

OBSERVATIONS ON COASTAL MARINE WATER CIRCULATION
IN THE ZONE MIDIA - VAMA VECHE*Ion Nae, Iulian Postolache*

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ABSTRACT:

Analysis is carried out on current measurements from 12 to 24 stations located along the coast at 5 and 10 m depths between Midia and Vama Veche, in the period 1972-1978; on about 4000 records obtained from self-recording currentmeters of the Alexeyev type in the bay of Mamaia; daily observations (three times every day) in the roads of the port of Constanța in 1979. The results were presented as arranged on type of resultant circulation in the four cardinal directions.

The investigations carried out on the coastal currents along the Romanian coast of the Black Sea (2, 3, 4, 5, 6, 7, 8, 9) pointed out the unsteady character of marine water circulation as a consequence of the inconstant regime of wind circulation (1). It is to be noted that the investigations were usually carried out from 1 Nm distance from the shore seawards, so that we have very few data on the coastal currents within 1 Nm from the shore. Taking into account this fact we are trying to describe, in this paper, the circulation of the offshore surface waters in the zone between Midia and Vama Veche on the basis of the analysis of the measurements carried out in a net of stations distributed along

the littoral and in a fix point to the east of Mamaia and the systematic daily observations off the port of Constanța.

Current measurements along the coast were carried out with drifting floats and Eckman-Merz apparatus in a net of 12-24 stations disposed on the isobaths of 5 m and 10 m in the period of April-October of the years 1972-1974. From the obtained results the most representative situations, classified as a function of winds from different cardinal directions, are shown in figures 1, 2 and 3.

When winds blew from the north all along the coast between Midia and Vama Veche at speeds between 2 and 6 m/sec, the sea water circulation was prevalently southwards at speeds up to 31.2 cm/sec. (Fig. 1a). The relatively high speeds of the currents as related to those of the winds are due to winds from the same directions having blown in the previous days.

In the example presented in Fig. 1 b, it can be noticed that under conditions of winds from similar directions but stronger the currents were slower (below 20 cm/sec.); this is a consequence of the fact that during the previous days (July 26 and 27, 1977) the wind resultants were different: WSW 1.5 m/sec. and SSW 2.1 m/sec., respectively).

Under conditions of calm, a slow southward circulation with speeds between 10-15 cm/sec. is observed (Fig. 1 c). Analysing the wind resultants of the 4 previous days (15.05- SSE 0.5 cm/sec.; 16.05- S 4.2 m/sec; 17.05- S 0.9 m/sec. and 18.05- NE 1.5 m/sec.), it is found that only one day action of the northeasterly winds was enough to annihilate the effect of the southerly winds having blown during the three previous days.

As the calm periods are rare and short along the Romanian littoral and the winds have an irregular regime, frequent changes of the coastal currents are recorded. An example illustrating the above mentioned is given in Fig. 2a. Thus, during the three days previous to the measurements carried out on August 4, 1974, between Midia and Cape Singol, the winds had blown irregularly (NNW 2.5 m/sec.; W 0.9 m/sec.; SSW 1.6 m/sec.) and the current directions had been in good agreement with the northeasterly and easterly winds recorded during the observations. This is the explanation of the fact that at the two extremities of the Mamaia

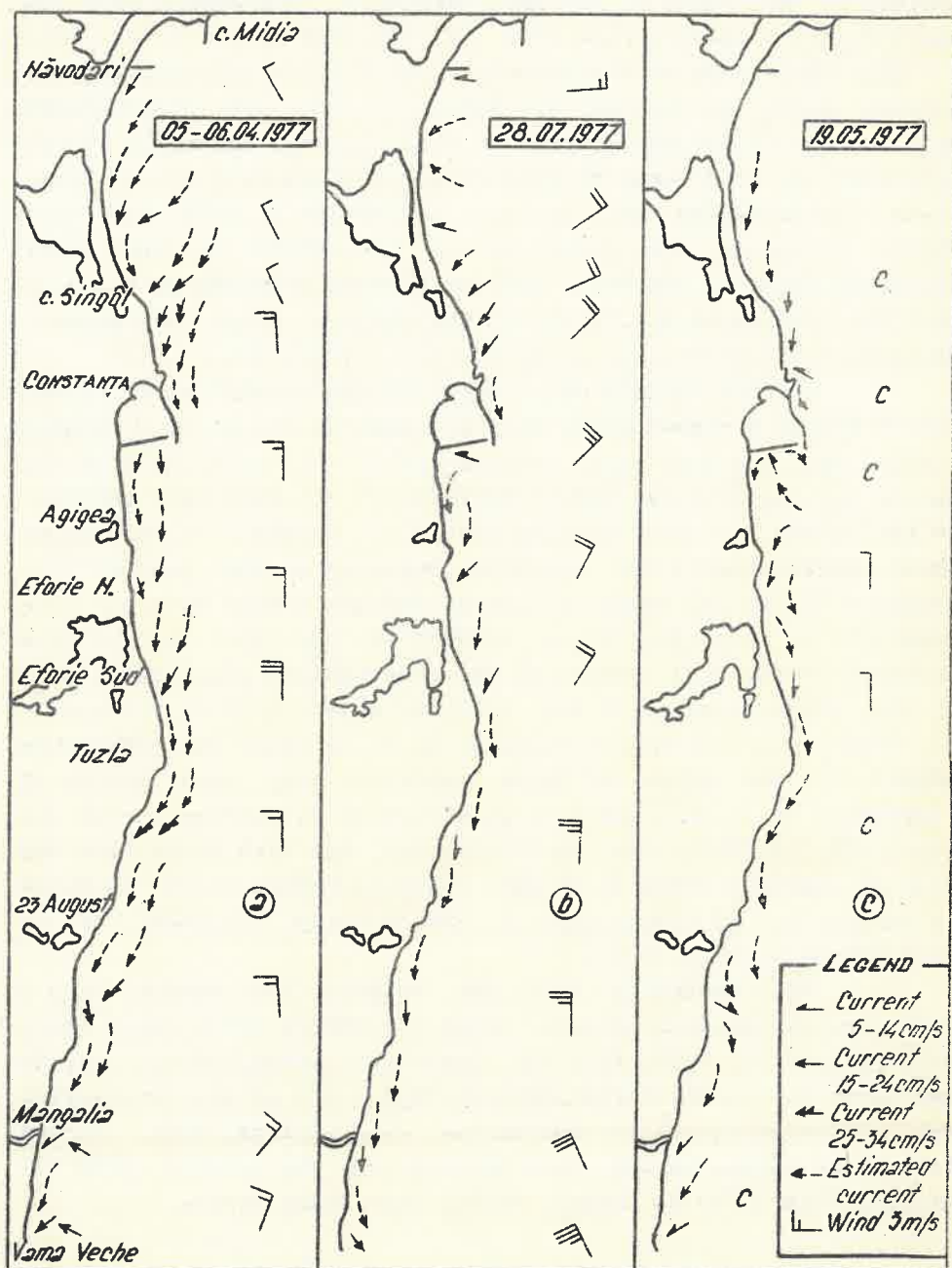


Fig. 1 - Littoral currents recorded between Midia - Vama Veche

bay there were two local circulations with opposite directions meeting at the middle of the bay, forming a convergence area and resulting in a seaward flow (Fig. 2c). The wind resultant on April 9 - when there were no measurements - was $N 0.2$ m/sec., driving the surface water southwards. On April 10, when the observations between Cape Singol and Eforie Sud were started, initially it was calm, then the wind began to blow from the south at 4 m/sec. Under these circumstances the current directions in this zone were rather irregular but generally in opposition to the local southerly wind. As the wind went on blowing from SSE at 6 m/sec. till the following day (April 4) the coastal water was given a definite drift northwards along the shore (Fig. 2 a).

Another example of a change in the coastal water circulation within a rather short time is given in Fig. 2b. On September 4, 1972, when the wind blew northeasterly, the water flow in the Mamaia bay was directed WSW. On September 5 the wind went through to the south and kept blowing slowly on September 6, too. Under these circumstances the currents recorded in the zone of Constanța - Eforie Sud began moving to WNW. The rather slow currents recorded on September 4 as related to the wind intensities measured at the very moment of the observations and particularly to the winds measured in the previous days (02.09 -NE 5.2 m/sec; 03.09 -NE 6.9 m/sec) do not surprise if we consider the components normal to the shore of these currents. This is a matter of diminution of current speed as an effect of decreasing depth and coastline direction. Such an attenuation can take place from one zone to another (from 34 cm/sec. opposite Modern Beach to below 15 cm/sec. in the Mamaia bay) as the easterly component of the wind increases (Fig. 2 c).

When southerly winds are constant for several days a northward circulation appears along the entire study area. Thus, on September 13, 1978, when the wind blew southeasterly - as it had blown during the three previous days - the marine circulation was northward (Fig. 2 d). During the observations, which started from Vama Veche, as the wind intensified, the current speed increased from 15 to 53 cm/sec. within only eight hours.

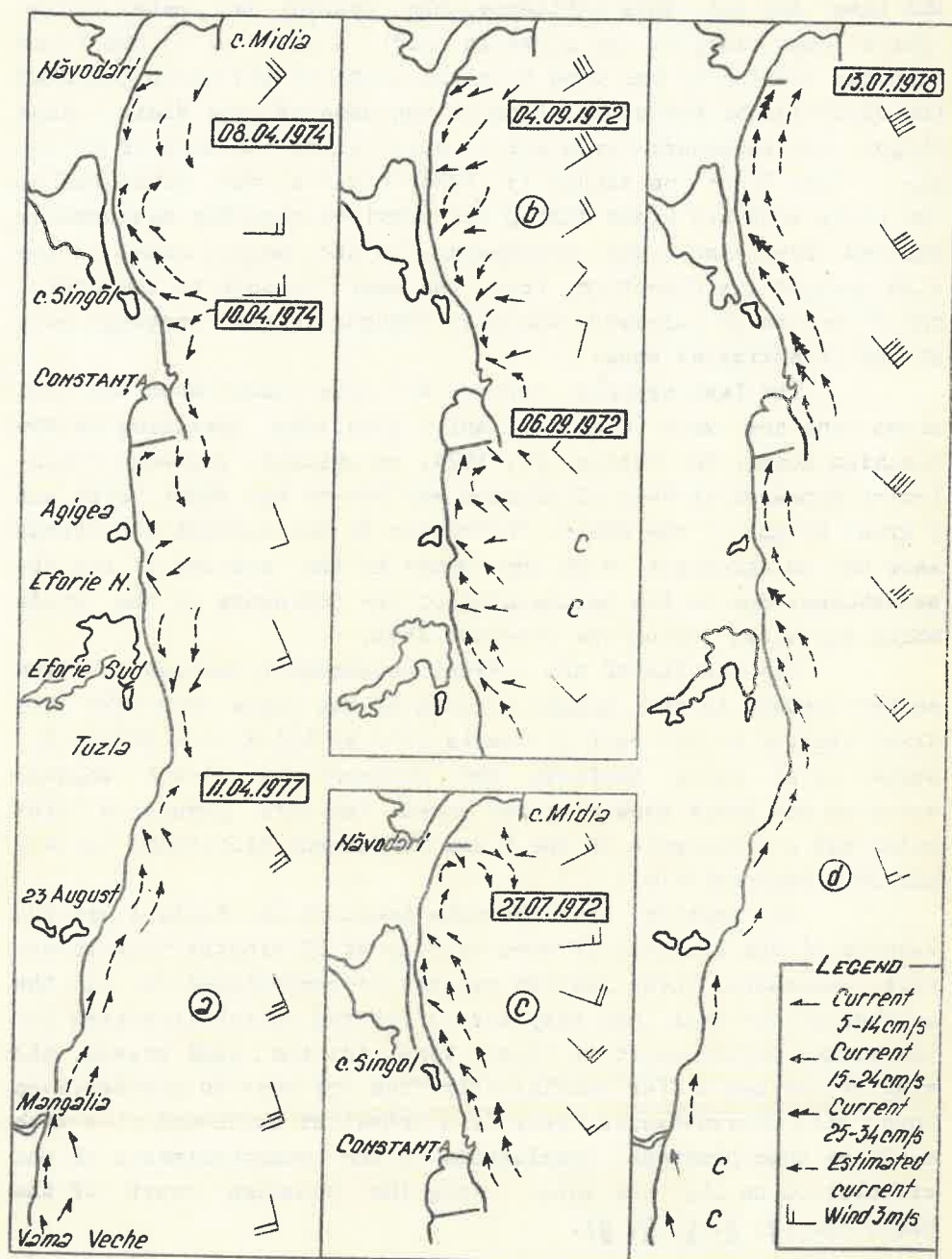


Fig. 2 - Littoral currents recorded between Midia - Vama Veche

The wind often changes its direction in the course of the same day and this influences the coastal sea water circulation. Such examples are given in Fig. 3 a and 3 b. In the first case the veering of the wind from the south to the north modified the direction of the circulation in the zone of Cape Midia - Cape Singol. The southward circulation observed in the zone of 23 August - Vama Veche on August 15, 1978 (Fig. 3 a) was generated by the winds which had blown during the previous days. The measurements started from Vama Veche northwards. In the second case, as the wind changed its direction from the west through to the south, the direction of currents was also changed in the northern part of the investigated zone.

The last example refers to some cases when the wind blows from the west (Fig. 3 c), which generates upwelling at the Romanian coast. On October 28, 1974, an evident eastward circulation appeared of which slightness was due to the short fetch and a great height of the shore. On October 31 the current directions were not in agreement with the winds at the moments of the observations, due to the maintaining of the influence of the winds which had blown during the previous days.

The results of the current measurements carried out with self-recorders in the summer periods of the years 1972-1974 at a fixed station to the east of Mamaia ($\varphi = 44^{\circ}13'_{\frac{1}{2}} \text{ N}$; $\lambda = 28^{\circ}40'_{\frac{1}{2}} \text{ E}$, depth 11 m) fully confirms the unsteadiness of the coastal currents and their generally low speed. The data presented below point out a prevalence of the S and SE current directions (33,4 % and 28 % respectively).

We mention that the data included in Table 1 are the results of the analysis of 4000 records at 15 minutes time-intervals. Obviously, these results can not be generalized for all the seasons of the year and they have a limited reliability even for the summer period as it is known that, for the same season, the wind regime may differ considerably from one year to another. Even under these circumstances there is a prevalent southward flow which confirms some previous conclusions on the characteristics of the circulation on the sea water along the Romanian coast of the Black Sea (2, 3, 6, 7, 8).

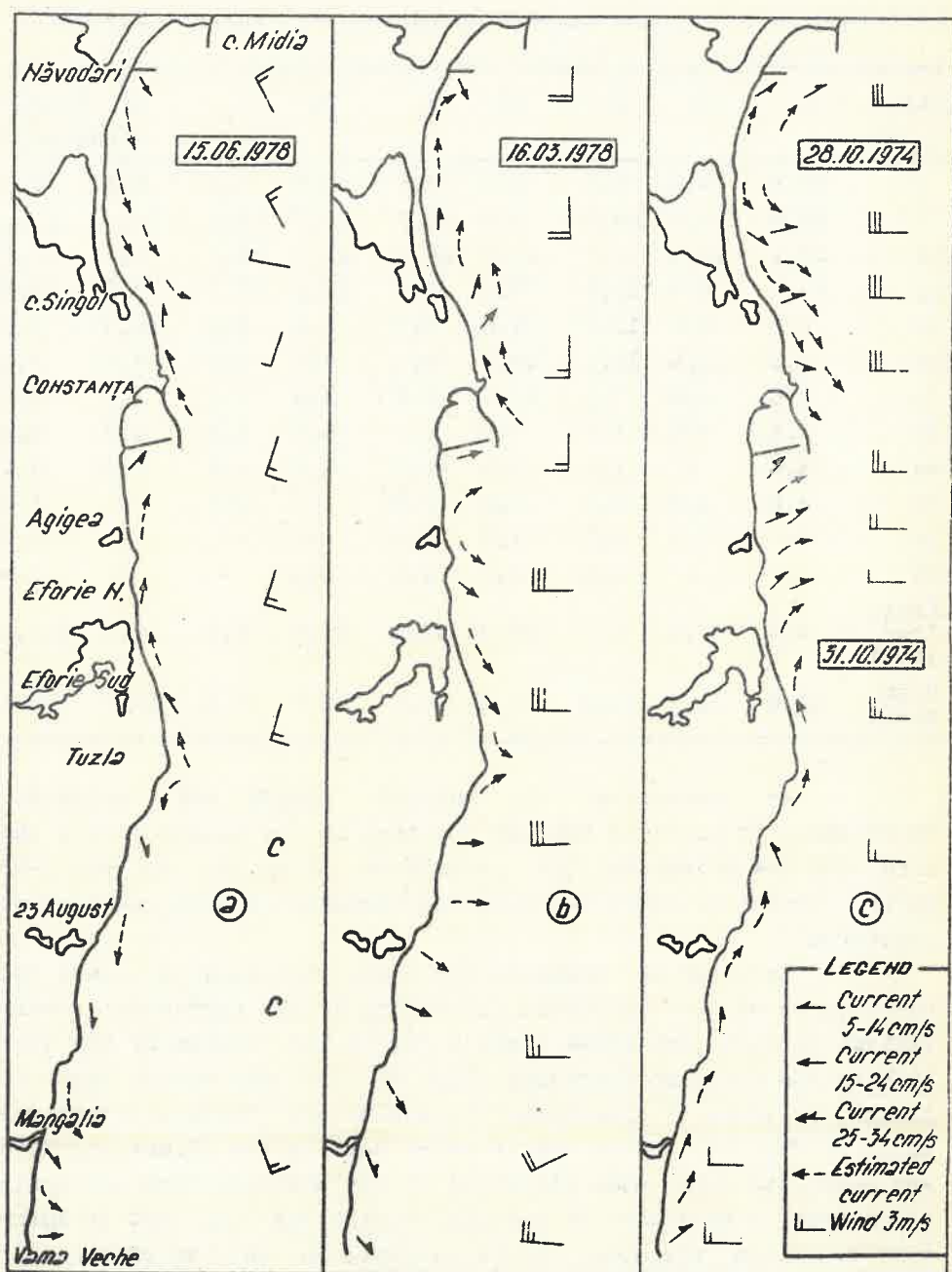


Fig. 3 - Littoral currents recorded between Midia - Vama Veche

Table 1

Distribution of surface current speeds on main current directions

Dir. Speed	N	NE	E	SE	S	SV	V	NV	Global frequency
2	11,3	9,6	6,6	0,7	2,5	8,6	4,2	5,3	3,8
5	26,6	31,7	20,7	9,9	23,7	36,7	28,7	16,0	21,3
10	18,1	18,3	16,7	18,3	24,7	21,2	26,6	36,7	22,6
15	14,7	6,7	15,6	17,4	12,3	12,2	26,3	17,7	15,3
20	7,3	9,6	12,1	9,8	8,5	7,1	7,3	10,3	8,9
25	5,1	11,5	11,6	10,7	6,0	4,8	2,8	4,0	7,2
30	5,6	6,8	7,2	10,3	7,9	3,4	1,7	3,0	7,0
35	7,3	3,8	3,5	7,9	6,1	4,6	1,0	5,7	5,9
40	3,4	-	1,0	7,5	4,3	1,2	1,0	1,3	4,1
45	0,6	1,0	4,0	5,6	2,8	-	0,4	-	2,8
50	-	1,0	0,5	1,2	0,8	-	-	-	0,7
55	-	-	0,5	0,7	0,4	0,2	-	-	0,4
Freq. from total	4,4	2,6	5,0	28,0	33,4	11,9	7,2	7,5	100,0
Mean speed	12,6	17,1	15,8	14,0	14,6	16,8	19,8	12,6	15,6

As concerning the current speeds not exceeding 55 cm/sec., it is to be pointed out that in the summer period the wind has low intensity. The prevalence of speeds between 5-15 cm/sec. should be connected with the frequent changes of current direction.

In order to complete the above mentioned we must add the results of the statistic processing of the systematic observations carried out three times a day in the course of the year 1979 in the roads of Constanța (Fig. 4). One may notice that the monthly polygons of direction frequencies are bimodal, except the month of May. The modes are in every case in the directions NE-E and S-SW, the main mode differing in its position from one month to another. A tendency of seasonal variations can not be identified. A high frequency of the currents in the two of the main directions, northwards and southwards, is clearly prevalent as

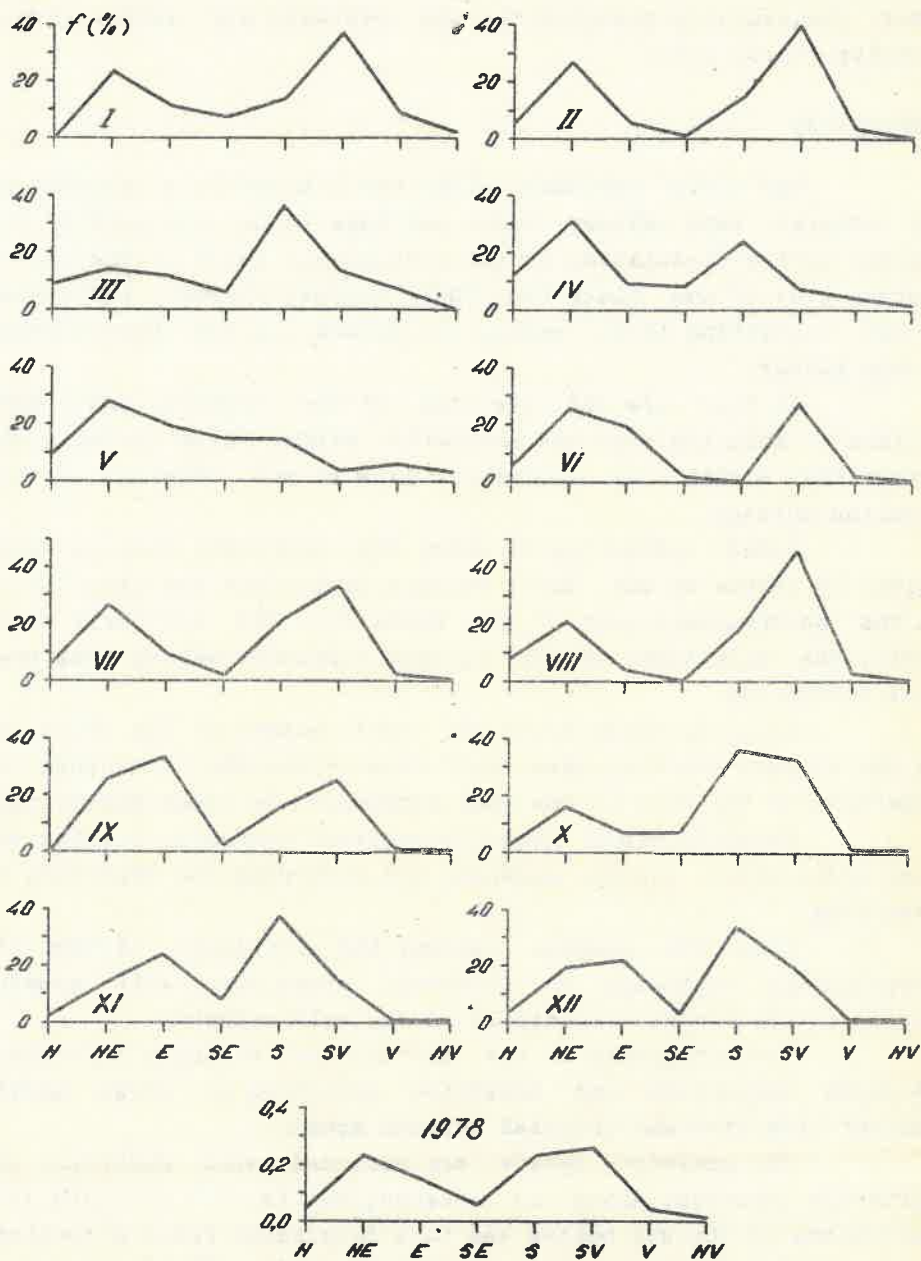


Fig. 4 - Polygons of sea current direction frequencies opposite the Casino of Constanța, 1978

related to the whole year; it is 23 % and 26 % respectively. The lowest frequency is recorded for the westward and northwestward currents (below 5 %).

CONCLUSIONS

The marine currents along the 5 m and 10 m isobaths in the coastal zone between Midia and Vama Veche are part of the general marine circulation on the continental shelf of the northwestern side of the Black Sea. Their regime, strongly influenced by the prevailing local winds, is marked by the irregularity of the latter.

As they are off the zone of the brakers, under conditions of moderate seas and northerly winds, these currents are integrated within the southward flow at the boundary of the Rumelian current.

Under conditions of calm, the southward flow is maintained by virtue of the major factors generating the circulation in the northwestern part of the Black Sea. The southerly winds modify the directions of the coastal currents making them even flow northwards.

Easterly winds drive the water masses to the shore and in its closest vicinity they will flow northwards or southwards, depending on the size of the wind components in these directions.

Westerly winds generate eastward currents, driving the near-shore water masses seawards and favouring the occurrence of upwelling.

Over the coastal region, the prevalent current directions are southward or northward every year, with greater stress on the former (especially in the cold season).

The parameters of the currents are strongly influenced by depth variations and coastline direction as these modify current direction and diminish current speed.

The greatest speeds are recorded with southward and northward currents, along the isobaths, that is with currents less influenced by the sea bottom and in a favourable fetch direction.

The greatest speeds we have recorded (53-55 cm/sec) do not represent the maximum values which the coastal currents may

reach under storm conditions.

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