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On correlation between the water temperature and the spawning times for Georges Bank herring

by

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Introduction

On the basis of available data on the spawning of herring and fluctuations of the water temperature in the Georges Bank area in the period 1963 -1973, an attempt was made to reveal the correlation between the water temperature in pre-spawning and spawning periods in order to predict the latter.

Material and methods

Complex surveys in the Georges Bank spawning grounds were made annually by the AtlantNIRO from 1963 to 1973 in order to estimate the spawning part of herring population by the eggs layed During the surveys the position and square of the main spawning grounds were determined as well as the times of the beginning, peak and termination of the massive spawning, and thermal regime in pre-spawning, spawning and post-spawning periods was observed (Noskov A.S., Zinkevich V.N., 1967; A.M. Pancratov and I.K. Sigaev, 1973). The material of the surveys allowed to specify the peak times of the massive spawning of herring which usually occurs in September - October with the peak times during September, by the ratio of maturity stages in samples.

The data on thermal regime were represented by the pre - bottom water temperature measured in the spawning ground in August, and also by summer temperature anomalies at depths of 50

and 75m taken from the paper by Karaulovsky V. P. and Sigaev I.K. (Karaulovsky V.P. and Sigaev I.K., 1976).

The dates of spawning and the indices of thermal regime are given in Table 1, where D is the date of the peak massive spawning in September, ΔT_{50} is the water temperature anomaly during the summer season at the depth of 50m, ΔT_{75} is the water temperature in the spawning area in August.

The only index T_a is prognostic (the other two include the data for September). The factor of correlation between T_a and ΔT_{50} was preliminary calculated to re-establish the missing values T_a for 1964 and 1972, and then to deduce the regression equation. The re-established values of T'_a are given in Table 2. The factor of correlation between T_a and ΔT_{50} estimated as 0.85 allowed not only to re-established the missing temperature values by the correlation plot but also to confirm the representative character of these thermal regime indices. The correlation between the latter is evidently caused by the significant contribution of the August temperature to the formation of the summer anomalies in the Georges Bank area where highly developed dynamic processes exclude thermal inertia.

Results and discussion

Despite the relatively short observation series statistically reliable correlation between the thermal condition indices and the spawning times for herring is observed.

The results of the analysis are shown in Table 2, where n is the number of the series terms, R is the correlation factor, D is the date of peak spawning.

The established relationship indicate that relatively high heat content of water before spawning determines the earlier dates of peak spawning, and, on the contrary, the lower heat content (lower water temperature in pre-spawning period) determines the later dates, i.e. the back relationship is observed. Figure 1 shows the plots of correlation between the heat content indices and peak spawning times for herring drawn from Table 1 data which confirm the correlation nature.

If the correlation between the summer anomalies (ΔT_{50}, ΔT_{75}) and peak spawning times is not prognostic, as it was mentioned above, the correlation between the August pre-bottom temperature (T_a) and the dates of spawning may be considered as the basis for the prognosis of the latter.

It should be noted that the maturing of reproductive products of Georges Bank herring occurs against the increase of the pre-bottom temperature in the spawning ground, the peak values of which are usually observed in September(Fig.2). This is characteristic of Sakhalin-Hokkaido herring(Probatov A.N; and Shelegova E.K.,1952), Baltic herring in the Vistula Bay and the Gulf of Riga(Berenbeim D.Ya.,1971), Azov anchovy(Berenbeim D.Ya., 1973) and Okhotsk herring(Zavernin Yu.P.,1972). The above species spawn in the period when the basin is most heated,i.e. approximately from March to July-August included, the spawning occurring earlier in the warmer pre-spawning period and later in the colder peridd.As it was shown above, this is also characteristic of Georges Bank herring.

From the above data it can be concluded that there exists a good correlation between the peak spawning times for herring and the pre-bottom water temperature in the spawning grounds in August.The estimated correlation can be used for the prognosis of the peak spawning times. This knowledge may be useful for determining of the times of the subsequent biological development stages, for example of the dates of the egg incubation period and the dates of massive hatching of herring larvae. This information will help in the operative planning of the complex surveys on herring ecology.

References

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Table 1. Initial data on the thermal regime and spawning times used for the correlation analysis.

No	Year	D	ΔT_{50} (°C)	ΔT_{75} (°C)	T'_a (°C)
1	1963	12	0.8	1.0	13.6
2	1964	29	- 1.2	- 1.2	10.8
3	1965	22	0.1	- 0.7	12.0
4	1966	25	- 0.4	- 1.5	11.1
5	1967	27	- 0.9	- 0.9	10.3
6	1968	19	0.4	0.5	11.0
7	1969	17	0.8	0.4	13.3
8	1970	18	- 0.5	- 0.5	11.5
9	1971	11	0.9	1.1	13.3
10	1972	22	0.7	1.1	12.9
11	1973	26	-	-	12.6

Table 2. The results of the correlation analysis of the thermal regime indices and spawning times.

Indices	n	R	Confidence level	Regression equation
ΔT_{50}	10	-0.81	0.01	$D = 20.6 - 6.50\ T_{50}$
ΔT_{75}	9	-0.83	0.01	$D = 20.5 - 4.95\ T_{75}$
T_a	9	-0.75	0.05	$D = 67.1 - 3.89\ T_a$
T_a	11	-0.71	0.05	$D = 64.1 - 3.62\ T_a$

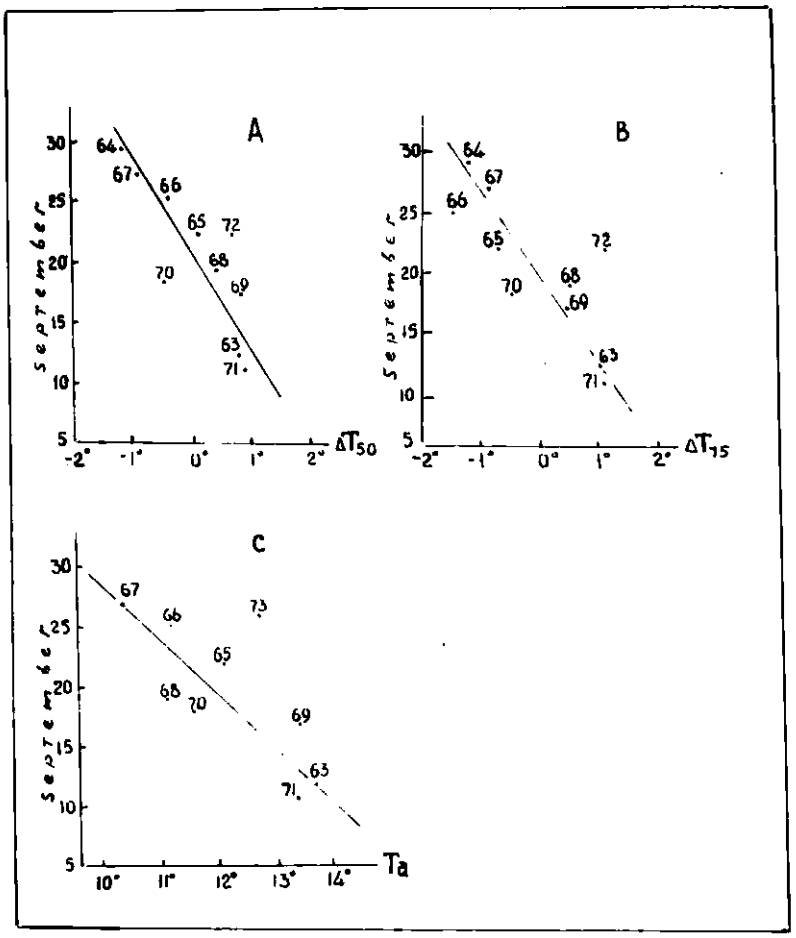

Fig.1 **The plots of correlation between the peak spawning times and thermal regime indices**

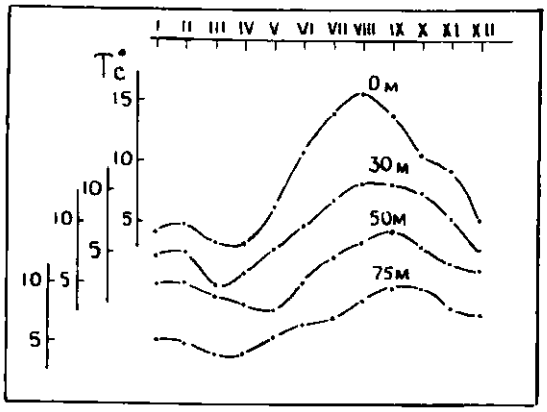

Fig.2 **The plots of the annual water temperature run in the spawning grounds of herring on Georges Bank by depth**