European Journal of Scientific Research
ISSN 1450-216X Vol.11 No.2 (2005), pp. 218-229

http://www.eurojournals.com/ejsr.htm

Surface Sea Level Changes in Relation To Swash Oscillation in the Coastal Shore of Ibeno, South-Eastern Nigeria

Eze Bassey Eze & E. U. Ukpabi
Dept of Geography & Regional Planning
University of Calabar
Calabar, Nigeria

Abstract

The primary geomorphological process along the Ibeno beach, swash oscillation, was studied during the rainy season in July, 1997. To study the swash oscillation, seven (7) equidistantly graduated pegs of 1.2m in height pinned at right-angles to the ground and lined from the berm edge to the lower foreshore were utilized. The pegs were separated by distances of 10m apart. Using a reference level, wave swash oscillation period was calculated with an electronic device-the stop watch, to record swash strokes per peg per unit of time. Swash oscillating periods were determined using cumulative period differentiation to determine relative swash per storm surge and backwash. The study provides information on swash oscillation periods, wave parameters, surface sea level changes and sediment movement along this littoral zone. The swash zone had a maximum run-up height of 22.6m, on the average, indicating that the swash process has an extensive range from the waterline to the foreshore. Swash strokes were highest during storm surges and contributed mainly to deposition of sediments while the backwash or ebbing rather resulted in sediment erosion. However, the alternating processes of erosion and deposition appear to be balanced thus resulting in a rather stable sandy beach. Rip currents were seldom and the beach is recommended for development as a holiday resort and a tourist centre.

Introduction

The beach is a geomorphological environment which is most dynamic and variable. The eastern flanks of the Nigerian shoreline extending from about Opobo to Bakassi have been poorly studied. Available literatures are scanty and limited to studies by oceanographers and non-geographers who concentrate more on the marine (planktonic) organisms than on physical processes (Ubom & Essien, 2003).

An understanding of the large-scale or small-scale behaviour of the coast is very crucial to the survival of coastal nations and settlements. At least, this is obvious from the recent tsunami experience in Asia. The key to the understanding of the behaviour of the coast is in understanding of local hydrodynamic agents of wind, tides, currents and waves. It is these agencies that actually determine the mode and pattern of movement of both water and materials and the morphology of the shoreline.

Wave action often falls within micro-scale or short term marine processes as it occurs daily, hourly and sometimes in matter of seconds. Waves contribute tremendously in altering the coastline and have a ripple effect on all other bio-physical processes along the shore. It influences the abundance or paucity of micro and macro organisms, sea surface temperatures, salinity, rain fall, etc. It even affects and impact settlement pattern as can be seen in the Lagos bar beach example.

Waves may result in subtle or dramatic changes along the shore. The dramatic changes appear to be of more interest to researchers and this may be attributable to the fact that catastrophic events make more news than constructive ones. Beach change along the Nigerian shores owing to the direct impact of waves is often subtle as a result of wave-swash-oscillations. Information about slow changing beach patterns is rarely documented in the Nigerian Geographical Journal. Yet this is an area that holds a lot of promises to coastal geomorphologists in the country. Of immediate relevance is the fact that the study was actually carried out to evaluate and provide information on the safety of the Ibeno beach for settlement, fishing and industrial activities.

Literature Review

Interest in the characterization of waves has received a boost since the tsunami crises of 2004. Though most of these literatures are not available to the authors, we recognize earlier studies by especially Wright (1976) who established that wave power dissipation is the source of swash oscillation processes and sediment motions all of which affect surface level changes. He equally discovered that the total amount of energy loss by friction increases as wave height increases and as the near shore gradient decreases. Nielson and Hanslow (1991) revealed that wave induced sediment motion consist solely of weak oscillatory agitations and sediment sorting with unidirectional flow transport at the swash zone. Kaphin and Andrew (1995) observed that coastal response to sea level changes and beach surface level changes are indicative of under sea level rise and that shorelines retreat exclusively because of inundation and down-slope movement of sediments. Masselink (1992) considers swash processes as a critical factor in beach surface level changes and general beach morphology. Lawson and Kraus (1995) developed an imperical model to predict cross-shore sediment movement and beach profile evolution as a result of short period breaking waves. Both authors agreed that net transport rate on the foreshore during run-up of individual waves is a function of the local beach slope, sediments and wave swash elements.

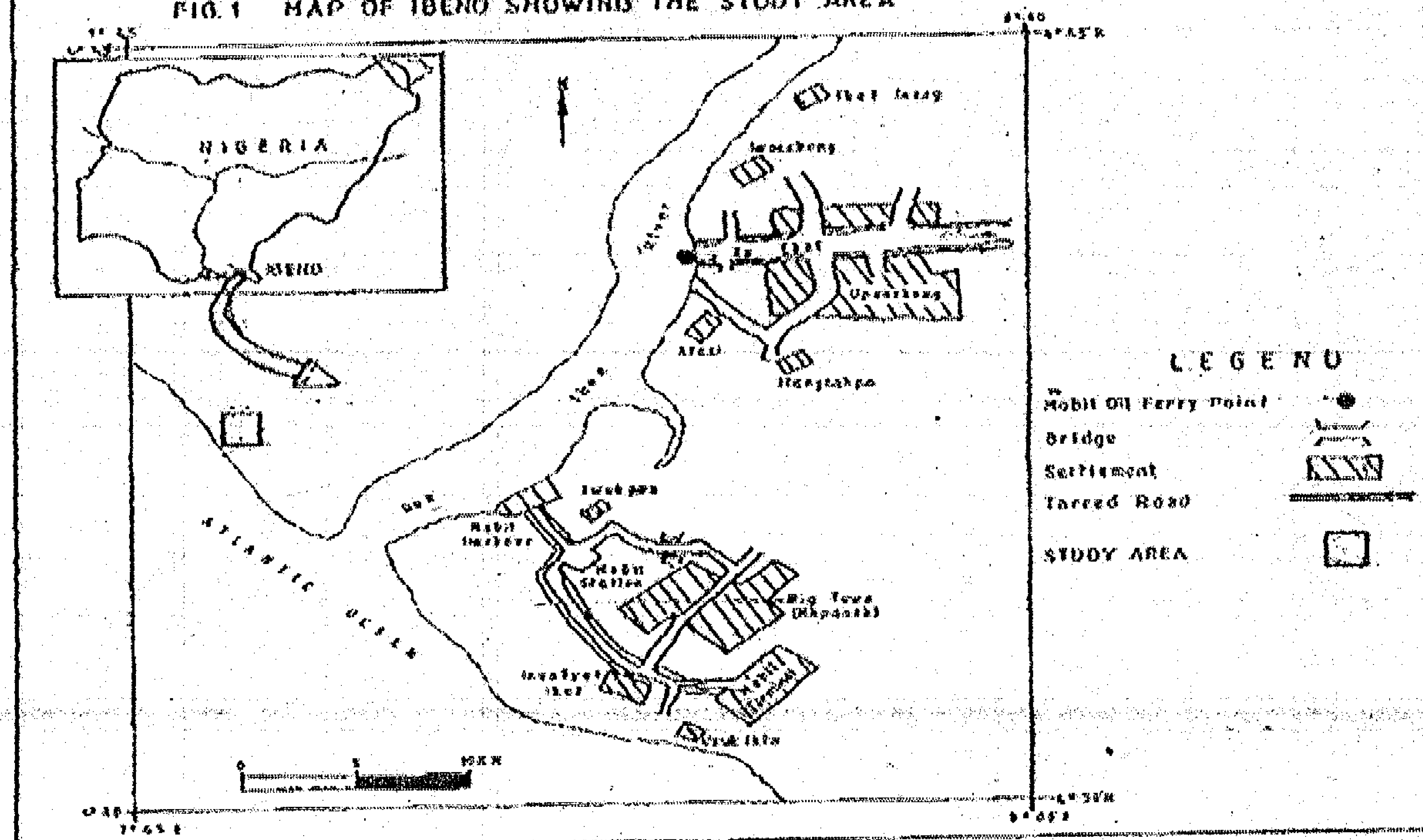
On the Nigerian scene, we consider informative the pioneer works on coastal geomorphology by Pugh (1953), Webb (1958) and Usoro (1977). The first two were European scholars who worked in Nigeria and the last; Professor Etop J. Usoro was the first coastal geomorphologist in Nigeria. His work remains a legacy in the field of coastal geomorphology in this country. It was Usoro (1977) in his study of the Victoria beach, Lagos, who observed that on-shore winds usually raised the level of water near the shore, leading to the formation of return currents seawards. Jeje (1978) using only air photograph interpretation concluded that the Nigerian shoreline from West to East share the same morphological characteristics and possibly experienced the same geological and geomorphological evolution processes. He also observed that the details of these processes are yet to be unraveled. The total lack of geomorphological equipments and laboratories in most of Nigerian Universities has made this task very difficult. This Study is an attempt to contribute in this direction.

STUDY AREA

This study was conducted in Ibeno beach located along the South-Eastern Coast of Nigeria (Fig.1). The beach is located between latitude $4^o.30^1$N and $4^o.45^1$N and longitude $7^o.45^1$E and $8^o.00^1$E. It is situated in Akwa Ibom State of Nigeria in Ibeno Local Government Area of the South Eastern Nigeria Coastline. It is hydrologically, geographically, and climatologically speaking, part of the Niger Delta region. Ibeno is bounded in the North by Eket LGA, in the South by the Atlantic Ocean, in the West and East by Qua Iboe River estuary. The study area is exactly 760m west of the mouth of the Qua-Iboe River Estuary. Geologically, the environment is underlain by coasted plain sands, composed mainly of sediments of marine and lagoonal materials and the entire topography is a monotonous gentle plain of sand whose slope rarely exceeds 4^o. The landscape is generally flat and low lying (Fig.2a). These sandy beaches are fringed by tidal and flats and mangrove swamps. The dominant mangroves include *Rhizophra racemosa*, R. *hairisonii*, R. *mabgle*, *Nypa fructicans* (Ubom & Essien, 2003).

The climate is typically humid tropical with double-maxima rainfall and annual totals exceeding 4021mm. Average humidity is 80 percent with minimum and maximum temperatures of 22°C and 30°C respectively (Ukpong 1955 quoted by Ubom & Essien, 2003). Winds are predominantly on-shore with average velocity of 6-9m/s (Ukpabi, 1995). The Ibeno people are predominantly fishermen. Dominant species of fishes caught in the area include catfish, bonga, barracuda, shrimps, prawns and crayfish.

FIG. 1 MAP OF IBENO SHOWING THE STUDY AREA



Settlements such as Mkpanak, Inuaeyet, Iwuokpam, Uwoachang, Upenekang, Itak Abasi, etc. exist. The beach examined is located at Itak Abasi, the updrift section of the Ibeno beach which is relatively undisturbed by settlements. Generally speaking, the Ibeno beach is the economic life wire of Akwa Ibom State and the operational base of Mobil Producing Nigeria, Unlimited, a multinational oil company (Fig.2b).

Experimental Design and Data Collection Procedure

The study was carried out in a littoral cell located 750m away from the mouth of the Qua Iboe estuary. The littoral cell consisted of seven (7) monitoring stations, 10 meters apart as shown in Fig.1. Each station consisted of a graduated staff of 1.2m pinned at 90o to the ground from the berm edge to the lower foreshore. By using a reference level and the shore line, wave-swash oscillation periods were determined through a stop watch electronic device for the recording of swash stroke per peg, per unit of time which was mainly in seconds. Swash oscillation period were tabulated with cumulative period differentiation applied to determine relative swash per storm surge and backwash. The pegs were experimentally placed to indicate beach surface accretion and erosion in relation to sediment transport on the foreshore under the influence of swash processes. The sediment accumulation or loss at the base of each peg was used to determine the rate of deposition and / or erosion. This was done by obtaining the difference between the initial length of each peg (L_o) and the final length (L_1) after the swash process of a storm surge and backwash. The new height of peg after a storm session was designated L_2 and the difference in height was called L_3.

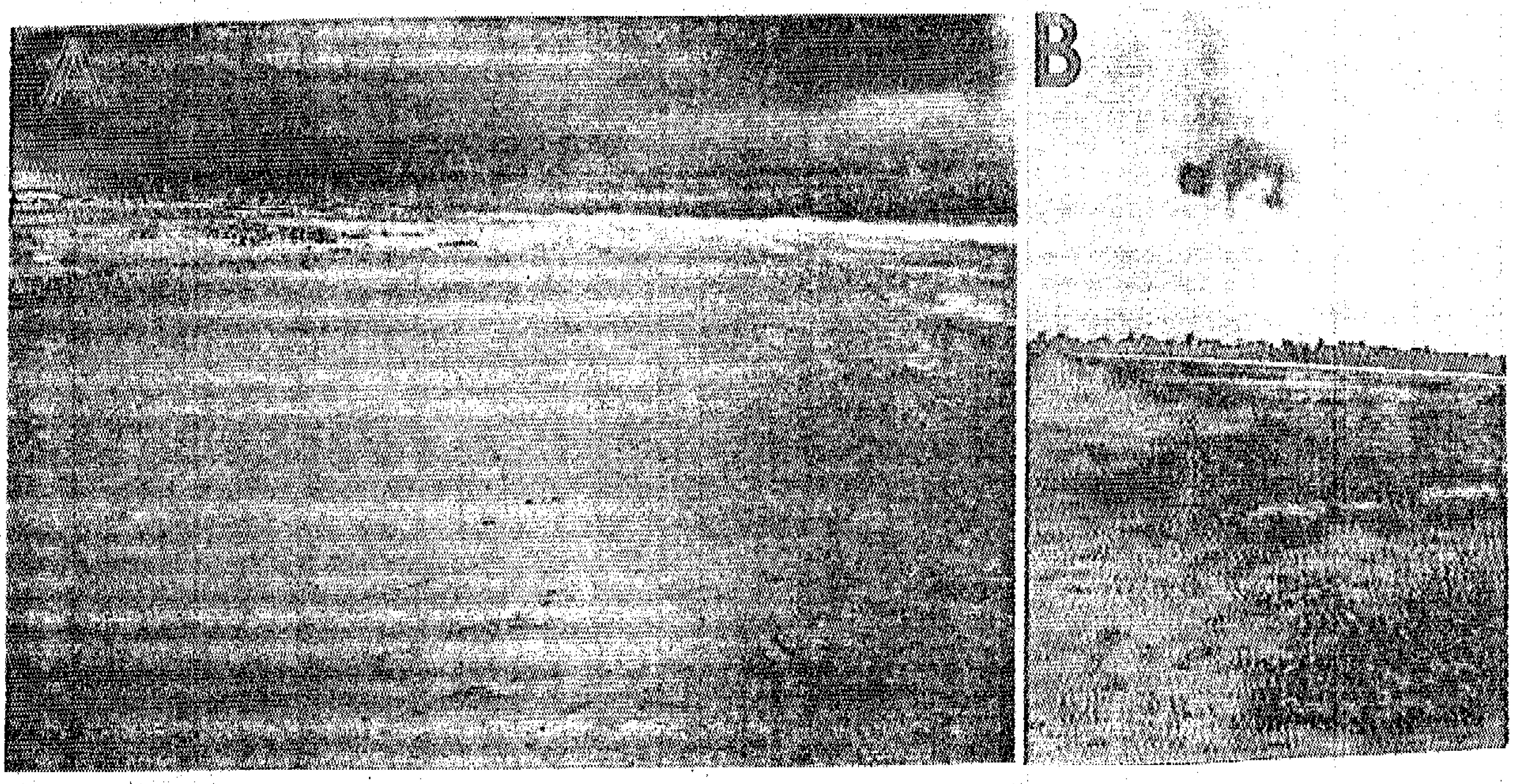


Figure 2: (A) Ibeno Beach: An extensive, stable shoreline and potential tourism haven.
(B) Ibeno: An oil producing beach.

Wave parameters such as wave length (W_H), breaker height (W_B), water depth (W_D) and tides were measured with staffs which were graduated in centimeters. The stop watch electronic device was used to measure wave period (W_P) and wave breaker period (W_{BP}). Recording was done on the basis of wave swash contact with each peg for two weeks, precisely from 7th July 1997 to 21st July 1997. Beach profiles were obtained using the stake and horizon technique of Emry (1961). The profile was clearly demarcated into beach morphozones namely, the back shore, the berm, upper, middle and lower foreshores. Specific wave measurements were performed at the surf zone which was about 80m from the shore line using metre tapes, calibrated staff, a compass and anemometer for wind velocity.

Results and Discussion

The main features of wave parameters of the Ibeno beach are listed in table 1.

The Ibeno waves revealed a maximum wave height (WH) of 92 cm and a minimum of 54 cm. The wave breaker height (WBH) ranged between 66 cm to 102 cm. Wave angle did not exceed 5° and we observed that wave period did not exceed 7 seconds. Wind velocity on the average was 3.3m/s^2 plots of the wave period and wind velocity are shown in Fig. 3a and 3b respectively.
The water height above water depth was obtained for the period of study and the result is displayed in table 2 and plotted in Fig. 4.

Table 1: Wave Parameters of Ibeno Beach.

Days	WH Wave Height cm	WBH Wave Breaker Height cm	WD H2 Dept. cm	WP Wave Period s	WV Wind Velocity m/s	WA Wind Angle	Plunge	Spill
1	66	74	36	5.6	$3.4m/s^2$	5^o	3	7
2	58	66	38	4.9	$3.0m/s^2$	3^o	3	7
3	82	100	48	6.1	$3.1m/s^2$	4^o	3	7
4	92	102	68	4.2	$3.2m/s^2$	3^o	4	6
5	64	82	58	4.5	$3.0m/s^2$	3^o	3	7
6	62	78	48	2.9	$4.0m/s^2$	4^o	4	6
7	60	88	48	3.2	$3.5m/s^2$	3^o	4	6
8	54	84	47	6.3	$2.0m/s^2$	4^o	4	6
9	64	84	49	4.8	$3.6m/s^2$	4^o	5	5
10	72	90	55	5.2	$3.5m/s^2$	3^o	4	6
11	69	101	54	4.6	$4.0m/s^2$	0^o	4	6
12	59	88	46	4.1	$3.2m/s^2$	2^o	5	5
13	68	89	52	3.9	$3.4m/s^2$	4^o	3	7
14	70	98	53	4.8	$3.4m/s^2$	3^o	7	3
X	= 67		50	4.7s	$3.3m/s^2$	3^o	4	6

Source: Fieldwork by Authors

The variation in water level was monitored and is shown in table 4. The table shows wave height (WH) and wave depth (WD) for the period of the study. The wave height over water depth (WH/WD) was computed for the 14 days to assess the mean water energy dissipation. This was observed to be high within the first 4 days but stabilized for most days of the experiment (See the 5th to the 14th day). It should be noted that high water energy dissipation is a factor in the formation of wave-swash oscillations and certain morphological changes experienced at the lower foreshore (Lfs). The low and stable mean water-energy rhythm is a reflection of a stable beach in equilibrium with other environmental elements. The graphical analysis makes the picture clearer (fig.5).

Table 2: Water Height and Depth in Ibeno

	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th
W.H	66	68	82	92	64	62	60	54	64	72	69	59	68	70
W.B	36	38	48	68	58	48	48	47	49	55	54	46	52	53
WH/WD	1.8	1.5	1.7	1.4	1.1	1.3	1.3	1.1	1.3	1.4	1.3	1.3	1.3	1.3

The waves showed a significant rise on the 3rd and 4th day. This may be attributed to tidal fluctuations. Precisely, on the fourth day, the wave height and water depth were highest recording 92 cm and 68 cm respectively. The lowest water depth occurred on the 1st day (36 cm). The tidal flow however regulated the wave regime.

The swash oscillation process was also rather interesting. Surface sea level changes affected the swash process as was to be expected. The swash contact with pegs occurred gradually as the sea level rose and storm surge increased. The contact became regular with the pegs as swash periods became regular and gradually decreased with decrease in sea level, flood fluctuation and ebb factors. The swash contact with pegs occurred mainly in seconds of 0-20 seconds before passing on to the next pegs.

Fig. 3a: WIND VELOCITY

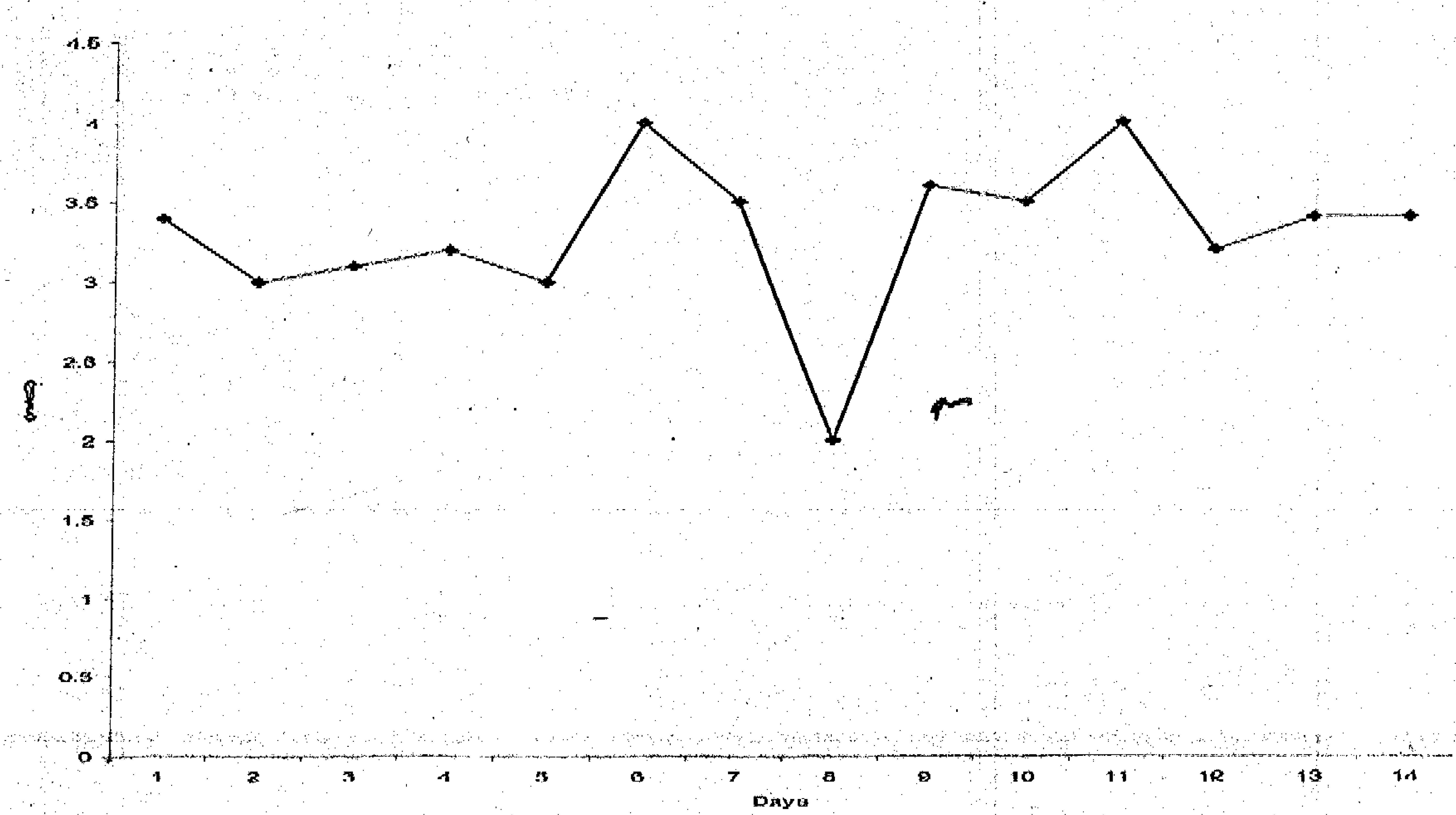


Fig. 3b: WAVE PERIOD

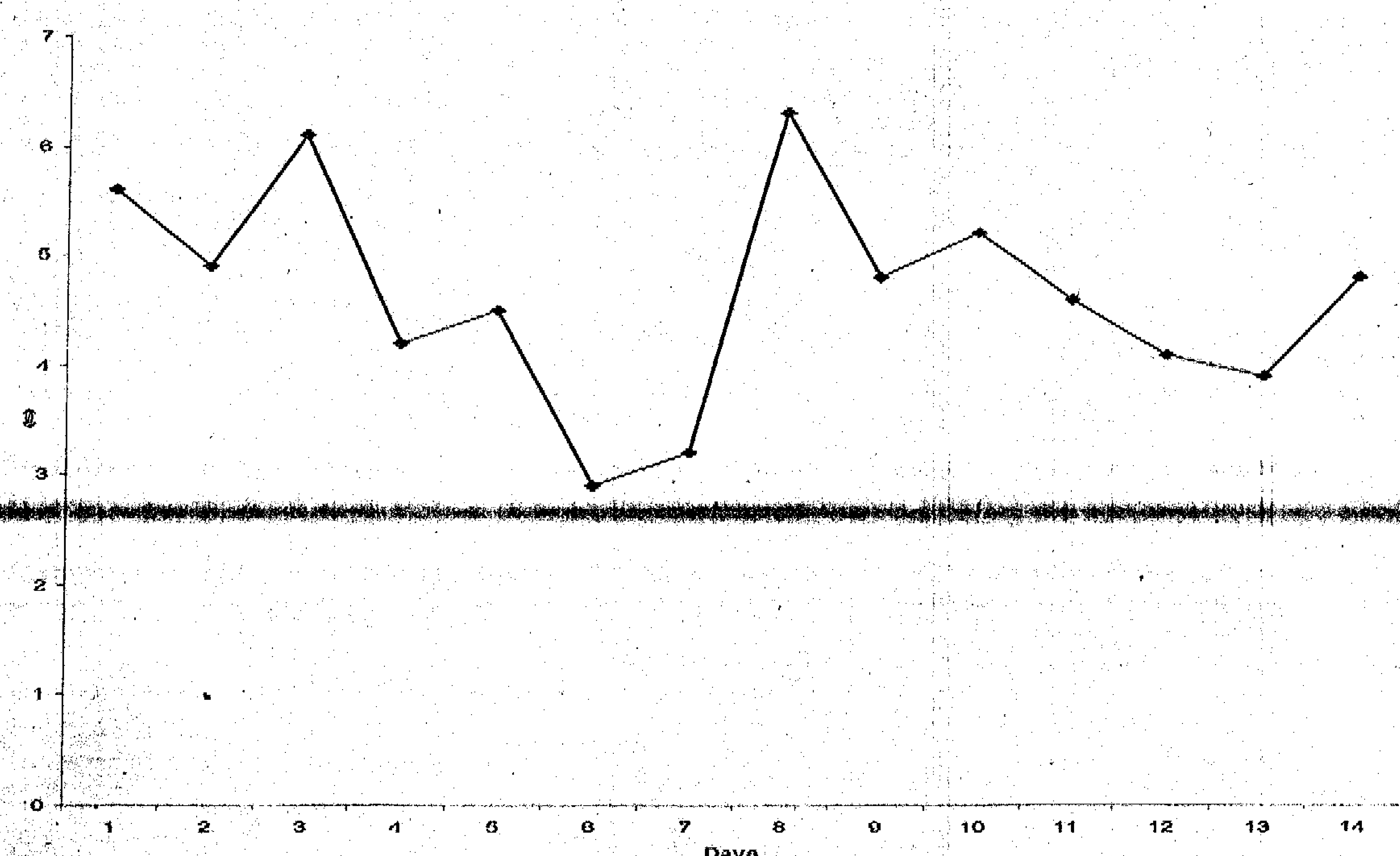


Fig. 4: Water Height in Ibeno Beach

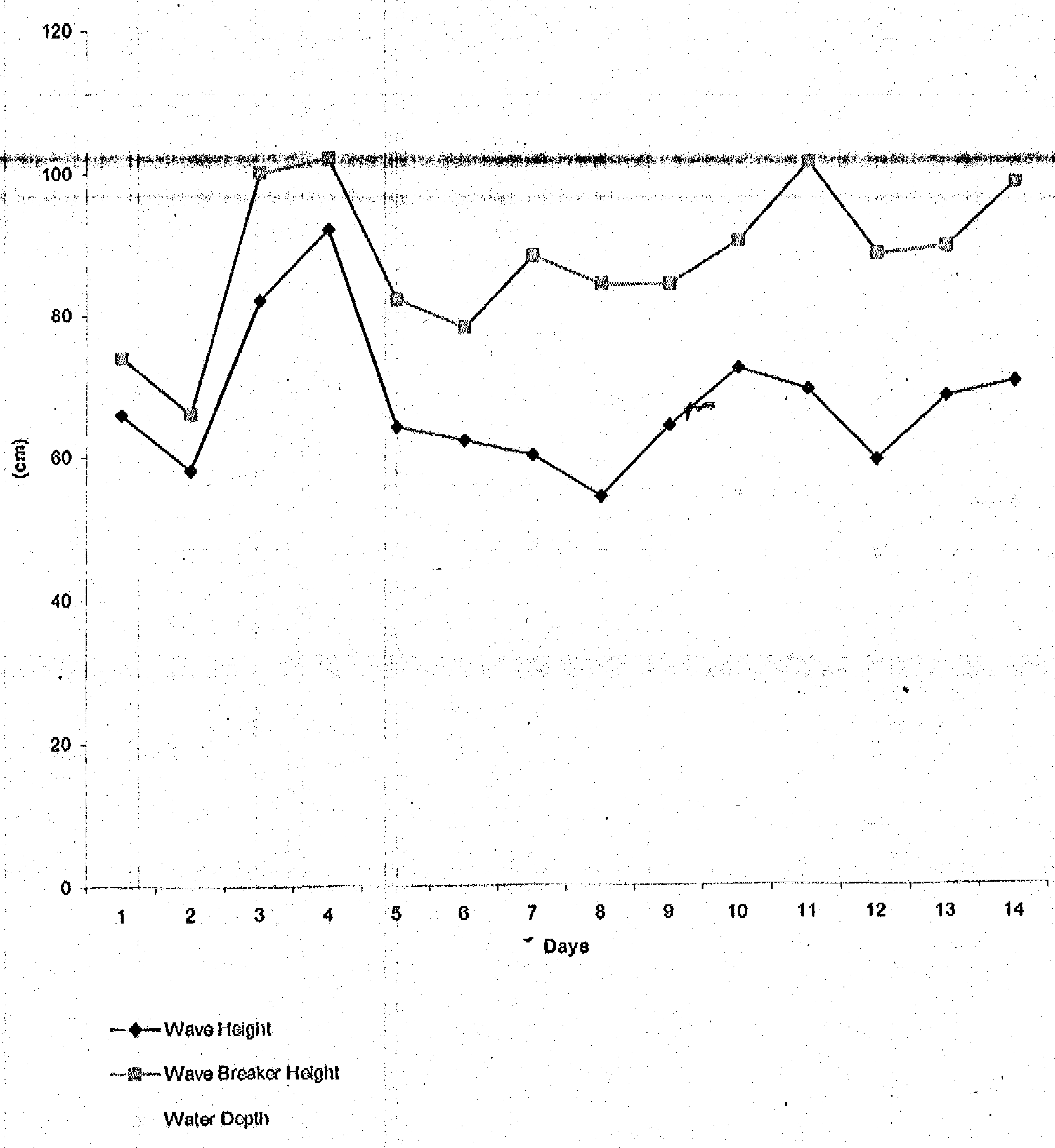
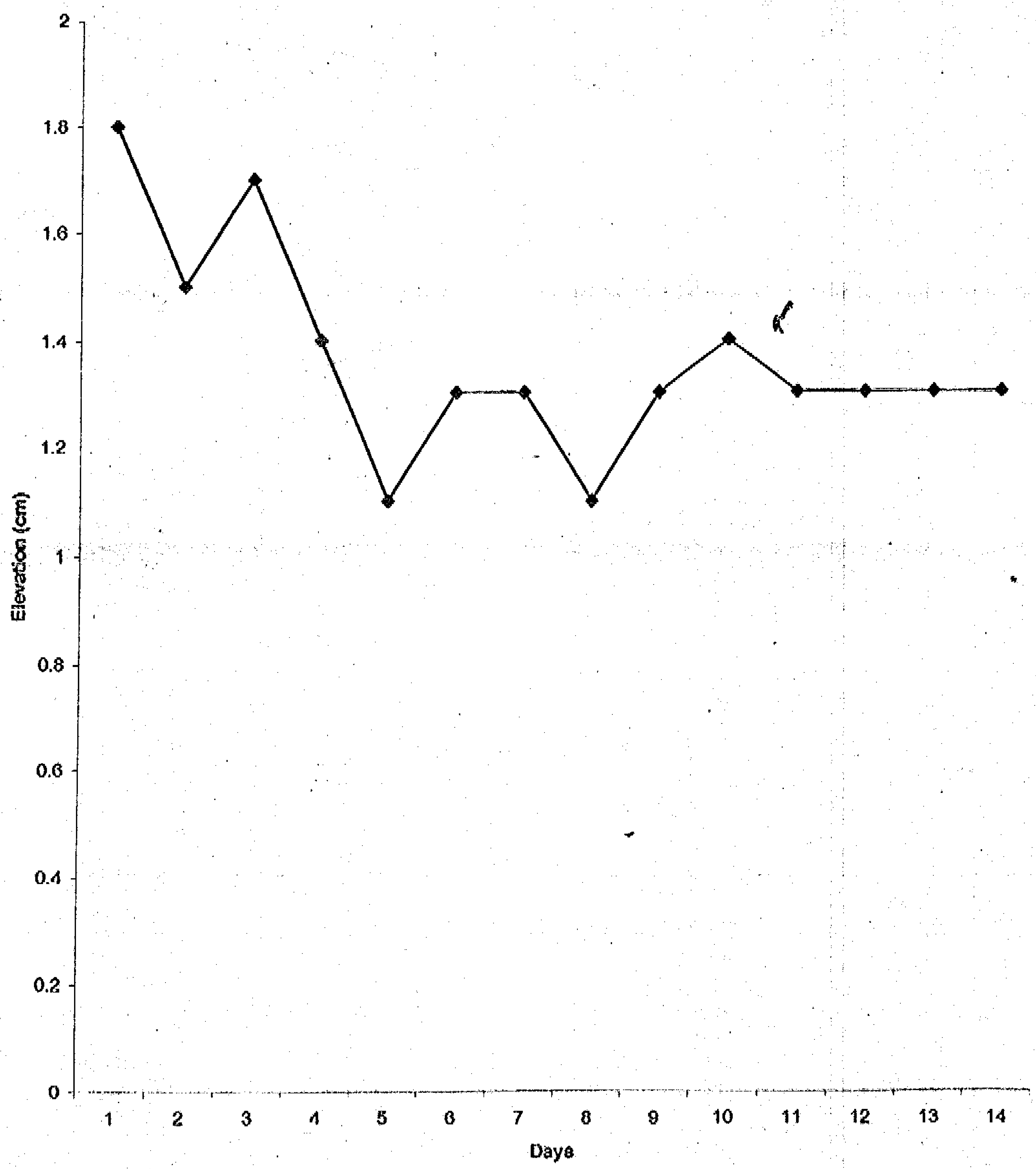


Fig.6: Water Energy Dissipation



A daily average of 400 swash period readings was observed during storm surges and 900 swash periods were recorded as backwash or ebbing. The first peg (peg 1) had the highest number of swash contacts during ebbing (160 contacts). In general, pegs 1, 3 and 4 received the highest swash contacts in the first day of the experiment while pegs 3, 4, and 5 dominated on the 14th or last day of the experiment. Pegs 3 and 4 on the whole were predominant from the first day to the last day in terms of swash strikes. The reason for this may be attributed to the fact that these two pegs, 3 and 4 were located on a slightly depressed end of the middle foreshore. The gradient therefore contributed immensely to the rapid in-flow of water into these pegs. In terms of sediment accumulation and removal, it was observed that more swash contacts meant more sediment accumulation and build up around pegs 3 and 4. In general, storm surge or floods encouraged deposition of sediments than ebbing. Ebbing rather contributed to sediment erosion. Cumulatively, peg 1 suffered more erosion than all other pegs because it was closest to the shore line. Peg 6 was observed to be an area of alternating process of erosion and deposition.

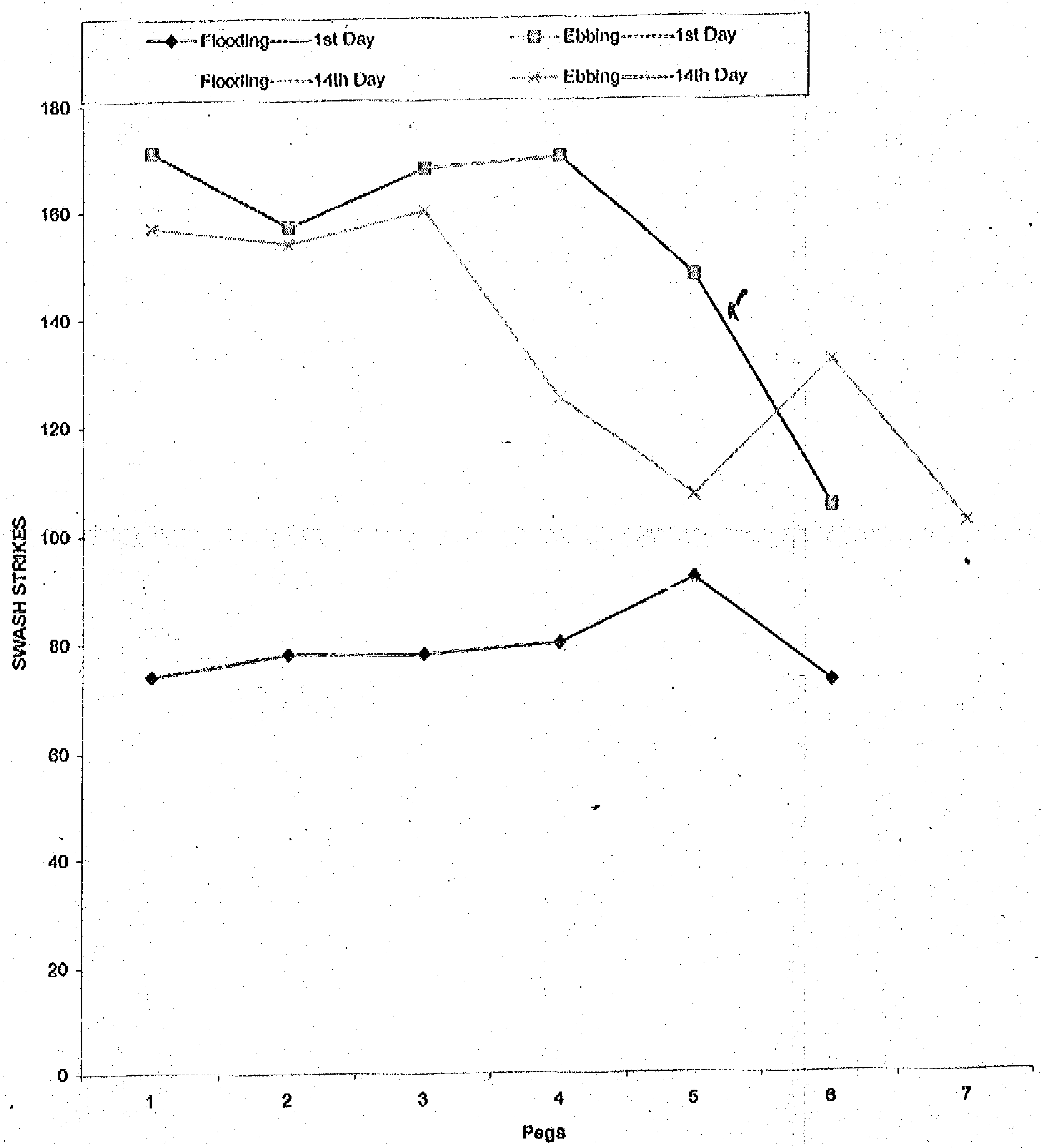
Table 5 : swash oscillation period

	Flooding									Ebbing							
Seconds	P1	P2	P3	P4	P5	P6	P7			P1	P2	P3	P4	P5	P6	P7	(1st DAY)
0-10	20	21	27	28	23	27				92	83	86	85	65	45		
11-20	19	23	21	22	26	14				52	40	43	46	39	29		
21-30	7	9	6	9	10	8				5	13	17	15	17	20		
31-40	16	49	4	8	8	8				4	2	3	5	5	5		
41-50	5	4	7	3	5	3				0	1	2	1	1	0		
51-60	1	1	1	3	5	2				0	2	0	0	0	0		
61-70	2	1	3	1	1	0				1	1	1	2	2	1		
71-90	2	1	0	1	0	0				4	3	4	3	3	4		
81-90	0	1	2	0	2	0				1	3	1	3	2	1		
90	2	8	1	5	2	11				12	9	11	10	14	14		
Σ	74	78	78	80	92	73				171	157	168	170	148	105		

Flooding										Ebbing							(14th DAY)
0-10	42	36	41	44	46	28	25			80	72	74	61	42	58	40	
11-20	20	15	31	20	18	17	15			34	42	48	28	31	41	32	
21-30	4	6	5	2	3	4	6			11	12	14	15	16	10	9	
31-40	4	3	2	0	1	1	2			6	7	8	5	1	2	0	
41-50	2	3	5	2	0	1	4			4	2	1	1	0	3	1	
51-60	1	1	1	0	0	1	2			2	1	0	2	1	0	1	
61-70	2	1	0	1	1	0	1			1	2	3	1	1	0	3	
71-90	0	1	2	1	3	0	2			2	0	1	1	3	0	1	
81-90	1	2	1	1	4	2	0			3	1	1	2	0	1	2	
90	8	9	12	17	18	12	11			14	15	10	9	12	11	13	
Σ	84	69	100	88	94	66	68			157	154	160	125	107	132	102	

Source: Fieldwork by Authors

Fig. 6.0 TREND OF SWASH STRIKES PER PEG



This factor, coupled with the low energy of the waves, has succeeded in keeping the Ibeno beach in a state of dynamic equilibrium. In other words, though swash oscillation contributes to sediment transport along this shore, the geomorphic nature of the coastline and the behaviour of the waves has produced little changes on the beach morphozones.

Conclusion

Our results indicate that the dominant geomorphic process of shoreline alteration in Ibeno is swash oscillation. The areas (pegs) closest to the shoreline 50m – 60m from the shoreline, were most vulnerable. Beach response to the swash process was accordingly a combination of deposition and erosion. The maximum wave height of 92 cm which the waves attained depicts the waves as low energy waves. The breaker waves had a plunging / spilling ration of 4:6. We did not encounter rip (violent) currents throughout the duration of the study. This, however, does not mean such waves, do not exist. They may exist, but are rare or not frequent. In general, the beach can be described as a dissipative beach (Ukpabi 1997, Bauer 1995, Duncan 1964). This study therefore recommends that the Ibeno beach should be developed as a holiday resort or a tourist centre to generate hard and local currency for investors. This information is likely going to benefit the tourism industry in the country, the Ibeno Coastal Community, Marine transporters and Mobil Producing, Nigeria, Unlimited, the major oil concessionaire in the area.

References

[1] Bauer, B. O. A. Jr. (1995) "Beach Steps: And Evolutionary Perspective", *Marine Geology* Vol. 123, Pp. 160 – 167.

[2] Duncan, J. R. (1994) "The Effects of Water Table and Tidal Cycle on Swash – Backwash Sediment Distribution and Beach Profile Development", *Marine Geology*, Vol. 2, Pp. 186 – 197.

[3] Jeje, L. K. (1978) "Geomorphic Features in the Western Half of the Coastal Plains of South Eastern Nigeria", *Nigerian Geographical Journal*, Vol. 21, No. 2, Pp. 153 – 160.

[4] Kaphin, P. A. and Andrew, C. (1995) "Recent Coastal Evolution of the Capsian Sea as a Natural Model", *Marine Geology*, Vol. 124, Pp. 101 – 175.

[5] Larson, M. and Kraus, N. C. (1995) "Prediction of Cross-Shore Sediment Transport at Different Spatial and Temporal Scale", *Marine Geology*, Vol. 126, Pp. 111 – 127.

[6] Masselink, G. (1992) "Simulating the Effects of Tides on Beach MORPHODYNAMICS", *Journal of Coastal Research*, Special Issues, Vol. 15, Pp. 180 – 197.

[7] Nielsen, P. and Hanslow, D. J. (1991) "Wave Run-up Distribution on Natural Beaches", *Journal of Coastal Research*, 7 (4), Pp. 1139 – 1152.

[8] Pugh, J. C. (1954) "A Classification of the Nigerian Coastline", *Journal of African Science Association*, Vol. 1, Pp. 1 – 12.

[9] Ubom, R. U. and Essien, J. P. (2003) "Distribution and Significance of Epipsammic Algae in the Coastal Shore (Ibeno Beach) of Qua Iboe River Estuary Nigeria", *The Environmentalist*, 23, Pp. 109 – 115.

[10] Ukpabi, E. U. (1997) "Beach Surface Level Changes in Relation to Swash Oscillation, Ibeno Beach, South East Nigeria. B.Sc. thesis, University of Calabar.

[11] Ukpong, I. E. (1995) "An Ordination Study of Mangrove Swamp Communities in West Africa", Vegetatio 116, Pp. 147 – 159.

[12] Usoroh, E. J. (1977) "Coastal Development in Lagos Area, Ph.D thesis, University of Ibadan, 1977.

[13] Webb, J. E. (1958) "The Ecology of Lagos Lagoon / The Lagoon of the Guinea Coast", Philosophical Transactions Royal Society Series B, Vol. 683, pp. 307 – 317.

[14] Wright, N. K. D. (1996) "Nearshore Wave Power Dissipation and Coastal Energy Regime of Sydney Jaria Bay Region, New South Wales", *Australian Journal of Marine and Fresh Water Research*, Vol. 27, Pp. 633 – 640.