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The effect of hydrometeorological factors on
the transfer of eggs and larvae of the North-eastern Arctic
cod into the Bear Island-Spitsbergen area

by

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Résumé

Il s'agit des conditions hydrométéorologiques à la limite des mers de Norvège et de Barents au printemps des années 1963, 1970 et 1975. On a relevé les facteurs hydrométéorologiques dont dépend l'apport des oeufs et des larves à partir des frayères des Iles Lofoten dans la région de Medvejinsk-Spitzberg. Les résultats obtenus permettent de prévoir, avec l'avance de plus de deux ans, l'abondance de la morue de trois ans dans la région de Medvejinsk-Spitzberg.

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Abstract

Hydrometeorological conditions in the border area between the Norwegian and Barents seas in spring 1963, 1970 and 1975 are analysed. Hydrometeorological factors influencing the transfer of cod eggs and larvae from the Lofoten spawning grounds to the Bear Island - Spitsbergen area are determined. The received data make it possible to forecast the abundance of three year old cod in the Bear Island - Spitsbergen area more than 2 years well in advance.

Introduction

Formation of the next year class of cod in the Bear Island - Spitsbergen area depends greatly on the abundance of cod eggs and larvae transferred into this part of the sea from the Lofoten spawning grounds.

The aim of the paper is to determine the hydrometeorological factors influencing the transfer of cod eggs and larvae into the Bear Island - Spitsbergen area from the Lofoten spawning grounds and to get an opportunity of forecasting cod

abundance in this area.

Materials and methods

The years of 1963, 1970 and 1975 were analysed because the year classes of North-eastern Arctic cod of these years were the most abundant. At the same time according to the results of young cod surveys* the transfer of cod eggs and larvae into the Bear Island - Spitsbergen area and the southern Barents Sea was quite different. For example, according to the results of young cod surveys the 1963 and 1970 year classes in the Bear Island - Spitsbergen area and the southern Barents Sea are estimated as rich, and the 1975 year class of cod is characterized as poor for the Bear Island - Spitsbergen area and very rich for the southern Barents Sea (Baranova, Ponomarenko, Trambachev, 1973; Trambachev, 1978). To understand the causes of different distribution of cod eggs and larvae between the Bear Island - Spitsbergen area and the southern Barents Sea, peculiarities of hydro-meteorological processes in the border area between the Norwegian and Barents seas in these years should be analysed. The materials of hydrological observations (Fig. 1A) carried out in spring 1963, 1970 Cruises 35 and 66 of the RV "Tunets") and 1975 (Cruise 9 of the RV "Akhill") are utilized for this aim. The dynamic method (Zubov, 1956) was employed for drawing the charts of dynamic topography. The 200 dbar level was taken for the reference level.

Discussion and results

The analysis of the dynamic topography charts in April-May 1963, 1970, 1975 (Figs. 1B, C, D) showed that alongside with *Biological materials of the PINRO laboratory of the North-European basin demersal fish were used in the paper.

common features of the water masses circulation which reflect the known ideas on water dynamics in the border area between the Norwegian and Barents seas (Kislyakov, 1964), the peculiarities in the relief of dynamic topography and current intensity are registered in these years.

Previously A.G.Kislyakov (1964) determined that in the border area between the Norwegian and Barents seas the region of high sea level called by him the dynamic ridge is located. In particular he found out that with weak development of the ridge cod eggs and larvae are not prevented from the drift to the southern Barents Sea; when the ridge is well-developed a great amount of cod eggs and larvae is transported northwards to the Bear Island - Spitsbergen area.

The analysis of geostrophic circulation showed that there was a well-pronounced ridge in the border area in spring 1963 (Fig. 1B). The data on young cod assessment testify to an intensive transfer of eggs and larvae both into the Bear Island - Spitsbergen area and into the southern Barents Sea. As a matter of fact there was no dynamic ridge in the border area between the Norwegian and Barents seas in April/May 1970 (Fig. 1C), but the data of young cod assessment in the Bear Island - Spitsbergen area showed that the transfer of larvae into this part of the sea was also intensive. In spring 1975 (Fig. 1D) the dynamic ridge in the border area between the two seas was well-developed spreading far to the north, but in spite of this the young cod abundance in the considered area was very low.

These facts illustrate that the existence of the dynamic ridge in the border area between the Norwegian and Barents seas

is not always of great importance for the redistribution of cod eggs and larvae in the Bear Island - Spitsbergen area and the southern Barents Sea.

At the same time the analysis of the intensity of currents in spring 1963, 1970, 1975 showed that in some years the correlation of the strength of the North Cape and Norwegian currents and primarily the intensity of the Coastal Current along the Norwegian coast and the North Cape Current was very important for the increase of transfer of cod eggs and larvae in the Bear Island - Spitsbergen area or the southern Barents Sea. This fact quite correlates with the results of the current intensity analysis carried out by A.I. Mukhin and E.I. Dvinina (Mukhin, Dvinina, 1978). In spring 1975 the intensity of the North Cape Current was much greater than in 1963, 1970, and the Norwegian Current flowing northwards is weak. This fact predetermined to some extent the main transfer of cod eggs and larvae into the southern part of the sea in spring 1975.

It is known that eggs and larvae drift in the sea surface layers and the direction of their drift depends on the direction of prevailing winds as well (Corlett, 1965).

To estimate the influence of this meteorological factor on the drift of cod eggs and larvae into the Bear Island - Spitsbergen area we utilized the difference of air pressure between the Bear Island and Jan Mayen in March - May. Previously it was illustrated that the direction of air streams is connected with the intensity of the Norwegian Current west of the Bear Island (Hill, Lee, 1957; Kislyakov, 1960; 1964a; Lee, 1961). In March - May 1963 the prevailing southern winds (the difference of air

pressure ΔP between the Bear Island and Jan Mayen was +11.9 mb) over the Norwegian Current intensified the transfer of cod eggs and larvae into the Bear Island - Spitsbergen area. In spring 1970 the resulting southern transfer ($\Delta P = 5.4$ mb) was registered, but it was less intensive as compared with the same period of 1963. In March - May 1975 the cyclonic activity predominated over the Barents Sea having conditioned the prevalence of the northern winds ($\Delta P = -15.8$ mb). The weak drift of cod eggs and larvae in the Bear Island - Spitsbergen area in spring 1975 is explained to some extent by this factor.

Now, the analysis of salinity distribution in the surface layers in April - May and June - July 1963, 1970 and 1975 (Fig.2) made it possible to suppose that the location of the Atlantic water masses in the area of the Lofoten spawning grounds is also one of the reasons influencing the transfer of cod eggs and larvae into the Bear Island - Spitsbergen area.

When the Atlantic water masses (the isohaline 35‰ was accepted for the border of the Atlantic water masses (Sarynina, 1970; Kislyakov, 1970) are located farther off shore than spawning grounds, the probability of eggs and larvae transfer into the Atlantic waters flowing northwards in the Bear Island - Spitsbergen area, lessens. Such situation was in 1975. Thus, the decline in salinity on more southern sections, i.e. the greater distribution of freshened coastal waters, indicates lessening possibility of eggs and larvae transfer into the Bear Island - Spitsbergen area.

So, the main drift of cod eggs and larvae is determined by a complex of hydrometeorological indices common to every year.

The transfer of cod eggs and larvae into the Bear Island - Spitsbergen area is favoured by the decrease of the intensity of the North Cape Current on the section North Cape - Bear Island (Stations 1 - 7) in the 0-200 m layer* (Q); by the prevalence of southern winds, of what the positive difference of mean monthly air pressure in March - May between the Bear Island and Jan Mayen (ΔP) is indicative; by the location of Atlantic water masses nearest to spawning grounds (the salinity value of the Eastern Branch of the Norwegian Current on the section along $69^{\circ}20'N$ in the 0-50 m layer in June ($S^{\circ}/\text{‰}$) is taken for the index).

Besides the above-mentioned facts influencing cod eggs and larvae transfer into the Bear Island - Spitsbergen area it was considered necessary to take into account such a factor as heat content of the Norwegian Current water masses. Water temperature indicates indirectly the intensity of the Norwegian Current flowing northwards and reflects the conditions of cod eggs and larvae drift (Kislyakov, 1964a). Water temperature (t°) of the Eastern Branch of the Norwegian Current in the 0-200 m layer on the section along $74^{\circ}30'N$ west of the Bear Island in June was taken as an index.

The connection of the index of cod 0-group abundance in the Bear Island - Spitsbergen area with the hydrometeorological factors suggested above is expressed by the following relationship:

$$y = f(Q; P; S^{\circ}/\text{‰} \text{ i } t^{\circ}).$$

The coefficient of multiple linear correlation $R=0.80 \pm 0.06$

 (1959-1975, n=17).

* Water discharge was calculated by A.I. Mukhin and E.A. Dvinina (Mukhin, Dvinina, 1978).

Comparing year-to-year fluctuations of the indices of cod 0-group abundance obtained as a result of autumn surveys and calculated by hydrometeorological factors, we receive a good correlation of the curves (Fig.3). As our investigations showed the indices of cod 0-group abundance in the Bear Island - Spitsbergen area are the indices of three-year-old cod abundance in this area, $r = 0.88 \pm 0.05$ (1959 - 1975, $n=13$, very poor cod year classes of 1965-1968 are excluded). The obtained results make it possible to forecast three-year-old cod abundance in the Bear Island - Spitsbergen area 2 years in advance.

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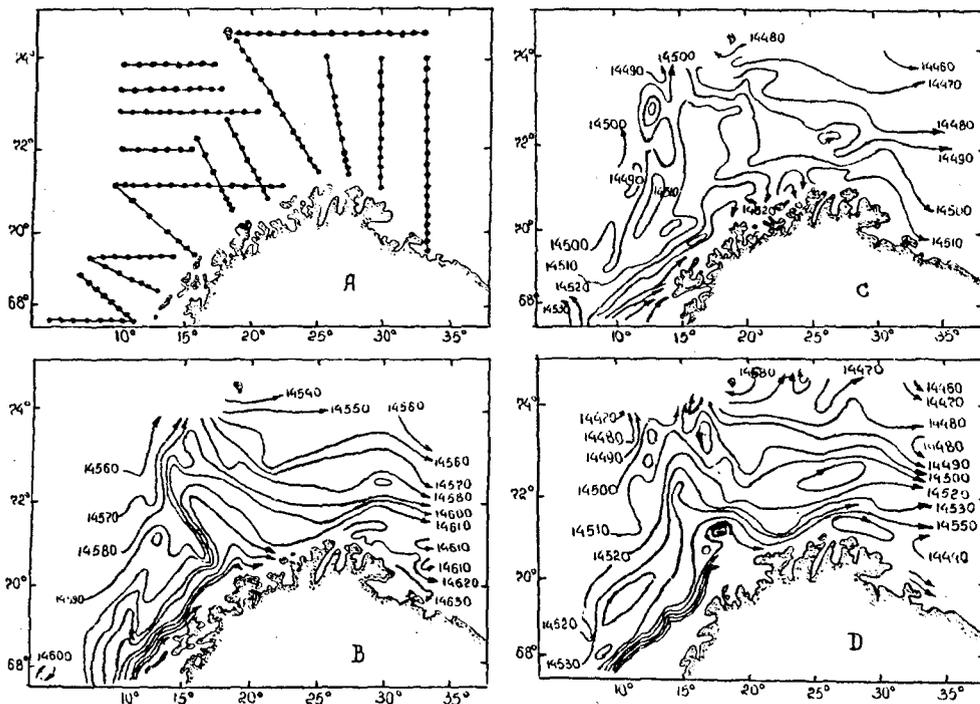


Fig.1A - the scheme of standard sections in the border area between the Norwegian and Barents seas. Geostrophic circulation in the sea surface in April-May (0-200 dbar); B - 1963, C - 1970, D - 1975.

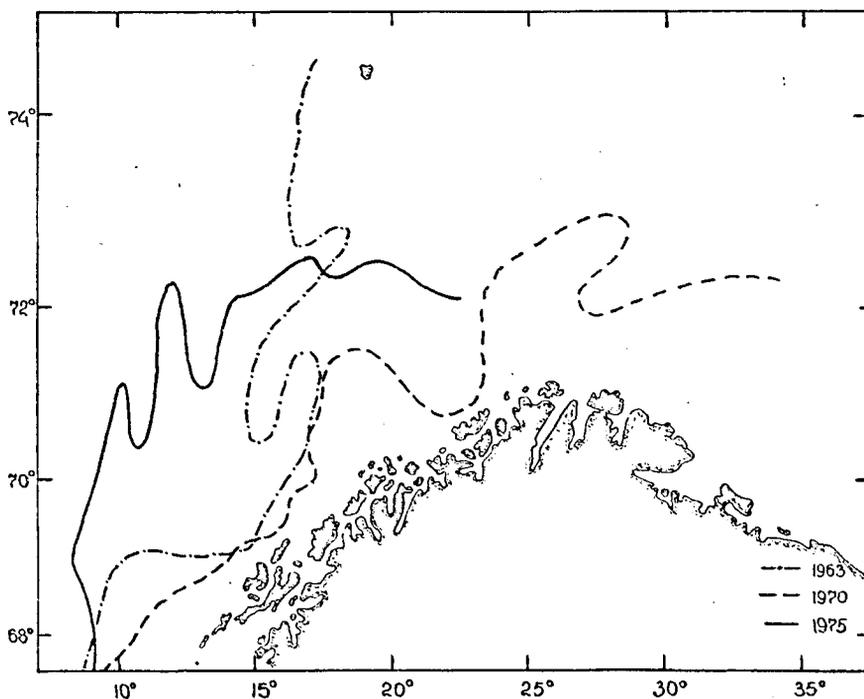


Fig.2. The location of the 35‰ isohaline at the depth of 20 m in June 1965, 1970, 1975.

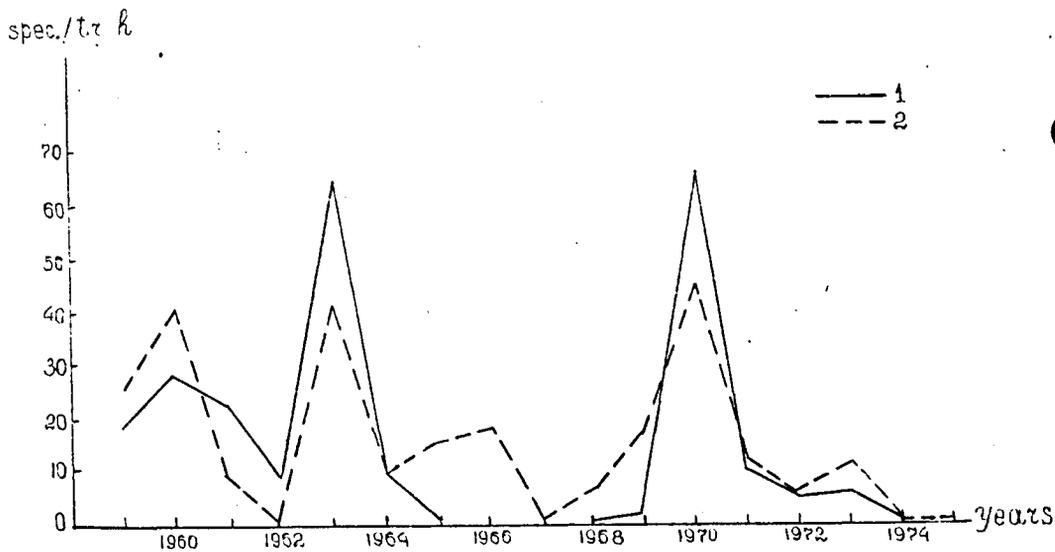


Fig.5. Year-to-year fluctuations of the index of col 0-group abundance: 1 - actual; 2 - calculated.