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Hydrological Conditions in Labrador and Newfoundland Areas in 1971

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A B S T R A C T

In the present paper the average water temperature on standard hydrological sections in the Labrador and Newfoundland areas in the March-July period and in November 1971 is compared with the temperature for some previous years.

The temperature conditions in various parts of the area and in various layers (0-50, 50-100, 100-200, 50-200, 0-200 and 200-500 m) are compared.

The curves of the yearly course of salinity on sections 6-A and 3-A and anomalies of salinity of the Labrador Current in 1970-1971 are given. In the first half of 1971, the salinity of the Labrador Current in the 0-200 m layer was considerably lower than the norm and it was only on the Hamilton Inlet Bank that the salinity had a positive anomaly in July.

In 1971 research vessels " Protsion", " Perseus III" and "Akademik Knipovich" conducted hydrological observations in the Labrador and Newfoundland areas.

The temperature and salinity were measured at 788 stations of the standard sections up to a depth of 2000 metres (Fig.I).

R/V "Protsion" carried out investigations in the March-May period, S/V "Perseus III" in the May - July period and in November and R/V "Akademik Knipovich" in June-July.

The comparison of temperature conditions was done as before (Burmakin, 1967-1971) on the basis of the average water temperature of various layers at standard sections within the boundaries according to A.A.Flizarov (1962) and V.V.Burmakin (1971). These boundaries are shown in Fig.I by square brackets.

Water temperature

Earlier we (Burmakin, 1971) constructed the curves of the average yearly course of temperature in the 0-200 m layer for sections:8-A,7-A,6-A,4-A,3-A,2-A and 44-A.These curves were also used to determine the temperature anomalies from the observations in 1971.

As table 1 shows the March-May period of 1971 is characterized by considerable negative anomalies (ranging from -0.7° to -1.4°) on sections crossing the Main Branch of the Labrador Current on the North-East (sec.7-A and 6-A) and Southern (sec.2-A) slopes of the Grand Bank.In April and May sections 3-A and 4-A (across the South-East slope of the Grand Bank) exhibited temperature anomalies from -0.1° to $+0.9^{\circ}$.

On sections across the South-West slope of the Grand Bank (1-A) and Cabot Strait (44-A) the temperature anomalies in spring were positive ($+0.4^{\circ}$ and $+1.3^{\circ}$).

In the June-July period the temperature anomalies in the 0-200m layer were positive on section 8-A ($+0.7^{\circ}$) in the South Labrador area,on sections 3-A and 4-A ($+0.8^{\circ}$ and $+0.6^{\circ}$)

across the South-East slope and on section 1-A (+2.4°) across the South-West slope of the Grand Bank.

These anomalies remained negative both in spring and summer on the North-East slope of the Grand Bank, section 7-A (-1.2°),while on the South-West slope of the Grand Bank and in Cabot Strait the anomalies became negative (-0.5° and -1.9°, sec.1-A and 44-A)in summer.

In November off South Labrador on sections 8-A the temperature in the 0-200m layer in the Main Branch of the Labrador Current (B) was below the norm by 0.1°.

Table 2 shows the average temperature in the 0-200m layer and its anomalies adjusted to the dates. This method to estimate the thermal conditions was employed by us in our previous works (Burmakin,1967-1971).

We made an attempt to elucidate which layers were the coldest in the spring of 1971.To this end we compared the average water temperature by layers:0-50m-surface layer,0-200m-active layer,50-200m- the core of the Labrador Current and 200-500m-Atlantic waters.The sections across the Southern slopes of the Grand Bank and the Cabot Strait had additional layers:50-100m-Labrador waters and 100-200m-mixed Labrador and Atlantic waters.

The comparison of temperature in these layers in the spring-summer period 1957-1971 reveals that in 1971 on sections: triangle (NW-side),7-A and 6-A (H_I) the minimum temperature was observed in the 50-200m layer,i.e.in the core of the Labrador Current, and amounted on these sections to: 0.02°, 0.11° and -78° respectively and the temperatures given were lower than the minimum temperatures observed at the same period in 1963: 0.90°, 0.66° and -0.74° respectively. On the same sections above and below the core of Labrador waters (in the 0-50 and 200-500 m layers) the temperature was about normal in spring 1971.

In the channel between the Grand Bank and Flemish Cape Bank (sector G of the 6-A Section) the lowest temperature was observed in 1971 for the whole period 1957-1971 not only in the 50-200 m

layer but also in the 0-50 m layer (-0.69° against -0.09° in March 1963). But in this area the relatively high temperatures were found in the 200-500 m layer (3.53° in March 1971 against 2.77° in March 1963).

Table 3 shows the more detailed data on an average temperature in different layers in spring and summer of the coldest years and in 1971.

In the 0-50 m layer on Section 3-A across the south-eastern slope of the Grand Bank the following temperatures were observed in April, May and June: 0.62°, 1.37°, 4.87° respectively and on Section 2-A the temperature was +1.44° in April, this temperature was higher than normal. During the same months the temperatures of waters in the 50-100 m layer on Section 3-A were: in April -0.41° in May -0.36°, in June - 0.47° and in the 100-200 m layer: -0.34°, -0.22° and -0.57° respectively, i.e. they were close to temperatures in cold years (Table 4).

In April and May 1971, the temperature of waters in the 0-500 m layer on Section 4-A was higher than that in the warm 1958.

On the sections across the south-western slope of the Grand Bank (1-A) and across the Cabot Strait (44-A) the temperature of waters in March, May and June 1971 was higher than in 1964, 1966, 1968 and 1970 (Table 5).

As it is evident from this table, especially warm waters were observed in March in near-bottom layers (200-500 m), in May warm waters were found in the 100-200 m and 50-200 m layers and in June an intensive solar heating was observed in the 0-50 m layer (8.11° was registered on the 19-th of June 1971 comparing to 4.84° on the 16-th of June 1968). Waters in the 50-100 m were also warmer than in the warm 1968 but colder in the deeper 100-200 and 200-500 m layers.

An intensive influx of warm waters of the Gulf Stream was observed between the St.Pierre, Green and Grand banks and especially in the Haddock Channel. Near the bottom in the Channel given in 45°20'N there was recorded the temperature higher than 4° whereas in the other years in this area there were found wa-

ters with a temperature below 0°.

Decreasing of the temperature on the south-western slope of the Grand Bank and on the St.Pierre Bank in July 1971 (Table 5) was due to displacement of the Polar front towards the ocean and to an inflow of cold waters of the coastal stream of the Labrador Current.

In November, on Section 8-A (AB) the temperature in the 0-50 m layer of the Labrador Current was 0.88° and was below the normal by 0.67° (as in 1969), in the 50-200 m layer it was by 0.20° below the normal and amounted to 0.43°; in the 200-500 m layer the temperature was 0.39° higher the normal and equalled 1.58° (approximately as in 1962).

Salinity

The comparison of schemes of the horizontal distribution of salinity with those of geostrophic circulation of waters for the same period (Kudlo, Burmakin 1972) shows that isohalines are in good agreement with lines of flow. Thus, one can assume that the distribution of salinity in the South Labrador and Newfoundland areas results from the interaction of the Labrador Current waters with more salted waters of the Labrador Sea and Gulf Stream restricting the area at the side of great depths along the shelf contour. In this process the relief of the shelf and also the carrying-out of diluted waters from the Hudson Strait and St.Lawrence Bay are of great importance.

The main feature of the distribution of salinity that may be marked in this area is its increasing towards the ocean in the whole of the water column and from surface to bottom.

Demersal waters of the Labrador Sea and Gulf Stream penetrate further on to the shelf, than surface layers; the frontal zone is sloping towards the ocean.

Vortices on the Great Newfoundland Bank cause formation of spots with increased or lower salinity, which evidently are not stationary.

In order to obtain the numerical characteristic of the salinity regime of the Labrador Current, mean values of salinity in the 0-200 m layer were calculated on Sections 8-A, 6-A and 3-A (Fig.1) and also on the corresponding sections of South Wolf Islands - Cape Farewell, F, and U, worked by the International Ice Patrol for a many years' period (Elizarov, 1962 & U.S.Coast Guard Bulletin, 1956-1964). Data on sections, corresponding each other, were joined together into one set and thus formed a foundation for the construction of the mean many years' curves of the yearly variations of salinity.

The value and sign of salinity anomalies in the 0-200 m layer on the date of observations were determined as a difference between the estimated value of salinity and many years' mean salinity for this date.

DIVISION 2J ; The curve of the yearly variation of salinity, average for the sector B of Section 8-A (arctic waters of the Labrador Current) in the 0-200 m layer, is given in the contribution by Burmakin,V.V., Kudlo,B.P.,1971. In accordance with the observations of 1970-1971, salinity anomalies indicate, that salinity of arctic waters of the Labrador Current on Section 8-A in 1970 and in July 1971 somewhat exceeded the norm.

In July 1971 on the Hamilton Bank positive salinity anomaly corresponded to the negative transport anomaly (Kudlo and Burmakin, 1972). One can make a supposition, that weakening of intensity of the current caused a stronger inflow of the Labrador Sea waters with a greater salinity on to the bank in the demersal layers.

DIVISION 3L. On Section 6-A (F), crossing the Flemish Channel along 47°N, salinity means in the 0-200 m.layer were calculated for sector G from 47°30' to 46°50' W. Basing on these data, the "normal" curve of the yearly variation of mean salinity was obtained (Fig. 2A). Values of salinity in accordance with the observations in 1970 and 1971 are marked with corresponding indices. Values of salinity anomalies on Section 6-A are given in Table 6.

As opposed to Section 8-A, on Section 6-A in 1970 negative salinity anomalies were observed; in October salinity reached the norm. In the first half year of 1971 salinity again decreased below the norm here, and in May negative anomaly was 0.47‰. On Section 6-A, as well as on the Hamilton Bank, in most cases positive anomalies of Labrador Current water transport correspond to the negative salinity anomalies, i.e., salinity in the 0-200 m. layer is evidently a function of intensity of current.

DIVISION 3 N. Mean water salinity on Section 3-A (U) crossing the Labrador Current on the Southwestern Slope of the Grand Bank, was calculated within 45°00' N, 49°10' W and 44°50' N, 38°30'W. The number of observations, basing on which the curve of yearly variation of salinity on this section has been plotted, is less than on Section 6-A (Fig. 2B). The portions of the curves, plotted in accordance with single observations, are given in broken line.

In four cases out of five, the signs of salinity anomalies on Sections 6-A and 3-A coincide, i.e. tendency to changing of salinity on both sections is equal (Table 6). During the second half year of 1970 (May, October) and the first half year of 1971 water salinity on Section 3-A in the 0-200 m. layer was comsiderably lower than the norm; in May and June 1971 it was at the minimum level, which is determined in agreement with the many years' data; negative anomalies reached 0.5 - 0.6‰. (Table 6).

CONCLUSIONS

1. In spring and in early summer 1971 water masses of the Labrador Current on the North Newfoundland Bank and on the Northeastern Slope of the Grand Bank were colder than in the coldest years of the available set of observations for the period of 1957-1971. At the same time on the Southwestern Slope of the Grand Bank and in the straits between the banks of St.Pierre - Green - Grand temperature was above the norm.

2. In July 1971, as well as in spring, waters of the Labrador Current on the Northeastern Slope of the Grand Bank

remained cold, however, to the north and south of this slope temperature raised above the norm. By summer time temperature fell below the norm on the Southwestern Slope of the Grand Bank and on the St.Pierre Bank.

3. In March-April 1971 on sections "Triangle", 7-A, and 6-A minimum temperature was registered in the 0-200 m. layer; it was lower than in "cold" 1963. In the upper 50 m. layer it was also colder, than in the "cold" years 1959 and 1963.

4. In March-May 1971 temperature above 4° was registered in demersal layers in the channel between the Green and Grand banks, whereas in previous years it was usually below 0°.

5. Curves of the yearly variation of salinity have been obtained for the Labrador Current on sections 6-A and 3-A in accordance with many years' data, which make it possible to determine anomalies of mean salinity on the sections.

6. In the 0-200 m layer of the Labrador Current salinity was considerably below the norm on Sections 6-A and 3-A in the first half year of 1971, and in June-July the anomalies reached - 0.5-0.6‰. In July salinity anomaly was positive on the Hamilton Bank (Section 8-A).

Table 1

Anomalies of temperature in the 0-200m layer ($^{\circ}$C)

on the date of observations in 1971

Sections and dates		Months					
		III	IV	V	VI	VII	XI
8-A (B)	29.07, 09.II					+0,7	-0,I
7-A	03.05, 28.05, I6.07			-0,8	-0,8	-I,2	
6-A(G)	I9.03, 30.04, 24.05	-I,4	-0,7	-I,4			
4-A	25.04, I8.05, 03.07		+0,9	0.0		+0,6	
3-A	20.04, I6.05, 26.06		0.0	-0.I	+0.8		
2-A	03.04		-0.8				
1-A	I0.04, I9.06, 23.07		+0.4		+2,4	-0.5	
44-A	28.03, 24.05, I6.07	+I,3		+I,2		-I,9	

Table 2

Average temperature of the 0-200m layer (°C) and its anomalies in 1971 adjusted to certain dates

Sections	Dates of adjustment of average temperature											
	20.03		I5.04		I5.05		I5.06		I5.07		I.II	
	t	t	t	t	t	t	t	t	t	t	t	t
8-A (B)									0.55	+0.29	I.I9	-0.I0
8-A (AB)									0.00	+0.I0	0.57	-0.33
7-A					0.26	-0.58						
6-A	0.56	-I.46										
4-A			2.33	+I.50	2.09	+0.83	2.9I	+0.42				
3-A			0.26	-0.09	0.65	+0.I7	I.68	+0.80				
2-A			0.89	-0.I6								

Table 3

Average temperatures of different water layers (°C) on sections "triangle" (NW is a side), 6-A and 7-A in the spring-summer period of the coldest years and in 1971

Section	Dates of observations	Layers, in m			
		0-50	0-200	50-200	200 -500
"Triangle" (side NW)	4-5.02.1962	0.79	I.I8	I.30	2.48
	5-6.05.I97I	-0.I0	0.07	0.09	2.67
	30-3I.05.I963	I.85	I.I6	0.90	2.49
	30.05.I97I	I.52	0.32	0.02	2.65
	I5.07.I963	3.72	2.02	I.35	2.78
	I2.07.I97I	2.I4	0.58	0.05	2.33
7-A	I5.05.I969	0.73	0.70	0.66	2.80
	I5.05.I97I	0.57	0.26	0.II	2.89
6-A (H_1)	25.03.I963	-I.03	-0.8I	-0.74	-
	I9.03.I97I	-0.6I	-0.69	-0.78	-
	I9.04.I963	-I.07	-0.46	-0.2I	-
	30.04.I97I	0.89	0.32	-0.38	-
	25.05.I963	I.I2	0.87	-0.06	-
	25.05.I97I	2.74	I.30	-0.25	-

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		0-50	0-200	50-200	200-500
	25.03.I963	-0.09	I.09	I.45	2.77
	I9.03.I97I	-0.69	0.56	0.97	3.33
6-A (G)	I9.04.I963	-0.52	0.66	I.07	2.90
	30.04.I97I	0.25	0.65	0.74	3.29
	I9.05.I959	-0.I3	0.56	0.54	2.42
	25.05.I97I	I.25	0.35	0.05	2.86
	I7.03.I959	2.65	2.70	2.7I	3.5I
	I9.03.I97I	I.50	2.64	3.02	4.70
6-A (H_2)	I9.04.I963	I.86	2.69	2.97	3.76
	30.04.I97I	I.35	2.84	3.34	4.48
	I9.05.I959	2.85	2.68	2.62	3.42
	25.05.I97I	2.46	2.74	2.84	4.56

Table 4

Average temperatures in the 50-100 m and 100-200 m layers (°C) on Section 3-A in April, May and June 1971 and in cold years

Section	Date	Layers, in m	
		50-100	100-200
3 - A	12.04.1959	- 0,68	1,48
	20.04.1971	- 0,41	- 0,34
	20.05.1963	- 0,08	0,84
	15.05.1971	- 0,36	- 0,22
	01.06.1959	- 0,54	0,82
	26.06.1971	- 0,47	- 0,57

Table 5

Average temperatures of different water layers (°C) on Sections 1-A and 44-A in March, May-July 1971 and in 1964, 1966, 1968 and 1970

Section	Date	Layers, in m					
		0-50	0-200	50-200	50-100	100-200	200-500
I-A	I6.06.I968	4,84	4,87	4,38	3,2I	7,62	6,89
	I9.06.I97I	8,II	6,86	4,96	4,98	7,09	5,29
	20.07.I970	8,35	6,00	4,00	3,34	6,7I	6,II
	23.07.I97I	8.09	5,75	2,22	I,74	4,69	5,34
44-A	I4.03.I964	-0,59	0,33	0,64	0,53	I,23	3,58
	28.03.I97I	0,I6	I,50	I,95	0,4I	2,72	5,I6
	24.05.I966	2,43	I,87	I,64	I,06	I,95	4,30
	24.05.I97I	3,I8	3,28	3,59	2,07	3,78	5,I8
	6.06.I968	4,38	4,53	4,58	2,67	5,54	5,48
	I6.07.I97I	2,I5	2,99	3,I8	I,59	3,98	5,I6

Table 6

Water salinity of the Labrador Current and its anomalies on some standard sections in the area of Labrador and Newfoundland in the 0-200 m layer, 1970-1971, ‰.

Section	Date	Observed	Norm	Anomaly
8-A (B)	4-5 May, 1970	33,85	33,78	+0,07
	4-5 September, 1970	33,58	33,43	+0,I5
	30 October, 1970	33,59	33,55	+0,04
	29-30 July, 1971	33,67	33,4I	+0,26
6-A (G)	I-2 January, 1970	34,I7	33,99	+0,I8
	I9-20 May, 1970	33,63	33,76	-0,I3
	8 August,1970	33,64	33,84	-0,20
	5-6 October, 1970	33,72	33,72	0,00
	I9-20 March, 1971	33,73	33,99	-0,26
	30 Apr.-1 May, 1971	33,45	33,83	-0,38
	24-25 May, 1971	33,30	33,77	-0,47
3-A	I0-II January, 1970	34,I7	33,96	+0,2I
	I8 May, 1970	33,25	33,70	-0,45
	I0-II October, 1970	33,47	33,75	-0,28
	I9-20 April, 1971	33,4I	33,87	-0,46
	I5-I6 May, 1971	33,23	33,7I	-0,48
	26 June, 1971	33,30	33,87	-0,57

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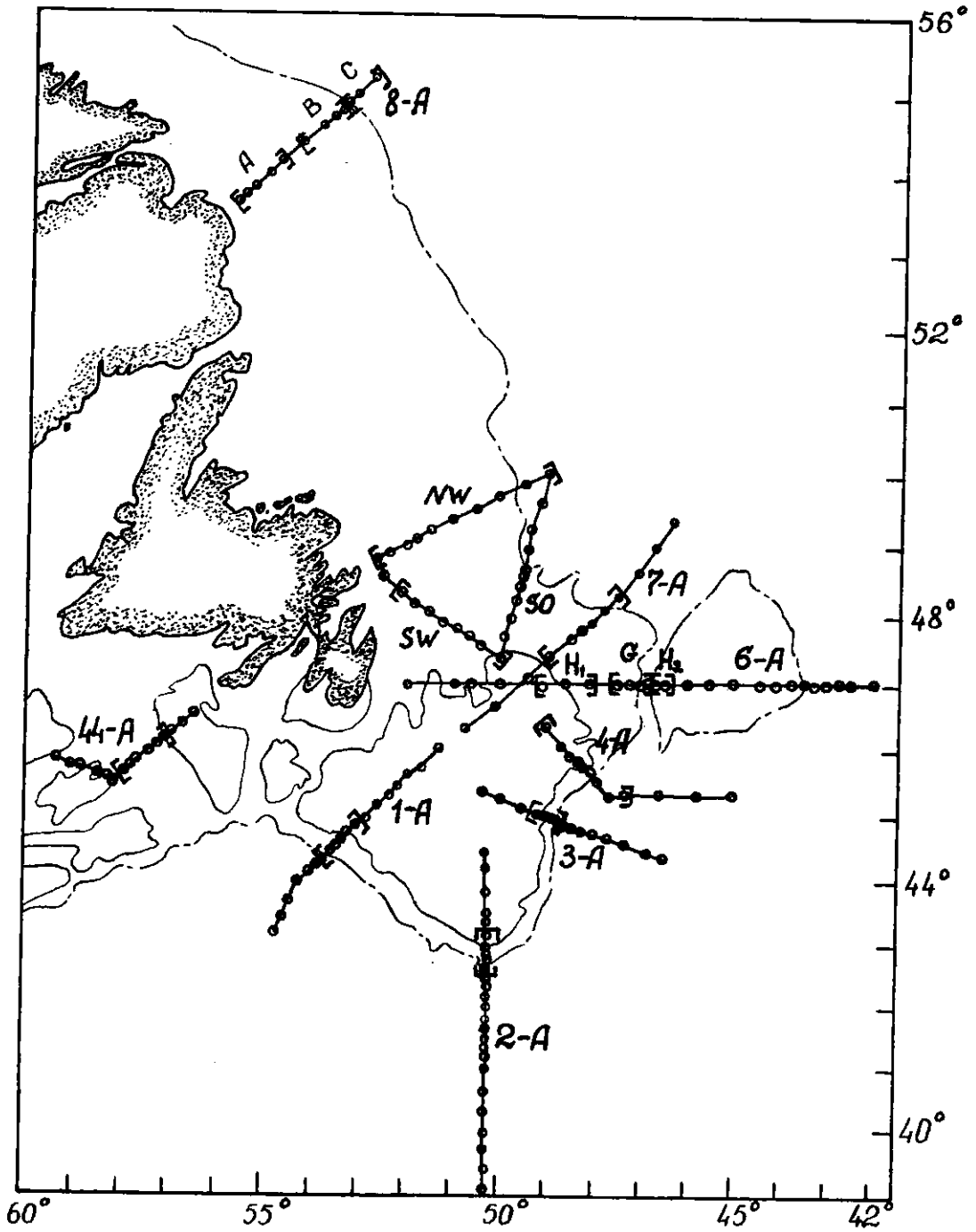

Fig.1. The location of the standard hydrological sections in the Labrador and Newfoundland areas. Square brackets denote the sectors of the sections for which average temperature and salinity were calculated.

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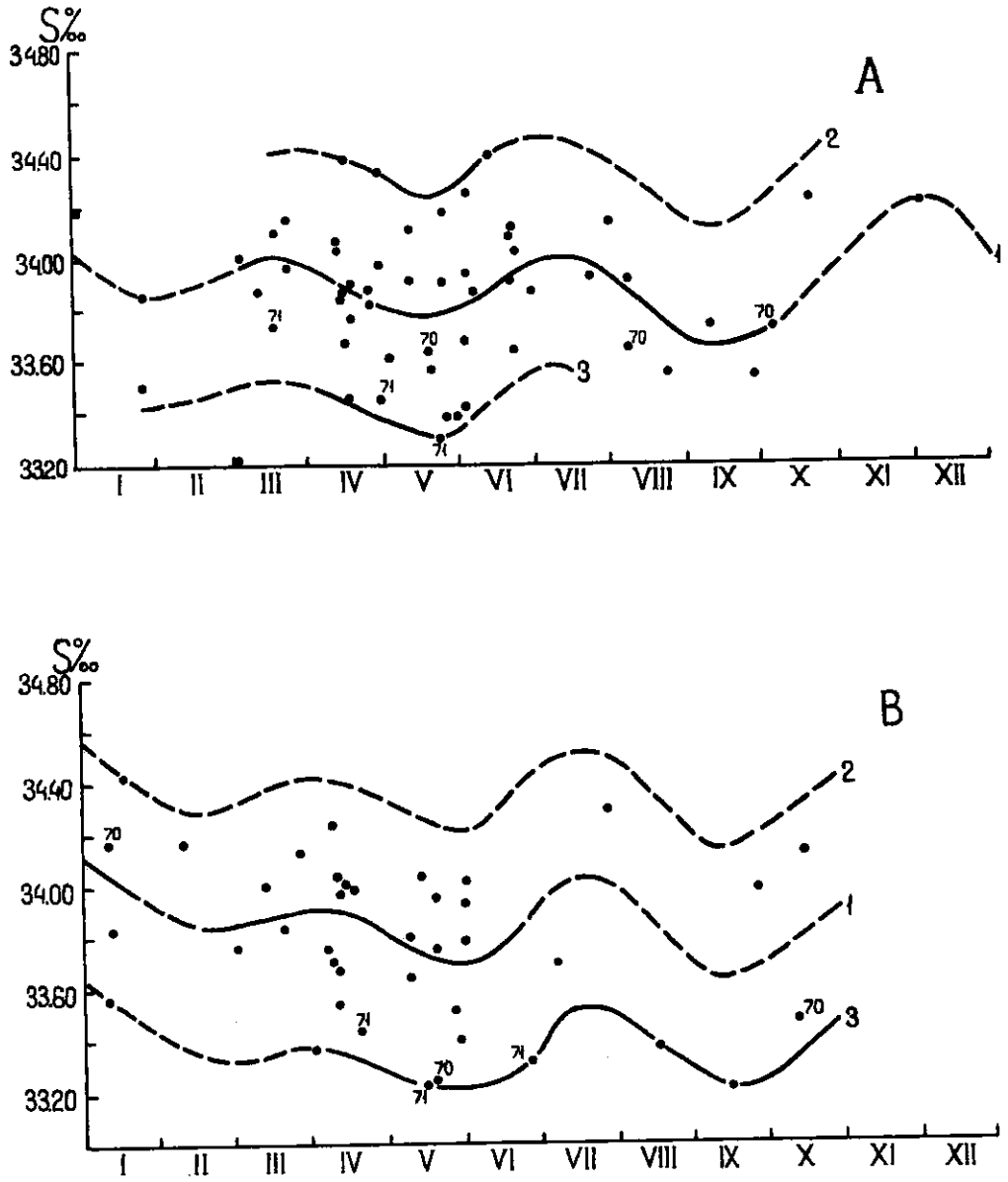

Fig.2. The yearly course of average (I) and extreme (2,3) values of salinity of the Labrador Current in the 0-200m layer in the core of the Current(G) on section 6-A along 47°N (A) and on section 3-A across the South-East slope of the Grand Bank (B).