CHAPTER 253

The Complementary Interaction between Beach Nourishment and Harbour Management : Four Cases in Spain

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ABSTRACT

This paper describes several results on beach nourishment and harbour management interaction, within the authors' area of responsibility. These positive results show the socio-economic benefits which can be achieved through effectively combining harbour and coastal requirements.

1.- INTRODUCTION.

Although harbour works have sometimes produced negative effects on the coast, there can be works which, by combining harbour and coastal requirements satisfactorily, could improve the scenario which exists in some coastal areas adjacent to the harbour. In particular, harbour dredged material, if adequate, should be used for beach nourishment and/or littoral drift restoration. Also, Coastal & Harbour Authorities should work in coordination from the initial stages of the projects where a combined design could satisfy the objectives of both parties.

2.- OBJECTIVE.

The main objective of this paper is to describe several positive results of beach nourishment and harbour management interaction, which have been achieved within the authors'technical area of responsability, at the Spanish Coast Directorate (MOPTMA). These cases have been chosen to demostrate the socio economic benefits which can be achieved through effectively combining harbour and coastal requirements.

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Although at the time of writing the first abstract our intention was to describe four Spanish cases, we have added one more case which we found interesting within the scope of this paper. The main points of this paper are the following : I.- Effects of Harbour Works on the Coast. (Some examples of "uncoordinated works"). II.- Positive Results of Coordinated Works. III.-Conclusions and Recommendations.

3.- EFFECTS OF HARBOUR WORKS ON THE COAST.

(Some examples of "uncoordinated works").

Before showing the positive results of coordinated works (which is the main object of this paper), we would like to show, as an example, some pictures related to what we could call "uncoordinated works" in Spain. The negative effects on the coast produced by the construction of harbour breakwaters are classic topics in Coastal Engineering and can be found all over the world.

Typical negative effects which the presence of harbours cause on the coasts could be the following: A) Littoral Drift Interruption B) Beach Change Induced by a Harbour and C) Effect of Wave Reflection on the Coast Induced by a Harbour Breakwater. Fig.1 depicts a view of Almerimar Marina, located in the Almerian coast. Note the interrruption of the littoral drift and the unproper design of the marina entrance.

Fig 1. A View of the Effect Caused by the Littoral Drift Interruption. (Almerimar Marina, Almerían Coast)

Fig.2 shows the destruction of the seafront due to the coastline erosion caused by the negative effect produced on coast by the construction of the aforementioned marina.

Fig.2.- Erosion Caused by Littoral Drift Interruption.

In Fig.3 the siltation at the entrance channel is clearly indicated "on site" by the length of the first author's kayack paddel.

Fig.3.- Siltation at the Marina Entrance Channel.

4.- SOME POSITIVE RESULTS OF COORDINATED WORKS

A summary of the cases of positive results of coordinated works is shown below:

A.-DREDGING WORKS
1.- HARBOUR ENTRANCE CHANNEL DREDGING AND URBAN BEACH NOURISHMENT (Cádiz Harbour and Urban Beaches)
2.- HARBOUR ENTRANCE CHANNEL DREDGING AND LITORAL DRIFT RESTORATION (Huelva Harbour-Playa de Castilla Beach)
B.- COMBINED HARBOUR/BEACH DESIGN
1.- A DESIGN WHICH COMBINES A SHELTERED INNER HARBOUR BASIN AND A NEW URBAN BEACH (Algeciras Harbour-La Línea Beach)
2.- A DESIGN WHICH COMBINES AN EXISTING INNER MARINA BREAKWATER AND A NEW URBAN BEACH (Gijón Marina-Levante Beach)
3.- CREATION OF BOTH BEACH AND HARBOUR (Luanco Beach and Harbour)

The first point deals with harbour dredging and how the dredged material was used : urban beach nourishment and littoral drift restoration.

In the second point Coastal & Harbour Authorities coordinated the combined design of harbour and coastal works.

5.- DREDGING WORKS

5.1.- GENERAL

Traditionally the dredging of a harbour channel was a matter which concerned only Harbour Engineers. The different phases of the dredging projects were mainly carried out focussing on harbour engineering requirements.

Years ago, the question of whether or not the sand in a harbour channel could be suitable for a posible beach nourishment or for a littoral drift restoration project was not a concern of the Port Authority.

In other words : the countless millions of cubic meters of sand regularly wasted in dredging operations might have been more suitably used in beach nourishment or littoral drift restoration projects if Maritime Civil Engineers at that time had been more aware of the importance of combining both harbour and beach considerations.

Speaking in general terms, harbours need more water depth for their extensions and the coastline will benefit with beach nourishment. To obtain a real benefit, dredged materials should accomplish the following requirements :

a.- Dredged Material Quality.

b.- No Negative Effect on the Coast.

c.- Proper Attention to Archeological Artifacts (if applicable).

Harbour and coastal engineers should "coordinate" their works from the initial stages of the project.

Multidisciplinary teams (marine biologists, geologists and archeologists, as well as environmental and landscape specialists) should participate during the different phases of the projects.

5.2.- HARBOUR ENTRANCE CHANNEL DREDGING AND URBAN BEACH NOURISHMENT: CADIZ HARBOUR AND URBAN BEACHES.

The need to dredge the entrance channel in Cádiz Harbour, together with the loss of dry beach width, at the popular urban beach of La Victoria under normal daily high tide conditions, prompted the Spanish Directorate of Ports and Coasts to plan a joint project looking at both harbour and beach requirements.

Furthermore,two other very popular urban beaches, Santa María del Mar (adjacent to La Victoria Beach) and La Caleta, were nourished.
It should be noted that this was the first time in Spain that a dredging project of such importance (more than 6 million m3) was planned fulfilling both harbour and coastal engineering needs.

Due to the great historical importance of Cádiz bay, archaelogical works were also carried out by specialists during different phases of the project, recovering more than 5.000 artifacts, mainly coins.

The sand volumes needed for the nourishment of the aforementioned beaches were (1.730.000 m3 in project). The total project budget was 3.900 Mill. Pts.

In order to identify suitable borrow areas for beach nourishment, specific survey, geophysical, vibrocoring and biological studies were undertaken by the Coastal Project Division of the Spanish Ministry of Public Works and Transportation (MOPTMA). Also, specialists carried out submarine prospects to investigate the existence of valuable archeological deposits.

Owing to the location of La Victoria beach and Cádiz Harbour, it was necessary to lay a 90 cm diameter pipeline from the La Cabezuela inner quay, where a barge was loading sand from the dredge, to the beginning of La Victoria beach. The sand by-passing works had to pass over the main motorway and a train line to reach the beach, using aproximately 5 kilometers of pipeline.

Two modern trailing hopper dredgers (ANTIGOON AND HAM 310) were used, the former performing 90% of the work. The average sand nourishment ratio was 45.000 m3/day. The fact that only 0.75% of the volume was refused for beach nourishment indicated the efficiency of the preliminary studies and dredging operations.

The selective channel dredging plan obtained from vibrocoring studies enabled the coastal project engineers to use different grain size diameters depending on wave exposure location : $0.2 < D50 < 0.30$ mm, for most of the beach and $0.30 < 50 < 0.30$ mm, for the relatively more exposed Northerly final part of the beach.

The initial colour of the sand (apparently very darked) changed very quickly into the same nice colour as the native sand, as soon as the dumped sand dried and oxidized, as was expected. Otherwise, the beach nourishment project would not have been a succes popularly speaking.

A three year field monitoring program is being carried out to obtain a better understanding of the La Victoria beach behaviour, with respect to the littoral processes and coastline kinetics. This will aid coastal managers to adopt effective coastal management strategies regarding beach stability.

The following picture depicts an aerial view of La Victoria Beach under daily high tide conditions. Notice the occupation of the former dune by high buildings and the seafrot as well as waves impinging upon the vertical face of the sea-front.

Fig.4.- A detail of the La Victoria Beach under Daily Tide Conditions Prior to Beach Nourishment.

The following pictures show the general dredging plan for beach nourishment, as well as a detail of the beach width (Notice the blocks used to protect the seafront from waves under daily high tide conditions.

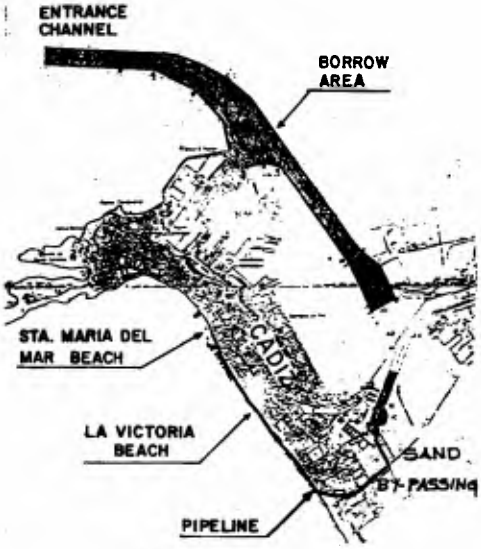

Fig 5.- General Dredging Plan for Beach Nourishment.

Fig 6.- La Victoria Beach after Beach Nourishment.

5.3.- HARBOUR ENTRANCE CHANNEL DREDGING AND LITORAL DRIFT RESTORATION (Huelva Harbour-Playa de Castilla Beach).

The Huelva Harbour Authorities have recently carried out a project to dredge the main harbour entrance channel. Aproximately 5 million cubic meters of sand could be adequate for beach nourishment. Presently Coastal Authorities are studying the feasibility to build a submerged bar at -4 m. water depth to restore the littoral drift interrupted, among other causes, by the Huelva Harbour breakwater. These works will enhance a previous littoral drift restoration project carried out at the adjacent beach, Playa de Castilla (Refer.1, 2 & 3), where 1.5 million cubic meters of sand were supplied to form a protruding area, aimed at restoring the net littoral drift balance. The following picture depicts the erosion existing at the end of Playa de Castilla, in Matalascañas Beach. It should be noticed that this erosion is also caused by the former construction of a seafront and buildings on the dune.

Fig.7.- Erosion at the End of Playa de Castilla (Matalascañas Beach)

6.- COMBINED HARBOUR AND BEACH DESIGN

6.1.- A DESIGN WHICH COMBINES A SHELTERED INNER HARBOUR BASIN AND A NEW URBAN BEACH. (Algeciras Harbour and La Línea Beach).

The need to provide a sheltered inner basin in Algeciras Harbour was combined with the creation of an urban beach in great demand by the La Línea city´s population. The following picture shows an aerial view of the works.

Fig.8.- A view of La Línea Beach Restoration.

6.2.-A DESIGN WHICH COMBINES A SHELTERED INNER HARBOUR MARINA AND A NEW URBAN BEACH (Gijón Marina-Levante Beach).

An urban beach and seafront were designed taking advantage of one of the marina's existing breakwater (Fig.9). Navigational and sedimentation problems at the marina entrance channel were two important problems taken into consideration, as well as the overall integration of the beach design into the existing urban development. In this case the Gijón Harbour Authorities were responsible of the whole project and work. The technical staff of the Coastal Authorities cooperated during different stages of the project.

The geophysical studies carried out by coastal specialists were used by the Gijón Harbour technical staff to determine the potencial sand reserve areas, after undergoing vibrocoring and biological studies. These latter studies were very beneficial to Coastal Authorities to plan future beach nourishment projects along the Asturian coastline, and in particular for the next case of Luanco Beach.

The project consisted of the construction of two breakwaters and the dumping of 380,000 m^3 of sea bottom sand. It was necessary to dredge 17,000 m^3 of rock, as well as to demolish 32,000 m^3 of an existing seawall protruding into the sea. The project cost was 1,000.000.000 pts. The projected magnitudes obtained for the new beach are the following : HTWL. beach : 60,000 m^2; (3 m^2 /p); 20,000 people; M.T.W.L. beach : 100,00 m^2 ; (3 m^2 /p) 33,000 people. Breakwaters'length: 400 m; Seafront length: 800 m.

Fig.9.- A Composite Aerial View of Gijón Marina & Levante Beach

Next figure shows aerial views just after project completion.

Fig.10.- Aerial Views after Project Completion.

6.3.- CREATION OF BOTH BEACH AND HARBOUR (Luanco Beach and Harbour).

This final case is the creation of both beach and harbour in Luanco (Asturias). The harbour has been designed by the Asturian Ports Division and presently there are local discussions about the feasibility of its construction. Since the construction of a lateral groin was considered necessary to create a new beach, the design of the beach was carried out taking into account the geometry of the future harbour. A relatively low-crested groin was designed in order to achieve the minimum visual impact. The section of this groin could be enlarged as a part of the outer harbour breakwater. Fig 11 is an aerial view of Luanco; note the scarce existing beach. The cost of the beach restoration has been 120 million pts. A sea front has also been designed to restore and integrate the maritime facade. Both projects are expected to be completed by the summer of 1995.

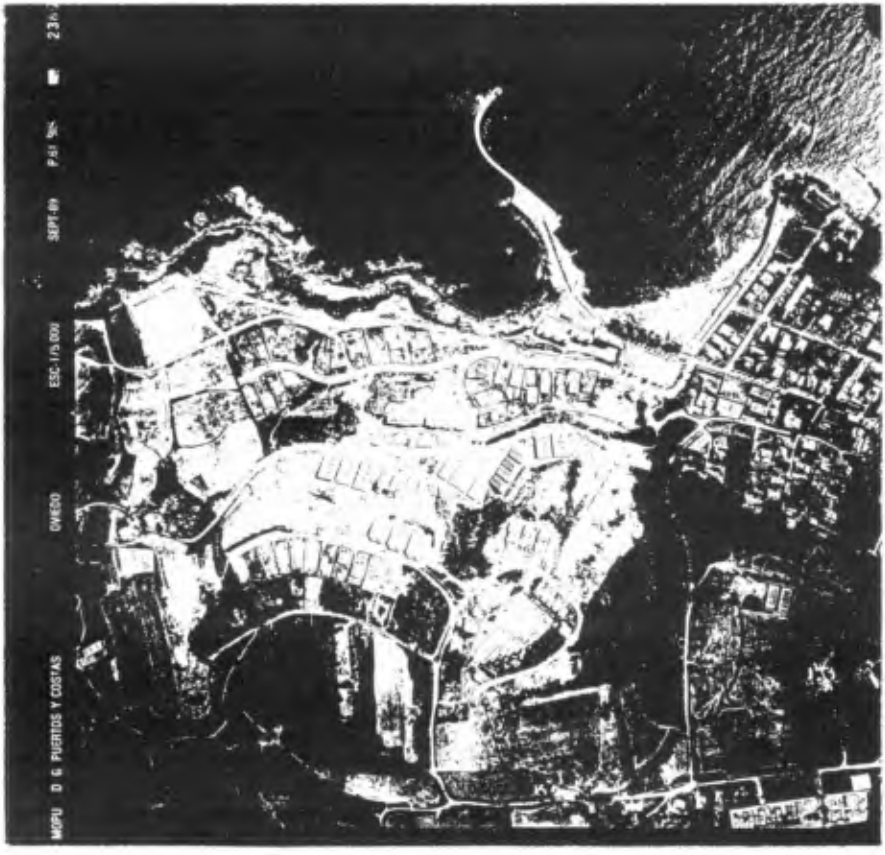

Fig.11.- An Aerial View of Luanco (Asturias).

Fig.12 schematizes the combined beach & harbour design.

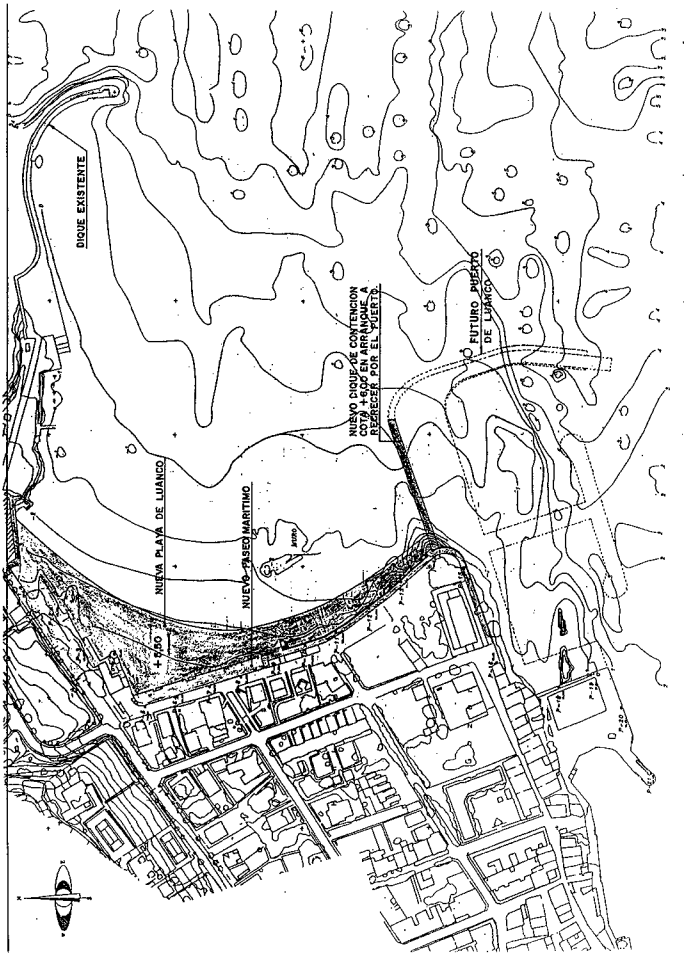

Fig.12.- Projected Luanco Beach .

7.- CONCLUSIONS AND RECOMENDATIONS

A.- Although it is known that harbour works frequently have produced negative effects on the coast, there can also be works that combined harbour and coastal requirements satisfactorily. This could improve the scenario existing in some coastal areas adjacent to the harbour.

B.- The harbour and coastal technical staff should coordinate the works from the initial stages of the project, taking into account other multidiciplinary teams such as marine biologists, geologists and archeologists, as well as environmental and landscape specialists.

C.- The existence of strong legislation which protects the litoral, such as the actual Spanish Shore Act, that prohibites the use of sand for purposes other than beach nourishment, make it possible to succesfully accomplish the works described in this paper.

8.- ACKNOWLEDGEMENTS.

We are grateful to the many people and multidisciplinary teams who have participated in all the projects described herein.

Without the interest and involvement of the Harbour and Coastal Authorities of Cádiz, Huelva, Algeciras and Gijón, these coordinated projects could not ever have been accomplished.

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