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Characteristic features of the hydrological conditions
on the Nova Scotia Shelf and Georges Bank, 1972

by

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Abstract

The characteristic features of the hydrological conditions on Nova Scotia Shelf and Georges Bank for 1972 were compared with those for 1971 on the basis of observations on water temperatures in the winter and the summer-autumn periods. Numerous concentrations of young herring on the Nova Scotia Shelf and Georges Bank in the winter of 1972 are supposed to be associated with the intensification of cold waters advection from Cabot Strait in this period. A possible reason is given for the lower mean water temperatures in 1972 as compared with 1971.

Introduction

The hydrological conditions in the area of Nova Scotia and Georges Bank in 1972 were characterized by a number of peculiar features as compared with the previous years. These peculiarities, mainly temperature variations, were likely to influence the behaviour and distribution of some commercial species. In particular, abundant concentrations of young herring on the Nova Scotia Shelf in the winter of 1972 can be related to the abnormal hydrological conditions in the winter period. The paper deals with the characteristic features of the water temperatures in the winter and summer-autumn periods in 1972 based on the analysis of observations on water temperatures made by RTM *Bakhchisarai* in January-March and by R/V *Argus* in June-October in the above mentioned areas.

Materials and Methods

The character of observations on water temperatures made by RTM *Bakhchisarai* and R/V *Argus* is different. The observations by *Bakhchisarai* were made episodically in parts of the area when searching for commercial concentrations of fish to determine the optimum fishing grounds and also on some standard sections.

Observations on water temperatures during the cruise of *Argus* were made in the period of ecological surveys on Georges Bank and parallel sampling for salinity, phosphates, nitrites, silicon, oxidability, oxygen and plankton, zooplankton and ichthyoplankton.

Sixteen surveys were made during the cruise. However, the analysis of water temperatures was based upon the data from three surveys which covered the whole of Georges Bank in June, August and October. These surveys were made according to three different schemes. The June survey was carried out at stations obtained using a table of random numbers. The August survey was made over standard hydrological sections adopted by AtlantNIRO. The October survey was carried out over the stations adopted by ICNAF to determine the abundance of herring larvae.

The character of hydrological conditions in January-March is evident from *Bakhchisarai* observations without additional analysis of the data from the cruise report.

The results obtained by *Argus* in 1972 were compared with the observations made in June, August and October 1971 both on the basis of water temperatures averaged for different parts of Georges Bank in June and October and averaged by standard sections and layers in August (Fig. 1). As can be seen from Fig. 1, the averaging was based upon the data collected on the Shelf between 74° and 70°N, 70° and 68°N, and 68° and 66°N, as well as in the northern and southern parts of Georges Bank separately.

Results of Investigations

Observations on the Nova Scotia Shelf made by RTM *Bakhahisaraí* revealed a decrease in water temperatures in January over the whole eastern part of the Shelf as a result of an intensive inflow of surface water from Cabot Strait. Water temperatures in 0-100 m layer ranged from 0.5°C (near Cape Breton) to 2.5°C (along the edge of the Shelf).

The 0° isotherm extended along the eastern and southern slopes of Banquereau. In 1972 water temperatures over the whole area were lower than in 1971, especially in the southern part. By the end of January further southwesterly movement of cold water onto the area of Sable and Emerald Banks was observed and became more intensive after mid February. According to observations made early in March, the movement resulted in further cooling within the 0-100 m layer where the temperatures dropped below zero. Negative temperatures were characteristic of the Canso, Misaine and Artimon Bank areas (Fig. 2). The position of the 0° isotherm in March was very close to the 200 m isobath from Cabot Strait to Galli. The second half of March was marked by a great deal of floating ice, the boundary being along 44°40'N approximately. The northern slopes of Canso, Misaine and Artimon Banks were occupied by floating ice during the whole month. Mean weighed water temperatures within the 0-100 m layer in Cabot Strait were considerably lower in 1972 than in all the previous years since 1967 (Table 1). At the same time it should be noted that temperatures of the offbottom layer were very much higher than in eight previous years. This fact indicates that in the winter of 1972 the intensive inflow of Labrador waters paralleled a strong intrusion of Gulf Stream water in the offbottom layer in the area of Cabot Strait.

Table 1. Mean weighed water temperatures (°C) in Cabot Strait for the winter periods 1963-65, 1967-72.

Layer	1963	1964	1965	1967	1968	1969	1970	1971	1972
m									
0-30	3.3	4.2	-0.2	3.7	2.4	1.7	3.6	2.5	0.0
30-100	3.0	0.7	0.4	3.2	2.2	1.8	2.9	2.9	1.4
100-bottom	3.5	2.4	2.7	2.8	4.4	3.5	4.8	3.1	6.5

Thus, abnormally cold conditions were formed in the upper 100 m layer on the Nova Scotia Shelf in the winter of 1972. However, water temperatures below 100 m and in Cabot Strait were the highest in eight years (Table 1).

According to the *Argus* survey data, water temperature distribution in the surface layer of Georges Bank in June 1972 reflects the characteristic features of the end of hydrological spring especially for the central part of the Bank where the temperature of the water column reached 11-12°C. The areas adjacent on the southern part were strongly influenced by the advection of warm oceanic water. In June 1972, the most intensive and prolonged influence of these waters was observed in the area of 67°W and 70-71°W. The northern, eastern and northwestern parts of Georges Bank were strongly affected by relatively cold waters from the adjacent area of Nova Scotia. Water of minimum temperatures from 4° to 6°C was predominant here near the bottom. For comparison with the observations in June 1971 the data on the surface and bottom temperatures were averaged using the above scheme (Table 2).

Table 2. Water temperature averaged for different parts of Georges Bank for June 1971 and 1972.

Layer	Year	Longitude West			Northern part of Georges Bank	Southern part of Georges Bank
		74°-70°	70°-68°	68°-66°		
0	1971	11.6	12.5	11.7	11.4	12.9
	1972	16.4	12.7	11.2	11.2	12.2
Bottom	1971	2.3	7.3	7.6	7.0	7.9
	1972	9.5	8.4	8.6	7.6	9.3

From Table 2, average surface temperatures in June 1972 appeared to be lower over the whole area as compared with 1971. Only in the western half of the Bank were they 0.2°C higher. However, calculated average temperatures for the northern and southern parts of Georges Bank, were lower in 1972 than in 1971. Bottom temperatures exceeded significantly the 1971 level. The analysis of the temperatures over the whole water column from surface to bottom gave comparative data for the three sections XV, XXIV and V only (Fig. 1). Results of the comparison are given in Table 3.

Table 3. Mean water temperatures along the sections in the eastern part of the American shelf in June 1971 and 1972.

Years	XXV	XXIV	V
1971	11.6	10.2	12.1
1972	11.5	13.7	12.9

Table 3 shows that water temperatures from the surface to the bottom along sections XXIV and V in the area of 70-71°W were considerably higher in 1972 than in 1971. This is probably due to the strong influence of the above mentioned Gulf Stream advection. To the westward in section XXV, June 1972 temperatures were very close to those for 1971. Thus, surface water temperatures were lower in June 1972, while bottom temperature was considerably higher, as compared with 1971.

From an analysis of water temperature fields obtained in August, the pattern of temperature distribution on Georges Bank was analogous to that in June. As before, there was upwelling of the intermediate layer into the area of South Channel, an inflow of Nova Scotia water onto the eastern slopes of the Bank, and advection of Gulf Stream water to the southeastern and southern slopes. Simultaneously the distribution of coastal water with higher temperature and lower salinity became more intensive in the western part of the Gulf of Maine and between 70° and 74°N. Surface coastal waters and intermediate layer upwelling resulted in the formation of a zone with strong temperature gradients in the area of South Channel. The southern slopes of the Bank were characterized by weaker horizontal gradients in August than in June, the latter being observed in the same areas between 67° and 68°W and near Witch Canyon. Temperature distribution in the off-bottom layer was also marked by a weaker advection of Gulf Stream waters on the south as compared with June, by availability of gradient zones on the northwestern slopes and by water inflow to East Channel.

For comparison with the thermal conditions in August 1971 the data on water temperatures were averaged by standard sections for the 0-30 m, 30-100 m and 100-200 m layers in the northern and southern parts of Georges Bank. From these data water temperatures were plotted (Fig. 3). As can be seen from Fig. 3, in August 1972 in the northern part of the area (north of shallow waters) the temperatures within all layers, except the offbottom layer along section III, were lower than in 1971 and in southern part (south of shallow waters) the decrease of temperature was not observed everywhere. Mean temperatures in the same parts of the southern area, where the advection of Gulf Stream water was rather pronounced, appeared to be somewhat lower than in August 1971. As the plots demonstrate, this is typical for the areas from 67°W to 19°W. Thus, as a result of water temperature analysis in August, it can be concluded that in the northern part of the Bank the temperature was lower within the 0-100 m layer, while below 100 m it was the same as in 1971. As for the southern part, the decrease of water temperature was marked mainly within 0-30 m, while in the layer from 30 m to the bottom it was higher than in 1971.

Analysis of surface water temperature fields in October 1971 and 1972 indicates a lower level in October 1972. This difference is strongly pronounced over the whole area of Georges Bank. In the central part of the Bank temperatures were from 14°C to 15.5°C in 1971 and fluctuating from 12°C to 14°C in 1972. In October 1972 temperature gradient zones were absent on the southern slopes where they were dominant in 1971. Advection of Gulf Stream water was observed only near Witch Canyon. Surface temperatures in the Gulf of Maine varied from 9.3°C in the east to 13°C in the west, while in October 1971 it was not below 10.5°C except for two local regions affected by intermediate upwelling, i.e. South Channel (9.3°) and the area north of Cape Cod (8.9°). In the offbottom layer the temperature difference was due to more dispersed horizontal gradients on the north and east in 1972 than in 1971. The bottom temperatures in the western part of the Gulf did not differ from those in 1971 (6.3-6.9°C), but were found over a more extensive area. Temperatures near the bottom in the deepwater depression of the Gulf of Maine which can be used as an index when evaluating the extent of transformed waters due to inflow from the Gulf Stream into the Gulf of Maine, were 0.5°C lower in October 1972 than in October 1971. The eastern part of the Gulf was also characterized by lower temperatures similar to the eastern part of the American shelf between 70° and 72°W. In order to compare October temperatures in 1971 and 1972 water temperatures were averaged by analogy with the June data. The results are given in Table 4.

Table 4. Water temperature averaged for different parts of Georges Bank for October 1972 and 1971.

Layer	Year	Longitude West			Northern part of Georges Bank	Southern part of Georges Bank
		72°-78°	70°-68°	68°-66°		
0	1971	17.5	14.0	13.7	13.1	15.7
	1972	15.2	13.1	11.4	11.6	13.2
Bottom	1971	12.9	10.1	10.4	9.4	12.1
	1972	11.5	9.6	9.8	9.4	11.1

As can be seen from Table 4, water temperatures on the surface and near the bottom in October 1972 were on the average 1.3° lower than in 1971.

Discussion

Summarizing the above, it can be concluded that, in the winter period, abnormal hydrological conditions on the Nova Scotia Shelf were due to the intensive advection of the cold Labrador waters from Cabot Strait and their extension to the areas in depths to 100 m. Numerous concentrations of young herring observed by RTM *Bakhchisarai* in the areas of Nova Scotia and Georges Bank can probably be explained by these abnormal conditions.

The results of observations made in June, August and October 1972 in the Georges Bank area indicated lower temperatures in the surface layer than in 1971, while October observations revealed lower temperatures in 1972 in the offbottom layer.

In June and August 1972, water temperatures in the offbottom layer in some parts of Georges Bank were greatly influenced by the advection of Gulf Stream water and were consequently higher than in 1971. On the whole, thermal conditions in 1972 were lower than in 1971.

As demonstrated above, temperature variations in the area under survey caused by different factors (seasonal variability and advection) were not the same vertically. In June 1972 surface temperatures were lower and bottom temperatures were higher than in 1971, in August the situation was the same and in October only similar temperature changes took place both in the surface and offbottom layers. Therefore, when determining the level of thermal conditions of the area, it is most desirable to have several indices characterizing the temperatures of the main three water masses, that is surface, intermediate cold layer, and bottom water. In addition, such indices should be obtained for each season, as well as for each part of the area.

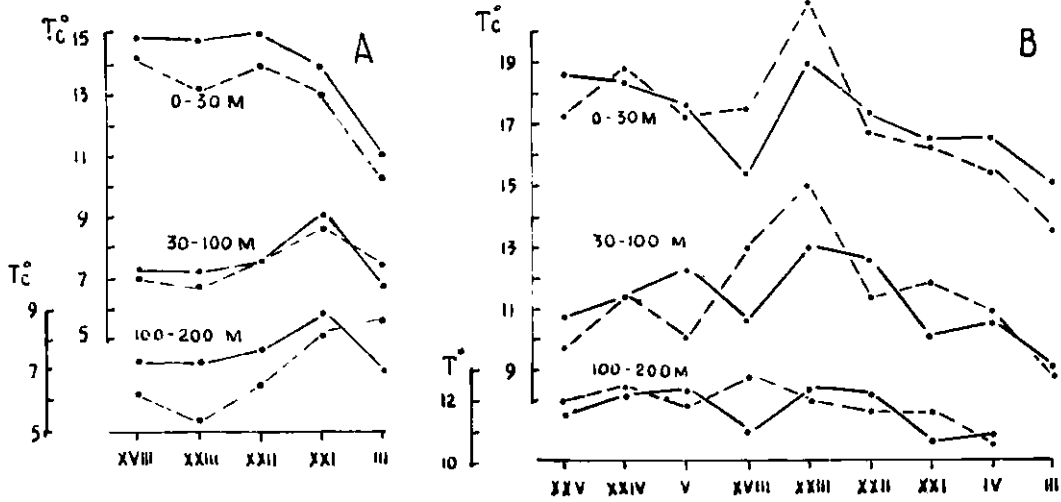


Fig. 3. Mean water temperature (°C) along standard sections in August 1972 and 1971 for the 0-30 m, 30-100 m and 100-200 m water layers on Georges Bank and on the eastern part of the American shelf.

----- 1972 A - northern part of Georges Bank.

———— 1971 B - southern part of Georges Bank.

III, IV, V and so on - numbers of the standard sections.