Cercetări Marine	I.R.C.M.	Nr.1o	7 - 16	1977

MORPHODYNAMICS OF MAMAIA BEACH AS AN EFFECT OF HYDROMETEOROLOGICAL AGENTS

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ABSTRACT:

On the basis of 22 topometrical measurements in 3 cross sections of Mamaia Beach and the permanent records of sea level and wind speed and direction at Constanta in 1975-1977,it has been possible to establish the effects of the hydrometeorological agents on the morphodynamical evolution of the beach.

As waves and longshore current induced by waves in the surf zone are generated under the action of wind, as defined by force (speed) and direction, an attempt of relating the morphological processes which result at the shoreline directly to the two wind parameters is fairly justified, in the absence of direct measurements on waves and currents in the nearshore zone of Mamaia Beach.

Among the secondary morphodynamic agents, sea level oscillations are of outstanding importance. On the one hand, these imply a horizontal oscillation of shoreline - as an intersection line between sea surface and the sloping surface of the beach. On the other hand, every variation in sea level means a vertical and horizontal displacement of the wave erosion base,which will move shoreward or seaward as the level will become higher or lower.

METHODS

Three sections of morphometrical transverse profiles were established on Mamaia Beach in the early 1975. Topometrical surveys of the profiles were carried out periodically, at short time intervals - from lo days to 3 months - usually every month, from February, 1975, to September, 1977.

The earlier two measurement sections are placed at the southern part of the seaside resort of Mamaia, where a stronger intensity of the shoreline processes was noticed, by the sides of Parc and Perla hotels. The third section is situated at the north end of the resort, in a stretch of shore that was presumed more stable, outside the zone of the hotels, where the beach is not arranged (Fig. 1). Here the measurements were started somewhat later,

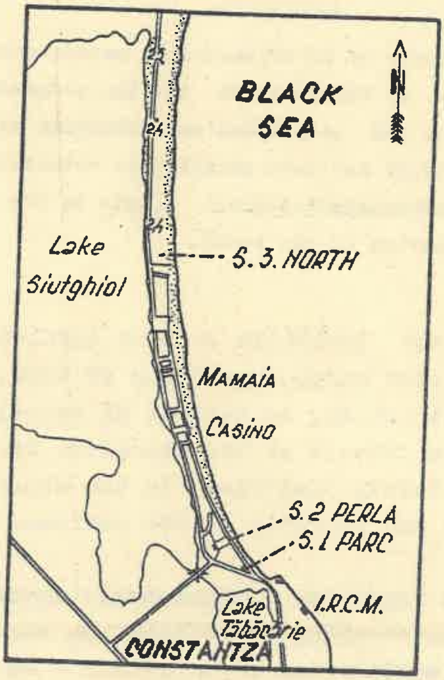

Fig. 1 - The barrier beach of Mamaia and the location of the morphometrical profiles

in May, 1975. During the investigation period, 22 morphometrical prophiles were surveyed in sections 1 and 2 and 18 profiles were done in section 3; the profiles were surveyed on the same dates in the 3 sections.

The topometrical two-dimentional data obtained in the field were referred to conventional marks with approximate heights from the Black Sea level and they are graphically plotted - beach width, as distance from mark to shoreline (Figs. 2 and 3) and extreme heights recorded at fixed distances on the range line of the profile (Fig.3). The shoreline was considered in the median zone of that strip of the beach on which uprush and backwash are confined and where the plane of the imaginary levelled wavy sea surface meets the foreshore slope.

Sea level oscillations during the investigation period were considered as ten-day mean values calculated after the records of the level-gauge at Constanţa (Port Tomis).

A generally meridian shore trend in the observed zone suits analysis of wind speeds as decopmosed vectorially in the four main cardinal directions on two axes: N-S and E-W, the former - parallel with the shore and the latter - perpendicular to it. Conventionally, on the chronological graph, in the two axes, partial speeds of north and east components were plotted as positive values, above zero line, while partial speeds of south and west components were plotted as negative values, below zero line (Fig.2). Two variation curves were thus obtained in a two-dimentional system, on both sides of two neutral lines separating two opposite directions and forming the time axes, concurrently. Time is marked in months (on top), seasons and years (down). Under this form, the variation of wind parameters becomes comparable to the variations in sea level and beach width in the three sections.

RESULTS

By following simultaneously the variation curves, some significant agreements can be noticed between the processed parameters.

An increase in the beach width by 6 to 18 m corresponds to the general lowering in the Black Sea level from the summer of 1975 to January, 1976 - by more than 4o cm. It is followed by a

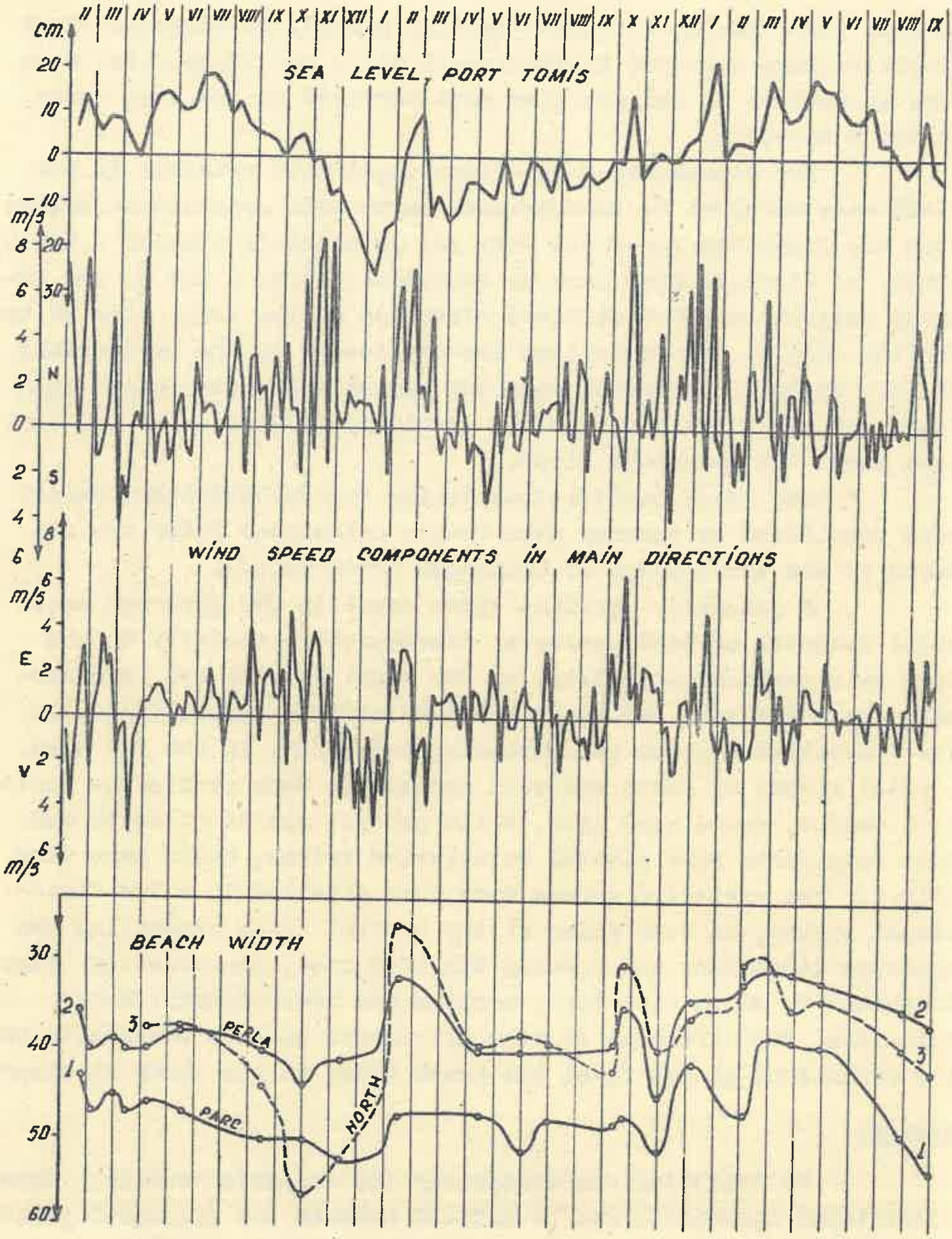

Fig.2 - The variation in sea level (ten-day means), wind speed components on main directions (five-day means) and beach width at Mamaia, 1975-1977.

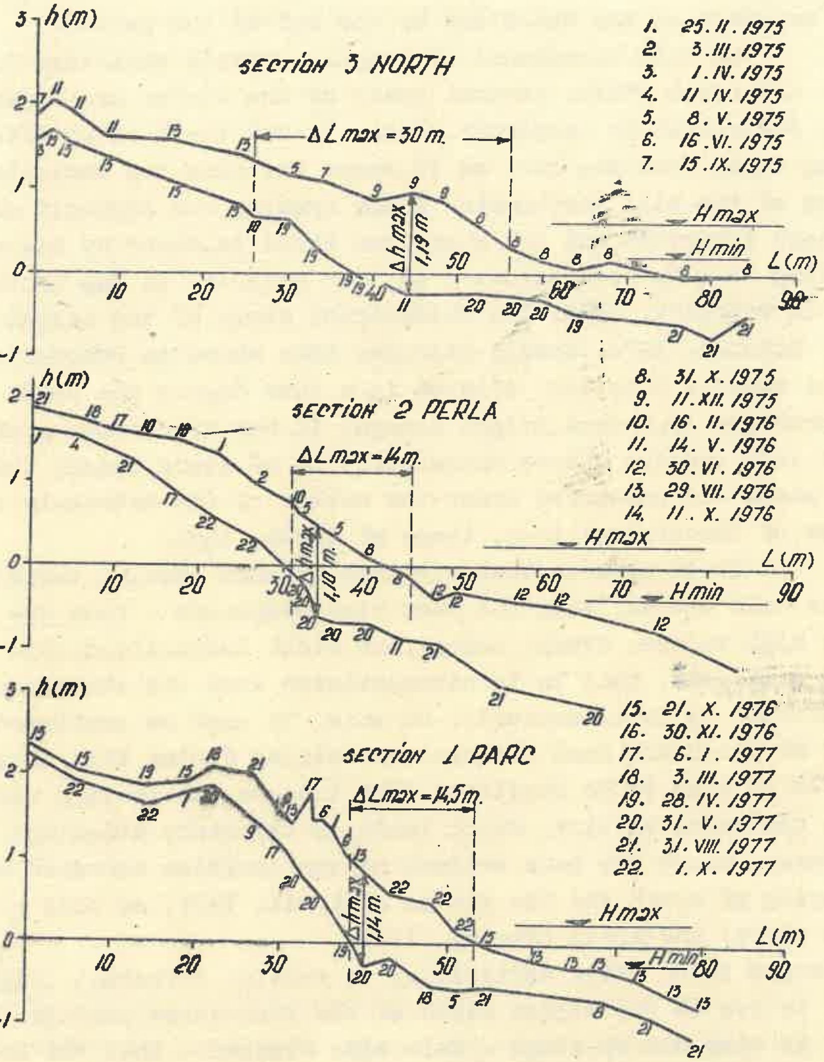

Fig.3 - The amplitude of transverse profile variations on Mamaia Beach, 1975-1977.

general, though discontinuous decrease, as the sea level rises gradually; the smallest width is reached in the spring of 1977. Further on, the decrease in mean sea levels beginning from May, 1977, is promptly followed by exundation of the low beach and seaward movement of the shoreline by the end of the period.

On this background of lengthy, yearly variation in sea level and beach width, several peaks of the curves are superposed, being determined by temporary rises in sea level as an effect of strong winds from the sea, as it comes out from the variation curves of the wind components. Beach erosion was strongly manifest in these intervals and the shoreline moved landward by distances reaching 2o m in some places - as, for example, in the north of Mamaia in February, 1976. The exceptional storm of the second decade of October, 1976, though stronger than those in February, having a shorter duration, altered in a less degree the beach width, but produced important height changes in the transverse profiles, which took concave shapes characteristic of storm beach; the concave shape was preserved under the action of the extremely strong storms of January and then, those of March, 1977.

It is obvious that the most intense erosion takes place in the cold season, when the east wind component - from the sea - takes high values, always concurrent width intensifications of the north component, that is in circumstances when the atmospheric circulation is north-easterly. On this, it must be mentioned that N and NE winds are most frequent and strong during this season (1). It is also to be mentioned that intense and lasting west winds cause sea level to sink, which leads to temporary widenings of the beach. These are made evident by the profiles surveyed at the beginning of March and the middle of April, 1975, as well as in March (Parc) and April (North), 1977.

The larger beach width variability in section 3 (North) (Fig.2, down) is due to the milder slope of the transverse profile (Fig.3), as it is also due to slope - this time steeper - that the beach by the side of Parc Hotel shows moderate variations during the first part of the studied period - but not in the last year too, when this profile became concave as a consequence of the extraordinary storms of October, 1976, and January, 1977. Even without taking into account an evident increase of sand grain dimentions toward the south of Mamaia Beach, the steepening of its transverse slope southward is an indication of the intensification of the erosion in this direction,which is otherwise pointed out by comparing the beach width variation curves in the three of the sections (Fig.2).

As regards the overall tendecy to erosion, confining to 1975-1977, one can observe that although the Black Sea mean level in the summer of 1977 did not exceed the mean level in the same season of 1975, the beach width is noticeably smaller - by over 1o m, S of profile 1, - suggesting an ended erosion cycle. A new increase in beach width follows concurrently with the decrease in sea level and roghness, but starting from a more landward shoreline and a poorer sand stock (Fig.2).

The variation limits of the transverse profiles are particularly wide near the shoreline, on the wet, lower beach (Fig.3). The widest variation range was recorded at the north end of Mamaia, both horizontally (3o m) and vertically (1.19 m). It can be observed that the maximum vertical variation, Δh_{max}, takes near values in the 3 sections and is always to be found in the zone of maximum shoreline fluctuation, ΔL_{max}. The fact that in section 2 (Perla) the same maximum vertical variability is also reached, seaward, on the submerged beach, denotes an intense sand transport across the nearshore zone in this stretch. This transport could cause irreversible dislocation of sand stock after strong storms, having in mind that it takes much longer to the sandy alluvium to be brought back to shoreline by slight waves, and new storms can occur before the sand loss being recovered. This is exactly the present circumstance in the southern stretch of Mamaia Beach.

Concurrently with the steepening beach slope from north southward, the line of maximum vertical variability, Δh_{max}, is moving from the lower beach toward the middle beach,which suggests advancing of wave erosion in this direction, while, at the north of the resort, a dynamic equilibrium is preserved in the beach profile, with wide variations on both sides of a relatively stable mean shoreline.

The 22 measurements done in each of the 3 sections on the same dates (4 surveys lacking in section 3) in the period of February,1975 - September,1977, are chronologically numbered (Fig. 3). By plotting the points of maximum and minimum height measured at each fixed distance and drawing lines between them, maximal and minimal profiles were obtained - fictitious profiles, on which are marked the order numbers of surveys done on succeeding dates, when the respective extreme values were recorded (2). It is significant that large numbers - showing more recent measurements - appear, as a rule, on the minimal profile, which proves once more the excavating erosion tendency in the beach. The range between the maximal and minimal profiles usually exceeds o.5 m and is smaller in section 1, where the erosion rate seems to be slowed down at present, after a period of intense activity. In fact, it is in this section, too, that, on the last of the series of profiles, accumulation was found at the shoreline: number 22 appears 3 times on the maximal profile in the foreshore portion. A conclusion can be drawn from this - and it is confirmed by the present aspect of this zone - that the most intense erosion processes are now slightly migrating northward, in the stretch of beach between sections Parc and Perla. In this zone, shore protection works were necessary, and they were recently undertaken, as some beach service buildings were being directly attacked by storm waves.

The presence of some greater order numbers on the maximal profile in the zone of high beach in section 1 indicates an alluviation tendency in this zone under the action of large storm surge, while the middle and lower beach, as well as the submerged beach, are submitted to progressive erosion. However, at both north and south of Mamaia, recent measurements define, as a rule, the minimum profile.

The most obvious prevalence of great numbers on the minimal profile appears in section 2 (Perla). Steady erosion is made evident in this stretch. Even the fact that ΔL_{max} and Δh_{max} take lowest values in this section reflects, in the last analysis, a better defined tendency in the beach profile - and this is erosion.

As regarding the maximal and minimál profiles, it must be taken into consideration that a small percent of the measurements were extended on the submerged beach - given the hard working conditions in the cold season - and so, amplitude of profile variation as it results from the graphs is less probable for the submerged beach. It is greater indeed and could exceed considerably the values calculated for the subaerial beach.

DISCUSSION OF RESULTS

A higher frequency of the measurements, or their time distribution so that they should come upon the characteristic circumstances from the point of view of the atmospheric circulation and sea state, would have pointed out more evidently the pronounced nonperiodical variations in beach profiles. But the main purpose on which the measurements were initiated on Mamaia Beach was to follow the periodical variations and to determine the tendencies in shoreline evolution. As for the variations produced by high steep waves - with greater h/L ratio - during storms, as an erosional agent, on the one hand, and by waves of low amplitude and steepness, as an accumulation agent, on the other hand, one can speak about a certain periodicity only in the measure in which the former are in conjunction especially with the strong winds from sector north-east, characteristic of the cold season, while the latter are most frequent during the warm season, when mild swell and waves generated by slow winds, especially from sector south-east, are prevalent. The west component is also more stressed during the cold season (1). The comparison of the curves of wind parameter and beach width variation (Fig.2) illustrates the statements above.

In spite of the agreement between the variation curves of sea level, wind components and beach width, no correlation equation could be drawn to provide a mathematical expression,founded on quantitative relations between the involved parameters. This impossibility is justified as following.

Firstly, if wind speed is a totally independent variable in the correlation,it is not the same with sea level near shore, where it is measured. It is dependent on wind speed and direction when the former takes high values, and forms an independent variable only if the wind-generated level chances are eliminated. On the other hand, wind speed alone, as an independent variable, cannot determine the beach width by itself - as a dependent variable. So, the imperfect independence of certain determining parameters is concurrent with their insufficient number. Actually, from among the secondary agents of the morphodynamical processes, having excluded more or less static, referring to coast and bottom topography, an important agent as the continental alluvial contribution or the balance of sand exchange with the adjacent zones should not be ignored. But, for the time being, the methods of quantitative determination of sand transport in the surf zone are not satisfactory.

Special mention must be made of some important losses of sand from the beach - however not determined quantitatively - by deflation under the direct action of wind. The sand dunes on the backshore, partially fixed in the zone of the bushes, bear witness of this permanent eolian denudation process of the dry beach in the middle of its profile, to which little attention was paid so far by researchers, in spite of the obviously unfavourable exposure of the beaches of the Romanian coast toward the predominant winds.

To conclude, the study of beach evolution by surveys of transverse profiles repeated in fixed points on fixed range lines during a longer period shows a close relation between the morphodynamics of the nearshore zone and the hydrometeorological agents and enables the determination of periodical variations and future tendencies in different beach stretches. In the latest years, Mamaia Beach was affected by an erosion process of which intensity increases southward with a maximum between the ranges of the hotels Perla and Parc.Here, the sandy strip of the beach is progressively narrowing as its slope is steepening and the storm waves attack the backshore, endangering some buildings.

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