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Off the Canadian Atlantic Coast

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THE HORIZONTAL DISTRIBUTION OF TEMPERATURES AND SALINITIES  
OFF THE CANADIAN ATLANTIC COAST

by

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Introduction

The Canadian Atlantic Coast stretches from Davis Strait in the north to the Bay of Fundy in the south. The waters lying over the continental shelf and in the adjacent parts of the Atlantic Ocean are extremely varied in their temperature and salinity characteristics. These waters are of particular interest and importance to the various fisheries that are carried on off the Canadian Atlantic Coast.

Oceanographic research has been carried out over the entire area from time to time. No attempts have been made to deal with the area as an oceanographic unit because of its size and the lack of resources for such an ambitious program. However, since 1950, there has been a sufficient number of organizations carrying out oceanographic research in the area during the summer months, that a full scale survey is approximated for the month of August.

Commencing in 1950, the Atlantic Oceanographic Group has carried out seasonal oceanographic surveys of the waters in the Bay of Fundy, the Scotian Shelf, and the Gulf of St. Lawrence. During the same period, oceanographic observations were made in the Labrador and Grand Banks regions by the staff of the Newfoundland Fisheries Research Station at St. John's. The location of the stations forming the two survey networks are shown in figure 1.

Relatively good coverage is provided by these two programs, with the use of data collected by various United States and Canadian agencies to supplement them.

Sufficient data were collected during the month of August in each of the years 1950, 1951, and 1952, to permit the construction of charts illustrating the distribution of temperature and salinity at three levels (0, 50, and 100 metres) for the years 1950 and 1952, and of temperatures alone for 1951.

#### Data Used

The data files of the Atlantic Oceanographic Group contain all published data collected in the area north of the 40° parallel and west of the 43° meridian, as well as that collected by Canadian organizations and that received through co-operative exchange with United States agencies.

In the preparation of the fifteen charts that are presented below, all data collected in the area between the last week of July and the first week of September in 1950, 1951, and 1952, were used. The charts are based principally on the data collected by the Atlantic Oceanographic Group and the Newfoundland Fisheries Research Station. The remainder of the data was used to fill in gaps, and to add further details. Unfortunately, the 1951 summer survey of the Atlantic Oceanographic Group was not carried out at a time which was suitable for use in this work, making the salinity distribution too scanty for presentation for that year. Sufficient additional temperature data existed, however, for the construction of temperature charts. The two northernmost sections on the Labrador Coast were not occupied by the Newfoundland

Station in either 1951 or 1952, but the lack of data was partially overcome through the use of data collected by other organizations. Considerable additional information was given from data collected by vessels of the International Ice Patrol, the Canadian Hydrographic Service, the U.S. Hydrographic Office, the Woods Hole Oceanographic Institution, the U.S. Coast Guard, the Fisheries Research Board of Canada, and the Defence Research Board of Canada. The interest and co-operation of these organizations is gratefully acknowledged.

#### General Circulation of Canadian Atlantic Waters

The general circulation of waters in the Canadian Atlantic is well known, but is not dealt with in any one treatise. Thus, it is of interest to trace the various waters as they move from one area to another.

In the vicinity of Davis Strait, the Labrador Current is formed by the junction of the Baffin Land Current with the West Greenland Current. The Baffin Land Current carries frigid water with temperatures as low as  $-1.7^{\circ}\text{C}$ , while the warmer West Greenland Current carries waters with temperatures as high as  $6.0^{\circ}\text{C}$ . (Smith, Soule, and Mosby, 1937).

The Labrador Current has been described (Iselin, 1927) as a cold water stream which flows southward over the continental shelf inside of the comparatively motionless homogeneous mass of North Atlantic water. As compared with the main body of water in the Labrador Sea, the Current is characterized by its low salinity and temperature.

The Labrador Current may be divided into two streams, an inshore and an offshore one. The inshore stream contains the greater volume of the cold water and is confined to the continental shelf. This stream enters Hudson Strait on the Baffin Land side and flows as far as Big Island before it recurves southward to mix with the waters flowing out of Hudson Bay, and flows out past Cape Chidley (Smith, Soule and Mosby, 1937). The offshore stream, which contains waters that are characteristic of the warmer West Greenland Current, tends shoreward near the mouth of Hudson Strait, but does not enter, and continues to flow southward over the continental slope (Smith, Soule and Mosby, 1937). Continuing down the coast, the Labrador Current follows an easy sinuous course which exhibits two major bends, the one between Cape Harrigan and Cape Harrison, Labrador, and the other between Cape Bauld and Funk Island, Newfoundland (Smith, Soule, and Mosby, 1937).

The characteristic low temperatures of the Labrador Current persist as the water flows southward, the great stability of the water layers preventing the penetration of solar heat by convection. On reaching the vicinity of Belle Isle Strait, water from the inshore stream is carried, at times, through Belle Isle Strait into the Gulf of St. Lawrence (Bailey and Hachey, 1950). Here too, at times, the Gulf of St. Lawrence waters moving outward along the southern side of Belle Isle Strait enters into the southward flow of the Labrador Current.

Southward from Belle Isle Strait, the Labrador Current meets the northern face of the Grand Banks in the latitude of St. John's, and is split, the slope branch continuing down the

eastern edge of the Grand Banks, while an inshore branch follows the Avalon Channel past Cape Race (Smith, Soule, and Mosby, 1937). The offshore branch, as it proceeds along the edge of the Grand Banks, is constantly being turned in a northeasterly direction so that by the time the current has reached the tail of the Grand Banks practically all of it has been turned eastward, joining the Atlantic Current. Small amounts of Labrador Current water may at times pass westward along the continental slope from the tail of the Grand Banks (Smith, Soule and Mosby, 1937).

The inshore branch of the Labrador Current which flows in the Avalon Channel past Cape Race, in general, reaches as far as the vicinity of St. Pierre Bank before losing its arctic characteristics, and, at times, it may reach into the Gulf of St. Lawrence as an arctic current. This idea of the general circulation along the south coast of Newfoundland was put forth by Bjerkan (1919), and has since been substantiated, in part, from time to time, by various oceanographic observations.

In the Gulf of St. Lawrence, the waters that enter via Cape Ray from the east are deflected to the northeast and flow along the west coast of Newfoundland. On reaching the head of the deep Esquimaux Channel, part of this flow is deflected towards the north shore of the Gulf by Mecatina Bank, while the remainder continues northwards to enter into the circulation of Belle Isle Strait. Investigations have shown that the circulation in Belle Isle Strait consists of (a) a progressive inward movement of Labrador coastal water on the north side, and (b) a progressive outward movement of Gulf of St. Lawrence water on the south side,

accompanied, at times, by (c) a dominant outward flow of Gulf waters (Huntsman, Bailey and Hachey, 1954), or (d) a dominant inflow of Labrador coastal water (Dawson, 1907). Along the north shore of the Gulf, there is a westward drift of a type of water which may have had its origin north of Belle Isle Strait. In any event, part of the northeastward flow along the west coast of Newfoundland is deflected to the Quebec shore by Mecatina Bank and rounds Cape Whittle to enter Jacques Cartier Passage.

In Jacques Cartier Passage the water movements are mainly tidal. The drift from the north is deflected southeastward toward Anticosti. It then rounds the eastern end of Anticosti and flows westward along the south coast of the Island to enter into the general circulation of the St. Lawrence River.

In Gaspé Passage between Anticosti Island and the Gaspé Peninsula, there is a steady movement of water to the southeast in the form of the Gaspé Current. This current is very strong and its effect can be seen and felt for many miles from the Gaspé Coast. It keeps well to the Gaspé Peninsula but loses a considerable amount of its velocity on passing into the shallows of the southern portion of the Gulf. The waters in this southern Gulf area form a general eastward flow which works toward Cabot Strait, where the main efflux from the Gulf of St. Lawrence takes place.

Dawson (1913) has described the efflux of the Gulf of St. Lawrence through Cabot Strait as the Cape Breton Current, and as being a steady current flowing to the southeast. The waters

borne by the Cape Breton Current on passing through Cabot Strait round Cape Breton Island and flow onto the Scotian Shelf. These waters have been shown to spread out over the shallow Scotian Shelf and form a major constituent of the waters found in this area (McLellan, 1954). On the Scotian Shelf, there is, however, an inshore movement of more saline waters that results in the consumption of the Gulf of St. Lawrence water through mixing so that the Gulf water has lost its original characteristics by the time it reaches Cape Sable at the western end of the Shelf. At the southern end of the Scotian Shelf, there is, at times a strong influence from the slope water found lying between the edge of the continental shelf and the northern edge of the Gulf Stream. Hachey (1953) has described an incursion of slope water which took place in the winter of 1949. In the Bay of Fundy, the waters exhibit a general cyclonic circulation with an inward movement along the coast of Nova Scotia from the Cape Sable area and an inward movement from further offshore in the Gulf of Maine, and an outward movement along the coast of New Brunswick. The inward movement constantly loses water to the New Brunswick side as it progresses toward the head of the bay. On the New Brunswick side, the movement is westward where the waters from the rivers are joined by the waters from the Nova Scotia side to flow out to the east of Grand Manan into the Gulf of Maine. A dominant feature in the hydrographic conditions of the Bay of Fundy is the effect of the strong tides. Tidal stirring causes the waters to become progressively mixed, as they proceed into the bay so that by the time they reach the head of the bay they are thoroughly mixed and are homogeneous as to temperature and

salinity (Hachey and Bailey, 1952).

In the Gulf of Maine, the waters show an anticlockwise movement which takes in the mixed waters from the Bay of Fundy along the coast of Maine. The outflow from the Bay of Fundy follows along the northern shore of the Gulf mixing with the river discharges on its inshore side and with central Gulf of Maine waters on the other. Part of these waters flows out past Cape Cod while the remainder follows the inshore edge of Georges Bank towards Nova Scotia. On reaching the Fundian Channel, part of the waters discharges around the northern edge of the Bank while the remainder is entrained by the inflow that rounds the southern tip of Nova Scotia on its passage into the Bay of Fundy (Bigelow, 1927).

The Gulf Stream System, which, with the Labrador Current, constitutes the main features of the circulation system of the waters of the Western North Atlantic, may be recognized off the Atlantic seaboard by its comparatively high temperature. Off Halifax, the northern edge of the stream may be within 230 nautical miles (425 km.) of the coast and as far away as 420 nautical miles (780 km.). Its meanderings, as shown by changing position of its northern edge, have an indirect effect on the waters between it and the coast due to the adjustments in the water masses that are associated with these shifting positions. Gulf Stream water breaking away from the system, and carrying with it many forms of marine life associated with more tropical waters, are incorporated in the water masses close to the coasts, and thus directly effect the characteristics of these waters. It is, however, in the area of the confluence of the Labrador Current and the Gulf Stream in the area southwest of the Grand Banks, and to the

westward, that large scale mixing processes occur which provide a type of "slope water" that contributes largely to the characteristic waters that are in contact with the continental shelf, and penetrate at greater depths even into the Gulf of St. Lawrence. These "slope waters" have a profound influence on the waters on the Scotian Shelf, both indirectly through gradual mixing processes, and directly when incursions of these slope waters upon the Shelf take place.

Temperature Distribution, August 1950

Most of the major ocean currents in the area are recognizable from the surface temperature distribution (figure 2). South of Greenland, the northward flowing West Greenland Current has surface temperatures ranging from 2 C. inshore to 8 C. offshore. The main body of the Labrador Sea exhibits temperatures above 8 C., while the southward flowing Labrador Current shows the influence of decreasing latitudes and mixing with warmer waters from offshore as its temperatures increase from 3 C. in the north to 7 C. at the tail of the Grand Banks. In the triangle between the Grand Banks and the Scotian Shelf, the slope water is seen to increase from a narrow band off Cape Cod to a wide one south of Cape Ray. Temperatures in the slope water are higher than 17 C. but less than 25 C. In the longitude of 60 W. an eddy from the northern edge of the Gulf Stream may be seen intruding into the slope water. Surface temperatures at the northern edge of the Gulf Stream are generally greater than 25 C. and traces of the stream just reach into the diagram.

Over the shallow portions along the coast and over the banks,

surface temperatures show only small variations from one area to another, ranging in general from 15° to 16° C. Along the south coast of Newfoundland where temperatures are less than 15° C., there is the suggestion of a movement from the east coast of Newfoundland into the Gulf of St. Lawrence. Increasing temperatures along the Gaspé Coast illustrate the warming of the Gaspé Current as it loses velocity and enters the shallow area in the southwestern Gulf. Along the southeast coast of Nova Scotia, the lowered temperatures off Halifax illustrate the upwelling of colder sub-surface waters. In the area south of Cape Sable, temperatures as low as 10° C. are observed which appear to be the result of strong tidal mixing over the shallows in this area. In the Bay of Fundy area, tidal mixing is extremely important. Temperatures there, during this period, are somewhat higher than on the Nova Scotia coast.

The temperature distribution at 50 metres (figure 3) has the same general form as that for the surface, but the main characteristics of the waters in the major currents are more readily discernable. In the case of the West Greenland Current, its composition as a mixture of a warm current (Irminger) and a cold one (East Greenland) is clearly shown. The marked horizontal temperature gradient near Cape Farewell shows the arctic nature of the East Greenland Current on the one side, and the warm Irminger Current on the other. Temperatures in the Labrador Sea are, in general, greater than 5° C. at this level. The arctic nature of the Labrador Current is revealed by the large quantity of below 0° C. water that can be seen stretching along the coast of Labrador as far south as the tail of the Grand Banks, and

inshore as far as the island of St. Pierre-Miquelon. Water colder than  $0^{\circ}\text{C}$ . is also found in the Gulf of St. Lawrence. Off-shore the warm slope water with temperatures greater than  $10^{\circ}\text{C}$ . can be seen occupying large areas off the continental shelf. Coastal waters along the coast of Nova Scotia are, in general, between  $2^{\circ}$  and  $4^{\circ}\text{C}$ ., and reflect the influence of the cold waters from the north and east. There is no suggestion that waters from the Labrador Current flow directly to the Nova Scotia Banks as a steady current. The Labrador waters which reach past Cape Race tend to press towards the Gulf of St. Lawrence along the south coast of Newfoundland, while the waters on the Scotian Shelf show the influence of waters from the Gulf of St. Lawrence. Between the Labrador waters along the south coast of Newfoundland and the waters on the Scotian Shelf, there is to be noted a tongue of warmer water reaching towards Cabot Strait from the slope water. This is the upper layer of a tongue of ocean water which reaches as far as the Saguenay River at greater depths. The irregularities in the boundary between the coastal waters and the slope waters are more clearly shown than in the surface temperature distribution. Some of the tongues and eddies are the result of bottom topography while others are the result of the balance between the dynamical forces in the two water masses.

At 100 metres (figure 4), the influence of bottom topography is most pronounced because the main banks are of depths less than 100 metres.

A major feature of the temperature distribution at this level is the extent of the large mass of arctic water with temperatures lower than  $-1^{\circ}\text{C}$ . This water extends from the Arctic

to the edges of the Grand Banks at latitude  $45^{\circ}$  N., but does not reach the Gulf of St. Lawrence nor the Scotian Shelf. In the Gulf of St. Lawrence, temperatures are all below  $0^{\circ}$  C. This water probably originated in part, outside the Gulf at an earlier time and in part was formed "in situ". Leuzier and Bailey (1952), estimate the amount of locally formed cold water (less than  $0^{\circ}$  C.) to be between one-third and one-half of the total volume of arctic water found in the Gulf. Outside the Gulf of St. Lawrence, in the Laurentian Channel, further details of the wedge of warm oceanic water that reaches up the channel are shown.

At the far eastern edge of the Scotian Shelf, a small isolated body of arctic water is to be noted. The exact origin of this water is not certain, but it may have come through the channels between the banks south of Newfoundland or have worked westward from the tail of the Grand Banks after a flooding in the early spring, as suggested by Bjerkan (1919).

South of Nova Scotia, in the deep channels that penetrate the Shelf, there are small bodies of relatively warm water which appear to have been left from an incursion of slope water that took place at an earlier date. The undulating boundary between the slope water and the shelf water probably causes this phenomenon to occur at fairly frequent intervals when the slope water lies close to the edge of the shelf, as it has been observed to do at times.

#### Temperature Distribution, August 1951

The portrayal of the distribution of temperature and salinity for 1951 was somewhat hindered through the general lack

of data from the Scotian Shelf and Gulf of St. Lawrence areas for this time of year. In addition only the most southerly of the three hydrographic sections from the Labrador coast was occupied. However, a good series of bathythermograph observations was made across the Labrador Sea along the 55° W. meridian.

In figure 5, surface temperatures in the Labrador Sea range from 5° C. in the north to greater than 10° C. in the south. This distribution reflects the northward warming of the Atlantic Current and the southward cooling by the Baffin Land Current. In-shore temperatures are less than 5° C. on both sides of the Sea. Data from the northern and central parts of the Labrador Current were not available in 1951, but observations from the southern portion show the gradual warming of the surface waters as they reach into the Grand Banks area. Over the Grand Banks, surface temperatures are, in general, between 12° and 18° C. In the Gulf of St. Lawrence, temperatures were between 15° and 18° C., while over the Scotian Shelf they are generally less than 19° C. Offshore, the slope water in the oceanic triangle between the Scotian Shelf and the Grand Banks has temperatures ranging between 20° and 25° C.

At 50 metres (figure 6) the below -1° C. water of the Labrador Current is seen to reach only as far as Belle Isle with a small patch near the tail of the Grand Banks. Less than 0° C. water is found lying over the eastern edge of the Grand Banks and over the deeper area between the Banks and Newfoundland. Over the Grand Banks, temperatures are between 1° and 5° C., while over the Nova Scotian Bank they are generally greater than 2°

but less than  $6^{\circ}\text{C}$ . The boundary between the slope water and the coastal water is well defined by the strong north-south temperature gradient that runs in an east-west direction across the chart. In the Gulf of St. Lawrence existing data do not indicate the presence of less than  $0^{\circ}\text{C}$ . water at this level.

In figure 7, the distribution at 100 metres reveals the extent of frigid water from the north and its influence on the waters in areas south of it. At this level, the temperature of the water in a given locality is primarily controlled by the state of the major ocean currents and the bottom topography.

#### Temperature Distribution, August 1952

In 1952 surface water temperatures were taken over a more extensive area than in previous years. In Hudson Strait (figure 8) the large body of less than  $2^{\circ}\text{C}$ . water with warmer water near the shore shows the effect of strong tidal stirring. The waters from south side of Hudson Strait are seen to flow southward along the Labrador Coast. The Labrador Current surface waters show a progressive warming from less than  $2^{\circ}\text{C}$ . at Hudson Strait to  $17^{\circ}\text{C}$ . near the tail of the Grand Banks. The northward protruding tongue of warmer water which extends along the coast of southern Labrador is a feature of interest whose reality requires further investigation. It could be the result of a more advanced warming in the less swiftly moving inshore waters coupled with some upwelling along the coast induced by the prevailing offshore winds of summer. Over the Grand Banks, temperatures increase from less than  $13^{\circ}\text{C}$ . in the north to greater than  $19^{\circ}\text{C}$ . along the southwestern edge. In the Gulf of St. Lawrence, temperatures

are relatively low in the Gaspe Current while a progressive increase is demonstrated from west to east. The outflow from the Gulf of St. Lawrence onto the Scotian Shelf is illustrated, temperatures being generally less than  $19^{\circ}\text{C}$ . At the southern end of Nova Scotia, the depressed temperatures reflect the influence of strong tidal stirring over the shoals along this part of the coast.

At 50 metres (figure 9), the temperature gradients clearly outline the various ocean currents. The Labrador Current being characterized by its frigid temperatures is seen to extend from the far north to past the tail of the Grand Banks. Off Nova Scotia, the boundary between the shelf water and the slope water is marked by the strong horizontal temperature gradient. Inshore waters are generally less than  $5^{\circ}\text{C}$ . and as low as  $0^{\circ}\text{C}$ . with the exception of Labrador water which has temperatures lower than  $-1.0^{\circ}\text{C}$ . Slope water has temperatures between  $10^{\circ}$  and  $20^{\circ}\text{C}$ . at this level. Several eddies of water are in evidence lying, respectively, at the tail of the Grand Banks, the southwestern slope of the Grand Banks, and at the western and eastern ends of the Scotian Shelf. These eddies provide an interesting point for theoretical discussion and will be discussed later. In the Gulf of St. Lawrence, two patches of less than  $0^{\circ}\text{C}$ . water are in evidence. One lying along the north shore of the Gulf indicates its origin to be the Labrador Current, while the second lying south of Anticosti and reaching onto the Magdalen Shallows may be in part locally formed through winter chilling or be continuous with the first patch of cold water from the Belle Isle Strait area.

Warmer water is to be noted flowing into the Gulf from the south coast of Newfoundland. Over the Scotian Shelf, temperatures are between 3° and 8° C.

At 100 metres (figure 10), the same general distribution of temperature as found at the 50 metre level prevails. This is particularly true in the areas bathed by the frigid water of the Labrador Current.

#### Salinity Distribution, August 1950

The distribution of salinities are based almost wholly on observations made by the Atlantic Oceanographic Group and by the Newfoundland Fisheries Research Station. One section across the Labrador Sea from South Wolf Is., Labrador to Cape Farewell, Greenland, made by the International Ice Patrol, was used as well as occasional stations taken by the Canadian Hydrographic Service.

The salinity distribution at the surface (figure 11) shows the Labrador Current to be composed of many tongues and eddies. This is particularly true in the offing of Belle Isle. Smith, Soule and Mosby (1937) show an eddy in the same area and suggest that this region is unmistakably associated with currents coming from farther south in the Atlantic. Actually the low salinity associated with the eddies shown in figure 11 and figure 12 argue against their originating in the south. A more simple explanation may be that they represent transient displacements of inshore waters or a residual condition from the spring when large quantities of sea ice are dissipated in this region.

The efflux from Hamilton Inlet appears to have a considerable influence on the surface waters off Southern Labrador and in the

vicinity of the Strait of Belle Isle. The lower salinities in the southwestern Gulf show the effect of the St. Lawrence River discharge.

At 50 metres (figure 12), the distribution is similar to that at the surface, but salinities are somewhat higher, particularly in the inshore areas. The three great channels which cut into the continental shelf and allow ocean water to be found many hundreds of miles inland, namely Hudson Strait, the Laurentian Channel, and the Fundian Channel all show the effect of the shoreward flow of high salinity water. At the 100 metre level, (figure 13), salinities are all above  $32.5^{\circ}/\text{oo}$ , and, in general, are above  $33.0^{\circ}/\text{oo}$ .

#### Salinity Distribution in August 1951

In 1951, there was an insufficient number of hydrographic observations in August for the construction of a salinity distribution chart.

#### Salinity Distribution in August 1952

In 1952, there was a sufficient number of hydrographic observations to give a good salinity distribution pattern for the entire area.

At the surface (figure 14), in the discharge of Hudson Bay salinities are as low as  $30.5^{\circ}/\text{oo}$ . As the water proceeds along the Labrador Coast, additions of fresh water reduce the inshore salinities to  $27.0^{\circ}/\text{oo}$  in the Hamilton Inlet area, while in the offshore portion of the Labrador Current, constant mixing with the saline waters of the Labrador Sea and the Atlantic Current cause this portion of the current to become more saline. The

central core of the Labrador Current, however, maintains its salinity between 32.0 and 32.5<sup>o</sup> / $\infty$  from Hudson Strait to the tail of the Grand Banks. The influence of the discharges of the Hamilton Inlet and St. Lawrence River is readily apparent from the reduced salinities. The outflow of the Gulf of St. Lawrence around Cape Breton Island is clearly outlined by the 30.0<sup>o</sup> / $\infty$  isohaline.

At 50 metres, the general distributional pattern (figure 15) shows only one feature worthy of note, that being near the mouth of Hamilton Inlet, Labrador, an eddy of low salinity water, which is centred on the central axis of the Labrador Current. With the small amount of data available in this area, it is difficult to determine whether this body of low salinity is associated with the outflow of Hamilton Inlet, is part of a semi-permanent feature of the Labrador Sea, or, merely a small body of low salinity water that represents the last vestiges of the melting ice and spring runoff that has reached this area.

At the 100 metre level in 1952 (figure 16), the salinities are somewhat higher than in the upper levels. Salinities range from 31.51<sup>o</sup> / $\infty$  in Ungava Bay to greater than 36.0<sup>o</sup> / $\infty$  at the edge of the Gulf Stream. In general, the waters have salinities greater than 33.0<sup>o</sup> / $\infty$ . This water type, except for the immediate inshore areas, covers the entire Atlantic coast. This fact demonstrates the nature of the various bottom waters that are found in the deeper channels along the coast. Waters of oceanic origin with salinities between 33.0 and 35.0<sup>o</sup> / $\infty$  underlie all coastal waters where there is sufficient depth. This at

first would appear to be excepted in the Gulf of St. Lawrence where salinities less than  $33.0^{\circ}/\text{oo}$  are found in Cabot Strait. In this case, however, it must be borne in mind that the Gulf of St. Lawrence is the receptacle for the outflow of the Great Lakes System. There is, thus, a large accumulation of fresh water mixed with salt water in the Gulf. The result of this is that towards the St. Lawrence Estuary from seaward, salinities decrease on any chosen horizontal surface. However, if one were to follow a given isohaline in the Laurentien Channel, one would find that it reached well into the estuary, but that the depth had increased markedly from Cabot Strait to a point where it reaches the bottom.

#### Discussion

In viewing the horizontal distribution of temperature and salinity off the Canadian Atlantic Coast for the years 1950, 1951, and 1952, it is readily apparent that no major changes in the general circulation took place. There is, however, a noticeable change in the extent of frigid water from the Labrador Current in the Grand Banks region. This was particularly noticeable in 1951. In this connection, it is of interest to note that record high temperatures were reported for this year from several points along the Atlantic Coast (Lauzier, 1952), and (Bailey, MacGregor and Hachey, 1954). From the data available, it is difficult to determine whether the increases were a result of an increased Atlantic influence or a decreased Arctic one. At any rate, temperatures were somewhat lower in 1952 and the amount of frigid water in the Labrador Current around the Grand Banks had increased.

Thus it would appear that there was some connection between the two. As may be seen in the accompanying diagrams and as pointed out by Sigelow (1927, p. 825-836), there is no direct extension of the Labrador Current along the Nova Scotian Banks or farther west. As noted by Smith, Soule and Mosby (1937), there is a relatively small area of cool water on the southwest edge of the Grand Banks which admits that there is some discharge of sub-arctic water westward past the tail of the Grand Banks. The warm slope water has a tendency to lie close to the southwestern edge of the Grand Banks as evidenced in figure 10. This effectively prevents a westward flow of Labrador Current water. It is conceivable that small quantities of Labrador Current water from around the tail may at times escape along the continental slope past the above barrier (Smith, 1924, stations 353 and 354), and join other small tributaries such as the occasional extension of Labrador water across the shelf south of Cape Race (figures 9 and 10). Bjerkan (1919) demonstrated a cold low salinity discharge from the Laurentian Channel, which displaced the slope water in this area. It is suggested that the relatively cool patches along the edge of the Scotian Shelf have their origin in the Laurentian Channel. McLellan, Lausler and Bailey (1953) have demonstrated how the bands found further offshore in the slope water are formed through southward extensions of mixed water from the Labrador and Atlantic currents. They support the thesis that these bands are a necessary feature of the slope water and that they illustrate one of the mechanisms by which the surface slope waters are generated, namely through oscillations

of the slope water-Gulf Stream boundary near the tail of the Grand Banks.

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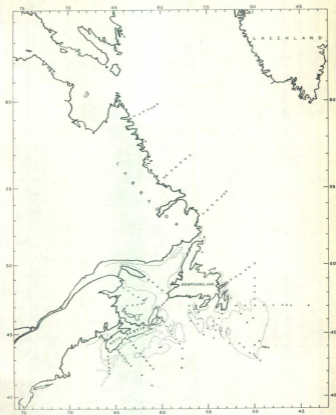


Fig. 1. Chart of the Canadian Atlantic showing the locations of the basic hydrographic stations and the 100 metre contour.

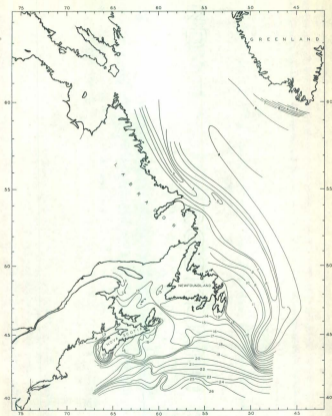


Fig. 2. Surface temperature distribution, August 1950.



Fig. 3. Temperature distribution at 50 metres, August 1950.



Fig. 4. Temperature distribution at 100 metres, August 1950.

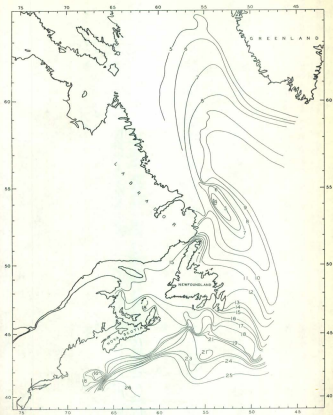


Fig. 5. Surface temperature distribution, August 1951.

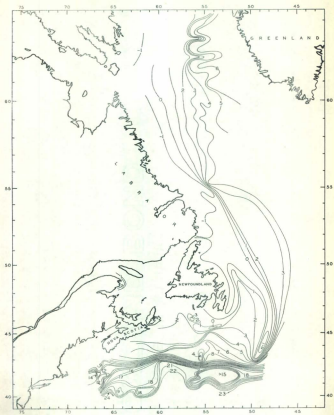


Fig. 6. Temperature distribution at 50 metres, August 1951.



Fig. 7. Temperature distribution at 100 metres, August 1951.

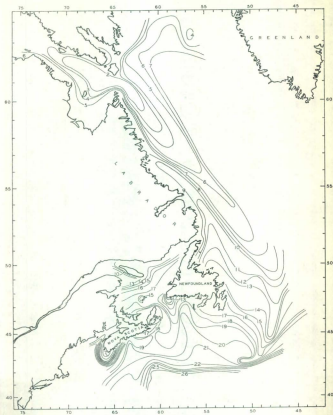


Fig. 8. Surface temperature distribution, August 1952.

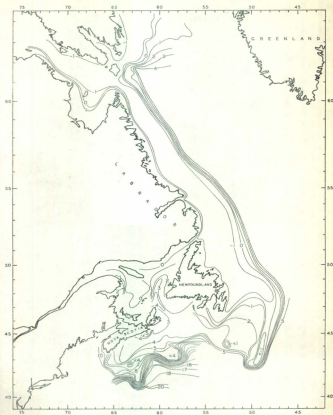


Fig. 9. Temperature distribution at 50 metres, August 1952.

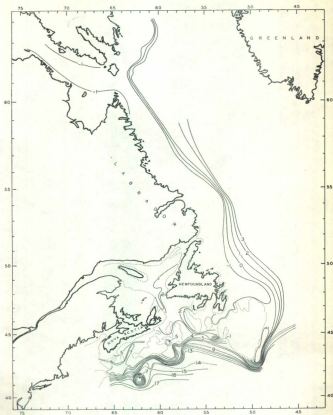


Fig. 10 Temperature distribution at 100 metres, August 1952.



Fig. 11. Surface salinity distribution, August 1950.

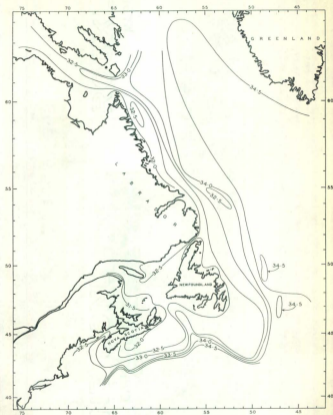


Fig. 12. Salinity distribution at 50 metres, August 1950.

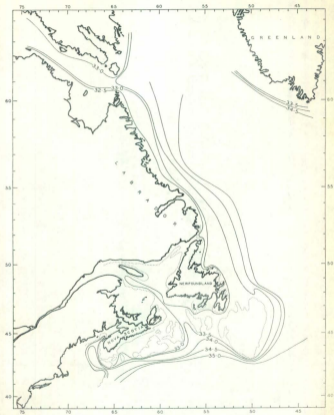


Fig. 13. Salinity distribution at 100 metres, August 1950.

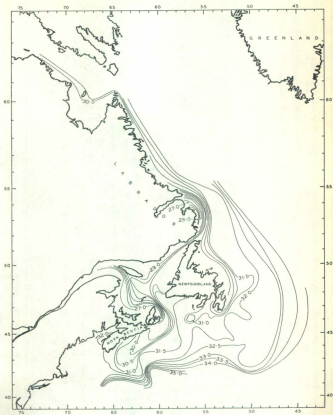


Fig. 14. Surface salinity distribution, August 1952.

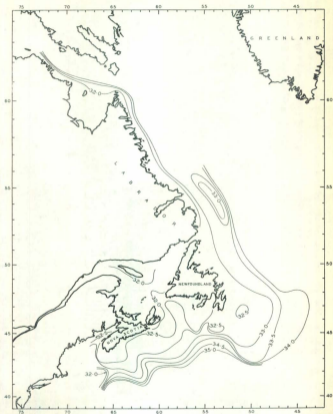


Fig. 15. Salinity distribution at 50 metres, August 1952.



Fig. 16. Salinity distribution at 100 metres, August 1952.

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1900