

LITTORAL PROCESSES IN CAMPELLO COASTS

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ABSTRACT

The coasts of Campello (fig. 1), just at the North of Alicante, have undergone important erosions in the last few years. A study has been developed for over one year to separate seasonal and permanent variations of the shoreline. The geomorphology and the recent generation of these coasts have been established and the study and wind wave regimes have been defined to evaluate the littoral transports, particularly the longshore ones. The seasonal transversal profiling may show the seasonal changes in the littoral zone and the sieve and mineralogical analysis of the different samples of the beaches have completed the data for the discussion.

Taking into account other studies of the authors in other parts of the East and Southeast coasts of Spain, an hypothesis on the littoral processes has been established, separating the seasonal and the permanent and degradative consequences. Some recommendations to keep at least the present situation of the beaches and to protect the other stretches of the shore are presented as final conclusions.

1 INTRODUCTION

The especial quality of Mediterranean Coasts in Spain has suffered lately somehow because of the concurrence of several circumstances, as the reduction of solid materials apported by the rivers or the inadequate use of the littoral and coastal zones, without the necessary suitable shore protection implementations (COPEIRO, E. 1978; DIEZ, 1982, a). It obeys to a common worldwide phenomenon related to actions badly planned, which ignores the littoral dynamic and its role in the beach formation and evolution.

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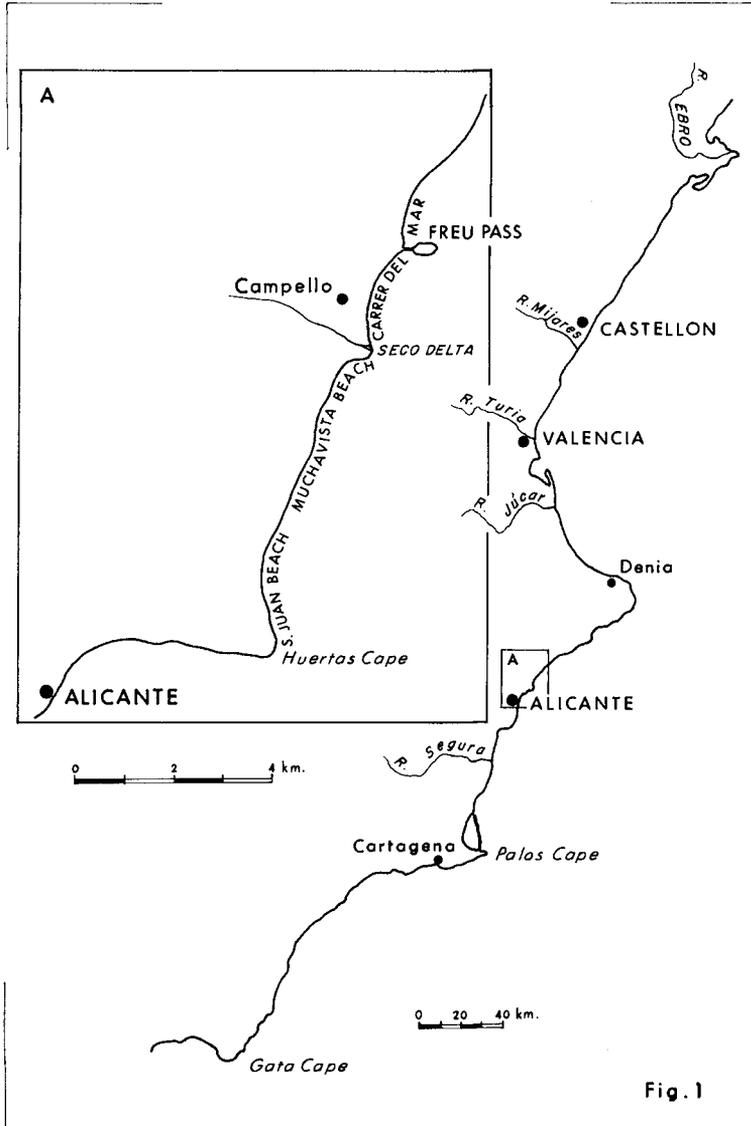


Fig. 1

Particularly, some parts of the coasts of Campello have suffered some apparently critical erosion in recent years. Since 1970 several shore protection systems have been tried without adequate results and, for that reason, a complete study has been developed along 1980-82. Even during the period of this study, while several perpendicular groins were being built, important damages in the village of Campello were produced by winter storms.

This study has been developed following two basic lines of research: a) Analysis of the littoral dynamic to define the littoral processes, and b) Identification of the forms existing in the coastal stretch.

The former has required the knowledge of the maritime winds to establish the accurate wind wave regimes (DIEZ, 1982, b) because sufficient wave register data are not available for this area. Advances in the methods for waves and storms forecasting (SUAREZ BORES, 1970; C.E.R.C., 1975), and the improvement in statistics data (HOGREN and LUMB, 1967; BRITISH ADMIRALTY, 1968) have been regarded.

The latter has been based on the present knowledge of the Geology of the area (MINISTERIO DE INDUSTRIA Y ENERGIA; ALONSO and PEREZ MATEOS, 1959) and on the results of the analysis of the samples obtained from the beaches of this coasts, placed at the South of La Mao cape, in the North end of the Southeastern Spanish littoral. Contributions for understanding the genesis and classification of the coastal formes (SUAREZ BORES, 1974) have been considered.

2 LITTORAL DYNAMIC

The principal and nearly exclusive factor involving the littoral processes in Spanish Mediterranean coasts is the wind wave regime. Winds affect somehow the formation and evolution of dunes and the filling of lagoons, and both surges and tides only modify the level of the wave action. Although changes of mean sea level caused by winds and/or pressure variations must be taken into account because of their incidence in the analysis of both observational data and changes of shoreline and transversal profiles. However this stretch is one of the least affected by them in all the Spanish coasts. The tide is extraordinary lessened here and the storm-surges do not seem to have produced elevations of the mean-sea level over 40 cm.

As in other coasts studied (DIEZ & ARENILLAS, 1982, a and b) no appropriate and sufficient registered or observed data of the sea exist to define the wind wave regime for this coast. Thus a forecasting method arising from wind regimes has been adopted, taking into consideration the criteria developed (DIEZ, 1982, b) which require establishing a wind regime first of all.

In accordance with those criteria the wind regime adopted for these coasts is the one adopted for Santa Pola bay by the authors. Other alternative based on the linear interpolation is neither too different nor more accurate here because of the position and the general orientation of the coasts of Campello. The dominant sea winds are from E and SE, nearly facing the general shoreline direction. The abundant breezes and other local winds are superfluous with this method because their influence on the littoral processes is weak here.

In the Appendix the wind wave regime is obtained in accordance with all these considerations and an evaluation of the longshore littoral transport is reached by applying the C.E.R.C. formulæ. The directional wave regime shows clearly the importance of the fetch configuration effect on waves reaching the coast, particularly on the ones from the first quadrant (N, NE, E). The reduction is specially important for N and, in a minor degree, for NE waves. On the other hand the S and SE wind waves are practically saturated when reaching the coast. The seasonal analysis shows that the strongest waves occur in winter and less frequently at the beginning of springtime, when the waves from the first quadrant are more dominant.

The evaluation of the longshore littoral transport -also in the Appendix- show a clear dominance of the Southward transport, perfectly noticeable in the direction of the annual average resultant. Independently of the accuracy of the C.E.R.C. formulæ for these coasts, the method followed in the Appendix may be accepted because its inaccuracy will affect all directions in a similar proportion. The aim of the evaluation method is not to define an accurate annual longshore transport rate, but to establish an average wave incidence direction in relationship with the capacity of the waves to generate the littoral drift. Nevertheless the relative importance of the total transport respect to the net southward transport must be taken into account, especially to understand the genesis of the present San Juan bay.

3 DESCRIPTION AND GEOMORPHOLOGY

This sector of Campello littoral corresponds to a stretch of plain coast placed between two other cliff-stretches: Huertas Cape at the South and an alternating system of cliffs and "calas" at the North, from the Freu pass. From a point of view based on the longshore transport, this stretch cannot be considered as an isolated one, that is, as a physiographic unit because not even the Cape is a total barrier for the littoral drift. Nevertheless it constitutes a particular subunit, a little apart off the littoral transport and fundamentally fed by a singular source of materials; therefore it admits an individualized study.

From "San Antonio" and "La Nao" Capes southward, Spanish coast shapes in accordance with the general geological system of the

Betic chaines, which direct their alignments from the Peninsular South to the capes and farther under the sea, emerging again in Pitiusas and Mallorca Isles. Prebetic and Subbetic chaines, at the North, and the actual Betic ones, at the South, close a wide Oval framing the coastal area between "La Nao" and "Palos" capes. The different chaines reach the sea transversally to the Coast in a wide and high mountainous arc and in other minor sierras and spurs. They structure a series of bays and coves opened to the second quadrant and filled with Neogenic and Quaternary sediments forming the present coastal plains. Within this frame, the Campello coastal area is placed between the Paleogenic sierras of Bonalba and Ballestera, at the North, and the Miocene of Huertas Cape, at the South, and constitutes an important Quaternary deposit between the mountains and the sea.

The Prebetic formations of the interior area may be easily characterized as Mesozoic or Low-Tertiary ones; but the characterization of the carbonated Jurassic and Cretaceous Subbetic formations offer many difficulties because of their strong tectonic in nappes and scales. The dominant materials in the plain are carbonates and detritus from the Prebetic and Subbetic Mesozoic, which, removed in different stages, have constituted most of the Tertiary and Quaternary sediments. Minor quantitative importance have the numerous Triassic and Jurassic outcrops from volcanic or sub-volcanic origin (however some of their constituent mineral appear in the beaches). The river Seco of Campello and its tributaries have principally canalized those materials towards the shore since the Pliocene. But other minor streams have collaborated in the drain of the generally intermittent run-off generating numerous alluvial cones and glacis between the mountains and the shoreline. So, three geological ensembles define this area: Betic chaines, the other minor Neogenic formations and the Quaternary fillings. These elements and the littoral dynamic have imposed the posterior evolution of the shore.

There are enough indicators of a progression of the shore in most of the points of this Spanish littoral since the final Tertiary in relationship with the variations in the Quaternary climatology and the tectonic factor affecting this zone; and the generation and posterior evolution of the lagoons of this area supports that hypothesis. Presently the human factor has introduced some incidences in the process.

The littoral of Campello may be considered divided in two stretches by the delta of the Seco river, but, initially, its shoreline should have been one only cordon-stretch, double-supported on the cliffs at the North, and on the Huertas Cape, at the South, and with an important massive singularity constituted by the river materials; its importance has led to the formation of an actual geometric singularity dividing the stretch. The evaluations of the average volume of materials dragged by the river establish it in $2 \cdot 10^6$ ton/year. At present, however, this volume

must be reduced because of the industrial use of the materials as aggregates and the reduction and control of the water streams.

Southward from the Delta a cordon-beach has closed an old lagoon up to the cape. Behind the beach and the berm, all along the cordon, one or several chains of dunes advance towards the plain which once before was the lagoon. The more towards the south the wider and flatter the beach is, the less pebbles appear and the thicker the dunes are, though different buildings hamper that observation at present. At the North of Muchavista all the beach is constituted by pebbles which disappear in the middle of San Juan beach. All together it looks like a double-supported, though somehow open beach, due to its length.

At the North of Seco river, along of "Carrer del Mar" the shore deposits look different. They are at the foot of a "rasa" of a gradually increasing level to reach the cliffs which shows both deltaic and littoral influence. All the up-beach shows a thick layer of large gravels, even cobbles, in spite of the sandy bottoms of the orshore zone.

4 STUDY OF THE SHORE MODIFICATIONS

The erosion of the beaches of Campello is noticeable for several years now, after their inhabitants observations, though no accurate documentation permits to define it. Inversely to other places like Denia, neither historical nor recent cartography has been available as a suitable reference. At the North of the old pass of the Freu, the sandy little beaches seem to show some regression for about 30 years now. Between the Freu and the delta ("Carrer del Mar") the erosion seems to have been obvious since the pass was closed, after some inhabitants, though others say that it began after the construction of the first groin (Fig. 2).

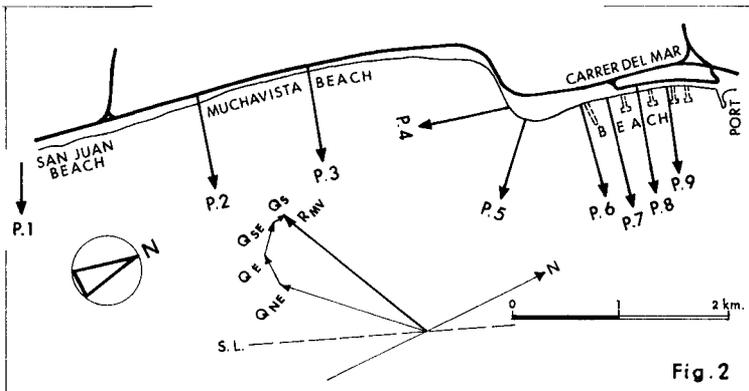


Fig. 2

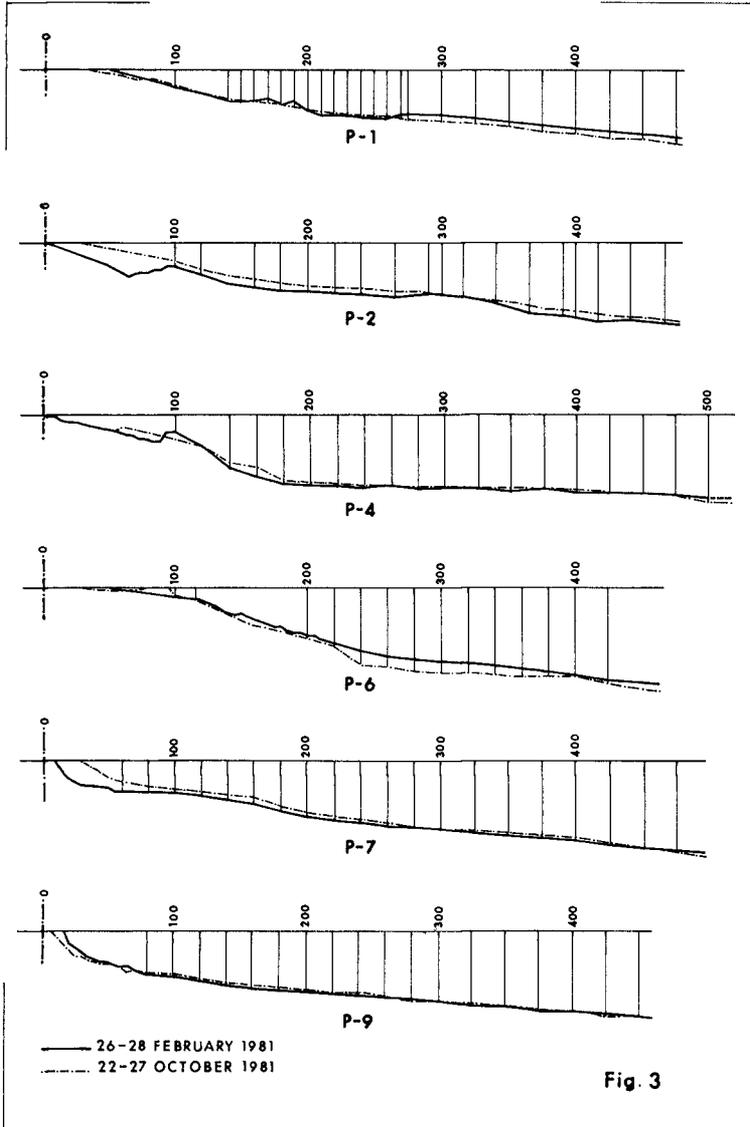
Actually the seawall must not have had a good performance as a protector and afterwards the beginning of other T-groins has accelerated the erosive process destroying the revetment in both 1979-80 and 1980-81 winters.

In the San Juan bay, Muchavista beach is undergoing a slow but continuous process of regression which affects the promenade every winter for some years now; (it probably has begun just after the last Seco's flood and subsequent advance of the delta, about 20 years ago). The erosion has been spreading southwards and, in the two last winters, has reached even most of San Juan beach.

Nine transversal profiles (P.1 - P.9) have been determined twice a year, considering the experience in other studies of this area, which show not more than two different seasonal profiles. The profiles P.4 - P.5 - P.6, and even P.7, show their deltaic nature. The mean slopes are smaller at the South (P.1 - P.3). In general, the variations of the different profiles between February and October correspond to typical transformation from bar (storm) to berm profiles (Fig. 3). P.1 shows, besides, a loosening of sands and some retreat of the shoreline, increasing its mean slope. P.2 and P.3, on the contrary, show some accretion and an advance of the shoreline, decreasing their mean-slope. Their pebbles were practically covered by sands. The deltaic front (P.4 - P.6) shows some erosion. The accretion in P.7 seems to show a dominant southward transport during spring and summer times. P.8 and P.9 do not show any recovery after the winter erosions.

As a whole the erosions seem to dominate in spite of the seasonal quietness. During winter the products of the erosion in both the delta and Muchavista beach may reach San Juan beach (P.1); during summer the materials of the delta reach Muchavista beach, because of a more perpendicular incidence of the waves. Also during summer eolic action takes the sands upwards to the berms and dunes in San Juan. The eolic circulation of the sands is easily noticeable in the bay all the year round though at present it is almost totally interrupted because of the wall of buildings, which border all San Juan beach. The orientation of the shoreline in P.1 and the incidence of the summer waves may permit also some transport towards P.2.

In the very nine profiles several sand samples have been taken from the beach and from several points of the bottom surface of nearshore zone, principally from onshore zone. All the "Carrer del Mar" and nearly all the Muchavista beach have a cap of pebbles which the nearer the delta the thicker and wider is, showing its deltaic origine. The visual survey of the sections of beaches in depth did not show variability but in the distribution of grain sizes. The samples were analyzed in their size distribution (after eliminating the organic material) and in their mineralogical nature. These latter analysis have only looked for the rate of the most abundant fractions and, in case, the roundness degree of the grains.



The rarer weight minerales had been studied (ALONSO & PEREZ MATEOS, 1959) and in this work it has been searched quartzs -white, grey and red-, tourmaline, circon, micas, lime organic rest and some meaning opaque one (particularly illmenita which is brought by Seco river from an ophitic outcrop).

Apart from the meaning of the mineralogical data, the influence of the deltaic materials in the formation of these beaches is well shown in the grain size distribution (Fig. 4) of some samples (change of concavity in P.4 - 150 m.; or variation of the slope around the n° 70 A.S.T.M. sieve size, in P.1, P.3 - 100 m. or P.7 - 200 m.). (Samples are named after the corresponding profile. If it is followed by a distance in meters it means that the sample has been taken at this distance from the shoreline; otherwise, the sample was taken at the beach).

The influence of the cap of pebbles in the formation of the beaches is shown, in turn, in the noticeable inflexion shown by several samples (P.9 - 100 m., P.8 - 50 m. and 100 m., P.2 - 100 m., P.3 - 300 m. and P.2 - 400 m.) about the n° 100 A.S.T.M. sieve size.

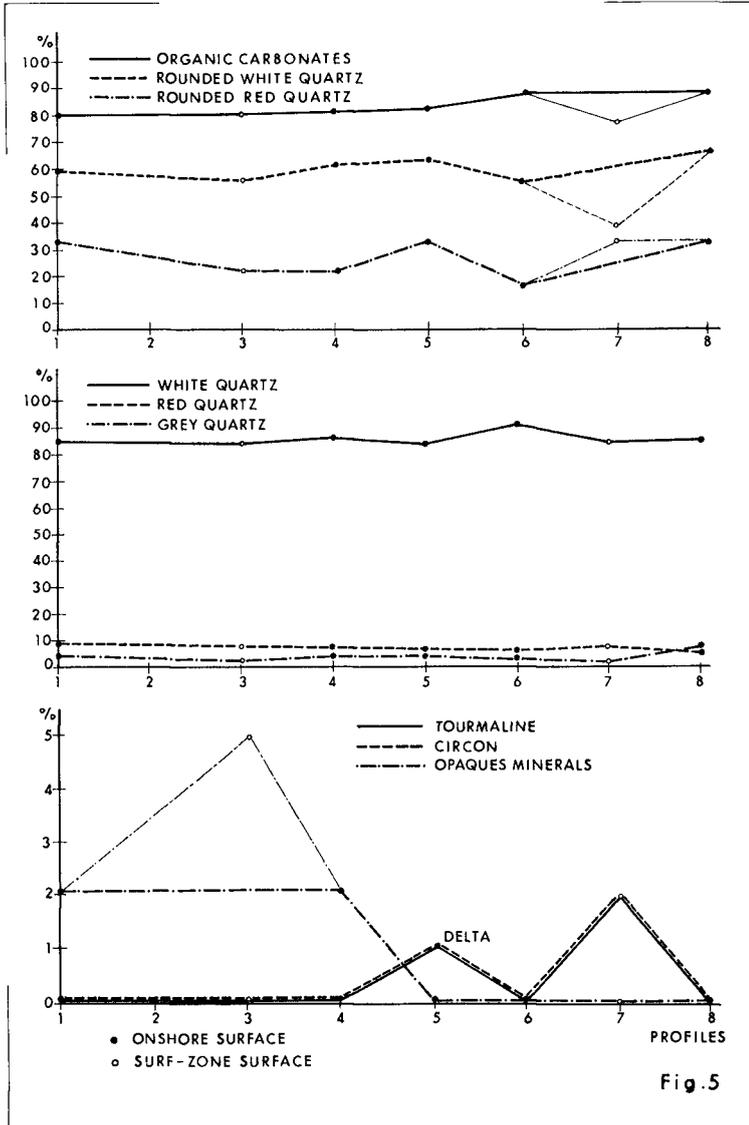
The uniformity of the size distributions of other samples must be due to the role of the littoral dynamic, and it is also noticeable that silts are more abundant at the North, and the farther from the shoreline the samples have been taken.

On the other hand, comparing the size distributions of all these samples to the ones of Santa Pola and Denia it seems that they are coarser here, the proportion of silts being minor.

The results obtained from the nature analysis are outlined in Fig. 5 in which the variation of the components along the shoreline is shown. The grey quartzs have abundant inclusions, which are not frequent in the other varieties of the quartz; this circumstance has not been found in the other areas studied in this littoral (Denia, Santa Pola). All but particularly the red quartzs show generally the crystalline faces of their grains, even the rounded ones, indicating a relatively short transport length. Tourmaline is especially angular. Carbonates are dominant in all fractions, constituting about 80% of the sands and the small grains show their shell nature; their source is here principally the cap of pebbles, which are rounded fragments of limestones.

The contains of organic material is minor than in other areas, being minima in the beaches (except in the beach of "Rincón", probably because some organic pollution), and maxima on the bottom of the deltaic front.

The lime fraction of sands varies very little either along shoreline or transversally. Quartzs are rather constant also: a) The roundness degree is higher at the South than at the North of the delta and in the nearshore than in the beach; b) the red quartz



outnumbers the grey one, unlike in other areas of this littoral (Denia, Santa Pola), but it diminishes in front of the delta. There are grains (rather sharp) of illmenita only at the South of the delta (but for a small quantity in P.6), probably in relationship with the dominant longshore transport. There are circon and tourmaline in San Juan beach (P.1) but not in Muchavista (P.2 and P.3); they seem to be in relationship with the quarrystones of the groins, in accordance with the studies of Denia and Santa Pola.

CONCLUSION

The study of the littoral dynamic shows a more or less pronounced dominance of the southward longshore transport. The results of the mineralogical analysis keep the same hypothesis. Nevertheless it is not possible to ignore the relevance of the longshore transport in both directions and the importance of the transversal dynamic. On the other hand a certain reduction of the available materials in the littoral zone is obvious and even the Seco river has diminished its activity lately. The present erosion of the deltaic front is therefore normal and, somehow, does not present any cause of worry. The situation is different, however, in the beaches.

In the "Carrer del Mar", at the North of the delta, the reduction of materials has become practically total because of the closure of the Almadraba pass, first of all, and of the construction of the first long groin, sometime later. The resultant physiographical pattern practically hampers any part of the littoral drift to reach the beach all along this stretch. Therefore the other shore protection measures adopted up to now could not be successful. But, on the contrary, the weak vertical sea wall firstly constructed as shoreline revetment should only accelerate the process, by recycling itself (The erosion takes the sandy materials off; consequently the slopes grow up, particularly in the surf zone; the breaking waves become higher also and their action increases over the pebbles and, using them, over the wall). At present the process have led to a mean slope of the surf-zone between 6-8%, which is rather significant though it has not reached the extraordinary values of some other coasts like almazora's (up to 25% in several stretches).

The posterior construction of three T-groins was badly developed, being simultaneously constructed their perpendicular branches and postponing too long the construction of their parallel ones which should constitute the actual and efficient protection. The presence of perpendicular elements of the groins have accelerated the erosion even more.

In San Juan bay the erosion had begun in Muchavista beach but have reached now the very San Juan beach. The data of previous chapter seem to show an easier natural nourishment of the South of the bay from the nearshore, receiving directly the materials

from both the deltaic front and the littoral drift from the NE. The nourishment of the North of it, from the South, is hampered by the asymmetric bottom structure of the deltaic front (P.4), which is due to the dominance of the southward littoral dynamic. This functional scheme must be completed with the eolian activity which permits sand to move in a cycle and to nourish the North of the bay (Muchavista beach) from the land. This hypothesis is perfectly compatible with all the results of the observation and analysis. The sands accumulated nearshore of San Juan beach during the winter, due to the NE and E waves, may reach the shore and backshore during the summer under the action of the winds perpendicular to the coastline. During the autumn the dunes move northwards and the sands spread on the plain in the same way they have filled the lagoon; part of them reach the extreme North of the bay and renourish Muchavista beach, closing the cycle: Sands move southward in the bay and northward along the backshore. The latter parts of the cycle is obstructed at present by the presence of an inadequate wall of constructions, which have destroyed and substituted the dunes. Therefore the erosion appears rather advanced in Muchavista and only seems to begin in San Juan, but an increasing of the regression of the latter beach is foreseeable.

As conclusions it is possible to establish the following statements:

- 1.- This stretch cannot be considered a physiographical unit since not even Huertas cape is a total barrier to the longshore transport. Nevertheless its most important source of material is interior to the very stretch (Seco river), being more difficult for the general littoral drift to reach its beaches, particularly that one of "Carrer del Mar" after closing the Freu pass. This difficulty is increased by the very presence of the delta which as counterweight is undergoing an appreciable regressive process, such as it has been noticed even during calm weather season.
- 2.- The littoral dynamic has an important transversal component. Its longshore component is alternating and significant in both directions though the southward transport is dominant along the mean year. This general consideration must be in accordance with the particular orientation of the shoreline in each point which may modify the direction of transport. So are the cases of the south end of San Juan bay and the north bord of the delta: southward of a certain point in each of them only northward transport occurs in the surf-zone.
- 3.- The importance of the total longshore transport and the delta activity all along has permitted the development of the present plain through the formation of one or several successive barriers and the posterior filling of the littoral lagoons. This evolution of the shore has been favoured besides by the progre-

ssion of the point delta, which acted as support of the barrier, and by the eolian activity, which accelerated the filling. During this period all this stretch, between Huertas cape and the cliffs of the North, behaved as a sink for total longshore drift in both directions.

4.- At present, however, the relative position of the deltaic front respect to the cliffs and the closure of the Freu pass avoids practically any nourishment of the "Carrer del Mar" beach from the littoral drift. The erosion has begun to dominate and afterwards, to increase by the inadequacy of the successive works for shore protection.

5.- The present dimensions of the San Juan bay, between the delta and Huertas cape, would be adequate, however to permit a sufficient nourishment, if the eolian migration of sandy cycle were not cut. Therefore the erosion has begun in the North of the bay as it always happens leeward of a geometric singularity (the delta itself), but it is spreading riskily southward and will reach the very San Juan beach.

6.- In order to implement some important harbour facilities for pleasure or a marina, within the district of Campello the very deltaic cone would be the best place since it would be planned without producing negative changes in the littoral processes. The port should be interior and especial cares should be taken to permit the evacuation of the floods and to avoid the entering of the sands.

RECOMMENDATIONS TO ACT

Considering the conclusions above some recommendations may be proposed. Apart from the delta, which would admit an interior port of pleasure, two sub-stretches will be distinguished:

a) The "Carrer del Mar" is very undernourished now from both directions and the transversal dynamic acts efficiently over it. Only some offshore system of protection, preferably complemented by an artificial replenishment might be suitable. The designed T-groins would likely have been successful if the parallel breakwaters had been constructed quickly after beginning each T-groin; it had obliged to construct one after the other instead of simultaneously. Besides, some other breakwater will be necessary northward of the last one and related to the little haven. In any case, an important artificial replenishment will be necessary to get a suitable beach, but a reduction of the amount of sands would be possible employing material from the delta in the deep and back layers.

b) In Muchavista the undernourishment is more endemic but it would be less severe if the eolian feeding were not so diminished now. Any construction in this bay would affect its present aes-

thetic quality. Only the artificial nourishment in the north end of the bay might be effective. Nevertheless a suitable revetment with a soft slope will be necessary immediately to protect the promenade.

APPENDIX: LITTORAL DYNAMIC EVALUATIONS

The sectorial definition of the Fetch for a point placed in front of the Seco delta and in deep waters is shown in Fig. 6. The number of sectors is enough and the limits between each couple are placed so as to adequate it to the real Fetch.

The parameters of the sectors are shown in TABLE A.1. The directional wind wave regime obtained is shown in Fig. 7. From these regimes a valuation of the longshore littoral transport has been obtained by applying the C.E.R.C. longshore transport rate formula (in decimal units):

$$Q \text{ (m}^3\text{/year)} = 2.045 \cdot 10^3 \cdot f \cdot H_o^{5/2} \text{ (m)} \cdot F(\alpha_o)$$

and following the method developped in other previous works to obtain an annual average resultant wave.

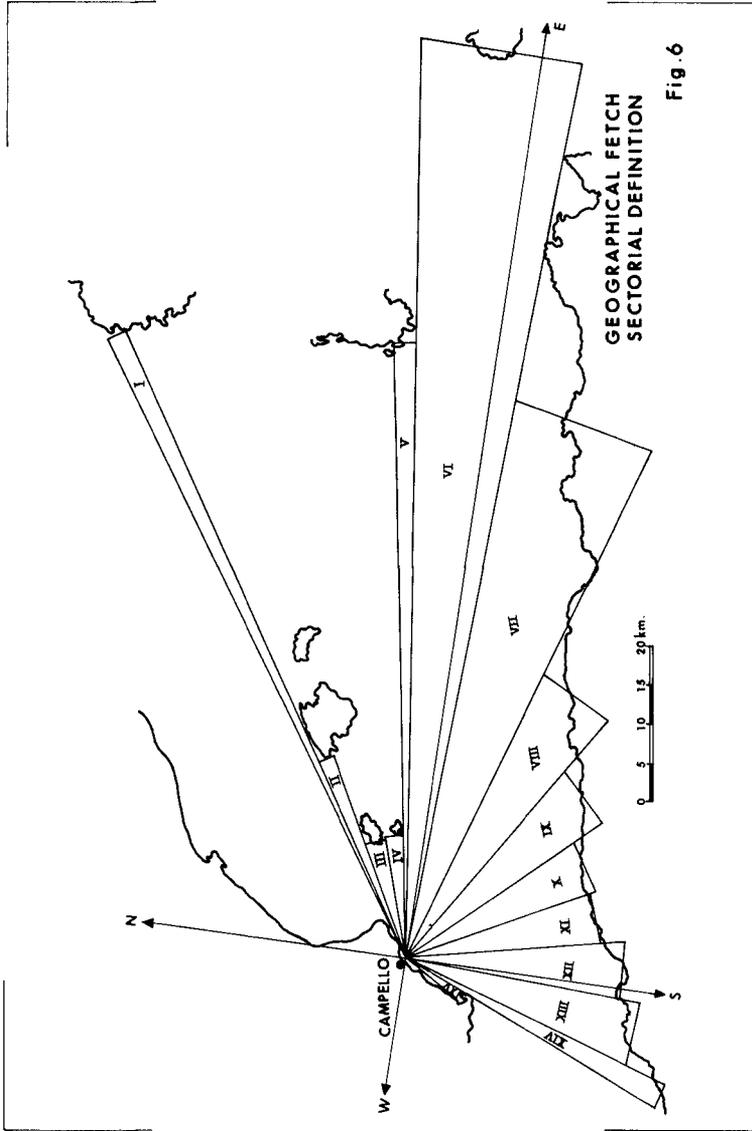
In it, $f = (1 - F_x) \cdot K_o \cdot K_f$, with

$$K_o = \frac{\text{n}^\circ \text{ of observations in the octant (sector)}}{\text{total n}^\circ \text{ of observations} = 1072}$$

TABLE A.1.

SECTOR (N°)	AMPLITUDE (°)	(θ_i / θ_{i+1})*	LENGTH (km.)
1	2	(56-58)	872
2	4	(58-62)	270
3	10	(62-72)	151
4	8	(72-80)	154
5	2	(80-82)	781
6	11	(82-93)	1155
7	15	(93-108)	709
8	15	(108-123)	393
9	15	(123-138)	300
10	15	(138-153)	544
11	15	(153-168)	248
12	15	(168-183)	278
13	15	(183-198)	308
14	5	(198-203)	371
15	7	(203-210)	82

*The angles (θ_i) are refered to an origin defined by the general direction of the shoreline.



$K_f = 1$ for all directions (sectors) because the general direction of the shoreline coincides, in this case, with the N.NE - S.SW direction.

F_x may be obtained from the Fig. 7, where the regime of each direction must be considered shortened by the $(H_o)_{max}$ corresponding to the respective top wind speed observed.

The α_o value of each direction is the average of the two extreme α_o of the correspondent sector (octant).

The values of these variables for the four established directions are as follows:

- a) NE direction: $\alpha_o = av(90^\circ, 45^\circ) = 67,5^\circ$
 $K_o = 162:1072 = 0,1511$; $(H_o)_{max} = 3,51$ m.
- b) E direction: $\alpha_o = av(45^\circ, 0^\circ) = 22,5^\circ$
 $K_o = 222:1072 = 0,2071$; $(H_o)_{max} = 5,56$ m.
- c) SE direction: $\alpha_o = av(0^\circ, -45^\circ) = -22,5^\circ$
 $K_o = 56:1072 = 0,0522$; $(H_o)_{max} = 5,04$ m.
- d) S direction: $\alpha_o = av(-45^\circ, -90^\circ) = -67,5^\circ$
 $K_o = 81:1072 = 0,0737$; $(H_o)_{max} = 3,72$ m.

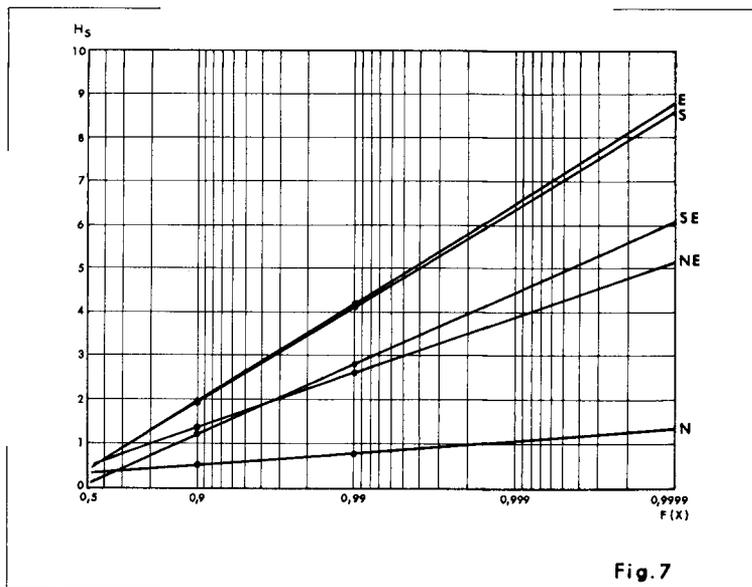


Fig. 7

where sign (+) means southward longshore dynamic and sign (-) means northward longshore dynamic.

With these data the respective longshore transport rate induced are obtained in TABLE A.2.

The results show a clearly dominant southward transport though both the resultant total ($Q_T = 1.071.404 \text{ m}^3/\text{year}$) and net ($Q_N = 593.158 \text{ m}^3/\text{year}$) annual longshore transport rates are not to be considered as accurate ones.

Ascribing to each direction a vector defined by de α_0 value and the particular Q value obtained from TABLE A.2. an average (equivalent) annual wave direction (A.V.) may be established (Fig. 2).

TABLE A.2.

$\frac{H}{i}$	$Q_{(NE)_i}$	$\frac{H}{i}$	$Q_{(E)_i}$	$\frac{H}{i}$	$Q_{(SE)_i}$	$\frac{H}{i}$	$Q_{(S)_i}$
0	2.738	0	2.833	0	- 582	0	- 876
0,5	18.467	0,5	26.350	0,5	- 4.629	0,5	- 7.920
1	28.656	1	56.388	1	- 8.470	1	- 16.470
1,5	28.757	1,5	78.037	1,5	- 10.024	1,5	- 22.149
2	23.325	2	87.287	2	- 9.588	2	- 24.073
2,5	16.669	2,5	86.023	2,5	- 8.080	2,5	- 23.053
3	10.952	3	77.944	3	- 6.261	3	- 20.297
3,5		3,5	66.519	3,5	- 4.569	3,5	- 16.832
		4	54.278	4	- 3.188	4	
		4,5	42.774	4,5	- 2.148		
		5	32.782	5			
		5,5					

$$Q_{(NE)} = 129.564 \quad Q_{(E)} = 610.214 \quad Q_{(SE)} = -57.540 \quad Q_{(S)} = -131.772$$

$$Q_B = 929.090 \quad Q_N = 550.466 \quad \alpha_i = 16^\circ$$

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