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On the Norwegian Current Structure
(according to observations in June 1972-1974)

by V.V.Rossov x)

Abstract

The paper contains review of the available schemes of currents of the Norwegian and Greenland Seas. On the basis of the analysis of temperature,salinity and some dynamic calculations it is shown that at least in the summer period the Norwegian Current should be more properly classified as a meandring stream rather than a "branchy" one. Stability of the sinking zones in the areas of anticyclonic curvature of large meanders and possibility of use of the depth of surface with a temperature of 0° to reveal the water exchange directivity between the Norwegian Sea and North Atlantic is noted.

Introduction

The scheme of the surface currents of the Norwegian and Greenland Seas (Fig.1a) suggested by Helland-Hansen (1909) up till now is recognized by a number of scientists (Metcalf,1960;

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x) PINRO,Murmansk,USSR

Stefansson,1962) as close to reality.

Schemes of currents calculated by the dynamic method by V.A. Berezkin (1939) and V.T.Timofeev (1944) corroborated,in principle, the scheme suggested by Helland-Hansen and Nansen.

Along with the scheme by Helland-Hansen and Nansen a wide application,especially in the USSR,was gained by the scheme suggested by A.P.Alekseev and B.V.Istoshin (1956) - Fig.1b. These authors, in contrast to their predecessors,came to the conclusion that the Norwegian Current spreads not in an unbroken stream,but is divided in a series of branches.

According to either general scheme, the main influx of the Atlantic waters into the Norwegian Sea occurs through the Faroe-Shetland Channel,and only a small amount of them penetrate to the east over the Faroe-Shetland Ridge and then return into the Faroe-Shetland Channel again.

Some improvements into the Alekseev-Istoshin scheme were made by V.G.Kolesnikov (1964) : according to his dynamic calculations a greater eddying of currents is registered in the western Norwegian Sea.

The scheme of currents constructed by the dynamic method by I.P. Karpova (1970),in our opinion,is closer to the conception of Helland-Hansen and Nansen rather than to views of Alekseev and Istoshin.

The most volumenous initial material (for 13 years of observations) was used by A.I.Tantsura (1970) for construction of the scheme of the surface currents of the Norwegian Sea. The author brought dynamic calculations into coincidence with the results of navigation and electromagnetic measurements of currents. The main features of the scheme constructed by him - "branchness" of the Norwegian Current and eddying of streams - are similar to the scheme by Alekseev and Istoshin.

In summary, up till now there are no unified poit of view on the Norwegian Current structure. In our opinion, differences in views are primarily responsible for methodical errors, which show up individually with each investigator.

The role of methodical errors and subjectivity is convincingly shown in papers by Defant (1950), Fuglister (1955) and G.N.Zaitsev (1959). Tha latter having excluded the influence of the diurnal tide wave, obtained rather a simple dynamic chart of the Norwegian Sea currents.

The aim of the present paper is to show the possibility of other interpretation of the data of observations and replacement of "branchness" of the Norwegian Current with its meandering.

Material and method

Distribution of temperature and salinity at standard depths were analysed for 1972-74 according to data obtained during June surveys (which are most complete by the number of stations). Therefore, results of investigations and conclusions refer only to the summer period. Data of observations on 700 hydrological stations were used. Velocities were calculated by the dynamic method by separate sections (calculations were made by V.Podolsky).

Results

Fuglister (1954) and a number of other authors pointed to the basic similarity of temperature distribution at a depth of 200 m with the scheme of currents in the surface layer. Distribution of the meridional component of the surface current (V_o) calculated by the dynamic method under the assumption that the depth of the reference surface coincides with the position of 0° isotherm and values of horizontal gradient of water temperature ($\partial t/\partial x$) at a depth of 200 m on the section along 67°30'N in June 1974 are presented in Fig.2. Attention is drawn to the fact that there is a good agreement between $\partial t / \partial x$ and V_o between 2°W and 8°E, that confirms Fuglister's point of view. It is characteristic that the area of agreement is accounted for by the zone of considerable gradients of temperature, while discrepancies between $\partial t / \partial x$ and V_o, even in their directivity, are mainly observed in the zone of small sizes of $\partial t / \partial x$ (by the absolute value) where a more frequent network of observations is apparently necessary for a more precise definition of V_o.

Four main peaks of V_o, between which the sign of V_o is changed into the opposite one, suggest, if not go in detail, of the existence of four branches or streams of currents, between which there are counter-currents. However, charts of isotherms at a depth of 200 m (Fig.3) makes it possible to give another interpretation of the reason of origin of these peaks on the section along 67°30'N. Thickenning of isotherms between 8° and 7°W and between 6° and 5°W corresponds to the first two peaks of velocity, direction of the velocity vectors between which doesn't change into opposite one (general directivity of isotherms doesn't change there either) Between 4 and 2°W isotherms (or stream line as a first approximation) are directed to the south-west, therefore a negative component of the current originates as well. This is not a counter--current but a part of the same current which is meandering, and the peak of the meander is in the point 67°30'N 5°W. Fairly high gradients of the temperature between 1°W and 0° correspond to the maximal velocity of the current, directed to the north. It is seen from Figure 3, that this current extends, meandering, eastwards as far as 8°E.

In an analogous way it is easy to be convinced in the existence of meanders of the same current and its strengthenings in some areas (in the zones of isotherm thickenning) and on other sections. A similar pattern of meandering was observed during surveys in other years as well. Naturally, the position of meanders is not stationary.

An analysis of charts of the depth of surface, having the temperature of 0° in the area discussed is of an interest. On Figure 4 charts for 1972 and 1974 are presented by way of example. A wide area with a great depth of isotherm 0° in the central Norwegian Sea, from which a deep hollow extends northwards as far as Spitsbergen, deserves attention. From year to year the position of this area and northern hollow changes somewhat, their depths change too, but as a whole one can consider this area to be quasi-stationary. The only thing can be the cause of its origin, to our mind: sinking of the atlantic waters in the zone of anticyclonic curvature of the Norwegian Current and its meanders; changes in the position of meanders and their curvature give rise to some variations in coordinates and depth of isotherm 0°.

Position of hollows and crest of surface, having the temperature 0°; in the southern Norwegian Sea reflects the main ways of water exchange in the deep water layers between the Norwegian Sea and North Atlantic. The crest along 10°W shows the way of penetration of cold waters to the south across the Faroe-Shetland Ridge. The hollow, stretching from the Faroes to the north-north-east, corresponds to penetration of the Atlantic waters to the Norwegian Sea in mid-layers, in 1972 the hollow adjacent to the Faroes from the north being well pronounced as well. The crest, extending from the western Faroe-Shetland Channel to the north-north-east, corresponds to the upwelling of the cold deep waters of the Norwegian Sea in the process of their movement southwards to the Atlantic Ocean across the Faroe-Shetland Channel. Really all these streams are distinctly followed, for example, on the isotherm chart for a depth of 500 m in June 1974 (Fig.5).

Conclusions:

1. Analysis of the temperature distribution and geostrophical velocities of the current made it possible to consider more properly the Norwegian Current to be rather meandering stream than a "branchy" one.

2. In the central Norwegian Sea there is a wide area of the anticyclonic sinking of waters, the position of which is quasi-stationary.

3. The depth of the surface, having temperature 0°, could be used for revealing the directivity of deep water exchange between the Norwegian Sea and North Atlantic.

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Headings for Figures

to the paper "On the Norwegian Current Structure"

by

Rossov V.V.

Fig.1 Schemes of currents of the Norwegian and Grrenland Seas
a-after Helland-Hansen and Nansen (1909)
b-after Alekseev and Istoshin (1956),branches of currents are shown in solid lines.

Fig.2 Meridionalcomponent of the surface current and gradients of temperature at a depth of 200 m(in C° per 1° of the arc of the latitudional circle) on the section along 67°30'N in June 1974.

Fig.3 Isotherms at a depth of 200 m in June 1974.

Fig.4 Depth of surface having temperature 0°in meters in June 1972(a) and in June 1974(b). Distribution of warm waters is shown in solid arrows,and distribution of cold waters-in dashed arrows.

Fig.5 Isotherms at a depth of 500 m in June 1974.

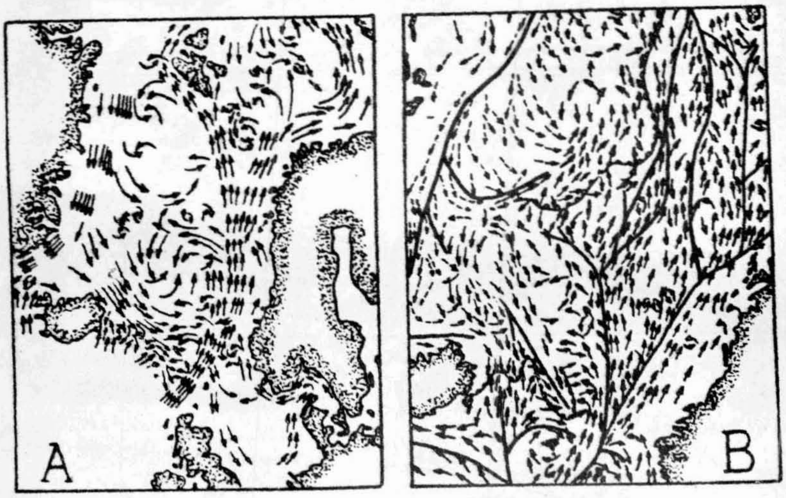
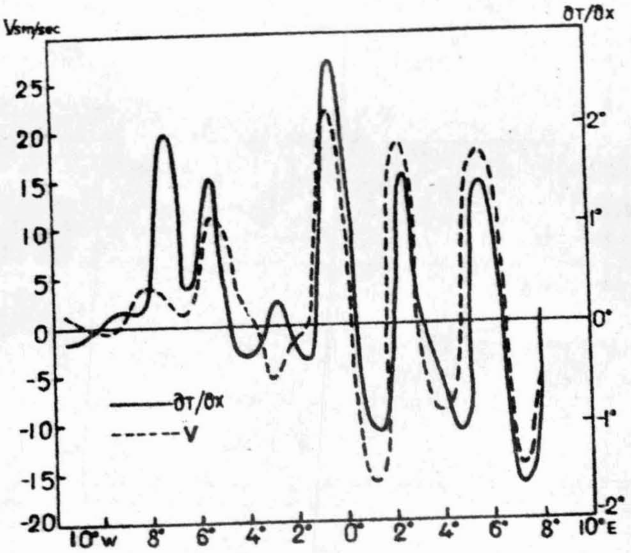

A
B

Fig. 1


Vsm/sec
∂T/∂x
25
20
15
10
5
0
-5
-10
-15
-20
2°
1°
0°
-1°
-2°
∂T/∂x
V
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8°
6°
4°
2°
0°
2°
4°
6°
8°
10°E

Fig. 2

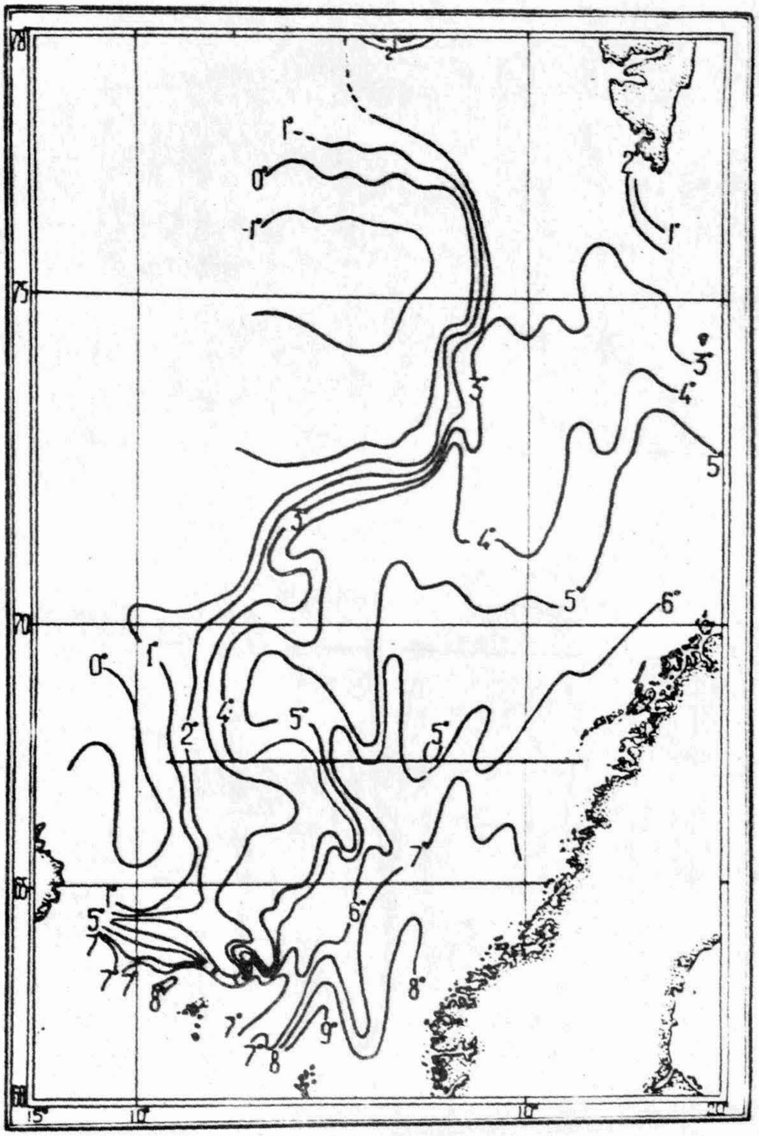


Fig. 3

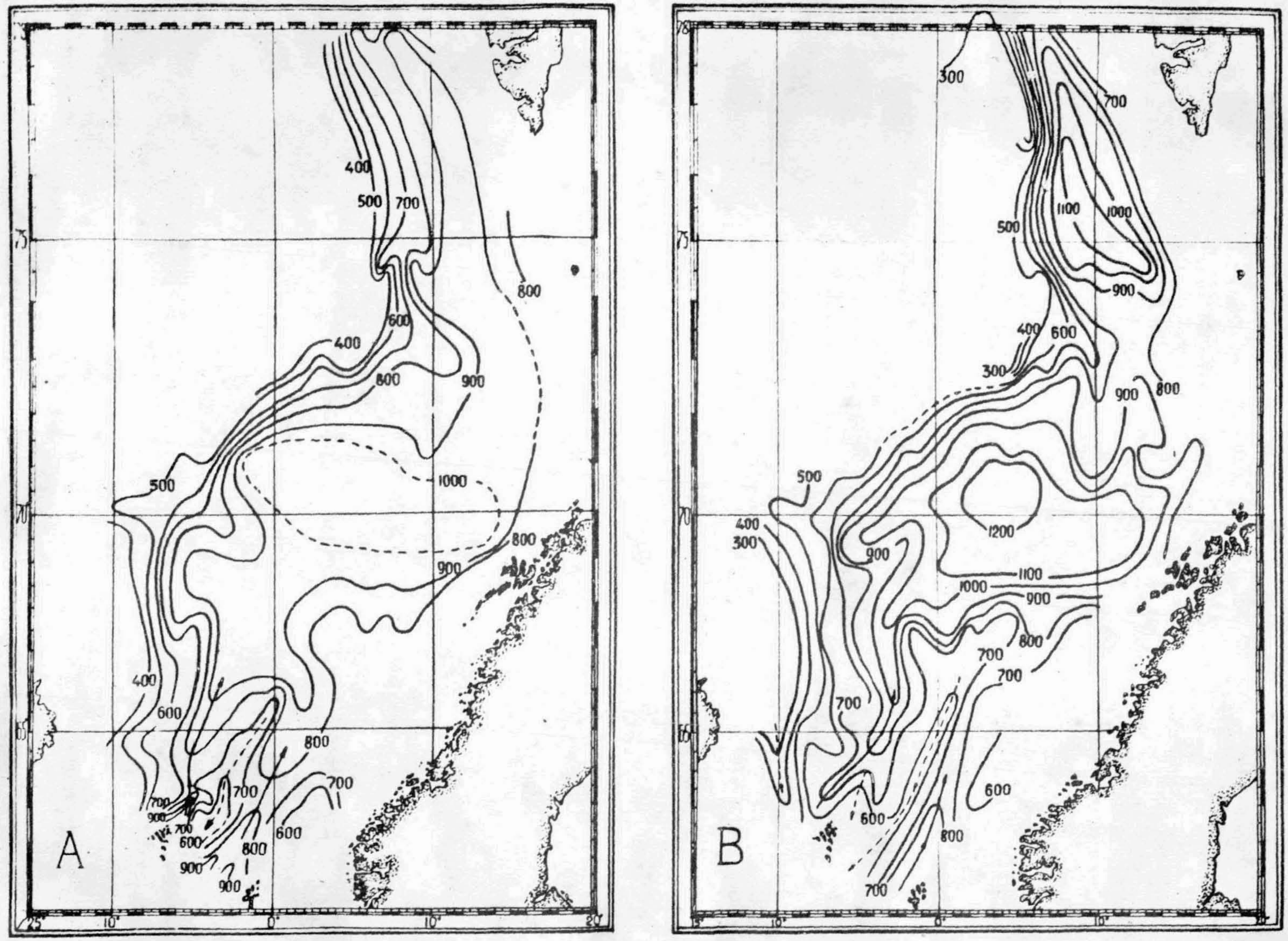
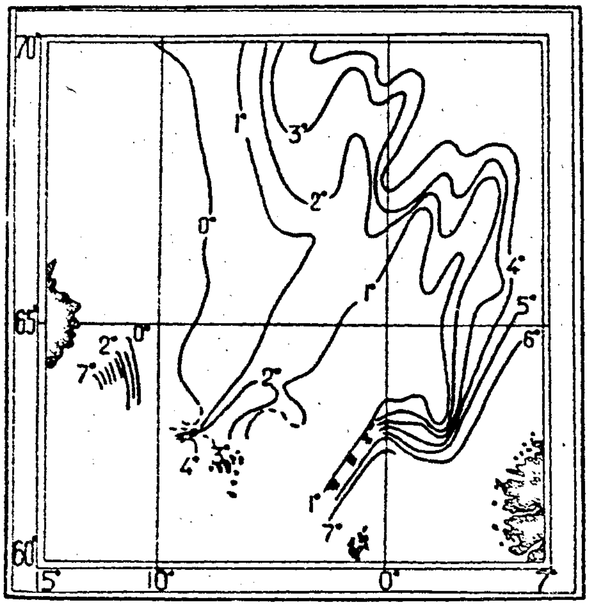


Fig. 4



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