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MAINTAINING BEACH MORPHOLOGY BY GROIN SYSTEMS (CASE STUDY: MARINA AL-ALAMEIN)

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ملخص البحث:

من حيث أهمية المناطق الساحلية في مصر ، بدأ هذا البحث بهدف اختيار تكوين نظام الألسنة البحرية الذي يحافظ ` على مورفولوجيا الخط الساحلي ، حيث تم اختيار مارينا العالمين كحالة دراسة. تمت مراجعة البحوث السابقة في مجال مورفولوجيا الشواطئ ومنطقة مارينا.
عمل زيارات للموقع إلى مارينا ، حيث تم تجميع البيانات وتحليلها. تم تنفيذ نماذج ال GENESIS , STWAVE لتوضيح تأثير الاشكال المختلفة للالسنة البحرية على الشاطْئ.
تم استخدام برنامج STWAVE لاعطاء البيانات الخاصة بحالات انكسار الامواج وعلى نفس السياق تم استخدام برنامج GENESIS كأداة لمحاكاة نظام الالسنة البحرية المقترحة كبدائل, بالاضافة الى تم مناقشة وتقييم النتائج.
وأخيرا ، استُنتجت استنتاجات واقتُرحت توصيات.

ABSTRACT

At terms of the significance of coastal areas in Egypt, this research was initiated with the objective of selecting a groin system configuration that maintains the shoreline morphology, where Marina-Alamien was selected as a case study. Previous researches in field of shoreline morphology and Marina's area were reviewed. Site visits were carried to Marina, from which data was assembled and analysed. GENESIS and STWAVE Models were implemented to elaborate the impacts of different groin system configurations on its shoreline. STWAVE was used to produce the breaking conditions at Marina. In the same context, GENESIS was tooled to simulate the proposed groin system configuration alternatives. In addition, the obtained results were evaluated and discussed. Finally, conclusions were inferred and recommendations were suggested.

Keywords: Groin; T-groins; erosion problem; mathematical models; zone A.

1. INTRODUCTION

The coastal zone is the interface between sea and land, where marine so as resources are terrestrial areas. These specific zones undergo morphological changes due to the wave attack, where some zones are in an 'in-equilibrium state' due to man interference (i.e. constructing coastal measures such as Marina Al-Alamien). However, at Marina groins are constructed to safeguard the lagoon inlets, as it is a rapidly developing recreation tourist centre. Such zones are important in terms of sustainable development and environment.

2. LITERATURE REVIEW

Worldwide, many researchers are involved in investigating shoreline morphology and some of them focused on Marina. Among them, for example, are:

- Delft Hydraulics, W.L. (2002) executed a vast investigation in order to develop the near water conditions in the framework of an Integrated Development Plan of Egypt's Northwestern Coastal Zone.
- EL-Saadek, E.M. (1998) executed a physical model to simulate marine works for El-Alamien Marina Recreation Centre. In addition, he planned the protection of inlets and outlets.
- Fahmy, H.R. (1998) evaluated the effect of breakwaters on coastal resorts in the context of the framework of the development of northern coast of Egypt to serve the Integrated Coast line Management and tourist activities.
- Frihy, O.E. (2001) designated the necessity of environmental impact assessment in implementing coastal projects. Moreover he elaborated the lessons learned from the Egyptian Mediterranean Coast (i.e. Marina).
- M.M. Iskander, A.I. Abo Zed, W.R. El Sayed and A.M. Fanos (2008) investigated Marina Coastal Problems.

In terms of the significance of Marina-Alamien as a tourist resort, this research was commenced with the impartial of choosing a groin system configuration that sustains the shoreline morphology at Marina. This paper presents the investigation phases under the following headlines:

- Site visits and description of Marina Al-Alamein
- Data assembly and analysis
- Numerical modelling and results discussion
- Conclusions and recommendations

3. SITE VISITS AND DESCRIPTION OF MARINA AL-ALAMIEN

Several site visits were carried out during 2014-2017 to monitor Marina Al-Alamien and to document its conditions, in terms of shoreline morphology. In addition, previous documentations were reviewed; photos were captured; remarks were documented and the native residents were interrogated, from which, it was clear that:

- Marina is located along Alexandria-Matrouh Coastal Road at kilo 94 West of Alexandria City, **figure (1)**.
- Its coastal length is 12 km. Its width is 1.6 km inland.
- It is a tourist resort that develops rapidly. Marina shoreline is divided into 5 zones, **figures (3) and (4)**.
- Periodical sand bypassing from accreted to eroded areas was recommended as a proper mitigation measure.
- The resort is constructed around artificial lagoons that are connected to the sea by 4 dredged channels, where their inlets are safeguarded by groins, whereas jetties were constructed to create beaches, as follows:
    - ✓ ***5 jetties*** were constructed, during 1989 to 1993, perpendicular to the shoreline to stabilize these channels. Their lengths varied between 350 and 1250 m, **figure (2)**.
    - ✓ ***8 short groins*** were constructed during 2002 to 2003. Their lengths varied between 150 and 400 m. Nourishment was placed within their gaps, as a remedy to the erosion due the westward sediment transport blockage. Accretion East of the 1st groin, at a rate of 18 m/year, was reported by the

native residents. In addition, the highest erosion rate, eastward of the 8th groin at **zone A** was narrated; **figures (3)** and **(4).**

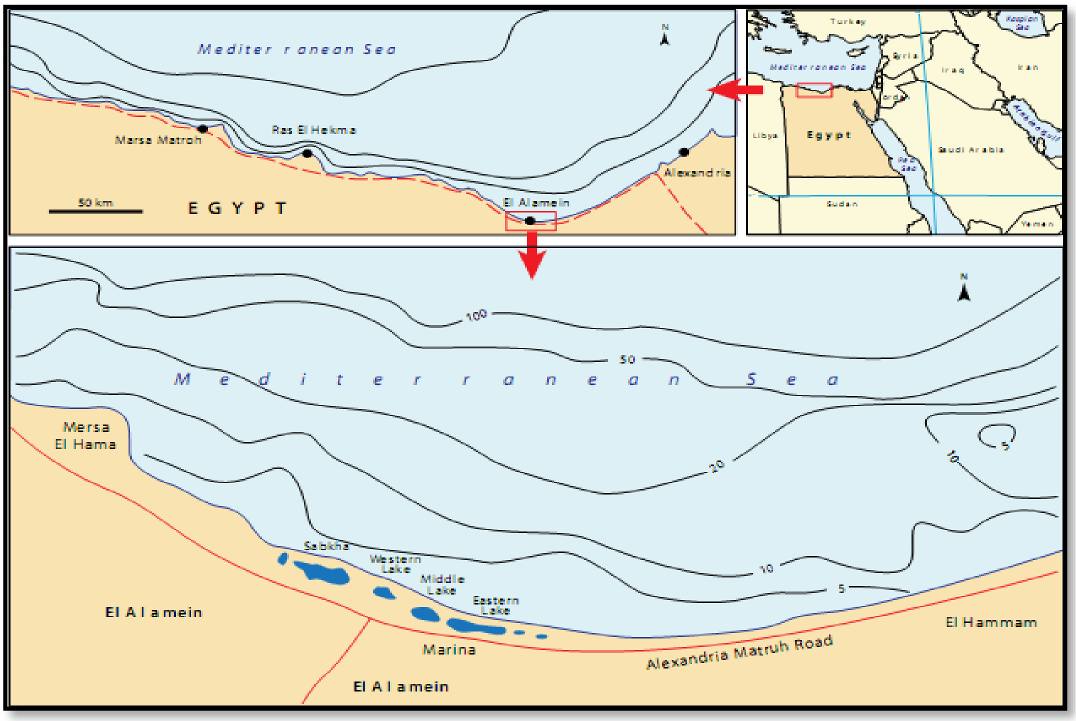

Figure (1) Location of marina Al-Alamein

(M.M. Iskander, A.I. Abo Zed, W.R. El Sayed and A.M. Fanos (2008))

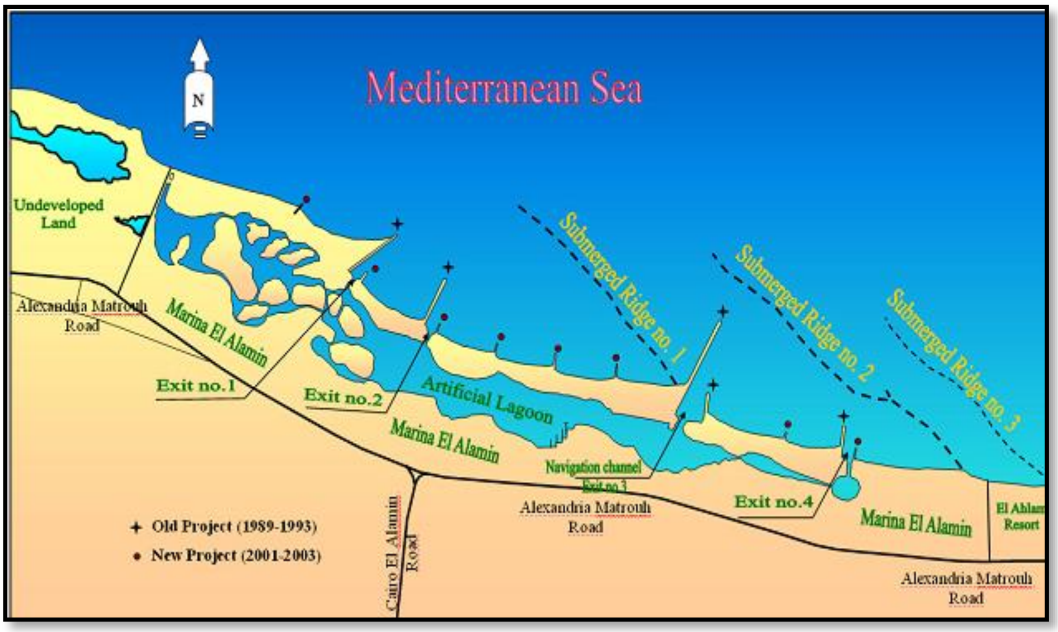

Figure (2) Marina Al-Alamein Resort artificial lakes and the protection works

(M.M. Iskander, A.I. Abo Zed, W.R. El Sayed and A.M. Fanos (2008))

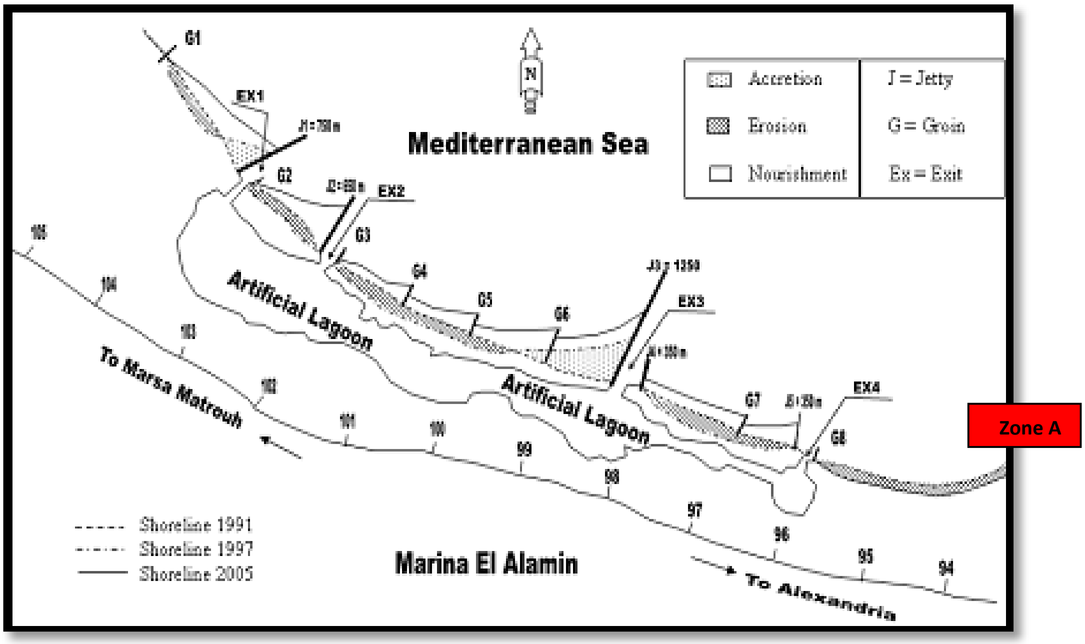

Figure (3) Zone A along Marina Al-Alamain shoreline

(M.M. Iskander, A.I. Abo Zed, W.R. El Sayed and A.M. Fanos (2008)

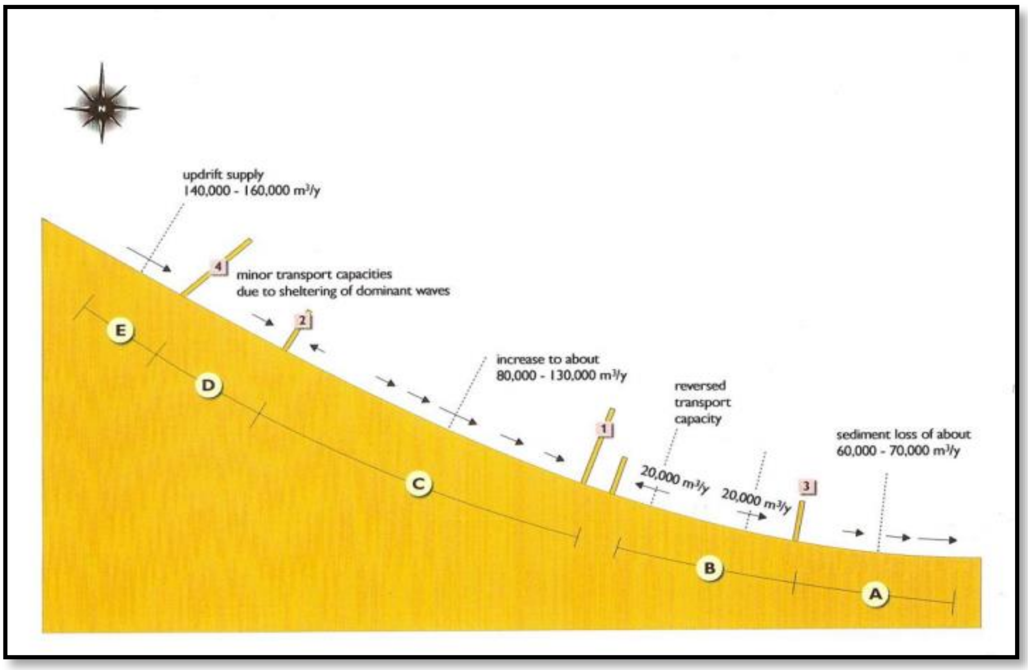

Figure (4) Shoreline of Marina Al-Alamein zones

(M.M. Iskander, A.I. Abo Zed, W.R. El Sayed and A.M. Fanos (2008)

4. DATA ASSEMBLY AND ANALYSIS

Data assembly and site visits were carried out simultaneously, where several data were obtained from ***M.M. Iskander, A.I. Abo Zed, W.R. El Sayed and A.M. Fanos (2008)*** and ***Delft Hydraulics, W.L. (2002).*** The data encompassed wave, wind, currents, soil, sediment transport rates, surveyed maps, bathymetrical surveys and historical actions. The data were analysed to obtain the following:

- ***Focusing on the waves data,*** it indicated that:
  - ✓ Waves come predominately from north-western sector with the highest offshore waves between 5.5m to 6.0m, **figure (5).**
  - ✓ The highest waves occur during winter from the NNW and WNW directions.
  - ✓ A small percentage of waves come from N to ENE sector.
- ***Based on the current measurements,*** its pattern indicated that:
  - ✓ There are circulation cells (i.e. long-shore currents and rip currents), **figure (6).**
  - ✓ The current velocity fluctuates between 0.02 and 0.13 m/sec.
- ***Regarding the soil data,*** it indicated that:
  - ✓ The mean grain size ranges between 0.09 and 0.54 mm, with an average value of 0.33 mm.
  - ✓ The values of carbonate content in these samples vary from 43.02 to 99.4 % with low specific gravity of 2.7 gm/cm^3, which makes the grain to be more active in the mobile layer.
  - ✓ The grain size, seabed morphology and hydrodynamic processes delineated the sediment transport direction.
- ***Based on the sediment transport data*** before constructing the jetties, it was clear that:
  - ✓ The Gross long-shore transport was estimated to be 180,000 m^3/yr
  - ✓ 40,000 m^3/yr are transported towards the West of the village.
  - ✓ 140,000 m^3/yr are transported towards the East.
  - ✓ This means that 100,000 m^3/yr are transported, as a net transport towards the East.
- ***As for the surveyed maps*** (i.e. 1991 and 1997), they indicated that:
- ✓ There is significant change, **figure (7),** along Marina sea resort.
- ✓ The estimated average erosion is 10 m/yr east of the 5th jetty and 15 m/yr accretion at up-drift the 3rd jetty.
- ***Focusing on the bathymetrical surveys*** obtained from ***Delft Hydraulic Laboratory (2002)*** and ***M.M Iskander (2008)***, **figure (8)**, it was clear that:
  - ✓ There are submerged ridges in front of the study area.
  - ✓ The contour lines indicated that the beach slope ranges between 1:8 and 1:10.
  - ✓ The near-shore slope ranges between 1:25 and 1:40.
  - ✓ The steep beach slope causes waves to break close to the beach.
- ***Concerning the historical data***, it was clear:
  - ✓ The length between the 1st and 5th jetty were nourished once in 2004 by a quantity of 400,000 m^3 of coarse sand, which enhanced the beach morphology .
  - ✓ 3 periodic nourishments (i.e. 80,000 m^3 /year) were placed between the 8th groin and Marina's borders (i.e. 1800 m).

✓ In spite of all the actions, erosion process took place in **Zone A** to reach the underlying rocks in this zone, **figure (9)**.

- ***Regarding the reviewed researches***, it was found that Delft Hydraulic Laboratory (2002) proposed to construct 8 groins with lengths 100 to 400 m.

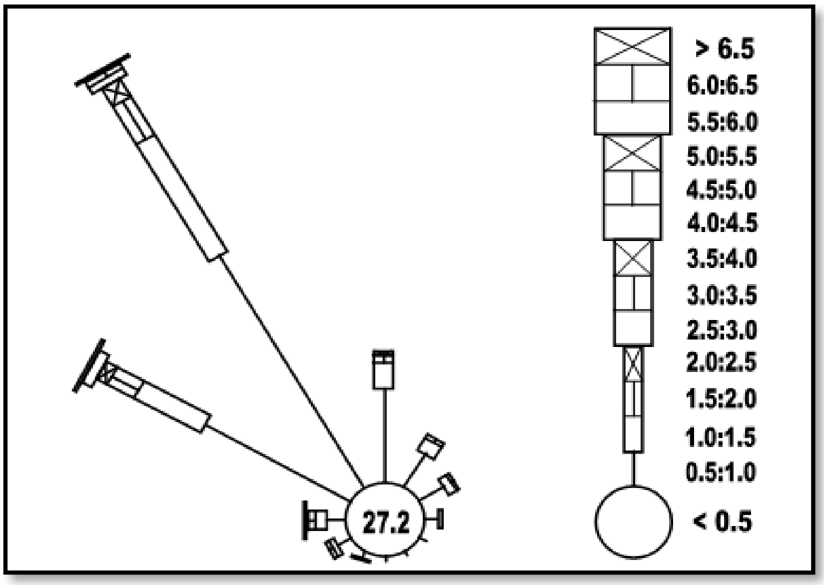

Figure (5) Wave Rose offshore of the study area all over the year

(Delft Hydraulics, WL. 2003)

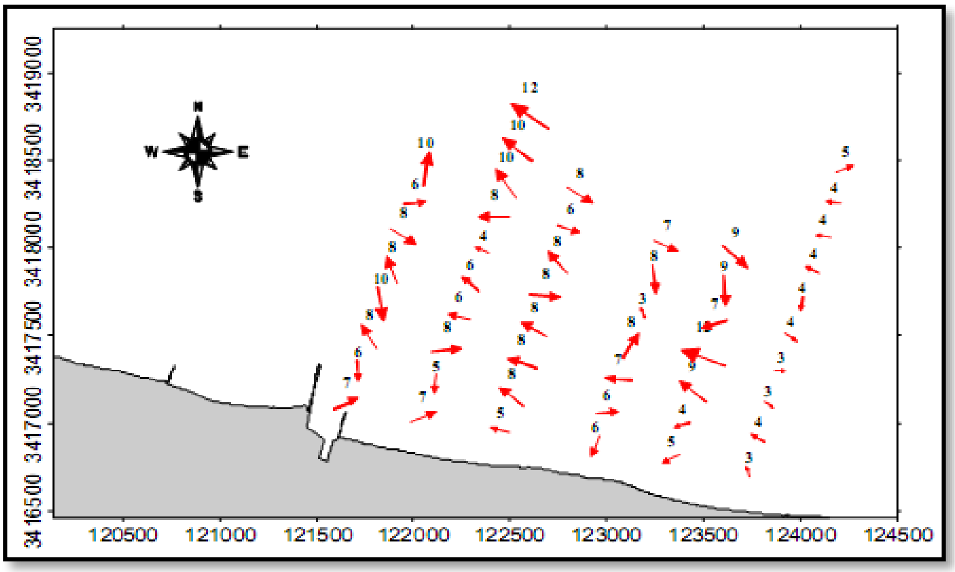

Figure (6) Measured current pattern in front of the study area in centimeters

(2007 field survey)

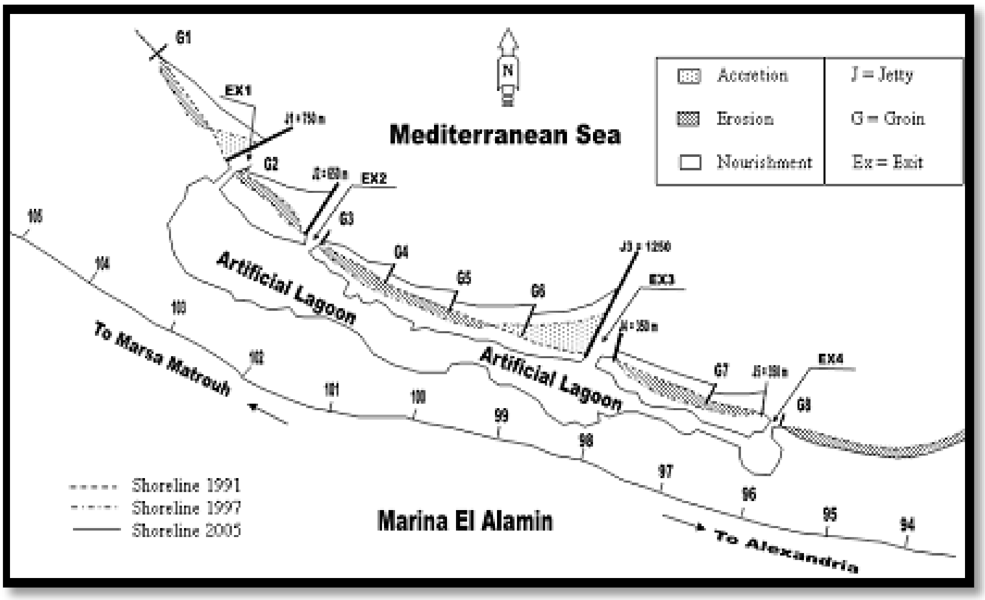

Figure (7) Shoreline changes along Marina El Alamin

(Delft Hydraulics 2002)

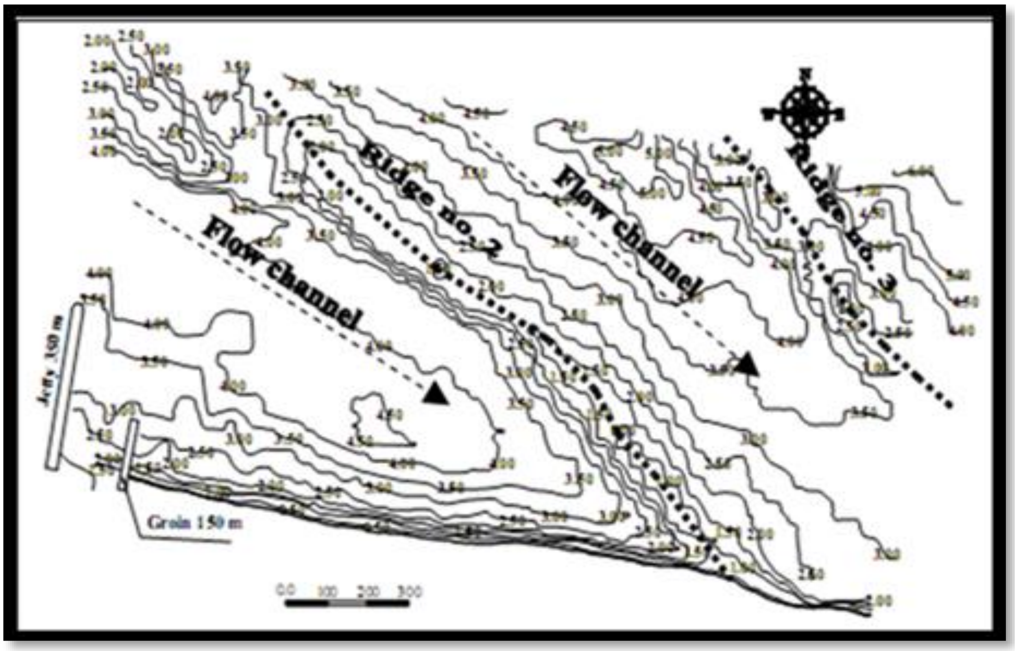

Figure (8)   Contour map of the eastern zone of Marina Center

(Delft Hydraulics 2002)

Figure (9) Erosion of the east shoreline from 8th groin in zone A
(Delft Hydraulics 2002)

5. NUMERICAL MODELLING AND RESULTS DISCUSSION

In order to achieve any numerical simulation, the available models should be reviewed and inspected in order to select the suitable tool to execute the calibration process to be able to simulate proposed alternatives. The section deliberates this procedure, as follows:

5.a REVIEWING THE AVAILABLE NUMERICAL MODELLING

There are several available numerical models. These models were reviewed. Among these models were the following:

- **MIKE21 FM:** It is a DHI software package. Its validation approach is published by ***Kristensen, S., Dronen, N., Deigaard, R. and Fredsoe, J. (2012).*** It is a shoreline model that uses one-line equation for long term shoreline response.
- **XBeach:** It is an open-source model. It was modified by ***Baykal, C., Sogut, E., Ergin, A., Guler, I., Ozyurt, G.T., Guler, G., and Dogan, G.G. (2015)*** to model long term changes at I and Y- groins. It is a depth average numerical 2DH model that deals with hydrodynamic processes (i.e. refraction, shoaling so as suspended transport dune to avalanching). XBeach could visualize the shoreline changes.
- **STWAVE**: It is developed by U.S. Army Corps of Engineers Waterways Experiment Station (USACE-WES), ***Thomas C. Massey (2011)***. It is a finite difference model based on wave balance equation. It simulates wave refraction, shoaling, current, wave breaking and wave diffraction. It provides nearshore wind-wave propagation.
- **GENESIS**: It is a model for simulating long-term evolution in response to wave, coastal structures and beach nourishment, ***Hanson, H. (1988)*** and ***Hanson, H. and Kraus, N.C. (1993)***. GENESIS is a “one-line” model or a “one-contour line” model. Sand is transported within a definite depth “closure depth”, where the shoreward and seaward limits are active berm and profile closure depth, respectively. The model computes transport in terms of wave height and direction.

5.b. SELECTING THE NUMERICAL MODELLING TOOLS

The available numerical models were inspected to select GENESIS and STWAVE, as they are widely implemented and proved their applicability, worldwide.

5.c. CALIBRATION PROCESS

Field data so as bathymetrical data were implemented to run STWAVE and nearshore wave data at Marina were produced. The nearshore wave data were introduced to GENESIS and the calibration process was executed against 2004 so as 2007 shorelines, **figure (10)**.

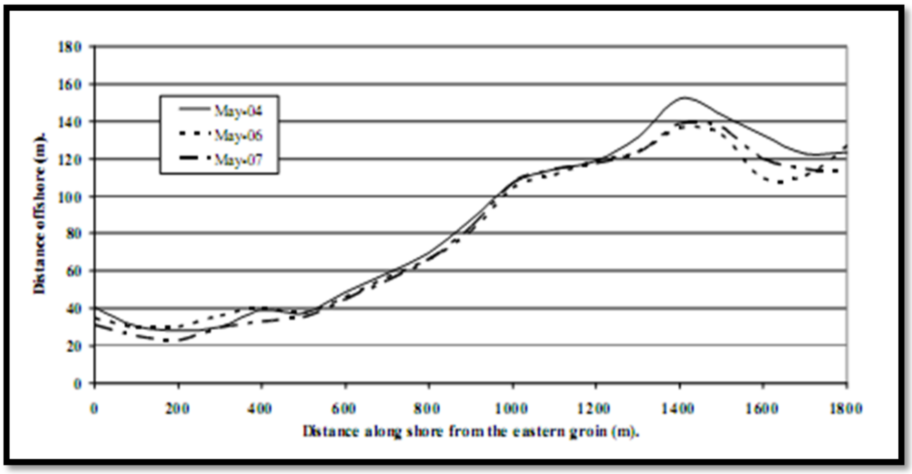

Figure (10) Calibration process (May 2004 to May 2007)

5.d. PROPOSING GROIN SYSTEM CONFIGURATION ALTERNATIVES

36 groin system configuration alternatives were proposed, where three parameters were varied [i.e. Groin Shape (I-, T-, L- and Y-groins), Groin length (L1=40, L2=75 and L3=300 m) and Groin gap (G1=100, G2=150 and G3=300 m)], table (1).

4.e. NUMERICAL MODELLING RESULTS DISCUSSION

Field data so as bathymetrical data were implemented to run STWAVE to produce nearshore wave data that were introduced to GENESIS and the simulation process was executed to obtain the expected shoreline after 5 years, for each case of the 36 proposed groin configuration alternatives. Results were obtained and discussed for STWAVE and GENESIS, as follows:

STWAVE results were obtained and scrutinized to indicate that:

- In general, the waves break at depth ranging between 1 and 3 m
- In all cases, breaking wave heights ranged between 0.78 and 2.3 m.

GENESIS results were plotted on graphs and inspected to indicate that:

- Y& T so as L groins improved the beach morphology at Marina
- A distance of 40 to 75 m enhanced the beach morphology at Marina.
- A gap width of 100 to 150, would sustain beach morphology.

The suitable groin configuration to the study area was selected and an extra run was achieved to inspect the shoreline morphology after 1, 3, 5and 20 years.

A sample of the results is presented on figures (11) to (14), for the 1 year simulation and figure (V.15), for the long term simulation of the selected configuration.
From the above runs, it was clear that:

- The groin shape affects beach morphology in a different order of magnitude that decreases from L- to T- to Y- to I-shaped.
- The groin length affects beach morphology in a different order of magnitude that increases from 40m to 75m
- The gap width affects beach morphology in a different order of magnitude that decreases from 300 m to 150 m to 100 m.
- The Y-&T- so as L- shaped groins, at a distance of 40 to 75 m with a gap width of 100 to 150, would sustain beach morphology. This configuration proved to be applicable for 1, 3, 5 and 20 years.

5. CONCLUSIONS

Based on the present investigation, the following were concluded:

- Based on the ***results obtained from STWAVE***, the following was deduced:
  - ✓ The waves break at depth ranging between 1 and 3 m.
  - ✓ The predominant significant offshore wave breaks at a distance ranging between 50 and 70 m.
- As for the ***results obtained from GENESIS***, the following was deduced:
  - ✓ For all the inspected cases, the updrift of groins accrete and their downdrift erode in different order of magnitude.
  - ✓ The Y- &T- so as the L-groins maintained the shoreline at Marina.
  - ✓ The Y&T so as L groins, at a distance of 40m to 75m with a gap width of 100m to 150m, will sustain the beach morphology.

Based on the present investigation, the following are the suggested recommendations:

- Y-&T- so as the L-groins should be implemented at marina to maintain its shoreline morphology.
- Other configurations should be investigated.
- A pilot area should be inspected in order to generalize the reached configurations at similar locations.

6. LIST OF REFERENCES

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Table (1) Proposed configurations

Shape	Gap	Length
I	G1	L1
		L2
		L3
	G2	L1
		L2
		L3
	G3	L1
		L2
		L3
L	G1	L1
		L2
		L3
	G2	L1
		L2
		L3
	G3	L1
		L2
		L3
Y	G1	L1
		L2
		L3
	G2	L1
		L2
		L3
	G3	L1
		L2
		L3
T	G1	L1
		L2
		L3
	G2	L1
		L2
		L3
	G3	L1
		L2
		L3

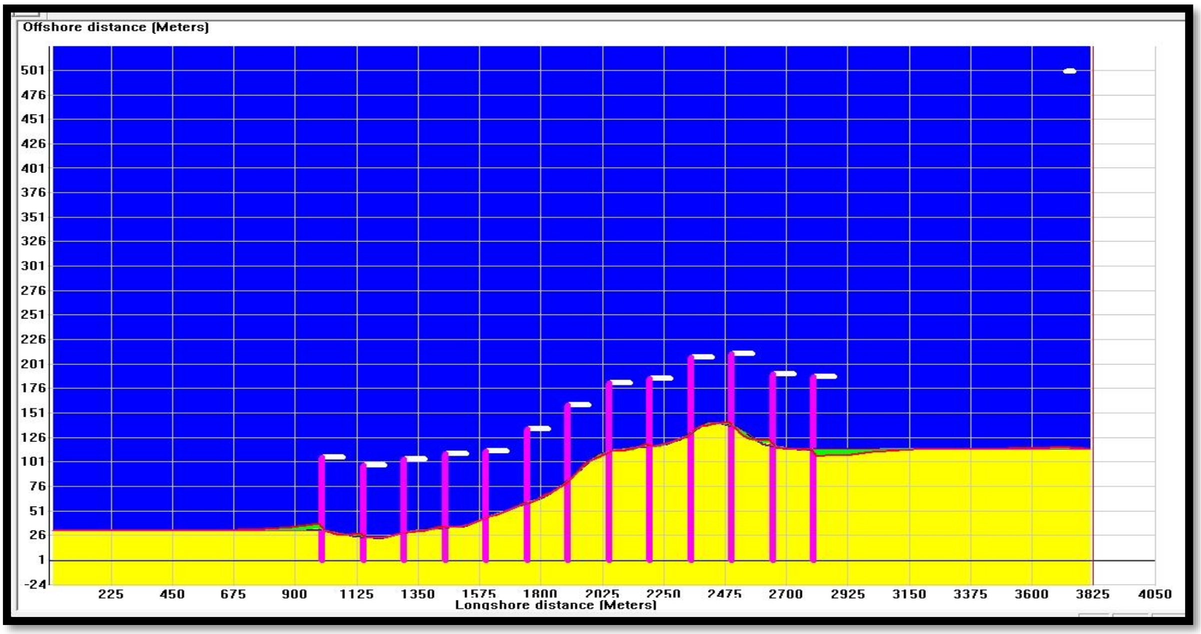


Figure (11) Computed shoreline by GENESIS after 1 year

with a L-groin system of 75 m long and 150 m apart

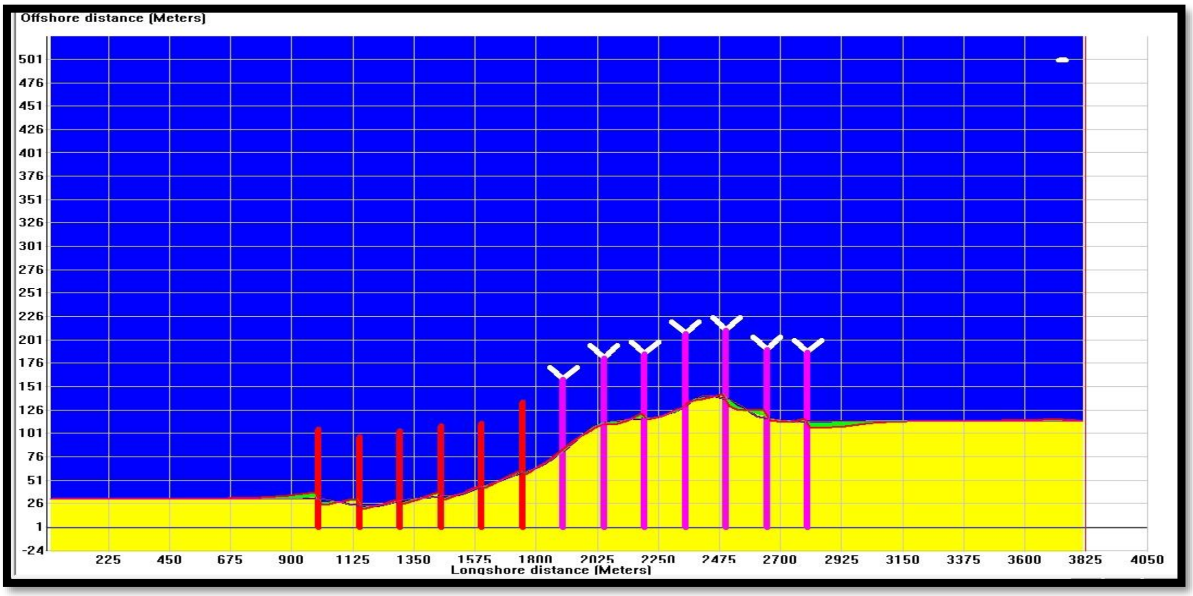


Figure (12) Computed shoreline by GENESIS after 1 year

with a Y-groin system of 75 m long and 150 m apart

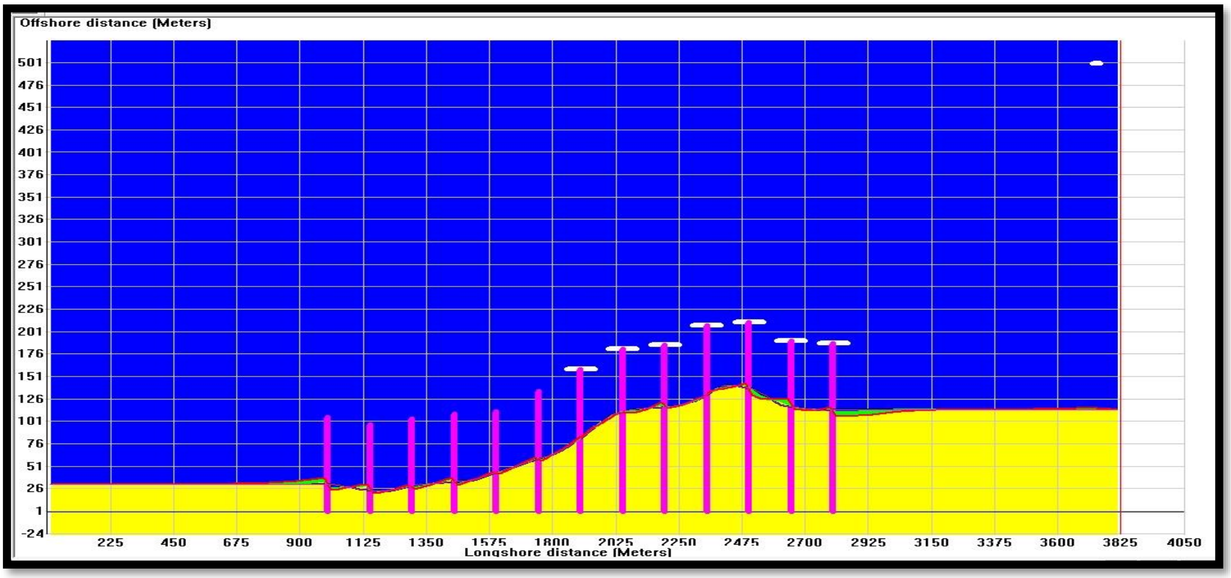


Figure (13) Computed shoreline by GENESIS after 1 year with a T-groin system of 75 m long and 150 m apart

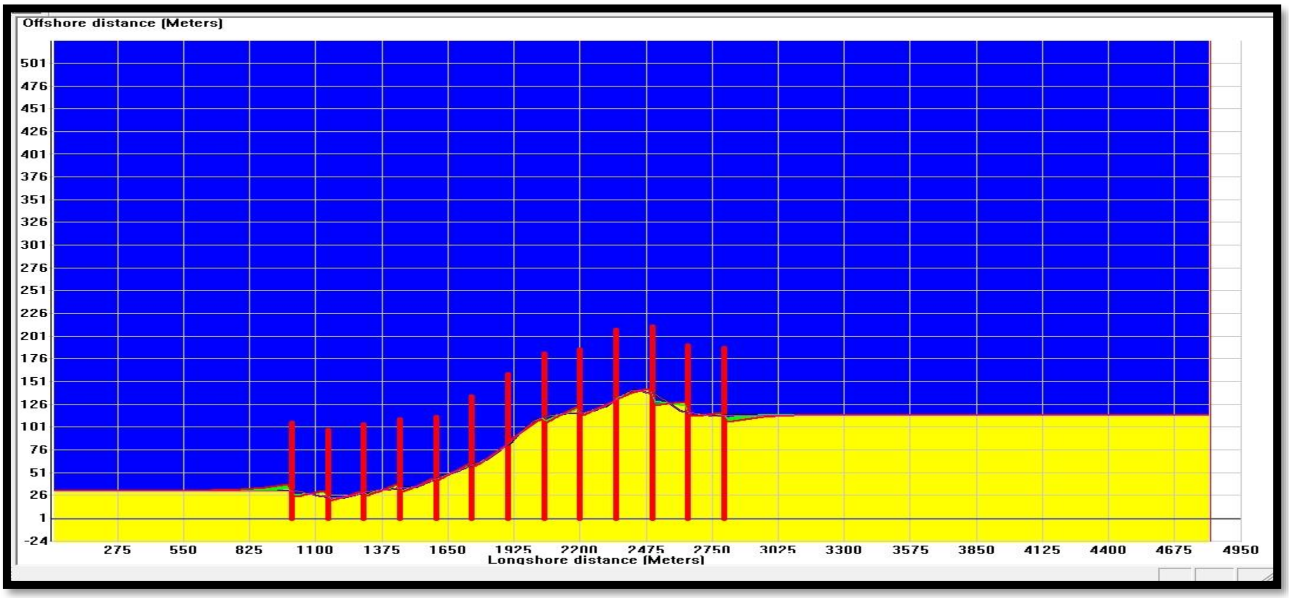
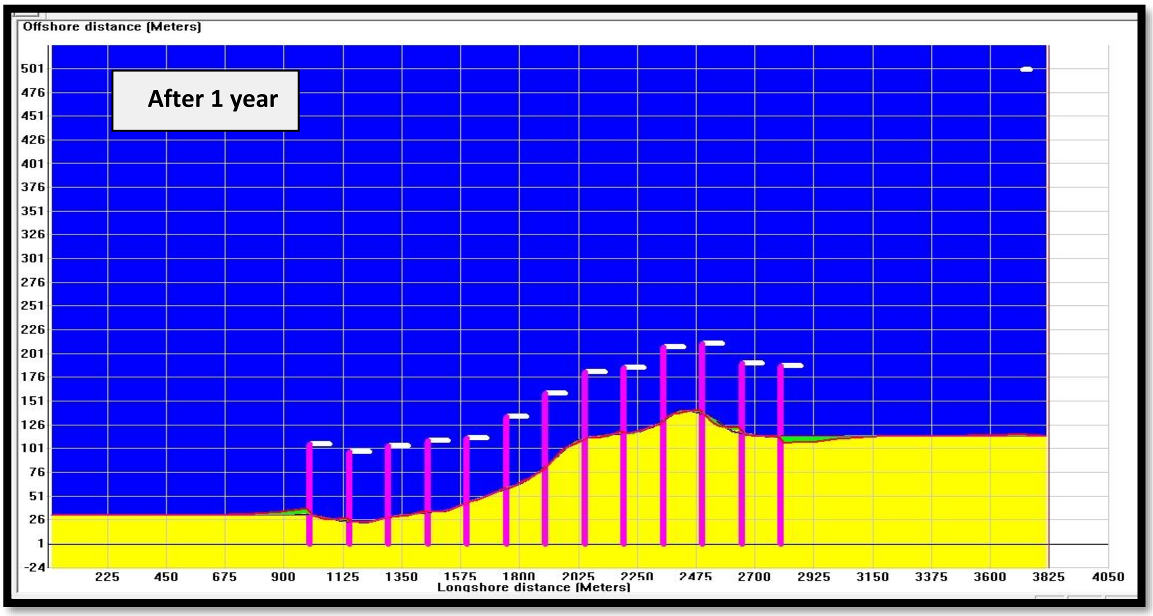
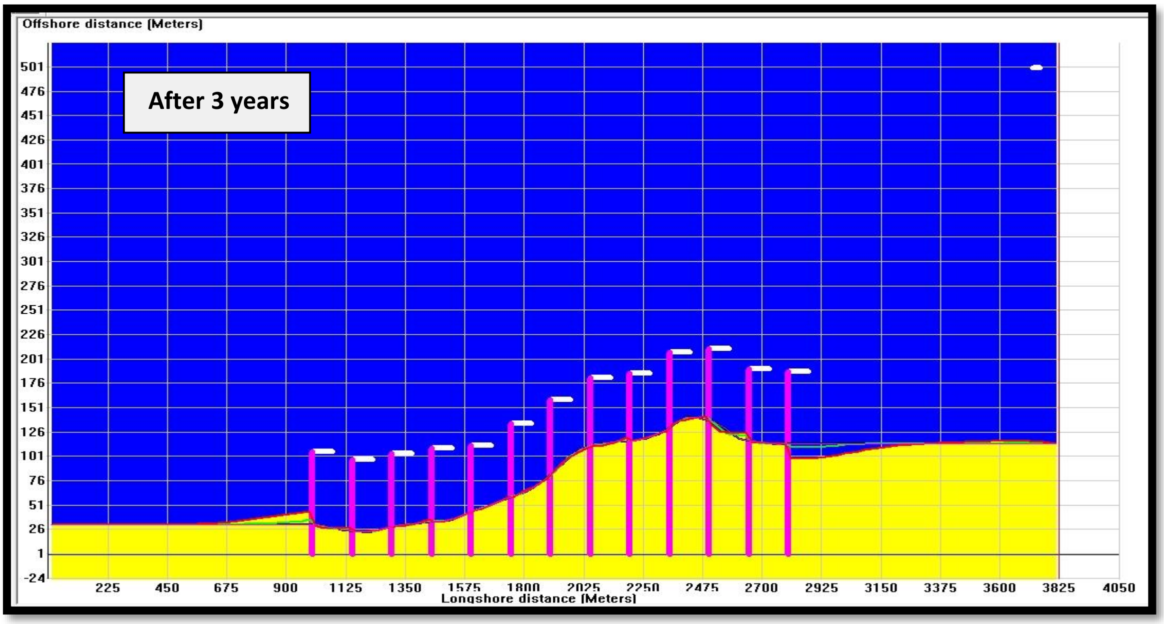
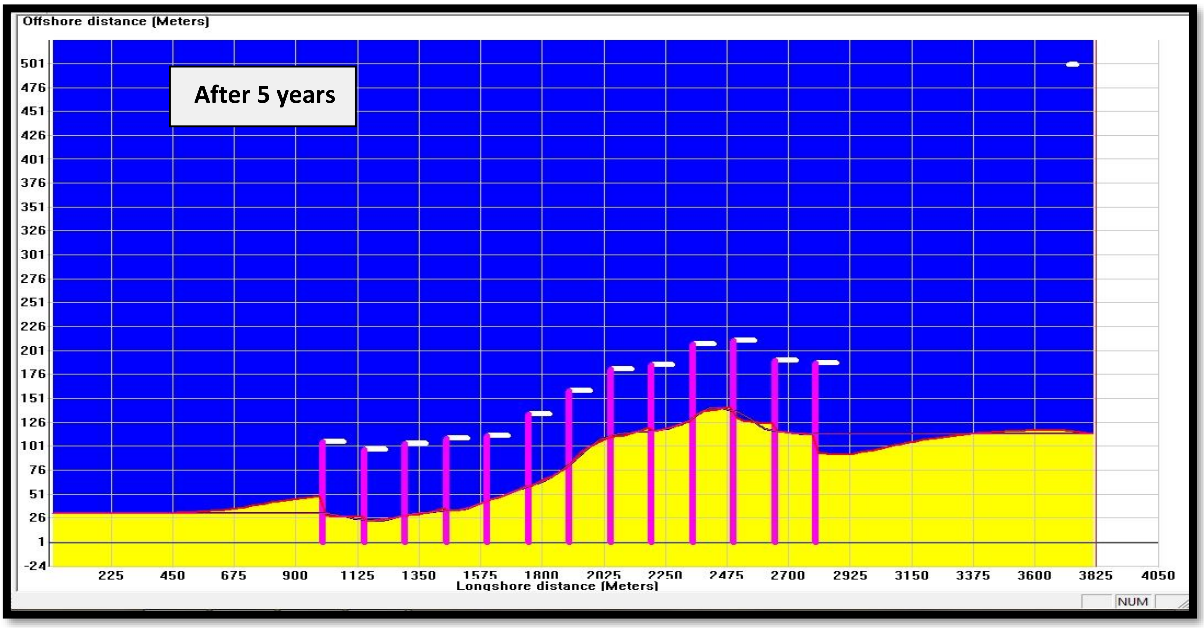
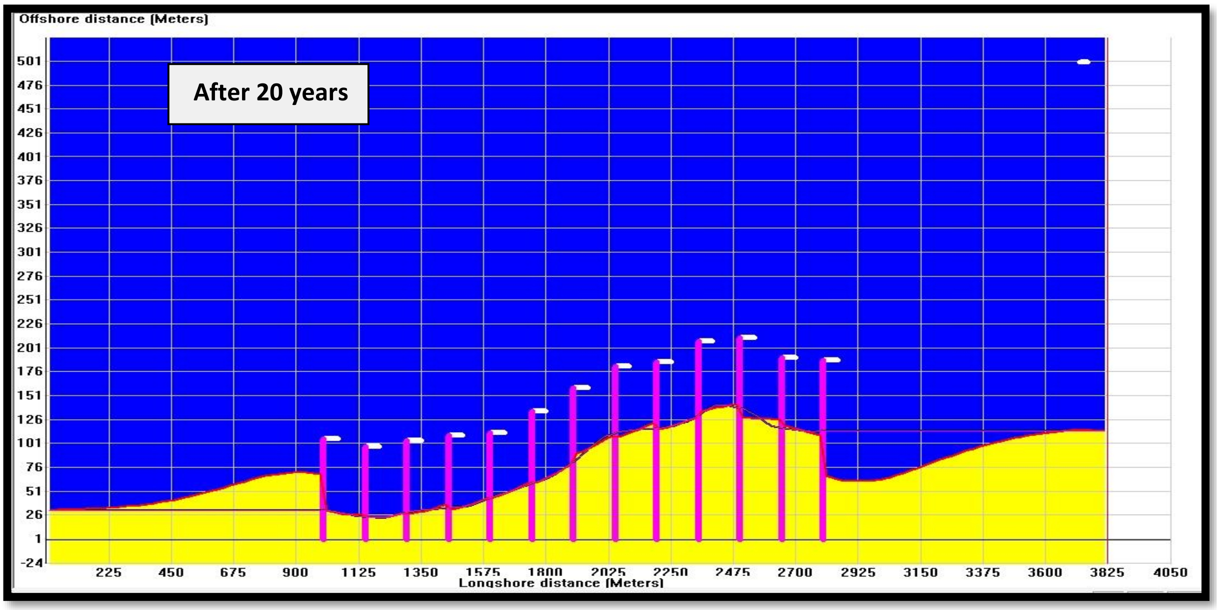


Figure (14) Computed shoreline by GENESIS after 1 year with a I-groin system of 75 m long and 150 m apart


Offshore distance (Meters)
After 1 year
501
476
451
426
401
376
351
326
301
276
251
226
201
176
151
126
101
76
51
26
1
-24
225 450 675 900 1125 1350 1575 1800 2025 2250 2475 2700 2925 3150 3375 3600 3825 4050
Longshore distance (Meters)


Offshore distance (Meters)
After 3 years
501
476
451
426
401
376
351
326
301
276
251
226
201
176
151
126
101
76
51
26
1
-24
225 450 675 900 1125 1350 1575 1800 2025 2250 2475 2700 2925 3150 3375 3600 3825 4050
Longshore distance (Meters)





`*Figure (V.16) Computed shoreline by GENESIS*

after 1,3,5 and 20 years with L-groin, G= 150 m and L=75 m