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An Assessment of the Impact of Erosion on the Shoreline of Ibeno Local Government Area of Akwa Ibom State, South-South Nigeria

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Abstract

The dynamic nature of the shoreline makes it difficult, to accurately assess a community's risk and vulnerability. Extreme storm events can cause rapid erosion that move the shoreline hundreds of feet inland followed by an extended period in which the beach accretes back, not completely to its former position. This study examines the impact of erosion on the shoreline of Ibeno beach. Observations and measurements were made of the sedimentary structures and hydrodynamic processes; these were done by employing the erosion pin/peg technique at regular intervals to assess the rate of erodibility. The swash and backwash action were determined using the pegging method for interval of six months. Wave height, wave breaker pattern, long shore current velocity and beach profile were adopted to assess the degree of erosivity. The Pearson's moment correlation was employed for data analysis. The results revealed that breaker period facilitates erosion. As erosion was intense on the berm-edge, spilling waves supersede the plunging waves. The result also shows that before the advent of spring tide, high deposition occurred on the middle foreshore, while erosion was highest in the month of August, when the breaker height racketed to 2.08m, about 5.2m of the beach area was eroded at the middle foreshore in response to waves condition. It was also observed that wave breaker height reached a maximum of 2.06m in the first week of August, as a result, 6.4m of the lowest foreshore areas was eroded. Spilling waves exceeded plunging waves to about 70 percent to 30 percent while the peak of spring tide experiences the deposition of the eroded materials. Based on these observations, recommendations have been advanced to curb the menace of erosion in the study area.

Keywords: Coastal erosion, Shoreline degradation, Waves, Ibeno beach.

Introduction

The dynamic nature of the shoreline makes it difficult to accurately assess a community's risk and vulnerability. Extreme storm events can cause rapid erosion that move the shoreline hundreds of feet inland followed by an extended period in which the beach accretes back, not completely to its former position Steers (1971). The coast, according to Bird (1968) is "a zone of varying width, including the shore and extending to the landward limit of penetration of marine influence" has constantly been deteriorating due to marine erosion influence.

The coast provides the geomorphologist with almost different opportunities for the study of active processes. The impact of marine erosion on the shoreline is of dual effects as it is worn down by erosion (degradation) on one hand, and builds up deposition (aggradations) on the other hand. In fact, the shoreline forms vary in shape and structure from one area to another (Thorne, 2005; Green et al.; 2001).

Studies have shown that while some coasts are prograding, others are eroded. Such variations are zonal in terms of geologic outcrops. Accordingly, attempts to modify coastal changes to halt erosion and their associated problems require an understanding of the factors and processes at work in the coastal morphogenic system, the pattern of changes, the source of sediment flow, and the quantities involved over a given period of time (Abua & Abua, 2013; Oyegun, 1991; 1997; 2011). The chance of researching and investigating more of our own or any other coast should never be lost. As assessed by (Steers 1971; Oyegun et al. , 2003; 2009;) "no two places even a mile apart are subjected to quite the same influences", even on a straight coast wave action varies and differs from one part of the coast to another. Steer's assertion reveals the fact that environment (coast) in which similar studies were carried out cannot be thought of as a particular representative of most of the world's coasts noting the various processes at work to be headed by timely intervention of preventing the coastland from degradation and devastation by accelerated soil erosion.

In some situations, coastlines emerged from the melting of ice during glacial age of the geologic time. Some coastal shores evolved through processes of volcanic activity and faulting. Newly formed coastlines are exposed to constant modification by the incessant bombardment of waves on seashores. Waves move in a 'to' and 'fro' basis when they approach the shoreline (Asila, 1997; Thorne, 2004). The work of erosion, transportation and deposition of sediments carried out by the sea depends on the interplay of waves, current and tides from this movement. A research such as this is important because it tends to uncover the causes of observed trends and how to rectify them hence, the thrust of this work. The study **is aimed at examining the impact of erosion on the shoreline of Ibeno Local Government Area of Akwa Ibom State, South south Nigeria.**

Study Area

Ibeno shoreline encompasses a stretch of sandy beach. It is generally flat with concave sloppy surface averaging about 500m stretch of sand beach with a mesotidal character of 2-4m and is textually homogenous. It lies between longitude $4^{0}35^{1}$E and $5^{0}10^{1}$E and latitude $8^{0}N^{1}$ and $8^{0}45^{1}$N. The area is bounded by Mbo on the East, Eket on the West, Oron in the North east, Onna on the South West and Okobo on the North. The coastal topography forms part of the deltaic terrain of Nigeria off the Bight of Bonny.

The population of Ibeno area is estimated at 42,249 (National population commission, 1991). The people are mainly farmers, fishermen and traders until the advent of oil exploration. The skilled and unskilled people of the area are employed.

The vegetation in this area is mainly mangrove (Nympa Palm) and fresh water forest. The area has a subequatorial type of climate. The area from time to time enjoys a coastal location with heavy precipitation, remaining under the influence of the maritime air mass throughout the year.

They area has about twenty-three (23) villages with Ubenekang as the Local Government headquarters.

Materials and Method

Beach profiles were carried out hundred meters away from the estuary/ocean edge. The beach fieldwork/ shoreline was divided into five stations each 250m apart. This was done by the use of cellophane tape. The beach profiles were derived by the use of two wooden staff, which were gauged in centimeters. The five stations were marked by a conspicuous object, so as to identify the stations until the experiments were concluded.

The two gauge staffs were held in opposite direction at 1.0m apart. The opposite stood erect in vertical direction in straight line with the sea horizon to enable the elevation mark at that distance to be read from the opposite staff. The experiments were repeatedly done from the backshore through the beam edge to the lower foreshore at every 10 meter interval.

The float method was used to determine the long shore current velocity of the beach. This experiment was carried out in one station. A distance of 10m was divided into 3 meters apart. The 3 divisions were designated into points A, B, and C. Long shore velocity distance is given as:

$$\frac{(A+B+C)}{\text{Time}}$$

Velocity is recorded in meter per second m/s either north or south.

Wave height was measured using the gauged staff. The distance between the floor and the wave crests was measured at every 15 minute, it was observed that at spring tides wave heights are higher and lower at neap tides. Water depth was measured using the graduated staff. The staff was inserted in the ocean water to ground level. Each datum was recorded when the sea waves were almost motionless. Four trials were conducted at every 30 minutes in all the five stations.

Wind velocity was also measured using the anemometer. To get the fetch of wind which is responsible for the transportation of sand deposit from the foreshore, landward to back shore and also to detect the velocity at every 220 minutes that aid the propagation of waves.

Wave period was derived and the time recorded in seconds within ten wave break. As the train of waves approaches the shore, a wave is singled out and it is counted as a curve, 10 times the time recorded at each 10 curves (is the waves period). It was observed that the wave period was faster during the spring at the time of observation than when it is ebbing. This experiment was done at every 30 minutes interval.

Plunging and spilling waves were mostly determined by the height of wave angle. Plunging waves are waves that cause erosion on beach terrain while the spilling waves are waves that support deposition. They are calculated in percentage. The researchers also profiled the beach, measured the beaker and pattern, observed the plunging and spilling waves, wave height and water depth were also measured including the wind velocity. The rate of erosion was determined by the number of pegs lost within six months duration of the observation, with the peg interval being 10cm apart.

All observations and measurements were carried out on the beach which is highly influenced by hydrodynamic processes, largely responsible for coastal geomorphology. The tides are semi-diurnal and may be classified as micro-tidal with maximum spring tide ranging between one and four meters. Ocean swell generally comes from the east and south east with wind waves locally generated by south-easterly winds. The beach typically exhibits a relatively gentle profile. The inter-tidal zone of the down drift beach is characterized by cuspate ripples (shore face sand band).

The researchers also profiled the beach, measured the breaker angle pattern and observed the plunging and spilling waves. Wave height and water depth were also measured including the wind velocity.

Analytical Tool

The analytical technique employed for data analysis was the Pearson's product moment correlation coefficient. Using the number of swash wave as independent variable, against the rate of erosion as dependent variable observing the number of time waves break on the coast, causing swash and subsequent backwash action at ten (10) minutes interval, the researchers achieved hourly estimate by multiplying in hourly value of twenty-four (24) and then the monthly value by thirty (30).

Using the data obtained from the field, the pearson's product moment correlation coefficient formula was applied. This is given as:

$$r = \frac{N\sum xy - \left(\sum x\right)\left(\sum y\right)}{\sqrt{(N\sum x^2 - \left(\sum x^2\right)(N\sum y^2 - (N\sum xy^2 - \left(\sum y^2\right)}}$$

Where:

r=product moment correlation coefficient

n=number of months

$\sum x$=sum of pegs eroded

$\sum y$=sum of swash/backwash for months

$\sum x^2$=sum of squares of x

$\sum y^2$=sum of squares of y

$\sum xy$=sum of product of y and x

Data Plots

Data plots of this research include the tidal range difference between the neap and spring tides in Ibeno beach. Other plot include volumetric change, based on accretion and erosion episode as they occurred on the back shore upper, middle and the lower foreshore on the stations. Graphs of distinctive waves, wave parameters were plotted against the stations and were mostly significant (figures 1 and 4).

Table 1: The number of swash and backwash for six months

Months	No. of swash in 10 minutes	For one hour x 6	For one day x 24	For one month x 30
July, 2013	25	150	3600	108000
August, 2013	20	120	2880	86400
September, 2013	30	18	4320	129600
October, 2013	35	210	5040	151200
November, 2013	28	168	4032	120960
December, 2013	32	192	4608	138240

Source: Researcher's Fieldwork, 2013

Table 2: The number of pegs eroded and swash/backwash for six months

Months	No. of pegs eroded (x)	No. of swash for 6 months (y)	Xy	X^2	Y^2
July, 2013	3	10800	324000	9	1166410
August, 2013	2	86400	172800	4	7464960000
September, 2013	1	129600	129600	1	167961610
October, 2013	2	151200	302400	4	228614410
November, 2013	1	120960	120960	4	1463132110
December, 2013	2	138240	276480	4	764411910
	11	734400	1326240	4	1009024610

Source: Researcher's Fieldwork, 2013

The computation reveals that r = 0.08 and table value of 2.78 at the 0.05 level of significant. The result shows that the calculated value of 0.08 is less than the table value of 2.78. This implies that there is no significant relationship between the swash and backwash action and the receeding Ibeno beach.

Analysis of the Beach Profiles and Wave Condition Based on Stations

Station one: Station one was located 100m away from the estuary ocean edge. Based on the tidal range, the difference of the period over review was determined. The wave height at station one ranged from 68.0m to 77.0m, from the observation, spilling waves were excessively domineering over plunging wave averaging 70.30 percent which was recorded within this period under review. Wave beaker heights were within 14.2m to 16.3m limit. Long shore current velocity was lowest about $6cm/^s$ to $8cm/^s$. The long shore current velocity accounted for the high deposition on the middle foreshore, while the backshore and berm-edge remained relatively stable. Erosion was mostly concentrated on the lower foreshore. Before the advent of spring tide, high deposition occurred on the middle foreshore while erosion was highest in August, when the breaker height racketed to 2.08m; about 5.2m of the beach area was eroded at the middle foreshore in response to these waves condition.

Station two: station two was located 350m away from estuary/ocean edge. The backshore of the station had no change in deposition and erosion from in the last week of July, plunging waves increased from the first week of August, as a result, 6.4m of the lowest foreshore area was eroded, only for replenishment to take place when wave breaker height reduced to 1.82m. However, the advent of spring tide occasioned the increase in plunging waves which resulted in erosion of the cliff beam-edge and the backshore. About 5.4 of the upper foreshore area were also eroded (figures 1, 2 and 3).

Station three: station three was located 600m away from estuary/ocean edge. The backshore of station three was highly vegetated, thus sediment loss was almost negligible. However, the highly cliff beam-edge was reduced at the peak of spring tide. Wave period had an average of 10 minutes 02 seconds. The upper foreshore experienced consistent erosion from 29th of July to the 7th of August. On the 1st of August wave breaker height had an average of 2.31m and the angle was 45^o which accorded the erosion on the middle foreshore; about 1.71m of the beach area was lost due to erosion (figure 5).

Station four: station four was sited 850m away from estuary/ocean edge. Unlike station three, station four is highly depositional, wave breaker period reduced to about 18 minutes 6 seconds on the 31st of July. Beach profiles on station four were uniform with little or no change from the 29th of July to 3rd of August. Wave breaker height rose from 2.03m on the 7th of August to 2.09m on the 8th of August. The volumetric changes on the lower foreshore of station four indicated high erosion from the 6th to 8th of August (figure 5 and 6) depicting the clustering of the line graph of the beach profiles indicating change in erosion and deposition on the beach surface at the period. But the spacious nature of the line graph in (fig.4) shows the influence of spring tide on the wave parameters. We have breaker height rose from 2.03m on the 7th of August to 2.09m on the 8th of August. The volumetric changes on the lower foreshore of station four indicated high erosion of the period under review.

Station five: station five was situated 1,100m away from estuary/ocean edge. Similarly, station five portrays all the similarities of station four, except that on station five, the backshore experienced sediment deposition on the 4th to 8th of August. Deposition on the backshore was highest on the 5th and 6th of August. On the 2nd of August, the mean wave breaker height was about 2.0m; plunging waves were about 50%, while the wave breaker period was about 13 seconds. About 1.14m of the middle foreshore was eroded. However, spilling waves exceeded plunging waves to about 70% to 30%, the eroded sediments on the middle, upper foreshore, and the beam-edge were deposited backshore at the peak of spring tide.

Discussion

The data collected at the peg sites over the observed periods revealed a monthly variation in swash/backwash erosion action. Given that the correlation coefficient of 0.04 is not significant, it therefore implies that swash/backwash action of the waves among other factors are not responsible for the observed residence of Ibeno beach.

As observed at the peg site, a total of 11 pegs, pinned at interval of 10cm apart were lost during the observation period (6 months). This implies that a distance of 110 meters was eroded during the observation period. Wave conditions were highly influenced by the nature of tide occurring at a particular point in time. It was that during neap tides, that period of low water, long shore current velocity was lowest at station one, which accorded sediment deposition on the middle foreshore. While at spring tide, increase in wave breaker period facilitated erosion on the middle foreshore. While at spring tide, increase in wave breaker period facilitated erosion on the lower foreshore of the five stations while erosion was intense on the beam-edge of station one shifting it 30m backward.

Based on the tidal range differences from July 29th to 31st, wave height at station one ranges from 68.0m to 77.0m, spilling waves were excessively domineering over plunging waves and averaging 70 to 30 percent, wave breaker height were within 14.2m to 16.3m limit, long shore current velocity were lowest at about 6cm/s to 8cm/s.

The result reveals that erosion was concentrated on the lower foreshore but during the advent of spring tide 7th and 9th August, the middle foreshore was eroded due to wave condition. The result in station two implies that there was no change in deposition and erosion from 29th to 31st July. On the 2nd of August wave breaker height reached the maximum of 2.06m as a result, the lower foreshore area was eroded. The advent of spring tides rise to erosion of the beam-edge and backshore and about 5.4m of upper foreshore area was eroded.

It was observed that station three and four were highly depositional, wave breaker periods reduced to 18 minutes, 6 seconds on the 31st of July. Beach profiles were uniform with little or no change on the 29th July to 3rd of August. The results indicate that the middle foreshore of station three was eroded and the lower foreshore of station four experienced erosion from the 6th and 8th of August. The result reveals that r = 0.08 and table value of 2.78 at the level of significance. The results show that the calculated value of 0.o8 is less than the table value of 2.78. This implies that there is no significant relationship no relationship between the swash and backward action on the receding Ibeno beach.

The result depicts that station five experienced sediment deposition from 4th to 8th August on the backshore, about 1.14m of the plunging waves were about 70% to 30%, the peak of spring tide experienced the deposition of the eroded materials.

Conclusion

Attempts to modify coastal changes to halt erosion and associated problems require an understanding of the factors and processes that operate in the coastal morphogenic system. Wave conditions affect the beach morphology at Ibeno beach during spring tides. Micro scale erosion occurred at the lower foreshore with destructive wave action exceeding deposition. However, during ebbing periods, constructive waves allow sediment deposition on the beach terrain predominantly at neap tides.

It is the view of the researchers that beach profile changes reflect on oceanic wave's condition. The assessment of the roles played by swash and backwash (as in this study) in producing the observed erosion at Ibeno beach, is not conclusive, rather it should serve as a platform upon which further studies and investigation on the erosion action of the sea on Ibeno shoreline can be carried out. It is therefore, imperative to recommend certain measures at combating or curbing the menace of erosion on the shoreline of Ibeno based on the findings:

1. To check erosion of materials off the coast, GROYNES should be constructed at where such activities are emphasized. This could trap materials moving along shore, thus, encouraging beach accretion especially in areas where natural supply of sand is small.
2. The presence of substantial backshore is import. This can be achieved by checking the erosion of the backshore into the sea as this has a major effect of lowering it.
3. To reduce the impact of wave breaking on the coast, sub-marine banks should be constructed to intercept the wave from off-shore.
4. In assessing the impact of erosion, modern equipment should be used to limit the amount of errors during data acquisition from the field.
5. There is need for artificial beaches for tourist attraction, constructional habour and wave breakers to prevent excessive flooding and erosion during spring and neap tides.

It should however be noted that the choice between these options depends on their effectiveness, their impact on the local area and the availability of funds.

Figure 1: Graphs illustrating the Measurement of Spilling and Plunging Waves of Station Two

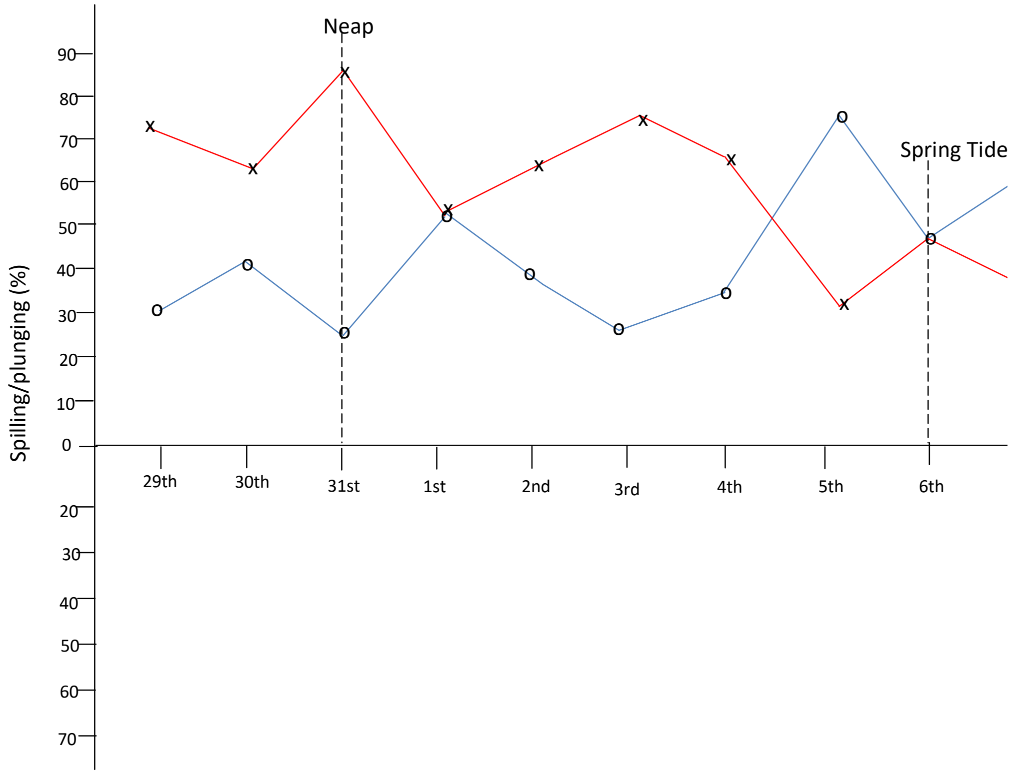


Figure 2: Graph of Beach Profiles of Station two 1st August against 2nd April

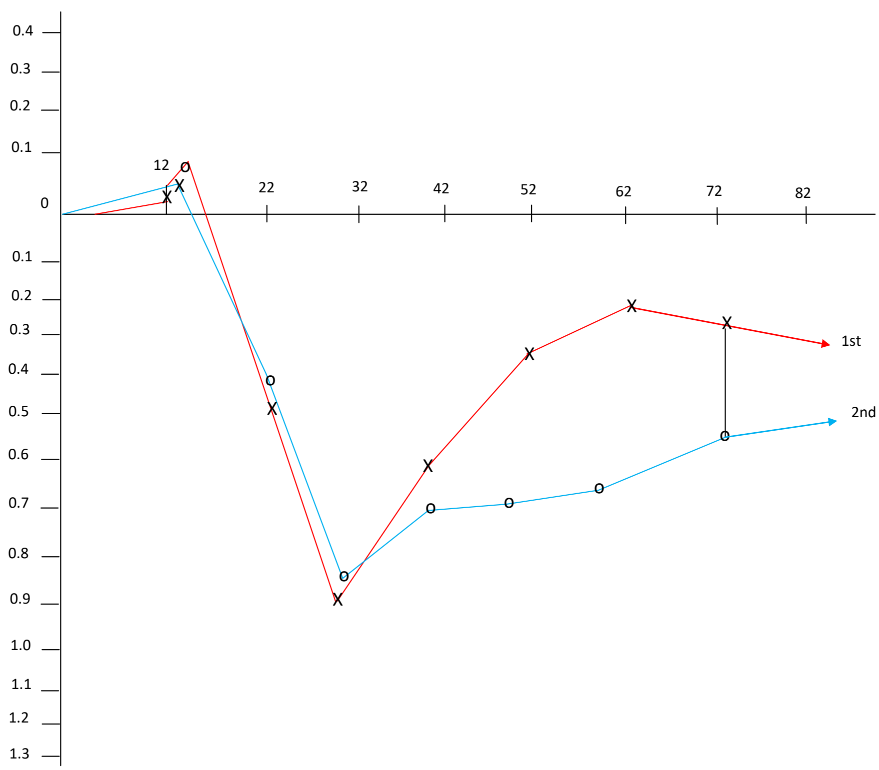


Figure 3: Graph of Beach Profiles of Station two 2nd August against 3rd August

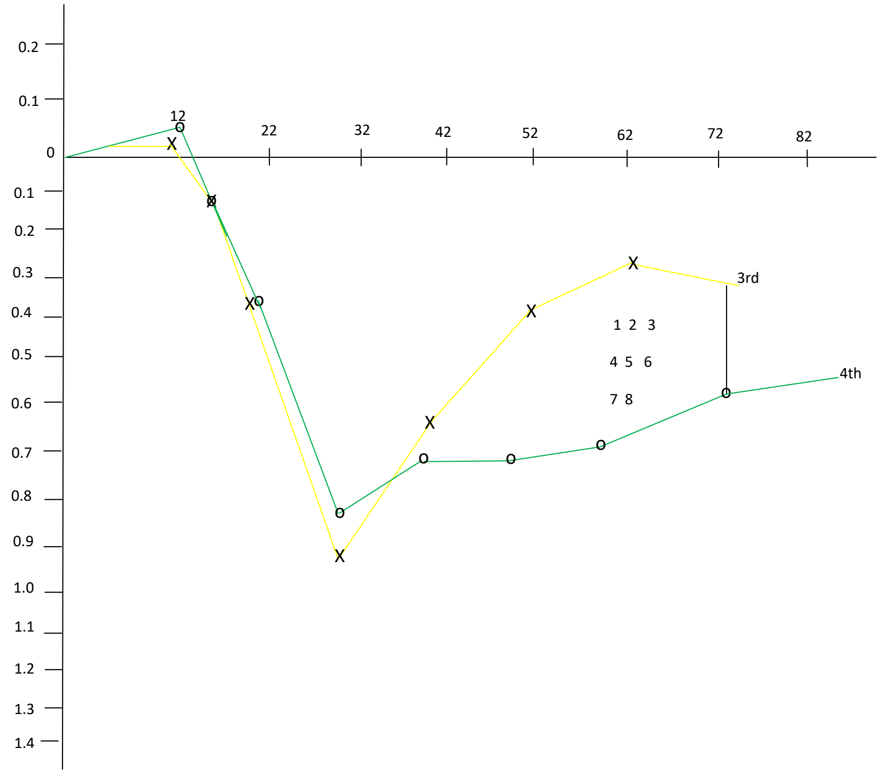


Figure 4: Graph showing Mean Measurement of Wave Breaker Height Station Three

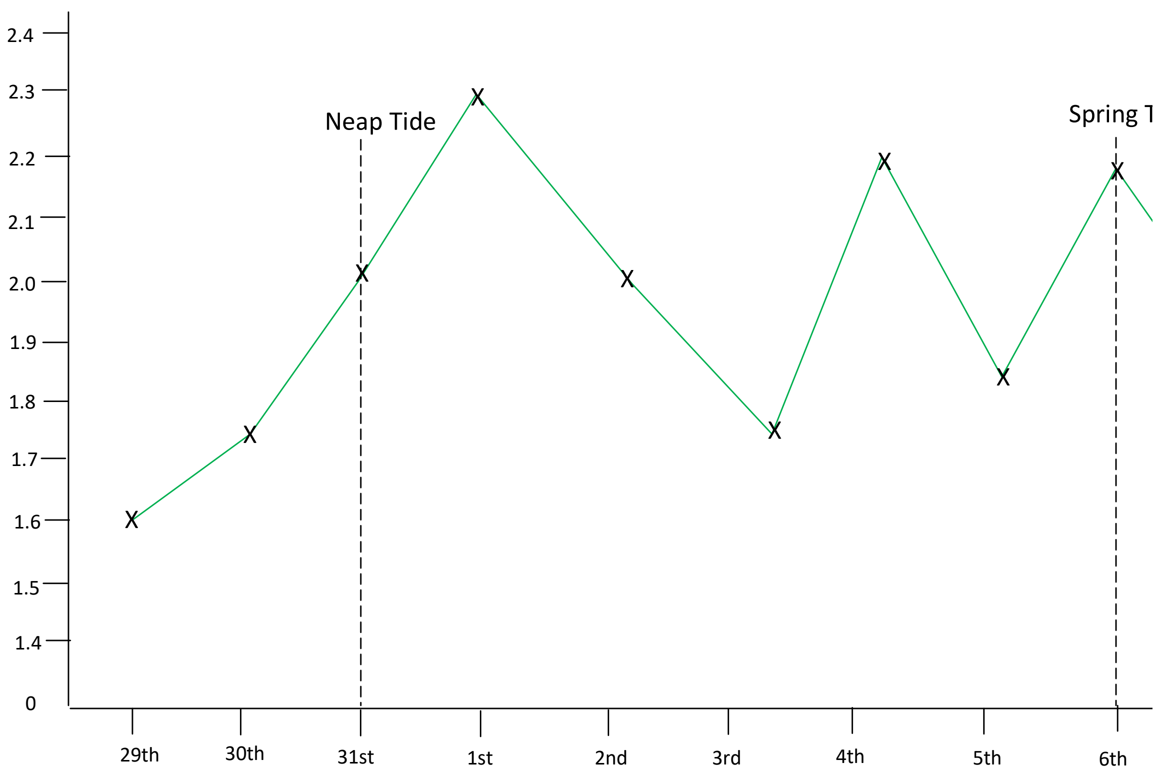


Figure 5: Graphs of Uniform Beach Profiles of Station Four 29th July – 5th August

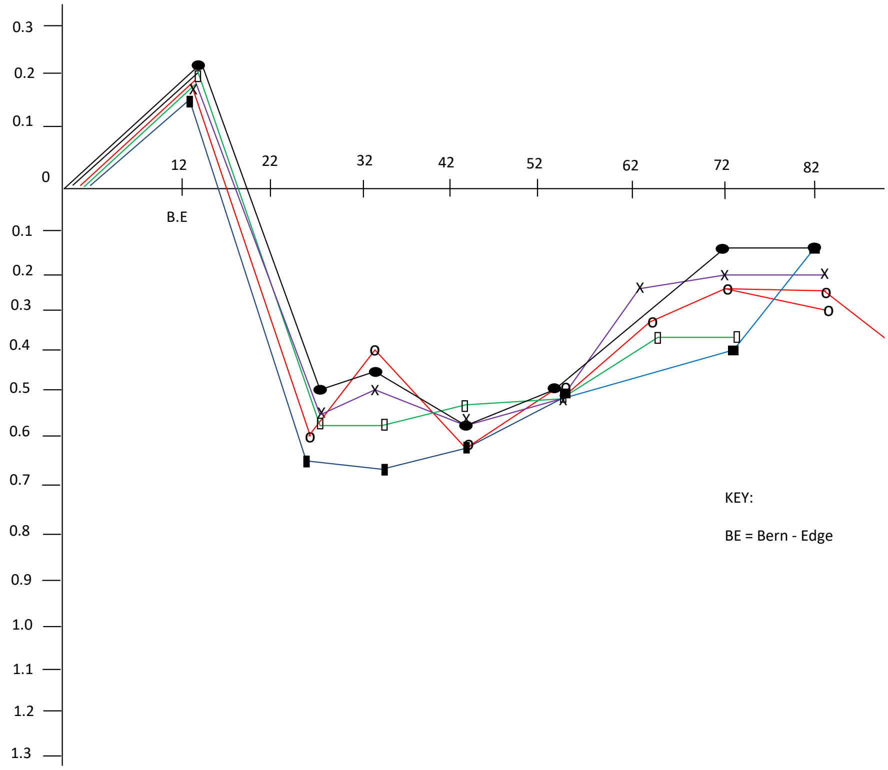
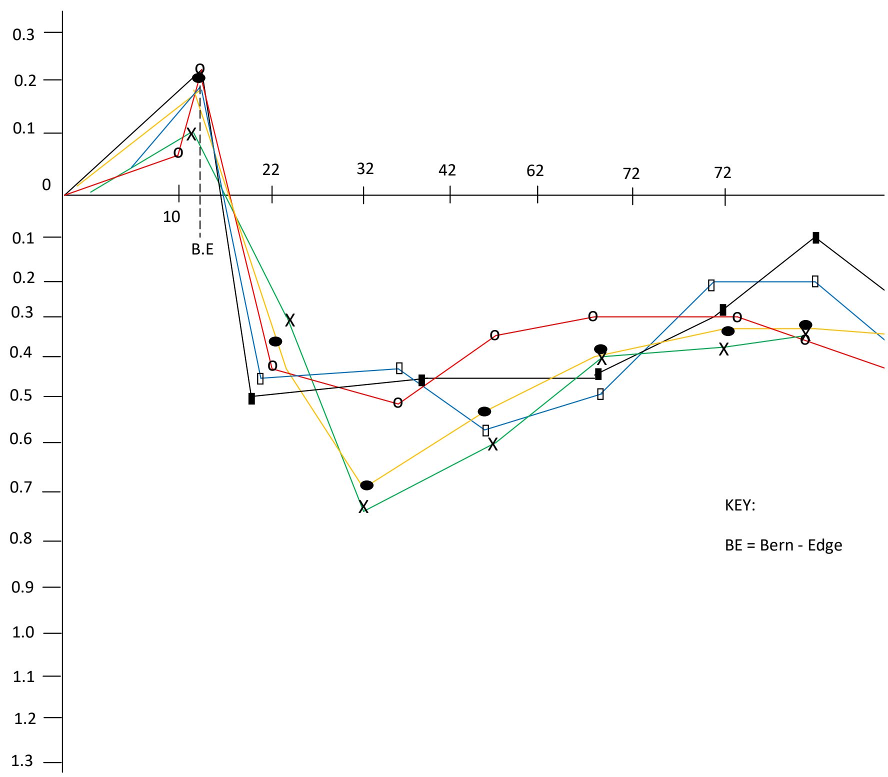


Figure 6: Graphs of Uniform Beach Profiles Distorted on the Peak of Spring Tide 6th – 9th August Station Four



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