CHAPTER 203

STUDY OF AN ARTIFICIAL ISLAND

by

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1 - INTRODUCTION

The location of large surface industrial zones along sea shores often competes with other coastal activities, such as recreational pusuits, fishing, nature reserves, etc. The construction of an artificial island in the sea, near the shore, is a solution to which it will perhaps be necessary to have recourse in the fairly near future. The design of such a project poses many problems particularly in respect of its impact on the environment. We present here the results of a study which examines this aspect.

The problems are as follows :

- influence of the island on the local wave climate, or swell, and consequent shoreline changes,
- influence of the island on tidal currents and resulting evolution of the sandy sea bed,
- dispersion of industrial effluents.

The effect of the island on swell and on shore stability and the calculation of pollutant dispersion are approached by the use of mathematical models ; the effect of the island on tidal currents is analysed on a reduced scale physical model.

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2 - IMPACT ON THE SHORE

The impact on the shore is determined by computer calculations [1] of the wave pattern and of its resulting effect on littoral drift (fig. 1). The computation of the wave pattern takes account of refraction, due to variations in water depth, and diffraction, due to the presence of the island : both mechanisms are computed independently and then combined by multiplying the coefficients of wave height variation so obtained.

The variations in wave height and incidence along the shore are determined for each wave period and direction considered ; then, using a classical littoral drift formula, the variation in the discharge of sand is estimated. By summing the volumes of sand transported by waves in each category considered, weighted according to their frequency of occurence, the net sand transport along the shore can be obtained. The stage-by-stage evolution of the shoreline is derived by calculation of the continuity.

During the computation the discharge of sand is modified daily according to changes in the orientation of the shoreline, and the computation of the wave pattern is repeated every three years. This computation is carried out for the existing situation in the absence of the island, and then repeated with the island present.

Without the island, waves (6s period, 4 m annual significant height) originating from directions between west and north-east produce a net littoral drift eastwards of 10 to 20 m^3/day on a straight east-west shore consisting of fine sand (0,25 mm).

The location of an island, 3500 m offshore, induces the formation of a tombolo with erosion of the beach on either side. Due to the predominant direction of littoral drift, the north-south axis of the tombolo is slightly west of the intersection of the north-south axis of the island with the shore (fig. 2). However, the drift being low, the shoreline changes are rather slow. The average shoreline advance is 0,30 m/year with a 2200 m long island & 0,45 m/year with a 3500 m long island. The average rates of shoreline recession are 0,10 m/year and 0,25 m/year respectively.

Shoreline changes may be prevented by periodical dredging. The construction of groynes on the shore on either side of the island would also reduce the volume of sand trapped in the sheltered zone between island and shore.

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[1] LEPETIT J.P. Transport littoral : essais et calculs. Proc. 13th Conf. Coastal Engineering. Vancouver 1972.

3 - IMPACT ON CURRENTS AND BATHYMETRY

This is analysed on a reduced scale model with a fixed bed (horizontal scale 1/1000, vertical scale 1/100) equipped with tide and current generators. The surface current paths are measured by taking time exposures of floats before and after the construction of the island on the model. The effect of the island can be assessed from charts indicating zones of increase and decrease in current velocity (fig.3).

A 700 m wide island oriented in the direction of maximum long shore currents has little significant effect on discharge. However, appreciable changes occur near the island. Decreases in velocity are noted around the island, both upstream and downstream. On both sides of the island, particularly between the island and the shore, increase occur. In both cases the maximum change in velocity is 25 %.

The result is very sensitive to several parametres which are :

- the lenght of the island
- the width of the island
- the distance from the shore
- and the shape of the island itself.

More tests are necessary to understand the effect of each parametre but as regards the increase of velocity between the shore and the island it seems that this variation is more important when the island is wider, is nearer from the shore and is shorter.

A particular shape of the upstream extremity of the island with deflects the current seawards reduces the increase of velocity between the island and the shore (fig. 4).

When the sea bed is sandy, these results may be used to give an indication of the likely zones of deposition and erosion. Thus, it is possible to extrapolate the formation of a sand bank behind the island, and an area of scour between the island and the shore ; furthermore, such an eroded area may limit the accretion of the shore due to wave refraction.

4 - EFFLUENT DISPERSION

The dispersion of industrial effluents is assessed by a stage-by-stage computer calculation, 2 dimensional in plan, which takes into account convection and dispersion due to tidal currents. The dispersion coefficient used is about 5 m^2/s in each horizontal direction. Concentrations are assumed to be uniform throughout the depth - an assumption which is satisfied during strong tidal currents. The current values used in the computation are those measured with the island represented on the physical model.

With a slightly rotating, reserving tidal current parallel to the shore, having a maximum velocity of 1 m/s and an effluent discharge of 200 m^3/s seawards from the centre of the island, the surface areas affected by concentrations of 10 % and 20 % of the discharged concentration are approximately and respectively 2 km^2 and 0,5 km^2 (fig. 5).

Computations carried out for a nearby coastal site with re er ing but non-rotating currents give 10 % concentrations over areas 2 to 3 times greater. For a site inside of an estuary the areas concerned are even more higher (fig. 6).

The comparison therefore favours discharging effluents into the open sea, but the difference is due to several factors whose effects are difficult to assess - distance from the shore, stronger residuel current, rotating currents and also greater depth.

A more succinct assessment is carried out by simulating the effluent discharge by coloured water on a reduced scale model. The results obtained are in relatively good agreement with the computed results, perhaps because the convection by tidal currents is the major effect and precisely the currents introduced in the calculation are those recorded on the model where dye tests are made.

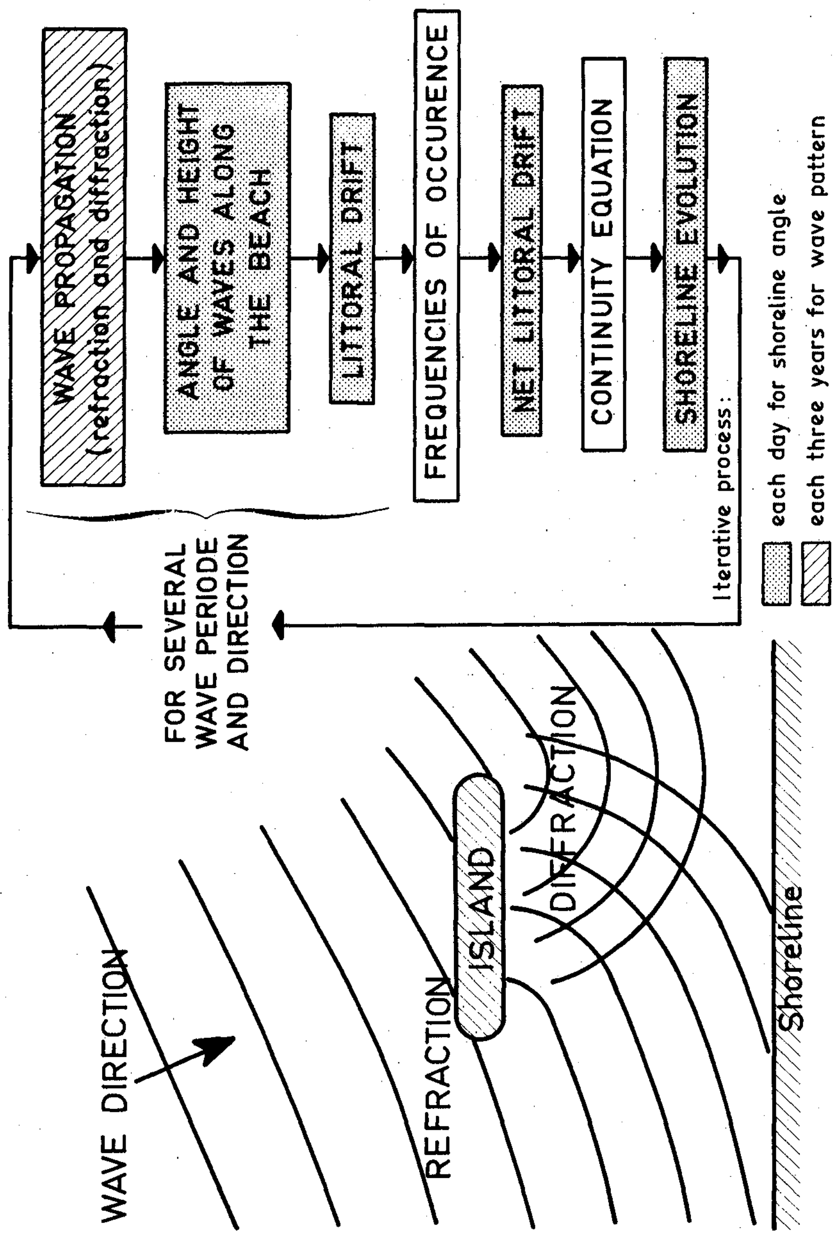

Fig.1- COMPUTATION OF SHORE CHANGES

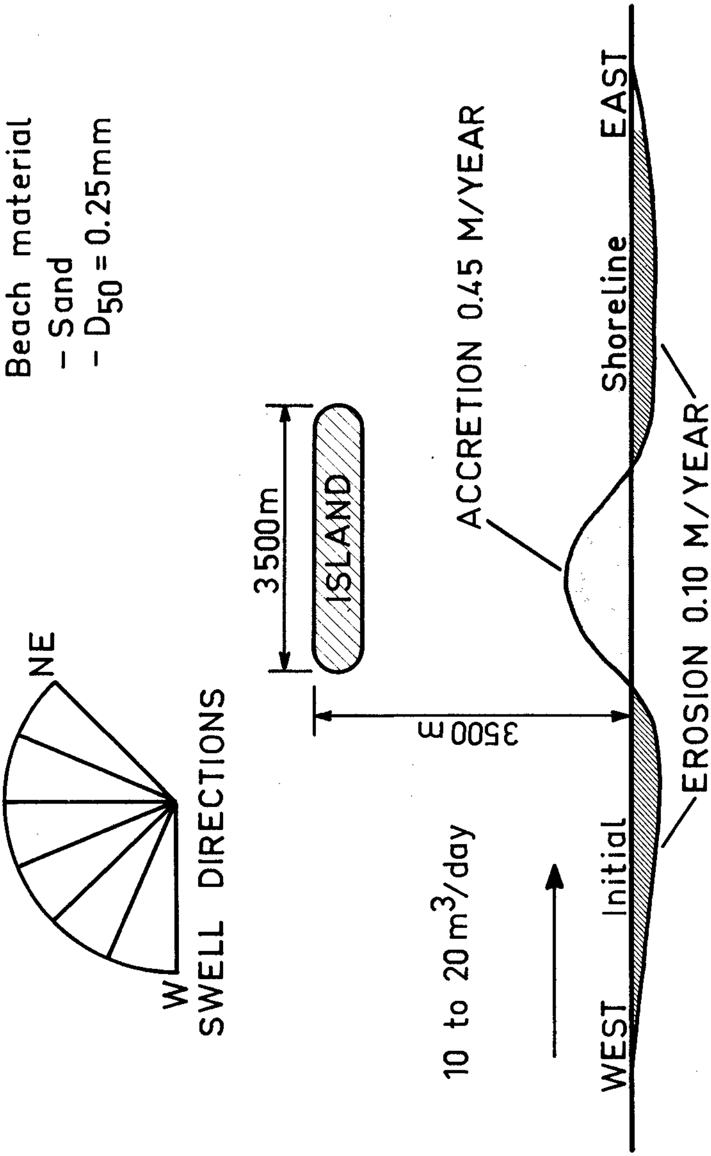

Fig.2 – TYPICAL SHORE EVOLUTION

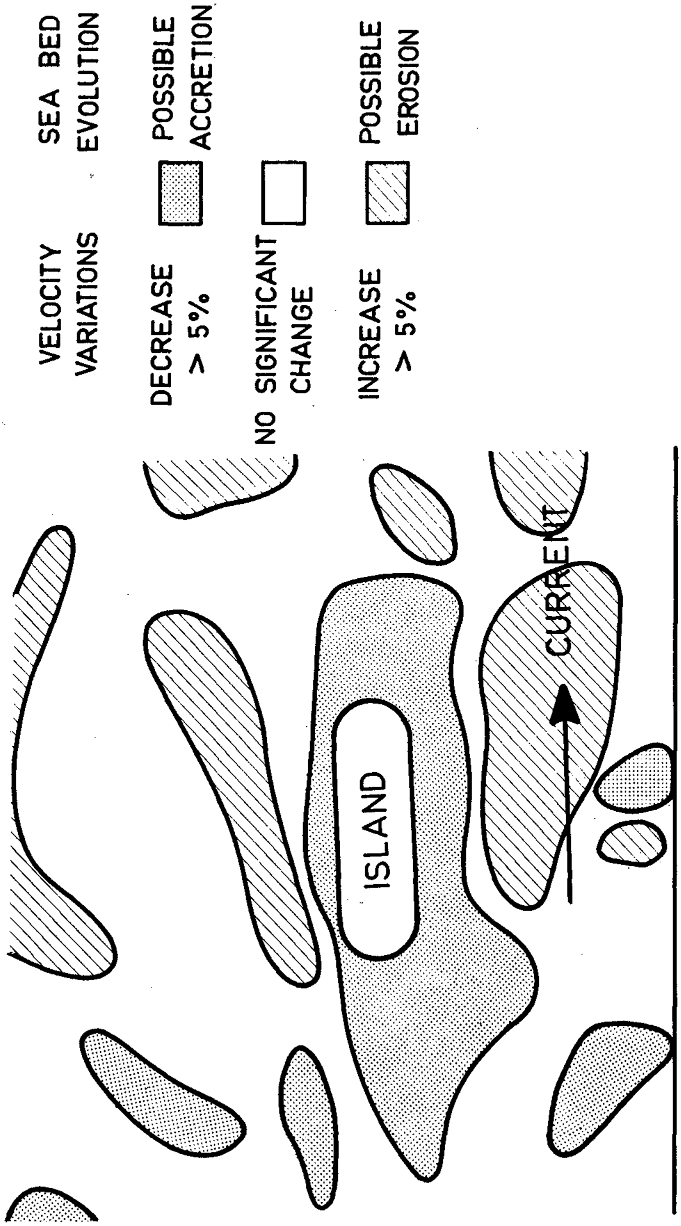

Fig.3–EFFECT OF ISLAND ON TIDAL CURRENTS

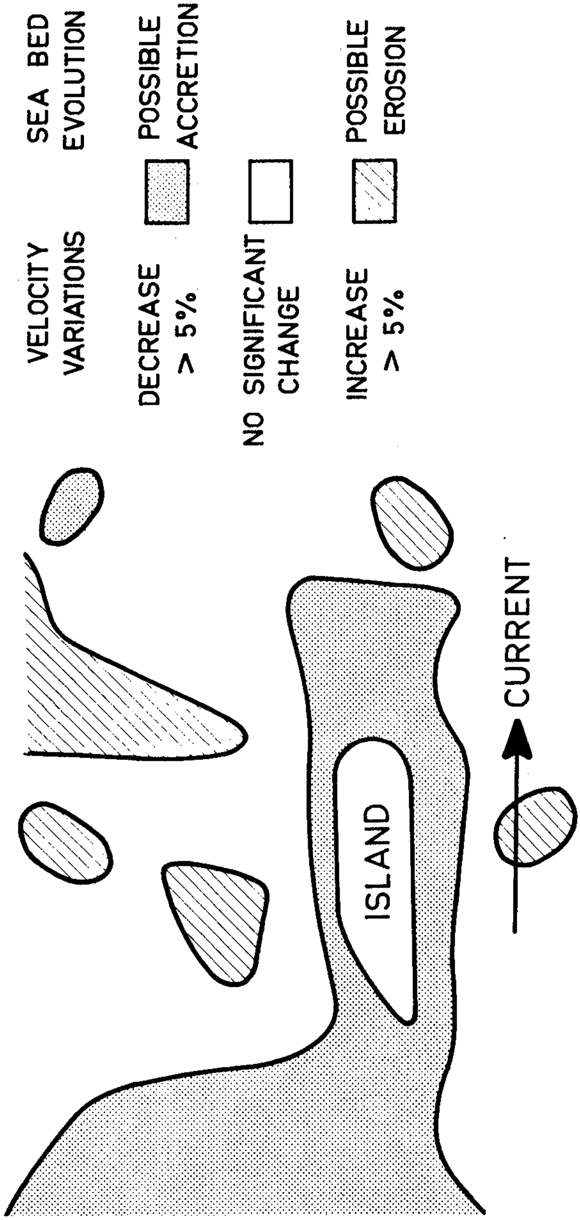

Fig. 4 – REDUCTION OF THE EFFECT ON TIDAL CURRENTS

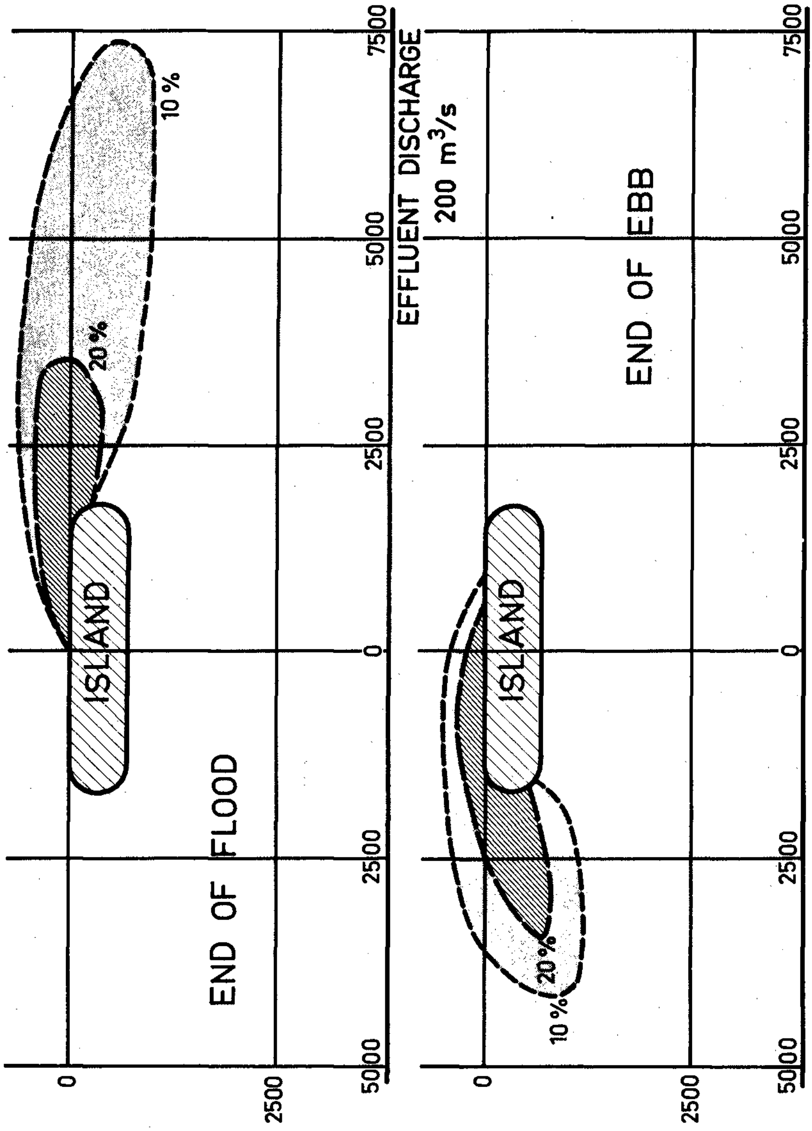

Fig.5 – DISPERSION OF AN EFFLUENT

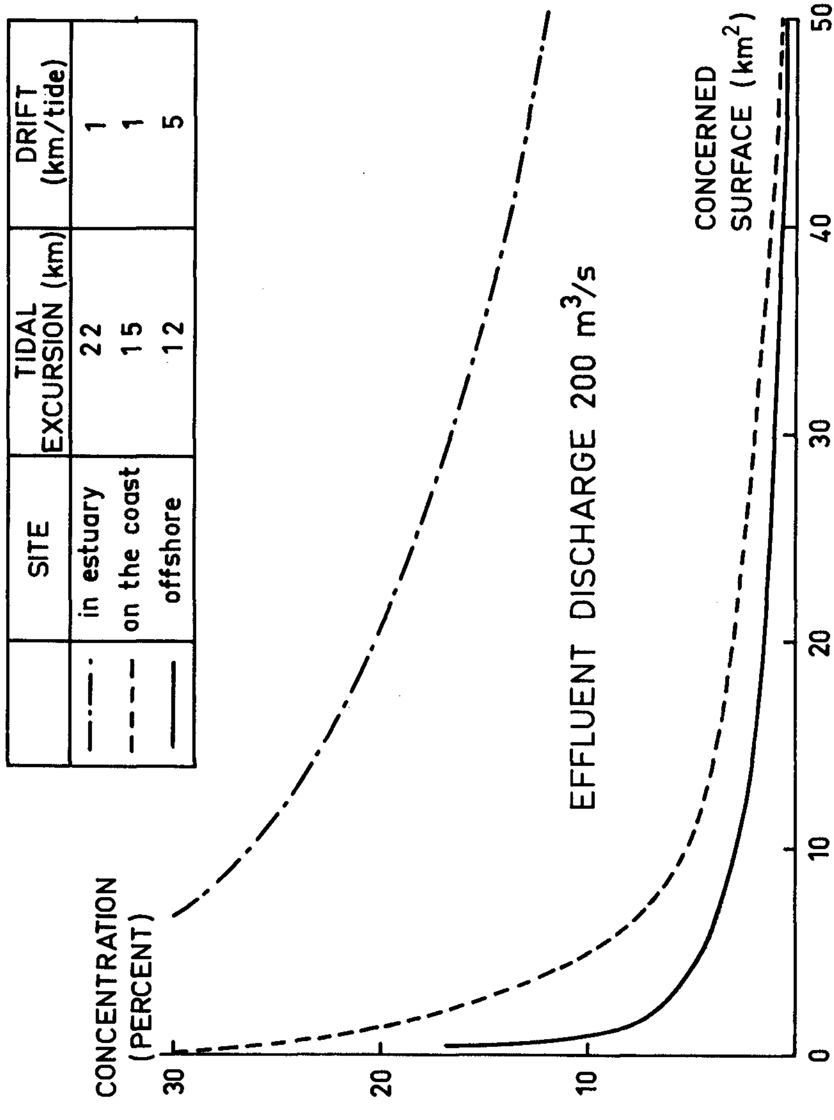

Fig.6 – COMPARISON WITH DISPERSION IN OTHER SITES