SOME RESULTS OF LONG-TERM HYDROGRAPHIC INVESTIGATIONS AT THE STONCICA STATION (MIDDLE ADRIATIC)

(Preliminary Report)

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The paper comprises the hydrographic material (T° and Cl ‰) collected at the Stoncica Station (N 43°00' E 16°20') near the Island of vis in the Middle Adriatic during the period from 1948 through 1963 . The data have been processed in such a way that the chlorinity and temperature values are presented as parameters on the time/depth graphs. So it was possible to read the parameter values for the 15 th day of most of the months under survey. In such a way, monthly averages for a sufficient number of layers (0, 10, 20, 40, 50, 60, 80, and 100 metres) were obtained, by means of which the normal annual T° graph and a similar normal annual Cl ‰ graph were drawn for the Stoncica Station.

The constructed normal annual graphs show some of the characteristics of the investigated part of the Adriatie. The T° indicates the phenomenon of upwelling obviously occurs in the area in the summer months, which is a new observation for the Adriatic Sea.

The differences between the values of the data referring to any year and the values of the normal annual data represent the anomalies. An easy way of obtaining the characteristics of a year is to examine the graph showing the anomalies for that year.

A short survey of temperature and chlorinity characteristics for the investigated area are given for a series of 10 years embraced in the period between 1948 and 1963.

The method will probably be usefully applied in places where, in the course of longer investigations, copious hydrographic material has been gathered. The exposed method of organizing the gathered material can include, besides T° and Cl ‰ data, any other data as well, such as σ t, $o_2$ml/l, o_2 %; P-PO_4 mg/t and the like.

A method is here given for the working out of hydrographic material that may find useful application in the investigation of fluctuations of temperature and chlorinity values in the Adriatic or elsewhere conducted over a period of several years. The basis was provided by the abundant material collected at the Stoncica Station (N 43°00'E 16°20') in the vicinity of Vis Island.

Method.

The hydrographic data processed in the present paper have been taken from M. BULJAN and M. MARINKOVIC (1956) and, partly, from an as yet unpublished paper by M. BULJAN and M. ZORE-ARMANDA.

This mid-Adriatic area has not yet been an object of notable hydrographic investigations (BULJAN, 1964 a). The T° and Cl ‰ data, covering the period from 1947 to 1963, are almost complete for some of the intervening years, but are not available for others. We do not intend, however, to enter here into details of this kind.

The data are first presented in graphs arranged according to depths in the column representing the sea water in the function of time for each factor. These graphs enabled us to read the mid -month values for a sufficient number of levels. Wherever the graph rendered it feasible, we employed the interpolation for the neighbouring month. By using these data we were able to calculate the typical T° and Cl ‰ values (several years' averages) at our checking point for each month and each level.

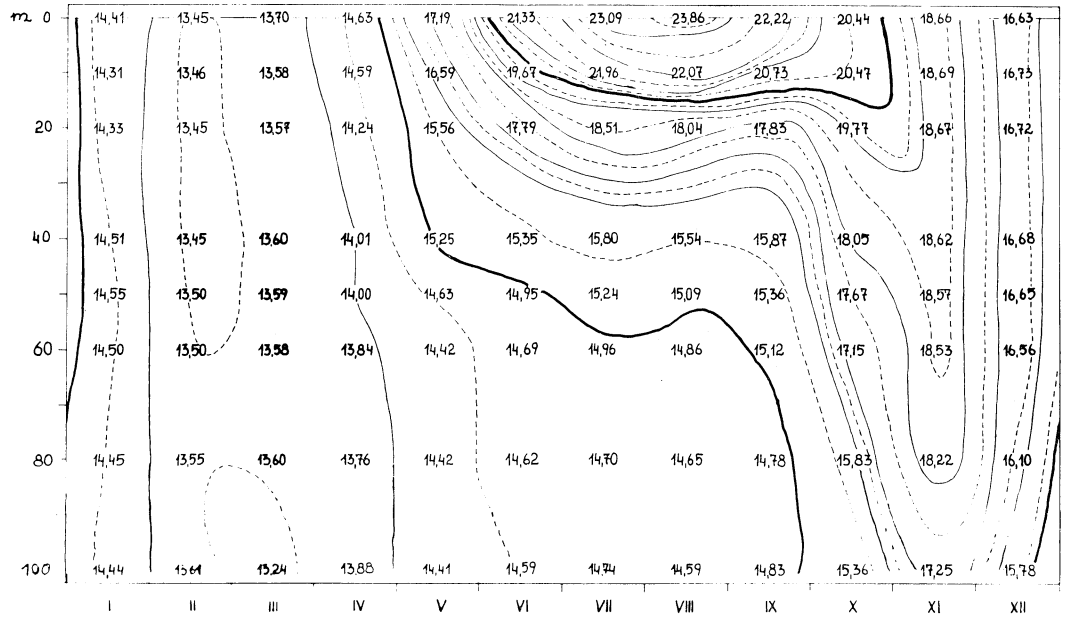

FIG. 1. — *The graph of normal annual temperature* (T°C) *distribution of the sea at the Stoncica Station* (near Vis Island, Middle Adriatic). *Abscissa :* months; *ordinate :* depths in meters.

The data from which the typical T° values were calculated had been obtained from the material collected over a series of years. The data were collected monthly, for the layer between the surface and the depth of 40 metres during a period of 9 to 12 years, and for the layers beyond 40 metres during a period of 6 to 12 years. The monthly Cl ‰ data for the layer between the surface and the depth of 50 metres were collected for 9 to 12 years, and for the layers beyond 50 metres for 6 to 11 years.

By means of the thus collected data, we have constructed a — so to say — « normal graph » for the temperature values of the Stoncica Station, and another « normal graph » for the chlorinity values of the same Station. A survey of prevailing conditions has thus been obtained showing the average values for each month and level or for a « normal » year (fig. 1 and 2).

Description of the normal annual graph (fig. 1).

The first four and the last two months of the year show no gradient, while the thermocline sets in in may, becoming more pronounced until september when it begins to dissolve by the dropping of the 15° isotherm to the bottom (100 metres). A 17° homothermic condition from surface to bottom sets in at the end of november. Owing to the winter cooling effect,

the temperature of the whole water column drops for additional four degress until the end of march.

The maximum temperature shown in this graph does not exceed 23.86° (at the surface in august) while the minimum one amounts to 13.24° (in march, at a depth of 100 metres). A phenomenon of considerable cooling of layers situated between the depths of 20 and 60 metres, appearing in summer (august, september), is revealed by the graph. A similar phenomenon results also from the abundant material collected at the Maslinica checking point, a place lying about thirty nautical miles to the north of Stoncica (BULJAN, 1964 b). Although this phenomenon of cooling of deeper layers of sea water in the Adriatic during the *summer* months requires closer investigation, we will only express our opinion here that the phenomenon might be associated with upwelling as has already been put forward in an earlier paper dealing with hydrography of the area around the Island of Vis (BULJAN, 1964 a).

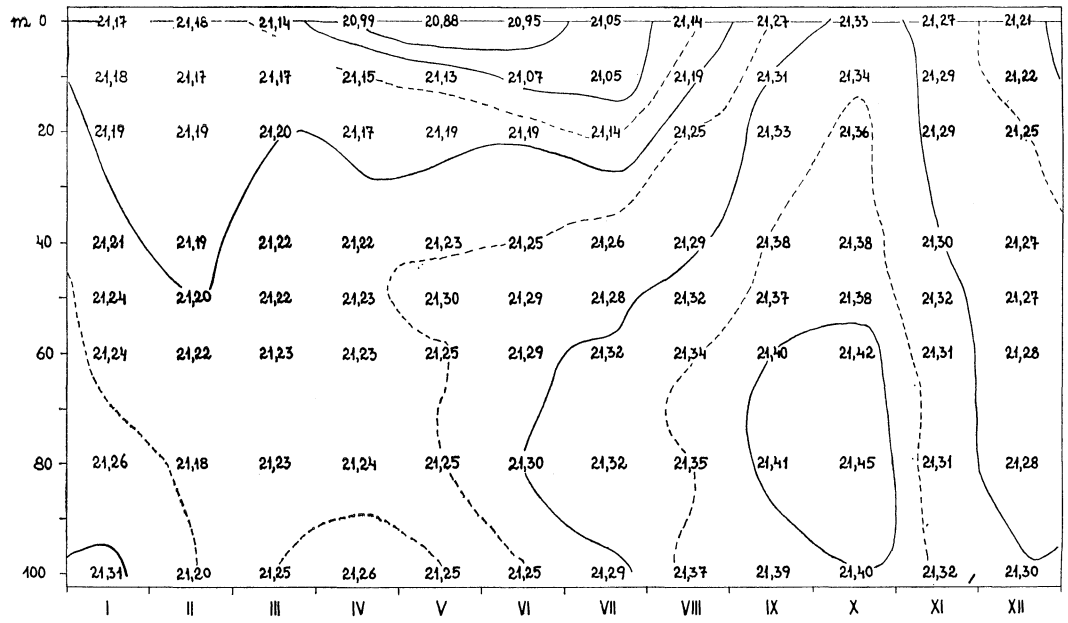

FIG. 2. — *The graph of normal annual chlorinity* (Cl ‰) *distribution of the sea water at the Stoncica Station* (near Vis Island, Middle Adriatic). *Abscissa :* months; *ordinate :* depth in meters.

By comparing the rates of temperature, recorded for a number of years, with the above data, we were able to construct a series of annual anomalies graphs showing the variances in temperature (plus or minus) or temperature anomalies, and throwing into relief the character of each of the surveyed years. Here are a few pieces of information in this connexion :

1963 : with the exception of March and a few insignificant fluctuations, all the months were warmer;

1962 : positive anomaly in the layers lying beyond the depth of 40 metres — as in 1963; negative anomalies in the upper layers;

1961 : positive anomalies during most of the year, particularly pronounced in october (up to + 3.45°), except in summer;

1960 : differing conditions;

1959 : positive anomalies during the first five months; negative ones during the rest of the year, particularly pronounced in november;

1958 : differing conditions

1957 : mostly positive anomalies, with the exception of december;

1954 : mostly negative anomalies (up to — 3,0° in october); positive anomalies at the surface in june and july; no data available for january, march, april, november and december;

1953 : negative anomalies during the first ten months; pronounced positive anomalies in november and december (up to + 2.25°) and even higher (up to + 3.17°) in the layer situated between 10 and 50 metres in september and october.

Description of the normal Cl ‰ graph.

The yearly values of normal salinity at our Station are shown in figure 2. Values under 21.10 ‰ Cl are found at the surface and up to the depth of 10 metres from march to august. Values under 20.20 ‰ Cl occur up to the depth of 30 metres from december to august. Beyond these limits, we find water the salinity of which exceeds 21.20 ‰ Cl.

High salinity values are grouped in the right hand side of the graph. The maximum salinity values, above 21.40 ‰ Cl, are found at depths beyond 60 metres in september and october. They are preceded by a three months' period of salinity values above 21.30‰ Cl, the latter occurring also in the surface layer in october.

The vertical gradient of salinity-halocline- reaches its best development between april and august, almost coinciding with the development of the thermocline. This undoubedly has a positive effect on the development of the picnocline (BULJAN, 1952).

By comparing the chlorinity values recorded over a number of years with the data shown in graph 2, we were able to construct a series of graphs showing the annual anomalies (plus or minus) of this property occurring at the Stoncica checking point. We can learn from the graphs, among others, the following;

1963 : negative Cl anomalies occurred at the checking point in august and september, and in the surface layers from june through december (with the exception of november); positive Cl anomalies prevailed through the rest of the year;

1962 : negative anomalies in april and december; positive ones during the remaining months (data not available for october and november);

1961 : negative anomalies throughout the year with the exception of november;

1960 : negative anomalies during the months for which data are available (no data from august through october);

1959 : negative anomalies extended over the period from april through december, comprising all depths; positive anomalies from january through march.

It results from the foregoing that the period from april 1959 through october 1961 was continuously a low salinity one :

1958 : this was an irregular year; positive anomalies prevailed during its first half, but pronounced negative anomalies occurred in the 10 metres thick uppermost layer;

1958 : positive anomalies throughout the year with the exception of spring months; contrasting with the conditions in 1959-1961, positive anomalies (i.e. high salinity) prevailed throughout 1957 and during the first half of 1958;

1954 : positive anomalies everywhere with the exception of surface (10 -20 metres) from june through august; n° data available for january, april, may, november and december;

1953 : negative anomalies from january through june; positive anomalies from july through december (with the exception of the layer situated between the depths of 40 and 90 metres about october when the negative anomaly occurs;

1948 : positive anomalies from january through september, most pronounced in the layer between the depth of 50 metres and the surface; the highest values are as high as + 0,55 Cl ‰.

These graphs can be very useful since they and the actual data collected during a certain year (or on a certain voyage) enable us to better evaluate the behaviour and character of that year with regard to the conditions and the dynamics of the studied factor, rendering the graph applicable to researches in the fields of hydrology, climatology, ecology, etc. This technique is suitable for the examination of character of any year under survey, i.e. whether or not it is a year of ingression into the Adriatic of high salinity water (BULJAN, 1953, 1957) carried by the

Mediterranean intermediate water (« l'eau orientale ») (ZORE-ARMANDA, 1963), as it was the case in 1948 and 1957, or does perhaps a reverse process of salinity decrease take place in the waters of the Adriatic as it occured according to the above data for 1959 and 1961.

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