EFFECTS OF WINDS ON NIGERIAN PORTS AND HARBOURS

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Abstract

This work aims at identifying the pattern of wind in Nigerian coast and its effects on ports and harbour operations. The wind speed, wind direction and wind duration were graphically analyzed. Their effects on near – shore ocean whose driven mechanism is mainly the local wind conditions were discussed and the associated weather phenomena highlighted.

Statistical analysis was used to investigate the nature and characteristics of the coastal winds for the period of ten years, 1997 – 2006. This was carried out on monthly basis, using data from Victoria Island, Lagos. The analysis revealed that winds were predominantly from WSW and WNW directions. Winds from fetch area (lat. 10ºS – 20ºS and long 10ºE - 20ºW) generally increase from East to West with their strength lying between 6-20kts. This agrees with previous works carried out by other scientist e.g. Afiesimama et al (2001). For the period of study, the weakest winds were observed between Oct – Jan while the strongest winds were mostly observed during summer period especially in the month of August which coincides with the period of little dry season.

There were no major interruptions in operations of ports and harbours as a result of direct adverse wind flow. Ports and harbour installations, engineering works, shipping operations, etc however face the risk of being interrupted and some facilities damaged during summer period, if not well protected. Some wind related meteorological factors such as storm surges, fog, thunderstorms etc generally disrupt coastal activities including those of ports and harbours.

1.0 INTRODUCTION

Nigeria coastline is about 853km of the Atlantic Ocean. It is bounded in the west by the republic of Benin and in the east by the Republic of Cameroun. It lies generally between latitudes 4º10` and 6º 20`N, and longitude 2º45' and 8º 35`E adjacent to the gulf of guinea. The elevation of the coastal region lies between 3 - 4 meters above mean sea level. The region geomorphic zones from west to east are; the barrier – lagoon coast, the transgressive mahin mud coast, the Niger – Delta and the strand coast (Fig.1). Victoria Island beach is known to be part of the barrier- lagoon coast of the Nigerian coastline. This is located east of the eastern breakwater (east mole) on the down drafts side of the inlet into the Lagos harbor. To the east of this island are the Kuramo waters and the Igbosere creek and stretches approximately 80km (Ibe 1988). It is bounded on the north by the five cowries and to the south by the Atlantic ocean (Ibe, 1988) where Tin can and Apapa Ports were located (Fig 2). There are busy ferry and barge operations and a growing population engaged in recreational sailing and other water sports.

Wind, earthquake, the volcanic eruption and landslide generates wave while tides are as a result of gravitational attraction of the moon and sun. Winds are by far the most common causes of observed ocean waves (lyons1994). Two air streams affect the weather over the coast of Nigeria especially in the southwest. These are the southwest monsoons, from South Atlantic Ocean, in summer, and the dry and dusty northeast trade from the Sahara anticyclone, in winter. In both northern summer and winter, the dominant air stream is the southwest

monsoon. The winds associated with southwest monsoon are the southwesterly wind Winds over most oceans are classified into light, moderate and strong depending on strength of the wind. The wind stress is more than the wind itself, it determines the exchange of momentum between the Earth and the atmosphere and exerts a strong influence on the typical variation of wind through the lowest kilometer of the atmosphere. Significant stresses arise within the lower atmosphere because of the strong shear of the wind between the slowly moving air near the ground and the more rapidly moving air a kilometer above and because of the turbulent nature of the airflow in this region. Details of the behavior of wind stress in the marine atmospheric boundary layer can be seen in Yelland and Taylor (1995) and chen et al (2000)

In this paper, the focus is on the nature and behavior of the winds speed, direction and duration as they affect port and harbour with emphasis over Nigerian coast. Coastal winds especially over the Nigerian coast have mean velocities between 5- 10knots but more consistent and strong during the rainy season especially when there are squall lines lying over the coast.

There is substantial agreement that the drag of the wind on the sea is small relative to that of a fixed soil surface with the same geometry. It is largely independent of the fetch and so seems to depend less on the larger waves than on the short waves and ripples. Plunging wave at breaking tends to marginally dominate the beach Ibe (1998). Surface – active agents, that affect the shortest waves, may therefore be important.

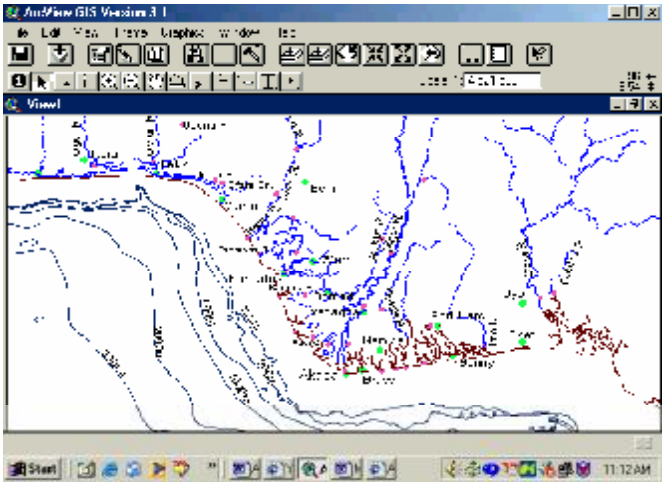


Figure 1: Map of Nigerian Coastal Areas

1.1 GEOMORPHOLOGY OF THE COAST

- The Barrier/Lagoon Coast - Characterized by fringes of mangrove ecosystem along the banks of the Lagos and Epe lagoons and extensive wetlands. Large irregular shaped Lagos and Lekki Lagoons.
- Mahin Transgressive Mud Coast - The inter-tidal zone typically has a slope of 1:50, while beach elevation averages 3m above mean low water level.
- The Niger Delta - The largest delta in Africa and is characterized by approximately 20 km^2 of mangrove swamps at or very close to present sea level.

- The Strand Coast - It is characterized by moderately wide (75 m) gently sloping (1:20) beach face that changes into beach ridge behind, with a few small swamps systems that extend to the shore.

1.2 CHARACTERISTICS OF NIGERIA COASTAL WIND

(1) Two air streams affect the weather over the coast of Nigeria namely:
The **southwest monsoons**, from South Atlantic Ocean, in summer, and the dry and **dusty northeast trade** from the Sahara anticyclone in winter.
In both northern summer and winter, the dominant air stream is the Southwest **Monsoon**.
(2)The wind associated with southwest monsoon are the southwesterly winds
(3)Winds over most oceans are classified into light, moderate and strong which are respectively influenced by trade wind, average cyclone and hurricane weather system (Lyons 1994). The classification is according to the strength
(a) Light 1 - 9kts
(b) Moderate 10 – 19 kts
(c) Strong 20kts and above.

1.3 AREA OF STUDY

The Nigeria coastline is about 853km of the Atlantic Ocean. It is bounded in the west by the Republic of Benin and in the east by the Republic of Cameroon. It lies generally between latitudes 4^0 10' and $6^0$20'N, and longitude $2^0$45' and $8^0$35'E, adjacent to the Gulf of Guinea. A common feature of this coastline is its low-lying nature.

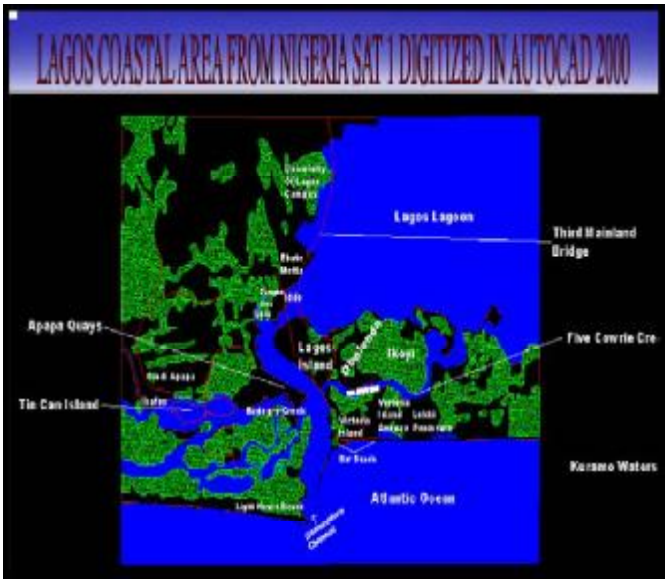


Fig 2: Area of study

2.0 WIND RELATED METEOROLOGICAL PHENOMENA AFFECTING PORTS AND HARBOUR OPERATIONS

Real time information on the nature and characteristic of wind and how they affect the ships could assist the captain / sailors in maneuvering and reducing the risk associated with berthing ships at the ports under adverse meteorological conditions. The wind related phenomena were highlighted below:

2.1 ADVERSE WEATHER AT THE COAST

Adverse weather at coast includes Thunderstorm, Rainfall, fog, dust haze etc

2.1.1 THUNDERSTORM is a typical meteorological phenomenon affecting port and harbor operations.

Cold wind blowing over warm surface of the sea results in formation of convective clouds from which showers and thunderstorm often develops.

Effects

(1) It reduces visibility and could be dangerous to operations and cargoes that are not well protected.

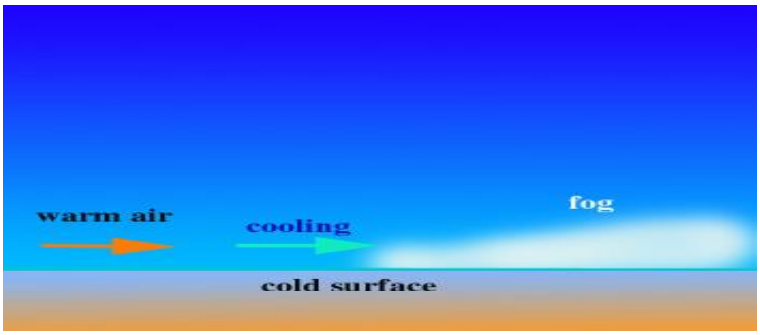
(2) Lightning associated with strong wind disrupt power supplies / radar and electronic installation at the port.

2.1.2 FOG / MIST the interaction of the sea surface and nature of air mass (wind) over it affect the coastal weather.

When warm air flows over cold water, it is cooled from below resulting in cold layer which is nearly saturated, forming mist or fog.

Effects

(1) It is often dangerous to shipping and ports operations like berthing of large vessels.



(2) Fog poses serious problems to coastal engineering work, port and harbour operations especially cargo handling, ship coming in and leaving the ports.

2.1.3 <u>WAVES</u>; Wind wave or Sea waves are waves raised by wind blowing over a stretch of water. Swell are waves that travelled a distance from where they are generated. The waves affecting the Nigerian continental shelf are wind generated with intensities generally determined by the wind velocity, duration and fetch. Plunging waves are dominant in the Barrier-Lagoon coastline in the southwest and the Niger Delta of Nigeria

2.1.4 STORM SURGES are changes in water level generated by storms passing over the sea. They are generated by wind stress acting over the sea surface and by variation of atmospheric pressure. It is the rise and fall of the sea level caused by a meteorological disturbance.

High waves often result in Ocean Surges. Winds play a huge role in the occurrence of a surge.

2.2 EFFECTS OF WAVES & SURGES ON PORTS/HARBOUR

(a)Surges can be very dangerous depending on the severity. Severe waves caused by strong wind could be very notorious to the mariners, coastal dwellers, Ports & harbour as they often result in flooding, coastal erosion, loss of recreational facilities, decreased water quality, damage to infrastructures, interruption of power and communication network, human injuries and loss of lives and property at ports.

(b)With the Atlantic Ocean overflowing its bank, the resulting flooding has become an annual occurrence, adversely affecting Nigerian coast line, ports and harbour activities etc.

(c) Increasing water level during some ocean surges in Nigeria to about 5m (Awosika et al 1995)

(d) Upsetting the ocean mix by creating large wave action. Not only will this upset the bio-diversity in the region but it threatens sea-going vessels and crew, also small fishing trawlers are highly affected during strong wind.

(e) Adverse effects on oil and gas transportation.

(f) Shipping of goods, commercial fish trawling and economic growth of Nigeria is not only retarded, but takes downward spiral thereby increasing poverty and unemployment in the country. (g) Causing serious flooding when an extreme storm surge event occurs.

(h) Decimation of coastal vegetation especially the mangroves.

(i)Uprooting of coastal settlements, and destabilizing coastal infrastructures along the entire coast.

2.3 COASTAL FLOODING

Affected areas

(1) The low lying densely populated areas

(2) Ports and Harbour Area

(3) Poorly defended coastal areas like the Lagos beach and

(4) The Niger delta areas.

The adverse effects of flooding are more apparent when stormy weather coincides with high tides.

Also high rate of erosion at the bar-beach has been linked to the construction of the moles built to stop the silting up of the entrance to Lagos harbour.

2.4 COASTAL EROSION

Result of flooding has led to the decimation of coastal vegetation especially the mangroves. All along the entire coast, erosion is uprooting settlements, and destabilizing infrastructure. Coastal erosion is very prevalent along the Nigeria coastline. The Bar beach in Lagos is the fastest eroding beach in Nigeria with average erosion rates of 20-30m annually. Between 1900 and 1959, the Bar beach retreated by over 1km near the eastern mole, decreasing to

about 400m some 3km eastwards in the area of the Kuramo waters. However, the Lighthouse beach near the western breakwater accreted by over 500m within the same period. This high rate of erosion has been linked to the construction of the moles built to stop the silting up of the entrance to Lagos harbour. Erosion of ground surfaces and the production of waves on water are manifestations of wind stress. Studies carried out by Awosika et al (1993) revealed that Victoria Island and lekki could lose well over 584 and 602 square kilometers of land from erosion while inundation could completely submerge the entire lekki barrier system. According to Asangwe (1993), more than 50 erosion sites have been identified along the 853 km coastline, consequently erosion poses great threats to coastal communities and their economic activities. Identified areas of major erosion along the Nigerian Coastal Zone are: Victoria beach, Awoye/Molume, Escravos, Ugborodo, Forcados, Brass, Bonny, Ibeno-Eket, Ikot-Abasi.

Projected total land loss km^2 due to erosion and inundation (Awosika et al 1992).

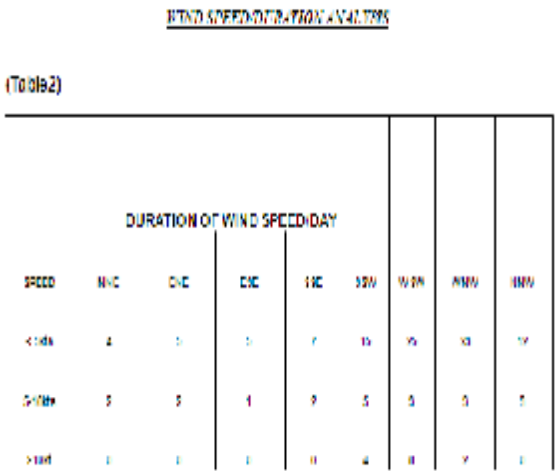
	LOW ESTIMATE				HIGH ESTIMATE			
SLR	0.2m	0.5m	1.0m	2.0m	0.2m	0.5.m	1.0m	2.0m
Barrier	177	284	584	1167	118	289	602	1204
Mud	403	1008	2016	3456	403	1008	2016	3456
Delta	2846	7453	15125	18398	2865	7500	15332	18803
Strand	79	197	395	575	85	212	446	677
Total	3445	8942	18120	23596	3471	9009	18396	24140

3.0 ANALYTICAL METHODS

3.1 **Data Collection.** Daily Wind speed & direction data at 0900z were obtained for a period of 10 years 1997 -2006, from Marine Met station at Victoria Island near Lagos harbour. The same meteorological phenomenon at east mole marine station is applicable to Apapa and Tin can Island ports. This station is meant to service these ports.

3.2 Data Analysis.

- Daily wind speed and direction at 0900z were graphically analyzed on monthly basis using the mean values and Relative frequency of occurrence analysis (empirical approach) in determining the proportion of times that a particular wind strength and direction occurs for the period considered.
- Analysis of speed, direction and duration of the wind were also carried out to determine the pattern of flow and strength of the wind in the coastal area.
- Statistical speed- duration analysis of the wind data was also carried out to determine the average duration that the wind of a specific speed blew from a certain direction.



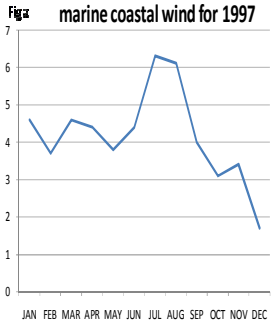
(Table2)

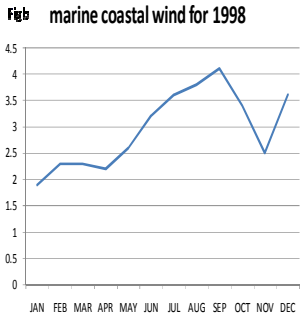
	DURATION OF WIND SPEED/DAY							
SPEED	NNE	ENE	ESE	SSE	SSW	WSW	WNW	NNW
< 10kts	4	3	3	7	15	15	13	14
10<20kts	3	3	4	9	5	5	5	7
>20kts	1	1	1	11	4	8	7	1

4.0 RESULT

4.1 WIND SPEED/DIRECTION ANALYSIS: The analysis for the period is shown in table 1 and reveal some key features. Fig.(a-j) and Fig.k show the mean monthly analysis and the frequency of occurrence for the period respectively. Winds blew predominantly from WSW and WNW direction (Fig l) during the period considered and there were no cases of wind speeds greater than 19kts on the average. Within the period under study, the weakest winds speed were observed between Oct – Jan. while the strongest winds were mostly observed in the month of August.

4.2 DURATION ANALYSIS: average duration for the wind from various directions are shown in table 2. The longest average duration of 34% was found in the WSW direction, this was for wind speeds lower than 10kt (light wind). An average duration of 8 % and 4% was found for wind speeds of above 10kts but less than 20kts in the WSW and WNW direction respectively. For wind speeds greater than 10kts have longest average duration of 8 % and it is in the WSW direction. The results indicated that the wind blew more frequently in the WSW direction (Fig m).


marine coastal wind for 1997
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC


marine coastal wind for 1998
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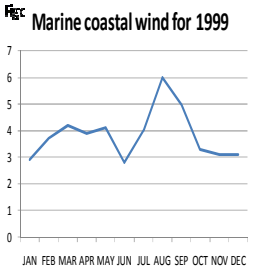
Marine coastal wind for 1999
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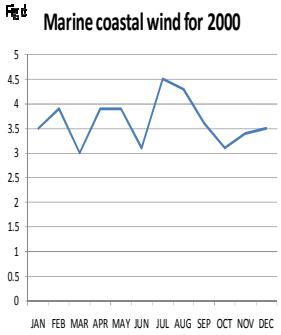
Marine coastal wind for 2000
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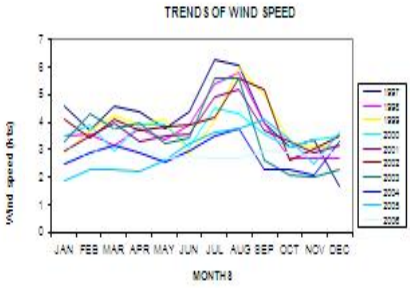
TREND S OF WIND SPEED
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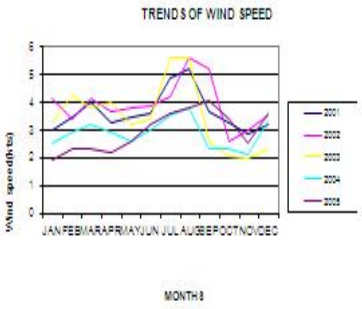
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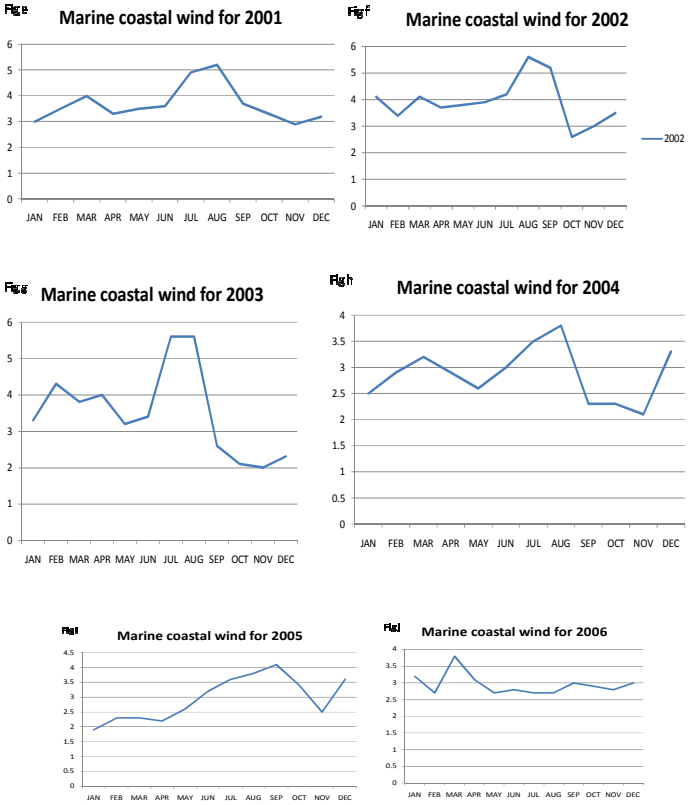
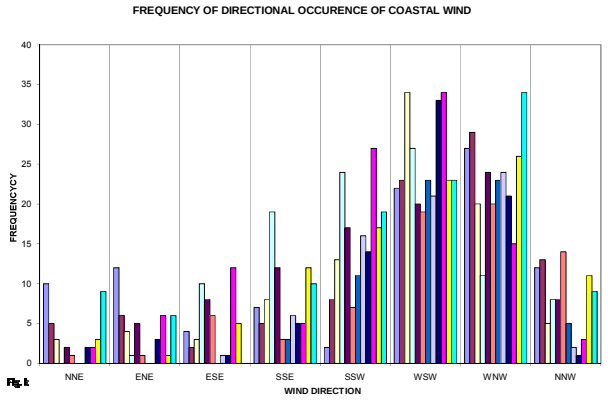


Fig a-j : shows mean wind speed for the period under study (1997-2005).



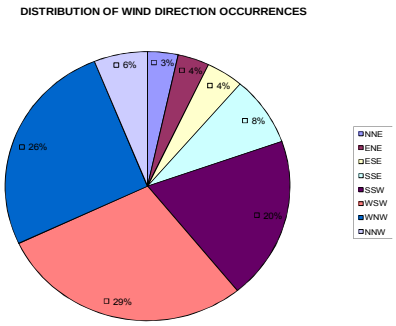


Fig. 1

CONCLUSION / RECOMMENDATION

- The effects wind has over the ports and harbor areas have been investigated. The analysis has revealed the pattern of the wind speed, direction and duration at the near – shore ocean. The wind blew predominantly from WSW and WNW direction. Generally, Nigerian coastal area experiences mainly the south westerlies which are onshore and confined to azimuths of 215º - 266º with velocities of 2-5m/s.
- The result indicated that coastal wind during the summer months could cause damages to port operations if not well protected. Also the weather condition resulting from coastal wind could affect everything from shipping, the operation of offshore structures, the breaking up of oil spill and coastal users etc. Uncontrolled felling of mangroves renders the coastal environment very susceptible to erosion and flooding since mangrove trees tend to reduce the impact of waves, tides and long shore currents along the coast. Mangrove trees also trap sediments brought in by tidal currents.
- Further research into the nature and characteristic of wind speed, wind direction and duration along the entire coastal area of Nigeria as it affect ports operations will enable more quantitative results to determine the socio economic impact this could have on ports operations in other to help in policy making and for proper functioning. Technical, Engineering and Structural Adaptation Strategies at the port that could be applied for optimal coastal protection and operation includes the use of protective devices or responses, which emphasizes the defence of vulnerable areas such as population centers, economic activities and natural resources. They include dikes, levees, flood walls, sea walls, revetments, and bulkheads, groins, detached breakwaters, floodgates and tidal barriers.

❖ Also the funding of appropriate meteorological and oceanography activities will provide relevant advice that will ensure efficient management and utilization of coastal resource for sustainable development.

REFERENCES

Asamgwe, C. K. (1993): Issues and Problems in Controlling treats of erosion along Nigerian Coastline: In Coastline of Western Africa, American Society of Civil Engineers pp 309 - 324

Awosika, L. and Folorunsho, R., 1995: Storm surges and Flooding of the Victoria Island on 17 August 1995.

Chen W. and Banner, M.L.,2000: The southern ocean waves experiment. PartII: Surface response to wind sped and wind stress variations. J. Phys. Oceanography., 3, 174-198.

Ibe, A.C. 1988: Coastal erosion in Nigeria. Ibadan University press, Ibadan. pp 217.

Olaniyan, E., and Afiesimama, E.A., 2002: On marine winds waves and swells over the west African coast for effective coastal management: a case study of the Victoria Island beach. Proceedings of Ocean 2002 MTS/IEEE conference oct 29-31 Biloxi, Mississippi. Pp561-568.

Lowe et al 2001: Changes in the occurrence of storm surges around the United Kingdom under a future climate scenario using a dynamic storm surge model.

Lyons, S.W 1994: Marine waves swells and winds. NOAA/NWS/SRH pp1-60.

Yelland Mandy Taylor K.P., 1995: Wind stress measurements from the open ocean