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# Water Circulation in the Baffin Land, Labrador, Newfoundland and Flemish Cap Areas in 1980

by

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## Introduction

During a long period of time the PINRO scientists have been investigating water circulation in the surface layer of the vast area ajacent to the Baffin Land, Labrador and Newfoundland. These investigations purpose a) to study ichthyoplankton drift, b) to find out year-to-year variations in directions of its transport and c) to determine conditions of formation of commercial fish generations strength. These investigations conducted within the framework of international collaboration were continued in 1980 as well, their basic results are presented below.

## Material and methods

Materials of observations on water temperature and salinity, collected by the PINRO vessels during 3 cruises, served as the initial information for diagnostic calculations of circulation (Table I).

Table I

Information on oceanographic surveys in areas of the Northwest Atlantic in 1980

| Vessel, cruise No. | Observation period | Number of stations with measurements of T, S |
|---|---|---|
| "N.Kononov", 2nd cruise | 23 April – 1 August | 344 |
| "Protsion", 20th cruise | 19 March – 11 July | 263 |
| "Protsion", 21 cruise | 31 July – 9 November | 409 |
| | | Total 1016 |

These data were processed by the dynamic method (Zubov and Mamayev, 1956); dynamic heights, currents velocities and water volume transport were calculated by the "Minsk-32" computer. The generalized results of calculations are presented on charts of dynamic topography of water surface which were drawn relatively to the 200 dbars level, and also in tables on the Labrador Current volume transport and water salinity.

Results and discussions

Large-scale horizontal circulation of surface waters in the investigated area of the Northwest Atlantic is formed by a system of quasi-stationary currents (Labrador and North Atlantic Currents) which during the survey period of 1980 (Figs 1-4) determined stable general southward water transport over the shelf and continental slope in the Labrador and Newfoundland areas and also northeastward transport to the areas southward of the Flemish Cap Bank. The Labrador Current volume transport in its different parts exceeded the corresponding values for the preceding years; in areas of the Grand Bank southeastern slope (Section 4-A and CG-3) the current intensity in spring-summer periods of observations exceeded long-term norms (Table 2). An increase of volume transport of the Current which carries less salted Arctic waters was, as a rule, accompanied in areas of the Grand Bank southeastern slope by a decrease of salinity values and occurence of its negative anomalies (Table 3). A negative relation between variations of volume transport and water salinity is traced also on the 8-A Section (Hamilton Bank area), where in the periods of observations (autumn of 1979 and 1980) it was indicated that negative anomalies of the Labrador Current volume transport were combined with positive anomalies of salinity.

Reverting to the charts on figures 1-4 we may note that water transport over the continental slope, i.e. in the Labrador Current deep stream localization zone, had the most stable direction. Outside this zone regulated large-scale water transports were disturbed by numerous and various dynamic formations of a less spatial scale. The most significant in this aspect is the chart presented on Fig. 1 which testifies to the existance of a complex system of local meanders and vortices in the Labrador, Newfoundland and Flemish Cap shelf areas in spring-summer. On the other charts (Figures 2-4) the corresponding parts of circulation fields are smoothed because of less detailed surveys in the Labrador and Newfoundland areas and show only some features of vortical activity.

Vorticity of local streams in the Labrador and Newfoundland shelfy zones is not specific for water circulation in 1980; the materials of numerous oceanographic surveys for the previous years indicate meandering and vortices formation in these areas (Kudlo and Burmakin, 1972; Kudlo, 1973,1975; Kudlo and Borovkov, 1975,1979; Kudlo et al.,1976, 1980; Kudlo and Boytsov, 1977,1978). Thus, there are grounds to state that mesoscale vortices and meanders are characteristic for the structure of water circulation in the Labrador and Newfoundland areas. From the ecologic point of view the system of these dynamic formations may be considered as a mechanism which provides plankton settling in the shelf boundaries and by this gives the possibility for commercial fishes larvae and juveniles to use effectively the rich nutritive base of this area. On the other

hand, due to meanders and vortices the passive transport of hydrocoles in the direction of general translation is retarded or even ceased, i.e. preservation of ichthyoplankton and juvenile fish in their area of dwelling is provided and, therefore, stability of populations proper is also secured. Non-mobile anticyclonic vortices serve as the ideal cells which keep ichthyoplankton from being carried away into areas with unfavourable conditions for development and dwelling. Functioning of these hydrodynamic traps is connected with the convergence of streams towards the vortices axis which conditions the passive hydrocoles concentration in the central parts of these dynamic formations. This effect was traced on the examples of juvenile capelin distribution in the Grand Bank southern part (Borovkov and Kovalev, 1976), larval cod and redfish on the Flemish Cap Bank (Serebryakov, 1978; Anderson and Akenhead, 1980) and during the 21st cruise of R/V "Protsion" (autumn 1980) this effect was marked in the area of anticyclone localized over the shelf of the Labrador peninsula northern part (Fig. 4).

Considering the influence which the mesoscale water circulation exerts on commercial fish reproductivity the Polar Institute arranged in 1980 in the framework of international collaboration a series of detailed oceanographic surveys in the Flemish Cap area. According to the results of these surveys (Fig. 5) during spring-summer period of 1980 the dominating form of water circulation over the Bank were non-stationary meanders. Only in early May there occured an anticyclonic vortex over the top of the Bank which was weakly developed during summer and was displacing towards the northwestern slopes. Such a long absence of an anicyclone over the Bank (like that observed in spring of 1980) was marked for the first time during 3 years of carring out the series of detailed spring-summer surveys. In this connection the peculiarities of abiotic and biotic surroundings in the Flemish Cap area in 1980 are worth of great attention and they may be a touchstone in relation to the hypothesis on leading role of water circulation in forming of strength of year-classes of fish that dwell on the Bank. In accordance with this hypothesis it follows that the circulation unstability, sharp changes of currents directions in the default of anticyclone results in carring of a considerable mass of ichthyoplankton away from the Bank and, therefore, in lessening of fish generation strength. This effect in specific conditions of 1980 may be estimated, in particular, using the prognosis for cod year-class yield, which permits to consider the year-class of 1980 to be very poor (mean catch of juvenile cod at age 2+ per hour trawling by fish-counting trawl is expected to bring less than 1 specimen). This prognosis was created using the method by Kudlo and Boytsov (1979).

Conclusions

The structure of horizontal water circulation in the Labrador and Newfoundland areas is characterized by a combination of elements of a large-scale system of water transport (Labrador and North-Atlantic Currents) with mesoscale dynamic formations - meanders and vortices. Proceeding from the vortical structure of shelfy waters we may explain reasonably the ichthyoplankton distribution and stability of commercial fish populations.

In spring-summer period of I980 the non-stationary meanders were dominant over the Flemish Cap Bank. In these conditions a considerable mass of ichthyoplankton could have been carried out of the Bank boundaries and lost irretrievably for the local fish populations. In this connection it is expected, particularly, that the I980 year-class of cod would be a very poor recruitment for commercial stock of the Flemish Cap Bank cod.

REFERENCES

Anderson, J.T. and S.A.Akenhead. MS I980. Distribution and abundance of Larval Cod and Redfish on Flemish Cap in I978 and I979. NAFO SCR Doc. 80/IX/I50, Ser.No. N226, I8 p.

Borovkov, V.A., Kovalev S.M., I976. Some data on hydrologic conditions in the Grand Newfoundland Bank area in the period of capelin spawn. "Trudy PINRO", vyp. 37: 6I-68.

Kudlo, B.P. and V.V.Burmakin, I972. Water circulation in the South Labrador and Newfoundland areas in I970-I97I. ICNAF Redbook, Part III: II-I8.

Kudlo, B.P. MS I973. Water circulation in the ICNAF area in I97I-72. ICNAF Res. Doc. No.42, Ser. No.298I, I2 p.

Kudlo, B.P., I975. Circulation of Waters in the ICNAF Area in April-June I972 and I973. ICNAF Spec. Publ., No.I0: 69-73.

Kudlo, B.P. and Borovkov V.A. MS I975. Circulation of waters in the ICNAF area in I973-I974. ICNAF Res. Doc. 75/79, Ser.No.3506, I2 p.

Kudlo, B.P., Borovkov V.A. and V.D.Boytsov. MS I976. Circulation and salinity of waters in the Davis Strait, South Labrador and Newfoundland areas in I974-75. ICNAF Summ. Doc. No.76/VI/70, Ser. No.3874, I4 p.

Kudlo, B.P. and V.D.Boytsov. MS I977. Circulation and salinity of waters in the South Labrador and Newfoundland areas in I975-76. ICNAF Res.Doc. 77/VI/36, Ser.No.506I, 8 p.

Kudlo, B.P. and V.D.Boytsov. MS I978. Dynamics and salinity of waters in the Newfoundland area in I976-77. ICNAF Res.Doc. 78/VI/7I, Ser.No.5242, 6 p.

Kudlo, B.P. and V.A.Borovkov. MS 1979. Geostrophic circulation and salinity of waters in the Labrador and Newfoundland areas in 1977-78. ICNAF Res.Doc. 79/VI/107, Ser.No.5472, 9 p.

Kudlo, B.P. and V.D.Boytsov, 1979. The effect of water dynamics on year-class strength of cod on Flemish Cap. ICNAF Sel.Papers, No.5, pp.7-9.

Kudlo, B.P., V.V.Burmakin and V.S.Sterkhov, 1980. Geostrophic circulation of Northwest Atlantic waters from David Strait to Newfoundland. Generalized from 1962 to 1978 data. ICNAF Sel.Papers, No.6: 53-54.

Serebryakov, V.P. MS 1978. Ichthyoplankton from the Flemish Cap Bank. ICNAF Res.Doc.78/VI/18,Ser.No.5172, 9 p.

Zubov, N.N. and O.I.Mamayev.1956. The dynamic method of calculation elements of sea currents. Gidrometizdat, Leningrad, 115 p.

Table 2

Labrader Current volume transports, their norms and anomalies on standard sections in I979-I980, millions of cu m · C $^{-I}$

| Section, layer, part | Vessel, cruise | Data of observation | Volume transport | | |
|---|---|---|---|---|---|
| | | | observed | norm | anomaly |
| 8-A, 0-2000 m, ABC | "Suley", 3 cruise | I-2 November I979 | I.8 | 5.0 | -3.2 |
| " - " | "Pretsion",2I cruise | 2-3 November I980 | 3.9 | 5.0 | -I.I |
| Flemish Cap, 0-bottom, $H_IGH_2$ | "Gemma", I7 cruise | 27-29 May I979 | I.6 | 3.2 | -I.6 |
| " - " $GH_2$ | "Pretsion", 20 cruise | 5 May I980 | 3.6 | - | - |
| " - " $H_IGH_2$ | "Pretsion", 2I cruise | 29 Aug. - I Sept.I980 | 2.2 | 3.6 | -I.4 |
| " - " $H_IGH_2$ | "Pretsion", 2I cruise | I8-22 October I980 | 3.3 | 3.7 | -0.4 |
| 4-A, 0-I000 m, I-I2 st. | "Gemma", I7 cruise | 26-28 April I979 | 3.8 | 4.5 | -0.7 |
| " - " | "Pretsion", 20 cruise | I6-I8 May I980 | 4.5 | 4.I | 0.4 |
| " - " | "Pretsion", 2I cruise | 22-23 August I980 | 5.I | 2.2 | 2.9 |
| CG-3, 0-2000 m, II-I4 st. | "Gemma", I7 cruise | 24-25 April I979 | I.4 | 4.8 | -3.4 |
| " - " | "Pretsion", 20 cruise | I5-I6 May I980 | 5.9 | 4.2 | I.7 |
| " - " | "Pretsion", 2I cruise | 2I August I980 | 5.3 | 2.8 | 2.5 |

Table 3

Mean salinity of the Labrador Current waters in the layer 0–200 m, its norms and anomalies on standard sections in 1979–1980, ‰

| Section, part | Vessel, cruise | Data of observations | Salinity | | |
|---|---|---|---|---|---|
| | | | observed | norm | anomaly |
| 8–A, B | "Suloy", 3 cruise | I November 1979 | 33.6I | 33.56 | 0.05 |
| –"– | "Protsion", 2I cruise | 2–3 November 1980 | 33.69 | 33.56 | 0.I3 |
| Flemish Cap, G | "Gemma", I7 cruise | 29 May 1979 | 33.95 | 33.78 | 0.I7 |
| –"– | "Protsion", 20 cruise | 5 May 1980 | 33.96 | 33.79 | 0.I7 |
| –"– | "Protsion", 2I cruise | 29 August 1980 | 33.48 | 33.68 | –0.20 |
| –"– | "Protsion", 2I cruise | 2I–22 October 1980 | 34.05 | 33.86 | 0.I9 |
| 4–A, 6–I2 st. | "Gemma", I7 cruise | 27–28 April 1979 | 34.02 | 34.08 | –0.06 |
| –"– | "Protsion", 20 cruise | I7–I8 May 1980 | 33.88 | 34.04 | –0.I6 |
| –"– | "Protsion", 2I cruise | 22–23 August 1980 | 33.76 | 34.00 | –0.24 |
| CG–3, I2–I4 st. | "Gemma", I7 cruise | 24–25 April 1979 | 33.50 | 33.83 | –0.33 |
| –"– | "Protsion", 20 cruise | 25 May 1980 | 33.94 | 33.7I | 0.23 |
| –"– | "Protsion", 2I cruise | 2I August 1980 | 33.62 | 33.77 | – 0.I5 |

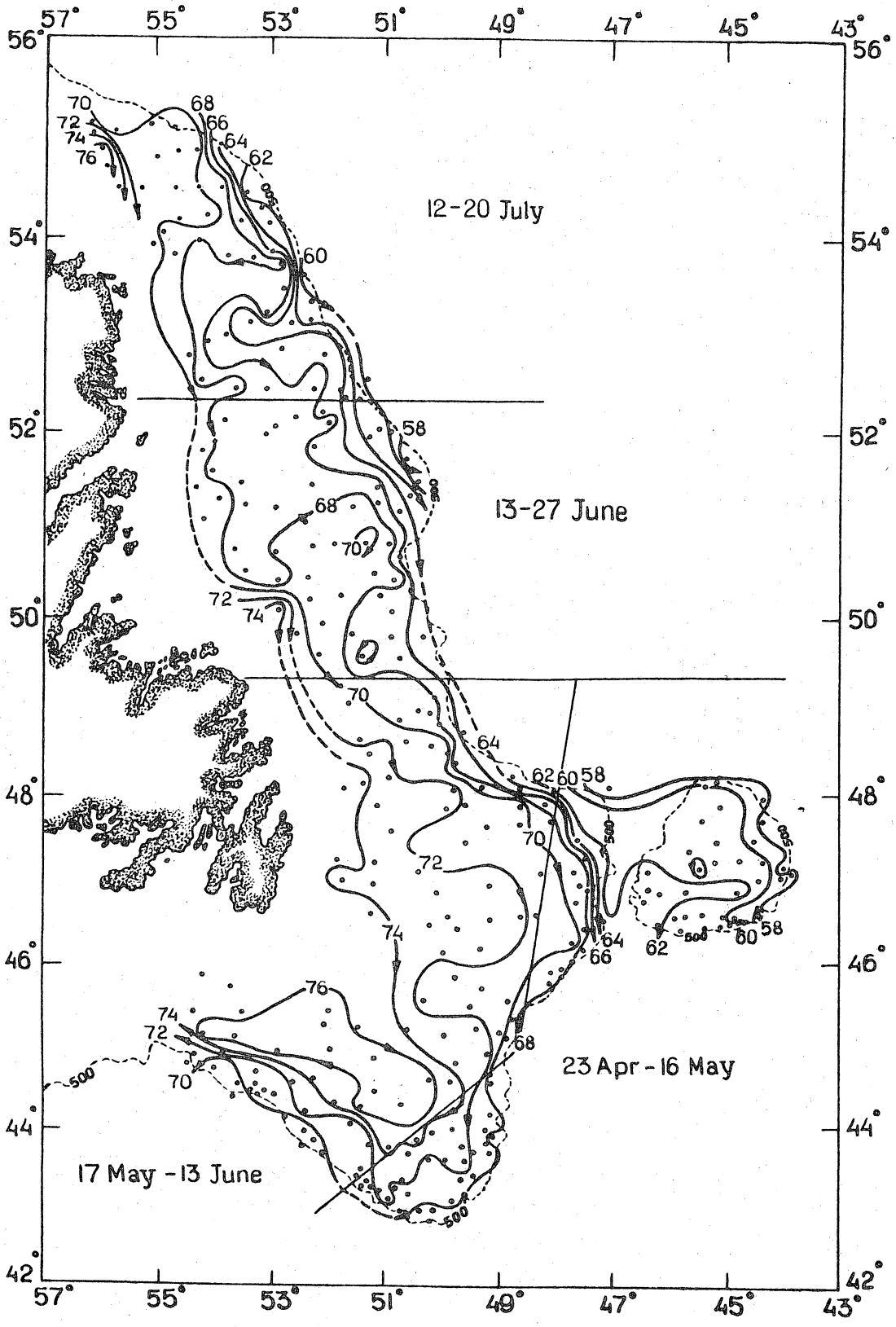


Fig.I. Dynamic topography (dynamic centimeters) of sea surface relatively to 200 dbar level in April-July 1980. R/V/ "N.Kononov" 2 cruise. Observation data for some areas are shown on the figure.

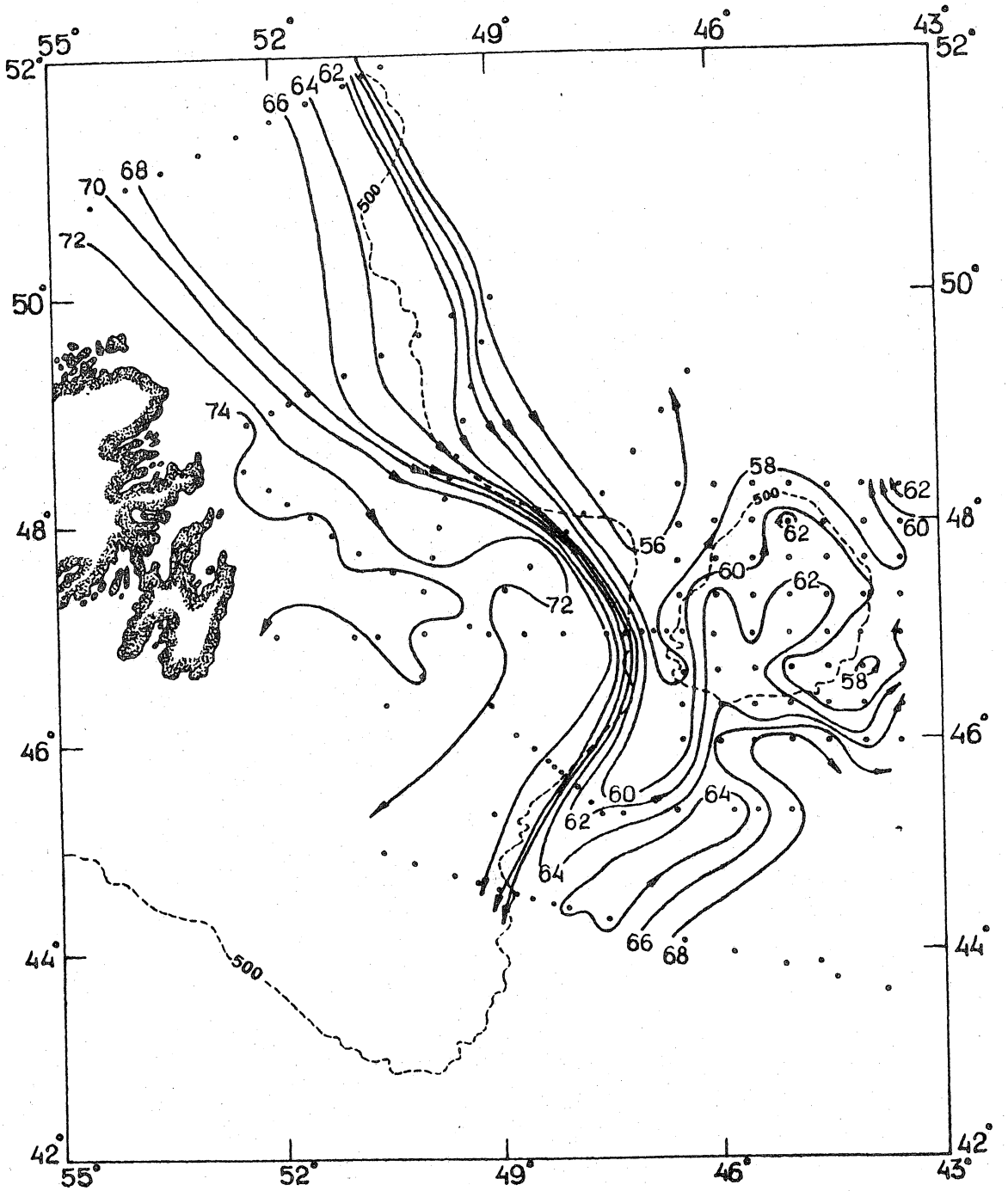


Fig.2. Dynamic topography (dynamic centimeters) of sea surface relatively to 200 dbar level in the period I3 May-II June I980. R/V "Pretsion" 20 cruise data.

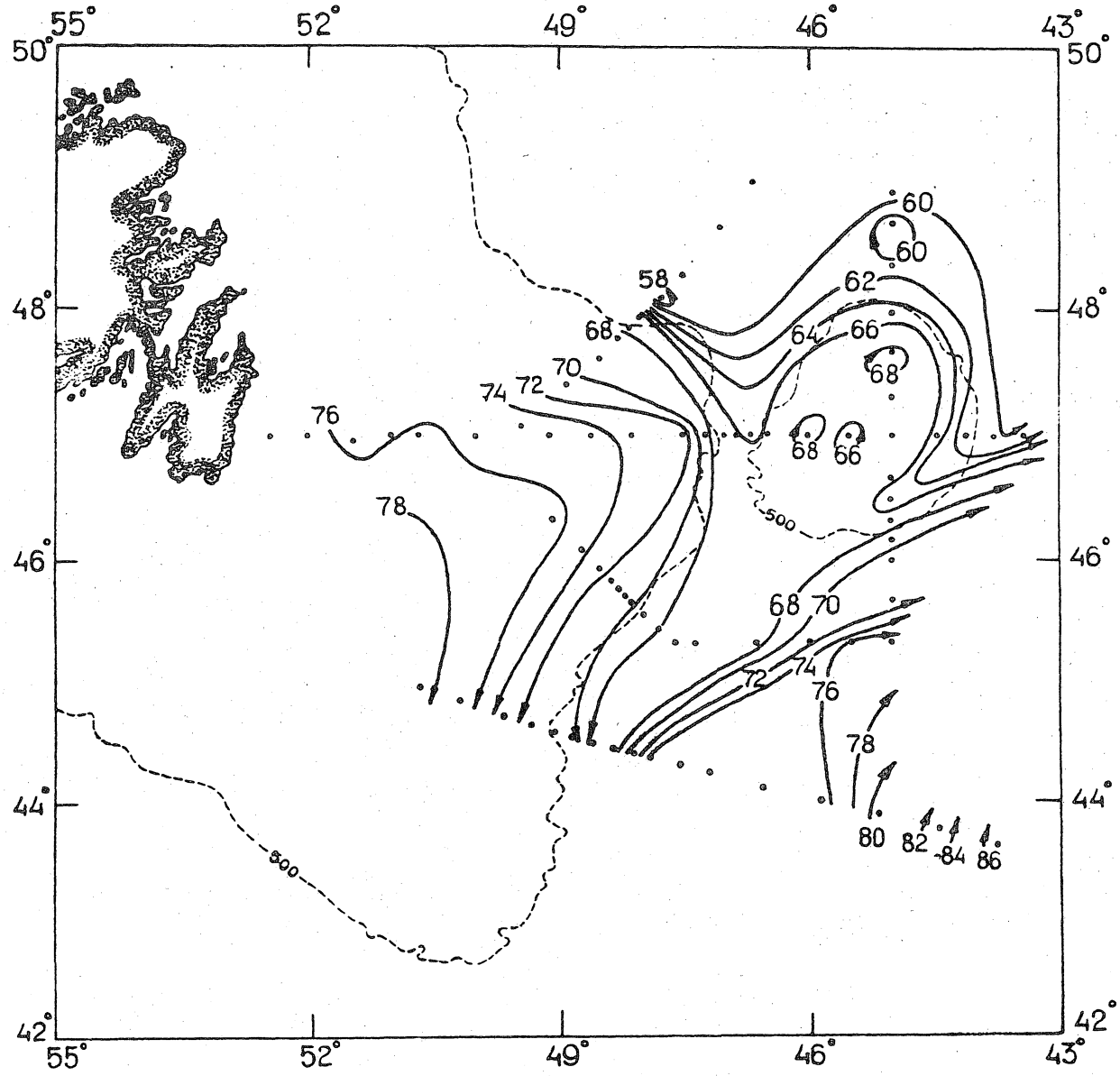


Fig.3. Dynamic topography (dynamic centimeters) of sea surface relatively to 200 dbar laval in the period I8 August-2 September I980. R/V "Protsion" 2I cruise data.

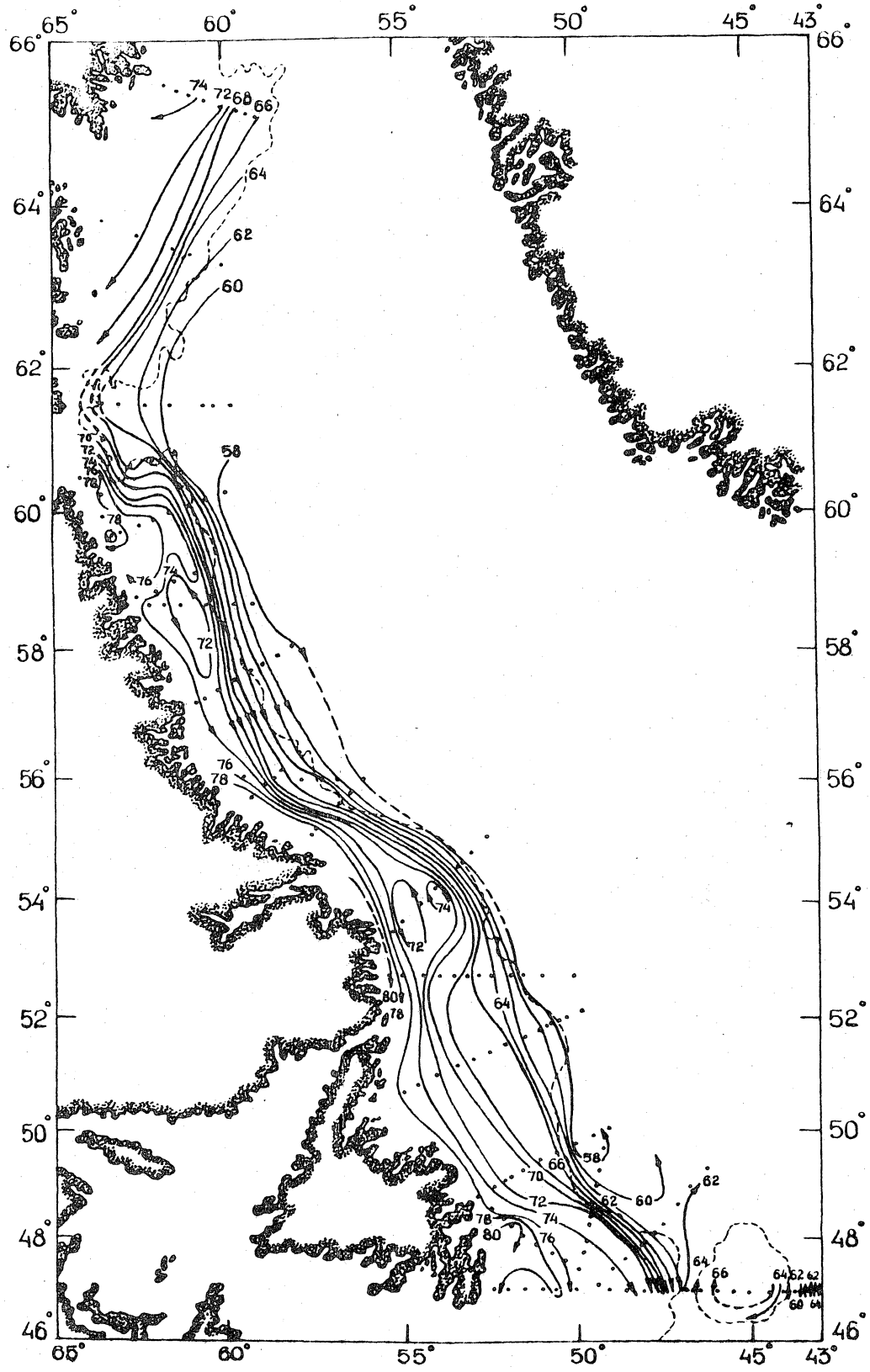


Fig 4. Dynamic topography (dynamic centimeters) of sea surface relatively to 200 dbar level in the period I3 September–23 October I980. R/V "Protsion" 2I cruise data.

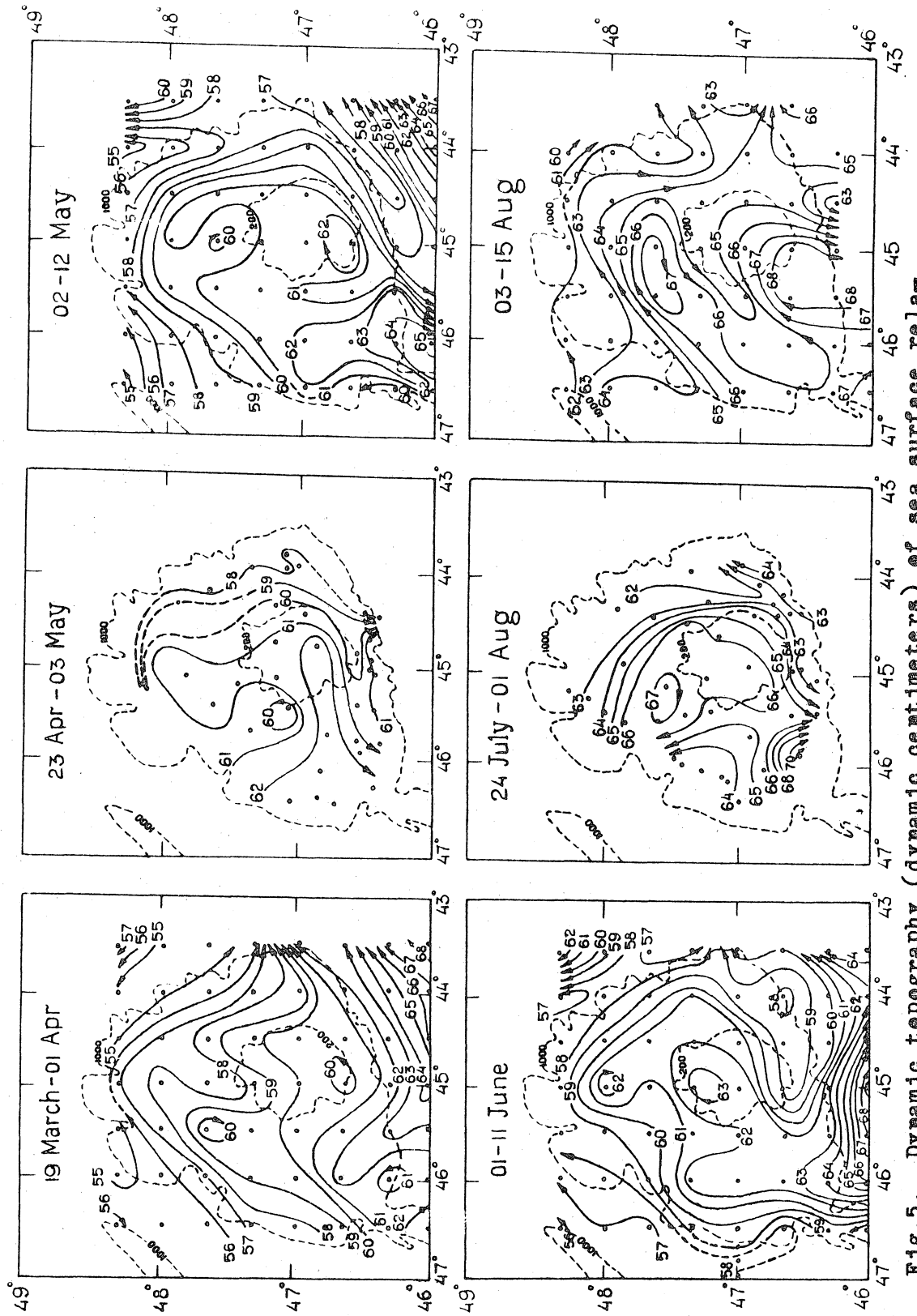


Fig.5. Dynamic topography (dynamic centimeters) of sea surface relatively to 200 dbar level in the Flemish Cap area in spring-summer 1980. R/V "N.Komonov" 2 cruise and R/V "Protsion" 20 and 21 cruises data.