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SEASONAL AND YEAR TO YEAR VARIABILITY OF WATER TEMPERATURE IN THE AREAS OF LABRADOR AND NEWFOUNDLAND

by

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The present work is aimed at following the variation of water temperature in the areas of Labrador and Newfoundland for the years 1936, 1938-1941, 1948-1970. Seasonal variation of the mean water temperature in the 0-200 m layer has been analysed on standard hydrological sections, worked across the Grand Bank, the South Labrador Shelf and at the coastal station 27 at the island of Newfoundland.

Temperature variations in the waters of the Northwest Atlantic and the Barents Sea are compared.

Materials and Methods

Mean water temperature on standard sections in the areas of Labrador and Newfoundland has been analysed (Fig.1). Mean temperature of the 0-200 m layer was calculated for the stations, which in Fig. 1 are restricted by brackets. On the sections 8-A and 7-A they are situated in the Coastal and Main branches and in the Irminger component of the Labrador Current; on the section 6-A, 4-A, and 3-A, in the Frontal zone of the Labrador and North Atlantic currents; on the sections 2-A, 1-A and 44-A, in the transformed waters of the Labrador Current and bank waters in the region of their meeting with the Gulf Stream waters.

Observations, which are due to be analysed, were conducted on these sections by Soviet research vessels (mainly by the vessels of the Polar Institute) and the vessels of the International Ice Patrol.

To characterize sun activity Wolf's digits were used.

Results of analysis

1. Seasonal variability of water temperature

No regular monthly observations were conducted on standard sections off Labrador and Newfoundland. We tried to obtain a mean curve of the yearly variation of water temperature in the 0-200 m layer for particular regions of each of the sections: 8-A (B), 7-A, 6-A (G), 4-A, 3-A, 3, 2-A, 1-A, 44-A, in accordance with the data of observations for different years and months.

In Fig. 2 the curves of the yearly variations of water temperature are given for the sections 8-A, 7-A, and 6-A, which cross the Main branch of the Labrador Current. From this figure one can see, that four extrema are distinctly pronounced on the section 8-A: two minima and two maxima. On the sections 7-A and 6-A the secondary minimum is less distinctly pronounced.

The spring minimum occurs due to winter cooling, the summer maximum, due to heating. In July-August the minimum is connected with the strengthening of the Labrador Current. The afflux of Arctic waters into it becomes more considerable as the result of ice melting, whereas, a considerable stratification of waters prevents penetration of heating in deeper layers by means of vertical circulation.

In September-October maximum evidently occurs due to intrusion of warm waters of the Irminger component on the slope.

From autumn to spring the waters of the Labrador Current are cooling more and more, the minimum temperatures (-0.7°) of the 0-200 m layer being observed in April. Insignificant rise of temperature is observed in February in some years; it is caused by a short-term intrusion of warm waters of the Irminger component on the slope under the cold waters of Arctic origin.

The marked maxima and minima of the Labrador Current temperature are observed in the West Greenland Current as well (Adrov,1962; Külerich,1943).

Off Newfoundland monthly observations of water temperature have been conducted by Canadian scientific workers at the station 27 (at the depth of 175 m) at the Cape Spear near the town of St.John's since 1950. This station is situated at the western edge of the Coastal jet of the Labrador Current. Templeman (1965) summoned up these data and built monthly mean isopleths for the period 1950-1962 (Fig.3,the upper part). In this figure one can easily follow seasonal variation of temperature in all the layers from the surface to the bottom. The maximum heating is observed in September, and it is followed by a uniform cooling,the minimum being observed in March. The most considerable penetration of warm waters to the depth of about 100 m is observed in November. In April the increase

of volume of the Arctic waters with the temperature below -1° is observed together with the beginning of heating of the surface waters, and in July-August they reach the bottom.

At the bottom of Fig. 3 we can follow the variation of mean temperature on the whole layer of 0-175 m at this station from month to month for the period 1950-1962. The obtained curve of the seasonal variation of temperature has one minimum in March (down to -1°) and one maximum in October (up to 2.2°). The available results of a series of observations allow to consider this curve as typical for the temperature variation within a year's period in the Coastal jet of the Labrador Current.

On the sections across the Grand Bank and the Cabot Strait (1-A, 2-A, 3-A, 4-A, and 44-A) the most complete series ofobservations were carried out in spring months (from March to June).

In Fig. 4 curves of the yearly variation of averaged temperature of the active layer (0-200 m) are presented. They are built according to these series of observations, that have been worked on sections 4-A, 3-A, and 2-A across the Southeastern and Southern slopes of the Grand Bank. The curve of the seasonal variation for the section 4-A has one minimum (in April) and one maximum (in August). Here stations, according to which the mean temperature for the 0-200 m layer was calculated (Fig. 1), were established in the waters, where the influence of transport of water masses is not so great as on the sections 3-A and 2-A. On the southern sections (3-A and 2-A) the influence of the North Atlantic Current is considerably greater and causes the appearance of the second maximum (in March). On the section 8-A worked across the Labrador Current and on the sections 3-A and 2-A across Labrador - North Atlantic Current the second maxima and minima are observed as well, caused by dynamic reasons.

The next group of curves for the sections made across the Southwestern slope of the Grand Bank and the Cabot Strait (sections 1-A and 44-A in Fig. 5) is peculiar for the minimum temperature in March-April and the maximum one in August.

Summarizing the comparison of the curves of the yearly variation of mean temperature on the sections in the areas of Labrador and Newfoundland and at the station 27, one arrives at a conclusion, that two types of curves can be singled out (Table 1).

As seen from Table 2, the curves of the yearly variation of temperature for the sections 8-A, 7-A, 6-A, 3-A, 2-A have two maxima and two minima, whereas, at the station 27 and on the sections 1-A, 4-A, and 44-A one maximum and one minimum is pronounced .

2. Variability of temperature from year to year

Generalization of data on water temperature on standard sections in the area of Labrador - Newfoundland for 1936-1941, 1949-1959 was made by A.A.Elizarov and L.A.Zotov (1960) and A.A.Elizarov (1962) mainly in accordance with the observations of the International Ice Patrol. We have continued these works.

As concerned the area of Labrador, section 8-A, the data on temperature of the 0-200 m layer of the cold component of the Labrador Current (AB) were at our disposal; these data were adjusted to the 15 of July for the years 1936, 1938-1941, 1948-1964 and 1969, and to the 1 of November for the years 1958, 1962, 1964-1970. In Fig. 6 curves 1 and 2 represent variations of this temperature in the years mentioned. In 1950-1968 one can easily single out three periods, comprising four years each, and two periods, comprising three years. As a rule, in each period one can single out two "cold" years (1950, 1954, 1957, 1960, 1964 and 1968) and one "warm" year (1953, 1955, 1958, 1961, 1966). Judging by this revealed rhythm, one can make a supposition, that the last cycle,which has begun since 1968, will finish in 1971. Temperature variations for the term of 3-4 years are registered in other parts of the ocean as well (Bochkov, Sarukhanyan, Smirnov, 1968).

G.K.Izhevsky (1964) showed, that fluctuations of water temperature in the areas of the Northwest Atlantic and in the Barents Sea occur in anti-phase. A.A.Elizarov (1962) proved this for the years 1936, 1938-1941, 1948-1959, and obtained the coefficient of correlation higher than 0.7.

During the analysis of the data, presented in the given paper, it was found, that the same fenomenon is characteristic of the fluctuations of the yearly mean temperature of the 0-200 m layer on the Kola section in the Murmansk Current. This was demonstrated by the temperature on the section 8-A in the cold component of the Labrador Current (AB), which was adjusted to the 15 of July for the years 1936, 1938-1941, 1948-1965, and to the 1 of November for the years 1964-1970 (Fig. 6, curves 1,2 and 3). It should be noted, that the reverse relation especially distinctly marks itself in the abnormally warm and cold years, which are difficult to be predicted by means of the methods available (Bochkov, Sarukhanyan, Smirnov, 1968).

Then, year to year variations of the yearly mean temperature of the 0-172 m layer at the station 27 in the Coastal jet of the Labrador Current were analysed (Fig. 6, curve 4). Data of observations conducted at this station in every year in the period 1950-1962 are loaned from a paper by Templeman. As seen from Figure 6, temperature at the station 27 ranges in one and the same phase with the temperature of the 0-200 m layer in the cold component of the Labrador Current on the section 8-A in July. The 4 and 3 year cycles for July, registered on the section 8-A can be easily traced in yearly mean variations of temperature at the coastal station 27.

The marked synchronism makes it possible to make a conclusion, that the temperature of the 0-200 m layer on the section 8-A of the cold component of the Labrador Current and yearly mean temperature of the 0-172 m layer on the station 27 change in connection with one of the main reasons, namely, the intensity of the Labrador Current.

The anti-phase relationship is observed between variations of temperature on the station 27 and that of on the section "The Kola Meridian"; it was correlated for the period 1950-1962. For this series of observations the obtained correlation coefficient is 0.523, the stability of the relation being less than 3. Thus, the availability of the reverse relation is proved, but the connection happened to be unstable, perhaps, due to the fact, that the revealed relationship is curvilinear.

The identification of periodicities of year to year variations of water temperature, related to the sun activity, was carried out at the station 27. The curve of the sun activity, expressed in Wolf's digits for the period 1943-1967, is presented in Fig. 7 (curve 2). The relationship between the sun activity and the mean monthly temperature in the surface layer at the station 27, can be traced 3-4 years later (Fig. 7, curve 1). Such a phase shift was registered also in the Barents Sea and is described in the paper by Bochkov, Sarukhanyan and Smirnov (1968).

The most complete picture of temperature variations by months for 1960-1970 can be obtained from the graphs of isopleths for every year (Fig. 8). These isopleths were compiled according to the mean temperature of the 0-200 m layer of the sections 8-A, 3-A, 2-A, and 1-A by separate regions, given in Fig. 1.

On these sections worked off Labrador and on the Grand Bank for the period from 1960 to 1970, a cold wave can be traced in the first half of the 1963 and 1964. On the other hand, warm waves were registered in 1965-1967. They were especially distinctly marked in the second half of the year (sections 2-A and 8-A). The quantity of observations being great enough, the graphs of such isopleths represent the picture of year to year variations. It is interesting, that a considerable cooling or heating simultaneously affects the whole area from Labrador to the south of the Grand Bank, though, according to G.K.Izhevsky, they are situated in the areas, which have different phases of the thermal regime.

This synchronism rather clearly marks itself in the waves of warmth (1965-1967) and cold (1963-1964), registered on the section 8-A in the layer of 50-200 m in the Labrador Current at Labrador and on the section 2-A in the 50-100 m layer in the extreme south of the Grand Bank (Fig. 9).

Conclusions

1. Four types of curves of the seasonal variation of temperature have been identified:
(I) for the area of Labrador, with two minima - in April and in July, and with two maxima - in June and November; (II) for the coastal Newfoundland waters, foe Eastern and North-eastern slopes of the Grand Newfoundland Bank with the minimum

in March-April and maximum in October; (III) for the Southwestern slope of the Grand Newfoundland Bank, the minimum being observed in March and the maximum in August ; (IV) for the Southern and Southwestern slopes of the Grand Newfoundland Bank with the minimum in April and maximum in September, an inconsiderable rise of temperature being registered from January (February) to March.

2. The analysis of year to year variation of temperature made for the section 8-A revealed 3 and 4 year cycles, which can be traced in the same succession also for the mean yearly temperature at the section 27 in the coastal waters of the Newfoundland Island.

3. Temperature fluctuations on the section 8-A at the station 27 are in anti-phase towards fluctuations of the mean yearly temperature on the section "The Kola Meridian" in the Barents Sea.

4. Waves of cold (1963-1964) and warmth (1965-1967) are revealed according to the graphs of isopleths of the monthly variations of temperature. These waves have determined the thermal regime of waters for the last eleven years.

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Table 1

The curves of the yearly variation of mean temperature in accordance with the time of extrema coming on the sections in the areas of Labrador, Newfoundland and at the station 27.

Sections	Climatic		Dynamic	
	Minimum	Maximum	Minimum	Maximum
8-A, 7-A, 6-A	March-May	June-July	July-Aug.	Sept.-Nov.
Station 27	March	October	-	-
3-A, 2-A	April	August-Sept.	?	March
1-A, 4-A, 44-A	March-April	August	-	-

REFERENCES

ADROV,M.M., 1962. Hydrologic investigations off West Greenland. Sovetskie rybokhozyaistvennye issledovaniya v severo-zapadnoi chasti Atlanticheskogo okeana. Moscow.

BOCHKOV,Yu.A.,SARUKHANYAN,E.I.,SMIRNOV,N.P.,1968. Main regularities of many years' changes of water temperature in the Barents Sea and their relation to geophysical processes. Trudy PINRO, vyp. 23, Murmansk.

ELISAROV,A.A. and L.A.ZOTOV, 1960. Fluctuations in temperature of the Labrador Current in the Grand Newfoundland area. Sovetskie rybokhozyaistvennye issledovaniya v moryakh Evropeiskogo Severa. Moscow.

ELIZAROV,A.A., 1962. On the interannual fluctuations of intensity in the Labrador and West Greenland currents and on the possibility of temperature prognosis in the commercial areas of the North-Western section of the Atlantic Ocean. Okeanologiya, No. 5.

IZHEVSKIY,G.K., 1964. Systematical basis for forecasting the oceanographical conditions and reproduction of commercial fishes. Moscow.

KÜLERICH,A:,1943. The hydrography of the West Greenland fishing banks. Medelelser fra Komission for Danmarks Fiskerag Havundersogelser. Serie: Hydrograpfi; Bd II, No. 3, Kobenhavn.

TEMPLEMAN,W., 1965. Anomalies of sea temperature at station 27 of Cape Spear and temperature at Torbay - St.John's. ICNAF, Spec. Publ., No.6.

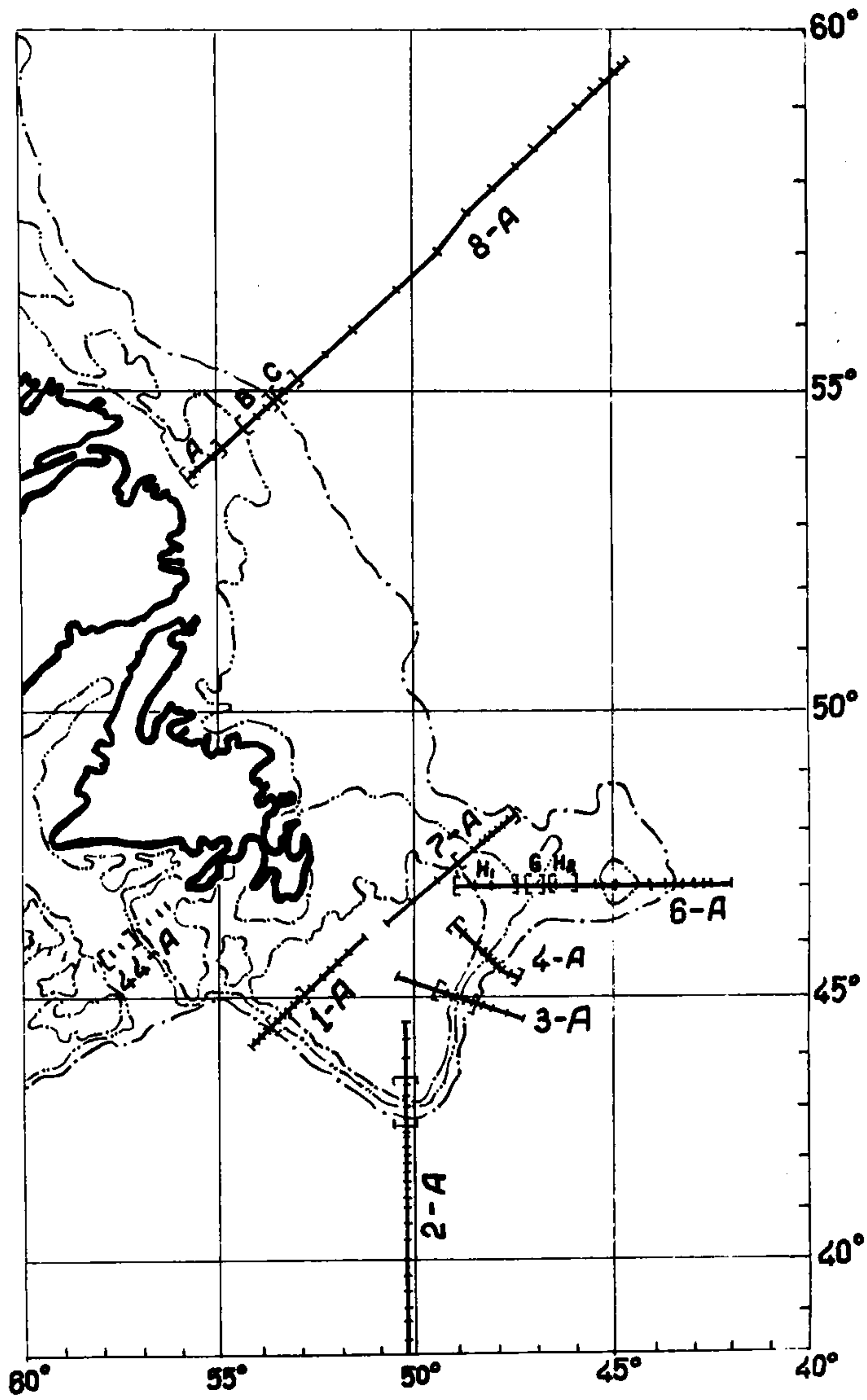

Fig. 1 The position of the standard hydrological sections in the areas of Labrador and Newfoundland (the stations are given in brackets, according to which the mean temperature was calculated).

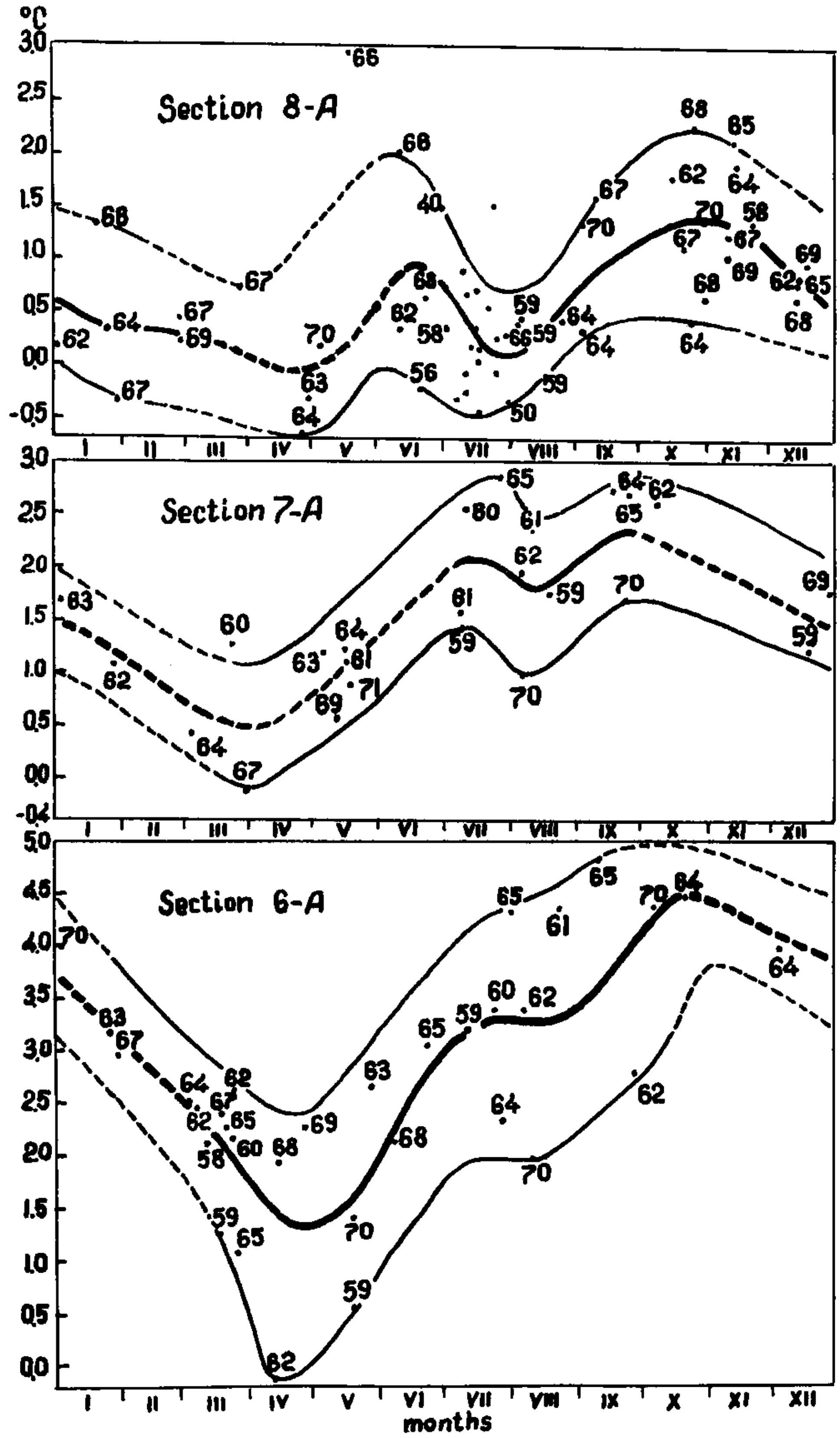

Fig. 2 Seasonal variation of temperature in the 0-200 m layer on section 8-A (B), 7-A and 6-A (figures mark the years of observations).

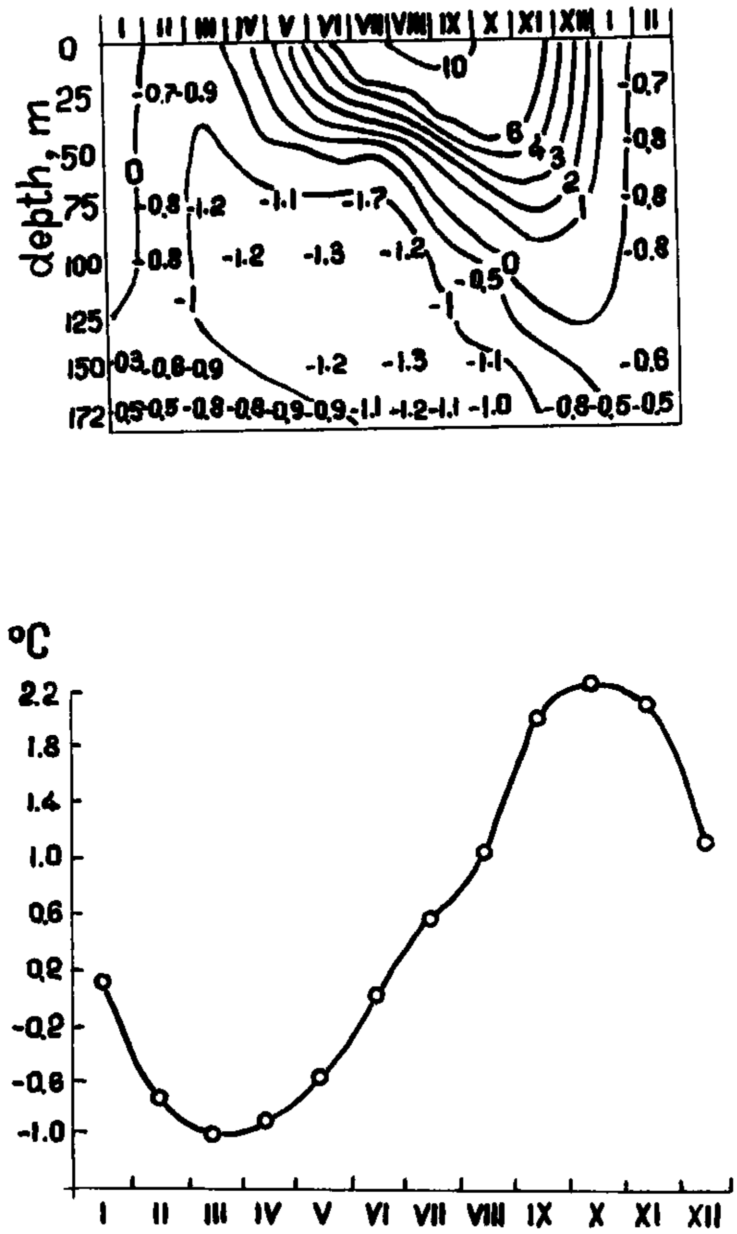

Fig. 3 Isoplets of temperature for 1950-1962 at the station 27 at the Cape Spear near the town of St. John's (in the upper part) and seasonal variation of the mean temperature of the 0-172 m layer for the same period (at the bottom of the figure).

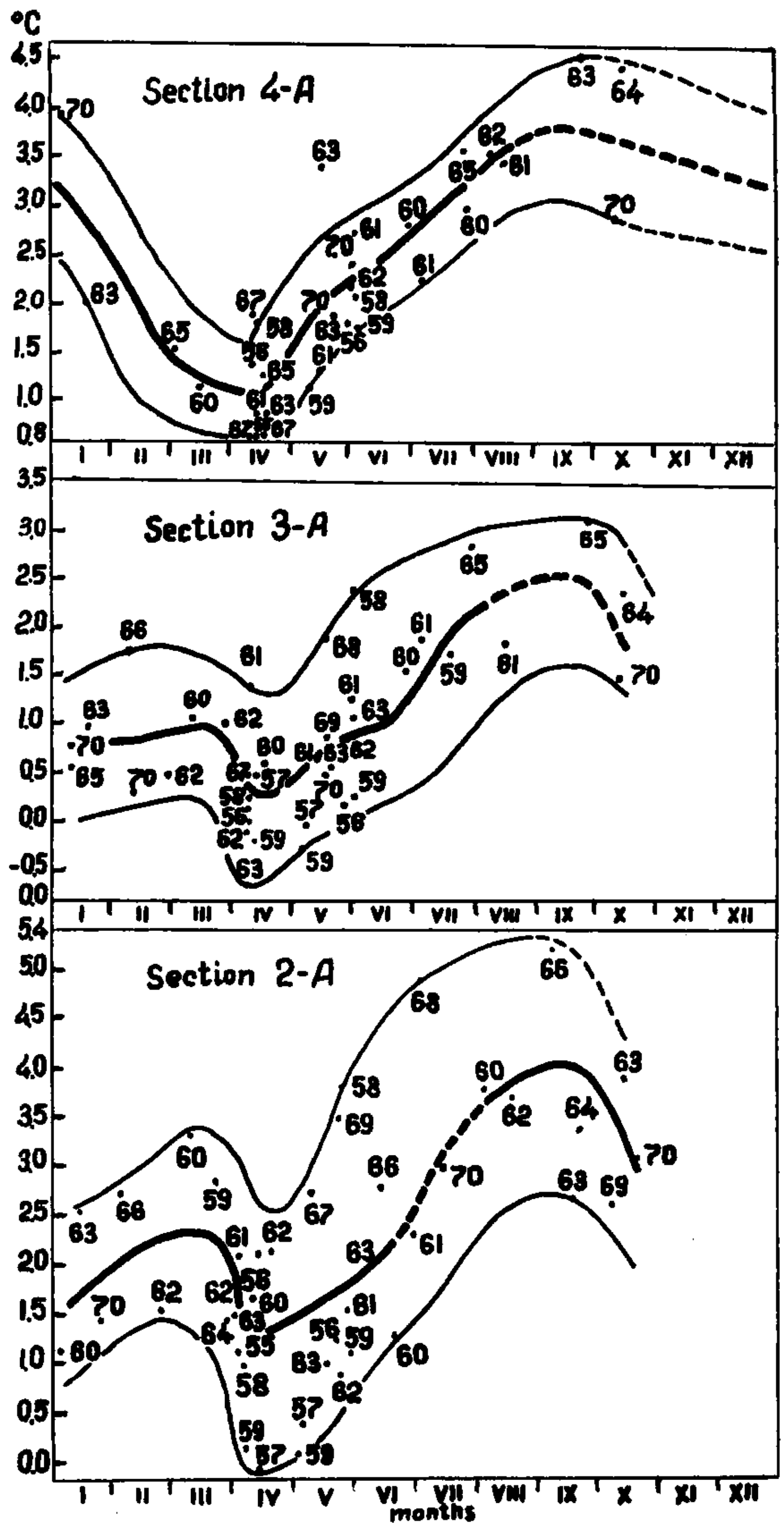

Fig. 4 Seasonal variation of temperature of the 0-200 m layer on the sections 4-A, 3-A, 2-A (figures mark the years of observations).

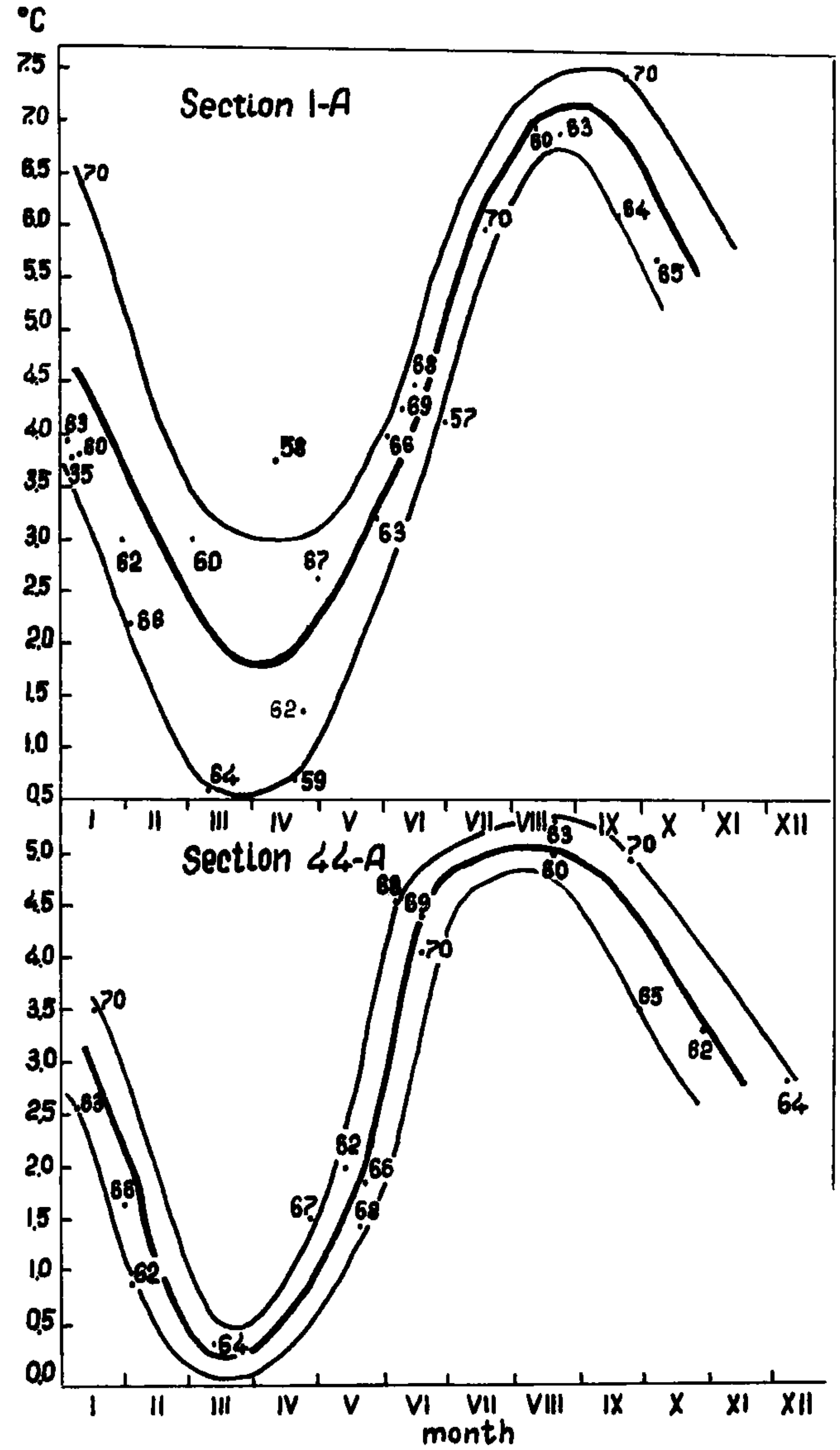

Fig. 5 Seasonal variation of temperature of the 0-200 m layer on the sections 1-A and 44-A (figures mark the years of observations).

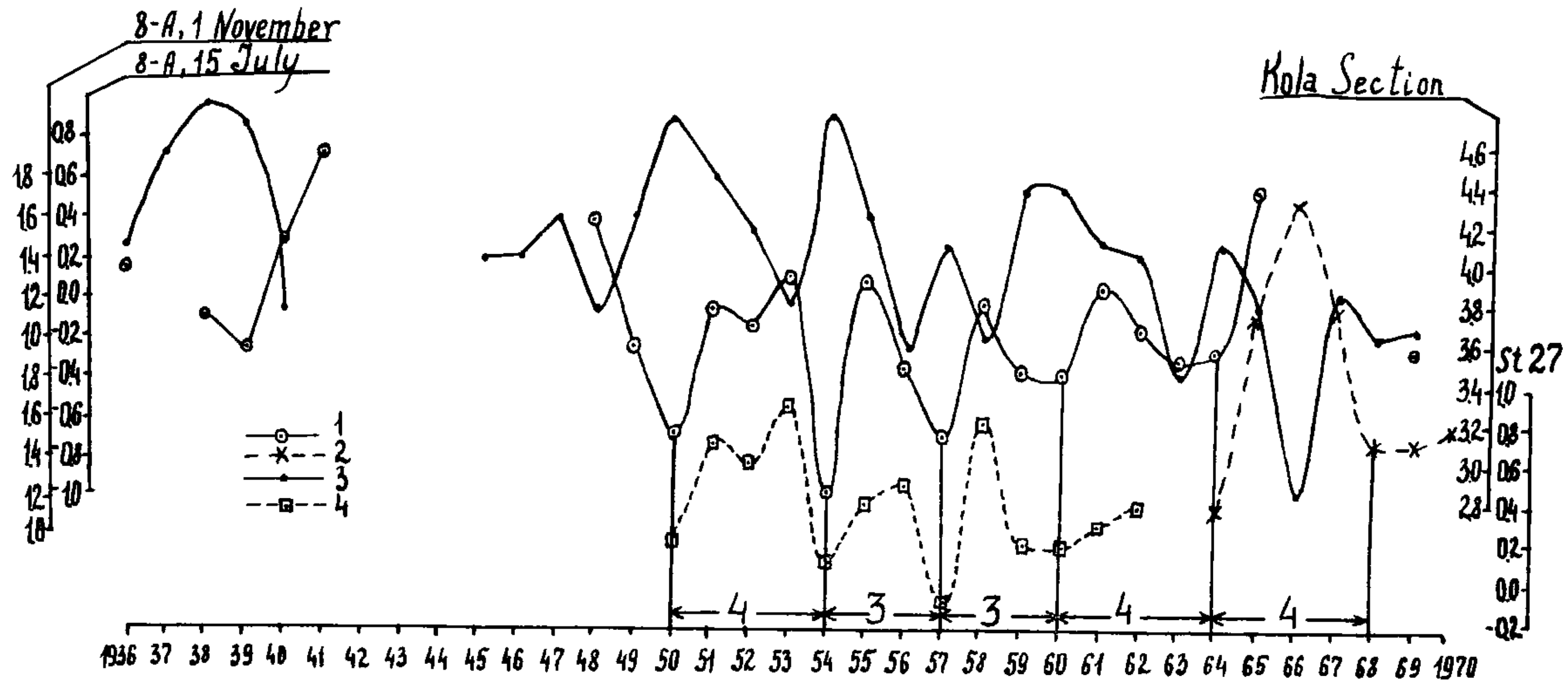

Fig. 6 Year to year fluctuations of temperature of the 0-200 m layer:

1) of the cold component of the Labrador Current on the section 8-A, adjusted to the 15 of July, 1936, 1938-1941, 1948-1964, 1969;

2) adjusted to the 1 of November for 1958, 1962, 1964-1970;

3) the mean yearly temperature on the section "The Kola Meridian" in the Barents Sea for 1936-1940, 1945-1969;

4) the mean yearly temperature on the station 27 and off the island of Newfoundland for 1950-1962.

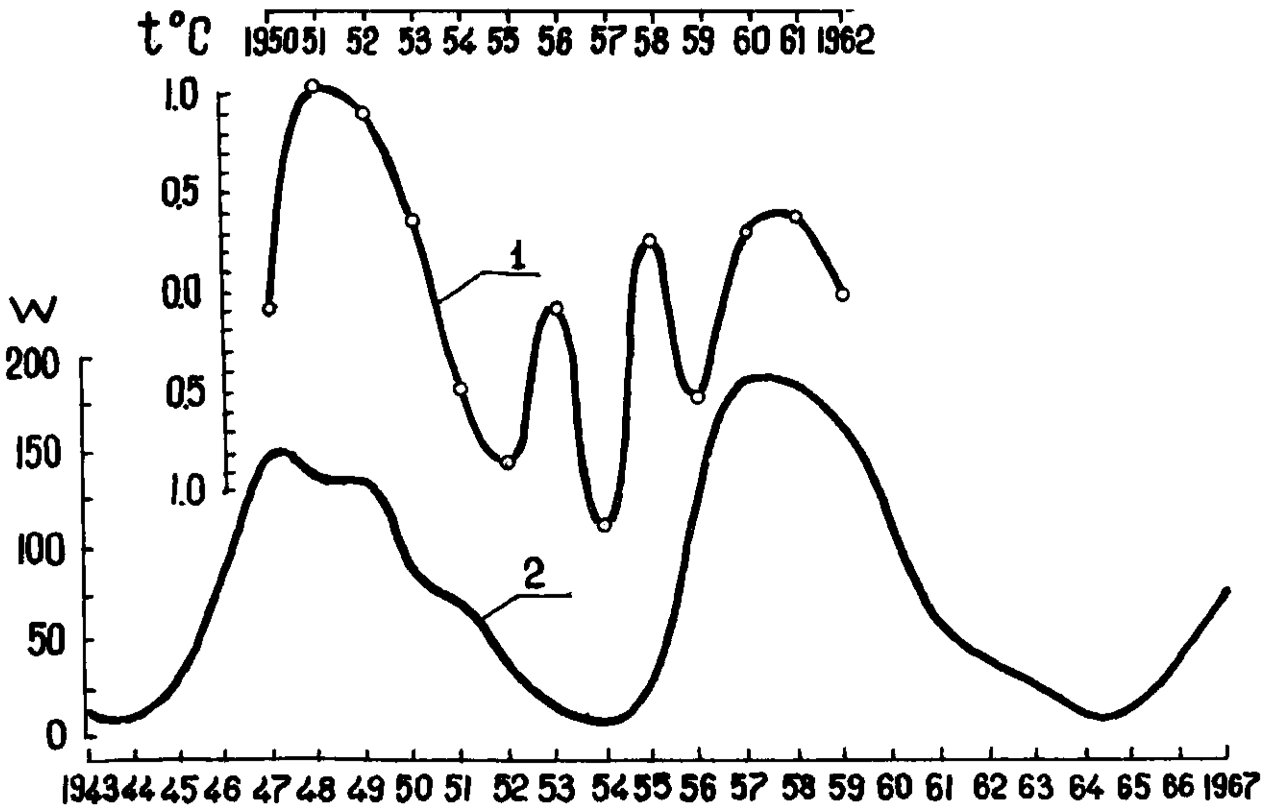

Fig. 7 Mean yearly variations:

1) of the surface temperature at the station 27 in 1950-1962;
2) of the sun activity for 1943-1967, as expressed by Wolf's digits.

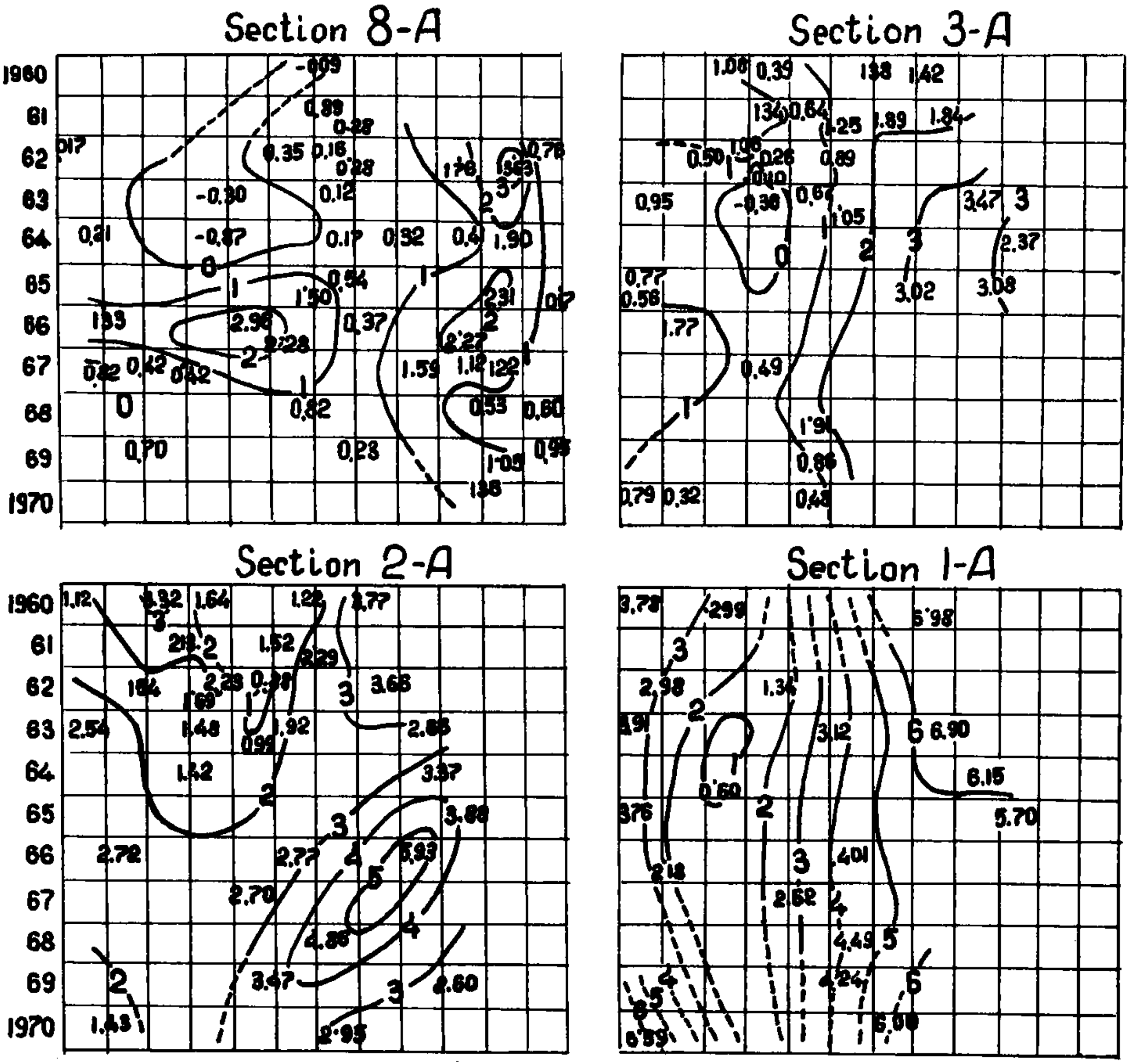

Fig. 8 Graphs of isopleths of the mean temperature of the 0-200 m layer for particular parts of the sections 8-A, 3-A, 2-A, and 1-A for 1960-1970.

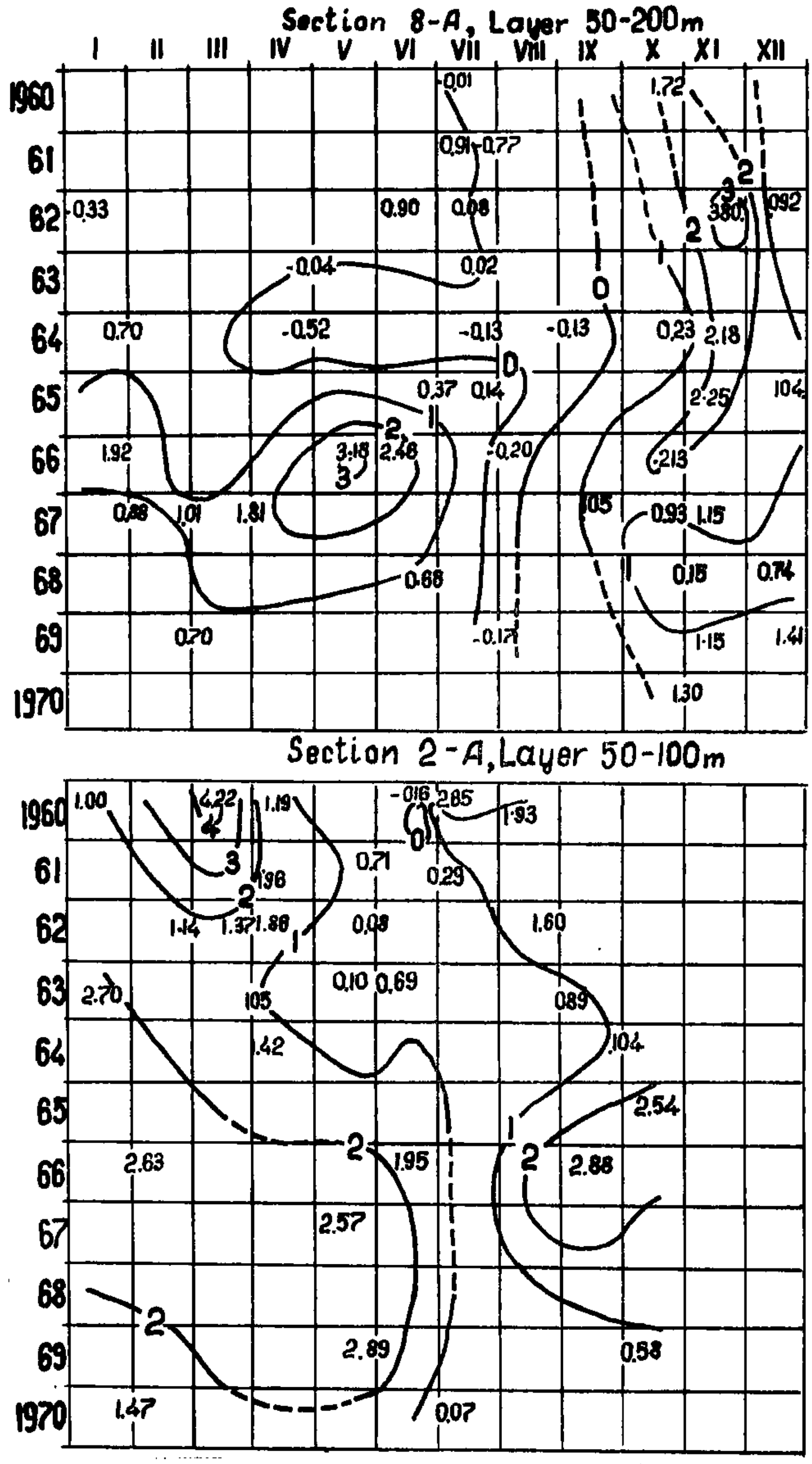

Fig. 9 Graphs of isopleths of the mean temperature of the layer 50-200 m on the section 8-A(B) and of the 50-100 m layer on the section 2-A in 1960-1970.