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On the Influence of Hydrometeorological Factors on the Distribution of Capelin in the Spawning Period and the Time of their Approach to the Southern Barents Sea Coast

by

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Summary

In this paper an attempt is made to determine the effect of some factors, such as temperature, atmospheric pressure, wind regime, etc. on capelin distribution in different parts of the southern Barents Sea coast, and also on the times of their spawning migrations. Observations were made in 1950-1970.

We suggest that the following forecasting factors should be used to determine the areas of spawning capelin : mean water temperature of the Main Branch of the Murmansk Current and of the Northern Branch of the North Cape Current in the fourth quarter of the preceding year; the intensity of cyclonic circulation also in the fourth quarter of the preceding year, and the position of the -1° isotherm in the Central Current in December of the preceding year.

The time of capelin migrations to the coast can be forecasted with respect to their first approach based on the fact that western approaches take place earlier and eastern ones later. For corrections one should use the number of days with anticyclones in Area I in December-February, temperature of the Norwegian Current in the 200-500 m layer in January-February, etc.

In this paper an attempt is made to define the influence of some factors, such as temperature, atmospheric pressure, wind regime, etc. on the distribution of capelin concentrations in different regions of the southern coast of the Barents Sea, and also on the time of their spawning migrations.

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There are some papers which discuss the influence of environmental conditions on capelin distribution and time of their migrations to the coast. The most detailed description of these problems is found in the papers by POZDNYAKOV (1958) and PROKHOROV (1965).

In order to define the influence of hydrometeorological phenomena on capelin distribution, different factors which precede and accompany capelin migrations to the coast were analysed for several recent years.

From 1951 to 1956 abundant capelin migrations to the Murman coasts were observed. The temperature anomaly of the Main Branch of the Murmansk Current from October to December 1950-1955 had positive values. From 1957 to 1959 capelin migrated to the Soviet coasts in small quantities. In the late autumn of 1957-1959 the temperature of the Murmansk Current had a negative anomaly.

From 1950 to 1960 the range of variability of the temperature of the North Cape and Murmansk currents was less by a factor of 1.5-2 than in 1961-1970, especially in October and November. In 1950-1960 capelin migrations to the Soviet and Norvegian coasts were observed, and only the intensity of these approaches was different, but in 1961-1970 the spawning area changed as well.

According to calculations by SPAIKHER and FEDOROVA (1969), the inflow of Atlantic waters into the Arctic Basin in 1961-1965, when distribution of capelin could be characterised as mainly western, was 10.6% lower and of heat 21.2% lower than in 1950-1960.

Thus, the common tendency in changes of spawning areas as dependent on heating conditions in the sea are fairly well marked.

As to coastal distribution of spawning capelin, 1962 and 1964 are contrasting years. In the first year, capelin did not perform any migration to the spawning areas at the Norwegian coasts, in the second year they did not migrate to the Murman coasts.

From October to December 1961 the temperature anomaly in the 0-200 m and 150-200 m layers of the Northern Branch of the North Cape Current was maximum for the period 1950-1970 (0.95°) and temperature of the Murmansk Current was a little above the norm. In this case, it would have been impossible to make any assumptions concerning dependency of capelin migrations to the Murman coast on water temperature of the Kola section.

In late autumn of 1964 the water temperature of the Murmansk Current in the 150-200 m layer was 0.7° below the norm which was the most reliable forecasting indicator, while the temperature of the North Cape Current which was slightly above the norm, made it impossible to make any assumptions related to the purely western approach of the capelin.

In 1969 the capelin did practically not approach the Soviet coasts. From October to December 1968 the temperature of the North Cape and Murmansk Currents was very low.

It should be noted that some deviations from the regularity mentioned above were registered. For instance, the late autumn of 1967 is considered to be the most severe for the last twenty years with respect to temperature conditions. Nevertheless, in spring 1967 capelin approached the Murman coasts as well. In spring 1966 very abundant capelin migrations to our coasts were observed, though in the late autumn the temperature of the North Cape and Murmansk Currents was very low and from January to March it was the minimun one for the years 1950-1970.

From the material under consideration one may conclude that the water temperature on the Kola section has not been a reliable forecasting factor in every case. Therefore, in order to increase the efficiency of forecasting, temperature on the section to the east of the Bear Island was used as the second criterion.

In a few cases however, the second criterion also happened to be unreliable. In such cases, distribution of temperatures of the near-bottom layer in the area of confluence of the cold Central and warm Murmansk Currents was used as a third criterion, particularly the position of the -1° isotherm (Figure 1).

In cases when this isotherm in the near-bottom layer penetrates far to the south and west, a more westerly distribution of capelin should be expected. And when waters with this temperature occupy some intermediate position or are displaced in a northeastern direction, then, in spite of low temperature in upper layers, capelin concentrations may approach the Murman coast as well.

In December 1963, for instance, the -1° isotherm of the near-bottom layer penetrated far to the south until 71°N, while in December 1961 this isotherm was found at 73°20'N, i.e. the cold Central Current was weakened at that time. In full conformity with the position of the -1° isotherm in spring of 1964, the capelin did not approach the Murman coast at all, while in spring 1962 they were only observed at our coast. In 1966, which was very cold, this isotherm was situated more to the northeast than in 1963 and that was evidently the reason for capelin concentrations migrating to the spawning areas at the Murman coasts in the spring of 1966.

It was also found that if in late autumn frequent affluxes of cold Arctic air take place in the area of the Barents Sea as was observed in 1963 and 1968 from October to December, capelin concentrations were characterised by a western distribution. On the contrary, when intensive cyclonic activities take place over the area in late autumn, capelin used to approach the Murman coast as well in spring of the next year.

Comparing the time of the first capelin approaches with the lunar phases in the period from 1943 - 1961, MOLLER and OLSEN (1962) found that the capelin mostly approached the coast either in a new moon or in a full moon. Several approaches of capelin can be observed in one and the same season and the later approaches were also observed in one of those lunar phases. Our data confirm this regularity mainly for the period from 1963 - 1971.

Many scientists have noted that more easterly the capelin spawn, the later do they approach the coast. An attempt is made here to determine the quantitative criterion which could explain this variability in time.

As seen from Figure 2, the time of capelin migrations to the coast in 1950 - 1970 varied between early February (1969, 1970) and the first half of April (1962, 1963). From 1950 to 1960 the time of approach varied from mid-February to mid-March, i.e. on average the variability comprised 35 days, while it was considerably greater from 1961 to 1970, namely 75 days. As has already been mentioned, the variability of atmospheric pressure and water temperature was also far higher in 1961-1970 than in 1950-1960.

Thus, the common tendency in the variability in time of capelin migrations to the coast as dependent on environmental conditions is clearly pronounced.

Close relations are observed between the date of capelin approach and the number of days with anticyclones in Area I in December, January and February according to VITELS (1965), (Area I includes the north-western Atlantic and the Norwegian Sea). This relation can be explained

as follows. When the Azoran anticyclon moves to the north and a region of high pressure is formed over Scandinavia, western winds appear over the Barents Sea, causing an outflow of cold waters of the Central Current in an eastern direction. As a consequence of this, favourable conditions for capelin migrations to the Murman coast are created, capelin appear here at later dates, then at Finnarken.

As seen from Figure 2, variability in air temperature at the coastal station of Torsvåg (70°15'N and 19°30'E) during the first quarter, and of water temperature in the 200-500 m layer in the Norwegian Current on the section along 63°00'N in March, is inversely related to the curve showing the time of spawning migrations of capelin to the coast. The correlation coefficient between the temperature of the Norwegian Current and the date of approaches is 0.61. A determination of reality of the relation was carried out according to PIRSON's criterion (X^2). $X^2 = nr^2$, where n is the number of terms of the row and r is the correlation coefficient. $X^2_{calcul.}$ is 5.2. As $X^2_{calcul.} > X^2_{tabl.} = 3.8$, so the relation is real. With respect to forecasting, one can be guided by the temperature anomaly of the Norwegian Current in January. The temperature anomaly in January is retained till March due to inertia. In Figure 2 the temperature of this current in March is given, because the series of observations made in this month is far more complete.

As it is rather difficult at present to express quantitatively such biological indices as "magnitude" or "insignificance" of capelin migrations to specific parts of the coast, the construction of a forecasting equation seems to be impossible. In order to predict the times and areas of capelin migrations to the coast, we take into consideration the variability of all factors mentioned above for the period 1950-1970. That is, we use the method of analogues. To make a better use of different factors, we refer to Table 1, in which their different quantitative criteria are given.

Judging from Table 2, the features of capelin spawning migration in 1971 can be estimated as follows :

Since water temperature in the 0-200 m and 150-200 m layers of the Murmansk and North Cape Currents in the period from October to December 1970 was about the norm, capelin migrations to the Finnarken and Murman coasts should have been expected and this happened in 1971.

The -1° isotherm in the channel line of the Central Current along 36°E in December was displaced to 71°45'N. This also led to expect capelin migrations to the Murman coast.

Judging from the number of days with anticyclonic circulation in December-February which were 23, capelin migrations to the coast should take place in the first half of February - this factor is an accompanying one. The forecasted date of approaches to the Murman coasts was determined in accordance with the beginning of a new moon period which was on 13 March.

Forecasting factors 3 and 4 are characterised by high reliability. To obtain a more correct forecast, one should use items 1 - 4.

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Table 1 Factors preceding and accompanying poor and abundant capelin migrations to the Murman coast

Preceding and accompanying factors	Migration to the Murman coast			
	poor	abundant	early (Febr.)	late (March)
1	2	3	4	5
1. Anomaly of water temperature of the Northern Branch of the North Cape Current in October-December of the preceding year	highly negative (-0.4° and lower)	highly positive (0.4° and higher)		
2. Anomaly of water temperature of the Main Branch of the Murmansk Current in October-December of the preceding year.	highly negative (-0.4° and lower)	highly positive (0.4° and higher)		
3. The position of the -1° isotherm in the near-bottom layer of the channel line of the Central Current in December of the preceding year.	Extreme southern (to 71°N) along 35-37°E.	North of 71°30'N along 38-40°E.		
4. Intensity of the anticyclonic and cyclonic circulation over the Barents Sea in October-December of the preceding year.	increased intensity of anticyclonic circulation (60 days & more)	increased intensity of cyclonic circulation (60 days & more)		
5. Total number of days with anticyclonic circulation in area I in December-February.			25 and less	30 and more
6. Anomaly of water temperature in the 200-500 m layer of the Norwegian Current in January-March			highly positive (0.4° & more)	highly negative (-0.4° and lower
7. Summary air temperature at the Torsvåg station for January-March			ΣT air -4° and more	ΣT air -7° and less

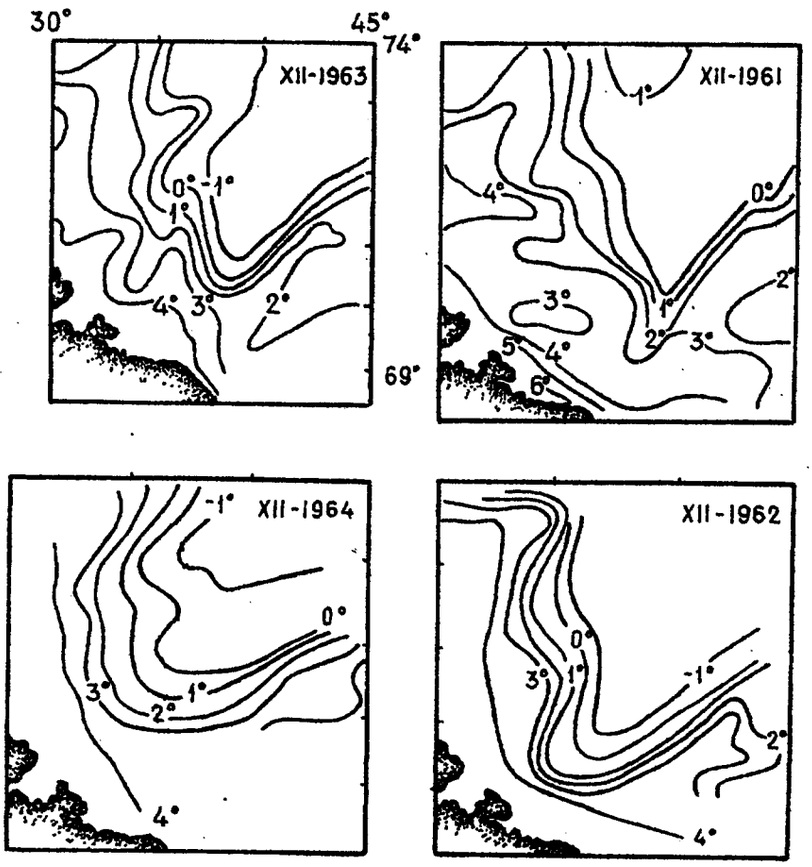

Figure 1. Horizontal distribution of water temperature in the near-bottom layer of the south-eastern Barents Sea in December 1961-1964.

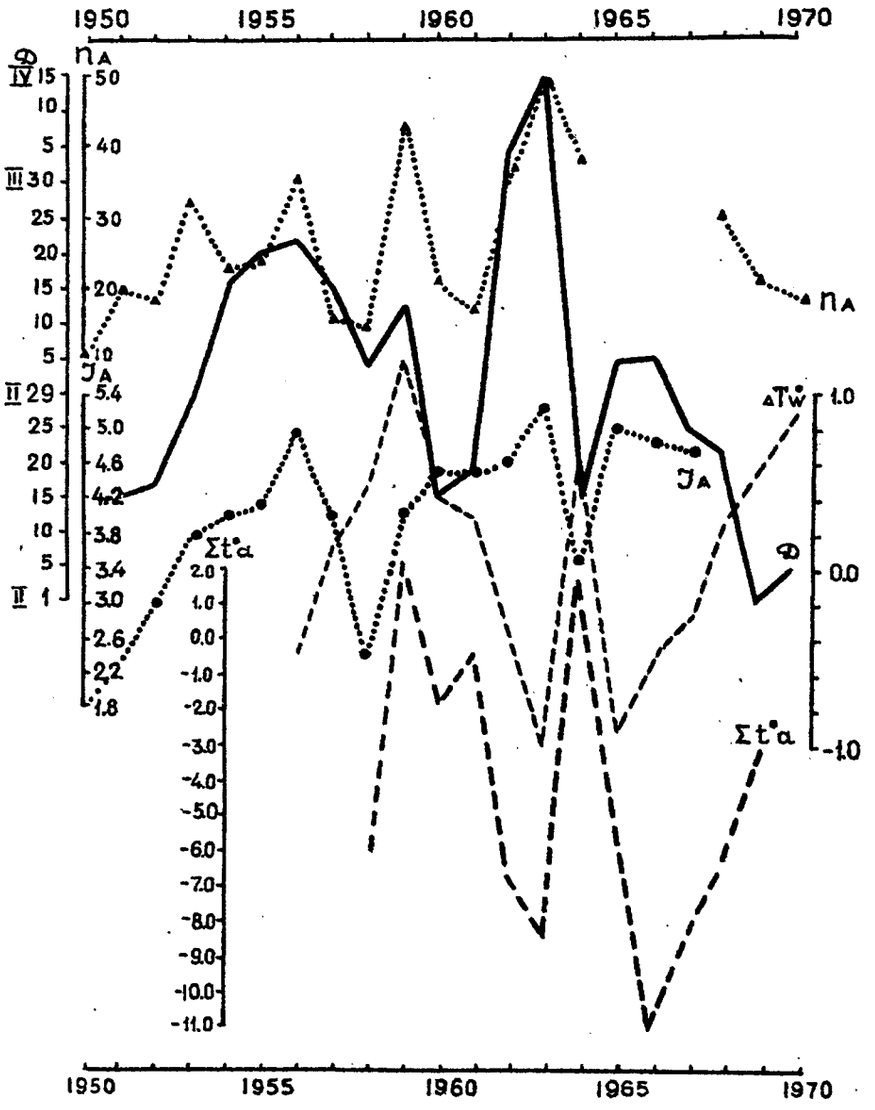

Figure 2. Year-to-year variation of:-

D - time of capelin migrations to the coast from 1950 to 1970;

n_A - number of days with anti-cyclonic circulation in Area I in December-February 1954-64 and 1968-70;

J_A - winter index of anti-cyclonic circulation in Area I in December-February 1950-1967;

$\Delta T°_w$ - temperature anomalies of the Norwegian Current in the 200-500 m layer in March 1956-1970;

$\Sigma t°a$ - summary air temperature at the station of Torsvag in January-March 1958-1969.