Using Spatial Images to Detect Changes in Shorelines

by

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
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in partial fulfillment of the requirement for the
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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the reference and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

....

(MOHD UZAIR BIN CHE AZUHAN)

ABSTRACT

The purpose of this study is to investigate the shoreline response toward the installed submerged breakwater and assess the performance of the breakwater with the shoreline response at the site. The coastal region has become one of the focus and choice to the society due to the aesthetic view and economic global especially fishing activities. Many activities such as manufacturing by the local and international, ports, tourism industries have been blooming in coastal cities. However massive activities such resort development, extreme water sports, and ports activity have caused the some problem and instability to the dynamic of the beach. In results of the activities, beach either erosion or accretion over the past years and calling for measures to protect this valuable asset from disappearing. Submerged breakwaters (SBWs) has been chosen for this studies and are becoming a popular structure protection and one of the options for coastal protection, mainly due to their low aesthetic impact on the natural environment area and marine habits. However, the effectiveness of the SBWs has rarely studied over the past years, and therefore the efficiency of the structure remains unknown. The main objective of this investigate the structural and environmental condition that govern the mode of shoreline response using satellite image and geoprocessing tools in the response (shoreline erosion vs shoreline accretion) to SWBs. The result from the studies is to provide a starting point to the future research at the site in estimating the shoreline response to SBWs.

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Coastal areas support some of the most diverse and productive resources in the world. Coastal are very dynamic region on earth that has constant sediment transport in the form of sand erosion and accretion. Human population growth has exerted pressures on marine shorelines around the world. The most devastating effects to coastal ecosystems are now recognized to be the cumulative effects from a combination of individual actions. Previous year, the coastal area was not an option or choices to be develop also for living. By year 2010, almost 44% of world population were living in at the coastal area. For the US, 52% of the nation's population lives in coastal area. The duration of years from 1970 to 2010 shows an increase of 50.9 million in US coastal area population. The number is equal to 45% of the increasing for the 40 years of period (Toro, 2012). The statistic shows that the coastal areas are being develop and currently facing the human intervention due to the activities like fishing or harvesting, the destruction of mangroves, and pollution and sedimentation from human activities all can affect the coastal environment. And the statistic and condition were expected to be worsen to increasing from time by time.

Coastal was form by many factors. This includes fluctuation in sea levels over time, type of sand along the coast, weathering condition and etc. Sediment drops at the mouth of the river or the meeting point of the river and sea and was transported by the longshore drift. The longshore current then will cause the sediment to move in the direction of current to replace sediments that are eroded along the beach or coastal. Longshore drift is influenced by numerous aspects of the coastal system, with processes that occur within the surf zone largely influenced the deposition and erosion of the sediment which resulting in erosion and accretion of the coastline.

At present, the installation of breakwater becomes popular and used wide around the world. However due to the section of the breakwater that emerges above the water considered to have reduced the aesthetic value of the beach for the tourist and extreme activity for example surfing activities. For this reason, submerged breakwater has been used to preserve the aesthetic value of the beaches. As the name suggests, a submerged structure is one whose top lies below the level of mean low water and is permanently covered. Experimental and field work carried out by the US Army Corps of Engineers (Dally and Pope, 1986) has shown that submerged breakwater can effectively reduce wave height and are particularly effective in reducing the large waves. While some investigations suggest that submerged breakwater may results in larger salients those that would result in emergent breakwater of similar size and also some investigations indicate that submerged breakwaters may result in shoreline erosion.

The studies will be involved monitoring the shoreline response toward the installation of the submerged breakwater for the coastal protection. The well established methods that currently used by the researchers to predict the shoreline response to emergent breakwater structures (e.g., numerical method, gap relationship) may not be suitable to investigate shoreline response to submerged breakwaters (Renasinghe *et al*., 2006). By using the right technique to determine and gather the data, the precise result and data will be achieved and it will be a great helps for the data analysis for the future reference.

1.2 Problem Statement

As observed through the years and by referring to the previous study, the submerged breakwater has more unsuccessful stories than successful stories. As the submerged structure only been adapted to the beach protection recently, the exact shoreline response to these structures still not well understood the effectiveness of the structure by the present. (Lawal et.al, 2012). The data of the performance submerged breakwater around the world might be insufficient that lead to the inaccurate result for the submerged breakwater.

At present, the published research paper and studies lead that the usage of the submerged breakwater more to the erosion that accretion. Research by Roshanka et. al. (2006) based on the previous studies stated that out of the 10 breakwater placed around the world, 3 of the place show that shoreline response toward accretion while the other 7 structures show the response of the shore toward erosion. The data can be assumed inconsistent and during the process, human error was made. For example, the imagery image was taken during the monsoon season as Asia has rainy season.

1.2.1 Significance of the Study

The significance of this study lies in the submerged breakwater ability of preserving the aesthetic value of the environment especially coastline. If at the end the study is able to successfully identify the response of the coastline towards the submerged breakwater, the data could be used as a reference for the further study to develop an empirical formula to predict the shoreline evolution for SBWs accurately. When the data was proved, the potential development of SBWs as a preferred structure and the usage will be wider for the protection purpose.

1.3 Objectives of the Study

The main objective of this study is to investigate the shoreline response to the installed SBWs breakwater. The sub objective of this study is to investigate the effect usage of the different structural parameter on the magnitude and mode of salient formation at the lee of various projects of submerged breakwaters around the worlds:

- Distance of the submerged breakwater to original shoreline
- Length of submerged breakwater
- Crest height of submerged breakwater
- Width of submerged breakwater
- Gap in between submerged breakwaters

The study will attempt to:

1. Estimate the shoreline response after installation using ArcGIS application and satellite image.
2. Evaluate the performance of the SBWs at the site (erosion vs accretion).

1.3.1 Scope of Study

The study will focused on the response of the coastal towards SBWs. The aim is to identify the response of the coastal toward SBWs with different structural parameters. The structural parameter that will be investigated are the distance of the submerged breakwater to original shoreline, length, crest height, width and the gap between submerged breakwater. For the validation of the result, the profile survey will be conduct during the monitoring process at the study area located in Kerteh.

Spatial image or satellite imagery will be obtained from the previous years before the installation of the SBWs at the site followed by image from the years after the installation of the breakwater. After all the data is achieved, then the data from the site will be export using the GIS software for the data analysis to see the movement of the sand and the beach either resulting erosion or accretion. Validation of the data will be achieved by means and compared to the calculation using formula on how much the sand been eroded.

1.4 Relevancy of the Project

This study involves the application of Coastal Engineering and Hydraulics discipline which is a branch of Civil Engineering Scope. The study also involves the usage of the Hydrology discipline in Global Information System (GIS) geoprocessing tools such as ArcGIS.

1.5 Feasibility of the Project

Geographical Information System has been used for years in monitoring coastal changes investigation towards SBWs. More recently, it has been used for the classified of building and the changes of the mangroves near the river mouth. The result from this study can be used for prediction of the geological assessment for the changes of the beach. The usage of GIS application method has plays significant role in the monitoring the changes of beach and the sand movement effect.

The satellite imagery can be used to help in finding the changes of the coastal. One of the major point is stressed in this research is the use of satellite imagery method to compare the data from the previous years before the SBWs was installed and after the installation. From the imagery data and the use of GIS, sand movement and the erosion or accretion can be calculated for the better result.

1.5.1 Time Feasibility

The study for this project required some fieldwork and also some modelling work of the beach profile. Fieldwork required especially during the validation of the data at the end of the study to be compare with the actual work and calculation done during the beach profile survey process. To ensure the work to be completed within the time frame, a Gantt chart has been created to make sure author follow the track and finish all the planned activity on time. Currently all the activities suggested by the author and supervisor is still within the time frame and it is expected to be finished within the proposed date and time.

CHAPTER 2

LITERATURE REVIEW

2.1 Study Area

The first area of studies is located at Kerteh, Terenganu. Kerteh is a town in the district of Kemaman in southern Terengganu, approximately 331 km to the north direction from Kuala Lumpur, and about 30 km or 20 minutes drive from north of Chukai. Kerteh is the base of operations for Petronas Carigali Sdn. Bhd operation off the base of Terengganu, overseeing the oil platform operations off the state's coast as well as petrochemicals production and crude oil refining in nearby Paka. Kerteh is served by the Kerteh Airport, a small airport catering mostly to helicopter flights to offshore oil platforms and charter plane flights for Petronas staff to Sultan Abdul Aziz Shah Airport near Kuala Lumpur. The rantau PETRONAS Complex consist of clinic, a school complex, public library and a golf club within the area of Kerteh Bay itself. Near the Rantau PETRONAS Complex, there are 3 submerged breakwater structure are located in between to beacons which are easily visible during the low level of water. Due to the installation of offshore oil platform in South China Sea near Terengganu, it has boosted the state economy and at the same time, the Kerteh area especially from sleepy hollow has transform into a beautiful town.

In order to accommodate with the rapid growing area near the coastal development, a number of method for the coastal protection has been proposed for the sustainable development for the upcoming years. The method or practice proposed must be considering the factor of safety and effect to the environment. As example, structure that has been used to protect the coastal is submerged breakwater, emerging breakwater, sea wall and etc. the most important aspect to be consider is to take count of the benefit and try as much as the proposed method can minimize the negative effect of the man made structure. For the structure, an important consideration when deciding which material to use in building the structure is that it needs to be strong enough to survive the wave climate concerned. The three submerged breakwaters are located in between two beacons which are easily visible at the site and the locations of the beacons are provided in Table 1.

No	Northing	Easting
1	4^o26’45.58”	103^o27’14.74”
2	4^o27’58.37”	103^o26’56.05”

Table 1: Coordinates of Beacon 1 and 2

From aerial earth image, the coast can be observed to a series of large and small hook shaped bays. The site connected with a few rivers near the area, the site receives sediment supply from the nearest river such as Sg. Terengganu, Sg. Dungun and etc. the sediment then been transported by the longshore drift along the coast at an angle to the shoreline, which is dependent on prevailing wind direction, swash and backwash. This process occurs in the littoral zone, and in or within close proximity to the surf zone. The process is also known as longshore transport or littoral drift. Globally, sea level has increased at approximately 1.8 ± 0.3 mm/year between 1950 and 2000 (Church et al. 2004). Study by Tilman et.al concluded that the littoral drift that takes place at the site is largely determined by the 30^oN wave sector, which generates littoral drift in the direction of North to South. The net littoral drift rate prior to breakwater installation for both NE-Monsoon and SE-Monsoon as reported in the study by Tilmans et al.. this indicates that the littoral drift takes place only in one direction, which is North to South. Prior to the installation of SBWs, the reported erosion rate at the Rantau Petronas Complex, which includes Kerteh Bay Coast, is 40,000 $m^3/year$ over the last 20 Years (1966-1987).

The second area for the study is located at Gold Coast, Australia. The Gold Coast is located on the east coast of Australia and its economy relies on preservation of its sandy surfing beaches. The Northern Gold Coast Beach Protection Strategy was implemented by Gold Coast City Council to widen and protect the beaches in the vicinity of Surfers Paradise at the northern end of the coastal tourist strip. The strategy includes construction of a large submerged reef type structure [Jackson et al, 1997] at Narrowneck, just north of Surfers Paradise. The primary purpose of the reef structure is to provide a coastal control point to stabilize the nourished beaches, but it has also been designed to enhance the recreational amenity including surfing, swimming, diving and fishing opportunities and providing aquatic habitat. For safety and cost efficiency, the reef has been constructed of very large geotextile containers ranging from 3 to 4.5m diameter by 20m long, which were filled with sand in a split hull hopper dredge on site, and dropped onto the nearshore seabed at the outer side of the surf zone. Experience with design and construction of such structures is limited and the inclusion of improved surfing as a secondary design criteria increased the complexity. In 1967, 8 million cubic metres of sand was eroded from the beaches and threatened the backing Gold Coast roads, houses and hotels. Moved by that, government start to take the mitigation measure because in 1995, Gold Coast almost lost its beach due to the continuous retreating of the coast. A few mitigation measure taken, including the beach nourishment pumped to the site to prevent the erosion from occurred. Then in May 1999 the installation of submerged breakwater at the site completed.

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2.2 Type of Breakwaters Available and Used

Previous studies by (Peter W. French, 2001) stated that many methods were tried and the different value or result was recorded according to the type of the breakwater structures type used. A possible alternative to protect the shorelines occurs in the form of offshore structures which actually reduce the wave energy that hits the coast by providing a barrier offshore. Typically, these structures tend to be break and expend much of their energy away from the beach. Because of this, the area between the shorelines and the structure tend to be of reduced energy conditions in which sediment can build up, thus protecting the coast and possibly also extending the beach (Peter W. French, 2001). Meanwhile, the region are found to have artificial protections, created by construction of seawalls and groin and dumping sandbag and gabions have caused localized breach accretion, beach lowering and severe erosion at several places (Maiti and Amit, 2009).

Their original use was largely as protection and shelter for ports and harbours until the year of 1930s that the first offshore were built on the open coast especially for shoreline protection purposes (Komar 1998, Magoon 1976). During early uses, the main type of offshore breakwater structure used such as submerged, emergent, non-segmented, segmented, solid and floating. The important consideration when deciding which material to use in building the structure it needs to be strong enough to survive in the wave climate concerned. Various methods used have included concrete bags, caissons, tyres and rubble mound is by far the most commonly used. When good quality and quantity of rubber is not available in the vicinity of the proposed structure, then concrete caissons are used (Neelamani and Vedagiri, 2000).

From the study by Neelamani and Rajendran (2002) on the performance different type of structure of T type and _|_ type used with the wave interaction, using the coefficient of transmission, *K*t, coefficient reflection, *K*r, and the coefficient of energy loss, *K*l find out that this breakwater is found to be effective closer to deepwater conditions. This confirms that the “T” type breakwater dissipates more energy, when the incident wave is increased. Under identical hydrodynamic and structural conditions for the ‘submerged’ case,the ‘T’-type breakwater is superior compared to the ‘_’-type breakwater in reducing the wave transmission, increasing the wave reflection and dissipation. Overall the “T” type breakwater structure is found to be better than” _|_” type breakwater under submerged condition. Study by Neelamani and Vedagiri (2000) on wave transmission, reflection and energy dissipation characteristics of partially immersed twin vertical barriers were carried out with regular as well as random waves of different height and period combinations at a constant water depth found out that twin barrier is better for random wave interaction than when it is interacting with regular waves.

Numerous studies were carried out on wave reflection, run-up and run-down aspects on seawalls and dikes, which are related to wave pressures. From the different type of structured studied, the different reading and different form of result was recorded. Therefore, it was likely need for more specific studies on the type of the breakwater as this research to study the performance of the submerged breakwater itself. For the type of breakwater, it can be argue that there is lacking of information and selection of which is the most suitable breakwater in certain condition. Some places have different frequency and height of the wave itself, and the selection of suitable breakwater need to be used for the optimum result.

2.3 Shoreline Response to Breakwater

A coastal region, without any structure especially in the middle of the sea where the offshore platform was constructed, may reach a coastal balance from the point of view of the sediment regime (Ali et. al, 2005). This balance is not broken until structure (groins, breakwaters, harbours, platform, etc.) which intervenes in the coastal zone is constructed. While the paper by Gelfenbaum et al,. (2009) stated that human interventions have dominated the coastal change within the past century. In the past, several and much general studies have been carried out by the researchers to study the effect of the breakwater (submerged and emerged) with the shoreline response. These studies were quite comprehensive and few method and validated using field study, physical and numerical modelling method relationship and prototype used to get the accurate result. Previous studies show the result of the breakwater has been more success stories than unsuccessful stories (Lawal et.al, 2012). While Rao et al,. (2009) in the previous study that no changes occur during the years of the study at the India beach, the beach without any breakwater shows no changes in erosion or accretion.

In the year 1987, Seiji et. Al comes out with the following gap erosion relationship, where the gap of erosion defined as the retreat of coastal to the lee of gap from the initial coastal or shoreline position:

$$\frac{G}{X} < 0.8\ (no\ erosion\ oppsite\ gap)$$

$$0.8 \leq \frac{G}{X} \leq 1.3\ (possible\ erosion\ on\ opposite\ gap)$$

$$\frac{G}{X} \leq 1.3\ (\ certain\ erosion\ opposite\ gap)$$

These relationships were evaluated with prototype data. The lower value was a good prediction of either accretion or very little erosion will happen. The ratio for the gap erosion occurred of G/X greater than 0.8 (Seiji et.al, 1987).

Nir (1982) suggested and develop based on the study from the prototype data (Israel Mediterranean Shore) the following relationship between the distance offshore to the breakwater length ratio (X/B) and average tombolo sand layer thickness (d_t) :

$$d_t = 1.78 - 0.809\frac{X}{B}$$

Dally and Pope (1986) presents several techniques for controlling the shoreline response to a single or segmented offshore breakwater project. The recommendation made to follow the limit for the structure length-distance offshore ratio (B/X) (and Gap (G) distance (X) for segmented systems) based on the type of beach platform desired and length of beach to be protected. For tombolo development,

$$\frac{B}{X} = 1.5\ TO\ 2\ (single\ breakwater)$$

$$\frac{B}{X} = 1.5, L \leq G \leq B\ (segmented\ breakwater, L\ is\ wave\ length)$$

For salient formation,

$$\frac{B}{X} = 1.5\ to\ 0.67\ (single\ and\ segmented\ breakwater)$$

In contrast, shoreline erosion is almost never reported in the lee of emergent breakwaters. Therefore, it is likely that the characteristics of and processes governing shoreline response to submerged and emergent structures are fundamentally different. As such, the well established methods that are currently used to predict shoreline response to emergent structures (e.g., empirical relationships, physical, numerical modes) may not suitable to investigate shoreline response to submerged breakwaters. Therefore, prior to the wider adoption of submerged structures for beach protection, it is imperative that an intensive study be undertaken to rigorously investigate characteristics of and process governing shoreline response to submerged structures.

Figures 1 shows the expected salient or tombolo formation at the end of this study.

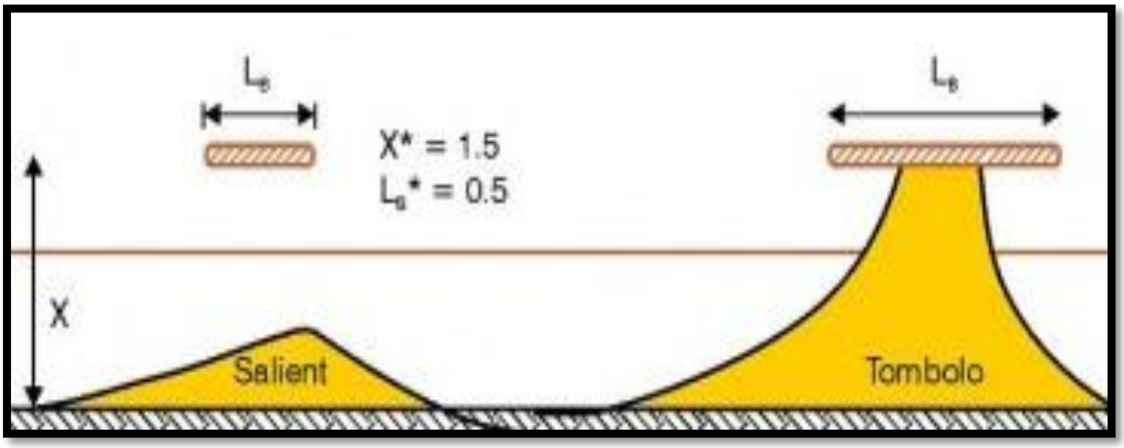


Figure.1: The shape of salient and tombolo formation

2.4 Shorelines Response to Submerged Breakwaters

Present, only few studies have systematically investigation conducted for the shoreline response to the Submerged Breakwater. Earliest study by Black and Andrew (2001) on the coastlines of south eastern Australia and New Zealand, they investigated the effect of the submerged breakwater structure and the natural reefs along the coastal line. Based on the study, the natural reefs assumed to have the same function as the submerged breakwater in reducing the impact of the wave on the beaches. From the aerial photographs, they draw the shape and dimensions of salient and tombolos formed in the lee of natural reefs. (Black and Andrews, 2001) also predict the salient formation when $L_{B/}X_B<2$, where L_B is the alongshore length to the reefs or structure and X_B is the distance to the reef/structure from undisturbed shorelines.

Few researchers like Dally and Pope (1986) implement simple criteria to predict the response of the shoreline for detached, submerged breakwater as shown below:

- For tombolo formation : $\frac{Ls}{X} > (1.0\ to\ 1.5)$
- For salient formation : $\frac{Ls}{X} = (0.5\ to\ 1.0)$
- Few Salient formation : $\frac{GX}{Ls^{\wedge}2} > 0.5$

  Due to multiple breakwaters

The G is the gap between breakwater and X is the wavelength at the breakwater and defined as:

$L = T(gh)^{0.5}$

Where T is the wave period and h is the local water at the breakwater.

Research by Roshanka et. al. (2006) based on the previous studies stated that out of the 10 breakwater placed around the world, 3 of the place show that shoreline response toward accretion while the other 7 structures show the response of the shore toward erosion. It concluded that submerged breakwater show the result has been more with unsuccessful stories than successful stories. Both structure single breakwater and multiple segmented breakwaters are taken into consideration for this result. The performance submerged breakwater at Keino-Matsubara Beach Japan that was reported by pass researcher Seguchi and Sawaragi (1986) stated that, an 80m long and 20 m wide shore-parallel was submerged break water placed in that beach. The structure was placed in approximately 4 m water depth. Then, a sand volume of 5000 m^3 was placed at the site. Survey at the sided indicated that about half or 50% of this sand volume was eroded within 2 month after the project completion. Although the incident wave was not described by Seguchi and Sawaragi (1986), it was assumed that the erosion was due to obliquely incident high energy wave. Figure 2 below show the previous study of the coastal with the response of breakwater structure:-

Table 1

Features of the sites and the submerged coastal structures reported in the published literature (B=length of structure, S=distance from undisturbed shoreline to structure, W=crest width, h=water depth at structure, h_c=water depth at crest of the structure, $\tan\beta$=bed slope in the vicinity of the structure)

Location	Reference	Structure type	Shoreline response	Nourishment	Longshore transport rate (m^3/year)	B (m)	S (m)	W (m)	h (m)	h_c (m)	$\tan\beta$
Delaware Bay, USA	Douglass and Weggel (1987)	Single breakwater +2 end groins	Erosion	Y	Negligible	300	75	Not reported	1	At MLW	Not reported
Keino-Matsubara Beach, Japan	Deguchi and Sawaragi (1986)	Single breakwater	Erosion	Y	Not reported	80	85	20	4	2 m below MLW	0.1 nearshore and 0.03 offshore
Niigata, Japan	Funakoshi et al. (1994)	Single breakwater +2 groins	Erosion	N	Exists, but not quantified	540	400	20	8.5	1.5 m below MWL	0.02
Lido di Ostia, Italy (#1)	Tomassicchio (1996)	Single breakwater	Erosion	Y	50,000	3000	100	15	4	1.5 m below MSL	0.05
Lido di Ostia, Italy (#2)	Tomassicchio (1996)	Single breakwater	Accretion	N	50,000	700	50	15	3–4	0.5 m below MSL	0.1
Lido di Dante, Italy	Lamberti and Mancinelli (1996)	Single breakwater	Accretion	Y	Negligible	770	150	12	3	0.5 m below MSL	0.02
Marche, Italy	Lamberti and Mancinelli (1996)	Multiple segmented breakwaters	Erosion	N	Negligible	Not reported	100–200	10–12	3	0.5 m below MSL	Not reported
Palm Beach, FL, USA	Dean et al. (1997)	Single breakwater	Erosion	N	100,000	1260	70	4.6	3	0.7 m below MLLW	0.04
Vero Beach, FL, USA	Stauble et al. (2000)	Segmented breakwater	Erosion	N	30,000	915	85	4.6	2.1–2.7	0.25 m–0.35 m below MLLW	0.03
Gold Coast, Australia	Jackson et al. (2002)	Multi-function surf reef	Accretion	Y	500,000	350	100–600	2	2–10	1 m below MLW	0.02

Figure 2: Coastal Responses to Submerged Breakwater

2.5 Shorelines Change Detection Method

In order to monitor the changes of the coastal and predict the shoreline response to the submerged breakwater, various type of method used in order to get the precise data and other important information. Past researchers have used for example, numerical prediction, aerial/satellite imagery, object based analysis and etc. For this study, the method of using the aerial/satellite imagery will be adopted for the data and information gathering. About 4 pictures from the study area are being purchased before and after the submerged breakwater structure were placed. The image will be used to detect the erosion and accretion along the shorelines and followed by the site survey.

The combination of using the satellite image with the application of GIS technique have been so popular since that GIS is a powerful tools that able to determined and retrieve valuable information from the aerial image. It has a lot of advantage using the application as example researcher (Alkan et.al, 2010) used the GIS to classify the building in the Zongulak study area of Turkey. By using the GIS application, not single pixels are classified by homogenous image object are extracted during the process. This segmentation can be done in multiple resolutions, by changing the colour and layer, with legend, the information can easily retrieve for the future used (Alkan et.al, 2010). Study by (Belaid, 2003), on the urban rural land use, GIS application was used to checking and analyzing the urban rural used change. According to Belaid, by using GIS application with imagery data, the technologies together can be used to assist decision makers to prepare future plans, in order to find the solution to the problem faced by urbanization encroachment.

Kasawani et.al has also used the similar method in detecting changes in coastline in Setiu Lagoon, Terengganu. The study had two objectives, which are to detect the change rate of the study area and to determine the exact current boundary at the site. Differential Global Positioning System (DGPS) OmniSTAR Scout 12 with accuracy 3-10 meter were used to collect the satellite image and transferred into the computer to the PsiWin using Data Logger. Then, the data are being transferred to MapInfo and converted to ArcView format ad stored as shapefile format so that it is easier to view in ArcView (Kasawani, Asbiyallah, Sulong, Hasmadi, & Kamaruzaman, 2010). The study managed to determine valuable information such the movement of sand and erosion rate at the study area. The objective of this study was achieve, but the changes of the coastline only due to natural processes and not the other aspect or factor that might lead to the changes such as man-made structures near the coastline.

For this study, the usage of the ArcGIS software is to detect the changes in the coastline and the response of the coastline with the installation of the three submerged breakwater structure at the Kerteh Bay.

2.6 Geographical Information System

A geographic information system (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data. The acronym GIS is sometimes used for geographical information science or geospatial information studies to refer to the academic discipline or career of working with geographic information systems and is a large domain within the broader academic discipline of Geoinformatics. In the simplest terms, GIS is the merging of cartography, statistical analysis, and computer science technology [Wikipedia].

Spatial data displays are increasingly complex and the visual capabilities of many users are being challenged (Turkey, 1990), sometimes to the degree where the visual sense is saturated and to represent more data another sense is required (Hughes, 1996). Recent advancement in remote sensing and geographical information system has led to improvements in coastal geomographical studies such as semi- automatic determination of shorelines (Ryu et al 2002). While Bearman and Fisher use the ArcGIS to evaluate the use of sound to represent spatial data using piano notes and example data within ArcGIS. For this study, in order to identify the feature of the coastline, shapeliness will be created from the satellite image and marking the beach and coastal with different colour and layer. Nowadays, GIS software widely used for a different purpose, an engineering department monitors the conditions of roads and bridges and produces planning map for natural disasters, a water department finds the valves to isolate a ruptured water main, and as for hydrologist scope, they used the GIS software to study the impact of construction plan on a watershed.

CHAPTER 3

METHODOLOGY

There are various method can be used to analyse the data and to calculate certain result for the study of coastal. For example, by using the super vector machine can be considered the best method for more accurate data. For this study, the method used is using the satellite image and then analyse the result using ArcGIS software. Satellite imagery from different years is being selected and purchased and will using the data to determine whether the images are suitable for the study. The image then will be transfer into GIS Software for the data analysis.

3.1 Project Activities

3.1.1 Using of ArcGIS Software and ENVI

The purchasing of high resolution images for various places in the world that has submerged breakwater installed as a mitigating structure. For this study, the images of the coastal study area near Kerteh, Malaysia and Gold Coast, Australia are used for the study. Then the image data transferred into the computer using the ENVI software (remote sensing) to process the satellite images specifically for classification.

The data then viewed in the computer using the Arc GIS software (Gographical Information System) to build a model for the processing the images, the model will include the sub-setting of classified images, vectorization of the classified images, and extraction of the waterline from the processed images.

Currently, the images used for the further study are downloaded from the USGS (U.S. Geological Survey) website, the images was used to replace the original high resolution images that has been ordered. But due to problem with the authorization, the images have been delayed. For this report, there are 7 images has been processes and the images are from the years before the breakwater was placed and after the breakwater placed to get the data of the shore movement. There are 3 places has been finalized by the Supervisor. The suggested sites location and coordinate are as followed in the table below:

No	Place/Site	Latitude	Longitude
1	Kerteh, Malaysia	4.5247	103.4561
2	Gold Coast, Australia	-28.0173	153.4257

Table 2: Coordinate of the study area

3.1.2 Cross Checking

The images are overlaid one on another using ArcGIS and checked for the permanent features. The permanent features should lie on the exact location for each year, on each image. This indicates that the images are of the same projection, an also not distorted. Images which are distorted will have the projection redefined again using the georeferencing tool in ArcGIS.

3.1.3 Enhancing Raster Image Quality and Creating Profile Lines

The raster images come with three colour band, which are red, green and blue. Using layer stretch option, the image colour quality is enhancing by manipulating the colour histogram and contrast to obtain the best quality that would expose the beach more, and conceal other irrelevant details such as cloud. To enable a much detailed comparison, the beach will be analysed in profile lines 100 metres apart, covering the beach area adjacent to the Mesra Mall up to the PETRONAS housing complex for the workers. For Gold Coast part, the beach area covered from Southport the northern area to national park southern. These profile line will extend from a boundary line, which set to be at 100 metres landward from the beacons, up to the most visible coastline in the satellite image. Figure 3 below shows the image processed using ArcGIS software by manipulating the band of the images.

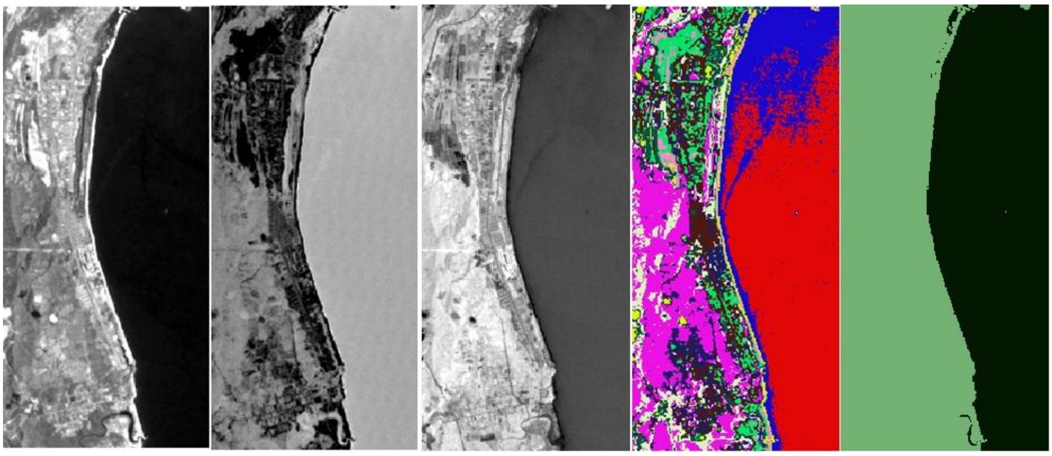


Figure 3: Manipulating the Images Band (wavelength)

3.1.4 Comparing Profile Lines

After creating profile line has completed, the profile line can now be compared with those from the other images. By overlying these profiles line from different years on each other, comparison can be easily made as to how much have the beach advanced (accretion) or receded (erosion) over years by using the geometry calculation tool. A reduction in the profile line length indicated the erosion, while addition in the length indicates sediment accretion. Figure 4 below show the illustrated of comparing profile line.

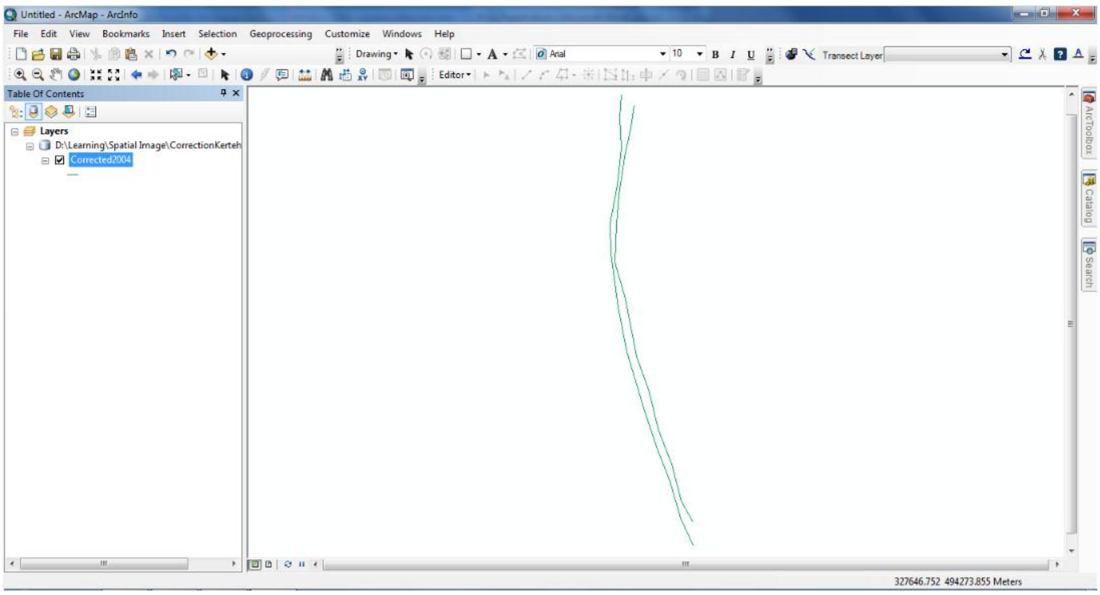
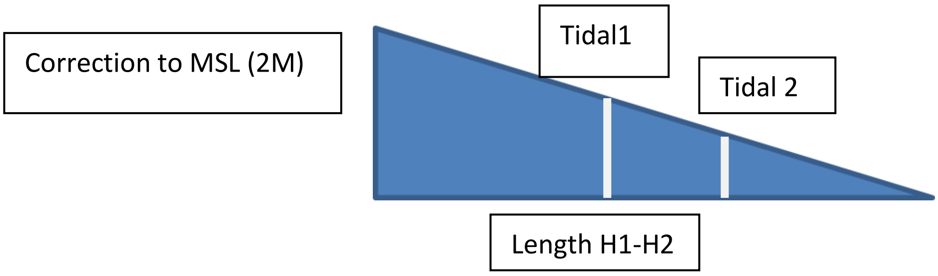


Figure 4: Print screen of Comparing Profile Line

3.1.5 Obtaining Tidal Conditions

Tides are very important to be considered to avoid any errors due to tidal difference. When one image taken during low tide and the other taken during high tide, it will obviously show signs of erosion at the study area when viewed using the ArcGIS software because of different tidal high. Tidal range, the beach slope, and simple linear equation will be used to predict how much the beach advances during low tide, and recedes during high tide. With this information, correction can be applied to the profile lines to discount the effect if tidal change.



$$\tan\theta' = T1 - T2 \div (Length\ H1 - H2)$$

After the slope has been calculated, then using the simple formula below to calculate the length for the tidal correction.

$$\text{Sin}\,\theta = MSL - Tidal\ 1 \div (distance)$$

Using the distance calculated, project the transect to the new length, and repeat the same step for all images.

3.1.6 Site Profile Survey

For the validation of the data achieved, a survey will be carried out for the beach profile on the actual site that has an installation of such mitigating structure, Kerteh Bay, Terengganu, Malaysia. During the visit, the valuable information data such as the gradient of the beach will be taken for the use to calculate the erosion or accretion volume of the sand at the beach. The result then will be compare to the result achieved from the Arc GIS.

3.2 Key Milestone

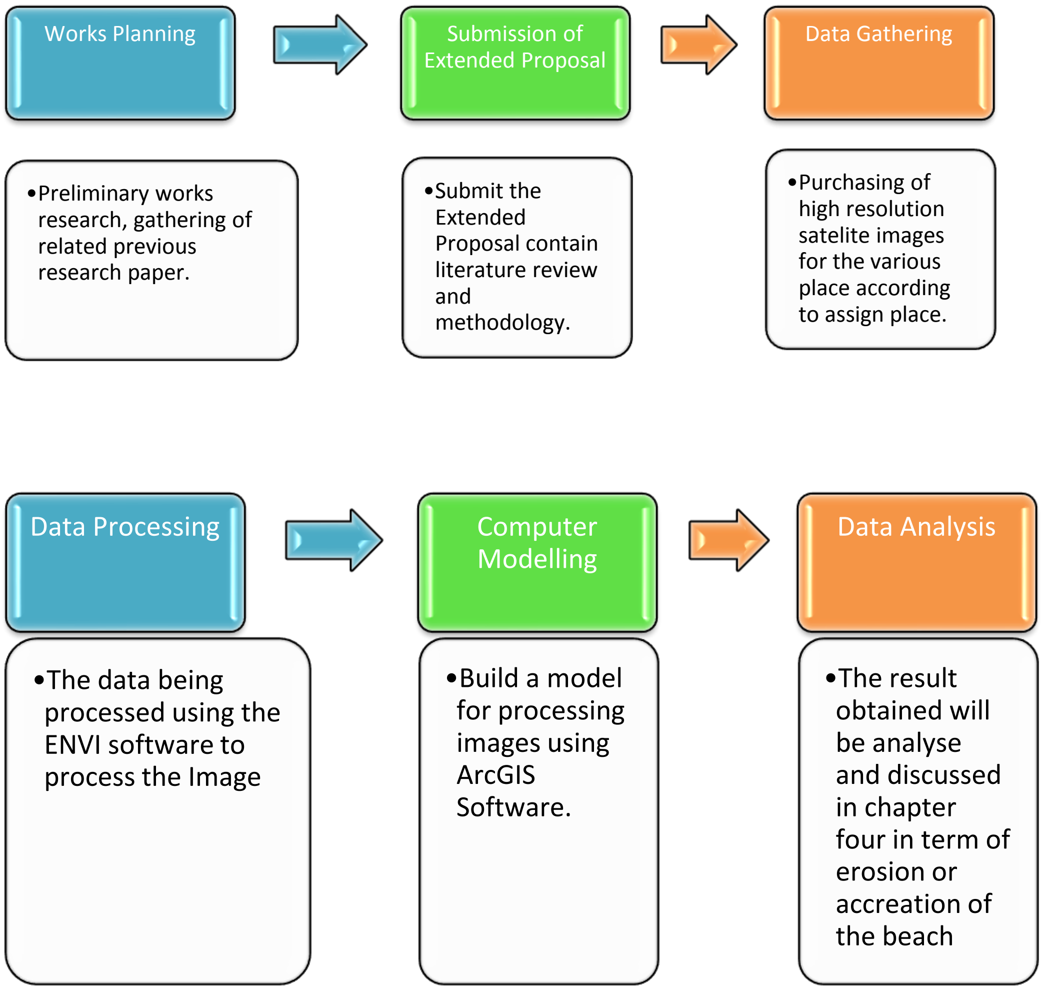


Figure 5: Milestone for Research

3.3 Gantt Chart

For the time being, the project is running smoothly and following of what author and Supervisor have planned for the whole study. The details of the activity every week are in the Gantt chart schedule and everything still within the time frame. Frequent meeting with supervisor have enabled the author to track the progress of the project and implemented the task given. Figure 6 below shows the activity planned with the suggested milestone for this project:

Detail/Week	1	2	3	4	5	6	7		8	9	10	11	12	13	14	15
Project Work Continues								M								
Submission of Progress Report								I								
Project Work Continues								D								
Pre-SEDEX								S								
Submission of Draft Report								E								
Submission of Dissertation (Soft Bound)								M								
Submission of Technical Paper																
Oral Presentation								B								
Submission of Project Dissertation (Hard Bound)								R								
								E								
								A								
								K								

Figure 6: Gantt Chart for FYP Project

Process
Suggested milestone

3.4 Tools/Equipment Required

3.4.1 Microsoft Office

For this study, Microsoft Office used to prepare the final report. The Microsoft Office for example, used to prepare a slide for the presentation and for the calculation, Microsoft Excel used to prepare a formula sheet for the calculation for the time saving purpose. Microsoft Excel will be used to store the data achieved and also for the plotting graph purpose. Microsoft Office basically is a powerful tool and will be big help in making this study successful.

3.4.2 Survey Equipment

The equipment survey will be needed during the process of validation of the data. A survey will be carried out at a beach to determine the beach profile on an actual site that as an installation of such mitigating structure at the study area. The equipments for the survey are including the survey tripod, theodolites, levels and transit-levels and etc. All the equipment for the survey will be used during the fieldwork that conducted for the data validation. The purpose of this process is to get the accurate data and compare with the data achieved from the GIS software and make the comparison of the accuracy data from arcGIS and the actual data at the site.

3.4.3 ENVI Software

ENVI combines advanced spectral image processing and proven geospatial analysis technology with a modern, user-friendly interface. When using panchromatic, LiDAR, SAR, multispectral or hyperspectral imagery, ENVI has the latest processing and analysis tools to help extract meaningful information to make better decisions. For this study, the use of ENVI software (remote sensing) is to process the satellite images specifically for classification.

3.5 Data Analysis

DEM (Digital Elevation Models) will be created from the processed image as stated in methodology section. Then, mode and magnitude of salient formed will be analyzed using the GIS and DSAS (Digital Shoreline Analysis System). The process of remote sensing and GIS technique adopted will be validated with the data obtained from the beach profile survey. The recorded data then will be analyzed based on each of the structural parameters investigated.

3.6 Limitation of Study

In every study, there will always be limitations that cannot be prevented. Usually, the problem starts in the process of data collection. Some of the limitation for this study is to get the latest image of the coastal. The satellite images need to be purchased, and the image was taken once for several period of time since the technology used to capture the image is using the satellite. Researchers believe that accretion and erosion occur between the range of 6 month, and for more precise data it is recommended to buy one image every 3 month. The image used for this study is medium resolution image since the images order delayed by the supplier.

3.7 Expected Result

In the past studies on the shoreline response to the submerged has been done using the numerical method, gap erosion method, numerical analysis and models developed for the generalized breakwater performance, but the empirical method predicted wrongly. This was proved from the fact that SBW that were constructed was for the purpose of accretion and end up resulting in the erosion of the coast. At the end of this study, the data recorded from the aerial/satellite image will be compare with the numerical model from the past studies and will be validate based on the fieldwork result from the beach profile. According to the result from the studies by Dinesh and Kamaruzaman (2012) the result recorded towards the accretion.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

In this part, the result and progress made will be presented in a way it can be easily understood. The result and the progress made will be divided into two parts, the expected result and the obtain result.

4.2 Kerteh Site Result

Figure 4.1 below shows the profile and the length of baseline to the shoreline that has been overlaid with the images from the satellite. Overall there are 5 images used for the analysis using ArcGIS software for the Kerteh submerged breakwater. The first satellite Image 1 taken on 3rd July 1995 (10.27am), the profile lines extended from the baseline, up to the most visible coastline on the image. When compared with the profile length from satellite Image 2, Image 3, Image 4, and Image 5 taken on 22nd June 1997 (10.51am), 11th March 2000 (10.55am), 30th May 2006 (11.14am) and 20th April 2009 (11.09am) respectively, an sign of reduction in profile line length indicates sediment erosion while addition in length indicates sediment accretion. Figure 6 below illustrate transect at the area of interest.

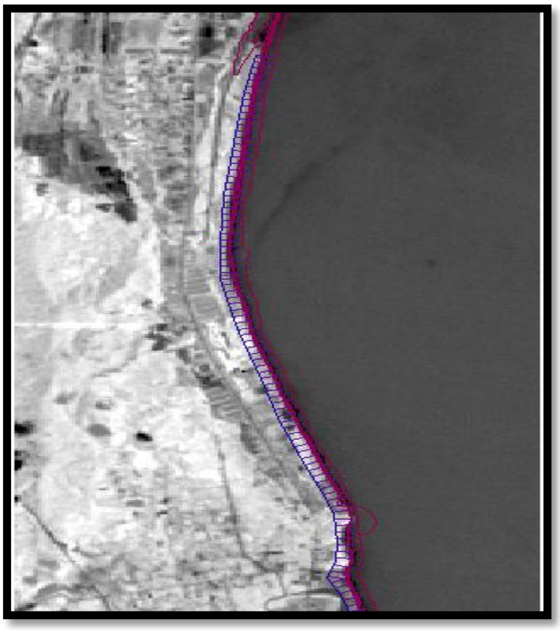


Figure 7: Kerteh Transect Profile Lines

Image	Date	Time	+/- MSL	Date	Time	+/- MSL
1	20/06/1995	10:25 AM	-0.64117	08/07/1995	10:27 AM	0.88650
2	18/03/1997	10:48 AM	-0.48912	22/06/1997	10:51 AM	1.37431
3	07/02/2000	10:48 AM	-0.19688	10/03/2000	10:55 AM	0.40910
4	24/04/2004	11:01 AM	0.62359	03/12/2004	11:07 AM	-0.28091
5	20/04/2009	11:09 AM	-0.37130	09/07/2009	11:10 AM	1.2543

Table 3: Tidal Range at the Time Image Were Taken

For this research, Kerteh area analysis has been divided into three part or section of the area. For the first part of analysis, the northern part is where the PETRONAS Quarters, middle part is where the Golf Course, and the Southern area where the School located. To make sure the analysis is more precise. The divided part will show any accretion or erosion in form of the distance from the section. Then the images from the same year overlaid then tidal correction made. Table below is the result from the shoreline movement after transect has been projected. By adding all the value then divided by the profile no, the average of the Net Shoreline Movement per year can be tabulated. For the PETRONAS Quarters, the profile line range from 1 – 10, for golf course starts from profile line 11- 20 and for the school, the profile line value start from 21-28. The result presented in Table 5.

Profile No	1995-1997		1997-2000		2000-2004		2004-2009	
	Changes	Status	Change	Status	Change	Status	Change	Status
1	0.96	Accretion	9.44	Accretion	8.53	Accretion	-9.02	Erosion
2	-4.05	Erosion	13.84	Accretion	13.22	Accretion	-10.33	Erosion
3	-1.29	Erosion	6.02	Accretion	18.86	Accretion	-2.01	Erosion
4	-13.81	Erosion	-6.92	Erosion	16.53	Accretion	-3.57	Erosion
5	-19.59	Erosion	-8.66	Erosion	18.51	Accretion	-6.38	Erosion
6	-14.33	Erosion	-0.28	Erosion	16.77	Accretion	-7.89	Erosion
7	-7.52	Erosion	-0.69	Erosion	20.5	Accretion	-3.79	Erosion
8	-5.12	Erosion	8.25	Accretion	10.18	Accretion	-0.45	Erosion
9	-5.46	Erosion	10.73	Accretion	7.1	Accretion	-1.57	Erosion
10	-5.42	Erosion	5.45	Accretion	17.47	Accretion	-4.34	Erosion
11	-7.93	Erosion	-3.98	Erosion	14.45	Accretion	-14.13	Erosion
12	0	-	-6.76	Erosion	19.93	Accretion	-10.09	Erosion
13	-16.64	Erosion	3.29	Accretion	10.76	Accretion	2.1	Accretion
14	0	-	-7.81	Erosion	8.27	Accretion	-3.04	Erosion
15	-15.51	Erosion	3.93	Accretion	13.61	Accretion	2.53	Accretion
16	-13.9	Erosion	-4.59	Erosion	16.58	Accretion	1.1	Accretion
17	-5.05	Erosion	-10.7	Erosion	12.84	Accretion	0.16	Accretion
18	-12.39	Erosion	-2.24	Erosion	14.49	Accretion	1.1	Accretion
19	-7.27	Erosion	-3.59	Erosion	16.97	Accretion	0.89	Accretion
20	-0.23	Erosion	-10.04	Erosion	18.74	Accretion	0.16	Accretion
21	2.4	Accretion	-15.29	Erosion	8.22	Accretion	-2.86	Erosion
22	-2.48	Erosion	-12.43	Erosion	17.49	Accretion	4.24	Accretion
23	-3.52	Erosion	-8.64	Erosion	23.41	Accretion	4.63	Accretion
24	-4.03	Erosion	-6.41	Erosion	20.92	Accretion	2.71	Accretion
25	-7.17	Erosion	-1.18	Erosion	16.11	Accretion	7.41	Accretion
26	-4.69	Erosion	0.34	Accretion	16.62	Accretion	0.95	Accretion
27	-5.9	Erosion	-0.83	Erosion	15.77	Accretion	1.9	Accretion
28	-11.29	Erosion	-5.62	Erosion	15.17	Accretion	0.61	Accretion

Table 4: Change in profile line after tidal correction, and its respective erosion/ accretion status (Kerteh)

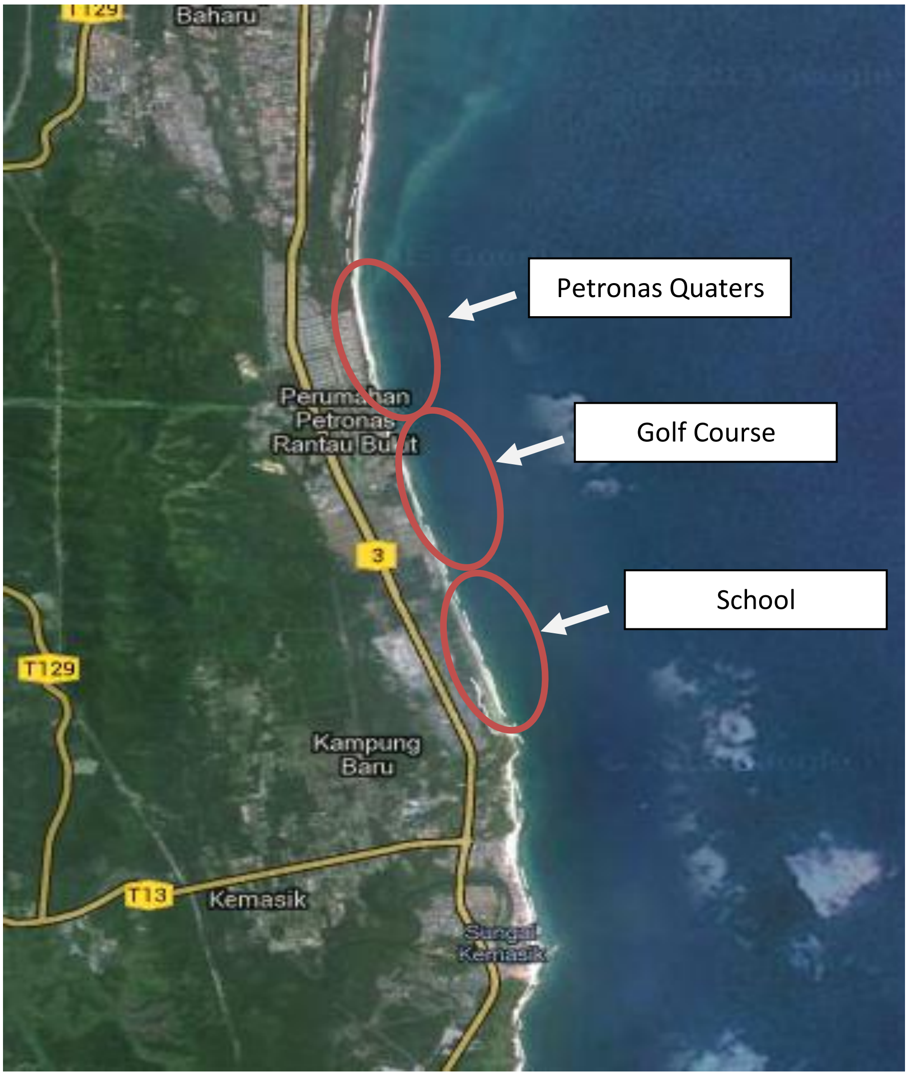


Figure 8: Divided Area for Data Analysis (Kerteh)

Years	Net Shoreline Movement		
	PETRONAS Quarters	Golf Course	School
1995 – 1997	-7.563	-7.892	-4.585
1997 – 2000	+3.718	-1.427	-6.2575
2000 – 2004	+14.767	+14.664	+16.7137
2004 – 2009	-4.935	-4.526	+3.226

Table 5: Kerteh Net Shoreline Movement Rate

Based on the result, at this point of time the movement of the shoreline shows different pattern of movement at the three part of the area. As for PETRONAS Quarters, the shoreline indicate of erosion from 1995 – 2000, then starting from years of 2000, the result show a huge amount of accretion process at the site with the movement about 6.5 meter per year from year of 2000. The Golf course part also shows the same pattern of accretion and erosion from year 1995. While, profile that show the positive result is at the school where the pattern of accretion occur starts from year of 2000 until 2009 which show signs of sediment accretion. At this point of time however, it is impossible to conclude if beach slope continues to change for the upcoming years. For more clear view, the movement of the shoreline vs distance from baseline is presented in the Figure 8, 9, and 10 below.

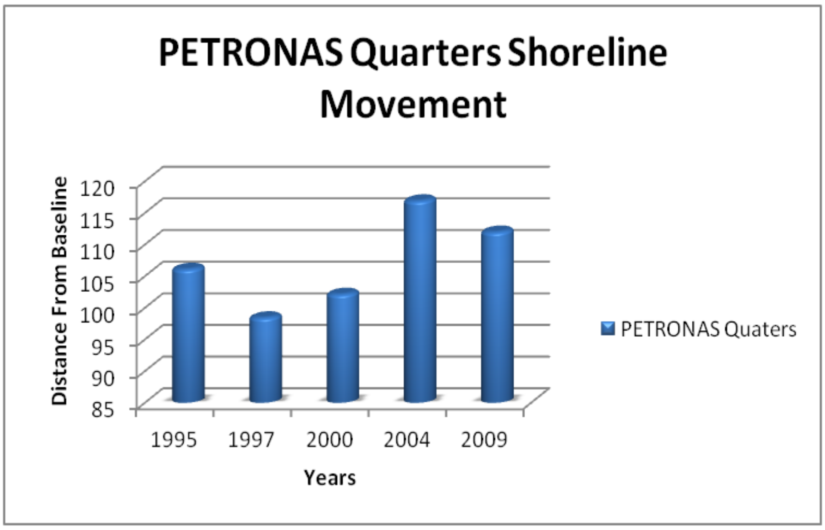


Figure 9: PETRONAS Quarters Distance from Baseline

Figure 10: Golf Course Distance from Baseline

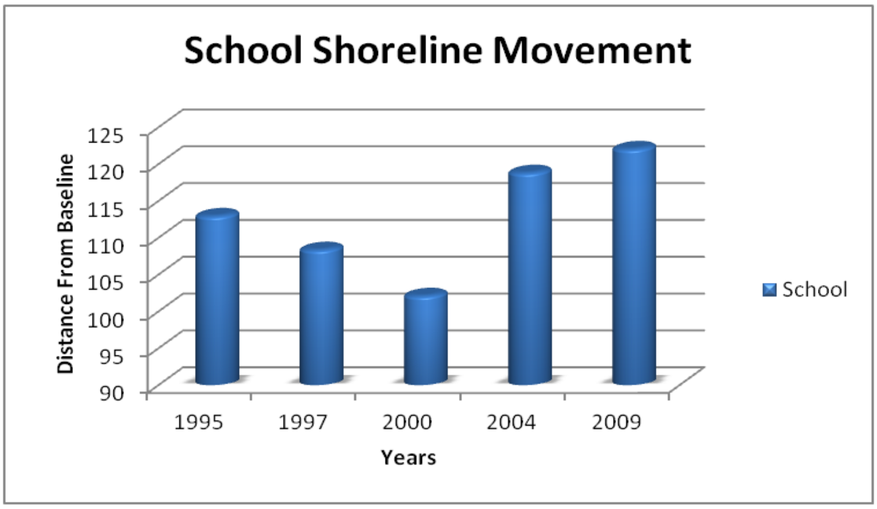


Figure 11: PETRONAS Quarters Distance from Baseline

And for the 3 area of the site compiled together, it presented in the Figure 12 below show the pattern of movement for the Kerteh Site. The pattern of the line that represent the distance for each year does not fixed for all years.

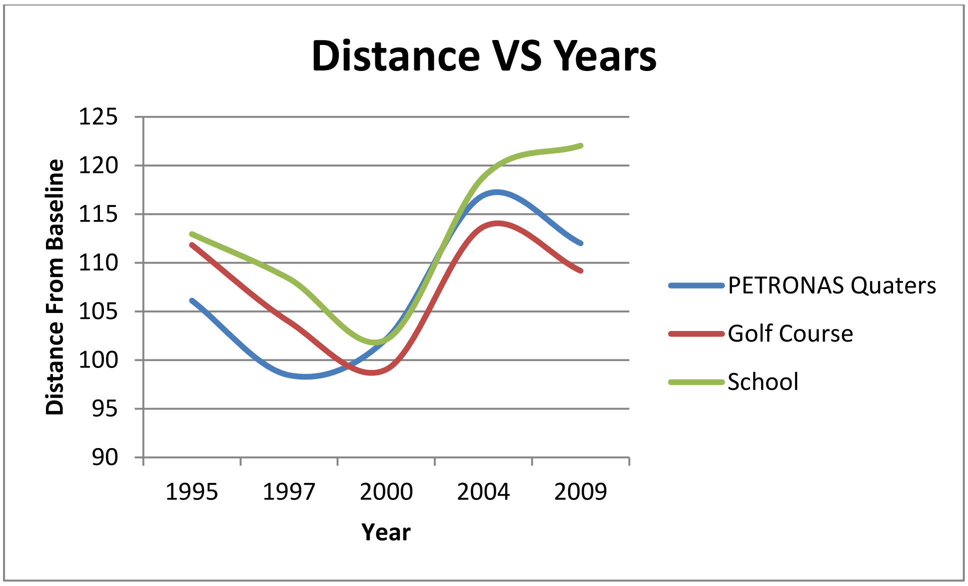


Figure 12: Kerteh Net Shoreline Movement Graph

From the result, the original coastline from 1995-1997 are facing serious beach retreating. In 2 years, the erosion at the site almost 3.5m per year. It can be seen that most of the erosion occur at the middle part of the coast. Overall, almost every years, huge amount of sand been eroded at the site. The breakwater show a positive result during year of 2000-2004 where all part of the coast resulting in accretion. This positive result might due to the installation of the submerged breakwater. While after the accretion until 2004, the pattern seems to change when both part at PETRONAS Quarters and Golf Course still facing the erosion problem. Only the southern part of the site show positive value with about +3.226m accretion. For years of 2000, the possible cause of the erosion might due to the North East monsoon start from November to March. The images on that year were taken during the monsoon. During the monsoon, the tidal high and the wind frequency changes to more severe effect to the coast.

It can be notice that only part PETRONAS Quarters show the positive value where that part accreted and the middle and southern part are facing the erosion. The direction of littoral drift that take place at the site is largely determined by the 30^{o}N wave sector, which generates the littoral drift in direction of North to South. From the direction that waves attacking the coast, only the PETRONAS Quarters was protected from the direct hit because of the hooked shaped bay at the site. This is one of the possible patterns at during years of 2000.

By consider the different parameters of breakwater used at the site, the submerged breakwater at the middle part with length of 400 meter and gap of 600 meter does not perform well in reducing the erosion at the side. While the other 2 part of breakwater shows more positive result comparing the 3 of the submerged breakwater installed at the Kerteh site. Probably, the sediments which are eroded might be replaced during the coming NE Monsoon. Continuous visit will have to be carried out to monitor the pattern changes of the beach with the result from the software. The result must be tally to support the reading from the ArcGIS reading.

4.3 Gold Coast Site Result

For Gold Coast Australia, same step used in order to get the result. There are 5 images from different years used for the analysis using ArcGIS software for the Artificial submerged breakwater. The first satellite Image 1 taken on 23rd April 1995 (10.42pm), the profile lines extended from the baseline, up to the most visible coastline on the image. When compared with the profile length from satellite Image 2, Image 3, Image 4, and Image 5 taken on 9th January 1997 (11.05pm), 4th May 2004 (11.22pm), 27th February 2009 (11.32pm) and 16th January 2011 (11.32pm) respectively, an sign of reduction in profile line length indicates sediment erosion while addition in length indicates sediment accretion. Table 6 below show the tidal range when the images were taken and figure 13 is the illustrated of Gold Coast survey profile.

Image	Date	Time	+/- MSL	Date	Time	+/- MSL
1	2/04/1995	22:50	+0.6	06/12/1995	22:42	+1.1
2	09/02/1997	23:05	+0.8	10/02/1997	23:06	+1.4
3	04/05/2004	23:22	+1.3	10/09/2004	23:25	+0.5
4	27/02/2009	23:28	+1.3	26/11/2009	23:32	+0.5
5	16/01/2011	23:32	+1.6	27/07/2011	23:31	+0.6

Table 6: Tidal Range at the Time Image were taken (Gold Coast)

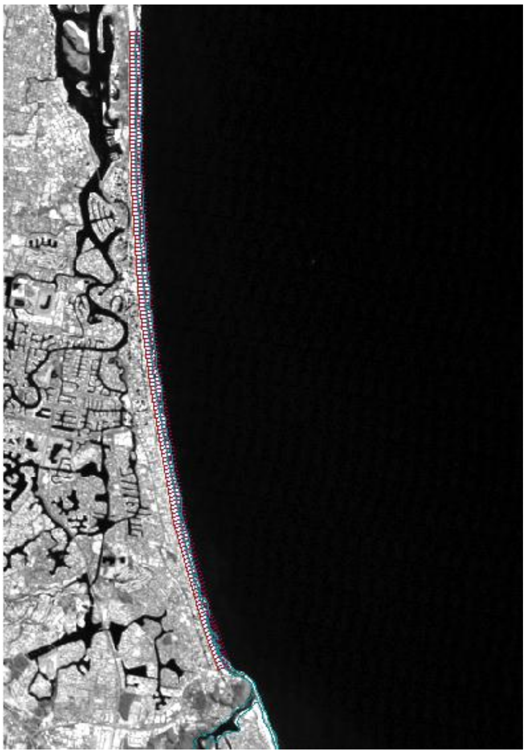


Figure 13: Gold Coast Transect Profile Lines

For analysis Gold Coast data, the same method and step used, and the beach stretch been divided into three parts. The northern part benchmark is at Southport, middle part benchmark is at Broadbeach, and the southern part of Gold Coast benchmark is at Burleigh Head National Park. Figure 14 below is the 3 part of area divided for the analysis and table 7 below is changes in profile line after tidal correction made. For the Southport, the reading taken from profile 1 -11, for Broad beach, profile reading range from 12- 22, and finally for the National Park, the profile calculated from 23-33. Table 8 is the summarized of the Mean Net Shoreline Movement result.

Profile No	1995-1997		1997-2004		2004-2009		2009-2011	
	Changes	Status	Change	Status	Change	Status	Change	Status
1	-15.54	Erosion	-10.38	Erosion	17.61	Accretion	12.08	Accretion
2	-16.46	Erosion	-16.61	Erosion	23.32	Accretion	5	Accretion
3	2.76	Accretion	-0.4	Erosion	22.62	Accretion	7.51	Accretion
4	-20.41	Erosion	56.41	Accretion	-2.66	Erosion	23.06	Accretion
5	-20.91	Erosion	23.3	Accretion	20.92	Accretion	6.32	Accretion
6	-7.24	Erosion	25.73	Accretion	15.15	Accretion	12.69	Accretion
7	-15.06	Erosion	37.27	Accretion	-0.99	Erosion	3.28	Accretion
8	-10.72	Erosion	26.61	Accretion	11.94	Accretion	11.52	Accretion
9	-13.64	Erosion	57.91	Accretion	-6.94	Erosion	-2.99	Erosion
10	1.89	Accretion	48.5	Accretion	9.93	Accretion	-6.26	Erosion
11	-16.01	Erosion	48.71	Accretion	12.74	Accretion	7.9	Accretion
12	-4.82	Erosion	28.18	Accretion	15.85	Accretion	17.61	Accretion
13	-25.77	Erosion	42.52	Accretion	11.36	Accretion	0.33	Accretion
14	2.8	Accretion	42.4	Accretion	20.04	Accretion	5.38	Accretion
15	-19.85	Erosion	33.12	Accretion	5.15	Accretion	5.16	Accretion
16	-32.78	Erosion	24.85	Accretion	8.88	Accretion	6.48	Accretion
17	-10.48	Erosion	19.14	Accretion	5.56	Accretion	8.5	Accretion
18	20.52	Accretion	9.12	Accretion	0	Accretion	0	Accretion
19	-23.06	Erosion	29.94	Accretion	2.74	Accretion	7.46	Accretion
20	-49.1	Erosion	-10.01	Erosion	24.65	Accretion	12.4	Accretion
21	-32.36	Erosion	-20.54	Erosion	12.53	Accretion	6.83	Accretion
22	-32.35	Erosion	22.79	Accretion	-1.89	Erosion	5.99	Accretion
23	-36.02	Erosion	26.13	Erosion	13.73	Accretion	5.06	Accretion
24	-7.43	Erosion	13.16	Accretion	16.1	Accretion	7.56	Accretion
25	-29.85	Erosion	27.89	Accretion	13.72	Accretion	8.86	Accretion
26	-29.04	Erosion	32.44	Erosion	-3.15	Erosion	12.75	Accretion
27	-39.41	Erosion	13.52	Erosion	12.07	Accretion	9.3	Accretion
28	-18.99	Erosion	12.19	Erosion	8.83	Accretion	7.09	Accretion
29	-26.38	Erosion	15.92	Accretion	8.46	Accretion	9.77	Accretion
30	-19.89	Erosion	49.66	Accretion	7.1	Accretion	2.66	Accretion
31	-1.2	Erosion	0	Accretion	15.71	Accretion	0	Accretion
32	-0.49	Erosion	32.69	Erosion	7.08	Accretion	4.71	Accretion
33	-8.09	Erosion	19.99	Erosion	22.44	Accretion	5.45	Accretion

Table 7: Change in profile line after tidal correction, and its respective erosion/ accretion status

Figure 14: Divided Area for Data Analysis (Gold Coast)

Years	Net Shoreline Movement		
	Southport	Broadbeach	National Park
1995 – 1997	-9.88	-19.77	-26.74
1997 – 2004	+27.00	+20.14	+23.45
2004 – 2009	+11.24	+9.53	+6.92
2009 – 2011	+7.28	+6.92	+6.6

Table 8: Gold Coast Net Shoreline Movement Rate (Kerteh)

The Gold Coast Australia coast was installed with the Artificial Reef as a mitigation measure for the erosion occur that endanger and threatened the backing Gold Coast roads, houses and hotels. The length covered and protected by the breakwater approximately 17 km in stretch.

By refer to the result, the movement of shoreline for are showing the positive result after the installation of the submerged breakwater. At first, the Gold Coast facing the serious erosion problem where according to past researcher, the Gold Coast almost lost its coast due to the erosion. During the 1995-1997, the erosion still occurred at all part of the beach. The eroded rate per year is almost 5 meter at the Southport, about 10 meters at Broadbeach, and 13 meter at the National Park. The most accretion recorded by using Arc GIS software is during year of 1997-2004. All part of the coast stretch. Below 15, 16, and 17 below is the figure of the distance from the baseline with the movement of the coastline.

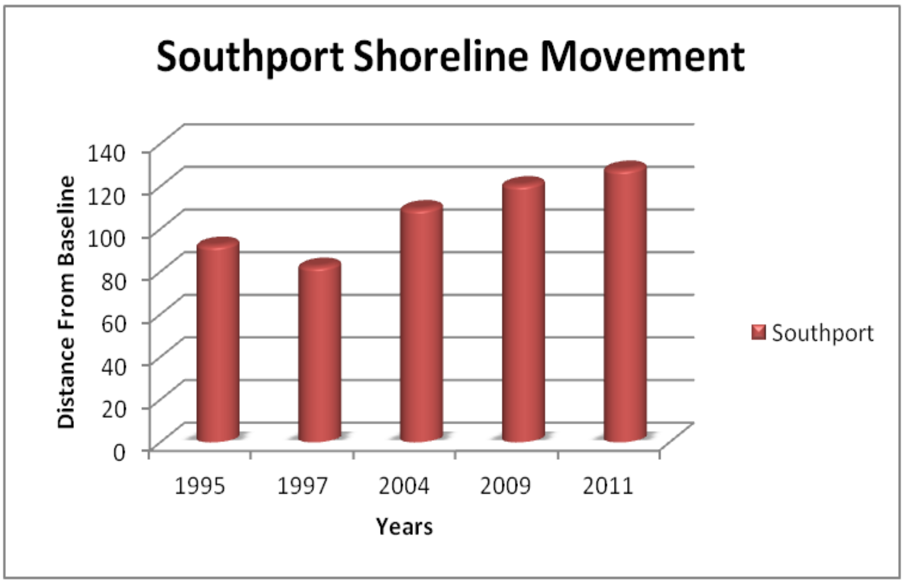


Figure 15: Southport Distance from Baseline

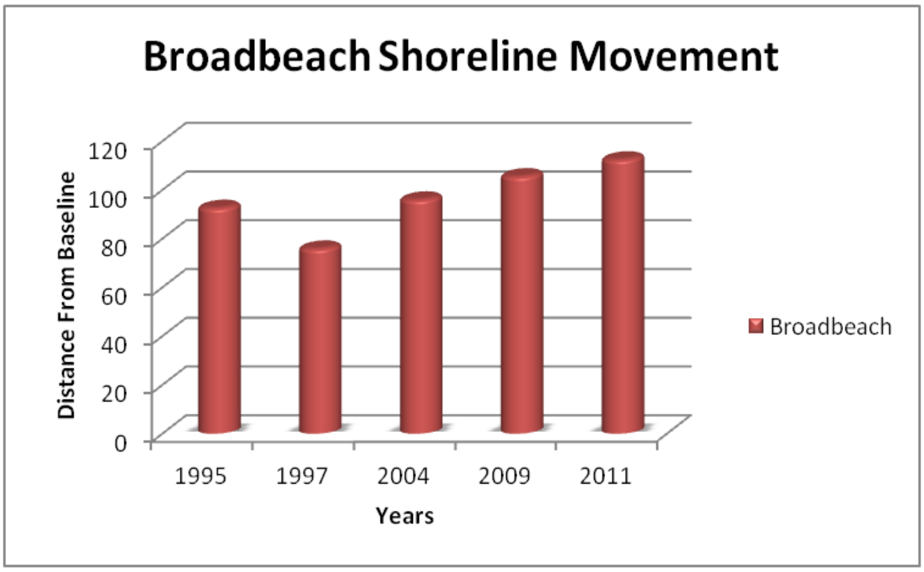


Figure 16: Southport Distance from Baseline

Figure 17: Southport Distance from Baseline

And for the 3 area of the site compiled together, it presented in the Figure 18 below show the pattern of movement for the Gold Coast Site. The pattern of the line that represents the distance for each year keep on increasing/accretion for all years start from 1997.

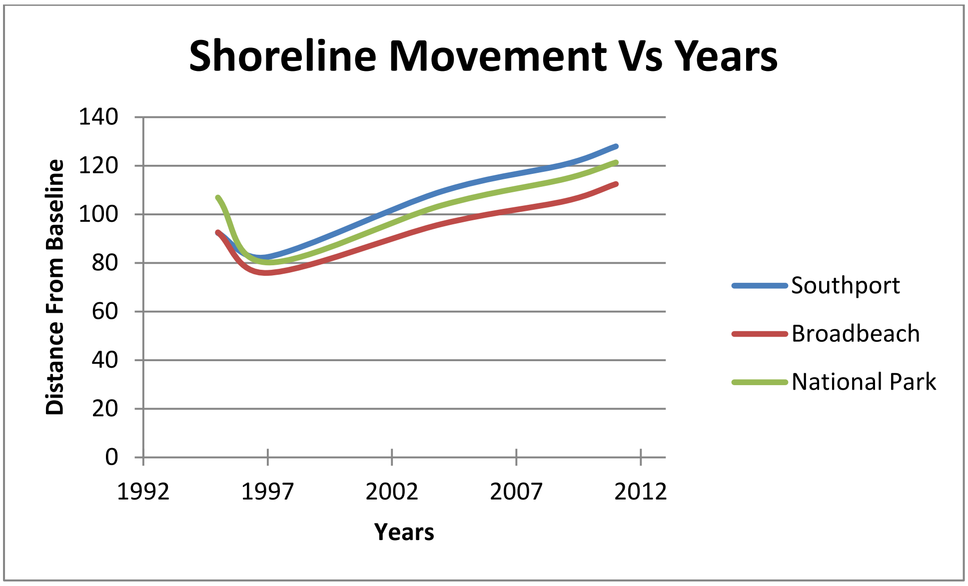


Figure 18: Gold Coast Net Shoreline Movement

Based on the movement of the shoreline and the Net Shoreline Movement rate, the graph shows significantly changes start in movement due to the installation of the breakwater. The breakwater that was installed on May 1999 has showed an positive result. The pattern occurred due to the different parameter used for every artificial reef at the site. It can be noticed that, before the installation of breakwater, the erosion start from year of 1967.

The accretion pattern noticed at all part after the installation of breakwater might due to the beach nourishment mitigation by the government. Each year, more than 50 000m^3 pumped from New South Wales. By combining the submerged breakwater and the beach nourishment every year, the submerged breakwater can be said that play an important role in order to stop the erosion at the site. In 2007 these beaches were as wide as they have ever been.

By refer to the result, the accretion trend still increasing but much slower that the earlier of the installation of the breakwater. The most effective part of the submerged breakwater is at the Southport area. This indicates that by using the variable parameter, the submerged breakwater purpose of design can be achieve to the fullest to manage the erosion problem. However, the continuous visit and reading must be observed to understand more of the pattern coast changes with the parameters used. Figure 19 and 20 below is the actual site images taken before and after the installation of breakwater.

Figure 19: Gold Coast Beach Condition on 1995

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Figure 20: Gold Coast Beach Condition on 2003

Based on the compiled result on the table 4 and 5 without the tidal correction method, it can be concluded that erosion still present at the site and the coastline will continue to retreat until it reaches the equilibrium state, where it stops retreating any further. The table are using the image from year 1995 as the original indicator of the shoreline. The site visit conducted before the monsoon season revealed that extend of erosion still occurring and is greater than what was predicted suggesting that wave climate has probably changed drastically.

For the first prediction, it can be seen that SBWs are performing its purpose of design well as it managed to reduce the erosion rate at certain part of the area calculated. For example, on the years of 2009, almost all part of the area covered by the breakwater shows a positive response where resulting the accretion at almost all places. However, on the 2009, at the transect point 3, it can be seen that most of the erosion occur at that point compared to the previous years before. This might because of the changes short of sediment transport needed annually because of the monsoon season which cause the erosion to occur. Some of the sediment transport might been blocked by structure which caused the erosion to occur because of the short sediment transport. Another factor that can be related to this event is the changes of the wave climate. The climate has seen an increase of about 10% in the 0.5-1.0m wave height sector, suggesting that the changes observed in erosion rate from 1995 to 2009 is probably due to changes in climate. This analysis made without the tidal correction which the movement will be calculated and will be uniformly set to Mean Sea Level.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Based on the compiled result, it can be concluded that submerged breakwater are performing its purpose and design well. For Gold Coast, the retreating of the beach due to erosion seems to be stop at the moment. From year to years, the result pointing to beach accretion where the original purpose of the installation of SBW's was met. For Kerteh coast, the erosion at the beach still occurred and the pattern of movement for the coast seems unpredicted. For the analysis of the three main part, both southern part of the area are facing serious erosion problem. If no further mitigation or study to correct the problem, in 20 years, it will endanger the public and private property. In case of Kerteh, the school are currently in danger due to the erosion getting nearer with the area. However, the performance result for both SBW's cannot be concluded because the duration of the study was too short, for more precise data, it is suggested that the study conducted must be within 3 years time with the result every year for the survey so that the changes can be detect since the area might exposed to a few possible erosion including the difference of environmental environment at different sites.

5.2 Recommendation

As for recommendation for future study, it is recommended to look into more parameters with different type of submerged breakwater to understand the exact response of coastline to the installed breakwater. The purchase of high resolution images from each years for the processing data also needed to avoid any error during the analysis stage of the research. For this research, the results are subjected to +/- 30m error due to medium resolution images used. Numerical modeling tool like Mike 21 software by Danish Hydraulics Institute (DHI), also important to calculate the precise data for the erosion rate changes of coast.

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