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Geostrophic circulation and salinity of waters in the Labrador and Newfoundland areas in 1977-1978

by

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Abstract

Charts of the dynamic topography of the surface in the ICNAF subareas 2 and 3 are constructed and analysed on the basis of hydrological observations made by the PINRO research vessels. Values of flow rate and salinity of the Labrador Current waters on some standard sections are determined and a comparative estimate of the state of the Current in winter 1977-1978 and in spring-summer 1978 in relation to the long-term mean conditions is given.

Material and methods.

The data on water temperature and salinity measurements made on about 950 hydrological stations in the north-western Atlantic from October 1977 to January 1978 (the 19th cruise of FRV "Perseus III" and the 16th cruise of RV "Protsion") and from May to July 1978 (the 17th cruise of RV "Protsion") are used in the paper.

The circulation of waters was studied with the help of a dynamic method (Zubov and Mamayev, 1956). Dynamic heights of the sea free surface were calculated relative to the 200 dbar level. Calculations of the velocity of geostrophic currents were made for each standard depth under the assumption that there is no motion near the bottom or at the maximum depth of observations equal to 2 000 m. Flow rate and salinity of the Labrador Current waters were calculated within those parts of standard sections for which the average curves of annual variations of the values mentioned above are known (Burmakin & Kudlo,1971; Kudlo & Burmakin,1972 ;Kudlo, 1973;Kudlo & Borovkov,1975;Kudlo,Borovkov & Boytsov,1976).With the help of these curves the norms and anomalies of flow rate and salinity for the chosen sections were determined in accordance with the dates of observations.

Geostrophic circulation on the surface.

Fig.1 shows the results of the calculation of fields of surface flows in winter.On the basis of the given schemes a general picture of the surface geostrophic circulation in the period mentioned as well as some of its elements such as anticyclonic vortices over the Flemish Cap Bank and in the southern part of the Grand Newfoundland Bank may be said to correspond to the field of flows observed usually in the area surveyed.

The anticyclonic vortex with its centre at 44° 30' N and 48° W formed by the Atlantic waters and situated inside the area of mixed waters with a lower heat and salt content should be also attributed to the peculiarities of the circulation.The mentioned vortex may be supposed to have appeared due to separation of meander from the left side of the North-Atlantic Current.

According to the results of calculation of the spring-summer circulation (Figs.2-4) the directions of flow lines and localization of the main currents eastward of the Grand Bank have hardly changed from winter to summer.The velocity of the Labrador Current decreased in this area therewith,which resulted in a less marked difference between velocities of the Current in its southern and northern parts.The comparison of the given charts implies also the weakening of south-eastern and southern water transports from winter to summer in the shelf area northward of 50° N,where the width of the coastal branch of the Labrador Current decreased , and unsteady eddy formations occupied the space between the streams (Figs.3,4).

It should be noted that the anticyclonic vortex registered near the eastern slope of the Grand Bank in winter was not observed in spring-summer. As for the eddy formations recorded in this area in the second half of June (Fig.3), their origin may be considered to be connected with an unstability of the mixed waters motion. The similarity of thermohaline characteristics of waters existed inside and outside the eddies is the basis for such a supposition.

Flow rate and average salinity of the Labrador Current waters.

When analising the schemes of the surface geostrophic circulation we have already paid attention to the peculiarities of spatial differentiation of the velocity of the Labrador Current. To judge of the peculiarities of transport intensity within the whole pelagial covered by the Current let us use the results of calculation and estimation of flow rate (Table 1).

Water flow rates given at the top of the Table show that in winter 1977/1978 the intensity of the Labrador Current between the Hamilton Bank and the "tail" of the Grand Bank was rather heterogeneous. The greatest intensity of the Current ($11.7 \times 10^6 m^3/s$) was recorded on the section 4-A in the area of the eastern slope of the Grand Bank. Northward and southward of this area the intensity of the Current decreased, the minimum water transport equal to 2.2×10^6 m^3/s being registered in the northernmost part of the surveyed area (Seal Island section). As the anomalies of flow rates show it is just in this area that the intensity of water transports was below the long-term mean (by 2.7×10^6 m^3/s), whereas the water flow rates across other sections exceeded the corresponding norms by values from 1.6 to 6.4×10^6 m^3/s. The results obtained confirm particularly the supposition, advanced earlier on the basis of the analysis of data on water temperature and content of dissolved oxygen, that at the end of 1977 the Labrador Current weakened in the Hamilton Bank area (Konstantinov, Noskov and Tokareva, 1978).

In summer the intensity of the Labrador Current was on the whole lower than in winter. The minimum flow rate was observed on the "tail" of the Grand Bank and the maximum one - on its south-

eastern slope.Data on flow rates and the dynamic chart (Fig.3) show that in summer 1978 the Labrador Current hardly reached the south-western slope of the Grand Bank.

The pattern of the distribution of salinity anomalies along the Labrador Current is ,as usual,rather patchy (Table 1).Considerable positive salinity anomalies in the Hamilton Bank area corresponded to negative anomalies of water flow rates.Down the Current the salinity anomalies were not great,as a rule,even with maximum anomalies of water flow rates,and the combination of opposite anomalies signs was not a general regularity.

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Table 1.Flow rates and salinity of the Labrador Current waters,their long-term mean norms and anomalies on standard sections in 1977 - 1978.

Sections vessel cruise	Date of observations	Flow rate, mill.m^3/s.			Salinity,‰		
		observed	norm	anomaly	observed	norm	anomaly
Winter survey							
Seal Island (I)	3I.X-I.XI.I977	2,2	4,9	-2,7	33,93	33,55	0,38
Flemish Cap (2)	5-6.XII.I977	6,3	3,3	3,0	34,I6	34,20	-0,04
4-A (2)	I2-I3.XII.I977	II,7	5,3	6,4	34,07	34,I6	-0,09
Coast Guard-3 (2)	28-30.XII.I977	9,5	6,8	2,7	34,09	34,I0	-0,0I
Coast Guard-4 (2)	30-3I.XII.I977	4,I	2,5	I,6	33,83	33,46	0,37
Spring-summer survey							
Seal Island (3)	8.VII.I978	2,2	4,3	-2,I	34,I2	33,48	0,64
Flemish Cap (3)	2I-22.V.I978	4,I	3,2	0,9	33,64	33,76	-0,I2
	25-26.VI.I978	I,8	3,3	-I,5	33,86	33,96	-0,I0
4-A (3)	II-I2.V.I978	6,4	4,2	2,2	34,20	34,06	0,I4
	22-24.VI,I978	6,7	3,2	3,5	33,72	33,72	0,00
Coast Guard-3 (3)	I0.V.I978	9,7	4,4	5,3	33,70	33,74	-0,04
	I7-I8.VI.I978	7,8	3,2	4,6	33,57	33,78	-0,2I
Coast Guard-4 (3)	30.VII.I978	0,0	2,I	-2,I	33,I6	33,34	-0,I8

Sections were made: (I) - in the 19th cruise of FRV "Perseus-III", (2) and (3) - in the 16th and 17th cruises of RV "Protsion" respectively.

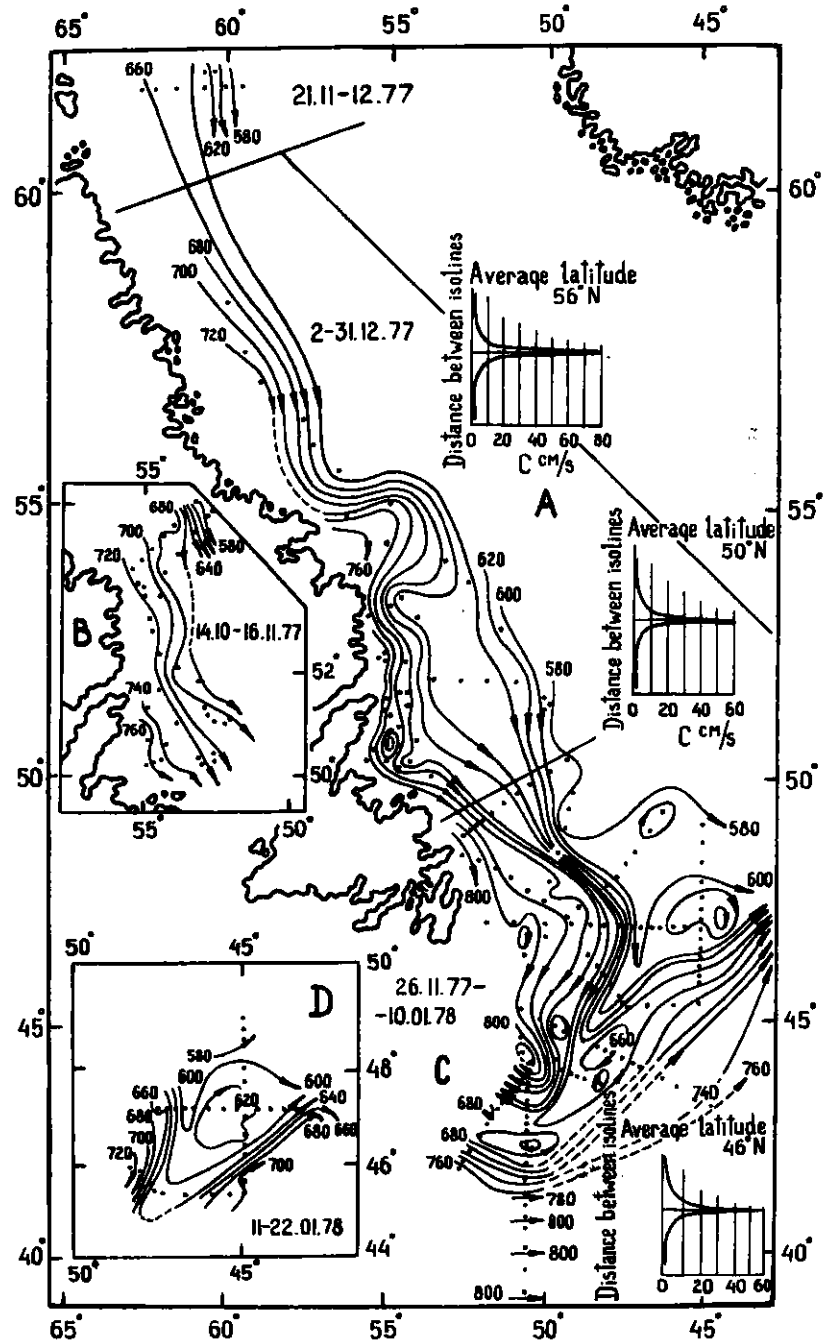

Fig. 1. Geostrophic circulation of waters in the Labrador, Newfoundland and Flemish Cap Bank areas (0-200 dbar) in winter 1977/1978 according to data from the 19th cruise of FRV *Perseus III* (A and B) from the 16th cruise of RV *Protsion* (C and D). Dates of observations in some parts of the area are given in the figure.

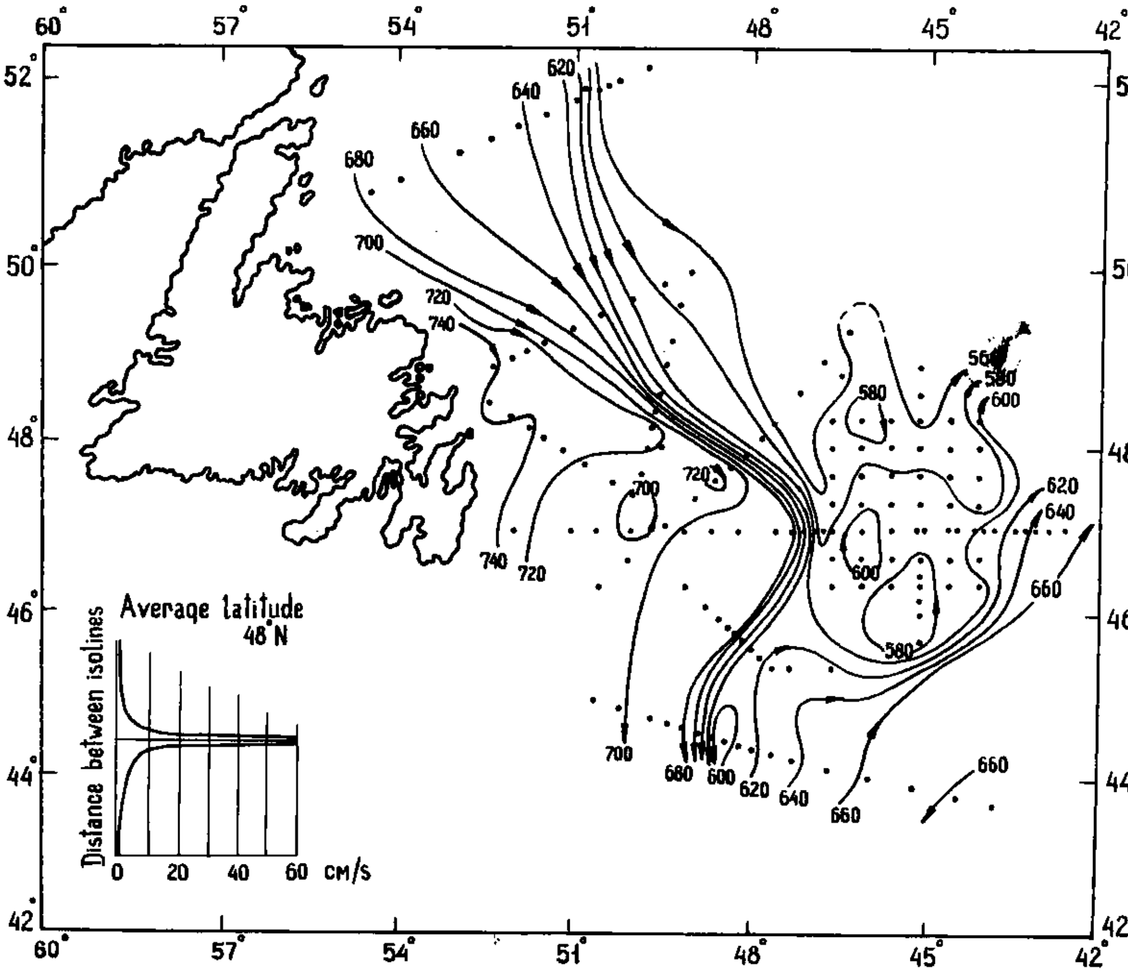

Fig. 2. Geostrophic circulation of waters in the Newfoundland and Flemish Cap Bank areas from May 6 to June 13 1978 (0-200 dbar, RV *Protsion*, the 17th cruise).

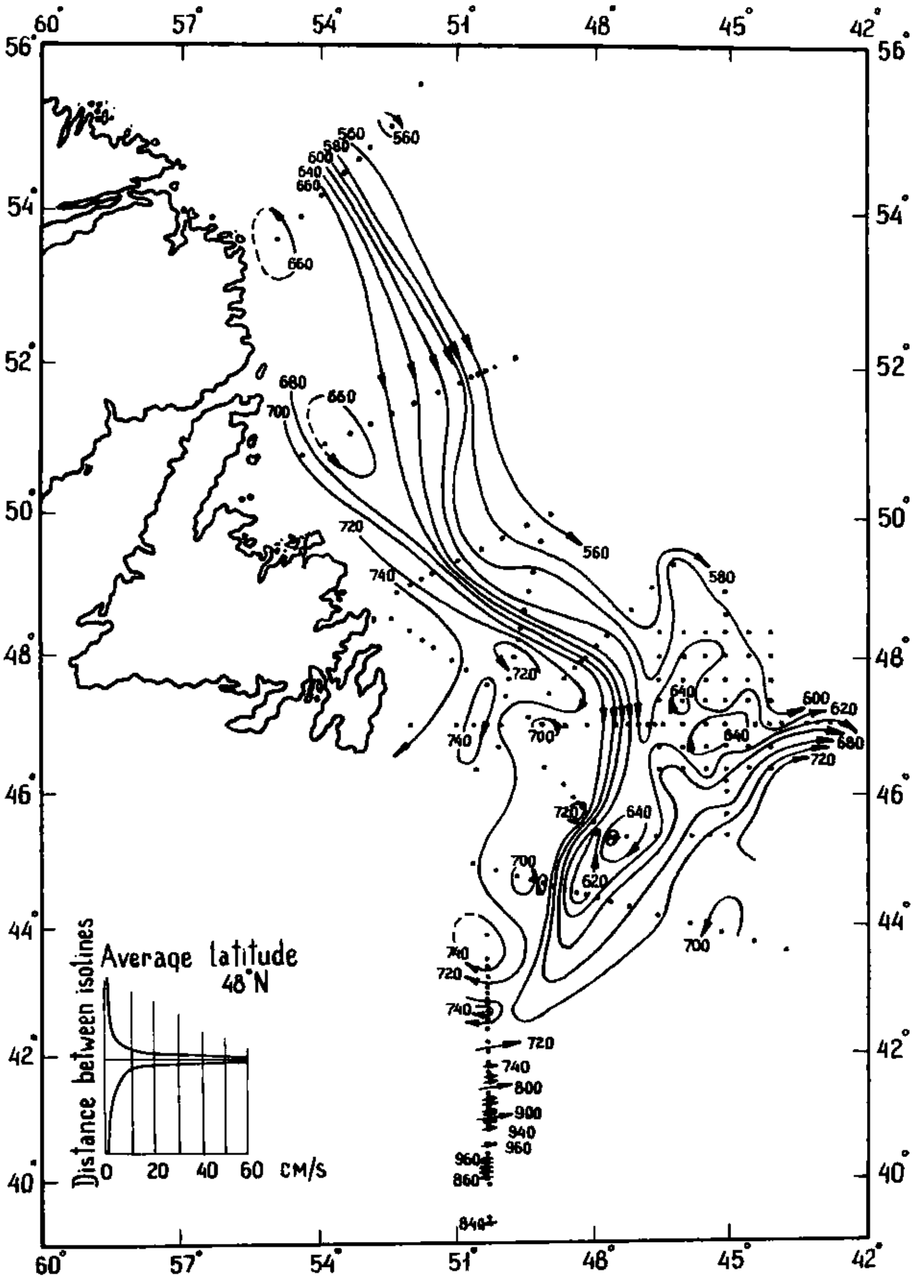

Fig. 3. Geostrophic circulation of waters in the Newfoundland, Flemish Cap Bank and Southern Labrador areas from June 17 to August 2, 1978 (0-200 dbar, RV *Protsion*, the 17th cruise).

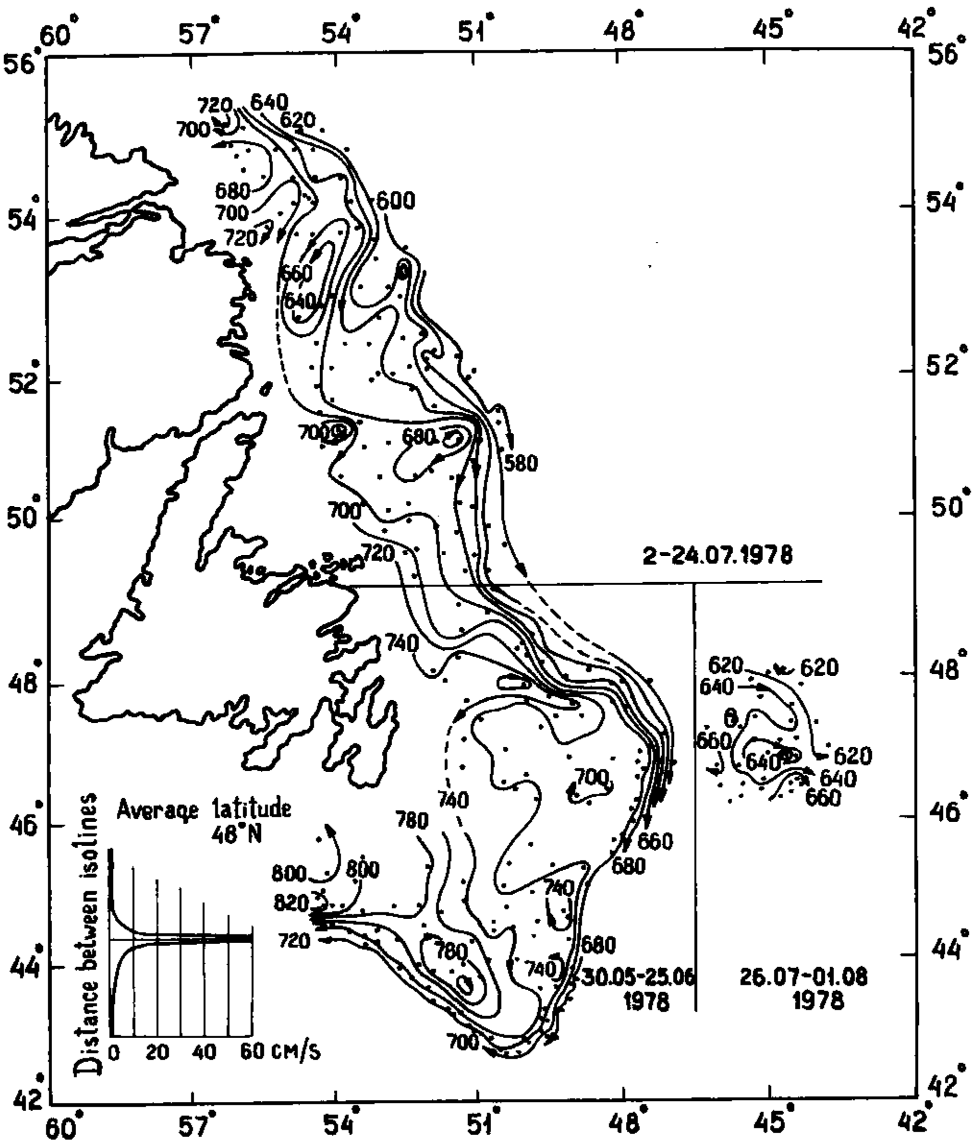

Fig. 4. Geostrophic circulation of waters in the Newfoundland, Labrador and Flemish Cap Bank areas (0-200 dbar) according to data from the 20th cruise of FRV *Perseus III*. Dates of observations in some parts of the area are given in the Figure.