CHAPTER 236

SEDIMENTATION AND EROSION PROBLEMS OF YAKAKENT FISHERY HARBOR

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Abstract

This paper summarises the studies carried out about sedimentation and erosion problems of Yakakent Fishery Habor. Since the start of the construction of the harbor, accretion in the west coast and erosion in the east coast occurs. Additionally, the entrance of the harbor shoals. As a result of accretion at the west coast shoreline moved towards sea and about 300meters of the breakwater was on land. Erosion at the east coast of the harbor caused collapse of two houses which were about 20meters inside the original shoreline. After identifying the causes, precautions for sedimentation and erosion problems are again studied using one-line model and a series of precautions are recommended.

Introduction

Yakakent Fishery Harbor is located at the Black Sea coast of Türkiye as shown in figure 1.

Construction of the harbor was started in 1972. Initially the harbor was protected by a 350meters long main breakwater and a secondary breakwater of 230m. lenght. Then in 1988 the main breakwater was extended to 475m. Figure 2 shows the plan of the harbor after this stage.

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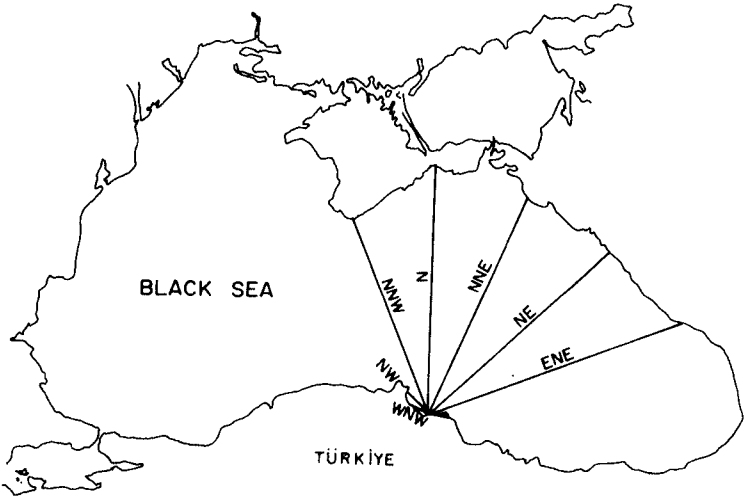

Figure 1 _ Location of Yakakent Fishery Harbor

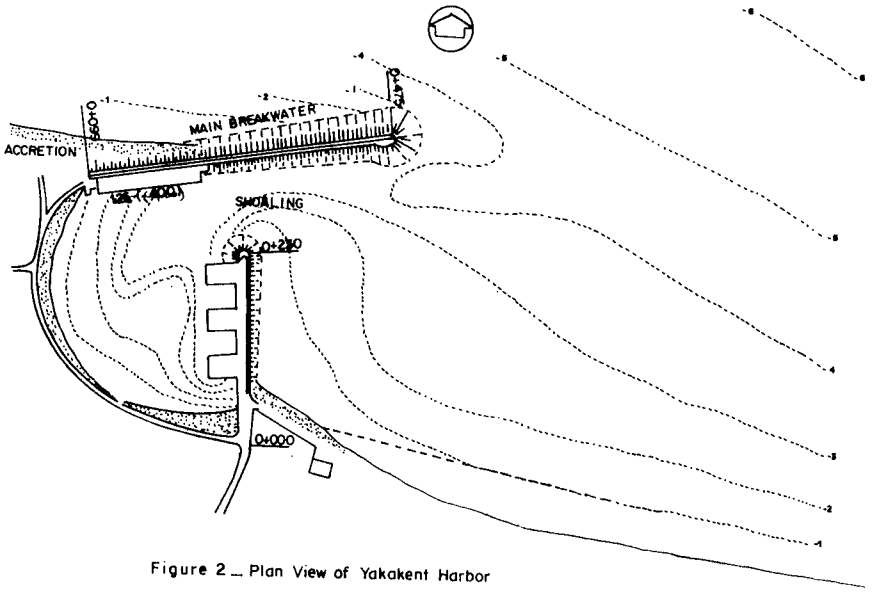

Figure 2 _ Plan View of Yakakent Harbor

Since the start of the construction of the harbor, accretion in the west coast and erosion in the east coasts resulted with considerable change in the shoreline. Additionally the entrance of the harbor which is situated towards east suffered from sedimentation and shoaling. Due to shoaling, depth of entrance of the harbor is about 0.7m. Just after the harbor entrance, depth increases suddenly inside the harbor (~3.0 meter water depth). Consequently continuous dredging was necessary to keep the entrance open even for the small fishing boats. This was tried to overcome by extending the main breakwater to 720m, but problem remained same.

As a result of accretion at the west coast shoreline moved towards the sea and about 300 meters of the breakwater was on land and just behind the secondary breakwater shoreline progressed about 80 meters towards the sea. At the further east coast of the harbor, severe erosion caused collapse of two houses which were about 20 meters inside the original shoreline. Then a seawall having 600 meters lenght was considered mainly aiming to protect the houses in the vicinity. Although seawall was observed to be functional in this aspect, it also enchanced the erosion down at the east coast. Seawall was further extended, this time to prevent erosion, but the result was same increased erosion at further east.

Wave Climate

Long term wave analysis were made using hourly average wind records, for a duration of 3 years (Pierson, 1964). Probality distribution of deep water significant wave height, $(H_{1/3})_0$ are shown on figure 3 and 4. Long term wave statistics showed that dominant wave direction is from NW to NE with 1703 hours per year above 1 meter significant wave height.

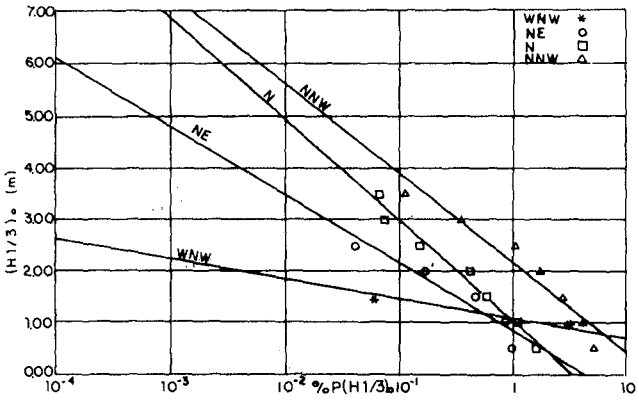

Figure 3 _ Longterm Probabilty Distribution of Deep Water Weve Height

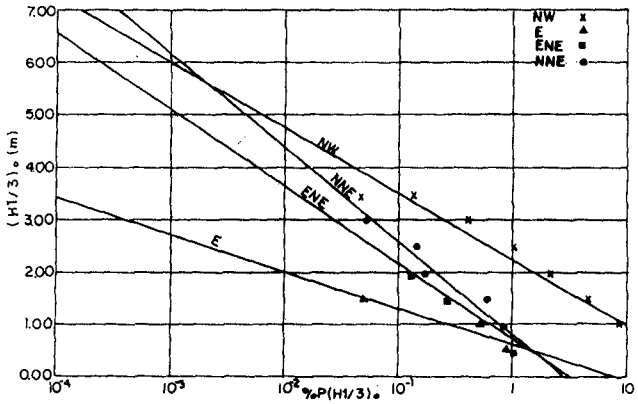

Figure 4 _ Longterm Probabilty Distribution of Deep Water Significant Wave Height

From the long term wave statistics, the mean wave height, period and their occurance of duration in a year are given in Table 1.

Table 1. For Yakakent Harbor region, mean wave height and their occurance of duration, t(hr) in a year.

DIRECTION	WAVE HEIGHT(m)	PERIOD	t(hours)
WNW	0.79	3.36	70.1
NW	1.1	4.01	2133.2
NNW	1.32	4.34	794.0
N	1.37	4.44	167.5
NNE	1.33	4.37	127.2
NE	1.14	4.04	154.5
ENE	1.19	4.13	118.7
E	0.88	3.56	129.4

The sea bottom is sand with mean diameter of D_{50}=0.16mm. Using Shields Criteria for incipient motion it is found that at the -8 meter water depth, initiation of sediment motion will start with 6 second period and 0.20 meter wave height. Sediment in suspension will occur with 0.52 meter wave height.

Methodology

Topographic field measurements available through the years were solely not sufficient, but together with the wave hindcast studies and further measurements, they formed guidelines for erosion and sedimentation patterns.

To investigate the variation of shoreline and the bottom topography and their reasons, the harbor region may be divided by six areas. (figure 5)

These are,

1. West Coast of the main breakwater
2. Entrance of the harbor.
3-Harbor basin
4-East of the secondary breakwater
5-Existing seawall at the east coast
6-East coast extending after the seawall

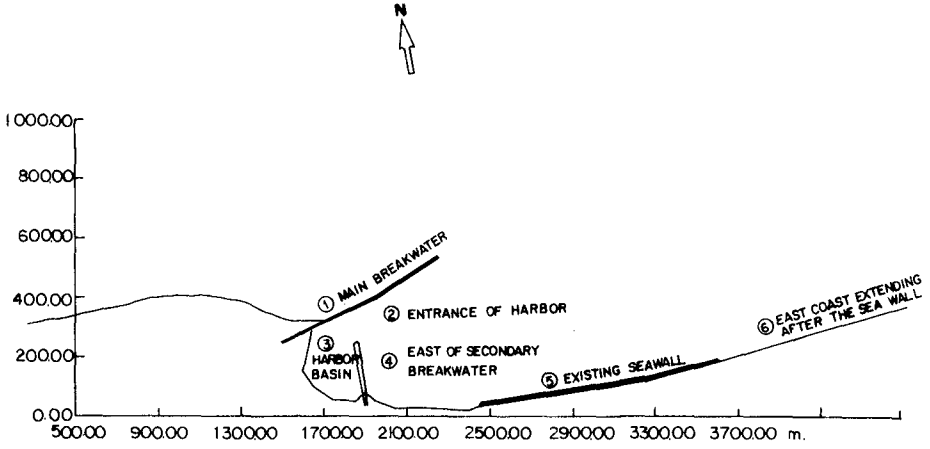

Figure 5 _ The Regions for Sediment Transport Pattern

Main breakwater protruding from shoreline, presents a littoral barrier and blockage of longshore sediment transport is the main cause of accumulation at the west coast. As normally expected significant erosion is experienced at the east coast. The seawall constructed to prevent erosion was not functional and erosion was enchanced.

Figure 6 gives a schematic explanation of the wave action and current circulation patterns around the breakwater. Based on this figure the sedimentation at the harbor is explained below.

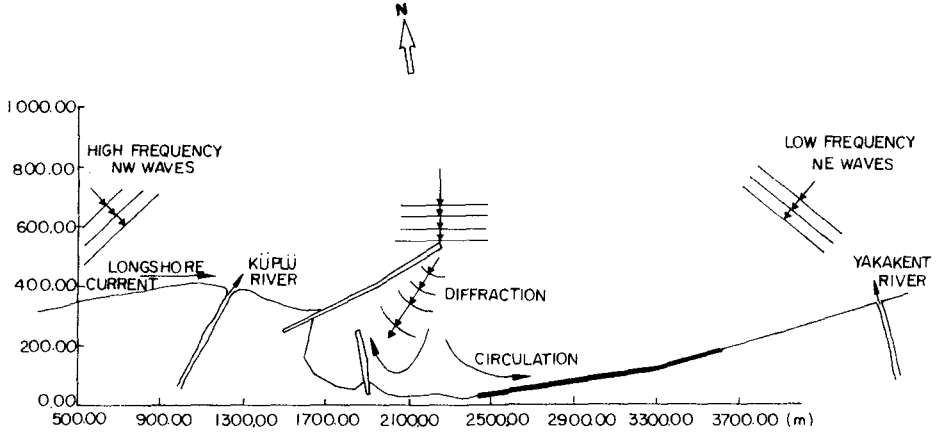

Figure 6 – Mechanism of Sediment Transport

Wave diffraction around the main breakwater resulted in settlement of suspended load as wave diminish in height could not carry suspended sediment any more. This sediment spreads out on a wide area shadowed by the main breakwater which may further be carried towards harbor entrance either by clockwise circulation waves or longshore current created by low frequancy NE waves. The suspended sediment is also carried towards the harbor entrance by the diffracted NW waves and settles at the harbor entrance due to sudden drop of wave height in the harbor.

Figure 7 shows the diffractions coefficients (K_d values) at the various points in the harbor for the NW waves.

The wave height at the head of main breakwater is 2.02meters as seen from figure 7, K_d value at the entrance of the harbor is 0.2. At this point, wave height will be 0.40meters. Just after entrance of the harbor K_d value drops to 0.09. This means that wave height decreases up to 0.18meters. Due to this sudden drop of wave height, suspended sediment could not be carried by the waves any more and sediment in suspension will settle. Then entrance of the harbor shoals. Rivers in the adjacent coast discharge huge amounts of the material which considerably increases the suspended sediment.

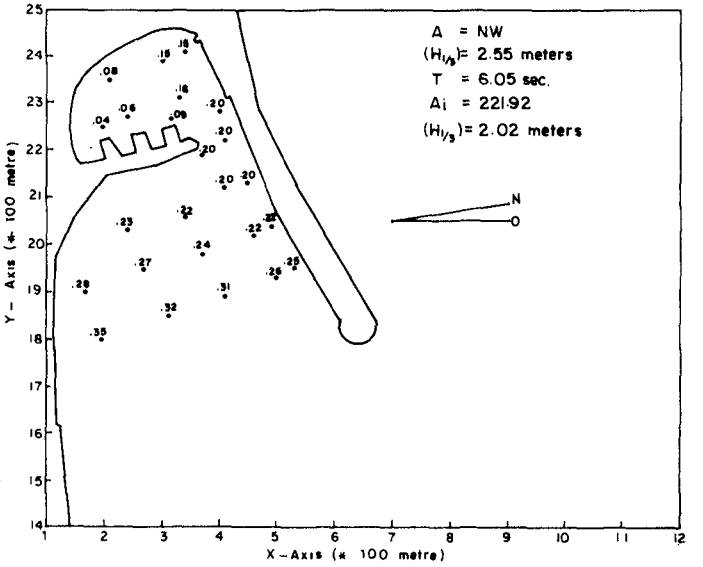

Figure 7 _ Diffraction Coefficients for NW waves

Application of one-line Model

The hindcasteD deep water wave characteristics were transformEd up to breaking point by a computer program using Goda's approach (figure 8 and 9). This program calculates breaking wave height distributions and breaking angles along the shore. Breaking wave heights, angles duration of storms, wave period, location of the coastal structures are used in the one-line shore evaluation model (Hanson, 1986). Model is calibrated by existing field measurements.

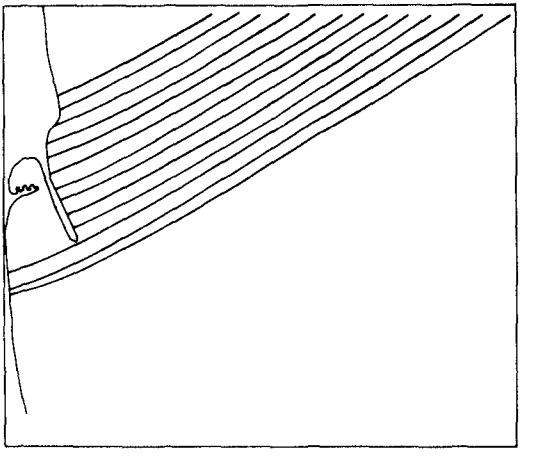

Figure 8 _ Wave Refraction Diagram NNW Direction T=6 sec.

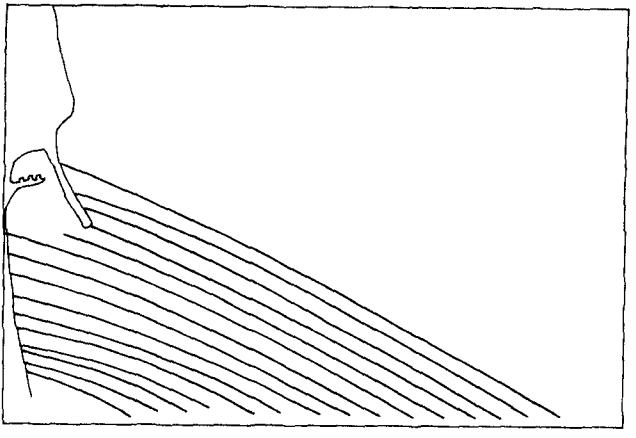

Figure 9 – Wave Refraction Diagram NE Direction T = 6 sec.

For the simulation, a series run were done. Figure 10 shows shoreline variation at the west coast by the effect of NNW waves. For the same waves seawall enchanced the erosion down at the east coast (figure 11) and figure 12 shows the accretion caused by NE waves just behind the secondary breakwater.

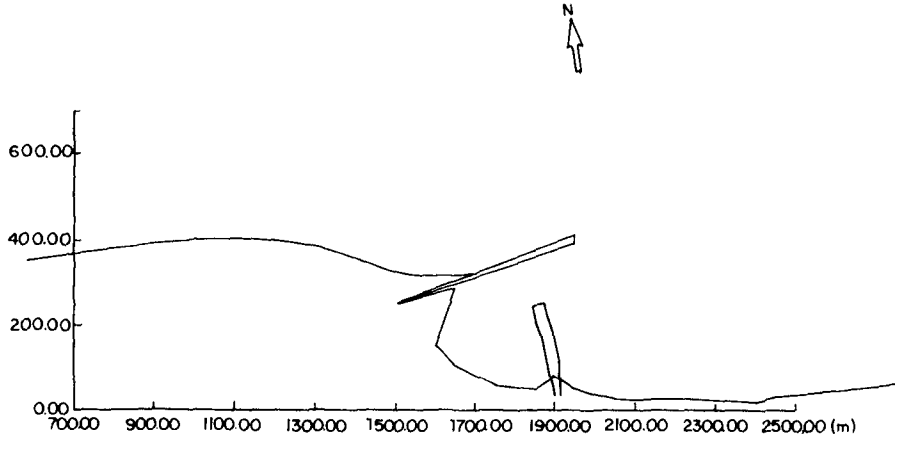

Figure 10 – Shoreline Changes Due To NNW Waves

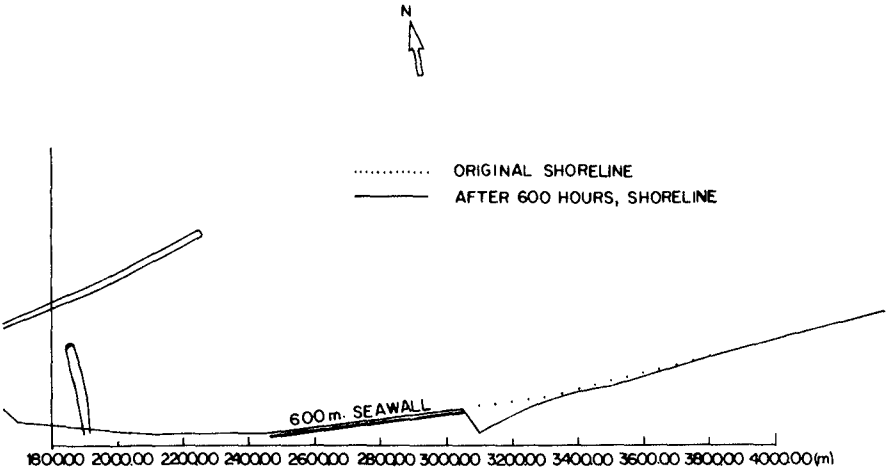

Figure 11 _ Effect of Seawall On The Shoreline under NNW Direction waves

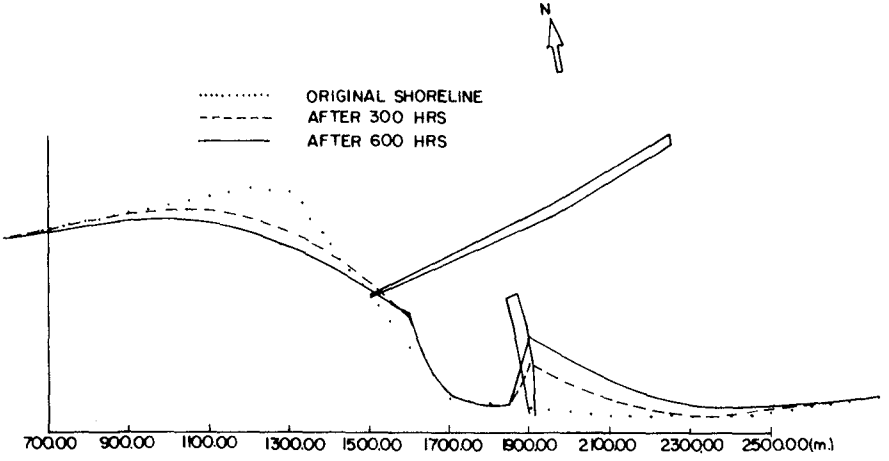

Figure 12 _Accretion The Behind Secondary Breakwater Due To NE Waves

Simulation with the one-line model are found to be satisfactory in the adjacent coast. Since the shoreline cannot reach equlibrium condition at the west coast, it will progress to the breakwater head and depth at the breatwater head will be -3 meter or less (figure 13).

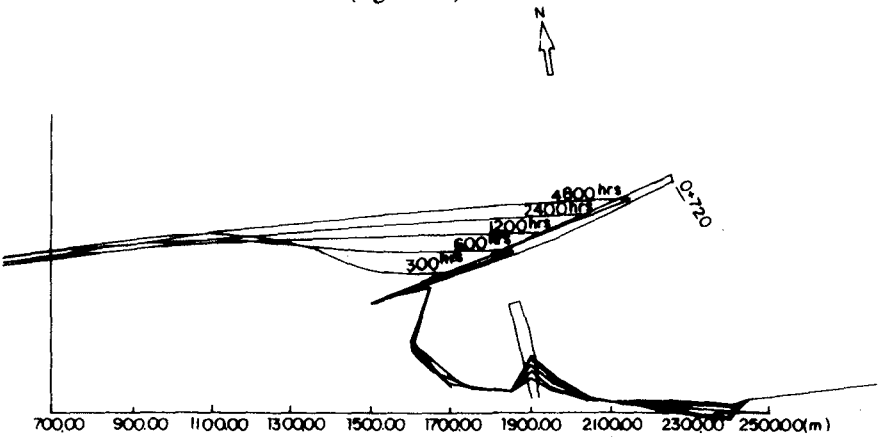

Figure 13. _ Shoreline Change by One Line Model Due To NNW Waves

Figure 13 shows the output of the model for the simulation of shoreline change in the close vicinity of the harbor. However, for the entrance as this model is inadequate, sedimentation pattern is studied analytically. Based on these studies the main reason for the siltation at the harbor entrance is found to be due to the settling of suspended sediment as explained above.

Conclusion and Recommendation

After identifying the causes, precautions for the sedimentation and erosion problems are again studied using the same one-line model. The effect of one groin on shoreline change at the east coast by the various direction waves is tudied and shown in figure 14 and 15.

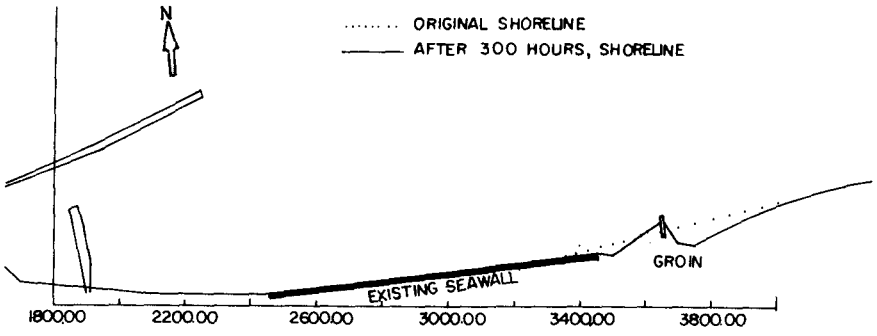

Figure 14 _The Effect of One _ Groin At The East Coast Due To NW Waves

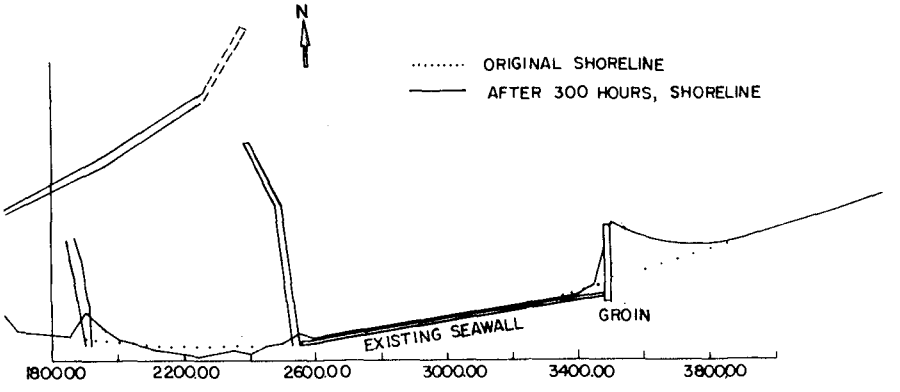

Figure 15 _ The Effect of One Groin At The East Coast To NE Waves

A series of precautions shown in figure 16 are recommended which include;

i. Extension of the main breakwater with a more perpendicular direction to the shore. This aims to cross the west-east directed sediment from sedimentation.

ii.A new secondary breakwater to provide a relatively more exposed entrance and to reduce circulation area which carries suspended load towards harbor entrance.

iii.Groin field at the east coast which will start from the existing beach. Sand by passing from west of breakwater to the East and artificial nourishment is recommended for the groinfield.

iv.Sand by-passing of accreted sediment from west coast to east coast periodically (When necessary)

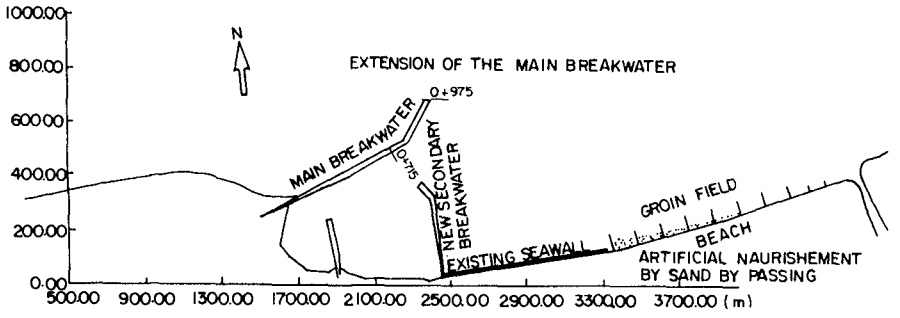

Figure 16 _ Recommended System

APPENDIX I. REFERENCES

Goda, Y. (1985) "Random Seas Design of Maritime Structure," University of Tokyo Press, Japan

Hanson, H., and Kraus, N.C. (1986) " Seawall Boundary Condition in Numerical Models of Shoreline Evaluation", CERC Technical Report No:86-3, US Army Corps of Engineers.

Pierson, W.J. and Moskowits, L. (1964), "A proposed spectral form for fully developed wind seas based on the similarity theory of Kitaigorodskii", Jour. Geophy. Res., V. 69, no 24.

APPENDIX II. NOTATION

The following symbols are used in this paper:

$(H_{1/3})_0$ = Deepwater significant wave height;

NW = North-West;

NE = North-East;

NNW = North-North-East;

D_{50} = mean sediment diameter;

Kd = Diffraction coefficients;