THE SCIENTIFIC ALTERNATIVE SOLUTIONS TO SOLVE THE HYDRODYNAMIC PROBLEM OF PALM BEACH

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ABSTRACT

Every year, tragic incidents occur in Alexandria's Palm Beach, where beachgoers drown after entering the sea. Deals with the problem of the crisis of Palm Beach in Agamy, west of Alexandria as a study case the problem is the continued drowning cases of swimmers in the sea at this beach which is about 1800-meter-long. For several years, the number of drowning cases increased until the cases reached 16 in one day, with the difficulty of recovering the dead bodies, which led to the attention of the executive organization to search for the causes of this phenomenon and try to put scientific solutions to face it to reduce the cases of drowning at the beach. So, this beach was called the "Death Beach" of the Egyptian north coast. Till now the problem of drownings was dealt with as a site problem and the existing protection structures were constructed without considering its side effect on the swimmers. The main reason for drowning on this beach is the existence of strong littoral currents and rip currents due to the existence of seven submerged breakwaters. This paper studies the hydrodynamics of the currents at the beach using MIKE21 FLOW MODEL to calculate the velocity of the rip currents and the velocity of longshore currents which cause the drownings of the swimmers. Also, the assessment of the existing protection structure on the beach is presented. Finally, the study case noticed that some shore protection structures had been constructed without taking care of their side effect. In this paper, A scientific alternative hydrodynamic solution was created to solve the problem of palm beach. A study case is presented to show the correction of the existing structure dimensions of the submerged breakwaters. The correct dimensions were reached, and the disaster of this beach would be reduced.

Keywords: Palm beach, Rip currents, Drowning, Breakwater.

INTRODUCTION

The coastal structures were built at different sites along the northern coast to protect the shore against erosion or for any other development purposes, causing some positive and negative impacts. To the west of Alexandria, between Alexandria and El Alamein, the zone suffers from unsuitability for swimming due to the steep slopes of the surf zone and rip current generation. So many coastal protection works are erected in the research joint Palm Beach. The Palm Beach village is located 20 km west of Alexandria center. Palm Beach located on the north coast Mediterranean starts at 758786.65 m E, 3442481.43 m N, and ends at 760479.67 m E and 3443520.71 m N. It is bounded by the West Nobria Drain in the west (Iskander et al., 2007). To protect the shore of this village, seven detached breakwaters were constructed of dolose units at water depths between 4 and 5m at 200 m from the shoreline. Each breakwater is 90 m in length and 50 m spacing and a temporary small harbor was built west of the detached breakwaters to serve the construction of these breakwaters from 1998-2003 as shown in Figures (1 & 2). It was found that this project has a low effect as breakwaters due to the existence of the natural submerged ridge parallel to the shoreline, bed sedimentation features, and the existence of the west Nobria drain with its two jetties. The submerged ridge dissipated the energy of the incident waves before reaching the breakwater. The coastline orientation and the bed sediment features decrease the amount of littoral drift. Recently, Palm Beach in Alexandria, one of Egypt's most hazardous coastlines, has earned the name of "the Death Beach" ever since dozens of cases of drawing.

The aim of the present study is to discuss the reasons for drowning due to the hydrodynamic effects on the existing coastal protection structures and the morphology of the seabed slope. Moreover, study alternative solutions to stop these severe phenomena. The methodology in the joint research is proposed by two different seniors. Firstly, modifying the breakwater dimensions and the other is reducing the crest level to be submerged breakwater. All these alternatives have been checked for the velocities of current by applying the MIKE21 FLOW MODEL.

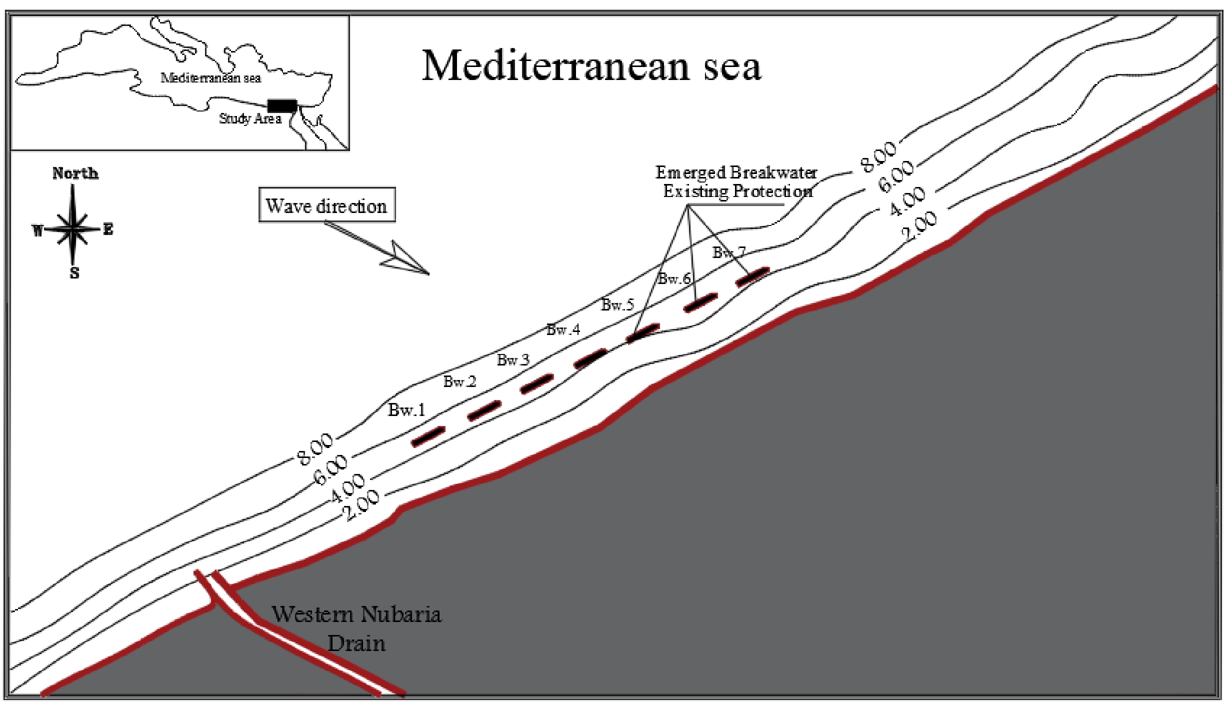

Figure 1: Palm Beach (google earth, Iskander et al., 2007b), Drawing by the author

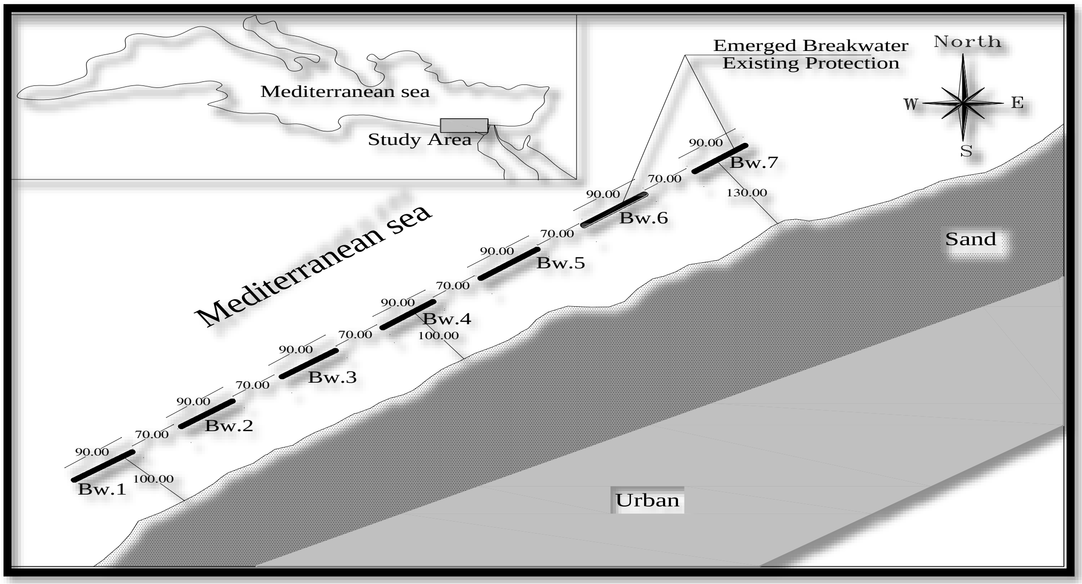

Figure 2: The details of the breakwaters (Iskander et al., 2007, **El-Kolfat A.Is, 2010**), Drawing by the author

The beach profile is a result of the action of waves and currents at the shoreline. The waves not only suspend the sediments but give rise to nearshore currents that carry the suspended sediment alongshore or cross-shore. A longshore current is driven by waves breaking obliquely to the shoreline and flows in a direction corresponding to the wave direction. Often, this current turns seaward and becomes a Rip current, taking sediment offshore. Nearshore current patterns are a combination of longshore currents, Rip currents, and undertow as shown in Figure 3.

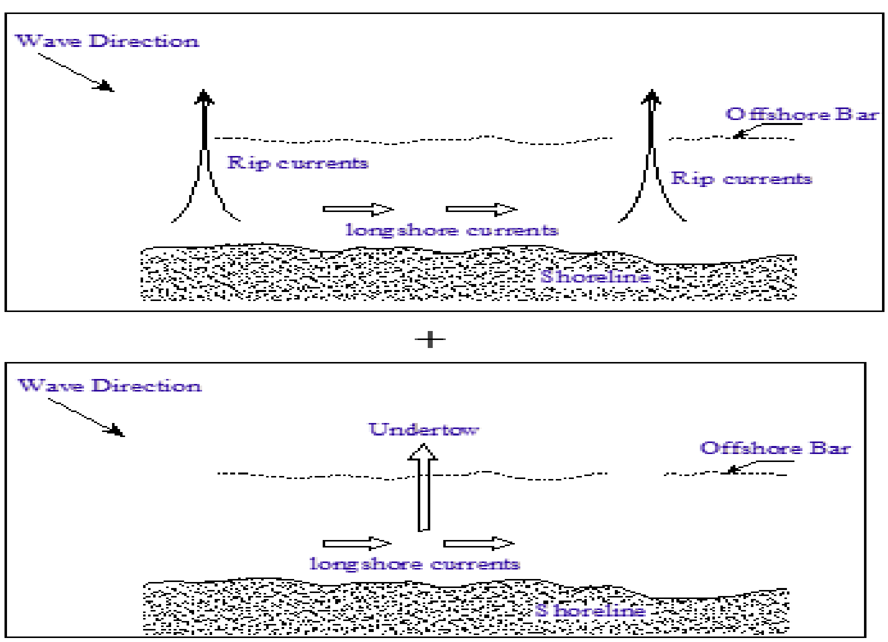

Figure 3: Types of currents near the shore.

For a large incident wave angle alongshore, the momentum generated by the wave-breaking process sets up strong longshore currents. Smaller incident wave angles generate weaker longshore currents; the onshore momentum of the waves holds some of this water close to shore, causing an elevated water level near shore called wave setup (Taha.Sh ,2016). However, most of the water flows from the shore to deeper water in the form of undertow and rip currents (concentrated strong local currents). This is a feedback system. Rip currents also increase the size of shoreline irregularities and breaks in the bars; they can also be triggered by local irregularities in the shoreline direction, such as at coastal structures or beach cusps. All the undertow and rip currents occur for different reasons at different locations along the beach.

Rip currents are extending perpendicular to the shoreline through the surf zone and serve as a conduit for water to escape from a zone of elevated water. Rip currents are important geologically because they have been shown to carry significant amounts of sand offshore. Rip currents can be located by observers at the shore and from aerial photographs. Their positions can also be identified indirectly by side-scan sonar when their characteristic Rip-scoured channels are imaged on the seafloor. Rip currents may occur at fixed locations such as breakwaters, groins, jetties, piers, or other man-made structures.

SHORE LINE CHNGE HISTROY

Shoreline change rates can be determined by recent data measured in the field or digitized from google earth software. The historical shoreline change data must be known to understand the behavior of the study area, For the present study, the recent shoreline data were obtained from the google earth program as shown in Figure (4), To digitize the shoreline data one construction must be fixed as a reference (the Nubaria outlet in this case study as a reference) to be sure there is not any movement in the digitized shoreline.

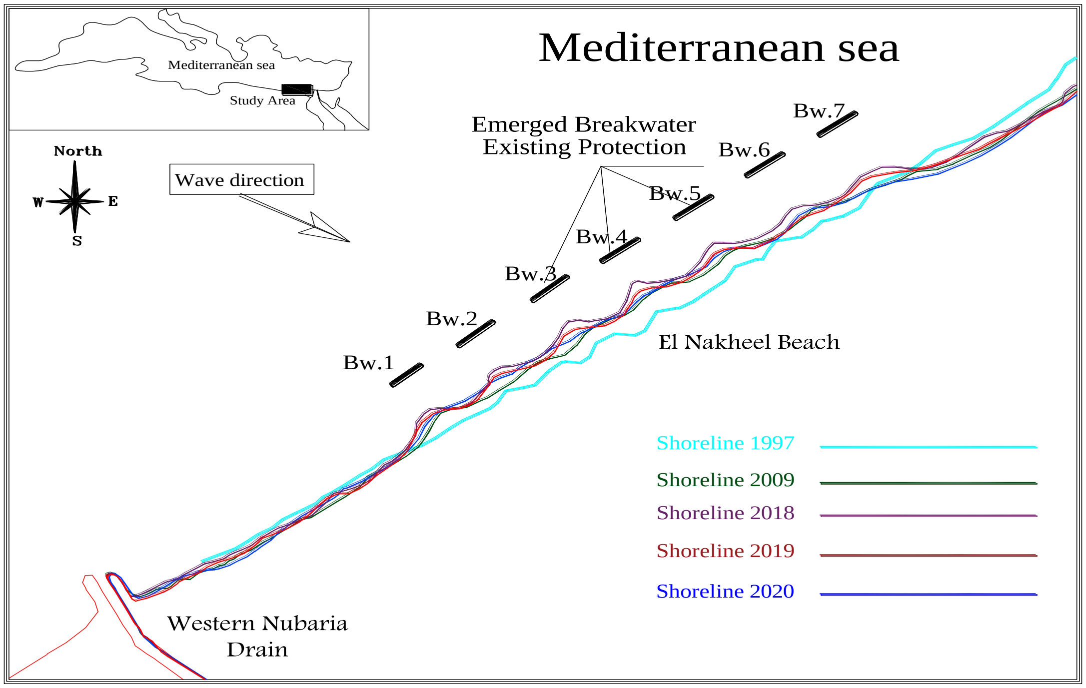

Figure 4: The historical shorelines of palm beach and the eroded locations (Analysis by the author)

Palm Beach has steep slope ranges from 1:25 to 1:35, making the breakwater area small, and this causes large currents and longshore currents. This means that the sea is not enjoyable during the summer period.

Palm Beach does not suffer from erosion problems within the distance in front of the breakwater, the erosion appears down drift the breakwaters and is recorded as 24 m erosion in front of breakwater no 6, and 62.00-meter erosion in front of breakwater no 7, and finally at the downward drift of the last breakwater (After 100.00 meter longshore) the eroded distance was recorded about 104.00 meters

The beach suffers from a big problem of drowning because of the Longshore current, the bathymetry varying, and the nearshore circulation. for this reason, the circulation flow in the mentioned area occurred and cause dangerous drowning for the swimmers as shown in Figure 5. (Iskander, 2021)

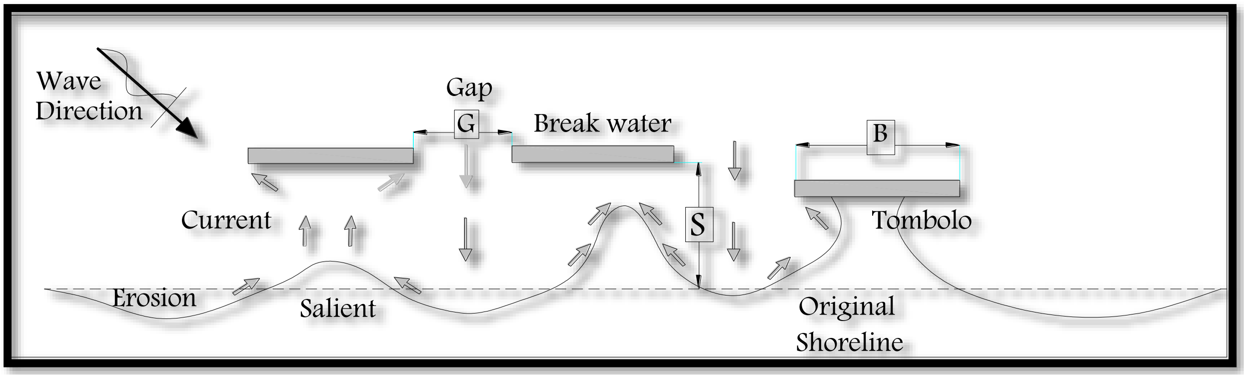

Figure 5: The circulation current among the breakwaters (Dean, 2001)

The design of the emerged breakwater must respect some design rules related to the length of the breakwater, the gap between the breakwaters, and the distance from the shoreline to the breakwaters (offshore distance). Offshore breakwaters intercept much of the incident wave energy, resulting in reduced wave action behind the structures. The waves enter through the breakwater gaps and then diffract as they travel toward the shore, the diffracted waves change the beach shape from a relatively straight shore to an attractively curved shoreline with salient or tombolo. A salient is an accretion formation that does not reach the breakwaters; a tombolo is attached to a breakwater. In general, breakwaters that are longer or placed close to shore form tombolo. Salient form when the breakwaters are further from shore and there are substantial gaps between the breakwaters, Choosing the breakwater type depends on the functional needs, wave action, water depth, and availability of material. Also, the shape of the breakwater depends on the requirement of a standalone breakwater or segmented. Segmented short breakwater is preferred over long breakwater, as the segmented one allows water to enter in the lee side between the gaps, also it is more economical.

The recommended governing formulas for the design of the breakwaters are as follows. (El-Kolfat,2010):

Salient ……………………..…….. For $2 > S/B > 1$ and $G/B > 1$

Tombolo………………………….. For $0.60 > S/B > 1$ and $G/B < 1$

Where:

B: breakwater length.

G: the gap between breakwaters.

S: distance from the shoreline as highlighted in figure 6

1.4 THE HYDRODYNAMIC STUDY OF THE BEACH:

The analysis of the wave hydrodynamics of this beach should include the following items:

a- the wind frequency, direction, and speed. The data of wind is presented and shown in the wind rose figure (7).

b- the bathymetry of the coast which is obtained c- the bed soil analysis (D50)

d- the existing protection structures was shown in Figure (3).

e- the use of the beach, is known as the area is a residential area and the beach is used as a tourist beach for the surrounding area.

The formation of rip currents due to the gaps between the existing breakwaters should be studied and a check of the design of the breakwaters is essential. Suggestion for solving the problem is given in this paper.

1.5 THE ASSESSMENT OF THE BREAKWATER DESIGN OF PALM BEACH:

This project consists of seven detached breakwaters made of dolose units. It was constructed in water depths between 4 and 5 m at a range between 120 m to 170 m from the shoreline. Each breakwater is 90 m in length and 70 m spacing [1]. A temporary small harbor was built west of the detached breakwaters to serve the construction processes of these breakwaters from 1997-2003 as shown in Figure (1). As shown in table(1) S/B>1 in which salient formed. This project hasn't had a good effect due to the existence of the submerged natural ridge parallel to the shoreline, bed sedimentation features, and the existence of the west Nobria drain with its two jetties. The submerged ridge dissipated the energy of the incident waves before reaching the break water. The coastline orientation and the bed sediment features decrease the amount of littoral drift. If sufficient studies and complete investigations were made before designing this project a lot of money would be saved. (Abd-El-Mooty,et al,2017). A major complication is introduced by waves overtopping the breakwaters. The currents behind offshore breakwaters can be dangerous to swimmers, during storm periods. Because the waves behind the breakwaters are benign, people are not aware of the strong currents, which are a function of the large waves outside the breakwaters. Careful lifeguard patrols during storms must keep people away from areas of strong current activity.

Table (1) The assessment of the Breakwaters design of Palm Beach:

B.W. Length(B)	Spacing between B.W.(G)	Offshore Distance (S)	Chech_1 S/B	Check_2 G/B	comment
90.00	**70.00**	**100**	**1.11**	**-**	**Salient Breakwater**
90.00	**70.00**	**100.00**	**-**	**0.70**	**Not Sufficient**

The first check is ok safe for salient design but the second is not ok, so the gap between the breakwaters must be increased as the following

Distance from shoreline "S"	100	meters

Breakwater Length “ B”	90	meters
Gap between breakwaters “G”	100	meters

1.5 CALCULATION OF RIP CURRENT AND LONGSHORE CURRENT DIRECTION AND VELOCITY:

The established numerical models require field data. The following section explains field measurements that have been performed to simulate the current problem at palm beach Additionally, pairs of vortices with an average current velocity of 0.6 m/s form behind the breakwaters. With velocities up to 1.2 m/s and associated with the rip pulsation that extends offshore, the dominant northwest waves cause rip currents on the lee side of the structures (Salama et al., 2023b) This is the main problem to be solved.

The field data have been collected by Coastal Research Institute (CoRI) as shown in figure 6

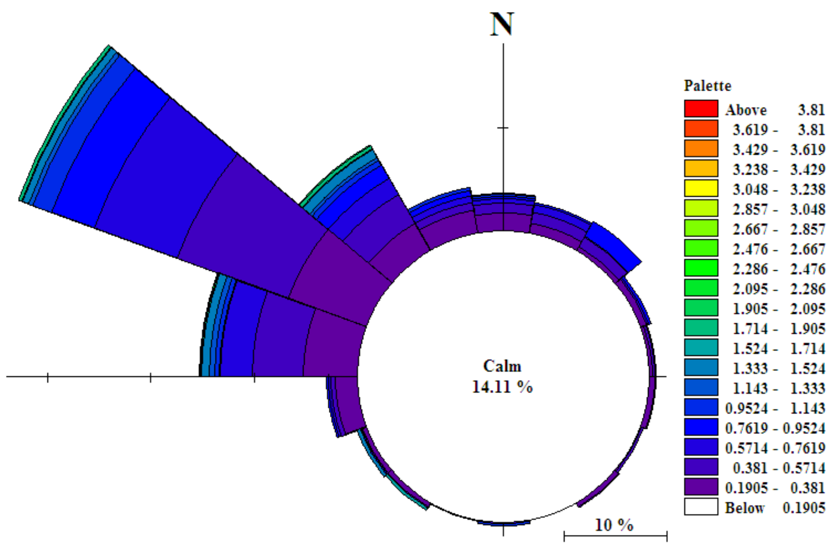

Figure 6: Wave height Rose in May, June, July, and August 2017 (Taha,2016)

The sea level variation is playing an increasingly important role in numerous fields, especially the values and patterns of the tide. Consequently, the knowledge of this variation must be essential to any thoughtful analysis of coastal processes. Regarding the region of study, palm beach is in the Mediterranean Sea and the field data is shown in figure 7

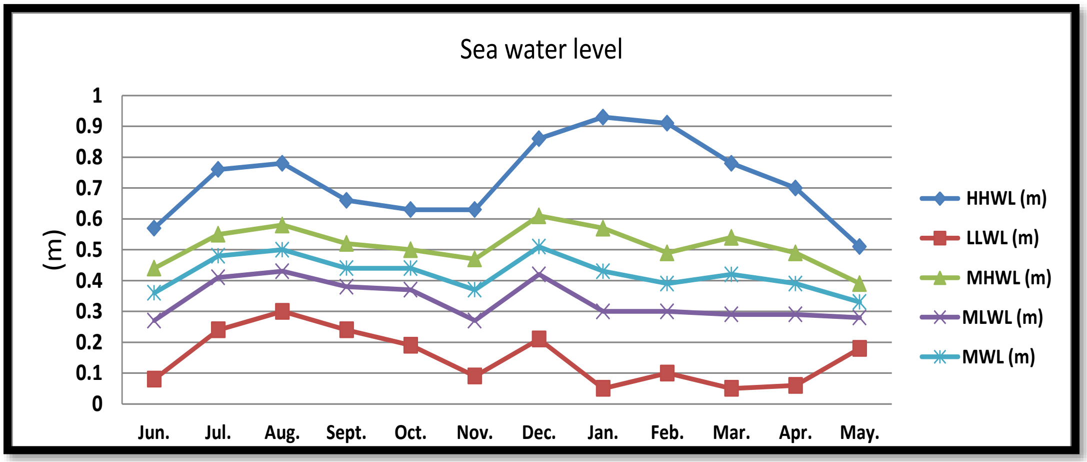

Figure 7: Wave height Rose for May, June, July, and August 2017

In palm beach, Mike 21 flow model was applied to calculate the directions and velocity of the currents because this phenomenon of current, longshore current, and rip current causes the drowning of swimmers. Firstly, applying the model of **MIKE21 spectral wave model**, the mesh generator provides for creating a detailed digital mesh by use in the MIKE Zero flexible mesh and then doing the interpolation. To run **MIKE 21 SPECTRAL WAVE** model on palm beach using the cell-centered finite volume method must be used. An unstructured mesh technique is used. to get the radiation stresses which cause the hydrodynamic change, The computational mesh generation is used to get the bathymetry of the study area as shown in figure 8.

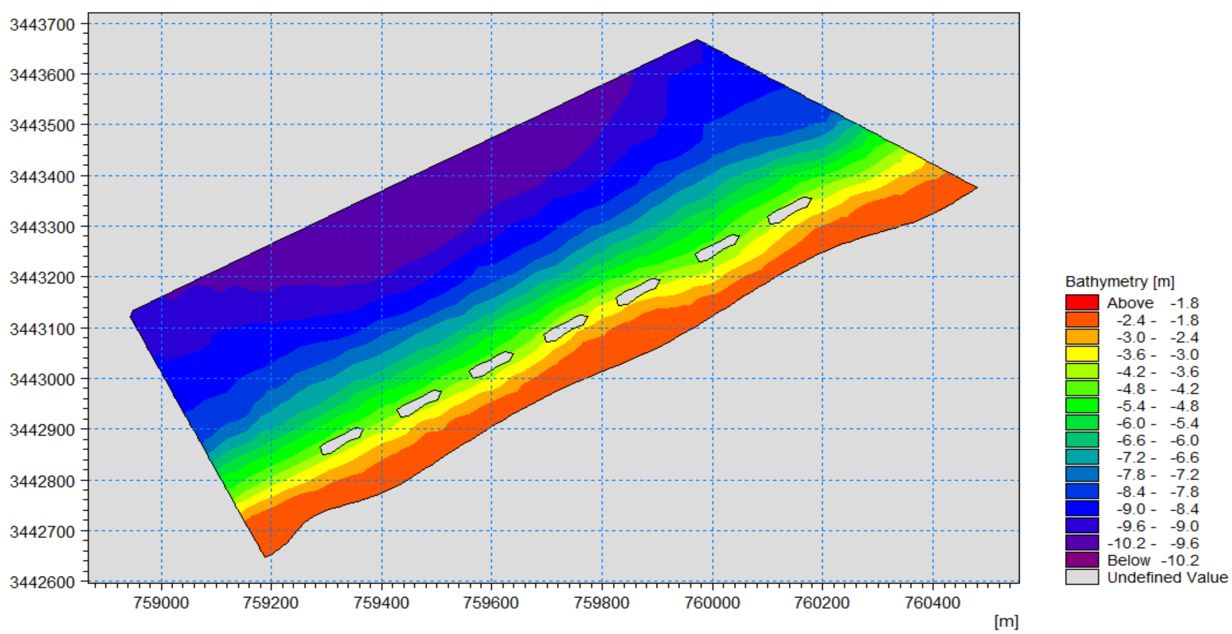

Figure 8: The bathymetry of palm beach by mike 21 for the existing breakwaters.

The current direction and velocity of the existing protection structure (7 emerged breakwaters) are shown in Figure 9, From this mike flow model output the current velocity at the shoreline is determined and it is recorded to be about 0.40 to 0.48 m/s almost near the shoreline

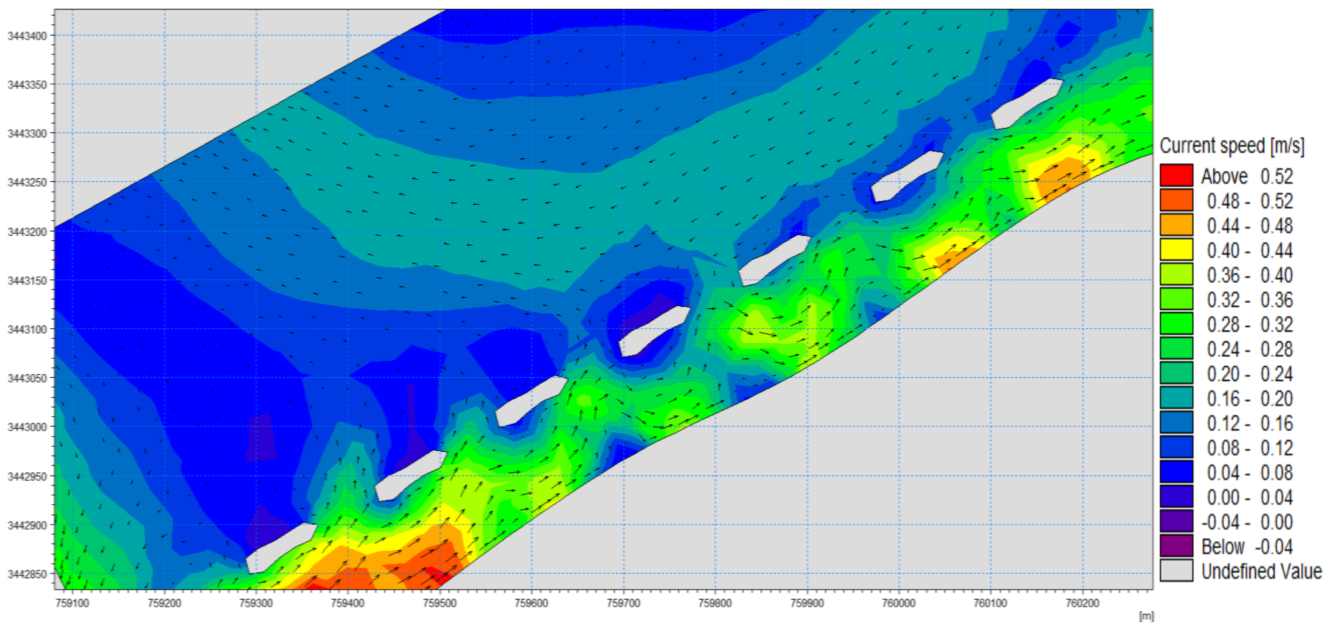

Figure 9: The first scenario (Seven submerged breakwaters)

So, to solve the problem of the big values of the current velocity in palm beach near the shoreline 2 scenarios are proposed, the first Scenario is to reduce the level of the existing breakwaters to become submerged instead of emerging as shown in Figure 10, From mike zero the new bathymetry of the first proposed solution is obtained as shown in figure 10

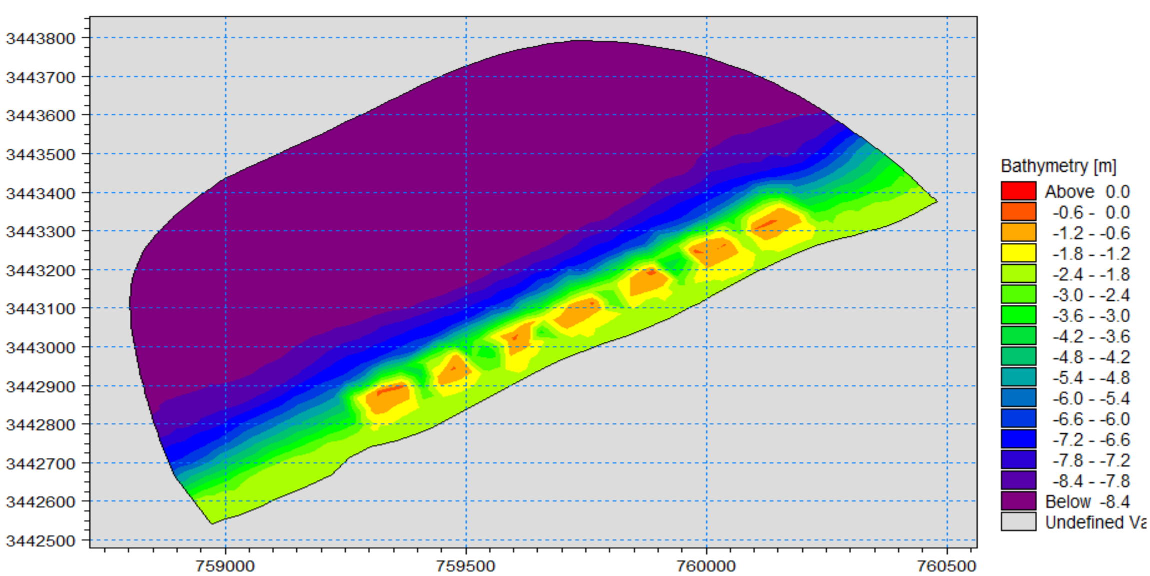

Figure 10: The bathymetry of palm beach by Mike Zero for the 7 submerged breakwaters.

By applying the first proposed solution with the seven submerged breakwaters we gain a calm area for swimming near the shoreline and extend to 50 meters offshore where the current velocity is recorded at 0.10 to 0.15 m/s without vortex, so this proposed solution is safe for the swimmer as shown in figure 11

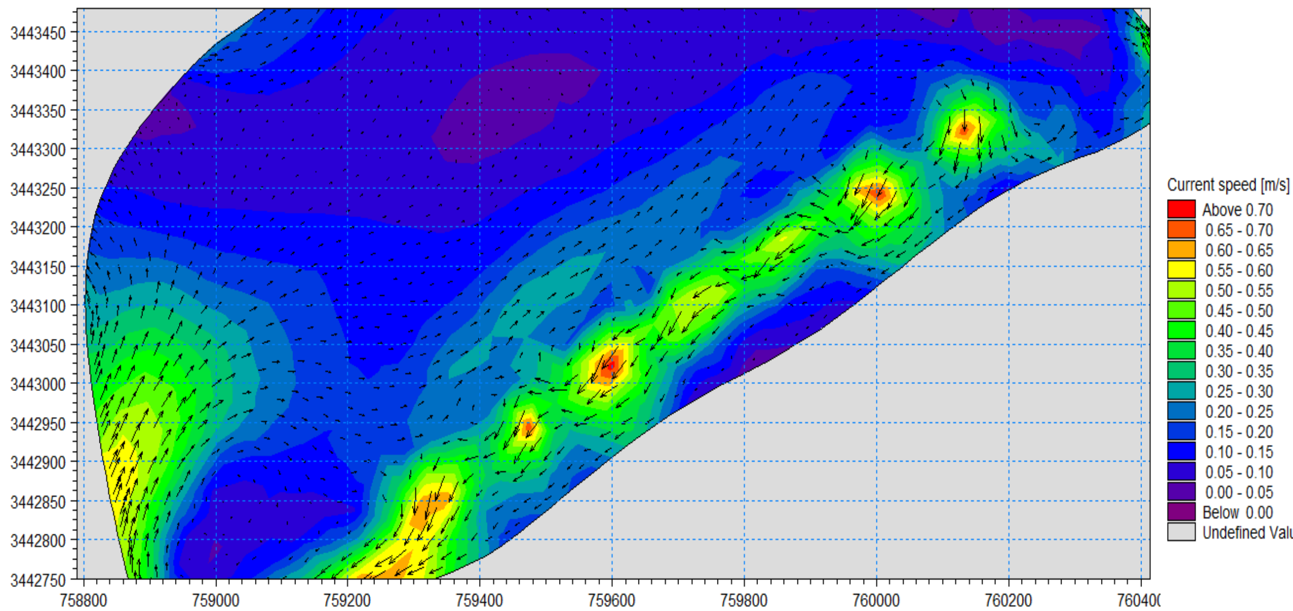

Figure 11: Current direction and velocity for the seven submerged breakwaters.

The second scenario is to connect the first four emerged breakwaters to be one submerged breakwater with a length of 550 m and connect the last three emerged breakwaters to be a submerged one with a length of 420 m and the gap between the two breakwaters about 70 m as shown in figure12

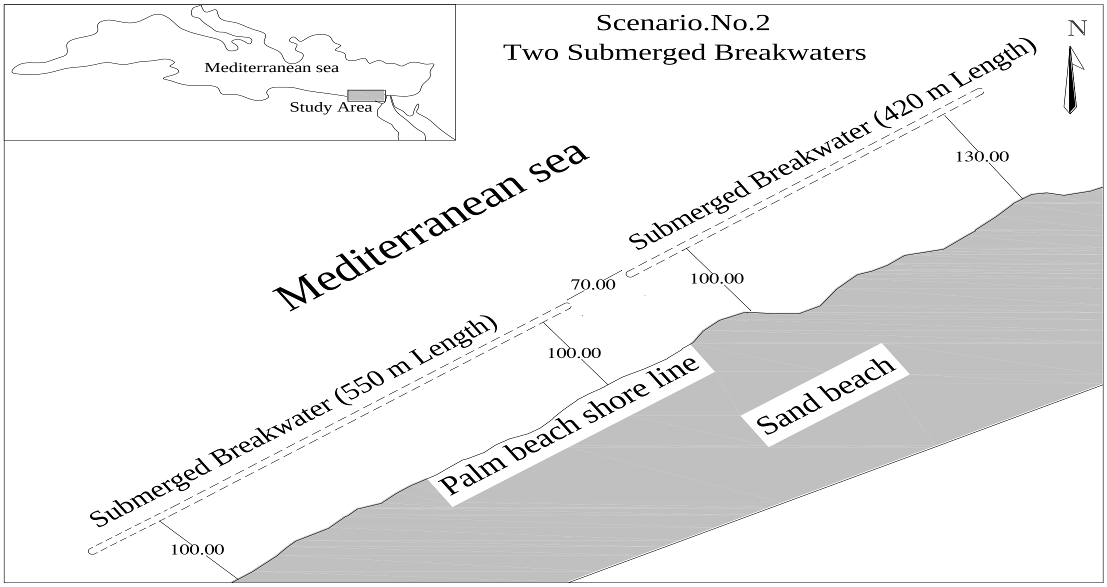

Figure 12: The second scenario (Two submerged breakwaters)

From mike zero we gain the new bathymetry of the first proposed solution as shown in Figure 13

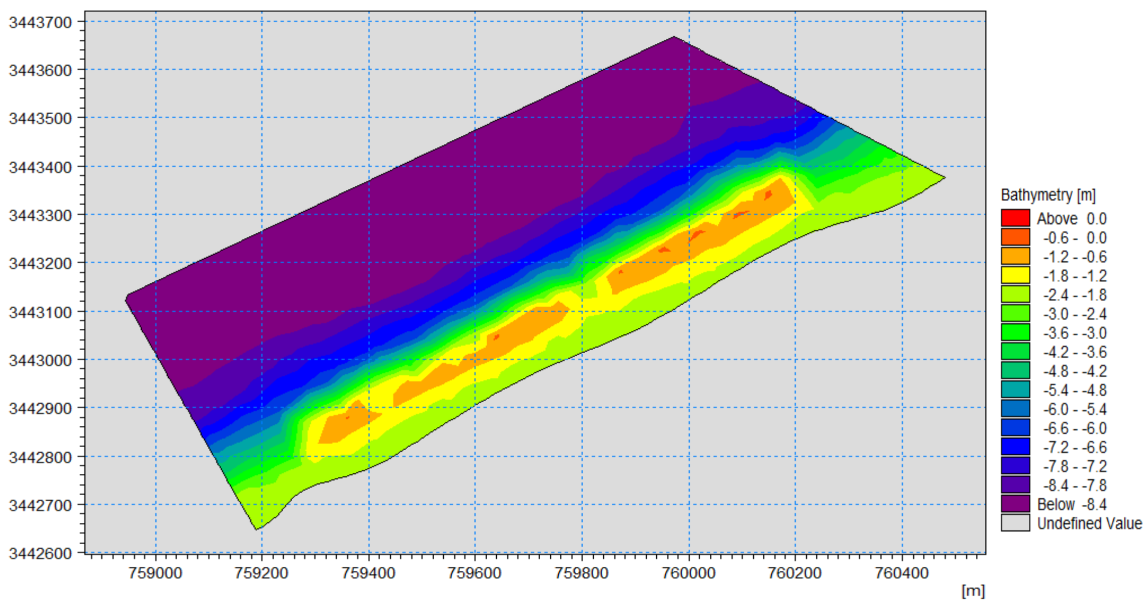

Figure 13: The bathymetry of palm beach by Mike Zero for the two submerged breakwaters.

By applying the second proposed solution with the two submerged breakwaters a calm area is gained for swimming near the shoreline and extending to 50 meters offshore where the current velocity is recorded at 0.05 to 0.20 m/s without vortex. This proposed solution is safe for swimmers as shown in Figure 14 and safe than the first proposed solution.

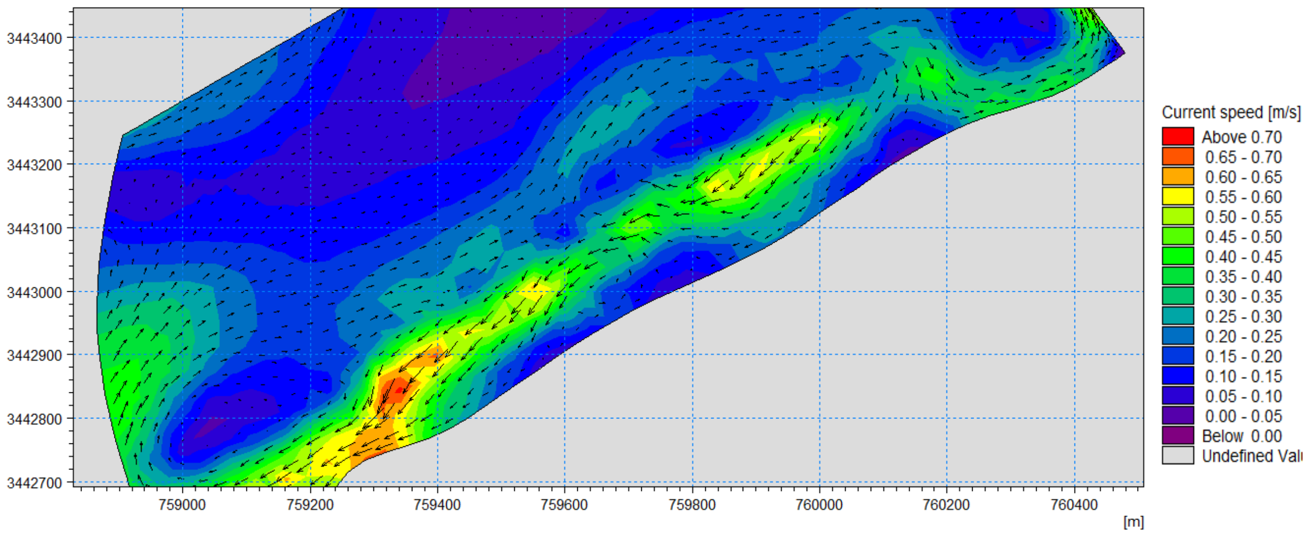

Figure 14: Current direction and velocity for the 2 submerged breakwaters.

CONCLUSION

For swimmers, rip currents created in the used zone can also be dangerous. This study aims to investigate whether detached submerged breakwaters could be used to create appropriate swimming conditions along Egypt's northern coast. Since they do not block the view of the sea and have less of an adverse effect on the environment, detached breakwaters are taken into consideration. This study tries to offer a numerical analysis for several configurations using various breakwater and gap lengths. Three numerical models were employed: a one-line model for shoreline movement, a hydrodynamic model for current circulation, and a refraction-diffraction model for waves. With an evaluation of the detrimental impact on the stability of the shoreline, the best breakwater configuration is advised. From the analysis of the problem the following conclusions are obtained:

1 - The Reasons which cause the drowning are:

a- The rip currents occur due to the unsuitable gaps between the breakwaters.

b- Rip currents consist of semi-enclosed large-scale vorticity.

c- The current velocities beside the shoreline have almost large values.

2- The two scenarios that have been proposed are appropriate for stopping the drowning occurrence at Palm Beach. Two different seniors have proposed the research methodology for the collaborative project. First, the breakwater's dimensions must be changed, and second, the crest level must be lowered for the breakwater to be submerged. By using the

MIKE21 FLOW MODEL, the current velocities of all these alternatives have been examined.

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