RESTRICTED

INTERNATIONAL COMMISSION FOR THE NORTHWEST ATLANTIC FISHERIES

Serial No. 2981
(D.c.1)

ICNAF Res.Doc. 73/42

ANNUAL MEETING - JUNE 1973

Water circulation in the ICNAF Area in 1971-1972

by

B.P. Kudlo
PINRO, Murmansk, USSR

Abstract

The paper includes five dynamic charts of some parts of the ICNAF area constructed on materials collected during three cruises by the PINRO research vessels in 1971-1972. There are given average curves of an annual course of the transport of the Labrador Current on Sections 8-A and 3-A constructed on the basis of long-term observations by the International Ice Patrol and PINRO. Anomalies of the transport of the Current in the South Labrador and Newfoundland were determined on the basis of observations made on standard sections in 1971-1972. Great positive anomalies of the transport of the Labrador Current were observed in spring 1972. This fact evidently resulted in increase of temperature and salinity of water and in severe ice conditions in the investigated area in spring and summer 1972.

Introduction

To describe a circulation of waters in the ICNAF area in 1971-1972 there were used materials of hydrological observations made during the sixth-eighth cruises by the R/V "Protsion" and in the seventh-eighth cruises of the research-scouting vessel "Perseus III". There were widely used the data collected by Polar Institute (PINRO) for preceding years and these of the International Ice Patrol in 1955-1963 (Bull. U.S.Cst.Guard 1956-1964). Currents were calculated by the dynamic method according to the distribution of temperature and salinity (Zubov,N.N. and O.I.Mamaev 1956).

Spatial Changes in Circulation

Five dynamic charts were constructed to examine spatial changes in water circulation (Figs.1,3,4). A small number of observations were made during the seventh cruise of the R/V "Perseus III" in October-December 1971 in the Davis Strait and Labrador (Divisions 1B-1D,2G-2J,the Baffin Land area) (Fig.1).

By its nature water circulation in the Davis Strait in in October-November 1971 (Fig.1A) may be referred to type 1 involving deformational field at which streams of the West-Greenland and Baffin Land currents are separated by a hollow of the lowered sea level (Alekseev,A.P.,Kudlo,B.P. et al.1972). Increased intensity is charecteristic of this type circulation. This type of circulation was observed in autumn 1962 and 1969.

Residual water exchange across the Davis Strait observed on Section 9-A in autumn was calculated by velocities estimated (Table 1,Fig.2). According to E.V.Solyankin (1965) an average annual transport of waters across the Strait amounts to 1.28 mill.m^3/c and is directed into the Atlantic Ocean. Our calculations show that in some periods a residual water exchange may be directed both to the south and to the north,into the Baffin Sea (Table 1). A sign of residual transport of waters can be changed due to inconstant strong flows with opposite directions which exist in the Strait (Fig.2). In October 1971, the West-Greenland Current brought to the north $2.62 \cdot 10^6$ m^3/c and to the south across Section 9-A the Baffin Land Current brought only $1.62 \cdot 10^6$ m^3/c. Evidently such conditions are scarcely probable during a long period of time as on the average. the residual water exchange is directed into the Atlantic Ocean.

In Labrador (Fig.1B) a number of observations was poor to analyse in detail the peculiarities of circulation. One can assume that in November 1971 the core of the Labrador

Current was placed in this area farther from the coast than usually.

Three charts (Fig.3,4) were constructed for the Newfoundland area (Divisions 3K-3P) and during the seventh cruise by the R/V "Protsion" observations were also made in Division 4V. These charts are continuation of a dynamic treatment of data collected in this area in 1970-1971 (Kudlo,B.P. and V.V.Burmakin 1972) and they represent the nature of a horizontal circulation of waters during surveys.

Fig.3 illustrates two dynamic charts constructed on the basis of data collected during two successive hydrological surveys in one and the same area in spring with about one month interval. The next survey of this area was carried out late in 1971-early in 1972 (Fig.4).

Examining of charts constructed and comparison with dynamic charts for 1970-the beginning of 1971 (Kudlo,B.P. and V.V.Burmakin 1972) show the following.

The general pattern of a horizontal circulation of waters in Newfoundland is rather constant. This was indicated by us previously (Kudlo,B.P. and V.V.Burmakin 1972) and results of treatment of data confirm our opinion. Anticyclonic movement of waters above the southern slopes of the Grand Bank was found in all observations made in this area in 1970-1972 (Fig.4).Evidently,location of this vortex is stationary and only its dimensions and pattern change.

There is well traced the coastal stream of the Labrador Current penetrating in the area of the Green and St.Pierre banks along the coast of the Avalon Peninsula (Fig.4). To the south of the Green Bank these waters meet with the Labrador Current waters skirting the Grand Bank from the east and south and mix with them. Then the Labrador waters move along the shelf to the south-west originating so called slope waters. The horizontal circulation in Divisions 3N-3P and 4V,i.e.to the south of Newfoundland,in both cases of observations - in March-April 1971 and December 1971-January 1972 - was almost analogous and only in the last case velocities of the current were greater.

Circulation of waters on the Flemish Cape Bank in spring 1971 was unusual (Fig.3) : instead of common movement of waters clockwise in both surveys in spring 1971 there was observed movement of waters the other way.

Change in Water Transport of the Labrador Current

Transport of the Labrador Current on standard hydrological sections was calculated by the dynamic method. Value of anomalies of transports on the day of observations was determined on the basis of long term mean curve of an annual course of transports on a section.

Division 2J. In this division there is located Section 8-A coinciding with the section of the Southern Wolf Islands-Cape Farewell of the International Ice Patrol (Bull. U.S. Cst.Guard, 1959). Given in this Bulletin the curve of the annual course transports drawn by the American investigators on the basis of observations made by the Ice Patrol covers only the period from the middle of July to August (Fig.5 ABC,Curve 1P). On the basis of observations made by PINRO since 1959 to 1971 (25 cases) we've calculated transports on Section 8-A in the area from 53°43'N to 55°12'N (ABC). As before 1969 these observations were carried out up to depths of 500-800-1000 m, in plot C on Section 8-A the average distribution of the total transport in the 0-1000 m layer was calculated by single layers in per cents. It was proved that in the 500-600 m layer there is found 7%, in the 600-800 m layer 11% and in the 800-1000 m layer 5% of the total transport in the 0-1000 m layer. With the help of these corrections all the calculations of the transport were given for the depth of 1000 m. On the other hand, values of transports estimated by data collected by the Ice Patrol were also given to the 1000 m depth according to the correlation graph between transports in the 0-2000 m and 0-1000 m layers ($n=9, R=0.966 \pm 0.015$). Thus, in some expeditions there was eliminated heterogeneity of values of transports at the cost of different depth on the section. Results of calculations are given in Fig.5. As it is evident from the figure, an amplitude of average seasonal changes in the transport of waters in the Labrador Current in Division 2J increases from the coast towards great depths (from part A to C) and the greatest fluctuations are common to the Current as a whole (part ABC).

Calculations made enabled to make precise a form of the long term curve of a seasonal course of transports of the Labrador Current from June to December (Fig.5). As it is evident from the figure, new data do not confirm the curve of transports for June-August obtained before by the American investigators. Probably, from January to June there is observed a decrease of transports. However, no evidence for it for the present.

The interannual changes in transports in some months are great and are always exceed a value of the average seasonal changes of transports for the second half of the year. Curves of seasonal changes of transports in some years can have both the positive and negative trends and due to this anomalies of transports quickly change their value and sign. In 1971 observations on Section 8-A were carried out twice (Table 2). It should be noted that the new verified curve of annual course of transports used as "normal" leads to the fact that the standards and anomalies of transports on Section 8-A given in this paper are not comparable with the standards and anomalies presented in the previous papers (Bull. U.S.Cst.Guard, 1956-1964; Kudlo, B.P. and V.V.Burmakin 1972).

Calculations show that intensity of the Labrador Current on Section 8-A (Division 2J) was in July 1971 close to the minimum according to long term data. By November 1971 intensity of the Current sharply increased and a positive anomaly of transports reached 1.3 mill.m^3/c. Evidently, an intensive influx of cold Labrador waters into the Newfoundland area since the second half of 1971 favoured the severe ice conditions in this area in winter 1971-1972.

Division 3L. Passing Section 8-A the Labrador Current moves along the shelf to the south-east and its main branch skirting clockwise the Grand Bank flows into the channel between the Bank mentined and Flemish Cape Bank. This branch of the current is crossed by Section 6-A in 47°00'N. To calculate anomalies of transports we (Kudlo, B.P. and V.V. Burmakin 1972) used as before the "normal" curve of an annual course of transports on section F in 46°50'N (Bull. U.S.Cst.Guard, 1963).

Observations made in 1971-1972 show (Table 2) that in the second half of 1971 intensity of the Labrador Current in the Flemish Cape channel was slakened but by April 1972 it reached the normal. In May 1972, the transport proved to be considerably higher the normal, at the level of maximum values obtained in the period of observations available. Thus, as on the Hamilton Bank but only with some delay the strengthening of the Labrador Current was found in the Flemish Cape Channel in winter and spring 1972.

Division 3N. To construct the long term mean curve of an annual transports of the Labrador Current on Section 3-A were used : a) data on transports of water on Section U along the parallel of 44°50'N for 1955-1963 (Bull. U.S.Cst.Guard, 1956-1964); b) data on transports on Section 3-A within the area from 45°00'N, 49°10'W to 44°50'N, 48°30'W up to the maximum depth of observations for 1959-1972.

Sections U and 3-A are located side by side, at a little angle, and this makes it possible to combine without any error the American and our calculations of transports and to construct the "normal" curve for the whole year (Fig.6). For April-June the curve didn't almost change, for the rest month a preliminary curve was drawn (dashed line).

As Figure 2 shows, the Labrador Current was more intensive in the second half of 1971. In April 1972, small negative anomalies of transports were observed and in mid-May intensity of the Labrador Current on the south-eastern slope of the Grand Bank sharply increased.

In other words seasonal changes in transports of the Labrador Current on the Grand Bank were in April-May 1972 sharply opposite to long term mean changes.

Conclusions

1. Circulation of water in the Davis Strait in October-November 1971 may be attributed to the type which is characterized by increased intensity. Such a type of circulation was observed in autumn 1962 and 1969. Residual water exchange in the Strait was directed into the Baffin Sea and amounted to $0.99 \cdot 10^6 m^3/c$.

2. In 1971-1972 an anticyclonic vortex of waters was observed above southern slopes of the Grand Bank. Evidently,its location is stationary,only dimensions and a pattern change.

3. According to long term data the new average curves of an annual course of transports were obtained for Sections 8-A and 3-A.

4. Transport of water of the Labrador Current in some its parts in the area of the Grand Bank and South Labrador was increased or close to the normal late in 1971, and in spring 1972 great positive anomalies of transports were observed. This probably resulted in decreasing of water salinity and its temperature and also in originating severe ice conditions in the area investigated in spring and summer 1972.

References

Alekseev,A.P.,Kudlo B.P. et al. 1972. Some aspects of water circulation in the Northwest Atlantic in 1960-1969. ICNAF,Spec.Publ.,No.8.

Zubov,N.N. and O.I.Mamayev. 1956. Dynamical method of calculations of elements of sea currents. Gidrometizdat,Leningrad.

Kudlo,B.P. and V.V.Burmakin. 1972. Water Circulation in the South Labrador and Newfoundland areas in 1970-1971. ICNAF,Redbook 1972,Part III.

Solyankin, E.B. 1965. On the water balance of the Polar Sea (water exchange between the Atlantic and Pacific). Trudy VNIRO, vol. 57, Moskva.

U.S. Coast Guard. 1956-1964. Bull. U.S. Cst. Guard, No. 41-49, Washington.

Table 1. Residual water exchange on Section 9-A across the Davis Strait in different years ($10^6 m^3/c$).

Vessel, cruise	Date of observations	Residual water exchange
"Topseda", cruise 58	13-15. IX-1962	-2,47
"Novorossiisk", cruise 22	16-18. IX-1967	-1,18
"Perseus III", cruise 7	25-26. X-1971	0,99

Note: sign "+" means water transport to the north, sign "-" means to the south.

Table 2. Transport of the Labrador Current and its anomalies on standard sections in 1971-1972, in mill. m^3/c.

Sections, its sectors and layers	Date of observations	Transport		
		Observed	Normal	Anomaly
8-A, ABC	29-30 July, 1971	2,50	4,4	-1,9
0-1000 m	08-09 November, 1971	6,50	5,0	+1,5
5-A; L_4GN_2	24-25 May, 1971	1,67	3,2	-1,5
0-bottom	14-15 December, 1971	1,13	2,5	-1,4
	10 April, 1972	3,03	3,0	0,0
	01-02 May, 1972	6,33	3,1	+3,2
	25-26 May, 1972	5,90	3,2	+2,7
3-A	15-16 May, 1971	3,72	4,2	-0,5
0-2000 m	[illegible], 1971	6,20	3,0	+3,2
	24-25 December, 1971	6,80	6,8	0,0
	18-19 April, 1972	3,99	5,0	-1,0
	22-23 April, 1972	4,14	4,9	-0,8
	16-17 May, 1972	8,64	4,2	+4,4

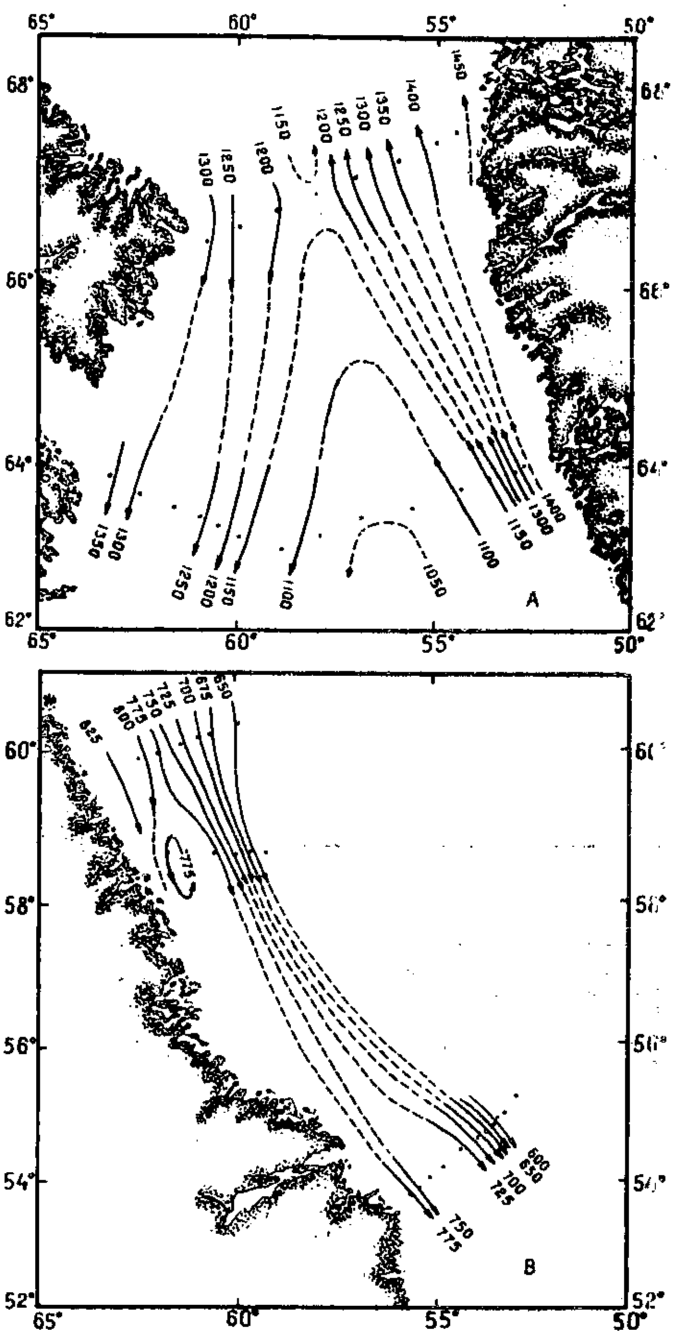

Fig. 1. Dynamic charts by data of the 7th cruise of the research-scouting vessel *Perseus III*.
A - Davis Strait, 0-500 decibar, 25 October - 21 November 1971;
B - Labrador area, 0-200 decibar, 8 November - 7 December 1971.

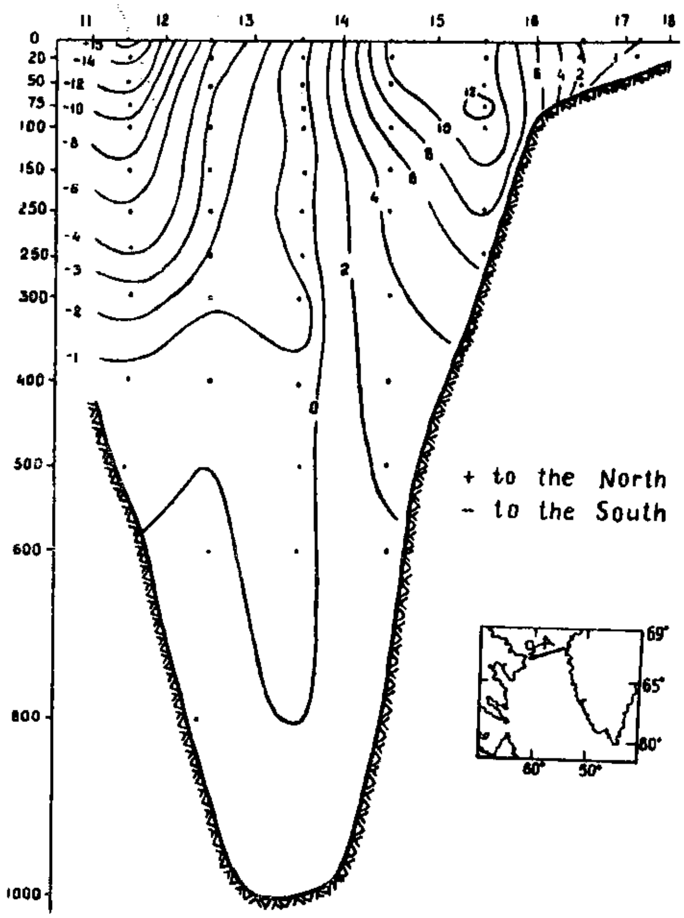

Fig. 2. Isotachs (dynamic method, cm/c) on Section 9-A across the Davis Strait according to data of the 7th cruise of the research-scouting vessel *Perseus III*, 25-26 October 1971.

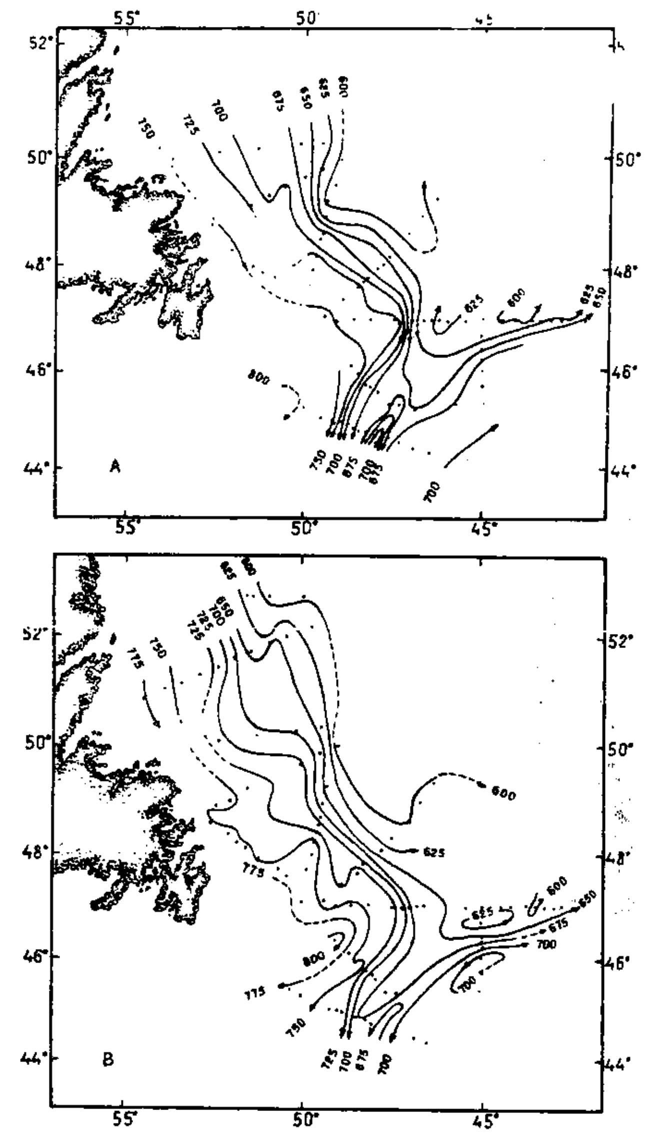

Fig. 3. Dynamic charts, 0-200 decibar, according to data of the 6th cruise of the R/V *Protsion*. A - first survey, 19 April-11 May 1971; B - second survey, 15 May-9 June 1971.

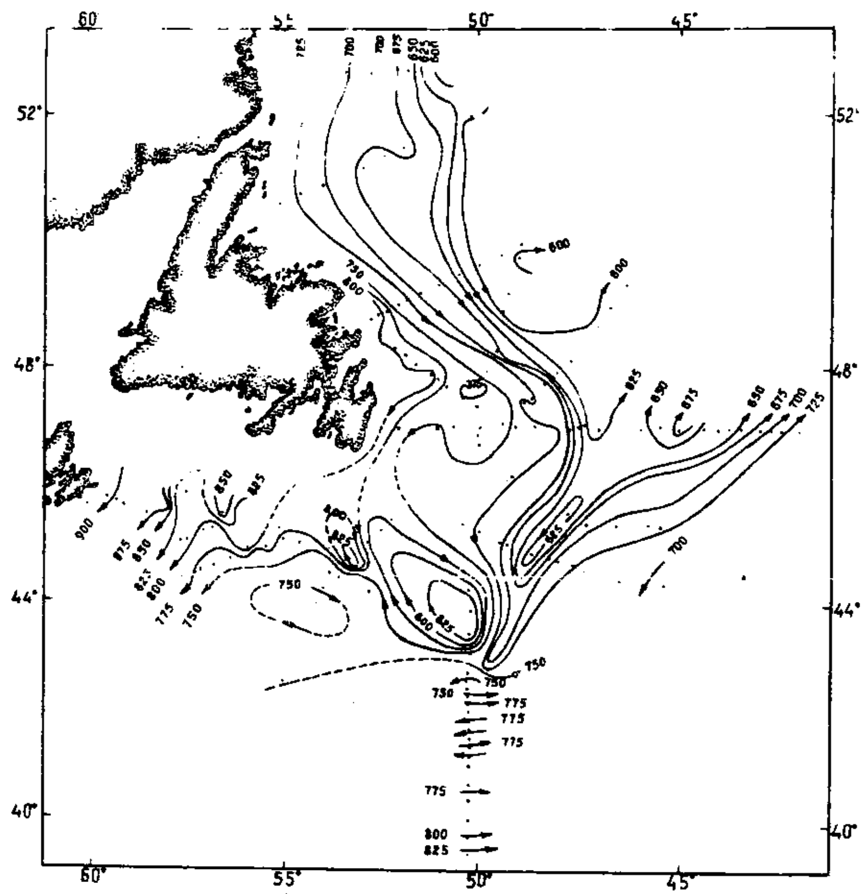

Fig. 4. Dynamic chart, 0-200 decibar, according to date of the 7th cruise of the R/V *Protsion*, 23 November 1971-11 February 1972.

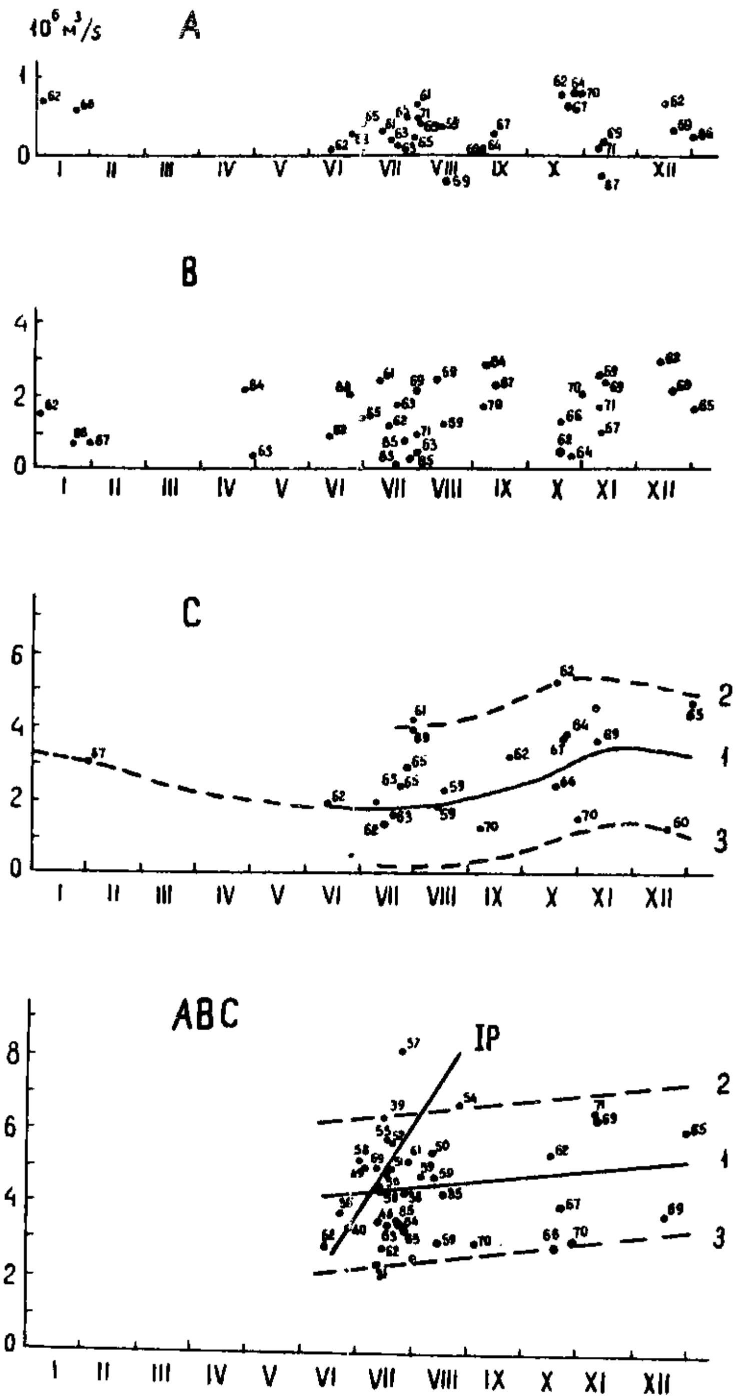

Fig. 5. Annual course of average (1) and extreme (2, 3) values of water transport of the Labrador Current on Section 8-A across Hamilton Bank in the 0-1,000-m layer according to long-term data.
A, B and C - transport of some streams of the Current;
ABC - transport of the whole stream;
IP - curve of the transport according to date of the Ice Patrol in the 0-bottom layer.

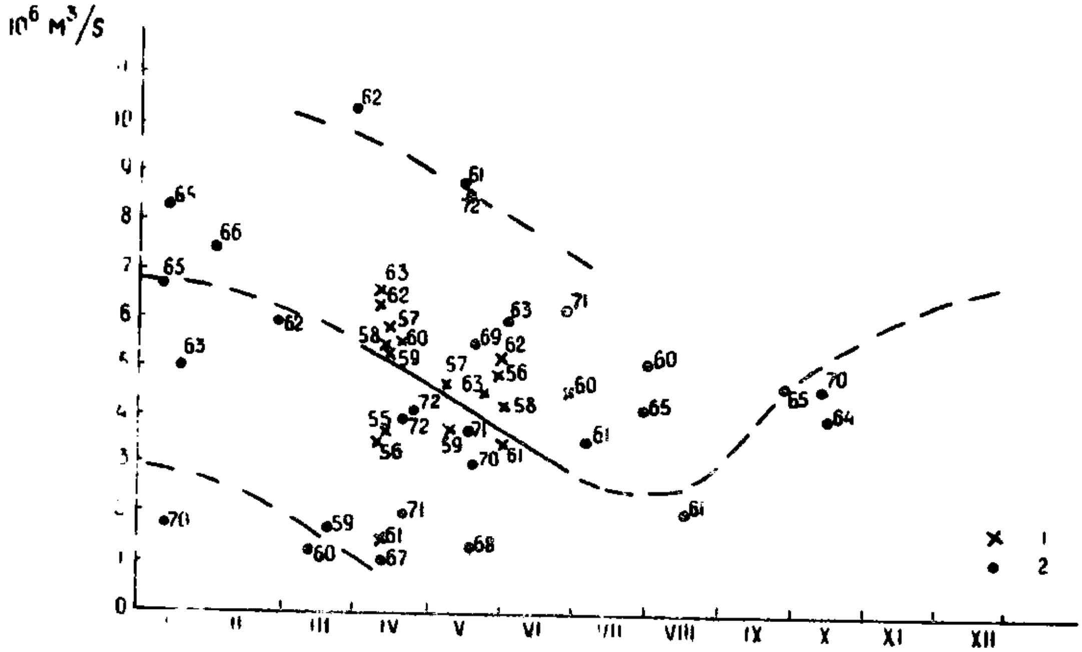

Fig. 6. Annual curve of average values of the water transport of the Labrador Current on Section 3-A (U) across the southeastern slope of the Grand Newfoundland Bank according to long-term data of the Ice Patrol (1) and PINRO (2).