TEMPERATURE AND SALINITY OF THE SEA WATER IN THE NEIGHBOURHOOD OF SPLIT

by Miljenko BULJAN

A systematic measuring of temperature and sample-taking of sea water, the latter for the purpose of determination of salinity, being carried out at the head of the pier situated in front of the Institute of Oceanography and Fisheries, at the western extremity of the Marjan Peninsula (N 43°30'30" and E 16°23'36"), were started in the spring 1949 and are still in progress. The data gathered from 1949 (april) until the end of 1954 are delt with in the present paper.

Hydrographic observations in the Kastela bay area were carried out in 1932 and 1933/34 (ERCEGOVIC, 1934, 1936), and from 1946 through 1952 (BULJAN and MARINKOVIC, 1956). All those data, however, refer to the central part of the bay of Kastela whose depth is up to 30 m ; our data, on the contrary, refer to the shallow coastal area with a depth of about 5 m while the measuring involved the 0,5 m water layer. This is why we have processed our data quite independently of the above-mentioned ones.

A thermometer of an exactness of ± 0°05 C has been used for temperature measuring while the salinity has been determined using Copenhagen normal water and partially our own auxiliary normal water (BULJAN, 1948). Water samples have been taken from the 0,5 m layer in the course of the morning hours. The author's thanks are due to his collegue A. ZUPAN who kindly permitted the use of his water temperature data covering the period from 1953 through 1954. The data referring to the river Jadro flow have been obtained from the Bureau of water économy, Split.

Salinity fluctuation.

The normal salinity curve for the investigated period is shown in graphic n° 1. The main annual salinity maximum, whose value varies around 37.77 ‰, lies between september and october. The secondary annual maximum, falling in february, reaches a value of about 35,70 ‰

The main annual minimum of salinity, occurring in may, has a value in the region of 34,27 ‰ while the secondary minimum, taking place in december, shows a value of about 34,90 ‰.

Salinity curves of this kind, displaying pairs of annual maxima and minima, are met in various places along the eastern Adriatic littoral : Maslinica, Kastela bay (ERCEGOVIC, op.cit.), Rovinj (VATOVA, 1948), or along the western coast of Adriatic sea; Fano (SCACCINI, 1953).

Atmospheric precipitations, probably, have a direct effect on the salinity of the area, but there is also an indirect effect resulting in this particular case, from the river Jadro. It is evident from picture n° 2 that Karst streams (Jadro) reach their annual maximal flow somewhere from november through february while the precipitations occurring in may do not appear to affect their flow intensity at all.

It results from the same graph, on the other hand, that Alpine rivers (Po), besides affecting the salinity of the waters of the Adriatic sea in late autumn (october and november) are particularly felt in may and june when they cause the salinity value to decrease in those waters, differing thus from Karst rivers.

The description of the graphic n° 1, perhaps, would be rendered easier if the above two salinity minima in the Adriatic were denoted (1) *Alpine minimum* in the spring, and (2) *Karst minimum* in winter.

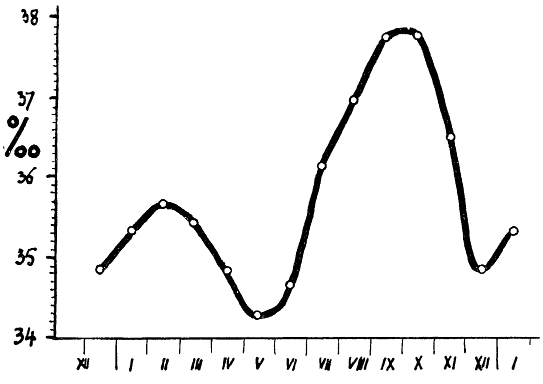

FIG. 1. — *The normal salinity curve for the sea water on the station situated at the head of the pier of the Institute of Oceanography and Fisheries, Split.*

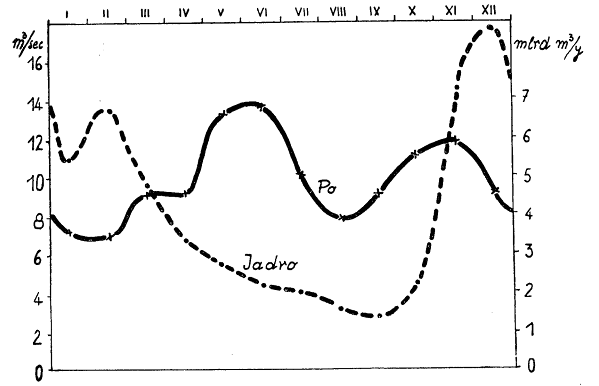

FIG. 2. — *The yearly distribution of run-off for two Adriatic rivers : Po river* (alpine type) *and Jadro river* (karstic type). *To Po belongs the right-hand scale and to Jadro the left-hand one.*

Temperature conditions.

The characteristic of the normal temperature curve reffering to our station (graph. n° 3) is the following :

Maximum	29°9 C	in july	Annual average	17°28 C
Minimum	10°8 C	in february	Amplitude	13°1 C

By assuming that the normal temperature curves are sinusoidal, our temperature curve should have the following form :

$$y = A - B \sin \frac{2\pi}{t} (x + e) \qquad (1)$$

where y stands for normal monthly temperature average in °C; A for annual temperature average ; B for ½ of the annual amplitude ; t for a 12 months' period ; x for the period of time expressed in months ; e for shifting in the phase of the curve.

In such a way we have obtained the following equation :

$$y = 17{,}28 - 6{,}55 \sin \frac{\pi}{6} (x - 2{,}27) \qquad (2)$$

Graphic n° 3 contains, besides the normal theoretic temperature curve, also the actual one resulting from monthly temperature averages obtained over a period of several years. The above two curves being in good agreement, *the fluctuations of the sea water temperatures are well represented by the equation (2)*, particularly if we consider that the investigated area belongs to surface and inshore waters.

Temperatures of the air and sea water.

As evident from graphic n° 4, the sea water is warmer than the air in the bay of Kastela from the second half of september to the second half of april, while the air is warmer than the sea during the remaining five months. The maximum difference of monthly temperature averages in favour of the sea water amounts to 4^{0} 73C (january), and to $3^{0}05$C (july) in favour of the air.

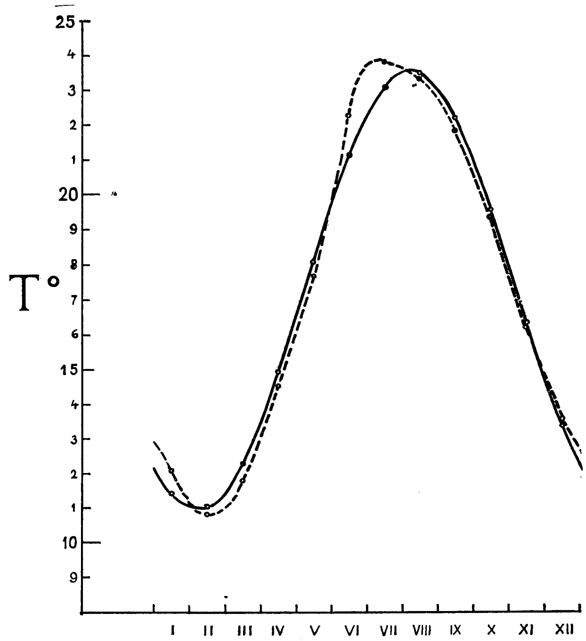

FIG. 3. — *The yearly temperature curve for the sea water on the station near the pier of the Institute of Oceanography and Fisheries, Split, Jugoslavia: the normal theoretic curve* (full line) *and the actual curve drawn from observed values* (dashed line).

The integrated average temperature of the air and sea in a years's period amounts to $0^{0}87$C, indicating that the sea water in the bay of Kastela behaves within a year's period, as if it were continuously warmer by the above value of $0^{0}87$C than the air. The sea in this case, then, besides exercising the effect of a buffer with regard to the fluctuations of temperature in the area, produces also additionnal heat, obviously owing to the inflow of warmer waters from the south.

The T-S Diagram.

Graphic n° 5, obtained by processing the monthly average values of T^{o} and Sal. in $^{o}/_{oo}$ resulting from a period of several years, appears to belong to an « eight » type curve with a regular and well developed clockwise part of the curve (which belongs to the warm part of year), while the anti-clockwise part of the curve (belonging to cold part of year) is poorly developed and insignificant.

It results from the study of the obtained results that the simple circular and oval types of the S-T diagrams, drawn for the area off the Island of Mljet (unpublished paper) and expected to apply to the open Adriatic area and to the Mediterranean too, belong to regions where only

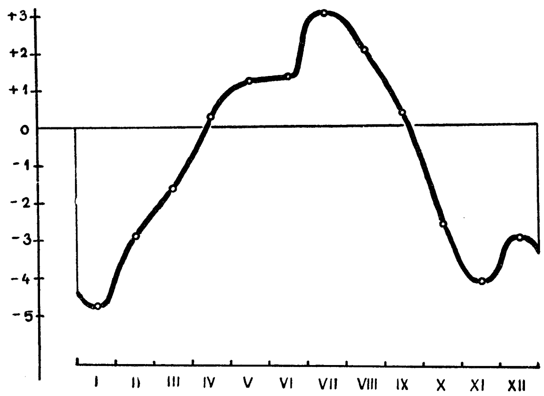

FIG. 4. — *Curve representing the differences between the air and the surface water temperatures on the station of Institute's pier.*

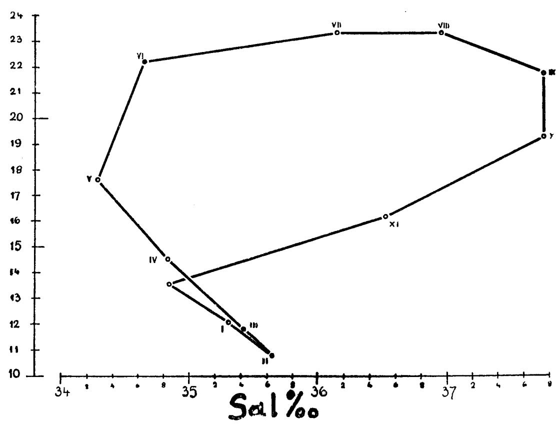

FIG. 5. — *T-S diagram of water on the station of Institute's pier.*

one significant annual minimum and one maximum of salinity takes place. The closed circular curve for the Adriatic area evolves in the clockwise direction since this is an area where the maximum of the salinity curve is in time shifted (by about 1/4 of phase) before the maximum of the temperature curve.

In the waters along the eastern coast of the Adriatic sea where there is a considerable discharge of fresh-water from the coast, e.g. in the bay of Kastela (from november through regular and well developed clockwise part of the curve (which belongs to the warm part of year), while the anti-clockwise part of the curve (belonging to cold part of year) is poorly developed and insignificant.
january), the S - T diagram from oval type becomes « eight »-shaped. In general this happens when, besides a normal annual sinusoid temperature curve, there is also annual salinity curve displaying pairs of pronounced minima and maxima.

ABSTRACT

The author presents the data resulting from the measuring of temperature and salinity of the sea surface near the Institute pier (N $43^{o}30'30''$; E $16^{o}23'36''$) during the period from 1949 through 1954.

The main maximum (37,77 ‰ Sal) takes place in september and october and the secondary one (35,70 ‰ Sal) in february. The main minimum (34,27 ‰ Sal) falls in may, and the secondary one (34,90 ‰ Sal) in december. The may minimum comes as a consequence of the influence in the Adriatic of *Alpine rivers*, and the december one redults from the increased inflow of *Karst rivers*.

The maximum monthly average temperature, occuring in june, amounts to $23^{o}9$ C, and the minimum one, taking place in frebruary, is $10^{o}8$ C. The annual average temperature amounts to $17^{o}28$ C. The following equation : $y = 17{,}28 - 6{,}55 \sin \frac{\pi}{6} (x + 2{,}27)$ looks appropriate for representing of the yearly walk of temperature of the area in question.

The temperature of sea water in this area from the middle of september to the middle of april, is warmer than the air temperature. By compariring the annual average temperatures of the air and sea water we find that the latter is higher by $0^{o}87$ C. This excess heat is produced by the inflow of warmer water from the south.

The S-T diagram is « eight » shaped and the clockwise part of the curve is well developed. This direction is a consequence of the fact that the salinity curve is shifted by about 1/4 of phase *before* the temperature curve. This part of the S-T diagram belongs to the type of water prevailing in the open Adriatic.

The other, anti-clockwise part of the S-T curve, referring to the cooler part of the year, is poorly developed and is due to the influx of freshwater resulting from the Karst rivers.

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