A COMPARISON OF COASTLINE CHANGES ON THE CAUTION REEF ROCKY AND WLOTZKASBAKEN SANDY SHORES AS A RESULT OF COASTAL EROSION.

BY

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A Report submitted to the Department Of Fisheries and Aquatic Science, Faculty of Agriculture and Natural Resources, University of Namibia, in partial fulfillment of the requirements for the award of the degree of Bachelor of Science in Fisheries and Aquatic Sciences of the University of Namibia.

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DECLARATION

I hereby declare that this work is the product of my own research efforts, undertaken under the supervision of Mr Kandjengo, Dr Graz and Mrs. Nguno and has not been presented elsewhere for the award of a degree or certificate. All sources have been duly and appropriately acknowledged.

Signature……………………. Date…………………….

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CERTIFICATION

This is to certify that this report has been examined and approved for the award of the degree of Bachelor of Science in Fisheries and Aquatic Resources of the University of Namibia.

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ABSTRACT

It is important to quantify erosion rates so that it could contribute to effective management of coastal areas. This requires the use of Geographic information Systems in order to perform spatial and geostatistical analysis. It is a useful tool that can be used in identifying coastal vulnerability and generation of maps of coastal risk. This study compares rocky shores of Caution Reef and sandy shores of Wlotzkasbaken along the Namibian coast. Erosion rate of 1.13m/yr with a seaward displacement of 0.72m was observed at Caution Reef indicating its stability overtime. Wlotzkasbaken showed an erosion rate of 16.29m/yr with a shoreline erosion distance of -40.23m overtime. Good knowledge and prediction of rates is an important aspect to consider due to the challenges faced by most coastal states as a result of coastal erosion.

CHARPTER ONE

1. Introduction

1.1 General introduction

Coastal areas are generally dynamic environments as continental and marine processes converge along them to produce a landscape that is subject to rapid changes. They vary in topography, climate and vegetation as well as in land use (De Pippo et al. 2008). This transition zone, which includes all the intertidal and supratidal areas that form a boundary as a result of the interaction between the land and sea, make up what is known as the coastline (Mafwila, 2008). Winds, waves, tides, currents, migrating sand dunes and mudflats, and the variety of plant and animal life combine to form these vulnerable habitats (Cambers, 1998).

The Namibian coastline is a straight lying landscape with a few indentations and is embedded within the Namib Desert with few embayments. It stretches approximately 1570 km in length from the Orange River in the south to the Kunene River in the north, with its beaches backed by low dune hummocks, high sand dunes and gravel plains (Tarr, 2009/10). It has for the most part sandy littoral and sub-littoral substrata (54%), with rocky outcrops (28%) running sparsely along the central-north part of the coast (Molloy and Reinekainen, 2003).

Coastal erosion is an event caused by wave action, tidal currents, wave currents or drainage that wear away beach or dune sand sediments (Rising Sea Level and Coastal Erosion Point to Global Climate Change, July 2008). Coastal erosion may also take the form of sediment and rock losses or the temporary redistribution of coastal sediments as a result of storm generated waves and fast moving winds. Masalu (2002) further indicated that coastal erosion may occur as a result of a disturbance in the sediment supply to a beach system. He also recognizes that several other factors, including sea level rise, geology and rapid coastal population growth accompanied by rapid increase of human activities, could be linked to some of the causes of coastal erosion.

Different shorelines have different geomorphic characteristics; therefore they are subject to different oceanographic conditions. Consequently, depending on the morphology and dynamics of the coastal area, erosion occurs in various forms and at various rates: on rocky coasts, waves remove fine-grained sediment which may lead to undermining of the coastline, events of detachment and collapse of rocks (Liguori and Manno, 2009). On sandy shores it depends on whether they are low standing or high lying. Low standing shores are prone to flooding while those at raised standings receive sediment from nearby rivers and eroding surroundings (Cambers, 1998). With this background, coastal erosion can then be defined as the wearing away of coastal sediments significant enough to maintain the shoreline (Masalu, 2002).

1.2 Statement of the problem

The Namibian coast is a highly sensitive ecosystem in terms of climate, biodiversity and ecological functioning (Molloy and Reinekainen, 2003). Among many coastal services, it also provides a gateway for economic growth through tourism, coastal infrastructure development and mining exploration (Nacoma, 2008). It is classified as one of the least densely populated coastal areas in the world, with a low human density (EcoAfrica, 2009). However, this coastal area is experiencing vast expansion resulting from urbanization, residential development and demand for recreational space (Nacoma, 2008). Therefore, there arises a need to assessing coastal changes in order to help determine how coastal areas can continue to support the increasing pressures. Coastal erosion is one of the major threats faced by most beaches and erosion studies of past years would help fill the knowledge gaps. It will also help to show how filling these gaps could be applied to current coastal changes and aid in coastal management decision making. Coastal erosion in most cases threatens beach front developments; studies of this nature can help in addressing whether current setback lines would offer the necessary long term protection of infrastructure or whether other defense strategies need to be developed. Although the study is limited to two areas of short length on the Namibian coastline, it could serve as a baseline study for further coastal studies that could incorporate the entire coastline With this background, the overall aim of the study is to illustrate the magnitude of the erosion and compare coastline changes that have occurred over the years along Caution Reef and Wlotzkasbaken shores as deduced from the analysis of available historical aerial photographs using Geographic Information Systems (GIS).

1.2.1 Study Area

The figures below show the locality of the study area. Wlotzkasbaken is located a few kilometers from Swakopmund while Caution Reef is situated south of Swakopmund.

Figure 1: Topographic map of Namibia

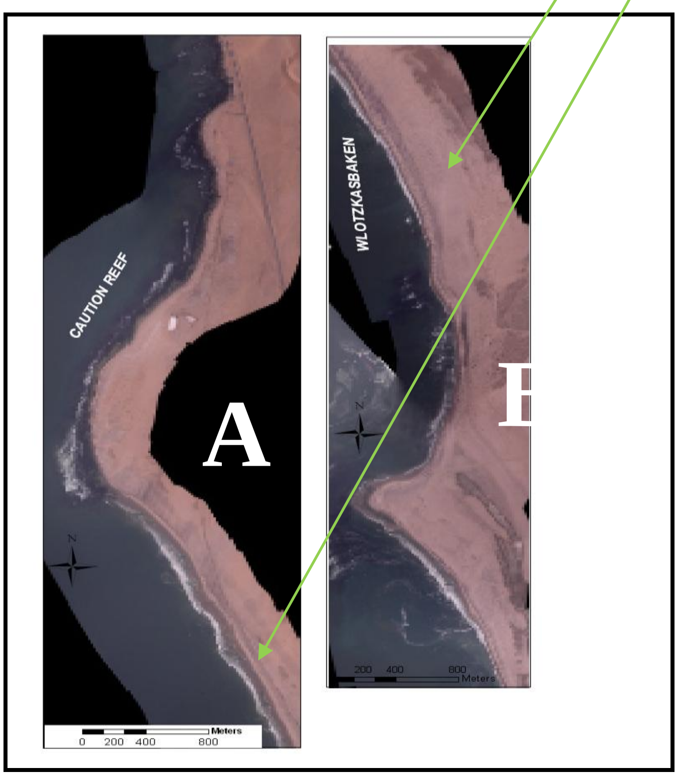

Figure 2: Map of Caution Reef (A) and Wlotzkasbaken (B)

1.3 Literature Review

Coastal zones are increasingly under pressure from human activities such as fishing, coral and sand mining, mangrove harvesting, seaweed farming and urban expansion, all of which have profound negative impacts on coastal sediment stability (Makota *et al.*, 2004). Studies of old and new aerial photographs of the Kunduchi beach north of Dar Es Salaam revealed that the amount of sand supply is extremely low on this beach, an indication that the sediment budget on the beach and nearby areas has been interfered with. Coastal erosion has further caused property and land losses, as well as ecosystem and natural habitat losses. For example the green turtles in Tanzania lost their breeding sites in the Maziwi Island as a result of being inundated (Masalu, 2002).

In Kwazulu Natal, in the Ballito area, stretches of the coast have been drained and the cohesiveness that was supplied by the groundwater has been lost increasing erodability (Breetzke *et al*., 2008) , while in Colombia natural erosion and sand extraction led to the destruction of the Punta Rey Peninsula during the 1968-1992 period (Correa *et al*., 2005). Saengsupavanich *et al.*, (2009) did studies on erosion in Southern Thailand and reported that erosion damaged houses and infrastructures, of which about 10–20 houses were swallowed by the sea each year displacing a number of people. Shrimp farms were also ruined, inducing economic losses to farm owners. Beach beauty was deteriorated by scraps and wrecks of eroded houses and trees, which reduced tourism and lessened the incomes of community members.

In the Northern Campanian shoreline, the beach consists of a long expanse of sandy beaches. These beaches experienced severe and persistent erosion despite the use of artificial structures to protect the coastline. Every year beaches decreased in width, for example during 1954, in Northern Campania the Volturno River mouth, showed the most critical rate of coastal erosion measured to be 10m/yr. Similar values were also found for beaches at the foot of steep rocky shores (e.g. Maronti on Ischia) (De Pippo, *et al*, 2008). A study done by Correa *et al*., (2005) assessing coastal erosion from historical data along the Colombian coast, revealed that at the Tinajones delta, cliffed areas that were fronted by narrow beaches eroded at mean rates between 0.5 and 4 m/year, while along sandy parts of the coast, erosion rates of up to 40 m/year were recorded. Recent coastal studies on the Portuguese coast indicated how shoreline retreat prevailed over the years. This study link the present shoreline evolution to sediment deficiencies that were experienced during the 1940s to the1950s (Ferreira *et al*., 2006).

There are no scientific documented studies on coastal erosion in Namibia; however this is no excuse to ignore the possibility of erosion taking place on this coast. Recent storm surges that seemed to affect the Namibian coast, pointed to climate change and coastal erosion (Bird Island damaged, 0ctober 2010). Several areas of ecological importance in Walvis Bay including the pronounced Bird Island sustained damages that would call for mitigation and adaptation against probable erosion. The Island serves as a guano collection operation area and as a breeding area for various bird species such as the Kelp Gulls, Cormorants, Flamingos, Pelicans, Oystercatchers and Turnstones. At the Swakop River mouth, the Tiger Reef Beach Bar also sustained damage, while the 'Donkey Bay' at Pelican Point was cut off from the mainland as water temporarily swept away sand banks (Bird Island damaged, 0ctober 2010). With this in mind, the dangers or threats that Namibia can face due to coastal erosion become a reality.

1.4 Objectives:

- to determine and compare the erosion rate and distance at which the coastline has changed overtime at the two types of shores;
- To compare coastline changes on rocky and sandy shores so as to indicate the significance of coastal erosion.

1.5 Hypothesis

H_0: There are no significant differences in the coastline erosion rate (m/yr) and distance (m) the shoreline at Caution Reef and Wlotzkasbaken has moved as result of coastal erosion.

H_1: There are significant differences in the coastline erosion rate (m/yr) and distance (m) the shoreline at Caution Reef and Wlotzkasbaken has moved as result of coastal erosion.

CHARPTER TWO

2. Materials and Methods

2.1 Materials

2.1.1 Data acquisition

The materials used for this study were aerial photographs for the dates shown in the table below and these photographs were obtained from the office of the Surveyor General, Ministry of Lands and Resettlement. Digital orthophotographs of 1997 were obtained from the Ministry of Mines and Energy. A 2003 orthophotograph from the Ministry of Mines and Energy was also used for the production of maps for comparison purposes. The photo and job number of the aerial photography is available in appendix 1. This can be useful if someone wants to use the same data that was used for this study.

Table 1: Aerial photograph dates of capture and scale

Area	**Date of capture**	**Scale of aerial photograph**
Wlotzkasbaken	1961-09-07	[1:36 000]
	1963-08-02	[1:36 000]
	1976-09-01	[1:50 000]
Caution Reef	1961-10-14	[1:36 000]
	1963-08-02	[1:36 000]
	1976-08-12	[1:50 000]
	1997-08-25	[1:80 000]

Aerial photographs of years later than 1997 are available at the office of the surveyor general. However, they are not yet available for public dissemination. There were no aerial photographs available for Wlotzkasbaken for the year 1997.

2.1.2 Software used

For the successful change assessment of the study areas, the project requires knowledge of Geographic Information Systems (GIS). GIS is used as a support tool that allows for integration of available information into a geodatabase in order to perform spatial and geostatistical analysis. It is a useful tool that can be used in identifying coastal vulnerability and generation of maps of coastal risk (Rodriguez *et al.*, 2009). The study made use of the of the Environmental Systems Research Institute (ESRI) ArcGIS 9.3 desktop software, namely ArcCatalog and ArcMap. Based on a method described by (Mank, 2002), ArcCatalog was used to manage and locate the spatial data which were than visualized in ArcMap. Maps used in the study were also produced using ArcMap.

2.2 Methodology

2.2.1 Scanning

The aerial photographs obtained where in analogue form and so they were first scanned to convert them into digital images. Once scanned, the images become raster data and are called bitmaps or scanned maps (Dudley, 2008). The images consist of dots called pixels, which together create an impression of an image. Typically a raster image will be a copy of a paper map, an aerial photograph, or a satellite image (Dudley, 2008). The resolution used for the photographs was 300dots per inch (dpi) and saved in JPEG file format. JPEG stands for the Joint Photography Experts Group. As the name suggests, the format was originally developed as an appropriate format for storing photographs (Dudley, 2008). The scanned maps were than cropped to bring into view the area of interest using Microsoft office picture manager.

2.2.2 Georeferencing

Georeferencing is a process whereby scanned aerial photographs are assigned to a coordinate system so that their X and Y coordinates can be located in space (Makota *et al*., 2010). This is done by referencing them to existing orthophotographs. This follows the method implemented for investigating shoreline erosion (Saengsupavanich *et al*., 2008). The scanned images were geo-referenced using the digital aerial photo mosaic (orthophotograph) of 1997 to the Universal Trans-Mercator (UTM) projection system using the World Geodetic System 1984 (wgs-84) datum. This is the projection system used by the Surveyor General of Namibia (pers. comm., 2010). *Fig. 3* below shows the control points that were used to overlay the aerial photograph onto the 1997 orthophotograph during georeferencing.

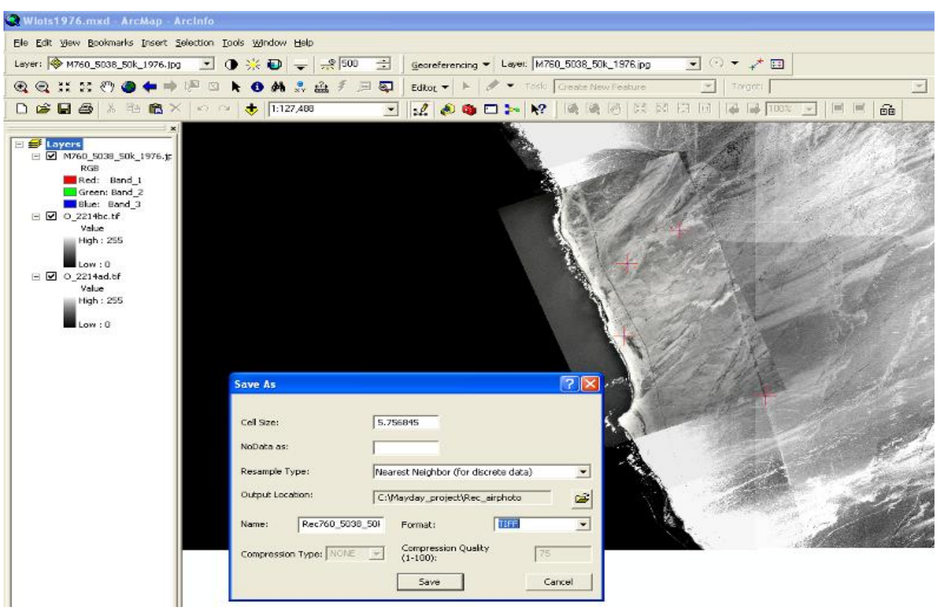

Figure 3: Screen print image for 1976 while georeferencing Wlotzkasbaken scanned map

2.2.3 Shapefile Creation and Digitizing

Before digitizing, shapefiles were created for the images. This was done by means of ArcCatalog, with the same projection that was used for the digital photos. Shapefiles store non-topological geometry and attribute information for the spatial features in a data set. The geometry for a feature is a shape (line or point) comprising a set of coordinates. Shapefile allow for faster drawing speed and edit ability (United States of America Environmental Systems Research Institute, Inc. 1998). The X and Y coordinates for the shapefiles of Caution Reef and Wlotzkasbaken can be seen in appendix 3.

The most commonly applied digitising techniques are: manual digitising from a digitising tablet or on-screen digitising using a backdrop of the actual map or imagery. For the purpose of this study, on-screen digitizing technique was used to digitize lines and points. The high water mark was used as a benchmark for digitizing to indicate the shoreline because it was visible on all the aerial photographs. The lines were digitized for every year and these show shorelines. The points were digitized on perpendicular shore transects as specified by (Kerhin, 1998). This helps to identify corresponding points on different year shore lines and determine the distances between them (see *Fig 4* and *5*). The points were drawn at every 50.24m for Wlotzkasbaken and at 50.35m for Caution Reef. 1961 selected as the baseline year on which to assess change because it was the oldest data year available for both areas.

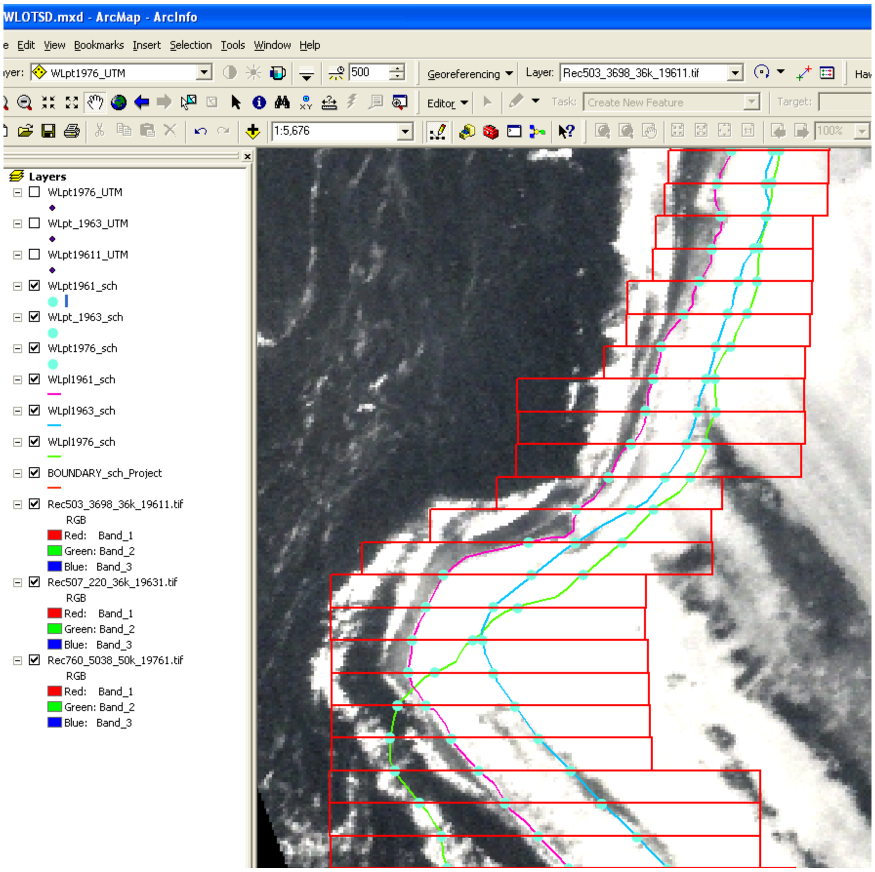

Figure 4: Digitizing screen print image of the points for Wlotzkasbaken

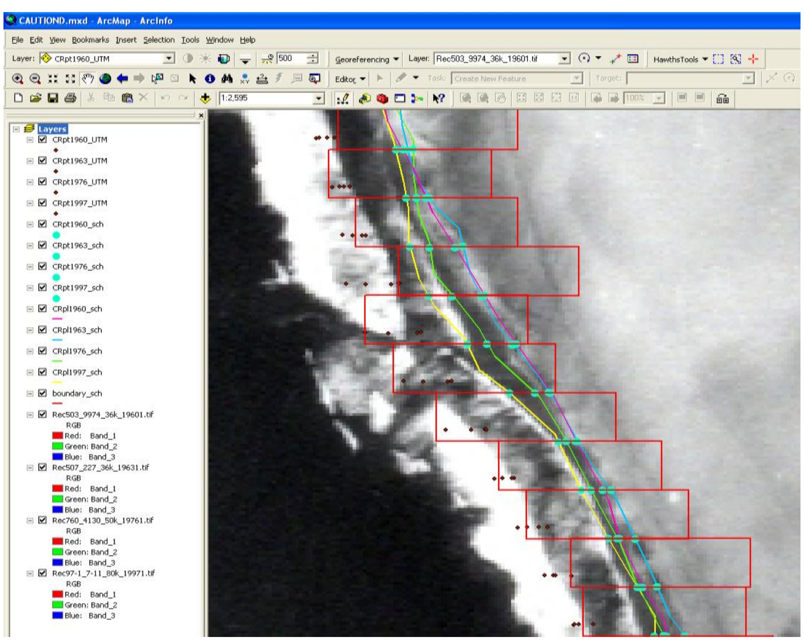

Figure 5: Digitizing screen print image of the points and lines for Caution Reef

Table 2: The number of points, the length of the study area and the scale at which they where digitized.

AREA	Number of Points	Area Length(m)	Scale
Wlotzkasbaken	87	4963.39	1:1010
Caution reef	109	6211.47	1:1347

2.2.4 Method for calculating shoreline retreat rate and statistical tool

The technique used by Lantuit and Pollard (2008) is the End Point Rate (EPR) Method for calculating shoreline retreat rate. This method is described as the distance separating two shorelines in meters divided by the number of years between them. The EPR is then the rate of erosion between the earliest and latest shoreline vectors.

When using this method, the landward movement of the shoreline (which is the actual erosion) is recorded as a negative number (Kerhin, 1998).This method was adopted from the Digital Shoreline Analysis System described by William Danforth and Robert Thieler of the US Geological Survey (Kerhin, 1998; Dolan *et al.*, 1991; Lantuit and Pollard, 2008). The objects needed to run this process are a baseline vector and at least two shoreline vectors with known dates of acquisition (Kerhin, 1998). Caution Reef has four shoreline vectors whereas Wlotzkasbaken has three, hence the preference for this method.

$$\text{End Point Rate} = \frac{\text{Distance of vector between shorelines (m)}}{\text{time between shorelines (yr)}}$$

Unit= m/yr

In this method, the erosion rate is recorded as both the end point rate (EPR) and the mean erosion rate. The mean erosion rate is the average rate between all the shorelines (Lantuit and Pollard, 2008). For example, if you have three shorelines *a*, *b*, and *c*, the mean erosion rate would be the average of the rates between *a* and *b*, *a* and *c*, and *b* and *c*.

$$\text{Mean Erosion Rate} = \frac{(a+b)+(a+c)+(b+c)}{3}$$

Unit= m/yr

The formula used for calculating the distance between points is a variant of the Pythagorean Theorem: $(c^2 = a^2 + b^2)$ known as the distance formula. When given two points, it is possible to plot them, draw a right angle and then find the hypotenuse. The length of the hypotenuse is then computed as the distance between the two points (Stapel, 2010), in this case the distance between the shorelines. Given two points (x_1, y_1) and (x_2, y_2), the distance between these points is given by:

$$D = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

Unit= m

The ArcGIS software used did not have a spatial analyst extension that is able to compute the distance. The formula was computed into Microsoft excel which enabled the calculation of the distance between points of the different years. Negative and positive values were assigned manually (see appendix 3 and 4) using the point shapefiles position relative to the sea and littoral zone as a reference. The points moving into the sea indicate accretion, while those towards the land indicate erosion. The statistical analysis tool used was the two sample t-test for independent means, with a pooled variance. The means used were those of the distance as well as the means for the erosion rate calculated. These were analysed using the GENSTAT statistical package under a two sample *t*-test for independent means with an unequal replication, thus they had a pooled variance (see appendix 2).

CHARPTER THREE

3. Results

From tables 3 and 4 below, Wlotzkasbaken shows the highest overall rate of erosion at 16.29m/yr, with the coastline having moved landward at a distance of -40.23m over a 15 year period. Caution reef indicates an overall erosion rate of 1.13m/yr, with a seaward movement of 0.72m over a 37 year period. There are significant differences in the erosion rate and shoreline displacement at Caution Reef and Wlotzkasbaken, illustrated by F pr=…< 0.001.

Table 3: table showing the mean EPR and distance over time, 1961-1997 for Caution Reef.

Caution Reef	Mean EPR (m/yr)*	Mean distance moved overtime (m)
1961_1963	0.55	-1.64*
1961_1976	0.11	-1.80*
1961_1997	4.06	5.60
Overall mean	*1.13*	*0.72*

*EPR taken as absolute values and negative values at distance indicate shoreline (erosion).

Table 4: table showing the mean EPR and distance over time, 1961-1997 for Wlotzkasbaken.

Wlotzkasbaken	Mean EPR (m/yr)*	Mean distance moved overtime (m)
1961_1963	31.41	-62.82*
1961_1976	1.18	-17.65*
Overall mean	*16.29*	*-40.23**

*EPR taken as absolute values and negative values at distance indicate shoreline (erosion).

3.1 Caution Reef

The highest rate of shoreline accretion, measured to be 4.06m/yr with a seaward displacement of 5.60m, was recorded between 1961 and 1976. This is clearly illustrated in *Figs. 6* and *7* occurring from point 77 to point 80 and from 90 to 96 respectively. The highest rate of erosion was observed during the period 1961-1963, measured at 0.55m/yr with a landward movement of -1.64m. This can be seen from point 30 to 35 in *Fig. 8*.

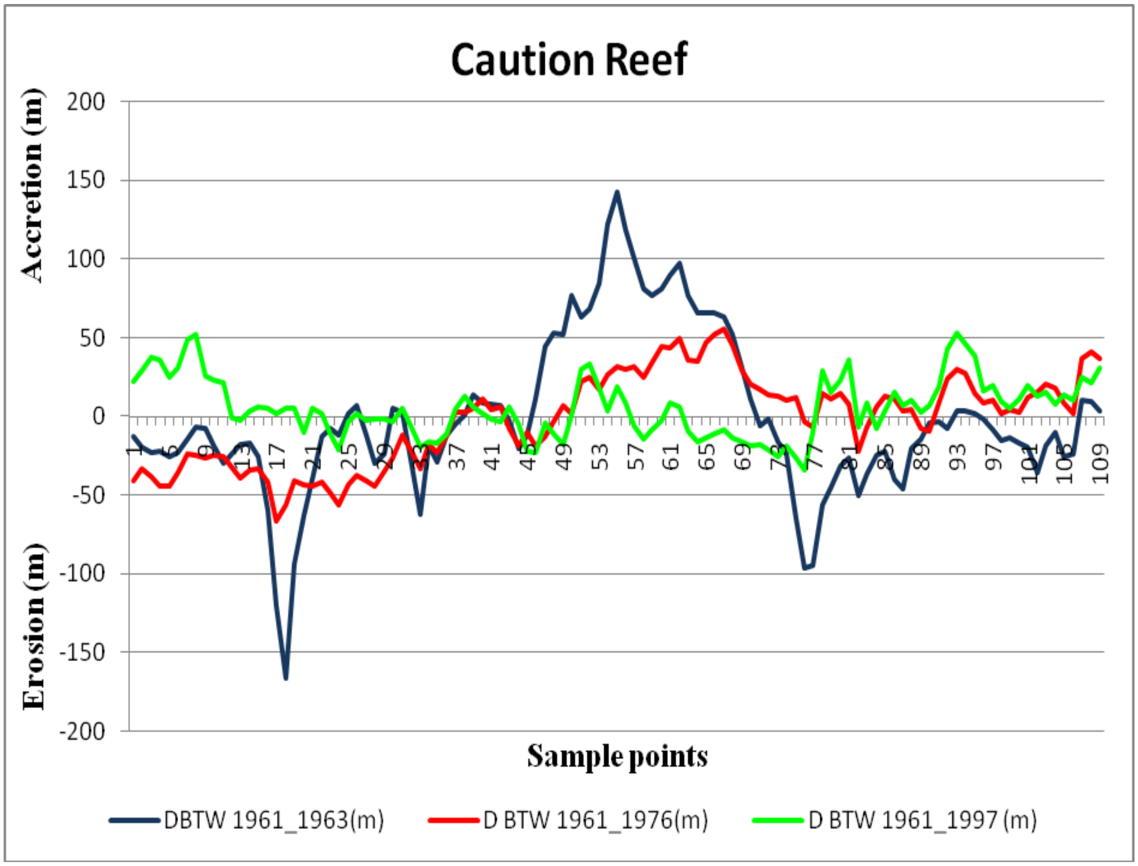

Figure 6: Caution Reef erosion and accretion rates

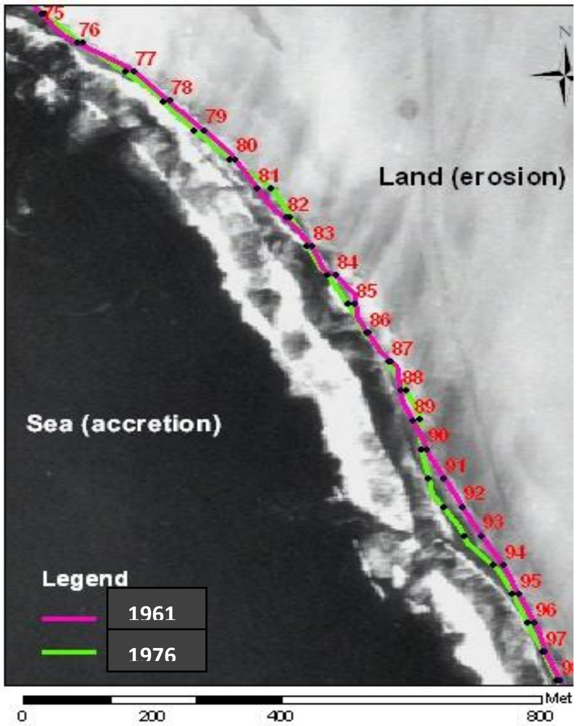

Figure 7: Map of depositional areas at Caution Reef 1961-1976

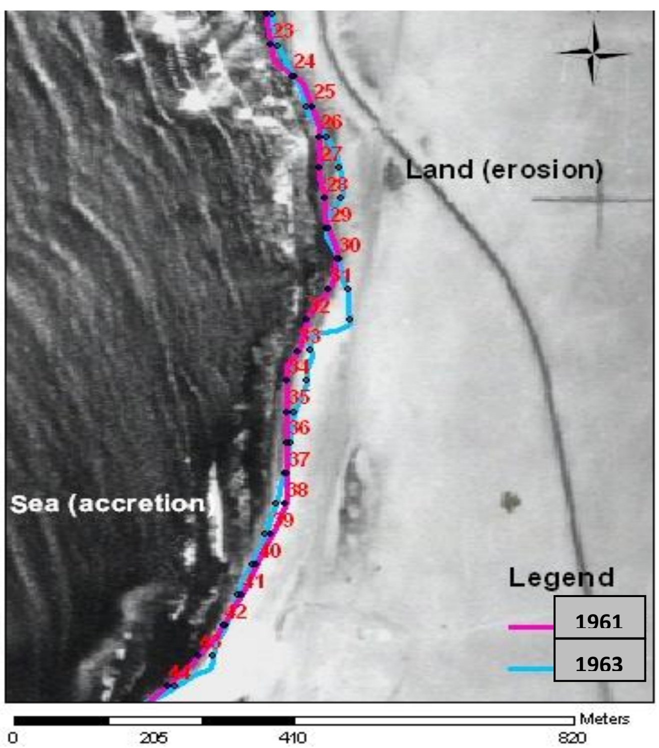

Figure 8: Map of eroding areas at Caution Reef, 1961-1963

3.2 Wlotzkasbaken

The highest rate of shoreline erosion was recorded between the 1961 and 1963 period measured to be 31.41m/yr with a landward displacement of -62.82m. This can be seen occurring from points 34 to 49, (*Fig.9 and 10*) below. During the 1961-1976 periods, accretion was relatively observed from point 5 to 11 and from point 15 to 18 (*Fig.11*), with the most prominent accretion occurring from point 74 to 87 (*Fig. 9*).

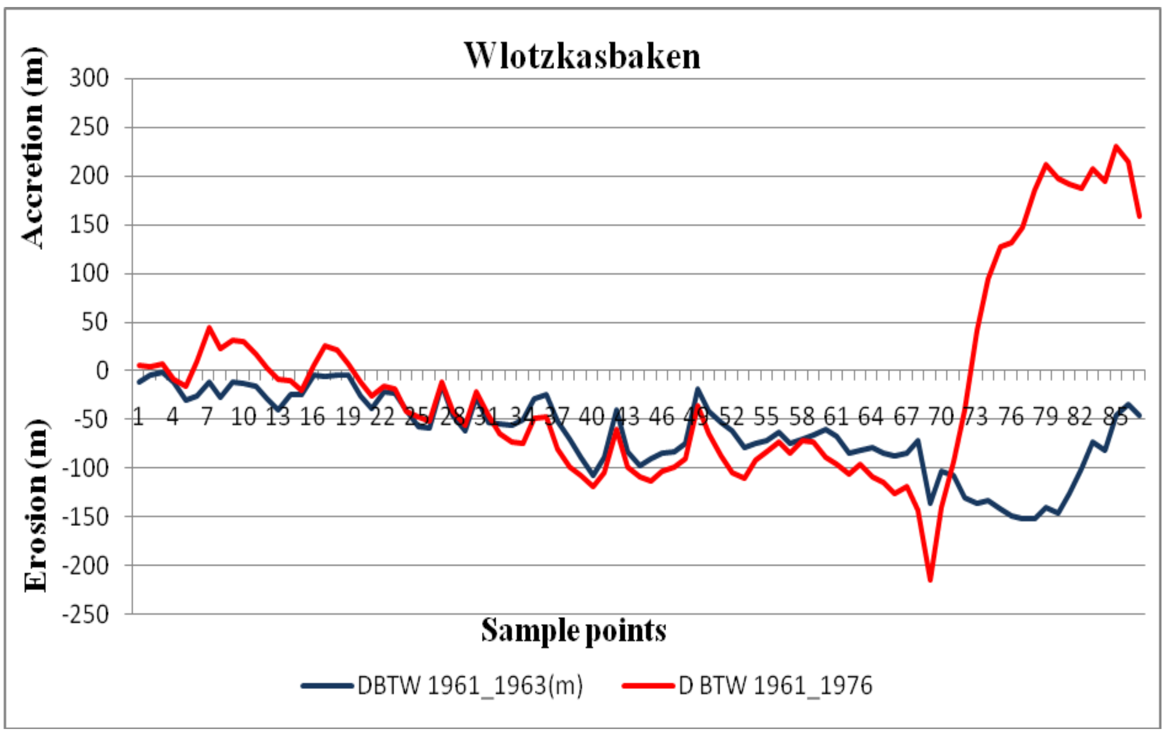

Figure 9: Wlotzkasbaken erosion and accretion rates

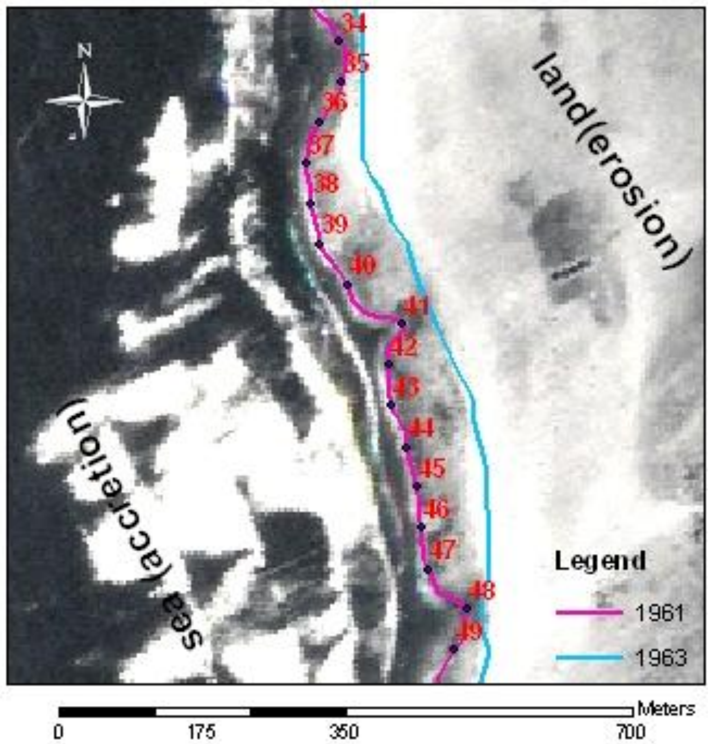

Figure 10: Map of eroding areas at Wlotzkasbaken, 1961-1963

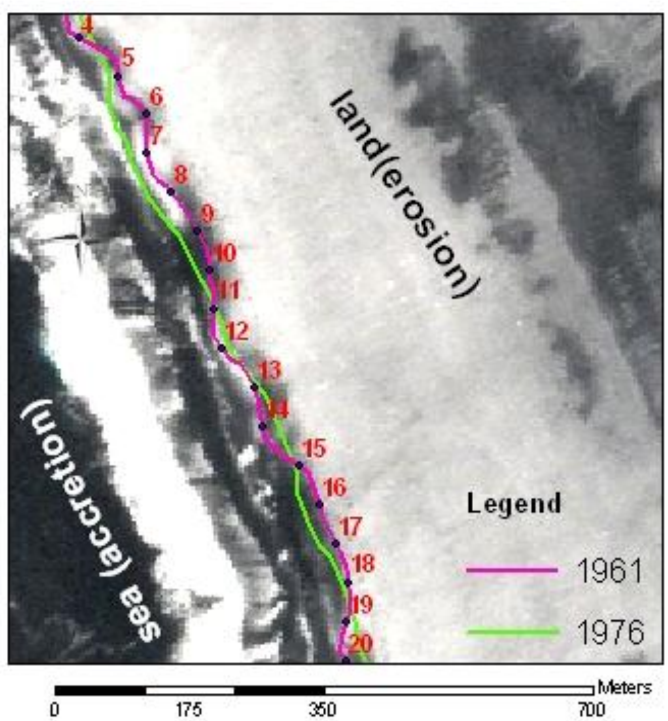

Figure 11: Map of depositional areas at Wlotzkasbaken, 1961-1976

Figs. 12 and *13* below show the overall shoreline change for Caution Reef and Wlotzkasbaken.

Figure 12: 0verall shoreline change at Caution Reef, overlaid on 2003 orthophotograph.

Figure 13: Overall shoreline change at Wlotzkasbaken, overlain on 2003 orthophotograph

CHAPTER FOUR

4. Discussion

The objectives of the study were to determine erosion rates and compare coastline changes between sandy and rocky shores. The 1961-1963 is a 2 year period, which is the shortest interval used in the study. During this period, the highest erosion rates were observed at both areas with Wlotzkasbaken having the greatest landward displacement experienced in the same year (table2). Over a longer period of time for example, 1961-1976 (15 years), which has a cumulative effect, erosion rate decreases and land displacement lessens at both areas. This is because equilibrium may have been attained over some time.

The 2003 orthophotograph shows a noticeable headland at both Caution Reef and Wlotzkasbaken. At these headlands, accretion events dominate (Figure 12 and 13). The initial position of the shoreline in 1961 is moved seaward at both areas. These figures also demonstrate the overall stability of the two areas. However, the means for erosion and landward displacement at the two areas show a significant difference (F pr=…< 0.001).

As indicated in table 1, most of the aerial photographs were taken between the months of August and September. This is a transitional period between winter and summer. Ocean upwelling is observed to be strongest during these times. This then increases the occurrence of wind, waves and ocean currents and their impact on land. Sediments are taken along during the backwash of the waves which inturn increases the erodability of the area. The impact of such events is more pronounced on sandy shores than on rocky shores as demonstrated at Wlotzkasbaken. The erosion of a coastline is then an outcome of the coastal system's response to its external conditions, driven by climate and marine processes (Brown et al., 2006).

On rocky shores, ocean activity works against the rocks of the land seeking out the zones of weakness caused by fractures and faults as a result of the orientation of the earth and variations in hardness found in rocks. In some places, the ocean energy may erode around a particular rock formation, leaving it exposed on all sides to the waves thereby increasing its vulnerability to erosion (http://www.oregon.gov, 05/11/2010). Also, the morphology and slope or elevation of the rocks may influence the rate of erosion on these shores. Gaps between the rocks may also provide a breakthrough for waves to erode lose material (Lantuit and Pollard, 2008). However, rocks are hard structures and this would aid in their ability to break wave energy. The rocks at Caution Reef offer some defence against ocean activity hence it appeared to be relatively more stable compared to Wlotzkasbaken (*Fig. 12* and *13*). Rocky shores also support a high diversity of adapted plants and animals such as barnacles and mussels mats (Smith, 2008) which may provide some defence against scouring effects of the waves. The presence of plants and animals allow for less exposure of the rocks and this increases their ability to buffers against the effects of wave action (Molloy and Reinekainen, 2003).

On sandy shores, erosion prevails more than on rocky shores. They normally lack vegetation and animal life that could also offer some sort of sea defense (Smith, 2008). They therefore lack the added advantage offered by the presence of plants and animals on rocky shores. Sandy shores comprise of lighter and loose particles that can easily be moved by action of waves or the wind (Lantuit and Pollard, 2008), as a result there is an increase in sediment removal. Erosion not only affects beach front development and livelihoods of people. In the long run coastal erosion may impact important breeding and nesting as well as feeding habitats for marine animals and sea birds (Smith, 2008). For example the Caution Reef area is regarded as an Important Bird Area (IBA). It serves as a feeding and seasonal breeding area for the well known Damara tern (Nacoma, 2008). Prevalence of erosion at this area may lead to the displacement of these birds' feeding, breeding and nesting areas. This might also increase the chance of reduction in biodiversity, as seen from the case of the green turtles in Tanzania.

In most erosion studies, events such as storms, waves and tides were found to be the most significant hazards to stability, sediment distribution and species diversity of coastal areas.

The stability of coastlines can be maintained or provided through the construction of sea defenses such as seawalls, barricade rocks jetties and groins or through beach nourishment. These structures offer temporary protection of coastlines by increasing deposition and decreasing erosion (Saengsupavanich *et al*., 2008). However, although these structures are believed to halt or reduce erosion, in some places it actually increases the severity of the problem. For example, the construction of sea defence structures in Northern Campanian coast removed vast amounts of sediment from the beach during extreme storm events, where sediment was sent out to the deep waters instead of being deposited on shore (De Pippo, *et al*, 2008).

Coastal areas have different ecosystem uses depending on the preference of its users. With prevailing coastal erosion, these ecosystem services provided may be held back and thus pose challenges for coastal management.

CHAPTER FIVE

5. Conclusion

The erosion rates observed at Caution Reef and Wlotzkasbaken helped to show the dynamics of rocky and sandy shores. Rocky shores where found to be more stable overtime compared to sandy shores. For development purposes, Caution Reef would be better to consider. Wlotzkasbaken may need to be protected in order to maintain the shore. Finally, the study revealed the significance of assessing coastal erosion and its impacts, using remote sensing techniques.

5.1 Recommendations

More studies on coastal erosion should be carried out in order to avail more scientific evidence and create awareness of the phenomena in Namibia. Future studies on coastal erosion could use similar studies to focus on the role played by the local and regional geomorphological factors in the different erosion rates as recorded along the Caution Reef and Wlotzkasbaken shores. These can then be applied to the Namibian coast at large. Although some of the attempts to coping with erosion such as beach nourishment may be costly, Namibia could adopt some approaches as a way of adapting to and mitigating the effects of coastal erosion. However, efforts such as these may be a contributing factor to erosion as in the case of Northern Campania. Thus care should be taken as to which is the best approach to implement. Finally, in order to support long term planning, more aerial photos for monitoring of coastal dynamics should be taken and made available in order to fill “information gap”.

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APPENDICES

Appendix 1*:* table showing identification features for aerial photographs

Caution Reef

JOB	PHOTO NUMBER	STRIP	SCALE	YEAR
503	9974	19	36k	1961
507	227	C7	36k	1963
760	4132	4	50k	1976
97-I	7-II	15/2	80K	1997

Wlotzkasbaken

JOB	PHOTO NUMBER	STRIP	SCALE	YEAR
503	3698	C4	36k	1961
507	220	C7	36k	1963
760	5038	3	50k	1976