the Sound, but increased in thickness to approximately 50 metres on the northern side. Within the 30-70 metre depth range, the salinity increased from 31.50 to 33.00‰ and the temperature to -1.20°C. In this layer, a region of relatively warm water was observed on both sides of the Sound. Temperatures in these water lenses were above -0.50°C., while the surrounding temperatures were in the range of -1.00°C. to -1.30°C. (Fig. 8).

The temperature between 70 and 250 metres remained practically constant at -1.30°C., except for an area of cold water -1.50°C. at 200 metres on the southern side of the channel. At depths below 250 metres, there was a uniform temperature increase to 0.40°C. at the bottom (Fig. 8). The temperature and salinity increase with depth is much less at this section than at the mouth of Lancaster Sound, In both the eastern and western sections across Lancaster Sound, the temperature and salinity increase with depth. However, the uniform increase of temperature and salinity is much more pronounced at the eastern end, indicating than an intrusion of warm saline bottom water from Baffin Bay is limited to the eastern half of the Sound. In both sections (Figs. 7 and 8), the isotherms and isohalines slope downwards to the north. The most pronounced slope is located on the northern side, indicative of a dominant westerly current.

The Barrow Strait section (Fig. 9) shows much colder water conditions than the corresponding sections (Figs. 7 and 8) in Lancaster Sound. The average bottom water temperature was -1.35°C. compared with 0.50°C. in Lancaster Sound. The surface layer of approximately 30 metres thickness was characterized by extremely low temperatures, -1.50 to -1.75°C., and low salinity 30.50 to 32.00‰. In Lancaster Sound, temperatures below the surface layer were higher -0.50 to -1.25°C., while the salinity remained about the same as in Barrow Strait, except at the eastern entrance where it averaged 33.00‰. In direct contrast to the warm water lenses in Lancaster Sound, a layer of cold water was found in Barrow Strait at shallow subsurface depths (Fig. 9).

There is very little correlation between the September data of the 1956 cruise and the reported conditions for August of other years in Lancaster Sound. The water temperatures, of approximately 4.00°C., that were found off Lancaster Sound by other expeditions, are probably part of the so-called "North water" that has been discussed by Dunbar and others (Dunbar, 1951; Riis-Carstensen, 1936). The relationship of this phenomenon to meteorological conditions has been investigated by Hare and Montgomery (Hare and Montgomery, 1949). The "North water" is described as an area in the northern section of Baffin Bay and Smith Sound which remains relatively free of ice throughout the year. In summer, the surface temperature in this region is about 5°C. and Bailey reports surface temperatures of 6.0°C. immediately off the eastern entrance of Lancaster Sound (Dunbar, 1951; Bailey, 1957).

No trace of this warm water was found off Lancaster Sound in 1956. The warmest surface temperature recorded in the eastern end of Lancaster Sound was -1.10°C. and slightly warmer water (0.28°C.), at 50 metres. This change in temperature would suggest that the position of the "North water" is variable, depending upon general meteorological conditions and the intensity of the current systems in Baffin Bay.

Thermal conditions in Prince Regent Inlet correspond more closely to conditions in Barrow Strait than those in Lancaster Sound. Temperatures in the northern section (Fig. 10) range from -1.50°C. to -1.00°C. In the southern section (Fig. 12) temperatures range from -1.50°C. to -0.50°C.

A cold-water core of temperatures of -1.50°C., extended at intermediate depths throughout the length of Prince Regent Inlet. This phenomenon was similar to that of Barrow Strait, and again was in contrast to the thermal conditions of Lancaster Sound.

The three sections in Prince Regent Inlet (Figs. 10, 11 and 12) show a vertical increase in salinity from 31.00‰ at 10 metres to 34.00‰ at the bottom. The bottom salinities are much higher than those found in Barrow Strait and probably are evidence of a deep water intrusion from Lancaster Sound. The isohalines in the upper 50 metres are almost horizontal. At deeper levels changes of slope are evident in the eastern half of the Inlet. In the two northern sections (Figs. 10 and 11) coastal bands of low-salinity water were found along the eastern coast of the Inlet.

The distribution of density shows no marked variation in the upper 150 metres (Figs. 10, 11 and 12). Below this depth, however, a sharp downward slope appears in the centre section (Fig. 11) on the eastern side. There is no evidence of a corresponding condition at the southern section (Fig. 12), although the downward slope reappears again in the Gulf of Boothia.

The cross-sections (Figs. 13, 14 and 15) in the Gulf of Boothia illustrate a southward continuation of the temperature and salinity structure found in Prince Regent Inlet. Temperatures vary from -1.00 to -1.60°C. at the surface to -0.54°C. at the bottom at station 162. The significant feature of the temperature distribution is the continuation of the core of cold water (-1.50 to -1.72°C.), between 10 and 75 metres in the eastern section of the Gulf. This core of cold water extends through the entire length of the Gulf of Boothia and Prince Regent Inlet. A moderate increase in salinity appears below the surface layer boundary at approximately 30 metres. The 32.00‰ isohaline was found at 50 metres in the northern section of the Gulf, but at greater depths in the south. Bottom salinities in the Gulf were less than 33.00‰ compared with salinities of 34.00‰ in Prince Regent Inlet.

Temperatures in the Gulf of Boothia indicate exceedingly small thermal variations with depth. In comparison the salinity and density distributions show a marked stratification which extends into the Gulf of Boothia from Prince Regent Inlet. The only instance where a vertical movement of water is indicated by the salinity, temperature, and density distributions are at station 160 (Fig. 14), and at the western end of Fury and Hecla Strait (Fig. 16). In these areas, the temperature and salinity distributions reveal a boundary between the mixed water along the eastern side of the channel and stratified water to the west of station 159 (Fig. 14). Another boundary appears at station 149, where the slope of the isopycnals indicates a change of flow direction on either side of the station (Fig. 16).

The distribution of both surface and subsurface temperatures and salinities in Prince Regent Inlet and the Gulf of Boothia appears to be determined by three distinct oceanographic conditions. One of the factors is the influx of deep high-salinity water from Lancaster Sound which passes south into Prince Regent Inlet; the second is the flow through Bellot Strait, and the third is the permanent concentration of ice in Committee Bay. These independent factors produce a complex distribution of temperature and salinity within the upper 20 metres. Below this depth, temperatures and salinities are less subject to large scale changes, but the characteristics of the types of water are still evident.

T-S Relationships

Temperature and salinity relationships have been plotted for the six water regions that comprise the area under investigation, Baffin Bay, Lancaster Sound, Barrow Strait, Prince Regent Inlet, Bellot Strait, and Fury and Hecla Strait (Fig. 17).

The most remarkable feature of these water masses depicted by the T-S curves is the similarity of the water characteristics below 200 metres for the Baffin Bay Intermediate water in Lancaster

Sound and Prince Regent Inlet. From 200 metres to the bottom, the T-S characteristics are almost identical, with temperatures increasing from -1.50° C. to 0.40° C. and 0.70° C., and the salinity increasing from 33.70‰ to 34.50‰. The T-S curves for Baffin Bay and Prince Regent Inlet, between 50 and 200 metres, show the approximate extremes of the relatively cold high-salinity water of Lancaster Sound. The T-S curve for Lancaster Sound for these same depths lies almost midway between the extreme curves for Baffin Bay and Prince Regent Inlet or Barrow Strait. This feature would indicate that the water in Lancaster Sound is a mixture of the waters from Prince Regent Inlet, Barrow Strait, and Wellington Channel. Below 100 metres the T-S curves for Barrow Strait and Prince Regent Inlet are similar, while at greater depths the T-S characteristics for Prince Regent Inlet are almost identical to those of Baffin Bay. Consequently from 30 to 150 metres one might expect to find in Lancaster Sound, water layers with various T-S characteristics.

The similarity of the T-S curves for the eastern end of Lancaster Sound with those of the "Godthaab" expedition of 1928 and "Labrador" 1954, suggest a continuity of the bottom water of Lancaster Sound and the Intermediate water of Baffin Bay (Riis-Carstensen, 1936). A bottom intrusion of Baffin Bay water into Lancaster Sound would be expected to alter by progressive cooling further west in the channel, on contact with the cold water of Barrow Strait. This effect could account for some of the variations in the T-S characteristics in Lancaster Sound. However, if there is a relationship between the warm water mass in Prince Regent Inlet and Lancaster

Sound as interpreted from the similar T-S curves, then periodically there must be a major movement of deep Lancaster Sound water from east to west. Evidence to support this view was found from dynamic computations of the 1956 survey.

Another possibility regarding circulation through the Northwest Passage is an intrusion of Polar Atlantic water from the Polar Basin through the channels leading into Lancaster Sound (Dunbar, 1951).

Between 300 amd 800 metres the Polar Atlantic water is defined by temperatures of approximately 0.0°C. and salinities 34.7 to 34.9‰ (Worthington, 1953).

Bailey's results revealed that water with these characteristics was found below 300 metres in the western end of Viscount-Melville Sound but not in Barrow Strait or Wellington Channel (Bailey, 1957). The 1956 data would tend to corroborate these findings. Bottom water in the eastern end of Lancaster Sound was warmer than 0°C., but with salinities less than 34.70‰. This type of water was not found in Barrow Strait, but traces of comparatively warm water were found in Prince Regent Inlet as mentioned earlier. Polar Atlantic water passing through Barrow Strait into Lancaster Sound would be expected to form a bottom layer throughout the entire region of Prince Regent Inlet, and Lancaster Sound. Water with these characteristic T-S relationships, has not been observed in Barrow Strait. However, the possibility of such an intrusion cannot be overlooked as it may occur with unusual meteorological conditions.

The waters of Barrow, Bellot, and Fury and Hecla Straits are very similar and have typical T-S curves representative of Arctic cold water. This water mass, usually referred to as "Polar water", is characterized by temperatures less than -1.30°C. and salinities ranging from 31.00 to 33.50‰. This type of water is common throughout the whole Canadian Archipelago.

It is interesting to note that within the eastern section of Lancaster Sound (Fig. 7) the range in temperature of -1.70 to 0.78°C., falls well within the limits of the "Polar water" defined by Dunbar, but below 300 metres, the salinity values are higher than either the maximum salinity boundaries of the "Polar water" or the Deep Baffin Bay water (Dunbar, 1951). This phenomenon may not be unusual because it is sometimes difficult to precisely define a water mass. Water masses of exceptional values of temperature and salinity are sometimes encountered. The results do, however, suggest that perhaps a re-study of the water masses should be undertaken in view of possible long term changes since the "Godthaab" or "Marion" and "General Greene" expeditions.

Distribution of Oxygen and Phosphate

Determinations of dissolved oxygen were carried out at 20 stations in Prince Regent Inlet and the Gulf of Boothia and at all 13 stations in Lancaster Sound and Barrow Strait. Average values of oxygen concentration in ml./l. and percent saturation for the surface, 20, and 100 metres, are shown in Table I.

Table I.

Average Oxygen Concentration in ml./l. and Percent Saturation

	Prince Regent Inlet and Gulf of Boothia		Lancaster Sound	
	Concentration ml./l.	% Sat.	Concentration ml./l.	% Sat.
Surface	8.6	103	8.3	99
20 M.	8.5	102	8.3	100
100 M.	7.2	86	7.0	85

Graphs showing oxygen concentration with depth for representative stations in the Gulf of Boothia, Prince Regent Inlet, Barrow Strait, and Lancaster Sound are shown in Fig. 18.

It was found that the percent saturation of oxygen was high and that in exceptional locations, such as the western approaches to Fury and Hecla Strait, oxygen saturation at the surface could be as high as 130%. Within the upper 20 metres, there was a slight increase in oxygen concentration, but below 20 metres, concentrations decreased gradually with depth (Fig. 18). The oxygen saturation at the surface showed a variation of 30%, while at 20 metres, the variation was only 12%. From 20 metres to the bottom in Lancaster Sound, the oxygen content decreased to 5 or 6 ml./l., slightly less than the concentration in Prince Regent Inlet and the Gulf of Boothia, where the oxygen concentration was found to vary from 6 to 7 ml./l. at the bottom.

Within the upper 20 metres, the oxygen concentration showed very little variation through the whole area of survey. However, in the bottom waters of Prince Regent Inlet, the oxygen content was found to be 1 ml./l. higher than elsewhere.

Phosphate concentration was determined at 20 representative stations in the Gulf of Boothia and Prince Regent Inlet. Graphs of phosphate concentrations with depth for four typical stations are shown in Fig. 19. The profiles show the wide fluctuations of phosphate concentration both at the surface and with depth. Variations from 1.00 to 1.88 ug. atoms/l. were found at the surface. The average surface concentration was 1.37 ug.atoms/l. Generally, a minimum concentration was found at 10 metres, but in several localities, a minimum was found at 20 metres. The minimum values of phosphate concentration also fluctuated considerably. These values ranged from a low of 0.83 ug.atoms/l. to a high of 1.42 ug./atoms/l. Below the minimum layer the phosphate concentration increased to a maximum of 75 to 100 metres, where values from 1.47 to 2.22 ug. atoms/l. were found. Below this depth the concentration generally decreased but seldom to values any lower than 1.50 ug.atoms/l.

Bottom Sediments, Gulf of Boothia and Prince Regent Inlet

Twenty-five bottom samples were collected in the Gulf of Boothia and Prince Regent Inlet with a Dietz-Lafond type bottom snap. Visual inspection of these samples revealed a marked uniformity of bottom material throughout the Gulf of Boothia and Prince Regent Inlet. The dominant constituent found in the samples was a sticky grey-brown clay containing small angular pebbles and occasional shells. The sediments collected in the northern end of Prince Regent Inlet were finer and contained fewer stones and less animal life than those found to the south, although the clay was of identical colour and similar composition.

Two bottom samples taken at the eastern end of Bellot Strait contained a high proportion of stones and very little of the characteristic clay. The predominance of stones and gravel at the eastern end of Bellot Strait could possibly result from the dumping of old ice in the Strait or from the washing of the bottom sediments by the strong tidal currents.

Of the 16 samples taken in the Gulf of Boothia, 10 contained angular stones and rocks in addition to clay. A comparison of the sediment distribution with the bottom configuration revealed that the stone and gravel layer was generally found between the shore and 100 fathoms. Below 100 fathoms, the bottom consisted almost entirely of fine grey clay.

Traces of bottom life were found in all the samples in the form of Annelida and other organisms. However, shells which are abundant in Foxe Basin sediments were noticeably scarce in the Gulf of Boothia and Prince Regent Inlet sediments (Campbell and Collin, MS 1957).

The rocks outcropping the Prince Regent Inlet area along the shores of Borden and Brodeur Peninsulas are composed of Silurian limestones and sandstones (Armstrong, 1947). The eastern coasts of Boothia Peninsula and Somerset Island are of similar geological composition. It is presumed from these facts that the dominant grey clay of the bottom sediments of the Gulf of Boothia and Prince Regent Inlet originate from these rock exposures. A characteristic brown surface layer, approximately 5 mm. thick, was found with all the grey clay samples. This peculiar layer on polar sea sediments is believed to be the result of oxidation of the grey sediment (Klenova, 1938). Klenova describes this phenomenon and reports that in the Polar Basin, the brown layer attains thicknesses of the order of 10 cm. (Klenova, 1938).

Circulation and Volume Transport

Estimates of speed and direction of the currents in Lancaster Sound, Prince Regent Inlet and the Gulf of Boothia are based for the main part on dynamic computations. There are definite limitations to the method arising from the assumptions of a steady state, a frictionless fluid, and the requirement that at some depth a level of no motion exists. In addition to these assumptions, part of a circulation system may be seasonal or secondary to tidal movements. However, in view of the lack of tidal and current data for such areas as Prince Regent Inlet and the Gulf of Boothia, the dynamic approach to the problem is the only feasible method available. Where possible, reference has been made to other expeditions in regard to the circulation (Tremblay, 1921; Sailing Directions for Northern Canada, 1951; and Winchester, 1954). Reference has also been made to the meteorological records of "Labrador", in instances where meteorological conditions appear to be a controlling factor in water movements.

The problem of deciding upon a "level of no motion" from which to calculate the dynamic heights was complicated in Prince Regent Inlet and the Gulf of Boothia by significant variations in depth (Fig. 3). In several cases where the bottom was less than the depth of an isobaric surface, the slopes of the σ_t surfaces were interpolated through the bottom using the method described by Groen (Groen, 1948).

The 150-metre level was chosen as a depth of no motion in Prince Regent Inlet and the Gulf of Boothia. The selection of this depth made it possible to use the maximum number of stations to obtain a more comprehensive picture of the water movement. Evan at this depth, several shallow stations had to be ignored for dynamic computations.

The general pattern of circulation in the Canadian Eastern Arctic has, in the past, been determined from the reports and investigations of the various expeditions which have navigated in these waters. From the evidence of a resultant southward flow through Davis Strait presented by Killerich in 1939, using data of the 1928 "Godthaab" expedition, it has been shown that the movement of water through Smith Sound, Jones Sound, and Lancaster Sound is southward and eastward into Baffin Bay (Kiilerich, 1939). Earlier evidence of the eastward current through Lancaster Sound was the drift of the U.S.S. "Rescue" and "Advance" in 1850, and H.M.S. "Resolute" in 1854. All of these ships became trapped in the ice of Lancaster Sound, but eventually drifted eastward into Baffin Bay (Taylor, 1955).

The oceanographic investigations in Lancaster Sound conducted by H.M.C.S. "Labrador" in August 1954 indicated that at that time the current through Lancaster Sound, Wellington Channel, and Barrow Strait was almost identical to the results found earlier by Kiilerich (Bailey, 1957). The two 1954 sections occupied in Lancaster Sound revealed a dominant eastward movement of water along the Baffin coast at speeds up to one-half a knot, and a narrow westward current along the Devon coast. Because this westward current did not appear at one of the sections, it was assumed that it was confined to a narrow band of water between the northern station of the line and the Devon coast, a distance of six miles. A weak easterly current was found in Barrow Strait. In Wellington Channel a definite southward movement of water occupied the full width of the passage.

The oceanographic data of the 1956 Arctic cruise indicate that the subsurface eastward current through Lancaster Sound is not as permanent a feature as may have been expected. In September 1956, the westward current below 50 metres was far more extensive than that encountered in 1954, and continued westward at least as far as the entrance to Prince Regent Inlet and perhaps as far as Barrow Strait.

At the surface, a westward moving current was confined to a narrow band along the Devon Island Coast. The width of this current in September 1956 was about eight miles, very similar to that inferred by Bailey (Bailey, MS 1955). A weak eddy was found in mid-channel in which the currents moved counter-clockwise about a centre near the position of station 188. North of station 188, the subsurface current moved in a westerly direction while south of this position, the movement was easterly. Along the southern shore, the eastward flowing current was approximately 14 miles wide.

The dynamic calculations indicate that the surface current strength was approximately 0.5 knots to the westward along the Devon Island Coast and 0.2 knots to the eastward along the Baffin Island Coast.

The distribution of density at the surface and 20 metres at the western section in Lancaster Sound indicates a change of the direction of flow (Fig. 8). North of station 184, the surface current would be easterly while between station 184 and the southern shore, the surface current would be westerly.

The difference in the direction of the surface currents within these two sections would indicate a surface convergence somewhere within the eastern end of the Sound. The reversal in surface current direction also appears when the dynamic heights are plotted using 50 metres as a depth of no motion, but if the dynamic heights are plotted from 200 metres as a depth of no motion, the reversal of direction does not appear. The selection of 50 metres as a depth of no motion was based on the horizontal distribution of the density surfaces (Figs. 7 and 8).

The westward current, below 50 metres, is confined to the northern section of the Sound in the eastern end of the Sound. It appears to expand across the full width of the channel between 50 and 150 metres and also from 400 metres to the bottom. In the western section, the eastward moving current is however, restricted to a region south of station 183, between 200 and 400 metres (Fig. 2). The speed of the current at the surface was found to be insignificant, being less than 0.1 knots.

In Barrow Strait the eastward current lies between 50 and 150 metres and extends through that part of the channel south of station 180. An eastward moving current also appears in mid-channel between stations 179 and 180. Its surface speed is of the order of 0.2 knots while at greater depths, the eastward velocity decreases until at 200 metres, the speed is negligible. A westward current was found to exist within the upper 50 metres on both sides of the Strait at the time of the 1956 observations. Along the northern side the western surface current was approximately 11 miles in width and from dynamic calculations, the speed was found to be of the order of 0.5 knots. The surface westward current on the southern side extended seaward for a distance of 10 miles. This speed was calculated to be approximately 0.3 knots.

Several references to voyages through Barrow Strait are mentioned in the "Sailing Directions for Northern Canada", such as the passages of the "Gjoa", the C.G.S. "Arctic", and the "St. Roch". It is of interest to note that without exception these vessels found the best ice conditions for navigation to be along either coast, that is, in the areas of the westerly currents.

When this evidence is considered with the assumption of a clockwise circulation in Viscount-Melville Sound as reported by Stefansson and Larsen, it appears that the eddy extends into Barrow Strait forming the mid-channel eastern current, and the western current along the south shore (Sailing Directions for Northern Canada, 1951). Between the northern edge of the eddy and the Cornwallis Island Coast, there is a set to the west which is possibly related to the outflowing current from Wellington Channel.

In Prince Regent Inlet dynamic calculations are somewhat restricted by the depth of water. As a result of this restriction, the dynamic calculations are based on an assumed level of no motion at 150 metres. In September, 1956, the movement of water in Prince Regent Inlet and the Gulf of Boothia was found to take the form of two cellular systems apparently controlled by the alternating tidal current through Bellot Strait and the discharge of melt water from Committee Bay.

In Prince Regent Inlet the predominant flow is northward throughout the greatest part of the Inlet except for a narrow southward current limited to the Somerset Island Coast (Fig. 20). The velocity of the northward current is calculated to be approximately 0.2 knots mid-channel. The narrow coastal current is estimated to be 0.5 knots southward.

The effect of the current through Bellot Strait is not yet completely understood owing to the lack of tidal information and current measurements. Nevertheless, temperature and salinity distributions indicate that the current through the Strait extends for a considerable distance eastward into the Gulf of Boothia and has a definite influence on the exchange of water through Prince Regent Inlet and the Gulf of Boothia.

Under conditions of an eastward moving current through Bellot Strait (flood tide) at an average speed of 5 knots, the incoming water appears to have the effect of a valve partially blocking the transfer of water southward into the Gulf of Boothia. With a change of tide, the blocking nature of the Bellot Strait flow is removed, and the change allows the southward moving current from Prince Regent Inlet to continue into the Gulf of Boothia.

A preliminary investigation of Bellot Strait in 1956 revealed a maximum estimated current speed of 7.5 knots to the eastward (Smith, personal communication). M'Clintock estimated that the current in the Strait runs to the westward from two hours before high water until four hours after, with the eastward stream much the stronger (Sailing Directions for Northern Canada, 1951).

It is suggested, therefore, that at the time of the strongest eastward flow through Bellot Strait, the counter-clockwise circulation in Prince Regent Inlet does not extend as far south as it would at times of westward flow through the Strait. At the same time, the transfer of water through Prince Regent Inlet into the Gulf of Boothia will be least at times of maximum eastward flow through Bellot and greatest during the time of westward flow.

As a result of the alternate flows through Bellot Strait, the mean southward current, which passes along the Somerset Island Coast through Prince Regent Inlet, crosses the Inlet and merges with the Gulf of Boothia circulation in the vicinity of Bernier Bay. From this position southward to Fury and Hecla Strait, the southward moving current is compressed against the Baffin Island Coast owing to the large quantities of low-density melt water discharged from the ice in Committee Bay. The extensive areas of ice which are reported to remain throughout the year in Committee Bay act as a summer source of brackish water. A large volume of low-density water flows northeastward and gradually blends with the southern flow from Prince Regent Inlet forming the southern current of the Gulf of Boothia. Calculated speeds in the Gulf of Boothia are 0.3 knots northward along the Simpson and Boothia Peninsula coasts, and 0.4 knots southeastward along the eastern shore of the Gulf of Boothia. In the vicinity of Crown Prince Frederik Island at the western end of Fury and Hecla Strait, there is a counter-clockwise eddy between the Island and the boundary of the southward current.

The current through Fury and Hecla Strait is not permanently to the eastward but alternates in direction with the state of the tide. Parry observed that the flood tide in the Strait set to the eastward, and the ebb to the westward (Parry 1824). The predominance of the easterly current often obscures the westward set (Sailing Directions for Northern Canada, 1951). In 1910 Tremblay made similar observations. "In mid-channel the stream constantly set to the eastward from daylight till dark, and that when on the south shore a westerly set was observable, the tide was generally falling. From these observations, it would appear that a regular stream of flood tide sets to the eastward and that the ebb to the westward in this Strait" (Tremblay, 1921). Manning refers to a permanent current coming from the west through the Strait combined with a strong northwest wind which lasted for at least two days (Manning, 1943). Under the influence of a prolonged northwest wind, it is altogether probable that the weak westward current is completely absent and an eastward current continues through the full tidal cycle as suggested by Parry.

The major difference of the circulation in Lancaster Sound revealed by the 1956 cruise of H.M.C.S. "Labrador" from previous observations was the predominant westward flow extending to Barrow Strait. This result is not new since Winchester has shown that on occasion, an easterly wind of 72 to 96 hours' duration at the eastern end of Lancaster Sound causes a blocking of the normal current system (Winchester, 1954). The effect is an increase of magnitude and interval of the westward current and a decrease in the eastward current.

Winds in Lancaster Sound are reported to blow predominantly parallel to the length of the Sound either from the east or west (Parry, 1821). The occurrence, frequency and periods of these winds are not precisely known, but the fact that easterly winds occur for long periods of time suggest that at least current and volume transport reversals are perhaps not too unusual in Lancaster Sound. Additional evidence of such a phenomenon may also be indicated by the close relationship of the T-S characteristics in Prince Regent Inlet and those at the eastern end of Lancaster Sound.

The wind, during the time the Lancaster Sound stations were occupied in 1956, was decidely different from that experienced in 1954. In August, 1954, the wind in Lancaster Sound was predominantly from the southeast. This condition existed for at least four days prior to the completion of the two oceanographic sections in the Sound. However, before the stations were occupied in Barrow Strait, the wind was from the northwest for two days (Bailey, MS 1955). In contrast, at the time the three oceanographic lines were occupied in Lancaster Sound and Barrow Strait in September, 1956, the wind was from the northwest at an average speed of 12 knots. However, for the eight days immediately preceeding the date of these observations, the wind was from an easterly quarter at 18 knots. Since the average wind speed in Barrow Strait is of the order of 2.7 knots, the wind speed for these eight days represents a significant variation from the mean. It is, therefore, reasonable to assume that the current condition encountered by "Labrador" in Barrow Strait in 1956 was similar to that experienced by Winchester in September, 1951. The major cause of the stronger western current through Lancaster Sound and Barrow Strait would have been the prevailing easterly wind.

Bailey has calculated the net volume transport of water through Lancaster Sound from the results of the "Labrador" cruise of 1954 and compared these findings with those of the "Godthaab" expedition, 1928 (Bailey, 1957; Kiilerich, 1939).

In September, 1956, a net volume transport of $1.0 \times 10^6 m^3/sec.$ was calculated to pass westward into Lancaster Sound from Baffin Bay. This figure is of the same order of magnitude as those obtained by Kiilerich and Bailey but the direction is to the west. A net transport to the west was found in the second oceanographic section in Lancaster Sound and also in Barrow Strait where the volume transport was $0.36 \times 10^6 m^3/sec.$ The only forces of sufficient magnitude to account for these phenomena are large scale changes in

Arctic meteorological conditions. An indication of the abrupt change in temperature between August and September is evidenced by the 13° F. decrease in surface air temperatures in Lancaster Sound.

In Prince Regent Inlet the net volume transport based on the dynamic calculations was $0.5 \times 10^6 m^3$/sec. to the northward. However, a study of the current movements in the Inlet reveals that there must be a considerable movement of water southward along the Somerset Island coast to maintain the outflow from Prince Regent Inlet and the eastward flow through Fury and Hecla Strait. The southward current must enter Prince Regent Inlet between Prince Leopold Island and Cape Clarence at the northeastern point of Somerset Island.

The net eastward transport through Fury and Hecla Strait has been ascertained to be in the order of $0.05 \times 10^6 m^3$/sec. while the transport eastward through Bellot Strait is probably not more than $0.1 \times 10^6 m^3$/sec. It is therefore necessary to presume that a flow transporting at least $0.35 \times 10^6 m^3$/sec. passes southward through Leopold Channel to maintain volume equilibrium in Prince Regent Inlet and the Gulf of Boothia. It is estimated that this volume could be transported through the channel between Prince Leopold Island and Cape Clarence, if the current through this passage is approximately 1.0 - 1.5 knots southeastward.

SUMMARY

1. An oceanographic survey was carried out in the Gulf of Boothia, Prince Regent Inlet, Barrow Strait and Lancaster Sound, September 1956.

2. Heavy winter floes were encountered near Committee Bay with young ice forming between the old floes. Further north, old winter ice was scarce but freshly formed ice was common.

3. The average surface temperature for the whole area investigated was -1.4°C. The coldest water was located in Barrow Strait where the average surface temperature was -1.7°C. No comparable warm water conditions were found in the eastern end of Lancaster Sound as in previous expeditions.

4. The surface salinity in Barrow Strait and Lancaster Sound ranges from 31.00‰ in the vicinity of Resolute Bay to 33.00‰ in the eastern end of Lancaster Sound. In Prince Regent Inlet and the Gulf of Boothia, the surface salinity decreases from approximately 30.00‰ in the north to 28.60‰ in the south.

5. The vertical distribution of temperature and salinity is quite different in each area of survey. The highest temperatures and salinities were found near the bottom in Lancaster Sound. Temperatures in this area increased from -1.25°C. near the surface to 0.75°C. at the bottom, while the salinities increased from approximately 32.50 to 34.70‰. At Barrow Strait, the vertical temperature varied from approximately -1.7°C. at the surface to -1.35°C. at the bottom, with a corresponding increase of salinity from 31.00 to

33.00‰. Thermal and haline characteristics in Prince Regent Inlet appear to be distinct from the other regions. Temperatures increased from -1.50°C. at the surface to -1.00°C. at 300 metres, while the salinity ranged from approximately 33.00‰ at the surface to greater than 34.00‰ at 250 metres.

Conditions in the Gulf of Boothia are more like those in Barrow Strait, where the salinities are relatively low. From the region of Bellot Strait south to Fury and Hecla Strait, both temperatures and salinities decreased to minima of -1.50°C. and 29.00‰ at the surface, and -1.50°C. and 32.25‰ near the bottom.

6. T-S characteristics reveal that within the central part of the Archipelago, so-called "Polar water" is dominant. In Lancaster Sound temperature and salinity conditions can be so varied that the upper strata of waters cannot be said to have any typical T-S characteristics. The deep waters, however, have temperature and salinity characteristics, typical of the Intermediate Baffin Bay water. Deep waters in Prince Regent Inlet also show similar characteristics as the deep water in Lancaster Sound. These conditions may be indicative of a westward intrusion of deep water from Baffin Bay. The question whether or not intrusion of this high-salinity water is steady, periodic, or not, is difficult to answer. It is felt however, that such a movement occurs aperiodically, coinciding with large scale meteorological changes.

7. Oxygen analyses revealed that surface oxygen concentrations were about 8.3 ml./l. decreasing to 6 or 7 ml./l. in Prince Regent Inlet and the Gulf of Boothia and further to 5 or 6 ml./l. in

Lancaster Sound at the bottom. Phosphate concentrations varied considerably, ranging from 1.00 to 1.88 ug. atoms/l. at the surface to values of 0.83 and 1.42 ug. atoms/l. at a phosphate minimum, and increasing again to values between 1.47 and 2.22 ug. atoms/l. at or near the bottom.

8. Bottom sediments were predominantly composed of a sticky grey-brown clay containing small angular pebbles and occasional shells. In the deeper waters, fewer stones and less animal life were found than in shallower water.

9. The main feature of the circulation was a dominant westward flow of water through Lancaster Sound extending almost as far as Barrow Strait. This phenomenon is believed to be directly related to the prevailing easterly winds occurring just prior to the time of survey. The circulation in Prince Regent Inlet and the Gulf of Boothia does not appear to be dominated by any single current stream. The lack of variation in the distribution of property suggests weak movements and the possibility of meandering streams. The only regions where strong currents are suspected are along the Somerset Island coast south of Leopold Island and farther south near Crown Prince Frederik Island. In the latter region, the driving force of the currents appears to be the discharge of melt water from Committee Bay. The fact that this phenomenon would be absent in the winter implies that the circulation would be different, and the question arises during a summer survey whether or not typical or representative circulations can be depicted for the southern regions of the Gulf of Boothia.

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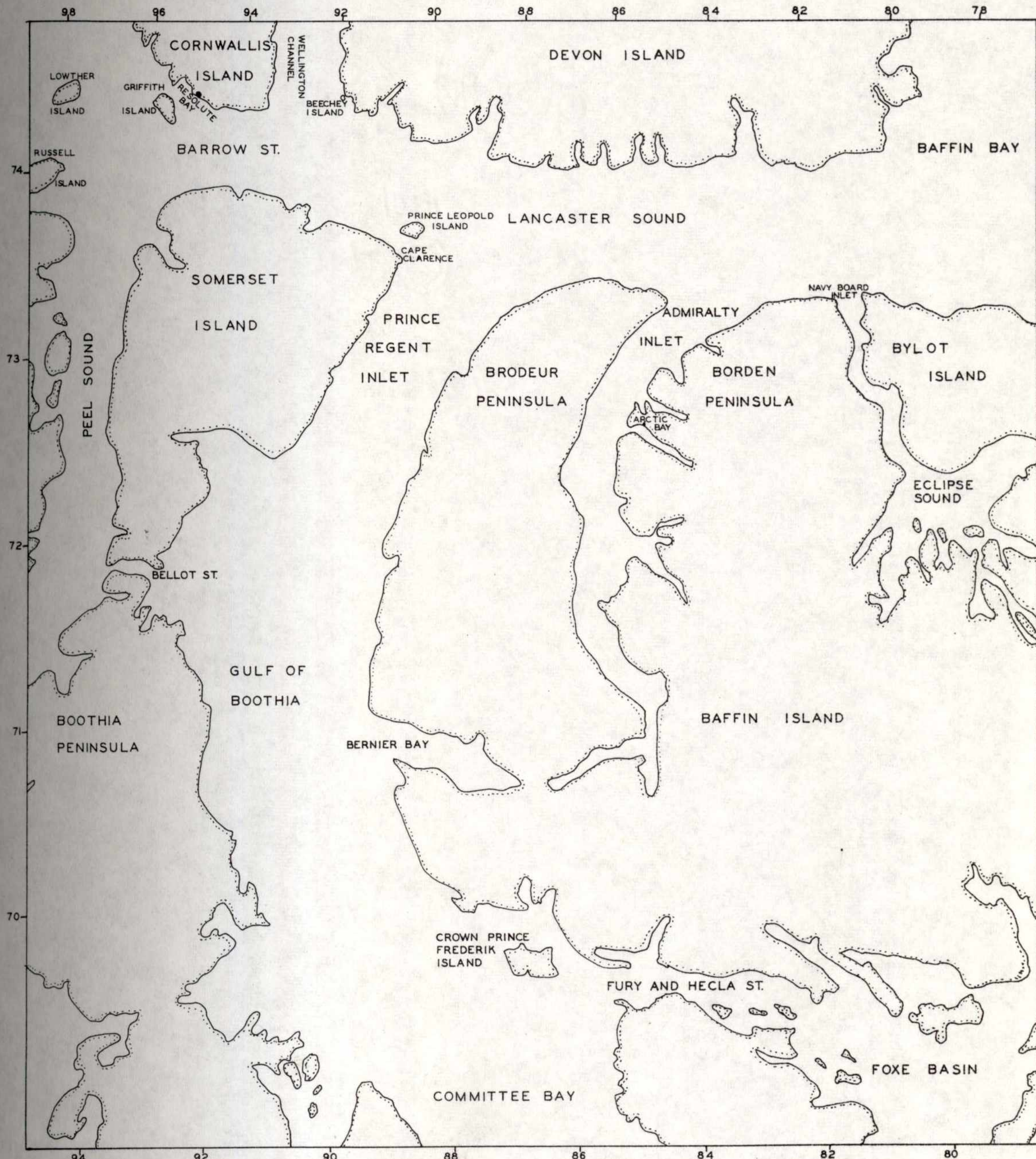

Fig. 1 Lancaster Sound - Gulf of Boothia Area.

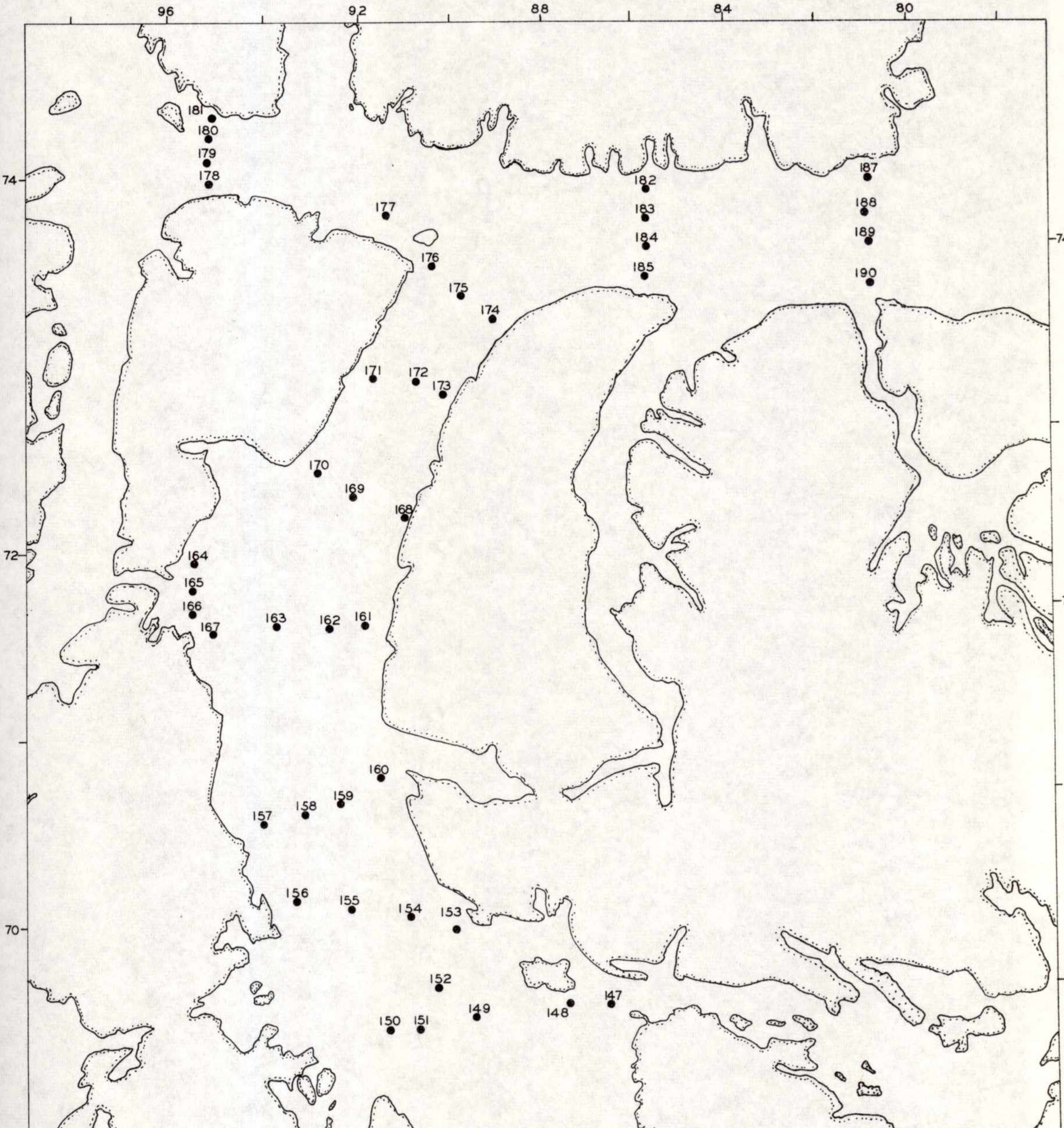

Fig. 2 Oceanographic Stations. Lancaster Sound, Barrow Strait, Prince Regent Inlet, and Gulf of Boothia. September 1956.

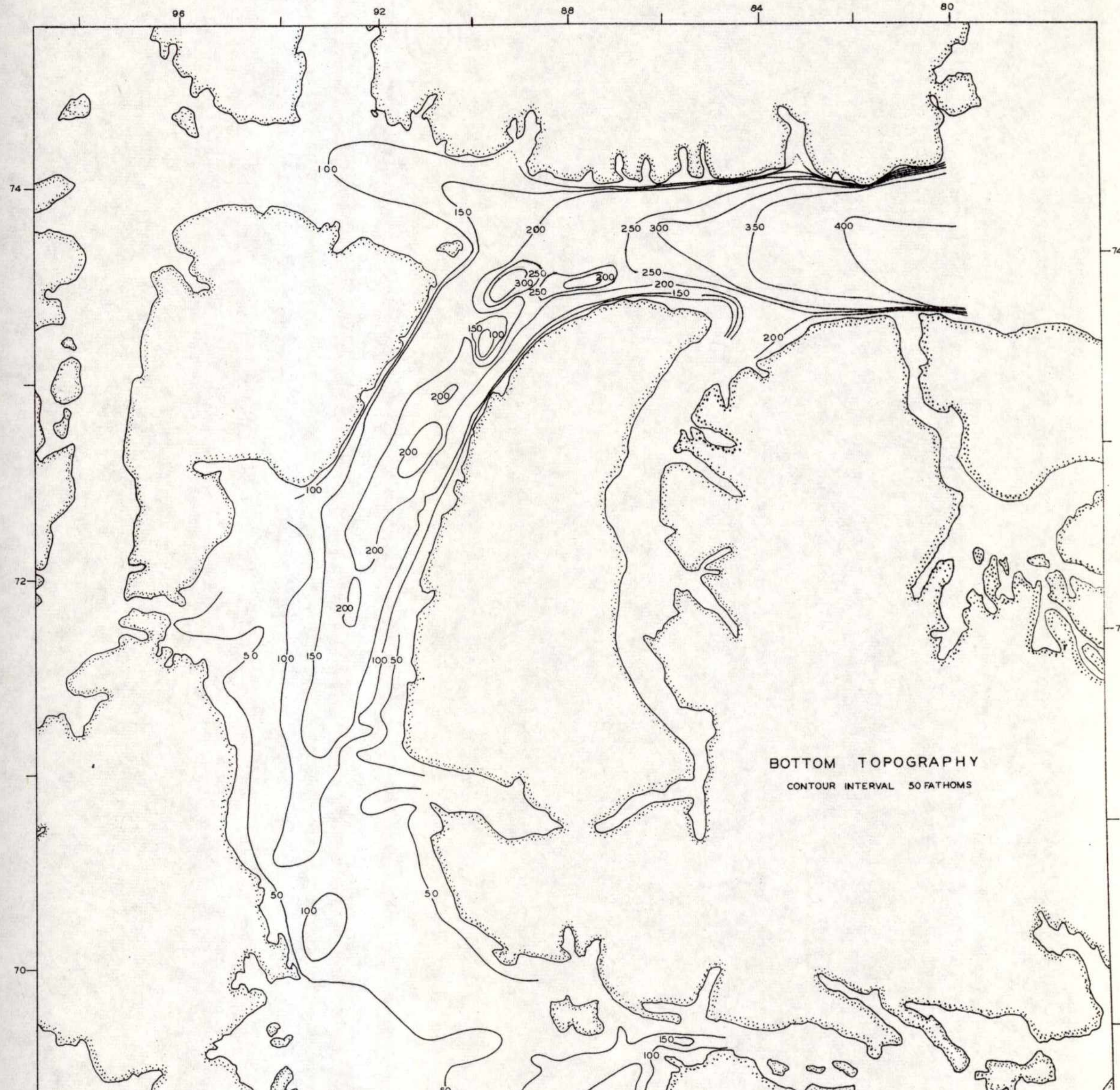

Fig. 3 Bottom topography, Lancaster Sound, Prince Regent Inlet and Gulf of Boothia. 1956.

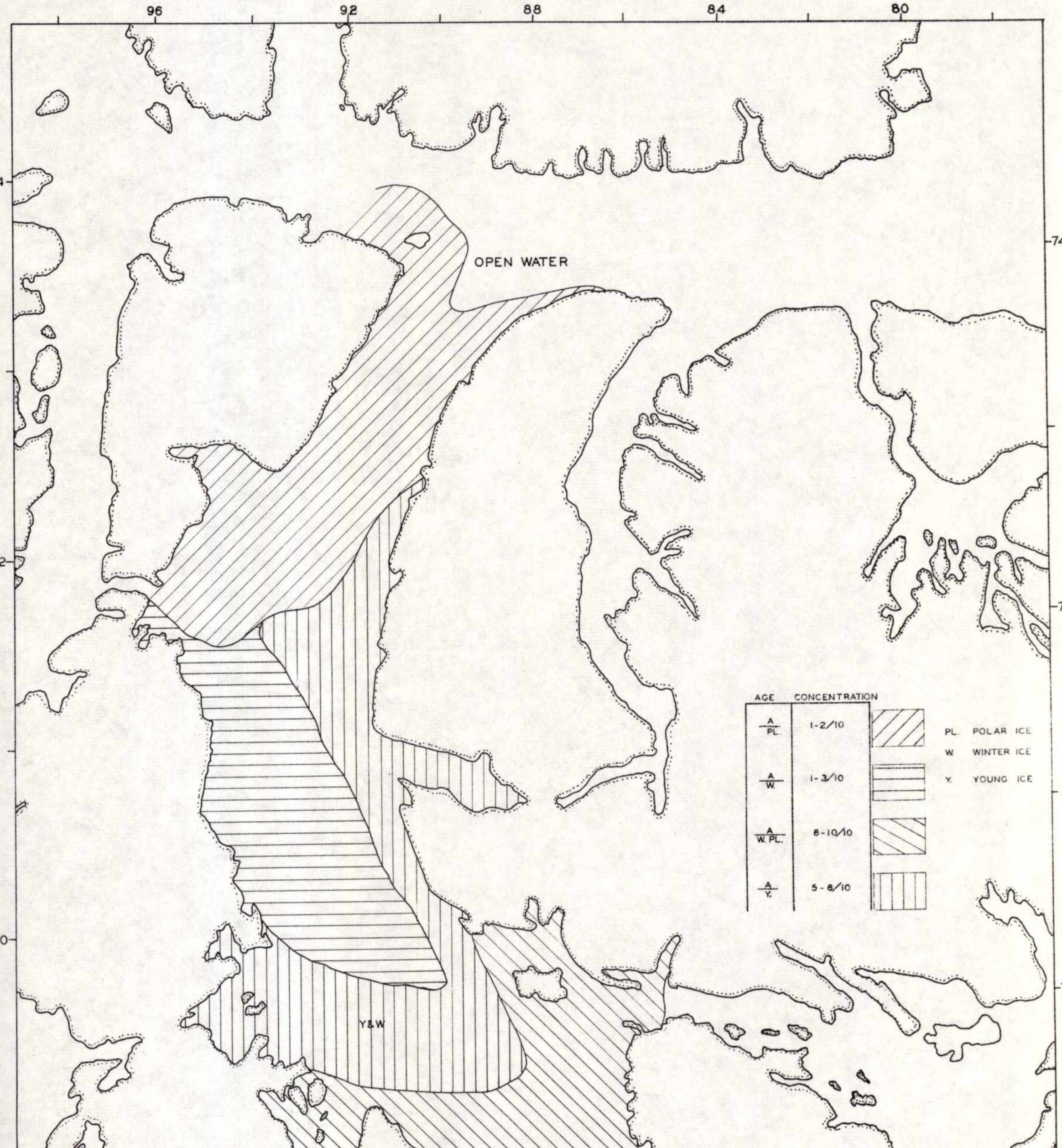

Fig. 4 Distribution of ice, Prince Regent Inlet and Gulf of Boothia, September 1956.

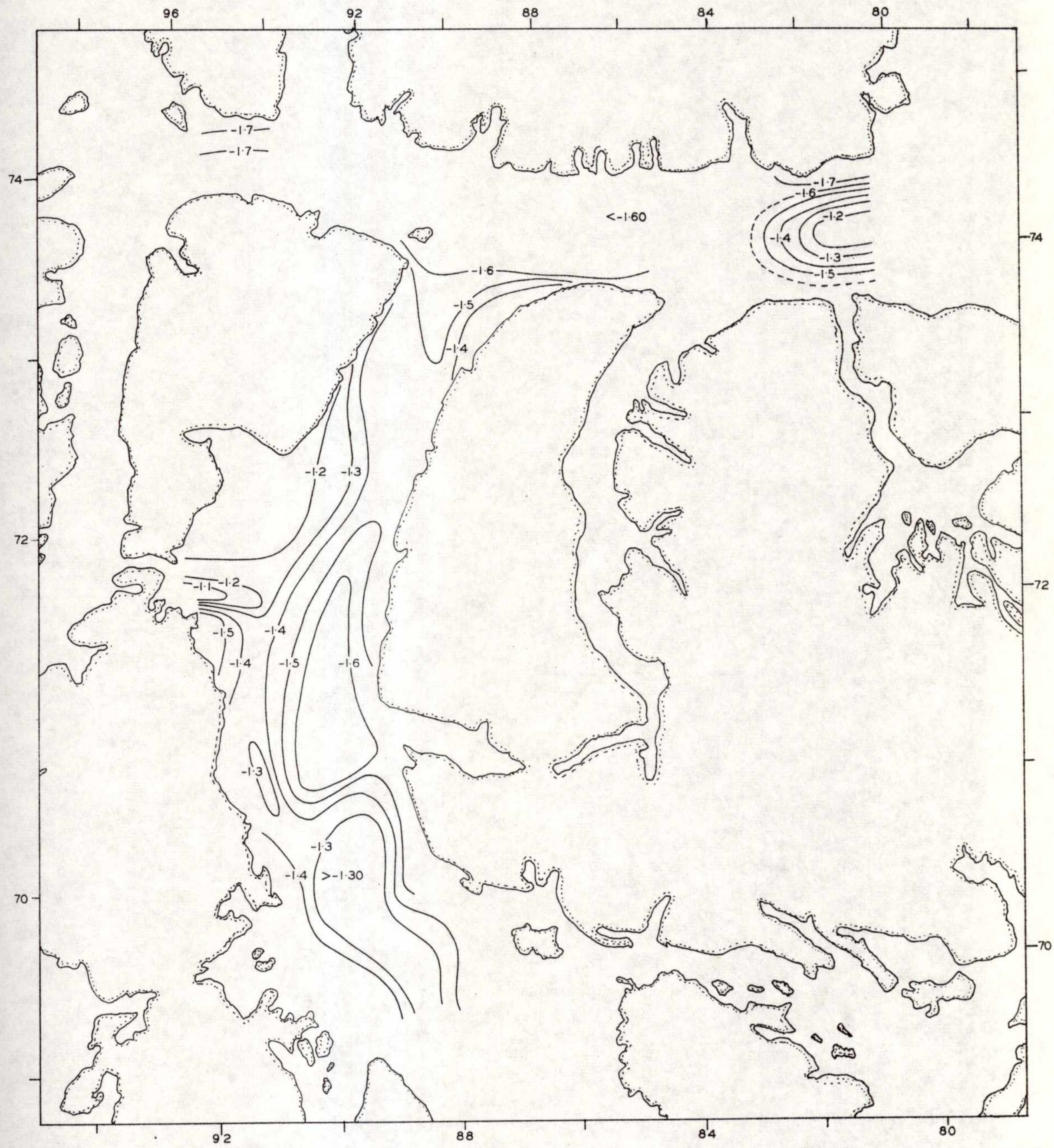

Fig. 5 Surface temperature, Lancaster Sound, Prince Regent Inlet and Gulf of Boothia, 1956.

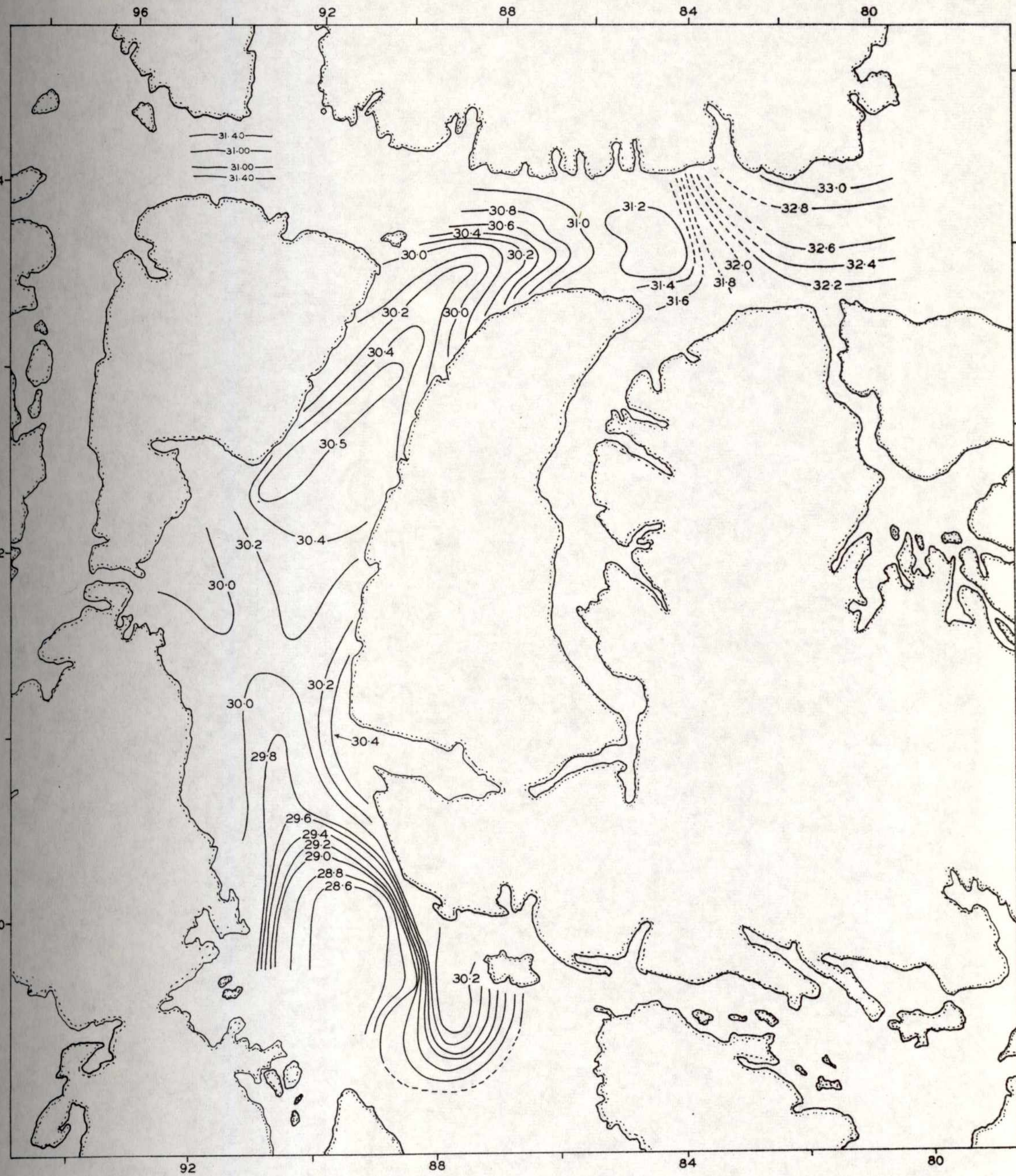

Fig. 6 Surface salinity, Lancaster Sound, Prince Regent Inlet and Gulf of Boothia, 1956.

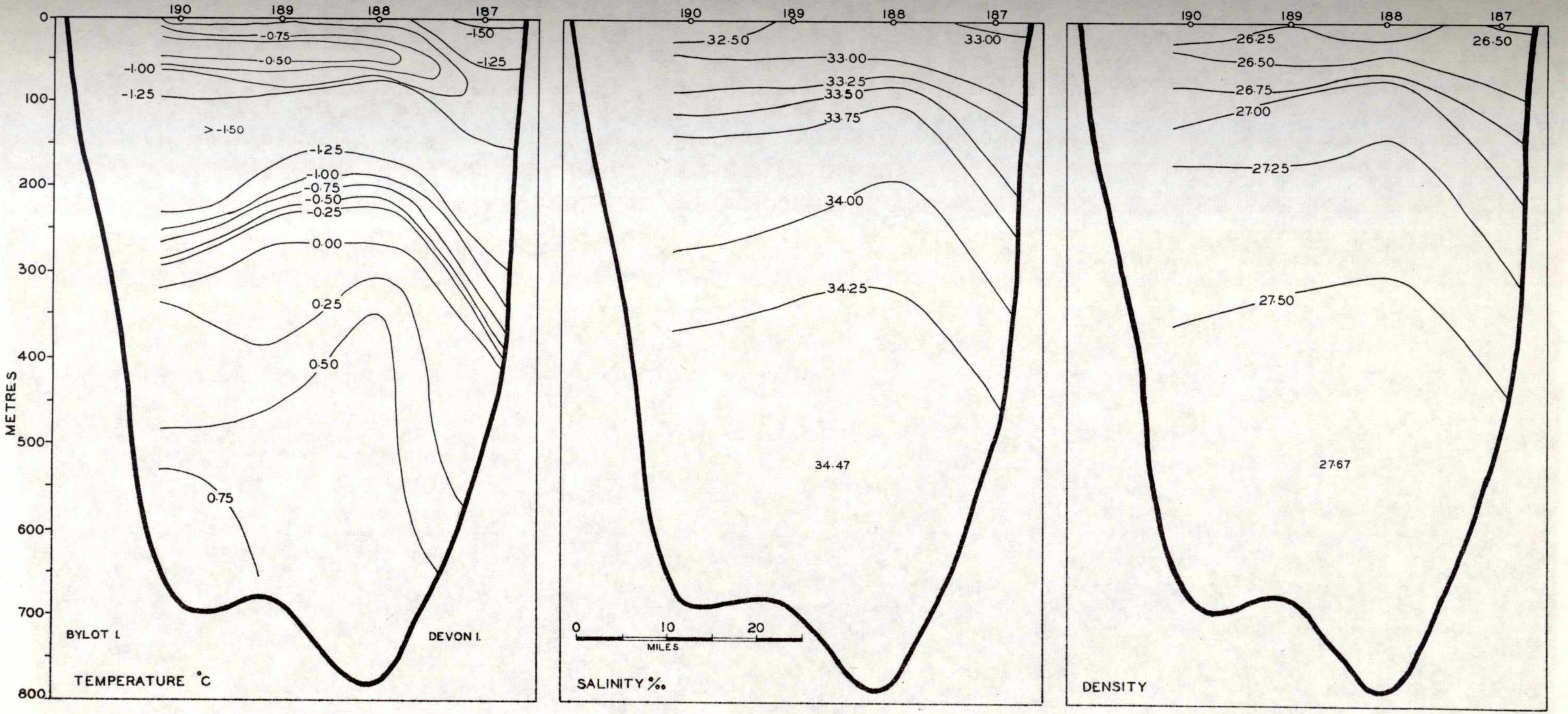

Fig. 7 Cross-sectional distributions of temperature, salinity and density in Lancaster Sound (east), 1956.

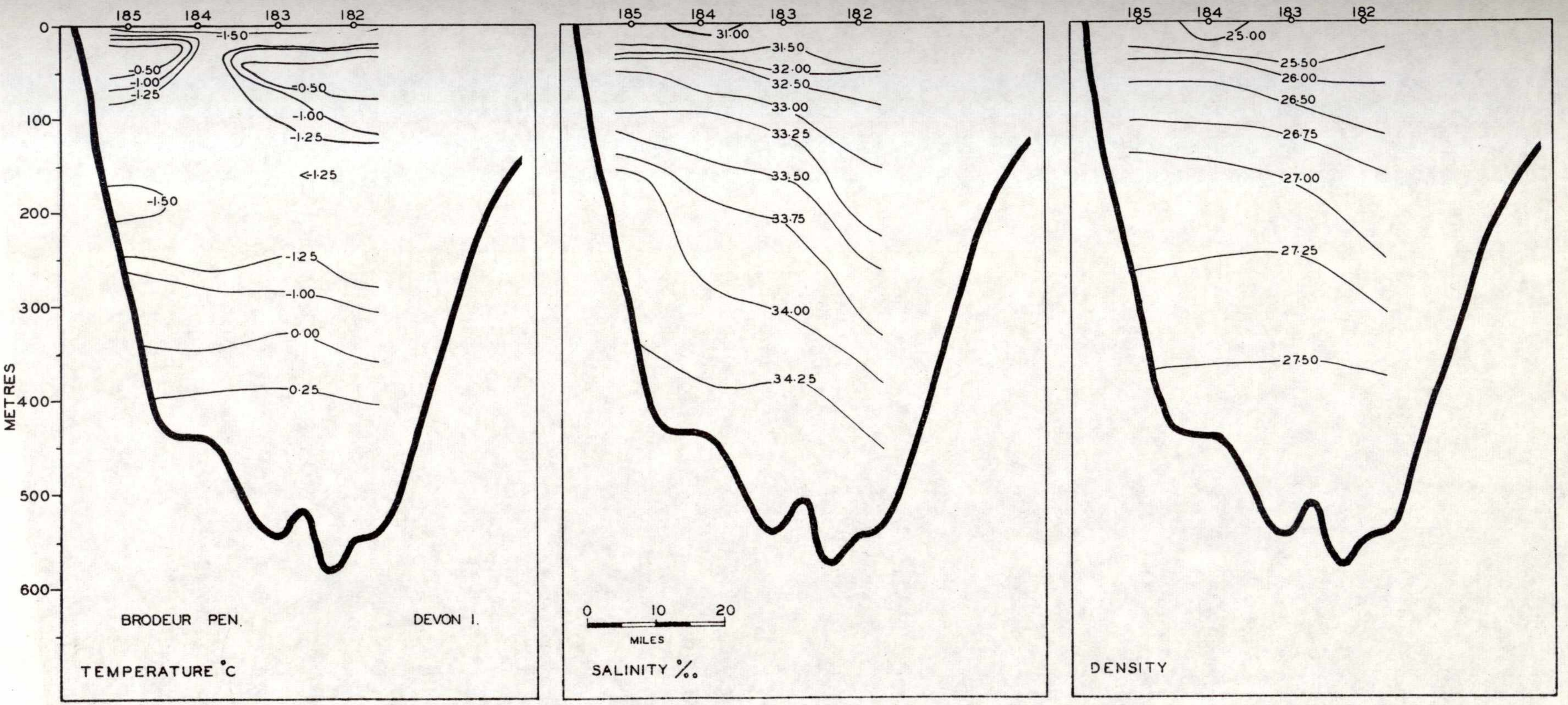

Fig. 8 Cross-sectional distributions of temperature, salinity and density in Lancaster Sound (west), 1956.

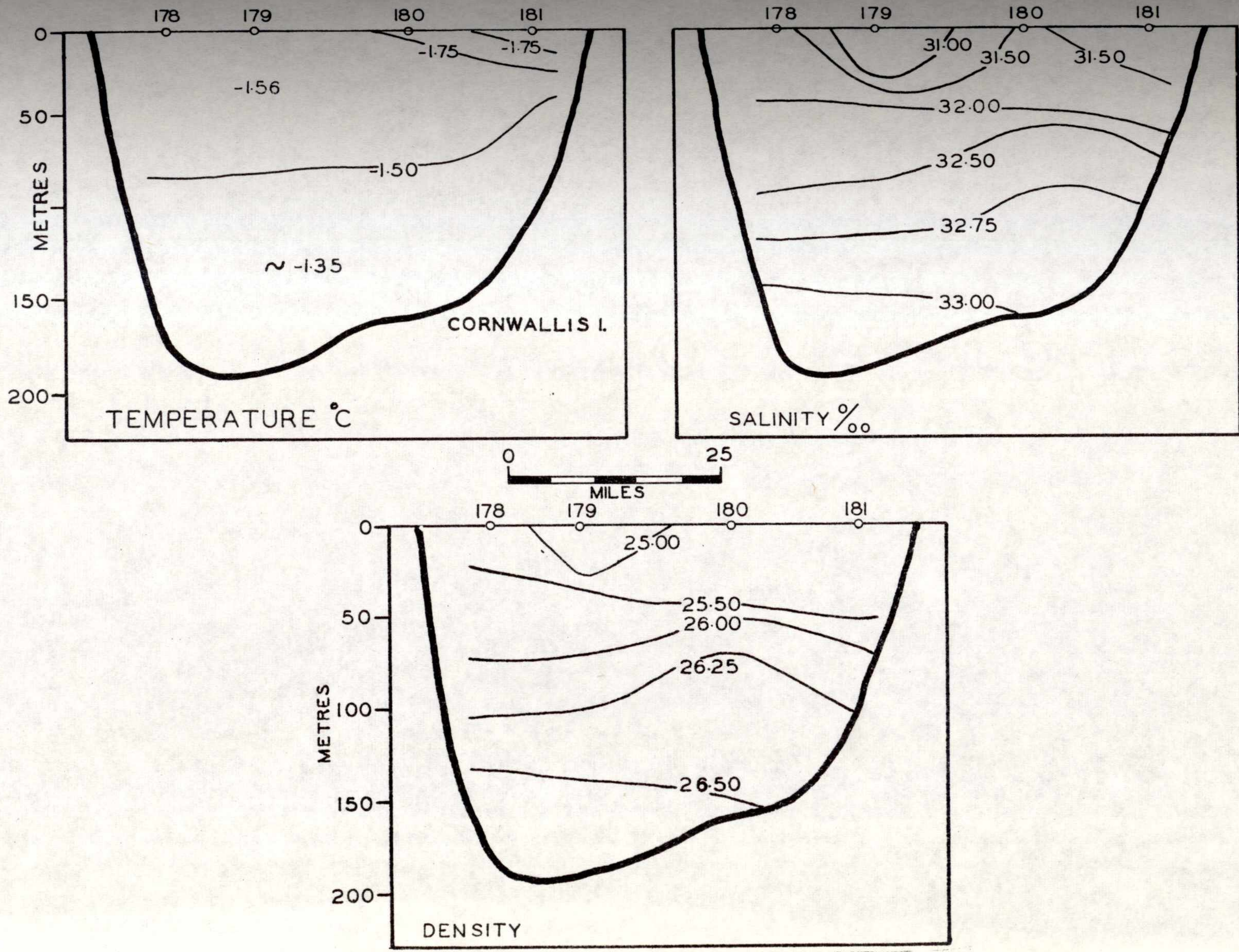

Fig. 9 Cross-sectional distributions of temperature, salinity and density, Barrow Strait, 1956.

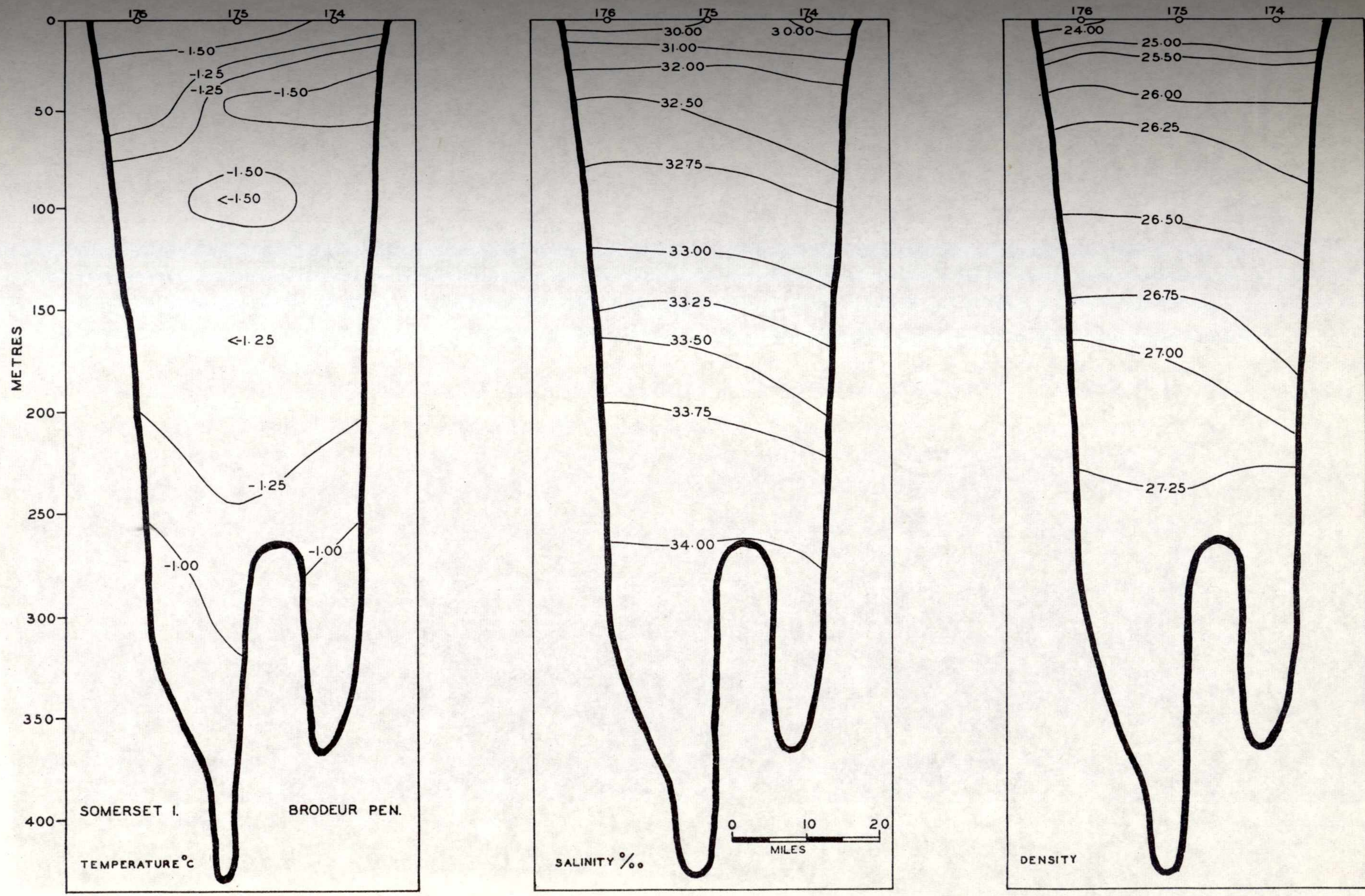

Fig. 10 Cross- sectional distributions of temperature, salinity and density, Prince Regent Inlet (north) 1956.

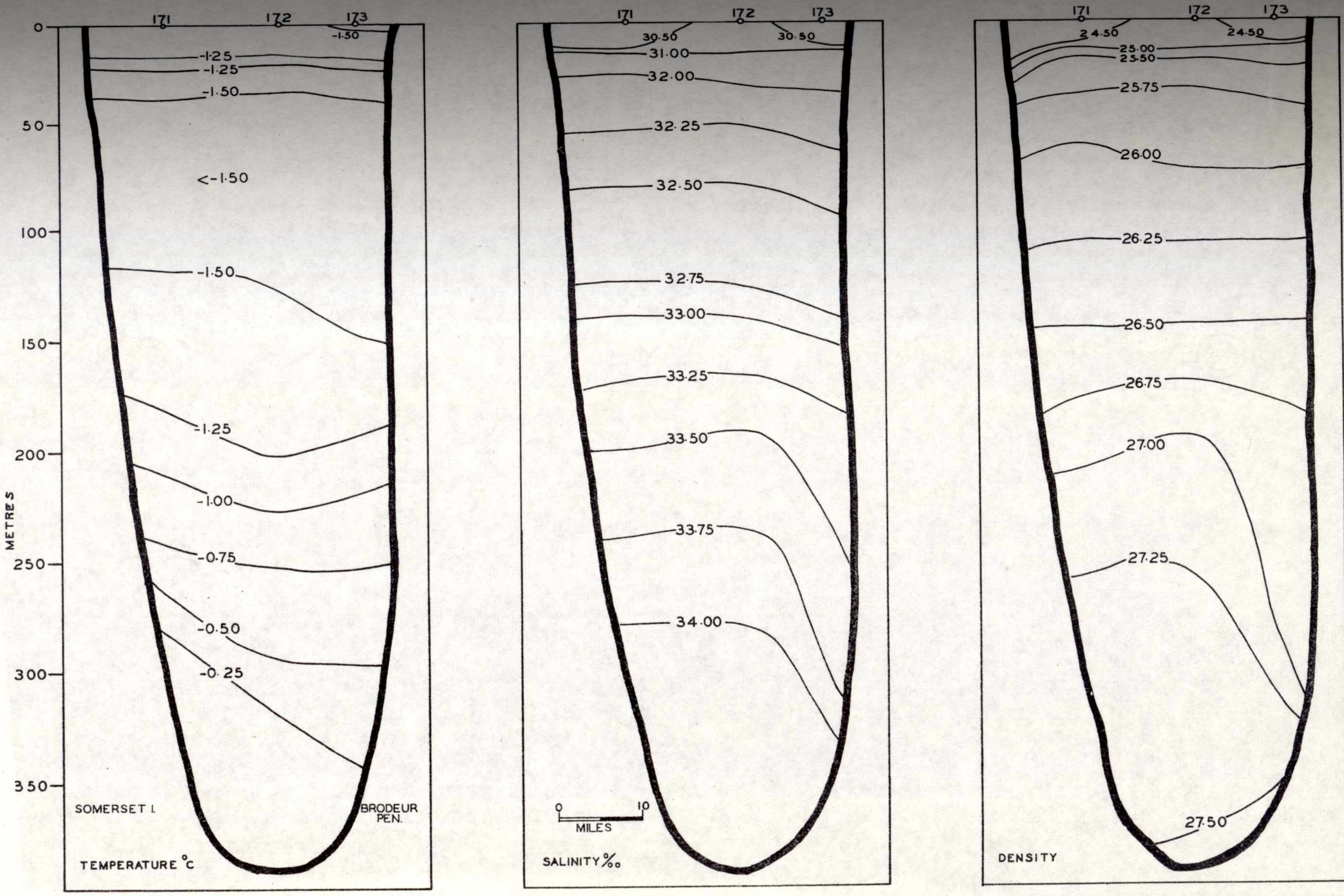

Fig. 11 Cross-sectional distributions of temperature, salinity and density, Prince Regent Inlet, 1956.

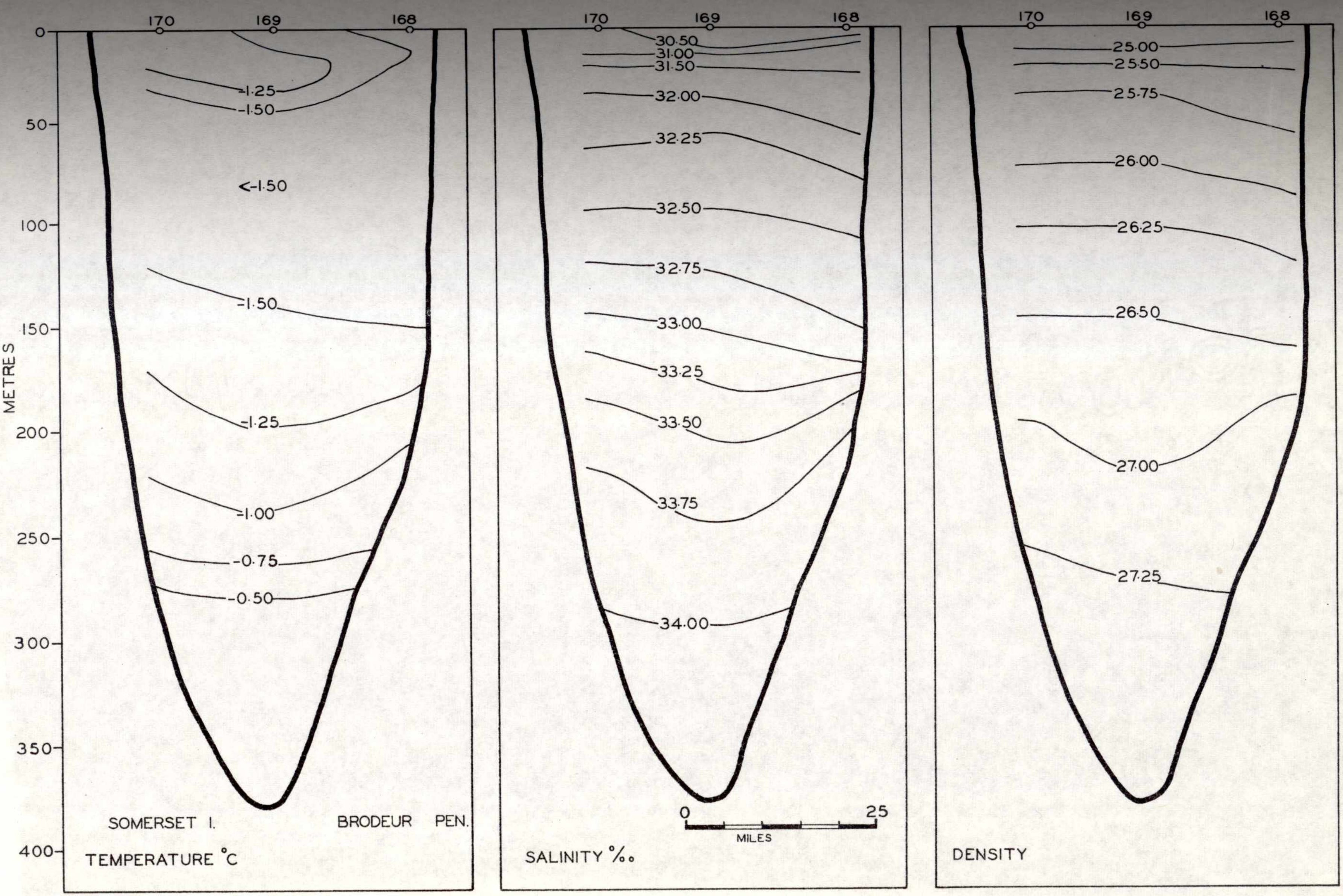

Fig. 12 Cross-sectional distributions of temperature, salinity and density, Prince Regent Inlet (south), 1956.

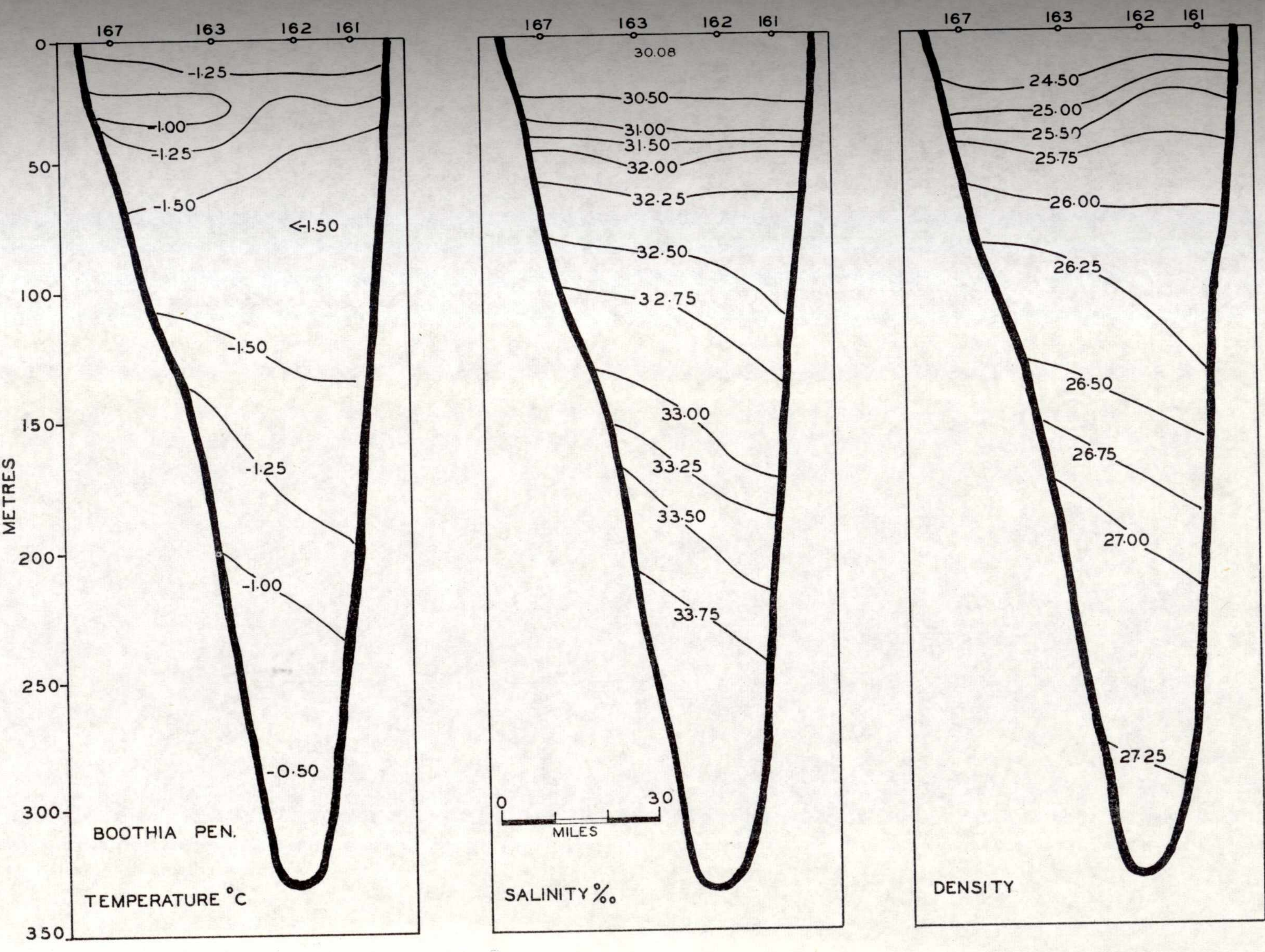

Fig. 13 Cross-sectional distributions of temperature, salinity and density, Gulf of Boothia, (north) 1956.

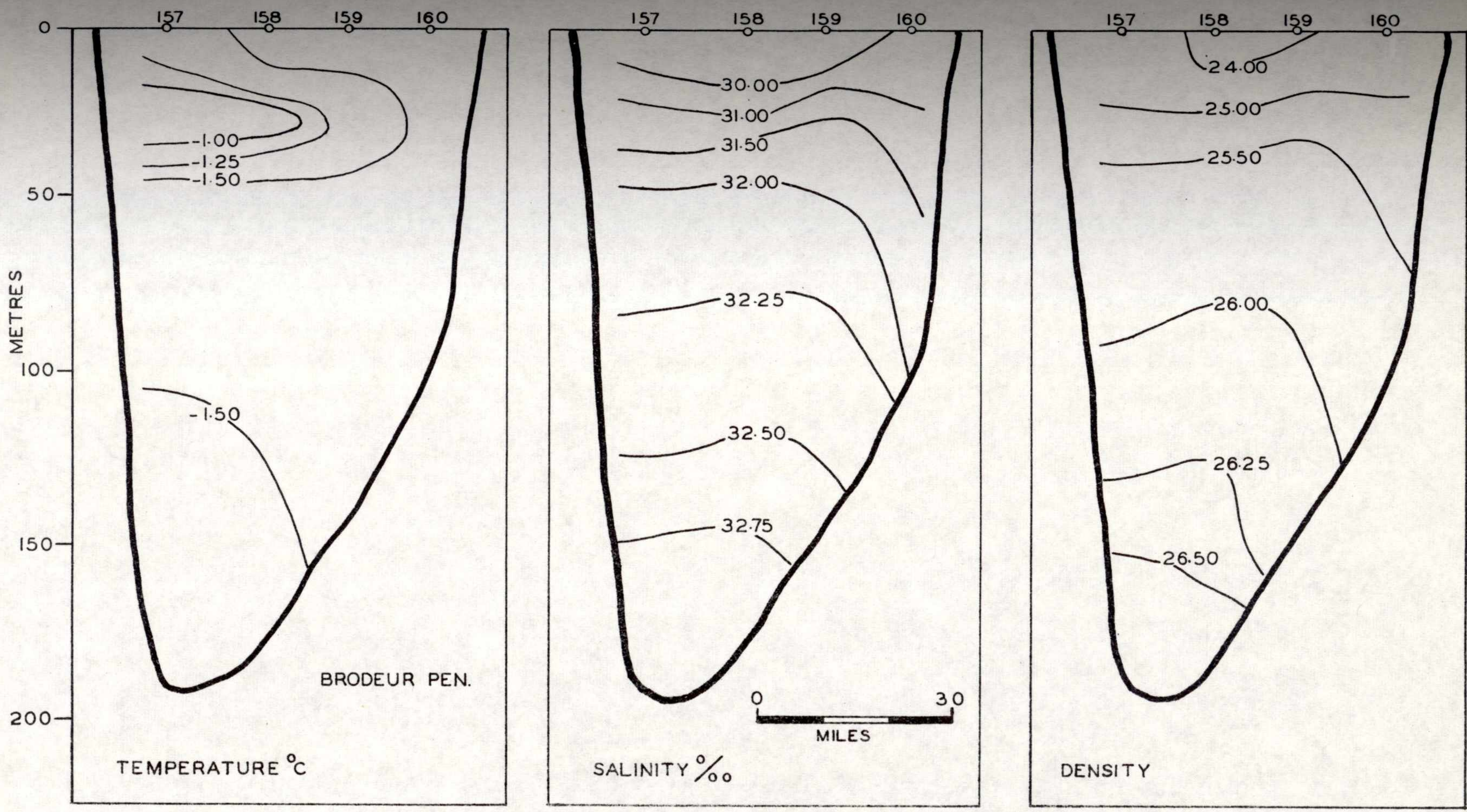

Fig. 14 Cross-sectional distributions of temperature, salinity and density, Gulf of Boothia, 1956.

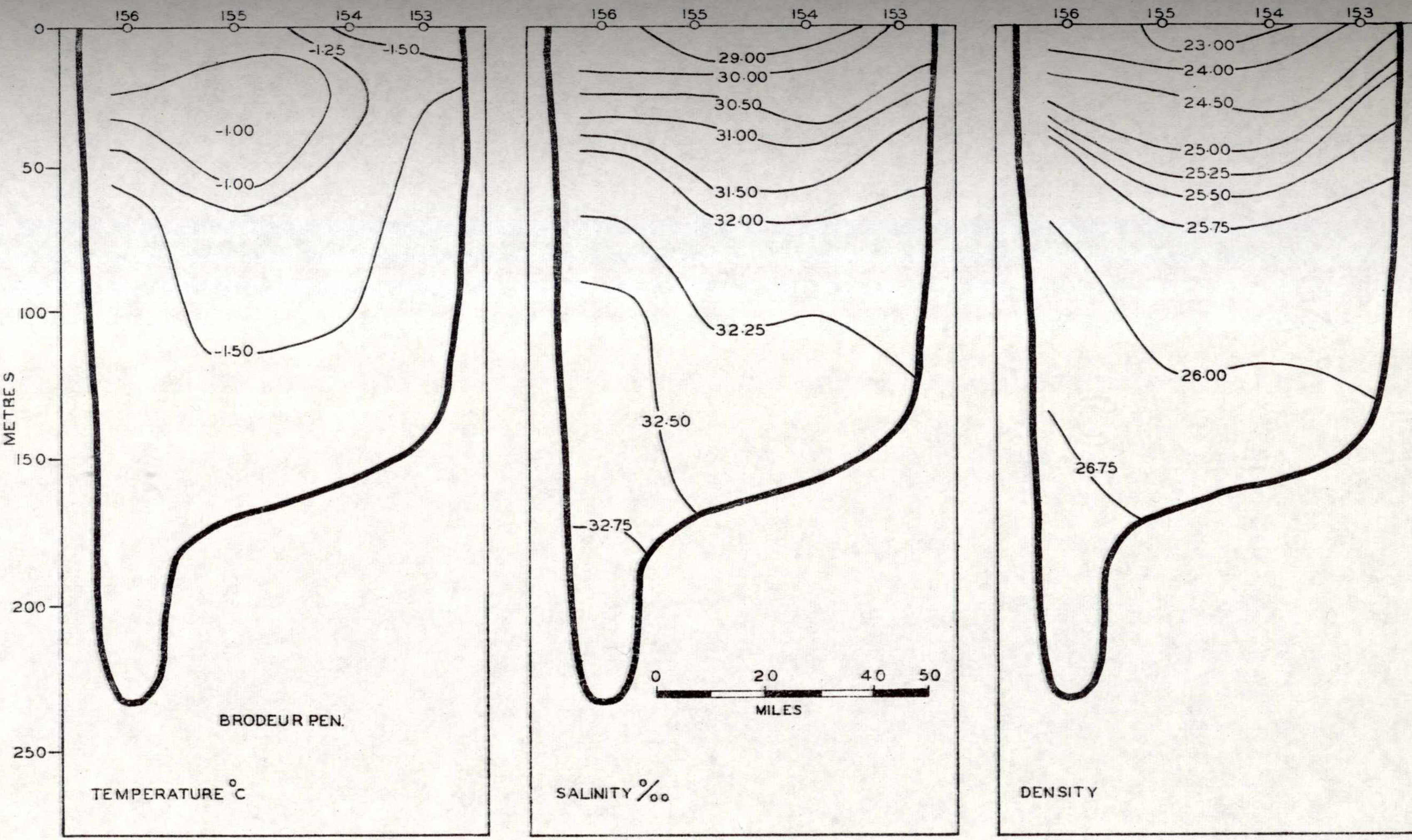

Fig. 15 Cross-sectional distributions of temperature, salinity and density, Gulf of Boothia (south), 1956.

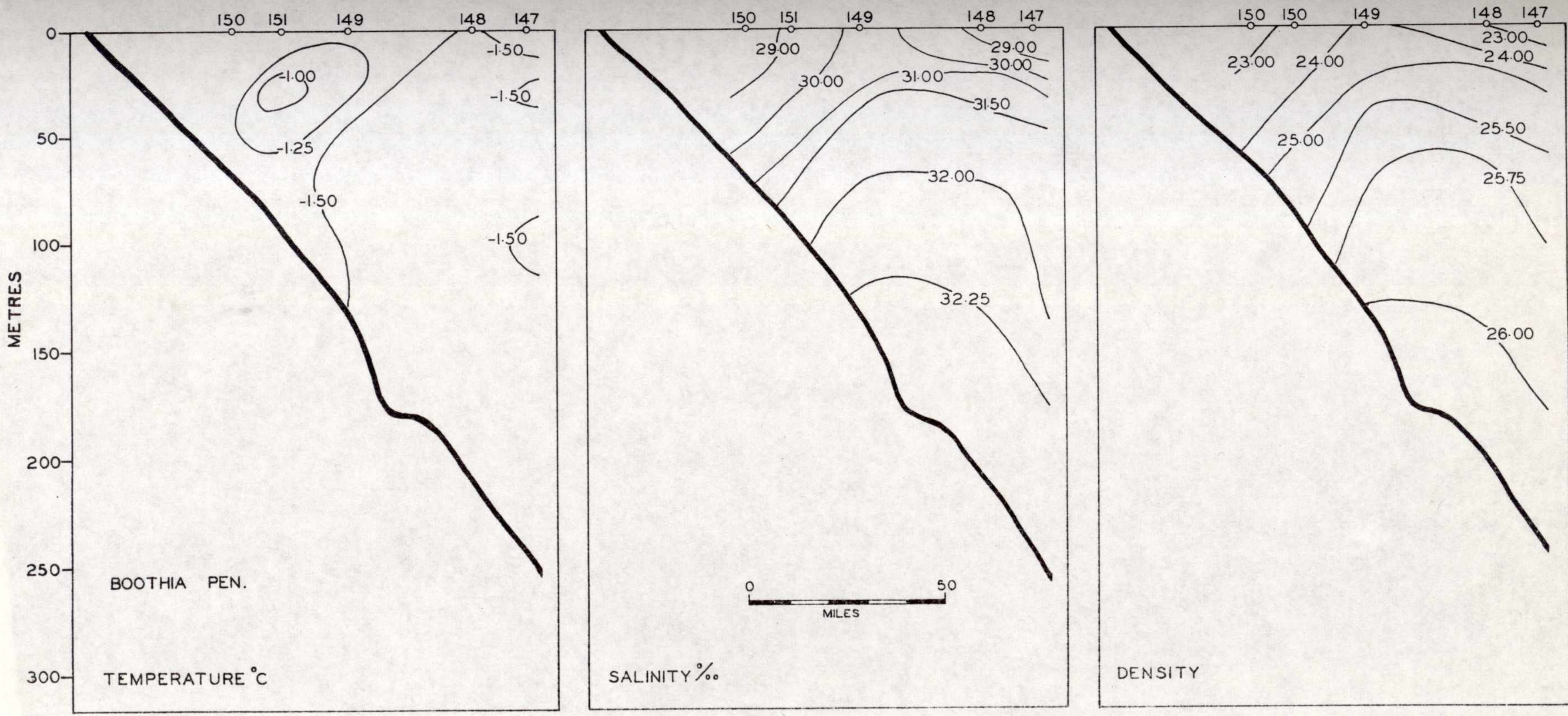

Fig. 16 Cross-sectional distributions of temperature, salinity and density, mouth of Committee Bay, 1956.

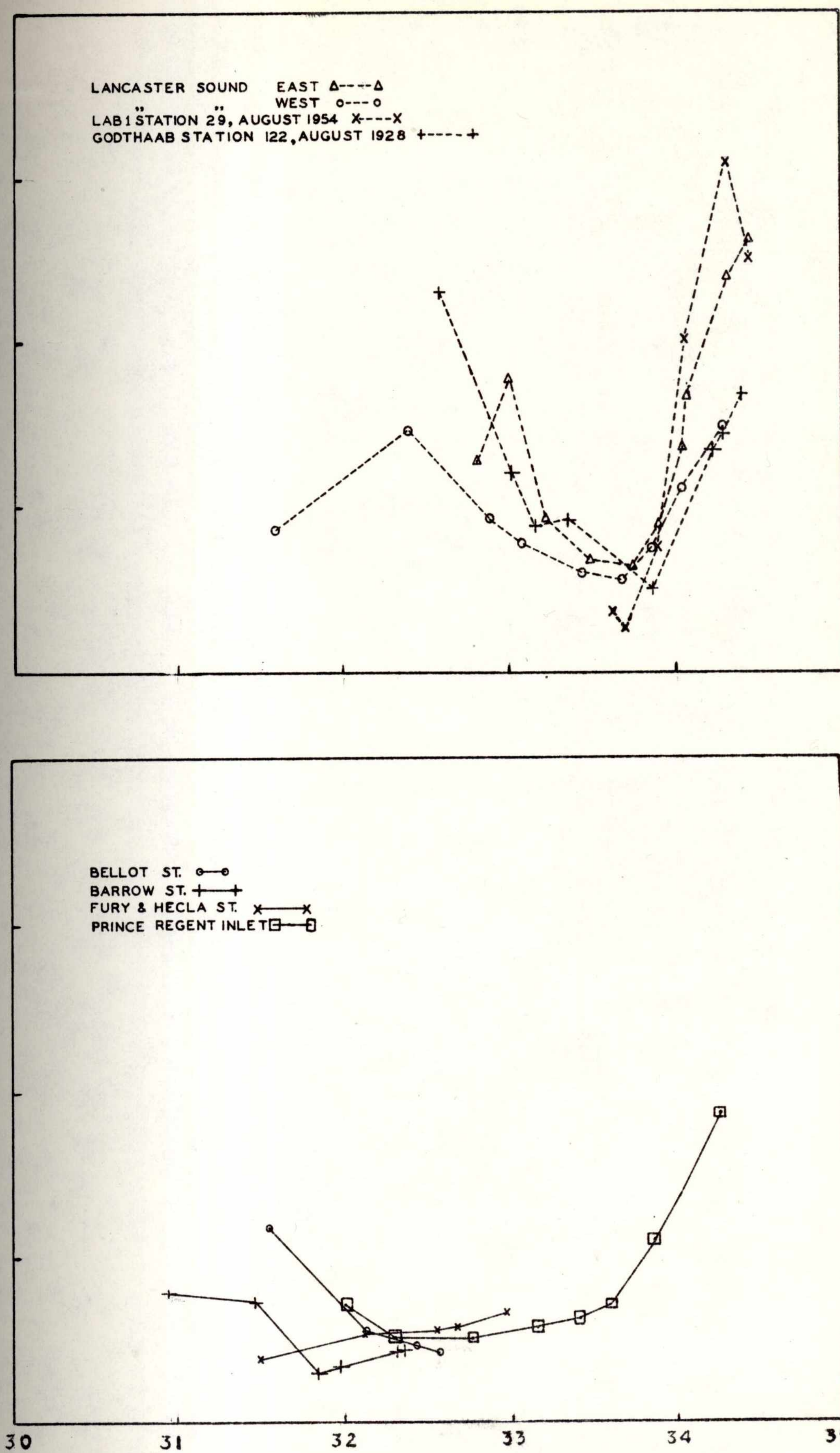

Fig. 17 TS characteristics.

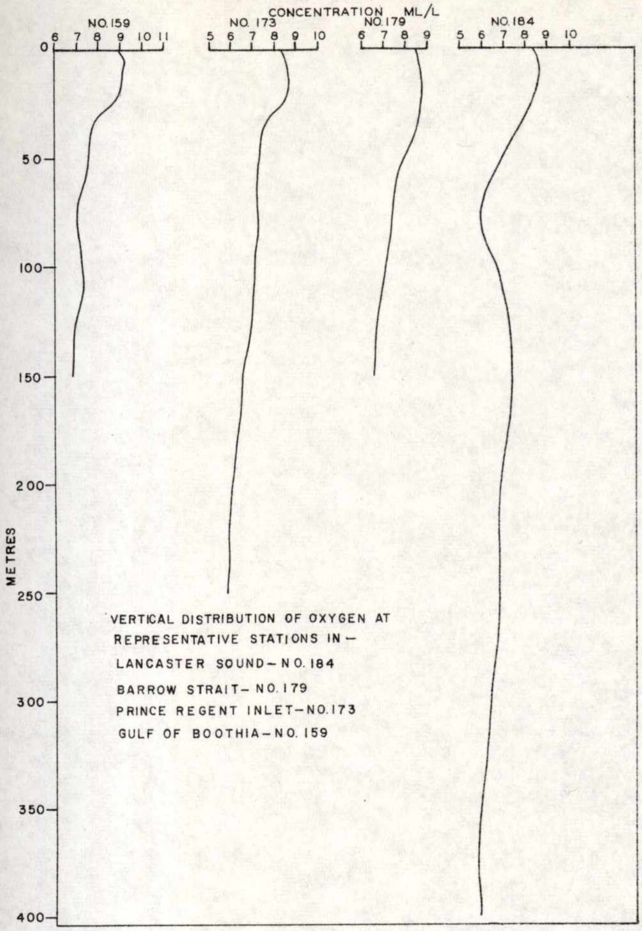

Fig. 18 Vertical distribution of oxygen, 1956.

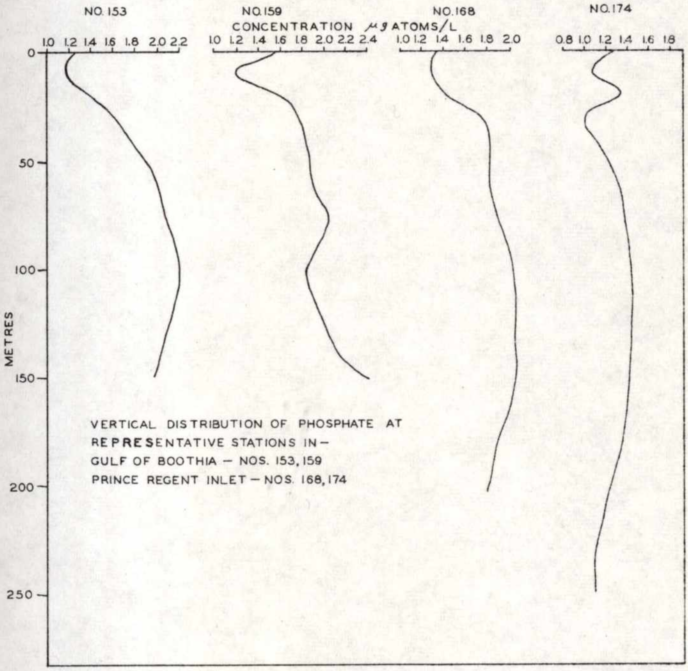

Fig. 19 Vertical distribuiton of phosphate, 1956.

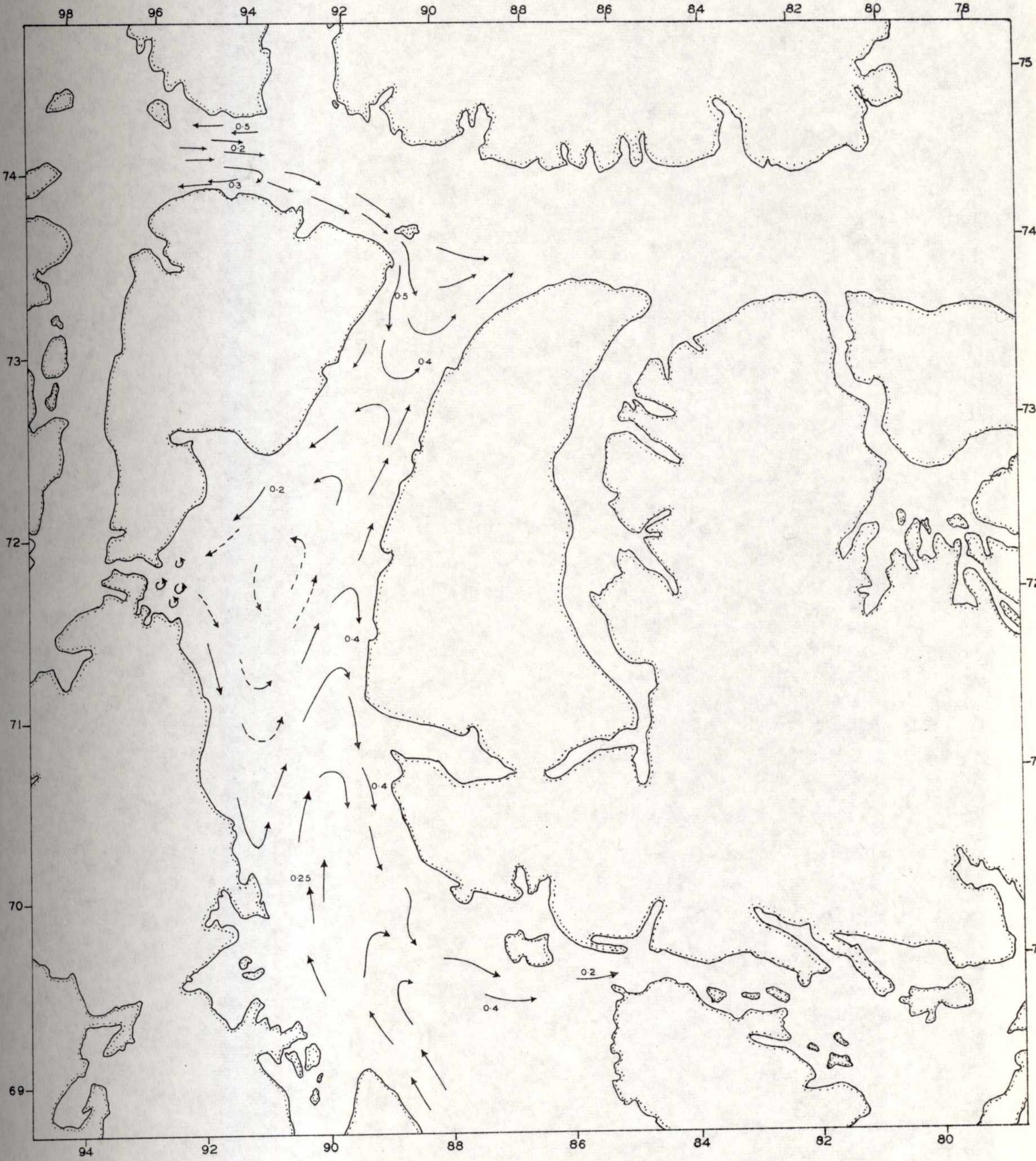

Fig. 20 Computed surface currents, relative to 150m., Prince Regent Inlet and Gulf of Boothia, 1956. Current speed in knots.