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A. Results of Soviet Oceanographic Investigations in the Labrador and Newfoundland Areas

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A number of oceanographic sections were worked by the Soviet research vessel "Sevastopol" in the Labrador area (up to 56°N), on the northern slopes of the Grand Newfoundland Bank, and on Flemish Cap Bank in July-August 1959. The program included measurements of temperature, salinity, content of dissolved oxygen and of some other hydrochemical elements. Eleven sections were made from July 7 to August 20 (see figure 1), the section across the north-eastern slope of Grand Newfoundland Bank being made twice, at the beginning and at the end of the trip. Some individual oceanographic stations were worked in the areas of trawl fisheries.

The main object of the trip was to study the habitat of the redfish. Therefore most of the stations were located in the area of the continental slope from 300 to 500 m.

Currents

In order to ascertain the pattern of currents, the hydrological data obtained were processed by a dynamic method improved by N. N. Zubov and O. I. Mamaev (1956).

As a result, a sketch of permanent currents was prepared (Figure 1), based on two dynamic maps calculated to 500 and 200 decibar isobaric surfaces.

The 500 decibar isobaric surface was assumed to be 0 surface on the strength of an analysis of the data obtained on vertical distribution of dissolved oxygen and density.

However, this proved to be applicable to the area of the slope only (the route of the main flow of the Labrador Current). For shallow areas the 200 decibar isobaric surface proved to be more suitable.

The velocities obtained for the area of Flemish Cap seem to be somewhat on the low side because, first, the sections in this area were running mostly along the current and, second, it was difficult to establish the true difference in specific volumes of two stations in relatively homogeneous water mass (through deficiency of the method used).

The current map shown on figure 1 does, on the whole, not differ to any considerable extent from the conventional summer-season pattern of currents for this area.

The general counter-clockwise movement of cold water masses around the Grand Newfoundland Bank, and a slight counter-current at the western boundary of this stream were observed. The current velocities were varying from place to place within the limits of 0.1-1.5 knots. The highest velocities (up to 1.5 knots) were observed on the north-eastern slope of Grand Newfoundland Bank (between stations 2162 and 2163) and the continental slope, east of Hamilton Bank (stations

2365 and 2366). The velocities and directions of currents found were confirmed by navigation calculations made by A.T.Petukhov, captain of the "Sevastopol", in July 1959.

For the Labrador Shelf and the Newfoundland Bank, including Flemish Cap Bank, the cold Labrador Current is the factor determining the hydrological regime. The water masses carried by the Labrador Current (approximately 4 to 5 million cub. m/sec., according to F. Soule) interact with the local bank water and with the Gulf Stream water, which come from the south to meet the Labrador Current. Interaction of the waters of different origin causes the complex picture of water circulation over the banks and their slopes.

One of the major characteristics of the Labrador Current is that it carries water masses of different origin. Many authors divide the Labrador Current into two streams: the coastal and the off-shore stream. It is believed (Hachey, Hermann, and Bailey, 1954) that the coastal stream carries a great volume of cold water and is bound to the continental shelf, while the off-shore stream, often referred to as the main flow of the Labrador Current, carries water from the West Greenland Current.

We find that the Labrador Current south of Hudson Strait is composed of the following three independent flows:

1. The coastal flow which runs in immediate proximity to the coast. Near Belle Isle Strait it moves away from the shore for a considerable distance (Figure 1). The velocity in July 1959, according to our dynamic calculations, did not exceed 0.3 knot. The cold layer of its central part, below -1°O, ran between 25 m and the bottom.

2. The cold part of the main flow with temperature and salinity similar to those of the coastal flow, but greatly subjected to the influence of the continental discharge and of the waters from Hudson Strait and Belle Isle Strait. Approaching the northern slope of Grand Newfoundland Bank, this branch of the Labrador Current divides into two independent parallel flows. Velocities of this part of the current in July-August 1959 did not exceed 0.5 knot. The thickness of the cold layer, below -1°O, was around 100 m (from 50 to 150 m).

3. The relatively warm part of the main flow, with temperatures from 3°O to 4°O and salinity from 34.50 to 34.80 in its mid layers These layers originate from the warm component of the West Greenland Current which joins the polar waters near the Cumberland Peninsula. According to our dynamic calculations, velocities of this part of the Labrador Current in the summer of 1959 were higher than those of the cold waters and reached 1.5 knots in the area of the north-eastern slope of the Grand Banks.

For characteristics of the water masses of the above-mentioned flows of the Labrador Current see the T - S diagram (Figure 2). The various sections of the curves of the 25-50 m layer have different positions, depending upon the categories of water which they represent. The lower parts of these curves indicate the increasing influence of the Atlantic water with increasing depth. The upper parts indicate the diluting effect of the river discharge on the surface layer.

Temperature and Salinity of Water Masses

Figure 3 shows isotherms and isohalines of the sections from the area of the Labrador and Grand Newfoundland Bank in the summer of 1959. The data give a clear idea of the hydrological conditions of the areas in that period.

Examination and comparison of these data reveal that the lowest surface temperatures (about 4°O), in July-August 1959, were observed in the Labrador area at 56°N (Figure 3a), and the highest

(10°0-12°0) - in the coastal areas of Newfoundland (Figure 3b). The near-bottom temperatures almost everywhere increased with the increase of depth, reaching the maximum at 400-500 m. The near-bottom temperatures on the slopes of the Flemish Cap Bank were, as in 1958, almost uniform, somewhat above 3° (Figures 3f, g). All the large concentrations of "beaked" redfish were found just at such temperatures. The surface salinity varied in the same period from 30.64 to 34.29‰ (Figures 3a through j). The lowest values of salinity (below 31‰) were observed at the stations located east and north of Belle Isle Strait, apparently caused by the outflow of water from this strait. Surface water of 34.00‰ was observed only on the eastern slope of Flemish Cap Bank, i.e. near the North Atlantic Current.

The salinity of the relatively warm part of the Labrador Current, in the 50 to 100 m horizons, was varying almost everywhere between 33.50 and 34.50‰, while the salinity of its coldest parts was always below 33.50‰.

Rather high salinities (above 34.70‰), in the 100 m horizon were observed on the north-western slope of Flemish Cap Bank and in the area between 50°00'N and 51°30'N of the continental slope (Figure 3f).

Apparently, upwelling was taking place in these areas. Increase in salinity was also observed in the 200 m horizon.

The salinity in the near-bottom layers varied from 32.60‰ at the Labrador coast to 34.90‰ in the underwater strait between Flemish Cap Bank and the Grand Bank, at the depth of 500 m (Figures 3f, g). The salinity in the near-bottom horizons of the Grand Banks proper, at shallow depths, did not exceed 33.50‰.

It is noteworthy that higher salinities were observed at stations 2218, 2219, 2238, and 2239, than in the neighbouring areas (about 33.25‰ at all the four stations, see Figures 3h, j).

Fluctuations of the Temperature in the Course of a Day

Observations of water temperatures and contents of dissolved oxygen were made in the course of 12 hours aboard the scouting trawler "Novorossiisk", on October 9-10, 1959. A semi-diurnal station was taken at 48°25'7N and 49°46'1W, in a zone of a sharp temperature drop. The diagram of the 12 hour course (Figure 4) shows that in surface horizons (0.10 m and 25 m) and in near-bottom horizons (200 m and 275 m) the temperature course was even, at the depths of 75 and 100 m fluctuations were rather considerable. For instance, at the depth of 75 m the temperature changed from 4°5 to -1°0 between 23:00 and 01:00 (i.e. in the course of two hours), and by 05:00 it rose again to 4°5. This indicates rather considerable lateral shifting of water masses at the conjunction line of the above mentioned components of the main flow of the Labrador Current caused both by recurrent tidal wave and by the changes in the boundaries of the Labrador Current itself, not associated with tidal phenomena.

Seasonal Fluctuations of the Temperature

Some authors (Hachey, Hermann and Bailey, 1954) find that it is not possible to establish the annual cycle of temperature variations of the Labrador Current because of the great inconsistencies (fluctuations) in the distribution of temperatures. We think that such a conclusion is rather premature since the available data used for characterising the annual cycle are still too scanty. Oceanographic observations in this area were made as a rule in spring or summer time. Therefore the data available for other seasons are fragmentary and inadequate.

The observations made by our expedition covered the period from July 7 to August 20, 1959. This season is characterised by intensive warming up of the upper water layers. By the beginning of September surface temperatures over the greater part of the area reach their top limit. At this time the amplitude of seasonal fluctuations of surface temperatures in the area of the Grand Banks and their slopes was 11°0-14°0. This considerable heating took place in the main during the three summer months (June-August).

Repeated observations made on the north-eastern slope of the Grand Bank revealed that in 1959 the water temperature at the surface of the sea changed by 6°0-6°5 during little more than one month.

On the other hand, it was observed that despite the considerable and rapid heating at the surface, penetration of warm water downward proceeded at an extremely slow rate. High vertical density gradients caused by simultaneous dilution of the surface waters and the almost complete absence of gales in this period, accounted for this phenomenon.

No substantial change in the near-bottom layers was observed during the trip. The 3° isotherm after a month remained in the same position.

Inter-Annual Fluctuations of the Temperature

We have earlier inferred some interdependencies which permitted the approximate estimation of the annual temperature conditions in the area of the Newfoundland Banks, on the basis of average temperatures of two sections. It was then established that 1958 was an abnormally warm year. This was proved by direct observations of hydrometeorological conditions (ice situation, etc.) made aboard scouting boats, as well as by the data from investigations by Canadian scientists (ICNAF Collected Works, 1959). The regularities inferred can hardly be used for evaluation of the temperature regime of 1959, because we have no data on hydrological sections crossing the eastern slope of the Grand Banks for April.

It is, however, evident that 1959 was characterised by somewhat lower temperatures than 1958, which was also confirmed by the volume and condition of cold water. The average temperature of the 0-bottom layer of section 6A running along the 47°N and within 46°56'-43°53'W, was 4°05' on March 10-11, 1958, and 3°96' on July 10-11, 1959, i.e. the latter temperature was a little lower despite the high degree of seasonal heating. On the other hand, other data from the 14th trip of the R/V "Sevastopol" led to the conclusion that 1959 should be regarded as an almost average year from the point of view of thermal conditions.

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Summary

1. Soviet investigations in the Western North Atlantic continued in 1959, with a complex oceanographic survey of the Flemish Cap Bank, Grand Newfoundland Bank and Labrador Areas, to study the habitat of the redfish, made aboard the R/V "Sevastopol" in July-August 1959 (Figure 1).

2. The data were processed by a dynamic method and a sketch of permanent currents based on two dynamic maps was prepared (Figure 2).

3. Based on the data available in literature or collected by Soviet expeditions in 1957 and 1959, the author divided the Labrador Current into the following three independent flows:

a. The narrow coastal flow of the Labrador Current, greatly influenced by the river discharge from the shores and by the water masses from the Hudson and Belle Isle Straits.
The velocities in the center of this flow, in July 1959, never exceeded 0.3 of a knot.

b. The cold part of the main flow of the Labrador Current. At the northern slope of Grand Newfoundland Bank it runs separate from the coastal flow along the slope of the bank to the south. Velocities in its center in July 1959 were always below 0.5 knot. Thickness of the layer with temperature below -1.0° was about 100m.

c. The relatively warm part of the main flow with temperatures from 3.0° to 4.0° and salinity from 34.50 to 34.80‰ in its mid layers. It forms a kind of prolongation of the warm component of the West Greenland Current. Its velocities in July 1959 were higher than those of the cold part of the flow, up to 1.5 knots.

The analysis of the water masses which form the above-named flows revealed interaction between the third and second flows of the Labrador Current resulting in formation of mixed waters (Figure 2).

4. Attached are diagrams of temperature and salinity distribution for the sections worked by the R/V "Sevastopol" in the summer of 1959. They present the summer-time hydrological regime, showing perfect conformity in the distribution of water masses of different origin with the pattern of currents prepared by the author (Figures 3a through j).

5. A semi-diurnal station taken in a temperature front zone in October 1959 showed a comparatively even course of temperature on the surface (0.10 and 25 m) and near-bottom (200 and 270 m) horizons (Figure 4). The amplitude of fluctuations on the 75 and 100 m horizons was up to 5.5° in the course of two hours, which indicates considerable lateral shifting of the flows.

The data are by far too scanty for analysing the seasonal fluctuations. Rapid warming up of surface water layers in summer months should be mentioned.

In 1959 the temperature of the surface layer on the north-eastern slope of the Grand Banks rose by 6°-6.5° in about one month.

On the whole, 1959 should be regarded as a thermally moderate year for the Newfoundland Banks, its average temperatures (by standard sections) being a little below the normal.

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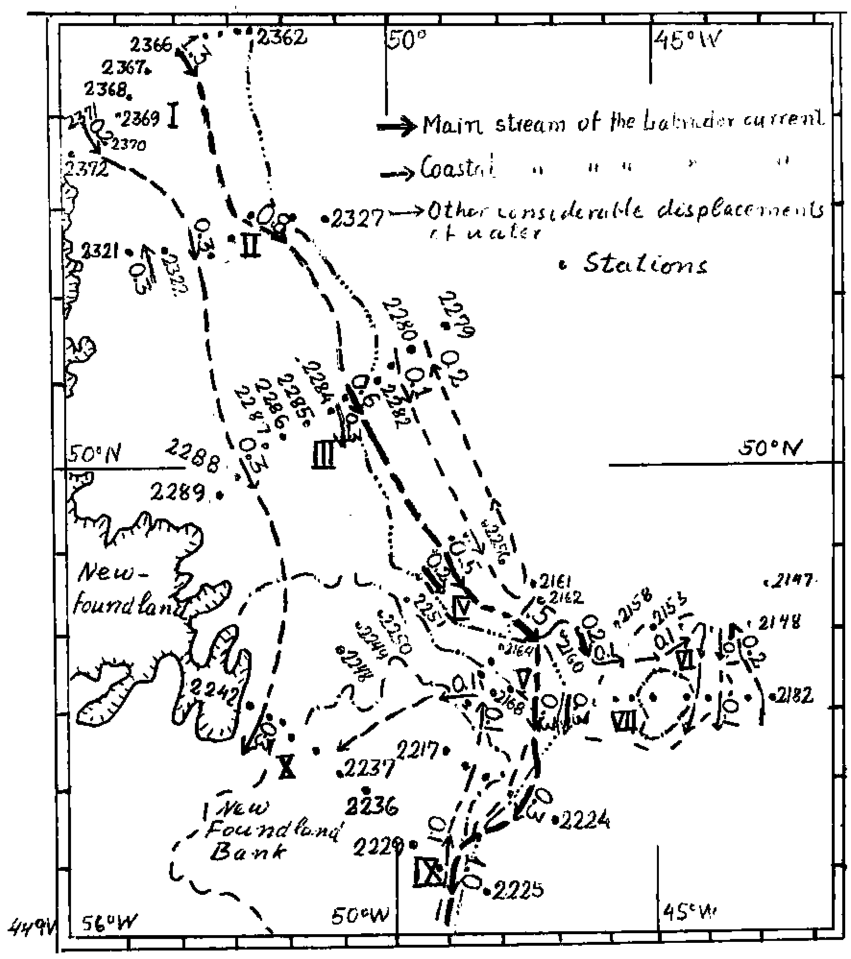


Figure 1 - Location of the sections and stations worked during the 14th trip of the R/V "Sevastopol", and a sketch of permanent currents. Velocities shown in knots.

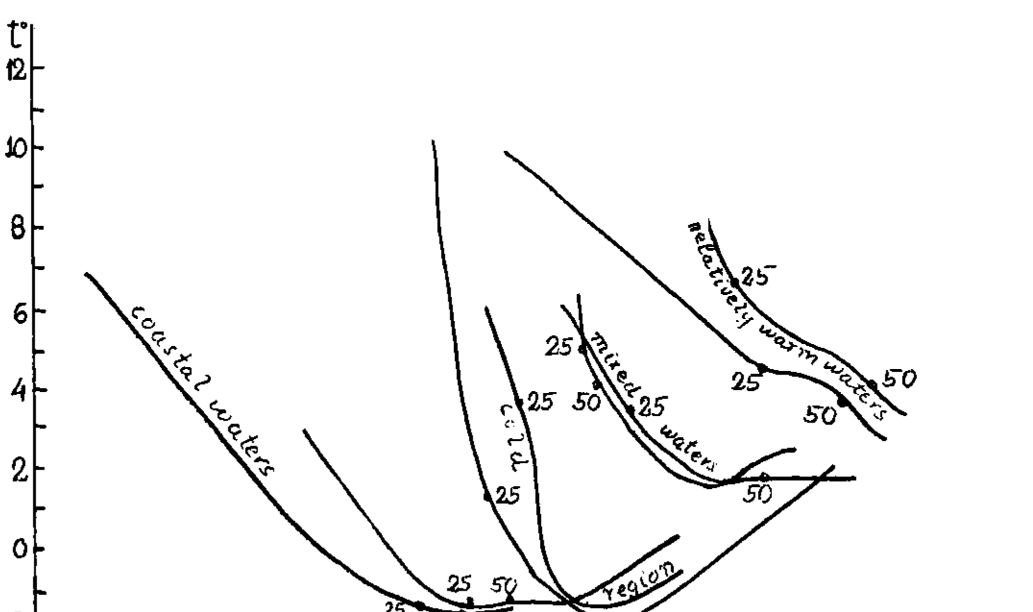


Figure 2 - Temperature-Salinity diagram characterising various water masses in the Labrador Current system.

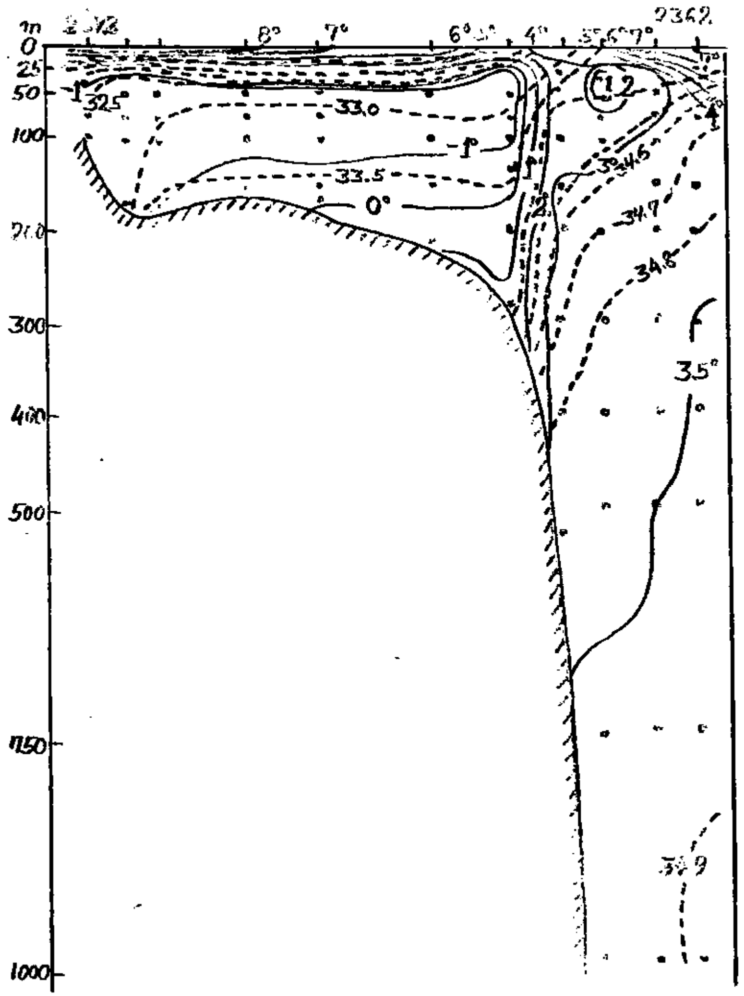


Figure 3a - Isotherms and Isohalines for Sections in the Labrador-Newfoundland area. July-August 1959.
Section I
t° and S‰
Cruise 14 R/V "Sevastopol"
10-11/VIII-1959

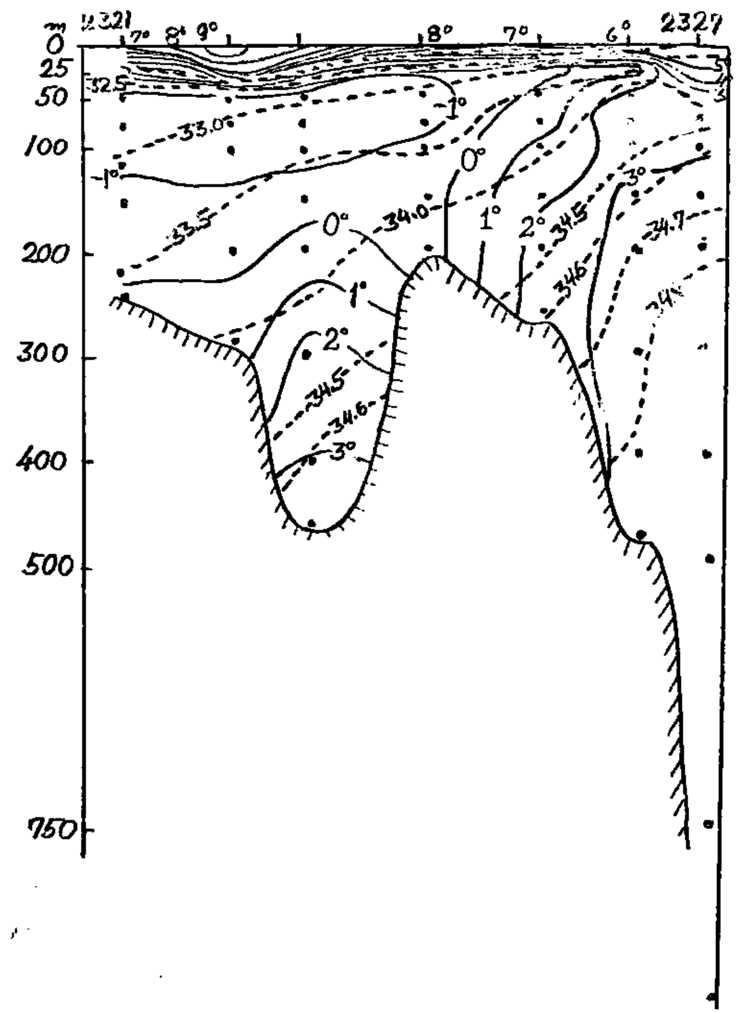


Figure 3b - Isotherms and Isohalines for Sections in the Labrador-Newfoundland area. July-August 1959.
Section II
t° and S‰
Cruise 14 R/V "Sevastopol"
4/VIII-1959

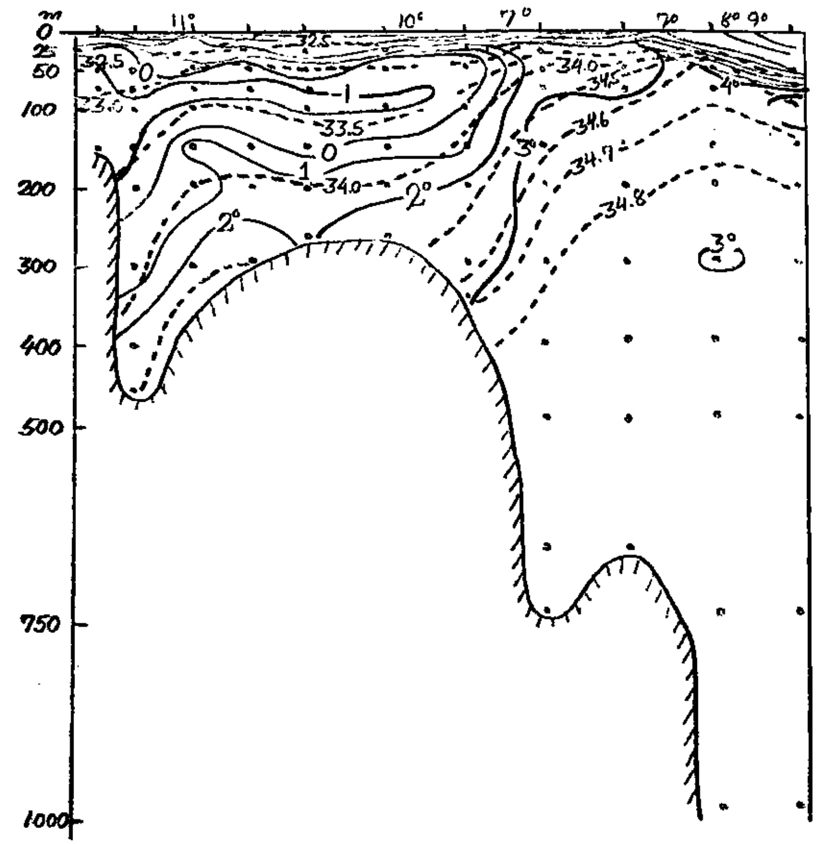


Figure 3c - Isotherms and Isohalines for Sections in the Labrador-Newfoundland area. July-August 1959.
Section III.
t° and S‰
Cruise 14 R/V "Sevastopol"
27-28/VII-1959.

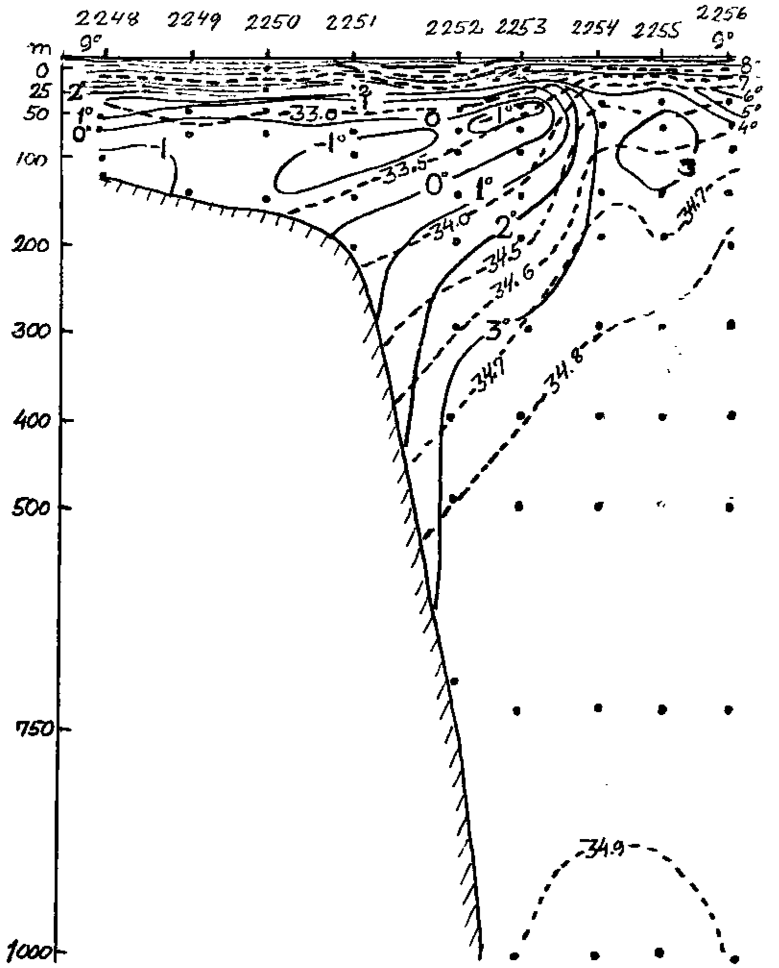


Figure 3d - Isotherms and Isohalines for Sections in the Labrador-Newfoundland area. July-August 1959. Section IV t° and S‰ Cruise 14 R/V "Sevastopol" 22-23/VII-1959

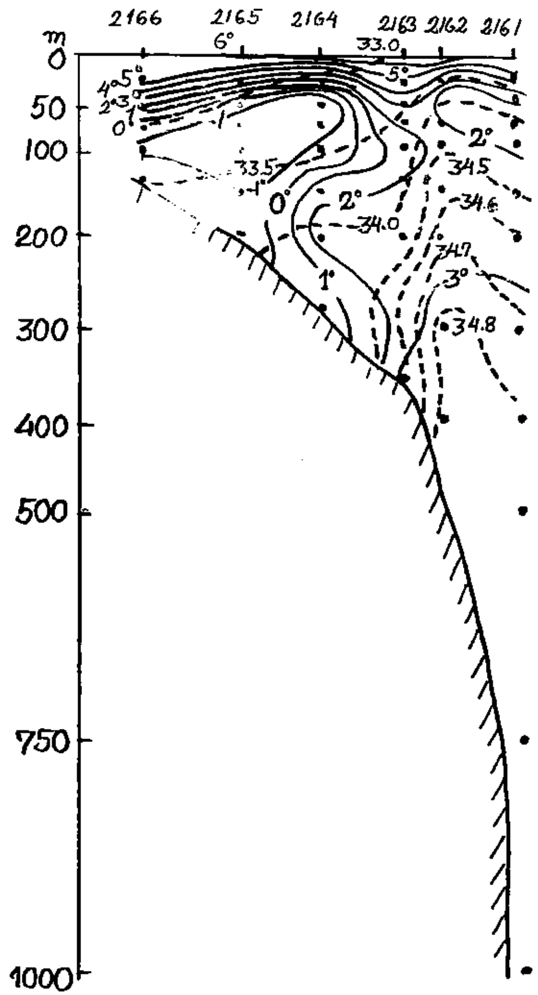


Figure 3e - Isotherms and Isohalines for Sections in the Labrador-Newfoundland area. July-August 1959. Section V t° and S‰ Cruise 14 R/V"Sevastopol" 9-10/VII-1959

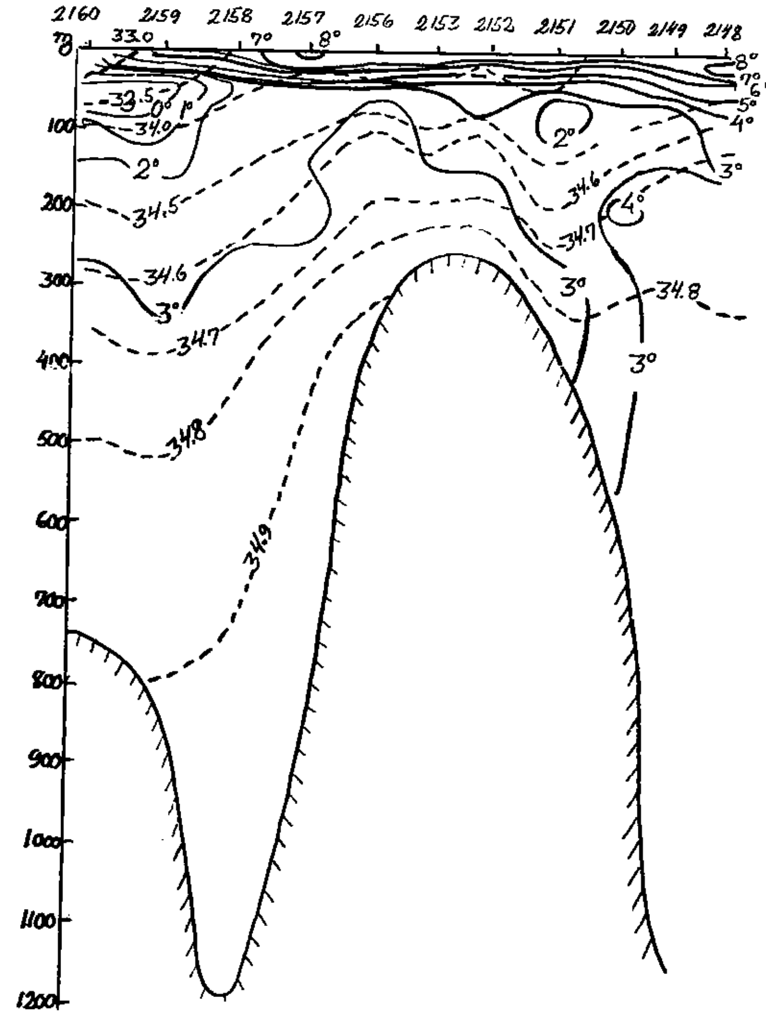
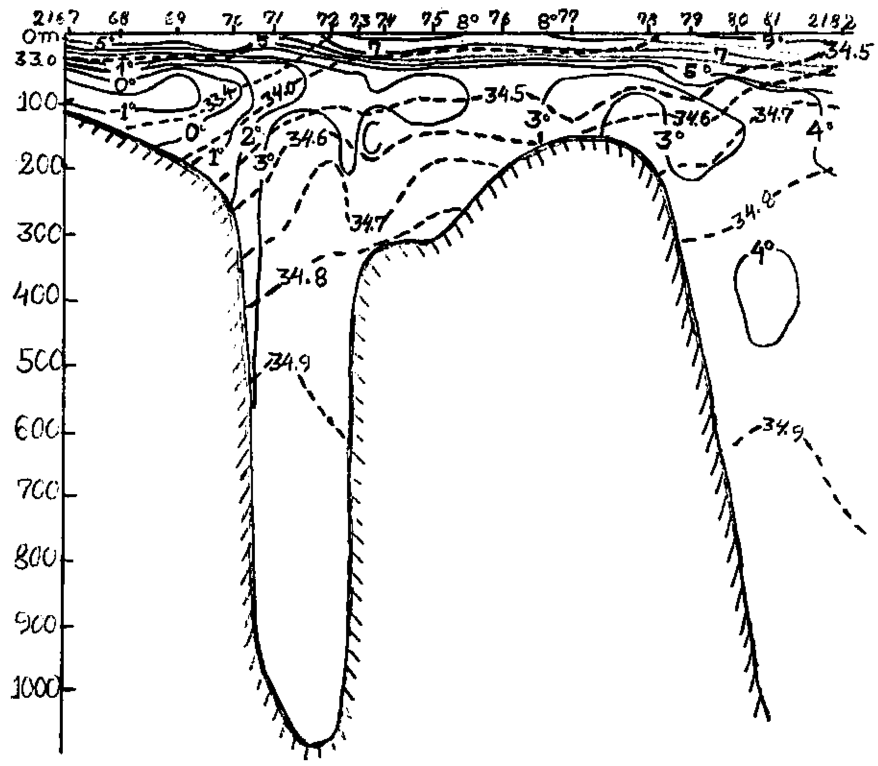
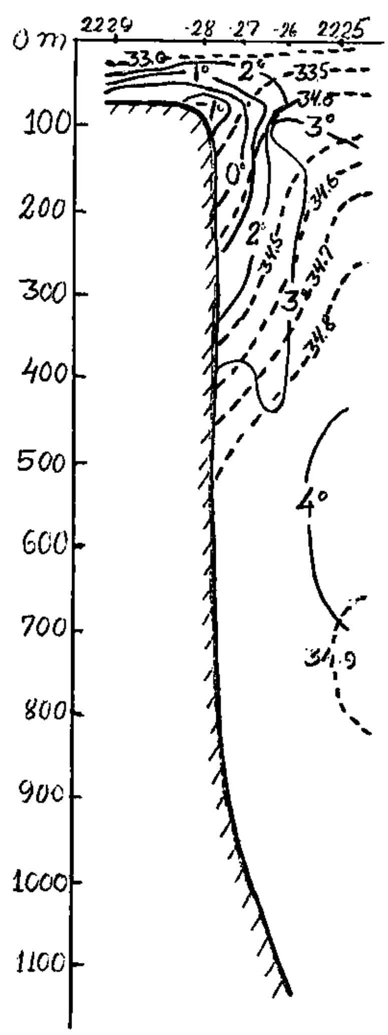


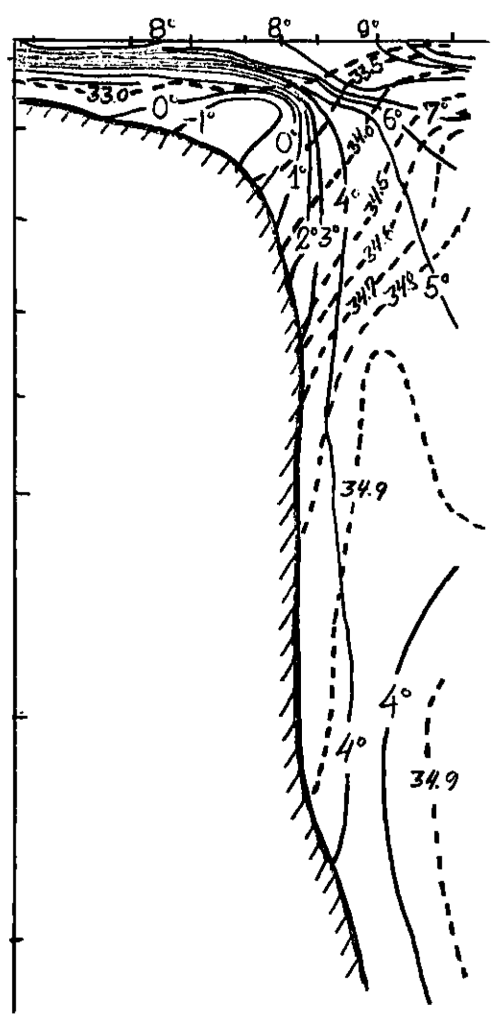
Figure 3f - Isotherms and Isohalines for Sections in the Labrador-Newfoundland area. July-August 1959. Section VI t° and S‰ 7-9/VII-1959



<u>Figure 3g</u> - Isotherms and isohalines for sections in the Labrador-Newfoundland area. July-August 1959.
Section VII
t° and S‰
10-11-VII-59



<u>Figure 3h</u> - Isotherms and Isohalines for sections in the Labrador-Newfoundland area. July-August 1959.
Section IX
t° and S‰
19-20/VII-1959



<u>Figure 3i</u> - Isotherms and Isohalines for sections in the Labrador-Newfoundland area. July-August 1959.
Section VIII
t° and S‰
18-19/VII-1959

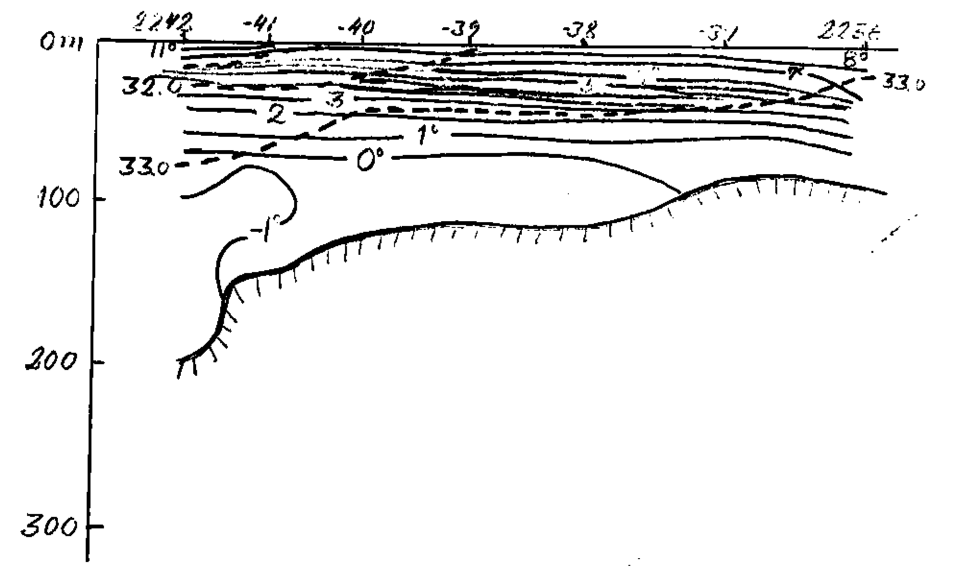


Figure 3j - Isotherms and Isohalines for Sections in the Labrador-Newfoundland area. July-August 1959.
Section X.
t° and S‰
21/VII-1959.

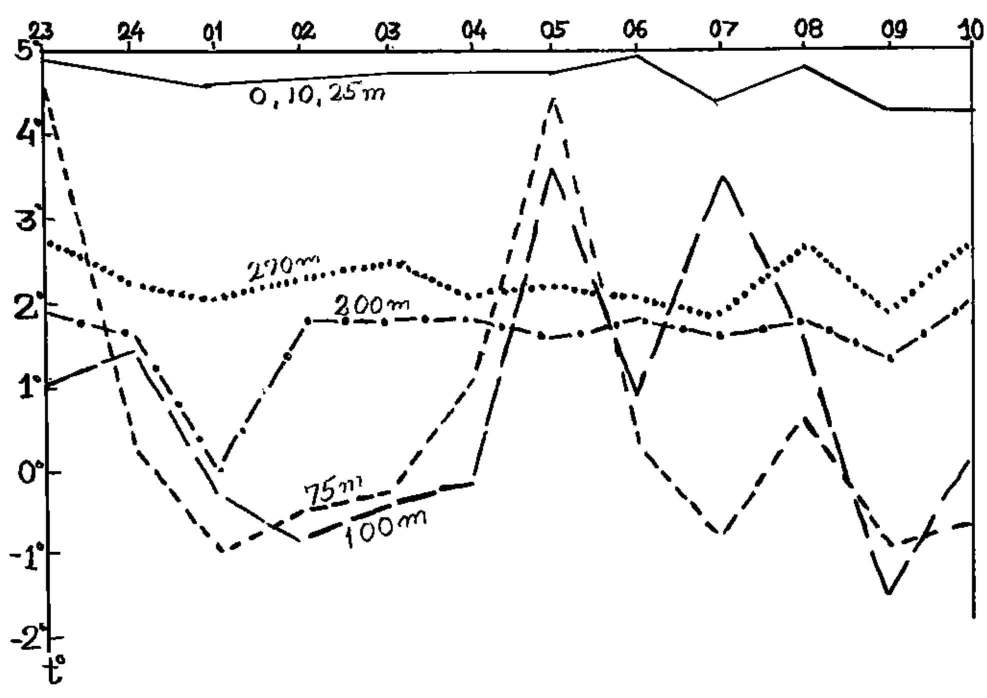


Figure 4 - Diagram of 12 hour variations of water temperatures in various horizons at 48°25'7N and 49°46'1W. Observations made aboard the trawler RT "Novorossiisk", October 9-10.