CHAPTER 107

IMPACT OF YACHTING MARINAS ON BEACHES

by

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The development of tourism resulted in the construction of very many small yachting harbours along the French mediterranean shore during recent years. Some of them were constructed on the rocky foreland located at the end of sandy beaches. Such beaches being a priori stable, no particular sedimentation investigation was carried out. In several cases, the construction of a port led to rapid evolution of the beach, accretion occuring in the vicinity of the port and erosion elsewhere.

1 - NATURE OF THE PROBLEM

When a port is situated on a sandy shore experiencing significant littoral drift, many precautions are taken to ensure the continuity of sediment transit (by passing) or to remedy the consequences of its interruption.

It is not the same in the case of a sandy beach enclosed between two rocky forelands and appearently stable. Generally there is very little net sand movement from one beach to another past the headlands and the coastal line does not change significantly with time. This can be misleading giving the impression that there is little or no longshore transport of sediment : this however is not the case

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as the resultant littoral drift along a shore is usually a balance between sand movement due to swells from opposing directions which may individually transport very significant quantities of material. Even though the resultant sediment movement due to the two opposing swells produces zero drift on a stable beach between two rocky headlands, a change in only one of the terms can induce spectacular evolution.

To illustrate such a mechanism, let us consider the schematical case of a west-east oriented beach submitted to two swells, having different origins (north-west and north-east, as in fig. 1), but the same frequency. In the natural state, the north-west swell induces a littoral drift eastwards when the north-east swell does the same westwards. On average, they cancel each other out and the shore is stable during a long period of time ; it comes under the influence only o alternated evolutions, generally small, as the continuance of each swell is limited.

Now, let us build a port with an enveloping breakwater at the west end of the considered beach (fig. 2) ; this port will achieve a sheltered zone from the north-west swell, where the transit eastwards becomes zero and where the only transit westwards, due to the north-east swell subsists. The equilibrium is broken and a net littoral drift appears in the sheltered zone ; the sand accumulates at the port entrance and, to satisfy continuity, the rest of the beach erodes. The evolution so induced is therefore doubly harmful : the port access is endangered and the beach disappears.

This mechanism and the consequent beach evolution are very obvious and the explanation of the damage suffered is easy for the specialists in the subject. Unfortunately, the mechanism is less evident a priori and the engineers, having overcome their apprehension about the stability of the shore in its natural state, do not feel the need to get advice from these specialists before designing a project.

2 - AN EXAMPLE OF EVOLUTION VERIFIED IN SITU

A spectacular example is provided by Bormes-les-Mimosas port (fig. 3), which was constructed on a rocky foreland separating two beaches of very fine sand, the first at the north and the second at the south. This port includes a jetty constructed on the rocky foreland oblique to the shore and a breakwater parallel to the shore. The entrance to the port is open to the north beach. The beach experiences swells from the east which ara almost parallel to the shore, and produce very little drift, swells from the south-east creating a south-north transport of sediment and north-east swells producing a contrary north-south movement. The port works considerably after the effect of the swells and result in a large zone on the south beach sheltered from the north-east swells and, on the north beach, a zone, as important as the first, sheltered from south-east swells. As a consequence of the imbalance, more sand is transported along the north beach from north to south than formerly and similarly more sand is transported along the south beach from south to north, procuding significant accretion in the vicinity of the port during the course of two or three years.

Figure 4 shows the evolution of the shoreline on each side of the marina during its construction.

On the upper part of the figure, only the south part of the breakwater is built, but it already creates a sheltered zone on the south beach where a beginning of accretion is clearly visible.

In the middle part, the accretion is increasing fastly and propagating to the north like a sand wave. The advencing of the breakwater to the north also induces an accretion on the north beach.

The last picture of figure 4 is a copy of a postcard showing the marina after completion. The accreation on both sides of marina is clearly visible.

Plan views of figure 5 show the initial configuration of the shoreline in 1968 and in 1973 after completion of the marina. There is a uniform recession of the north beach shoreline and it is quite evident that the sand trapped near the marina comes from this beach. But as the volume of sand trapped is greater than the volume lost by the beach, a part of it comes probably from offshore erosion which occured in front of the breakwater.

Another erosion occured on the south beach and a groyne was constructed to stop this erosion and its extension to the whole beach.

The advance of the shoreline at the south is more than 100 m, and on the side of the entry channel the accretion necessitates maintenance dredging.

3 - MEANS OF STUDY

For reasons of cost and time allowed, it is not possible to carry out a study on a movahle bed model for each yacht-port to be built, but the noted evolutions may be anticipated thanks to simple studies on drawings. Such studies consist of the determination of the direction where the existing in situ swells come from, the establishment for these swells of wave refraction diagrams giving the propagation of swells as well as their angle of incidence with the shore and diffraction diagrams giving the effect of the port on the swells spreading. By reasoning from the results of these calculation or from the operation of a littoral drift mathematical model, it is possible to estimate both the effect on sand transport and the resulting evolution of the shoreline.

4 - POSSIBLE REMEDIAL MEASURES (fig. 6)

In order to avoid such a type of evolution, it is necessary to desing ports that don't create sheltered zones from certain swells outside the structures. For that, the pegging out of the port along the shore shall correspond with a maximum possible accuracy to the extent of the zone where the spreading of various swells is disturbed by the presence of the port structures. The best way seems to desing a port including two convergent breakwaters, the direction of each of them corresponding to the swells extreme origine. In the case of an asymmetrical port that includes only one breakwater starting from the shore, it seems necessary to build on the other side a groin long enough to allow the sands transit to stop just at the limit of the sheltered zone created by the port.

CONCLUSION

It should not be forgotten that a beach seeming stable is in fact in dynamic equilibrium under the action of various movements of sand that cancel each other out. Therefore, it is enough to change one of these to disturb the general equilibrium and provoke rapid evolution. The construction of a port, even of small importance, in the vicinity of sandy beaches must consequently be preceded by a minimum study by drawings, that will allow an assessment to be made of the future evolution resulting from port construction and the définition of a certain number of safeguards that will be used if the noted evolution is effectively as dangerous as the predicted one.

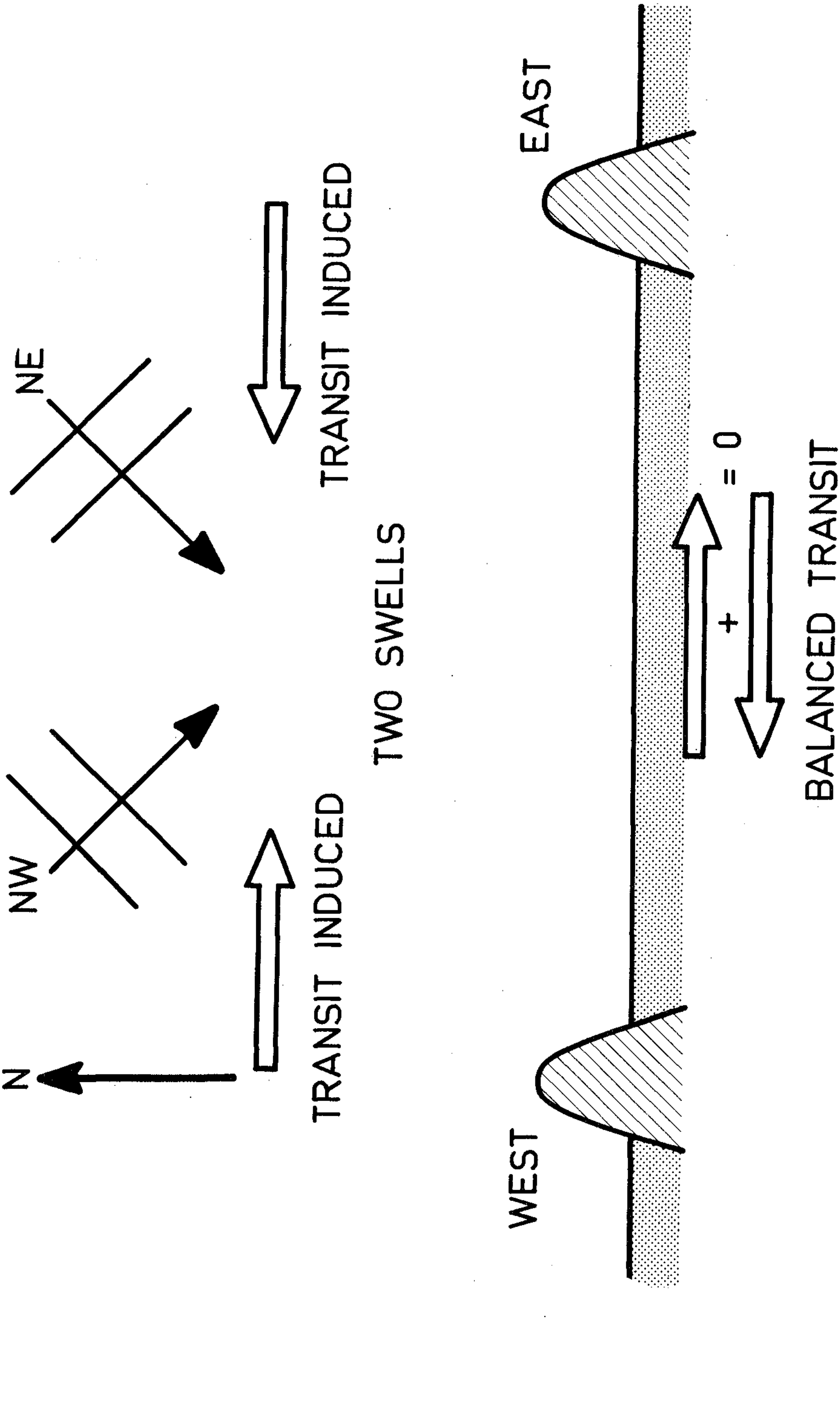

Fig.1–BEACH IN EQUILIBRIUM IN ITS NATURAL STATE

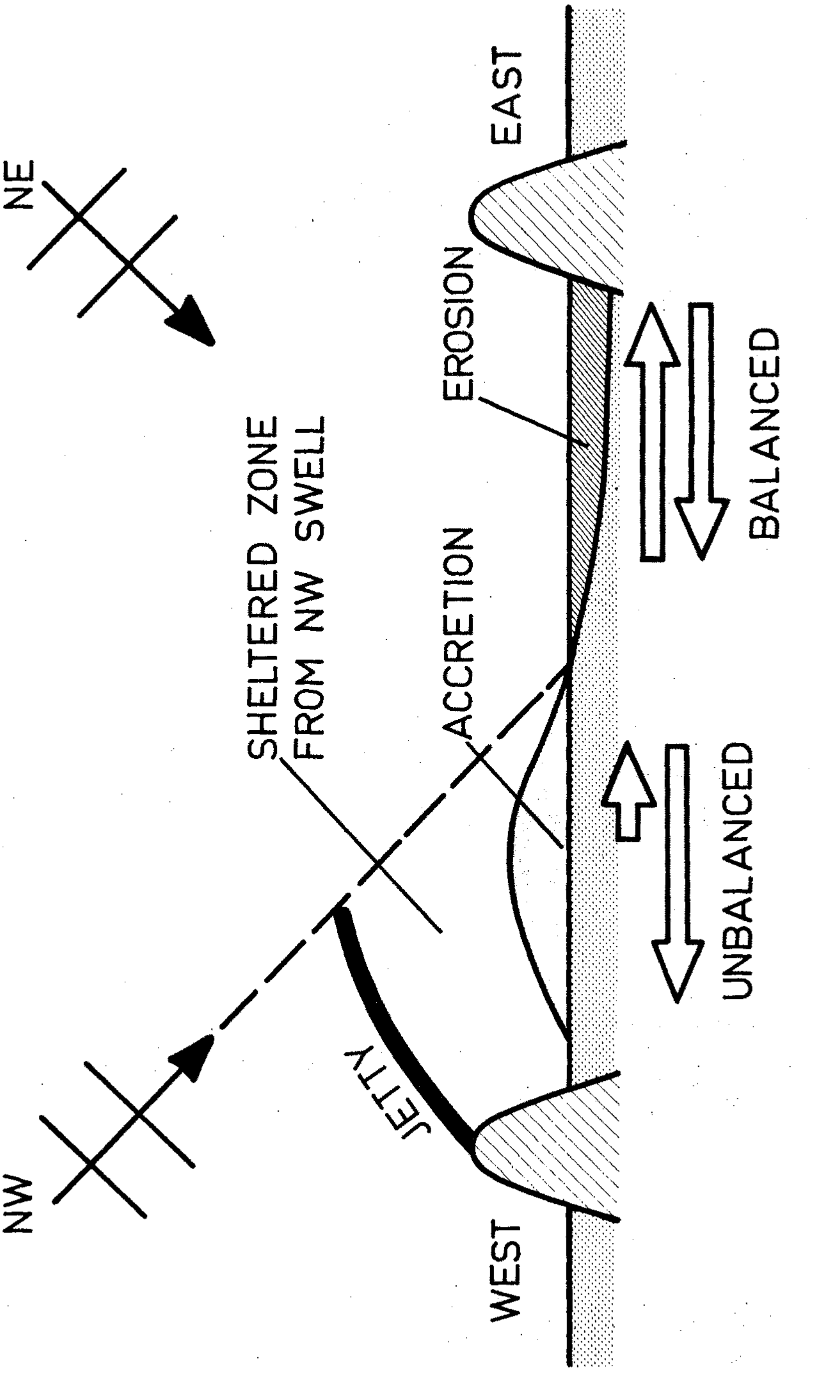

Fig.2 – BEACH CHANGES AFTER BREAKWATER CONSTRUCTION

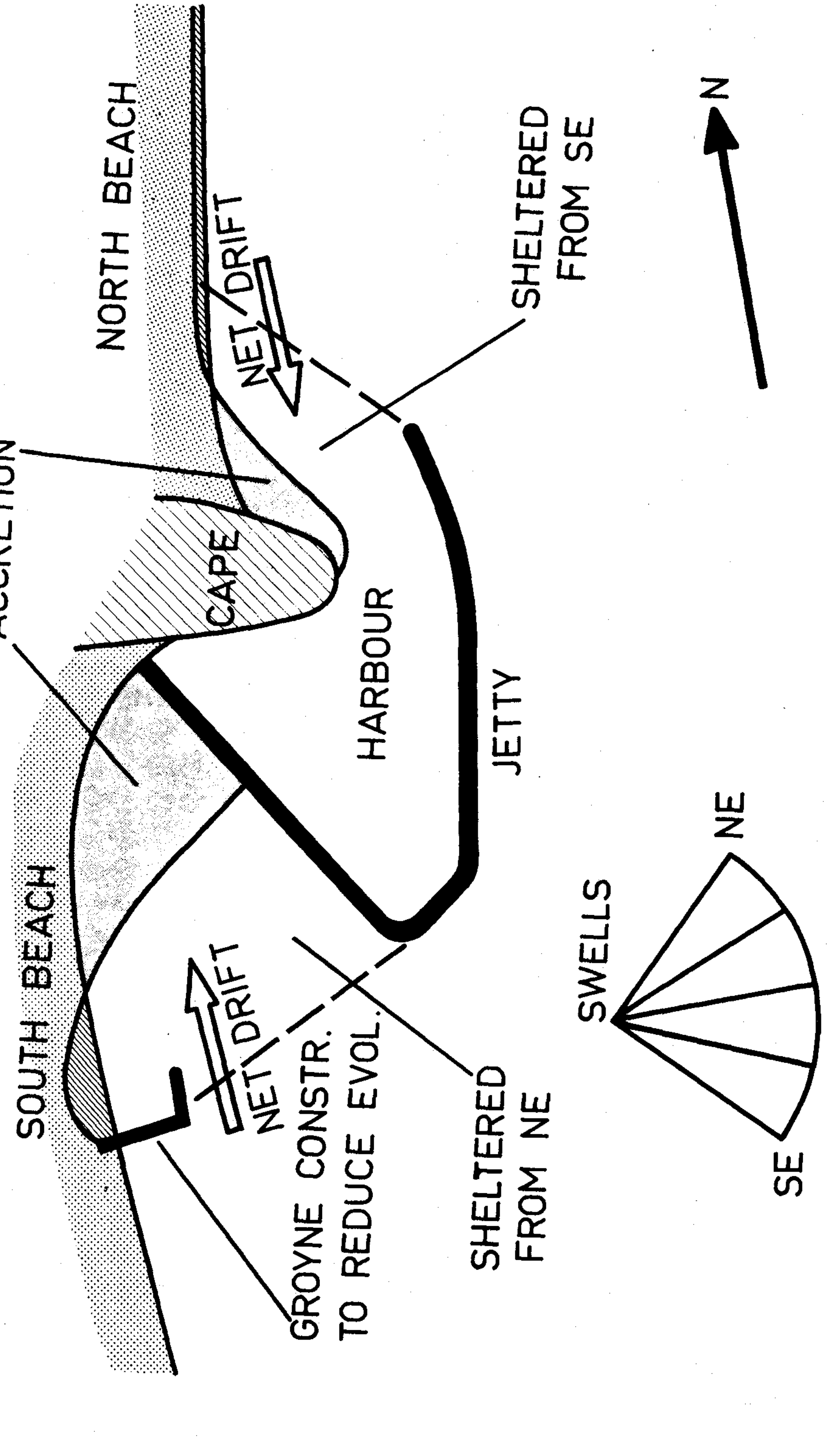

Fig.3- BORMES LES MIMOSAS PORT

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Fig. 4 – EVOLUTION OF SHORELINE DURING MARINA CONSTRUCTION

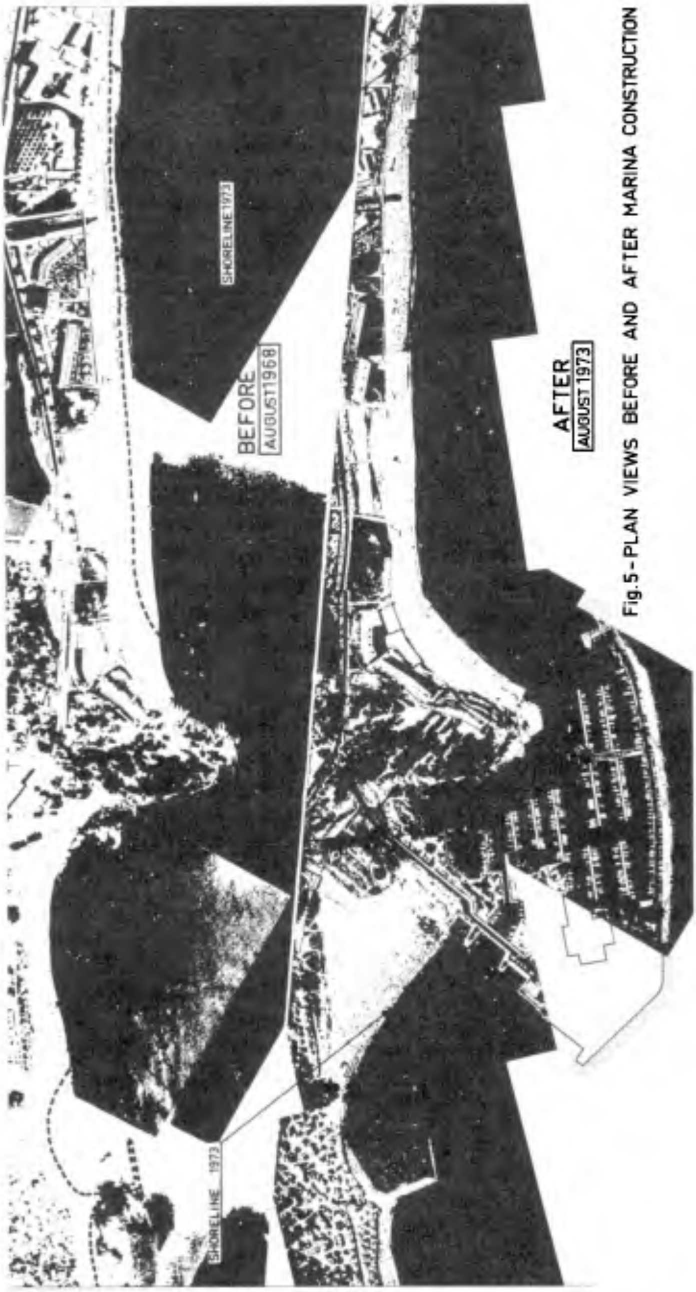

Fig.5 - PLAN VIEWS BEFORE AND AFTER MARINA CONSTRUCTION

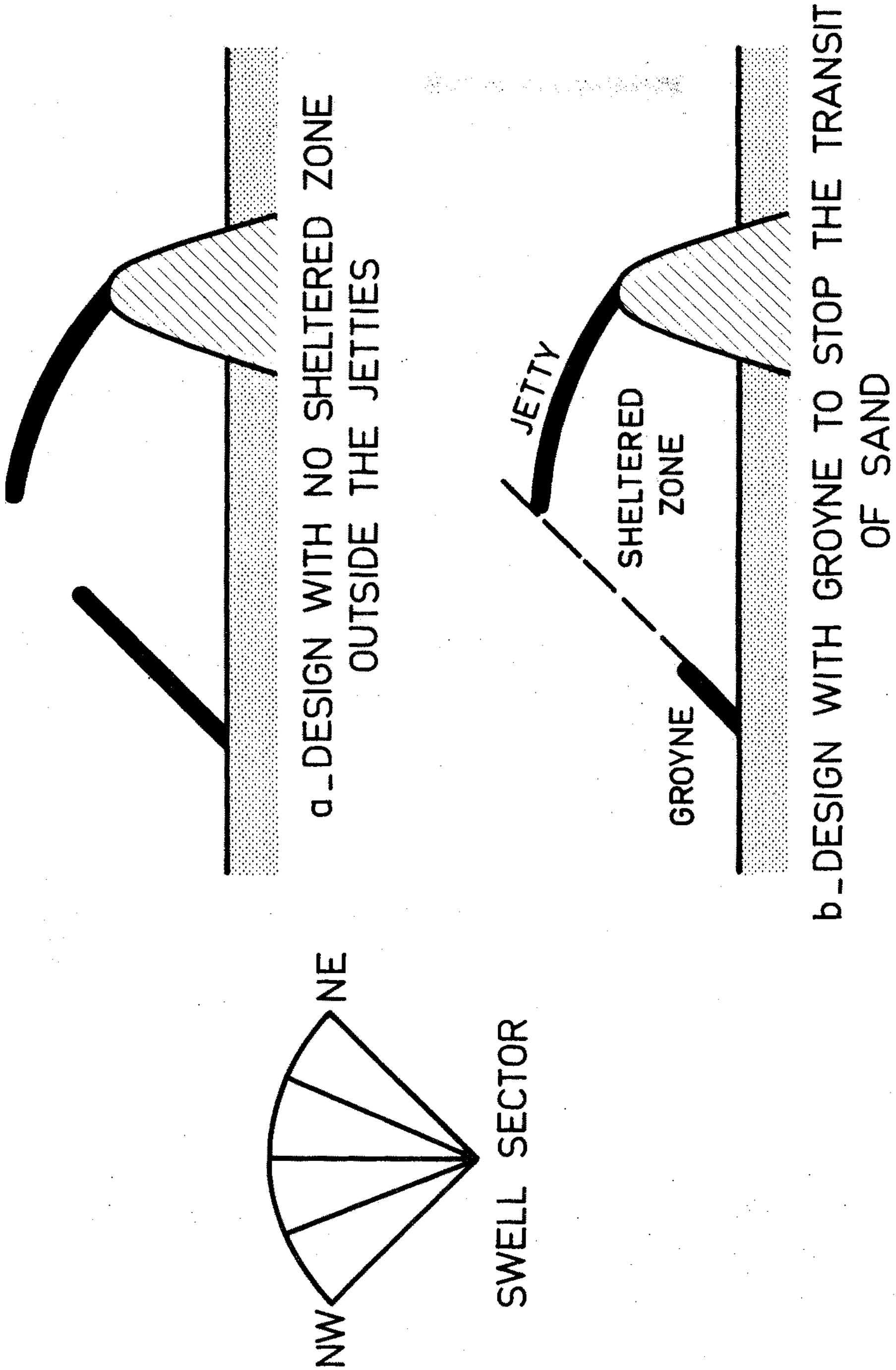

Fig.6 – DESIGNS REDUCING IMPACT