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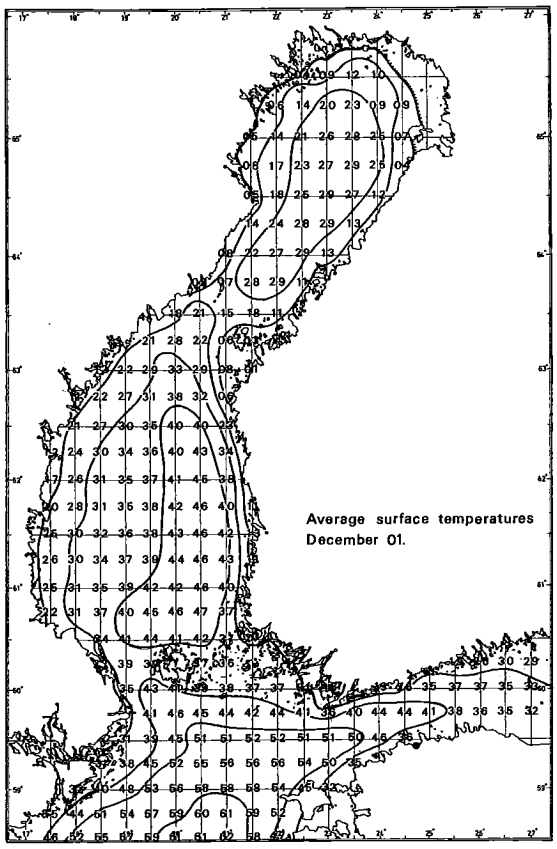
WINTER NAVIGATION RESEARCH BOARD

Research Report No 15

THE AVERAGE SURFACE TEMPERATURE IN THE AUTUMN AND THE EARLY WINTER ON THE GULF OF BOTHNIA, THE NORTHERN BALTIC SEA AND THE GULF OF FINLAND (1966—1974)



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INSTITUTE OF MARINE RESEARCH

UNIVERSITY OF HELSINKI, DEPARTMENT OF GEOPHYSICS

The average surface temperature in the autumn and the early winter on the Gulf of Bothnia, the northern Baltic Sea and the Gulf of Finland (1966—1974)

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Preface

The Winter Navigation Research Board presents its report Nr. 15. It is a research of surface temperatures in the Bothnian Bay, in the Northern Baltic and Gulf of Finland during the autumn and early winter of the years 1966-1974.

Surface temperatures of the autumn are of special significance for ice formation and shall be a base for rating the ice conditions in the coming year.

The investigation was accomplished by Professor Erkki Palosuo, University of Helsinki and Mr. Hannu Grönvall, Institute of Marine Research. The Winter Navigation Research Board wishes to express their thanks to scientists for the work introduced.

Helsinki and Stockholm February 1976

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The average surface temperature in the autumn and the early winter on the Gulf of Bothnia, the northern Baltic Sea and the Gulf of Finland (1966-1974)

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SUMMARY

The observation of the surface temperatures has nowadays become a still more important part of the ice service as in the autumn and winter the heat content of the various sea areas can be estimated with the aid of the surface temperatures, and thus give the management of the winter traffic forecasts conserning the forming of new ice.

By the help of surface temperature averages from several years an opinion can be formed about the particular current situation and the outlook on the development compared with an average winter can be estimated.

The temperatures in general in the sea areas surrounding Finland, the significance of the surface temperatures, the observation work and the calculation of the average maps have been dealt with below in this paper and also the average temperatures have been examined.

1. GENERAL ON TEMPERATURES

Parts of the sea areas surrounding Finland freeze in the winter. Bothnian Bay and the eastern part of the Gulf of Finland as far as Gogland freeze every winter, however, the Bothnian Sea and Gulf of Finland totally only in fairly severe winters. Only in very severe winters the ice cover reaches far into the Baltic Sea. The last time the entire Baltic Sea froze was in 1947.

The highest temperatures of the surface water are usually observed in the middle of August when the temperature of the surface water is almost 20° C in the Gulf of Bothnia and often over 20° C in the southern sea areas. Because of the temperature conditions in the summer the annual variations are big. At that time there is a warm surface layer in the sea reaching a depth of 20 - 40 metres. In the middle of August begins a rapid cooling of the water, at which time the temperature of the surface water drops before the beginning of September, in the northern sea areas to 13 - 14° C, in the southern sea areas to 14 - 16° C.

During the autumn storms in September-October the warm surface layer observed in the summer vanishes when the water gets mixed, at which time the water is of the same temperature to a great depth. At that time the temperature of the water has usually dropped to less than 10° C.

2. ON THE SIGNIFICANCE OF SURFACE TEMPERATURES

Continuous knowledge of surface temperatures is important for many reasons. For instance in weather forecasts, particularly for estimating the visibility and the mist, the surface temperature must be known. Likewise the fishermen follow the temperature in planning their fishing trips. In the late autumn and the winter the cold sea water in combination with the frost and gale create a considerable

danger factor especially to small craft as the ice begins to get hold of the various structional parts of the craft.

This paper concentrates on observing the knowledge of temperatures with the estimating of the severeness of the ice winter in view, and considering the needs of the winter traffic management.

As the water generally in October has the same temperature to a depth of dozens of metres, the water of different temperature deeper down can be considered not to have any influence on the cooling of the surface water and thus on the freezing (not even in connection with storms will there be any mixing with the deeper layers of water). Thus the heat reserve of the sea areas can be calculated with sufficient accurary on the basis of the surface temperatures. Changes of heat content can by then only be caused by advection, which might bring additional heat particularly to the Gulf of Finland, the northern Baltic and the Sea of Bothnia.

It is clear that the forming of the ice cover in every case depends in the first place on the weather, that is, the temperatures of the air and the wind conditions, however, the extent of the heat content might cause alterations of several days, even weeks at the times of freezing. In other words, in average weather the freezing is nearly a function of the heat content. The management of the winter traffic can, in many various ways, profit the knowledge of the heat content when planning the operations of the icebreakers.

Thus the placing of the icebreakers and the decisions concerning the time and range of the traffic restrictions need the support of sufficient information about temperatures in different sea areas.

3. TEMPERATURE SERVICE AS A PART OF MODERN ICE SERVICE

Before the freezing the heat reserves of the various sea areas are followed up by measuring the temperature of the surface water twise a week on Mondays and Thursdays at the coastal stations as well as on the open sea. The observations thus received are marked out on a map, which is analyzed. By comparing the analysis to the average temperatures, which are shown on the maps an idea about the duration of the ice winter can be formed. The following up of the temperatures is usually begun by the middle of October. The maps are delivered by various modern means like picture transmitters at the disposal of seafarers.

4. AVERAGES OF THE SURFACE TEMPERATURES; OBSERVATION MATERIAL

4. 1 Averages of the surface temperatures

Since 1966 there has been at the Institute of Marine Research sufficient material available for the drawing of comparatively exact temperature maps.

At the same time, right from the start the aim has been to obtain observations from several years in order to enable the calculation of average maps for various sea areas thus obtaining an object of comparison for the actual temperatures. The averages are calculated from the observations of 1966-74 so that the observations from the autumn 1966 and January 1974 are included, that is eight years.

4. 2 Observation material

The surface temperature observations have been achieved in many various ways. The main part are the values obtained by means of infrared thermometer from an aeroplane.

Other points of observation have been various vessels such as the state icebreakers and the ferries in regular line traffic as well as the stationary observation stations operating from the coast. It

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has also been possible to benefit rather much of the observations made from the research vessel Aranda, as Aranda in the autumn 1968 started to make regular research expeditions to the Gulf of Bothnia in the late autumn and early winter.

Near the shore of Sweden it has been possible to use the SMHI system of observation of surface temperatures, which is tecnically similar to that of the Institute of Marine Research (cf. J-E. Lundqvist et al. 1974). Regarding the different temperature measuring devices reference is made to a paper previously published in this series (cf. above).

5. ON THE ERRORS PRESENT IN THE TEMPERATURE OBSERVATIONS

At the measuring of the surface temperature of water is not a simple task the measuring values include sometimes actual mistakes or deviations caused by the circumstances. Although the observers of the Institute of Marine Research are made well acguainted with their task occasionally faults will appear, because of inexperience, particularly on the vessels. The biggest mistakes can immediately be filtered out of the material and it could be said that the remaining ones do not even affect the decimal tenths of the averages, which is the accuracy of the maps. On the other hand all kinds of deviations might appear, the most important of which are the daily variation in the surface temperature (a factor depending of the weather), and a very thin (less than 1 mm thick) film, which is cooler than the water mass below, appearing in special weather conditions (in cloudless cold weather) on the surface of the sea. The former is in the autumn a factor of comparatively minor consequence. The latter type of deviation especially occurs when using infrared thermometer from an aeroplane. An attempt has been made to eliminate it by calibrating the thermometer during the flight with several stationary measuring stations and in this way it has been possible to take the

differences in the readings in the various sea areas into consideration.

6. CALCULATION OF THE AVERAGE MAPS

The average maps are calculated for the 1st, 11th and 21st day of each month so that the first map is for the 21st October and the last one for 21st January. The corresponding temperature maps for the various years (1966 - 1974) have been analyzed as carefully as possible and by interpolating the corresponding temperature has been fixed for the various grating points. The grating points have been determined so that the north-south co-ordinates have been divided into intervals of 15 minutes and the east-west co-ordinates into intervals of 30 minutes. Thus there is a total amount of 269 grid points (the area reaches the height of Fårö beacon). In every grid point the average of the temperatures has been calculated separately and the average maps obtained in this way have been analyzed.

7. CONSIDERING OF THE ICE

In cases where ice has appeared in the grid points the median has been taken as rate of temperature. In this way also the edge of the ice field has been included in the average maps but no attention has been paid to the quality of the ice.

8. ON EXAMINING AVERAGE MAPS

In all maps clearly appears the influence of the southern advective heat on the Bothnian Sea near the coast of Finland and the western and middle parts of the Gulf of Finland.
In the southeastern part of the Bothnian Sea and the middle parts of the Gulf of Finland the water is on an average of the same temperature until the middle of December. In the northern Baltic the water is approximately two degrees warmer than in the southeastern part

of the Bothnian Sea. In both cases the water area farther to the south is cooling more rapidly after the middle of December. The farthest corner of the Bothnian Bay is completely covered by ice as far as the southern side of the Kvarken. In the Gulf of Finland the open sea is by that time covered by ice from the east up to Gogland and in the Archipelago Sea. The inner archipelago is covered by ice from Turku up to the neighbourhood of Lohm and Kustavi. On the 21st of February when the last average map is available, there is over 1°C warm water on an average in the Bothnian Sea. In the northern and middle part of the Baltic the temperature of the water is approximately 3°C. In the first part of March, when the largest ice situation on an average is reached, the Bothnian Sea is covered by ice, likewise are the Gulf of Finland and the northern Baltic. In the middle part of the Baltic the temperature of the surface water is approximately 1°C.

Map symbols

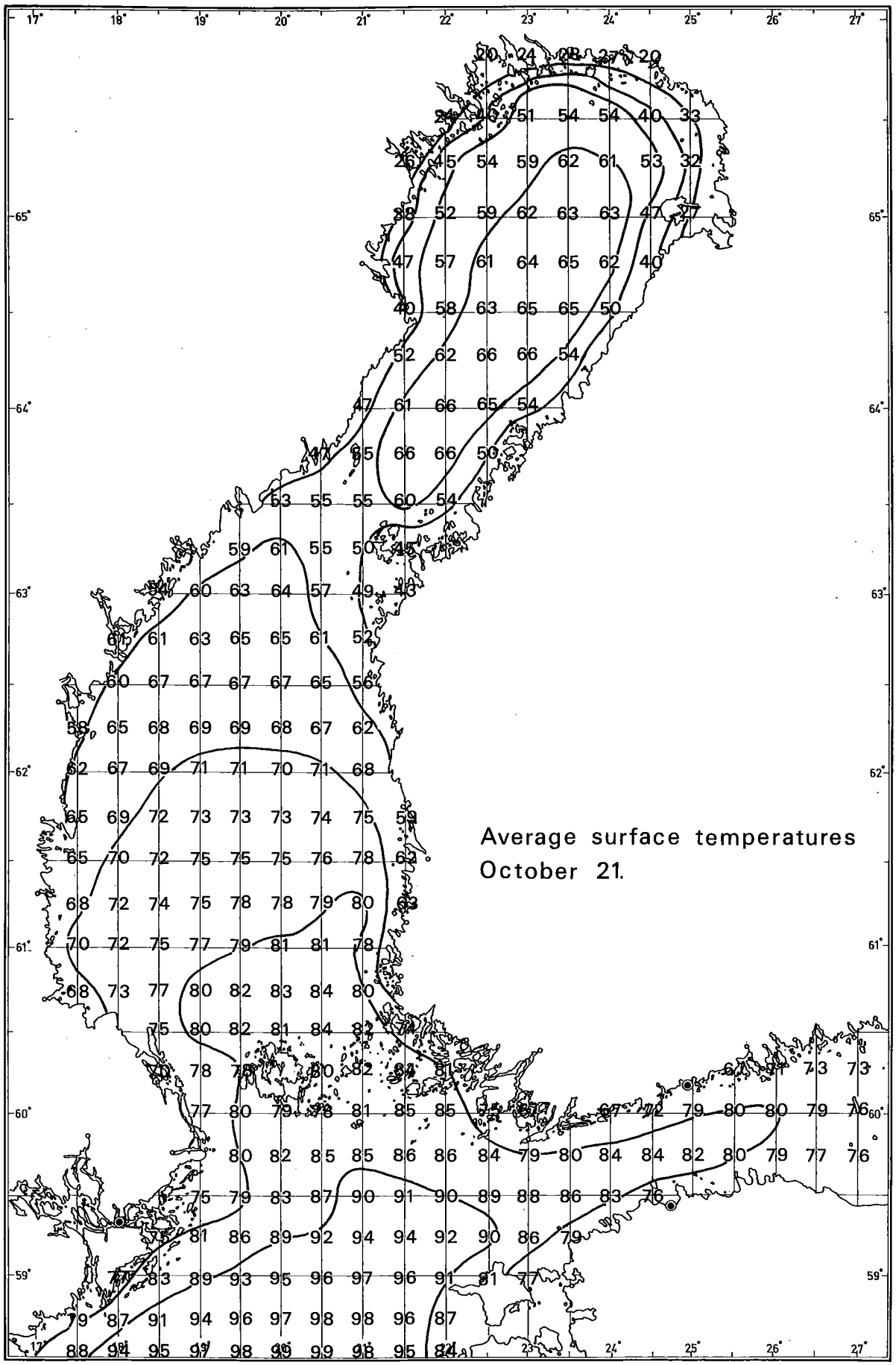
05 median of the temperature

00
05 in the same gridpoint = median of the temperature between 00 and 05

ice limit

Reference

Lundqvist, Jan-Erik, Omstedt, Anders och Udin, Ingemar, 1974: Kartering av ytvattentemperaturen i vattnen runt Sverige. Styrelsen för vintersjöfartsforskning n:o 9.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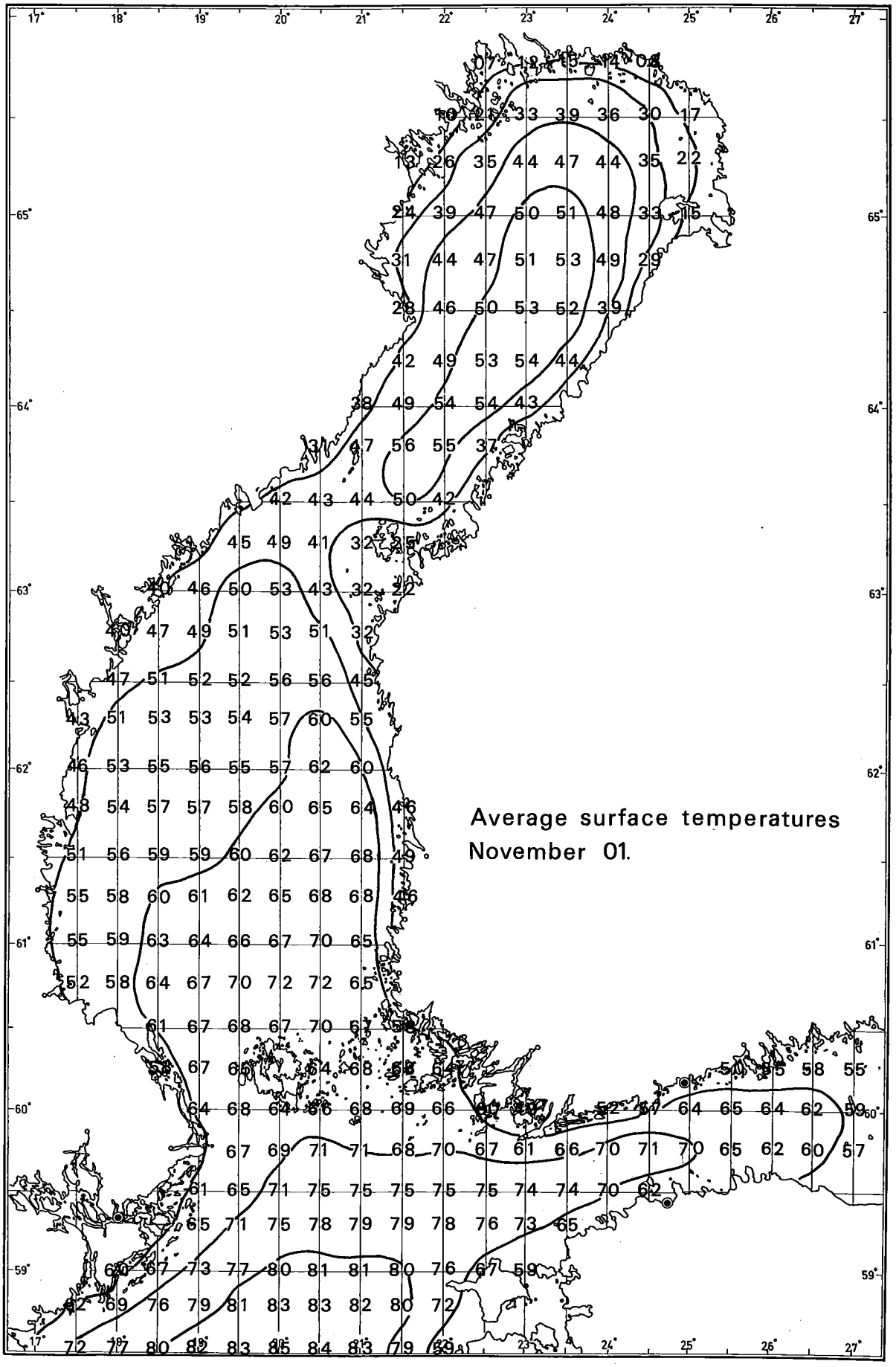
October 21.



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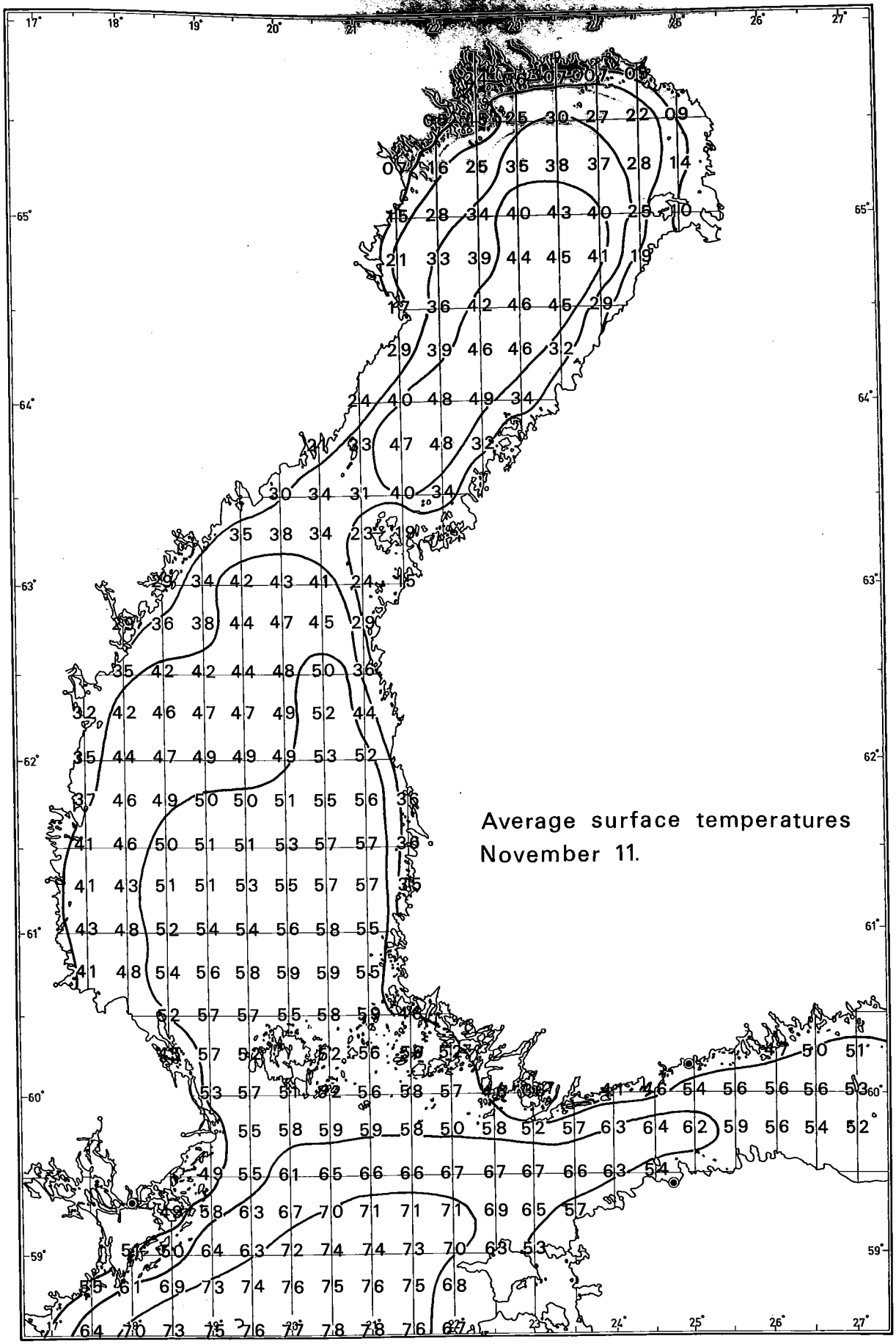
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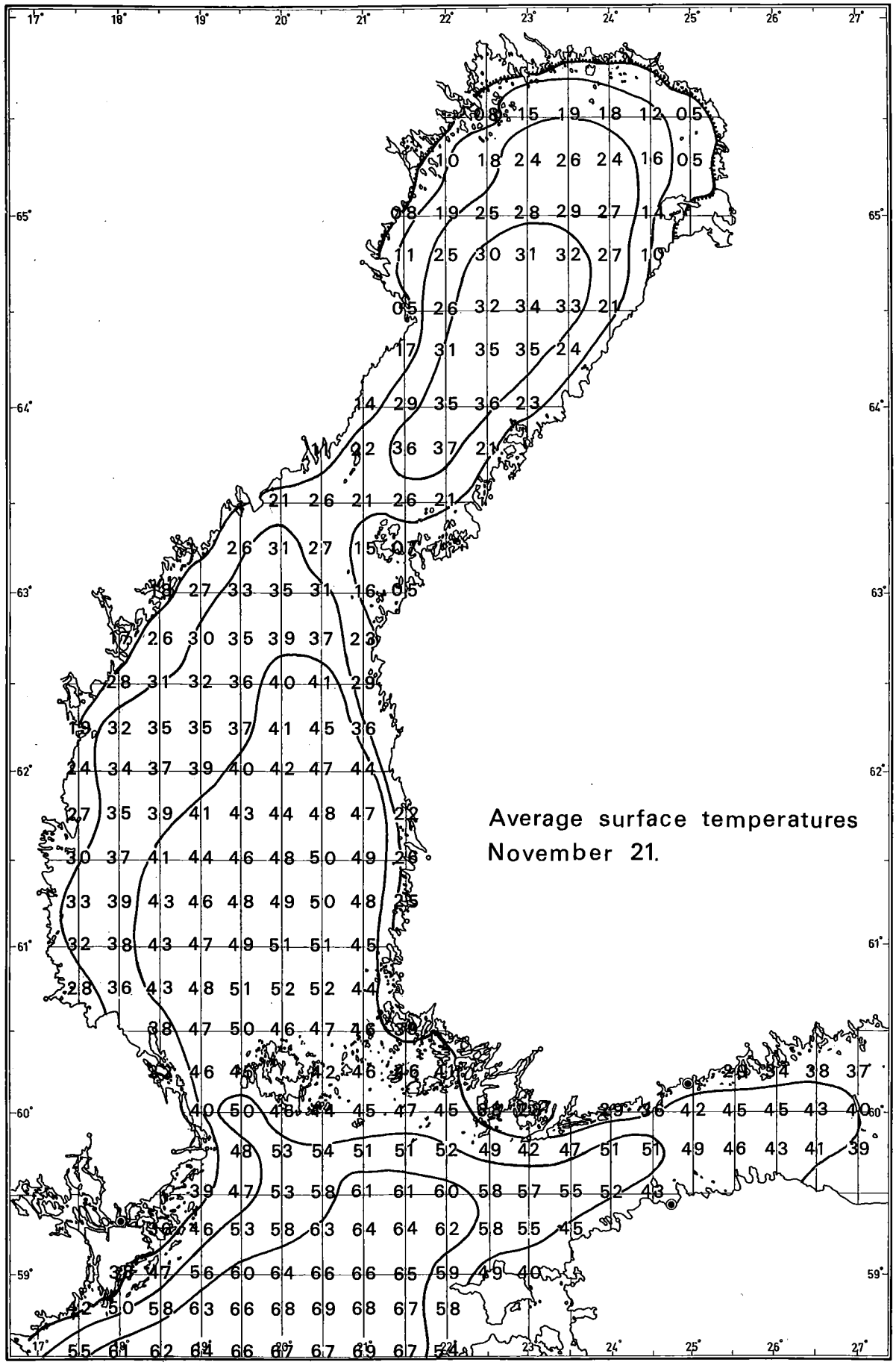
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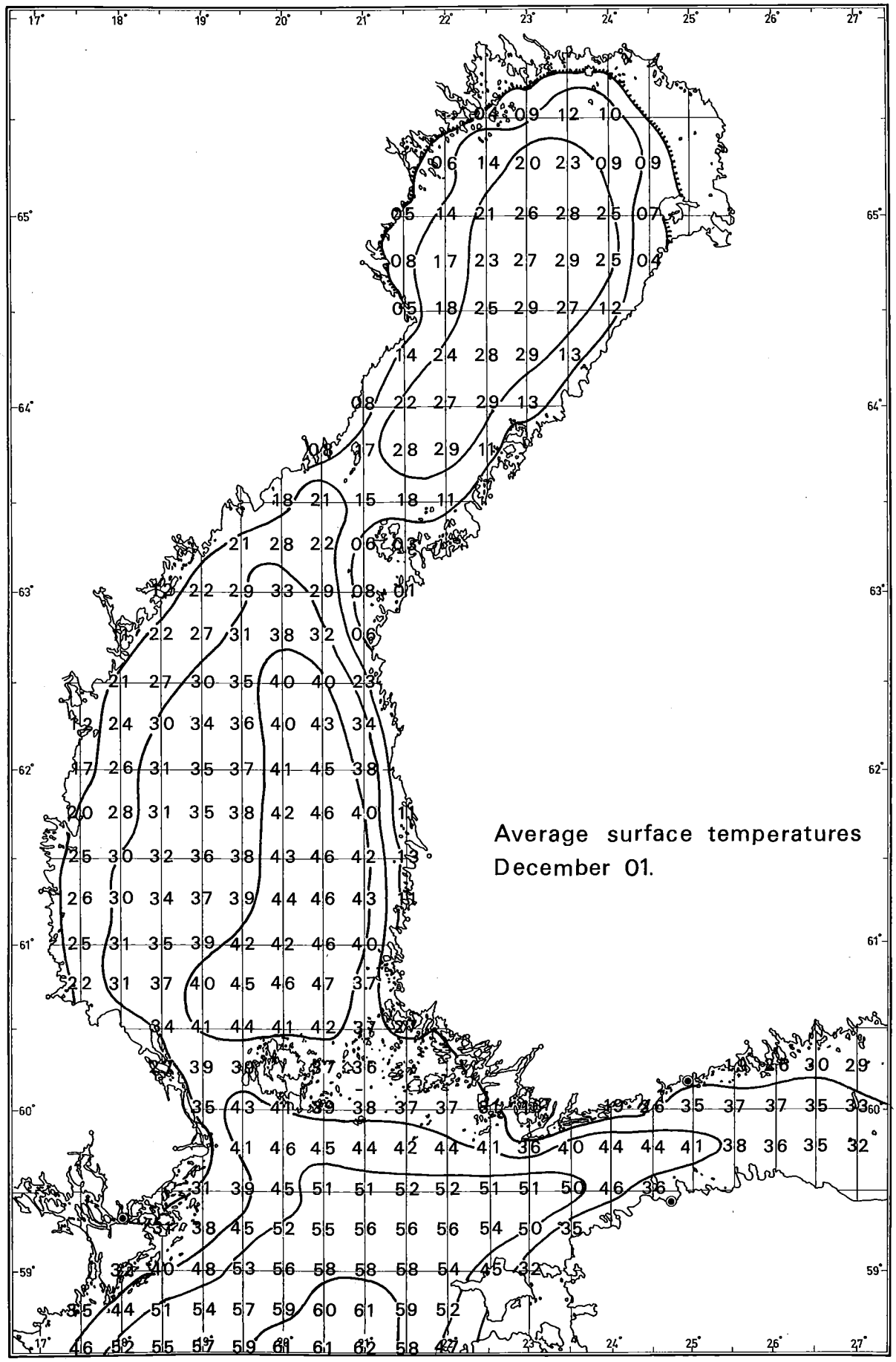
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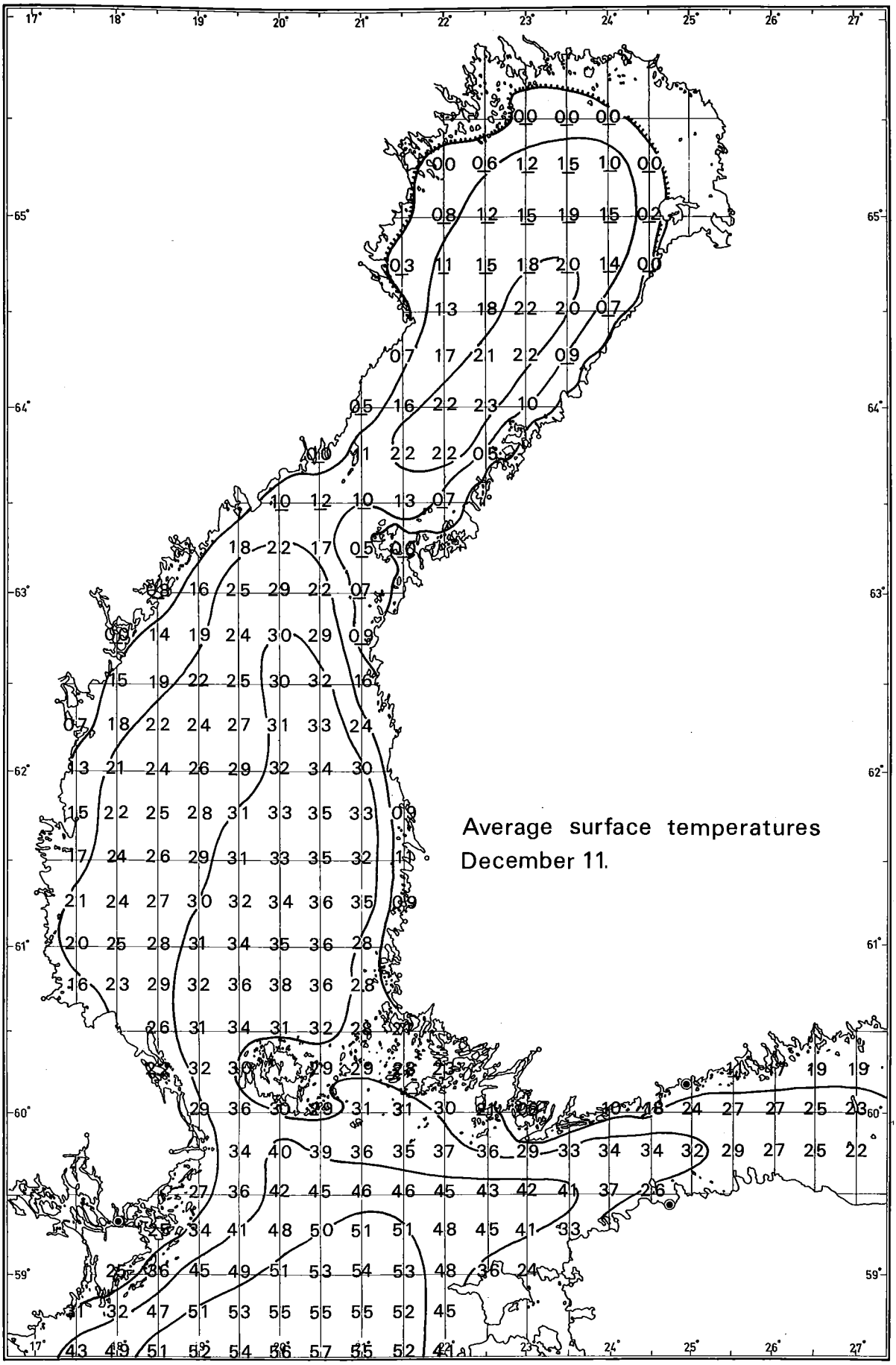

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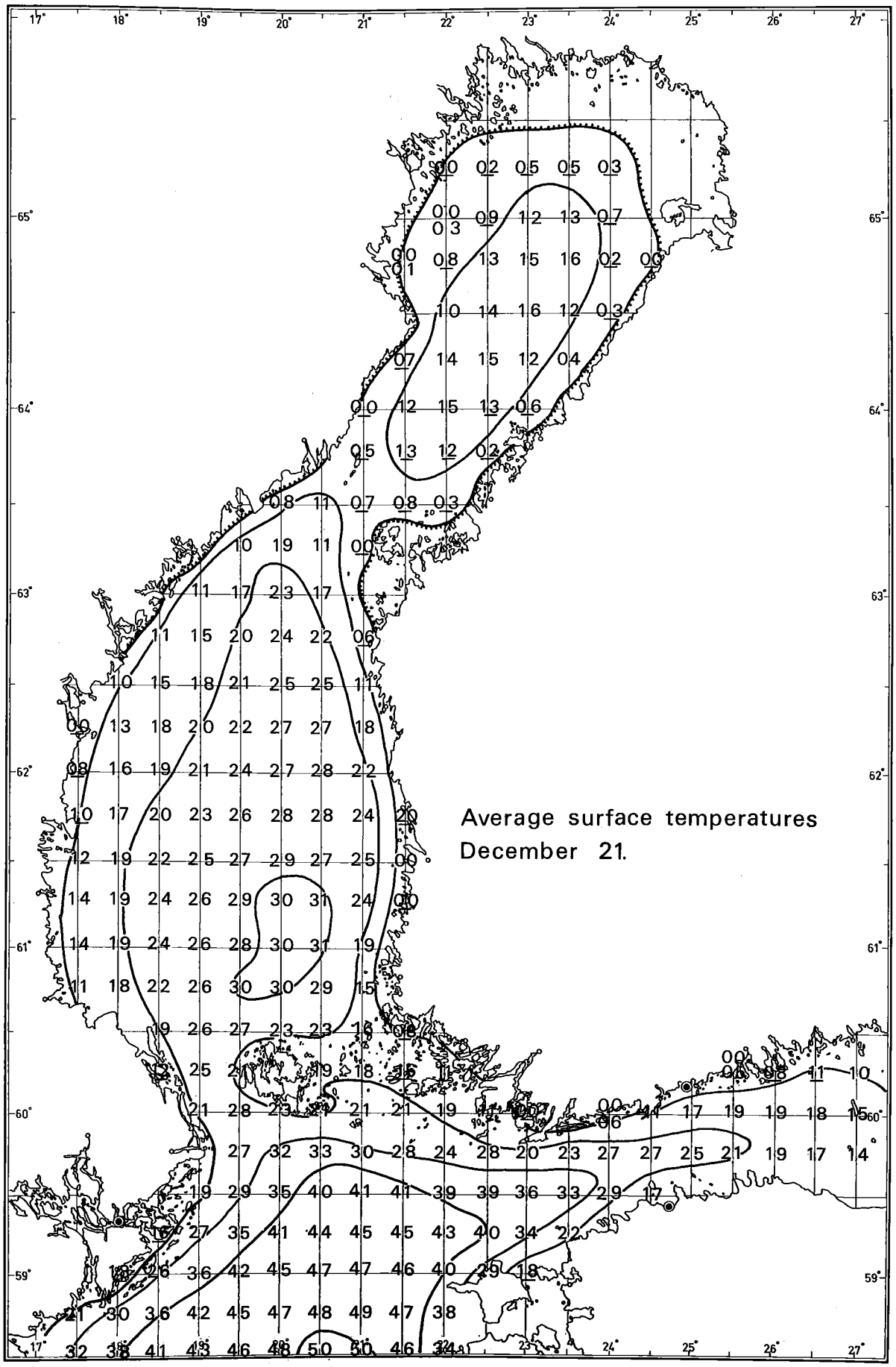

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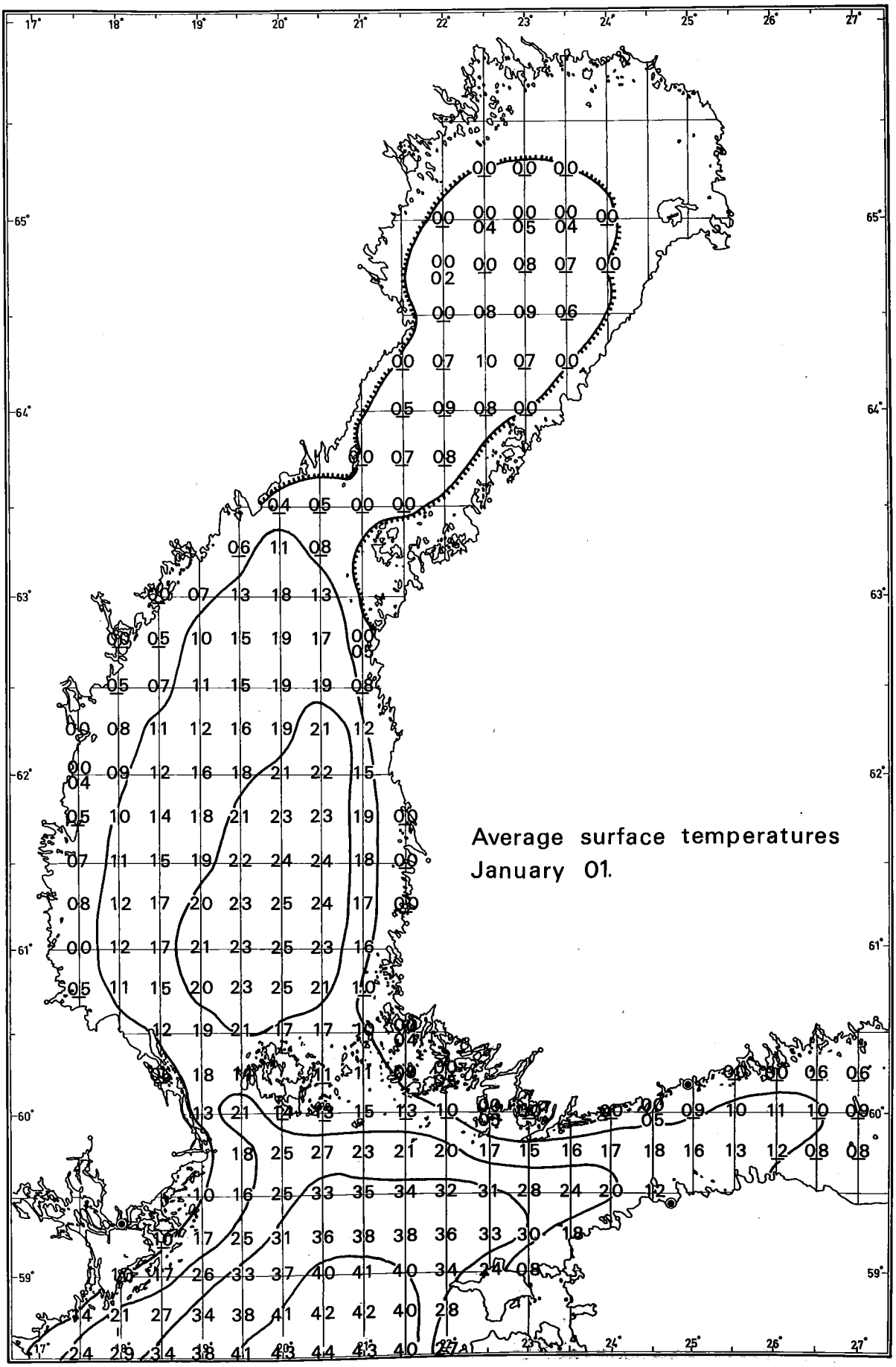
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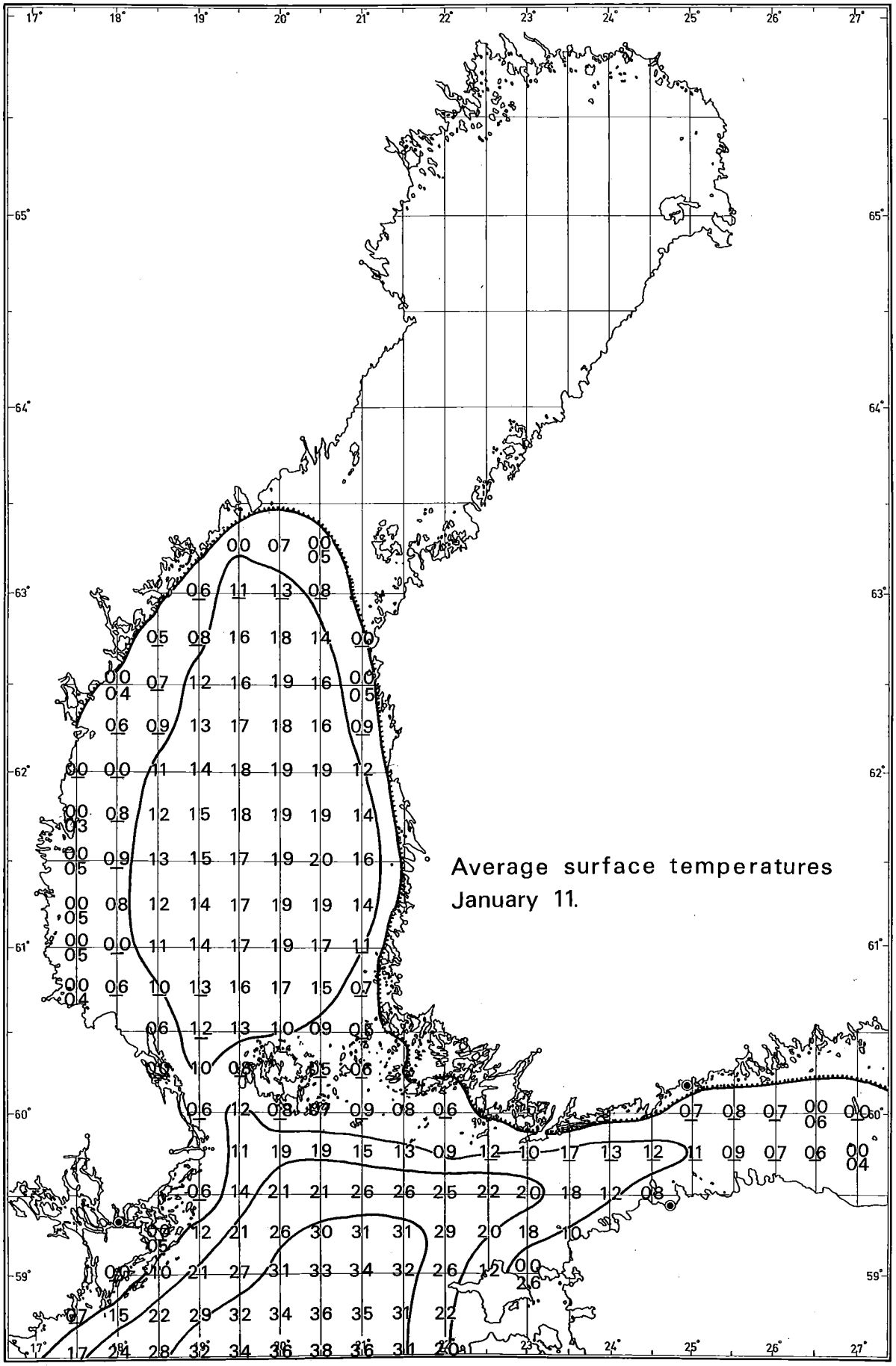
January 01.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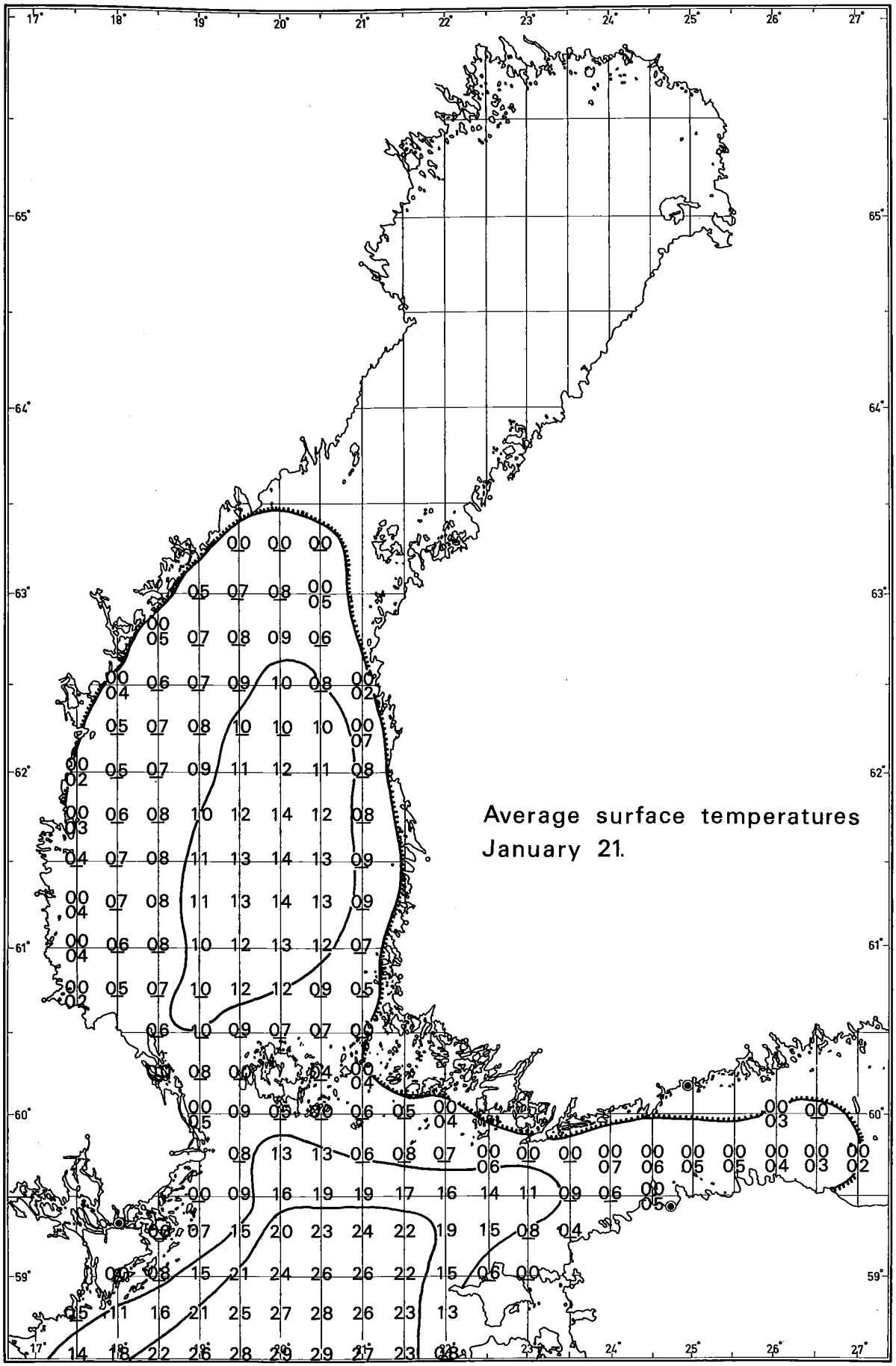
Average surface temperatures
January 21.