Pyrex Journal of Geography and Regional Planning

Pyrex Journal of Geography and Regional Planning
Vol 3 (4) pp.25-31 October, 2017

http://www.pyrexjournals.org/pjgrp

*Full Length Research Paper*

# The Importance of Gauge Stations along Nigerian Coastline

**Yiinu Needam[1] and Felix Ogbonna[2*]**

[1]Department of Surveying Ken Saro Wiwa Polytechnic Bori Rivers State, Nigeria.
[2]Department of Surveying and Geoinformatics, Nnamdi Azikiwe University Awka Anambra State, Nigeria.

Email: Felix_chuks82@yahoo.com

Accepted 27th September, 2017

***Abstract***

**According to World hydrographic day (2015), Man is turning increasingly towards the sea and oceans for resources. The seas and oceans are now acknowledged as a major contributor to the world economy and well-being. Over 90% of the world's trade travels by sea. In addition, the seas and oceans, including the seabed and the sub-seabed, represent a vast resource for food, mineral resources, energy, water, bio-medicine, and infrastructure. The safety and protection of life and properties of the people that are living or doing business along the coastline cannot be taken lightly, but that is not the case in some of the developing countries including Nigeria, where the majority of the locals does not have the basic knowledge of the characteristics of water and the danger this may pose to them. The government and the various agencies have not fully followed the required system of making sure that the necessary infrastructures are put in place to check and maintain a coordinated up to date information system. This paper looks to enumerate the importance of establishing gauge stations along the Nigerian coastline with the view of a coordinated information acquisition and sharing, which in turn will increase the awareness of both the Government, agencies and the locals directly involved.**

**Keywords:** Water, Wave, Ocean Current, Tide, Gauge Station.

## INTRODUCTION

It is quite disturbing that many countries around the world, most especially the African continent lack awareness in hydrographic operations and serious studies. And this has remained a plaguing problem in the developing countries including Nigeria, according to Oliver Chinagoro Ojinnaka, in his publication at FIG Working Week 2013; Hydrography in Nigeria and Research Challenges. In Nigeria, hydrographic operations have often been limited to profit-oriented projects and uncoordinated studies which are scattered across the nation. Several aspects of national hydrography continue to pose problems without visible solutions. The case of a planned or systematic program to address the nation's need in hydrography has continued to remain a mirage. The numerous problems which have continued to demand attention include but are not limited to the following:

Corresponding author email: Felix_chuks82@yahoo.com

i. Comprehensive charting of the nation's coastal waters and estuaries
ii. Systematic study of the tidal pattern along the Nigerian coastlines and estuaries and establishment of surge monitoring systems.
iii. Establishment of Institutional framework for hydrographic education and practice.

Water is actually very essential to every living thing; therefore every hand must be on desk to make sure that the relationship between water bodies and man is maintained and preserved for the future generation. To maintain this relationship, man has developed some devices which are helping him get in touch with what is happening out there in the water. One of them is water gauge or simply put, gauge station. A gauging station is a location used by hydrologists or environmental scientists to monitor and test terrestrial bodies of water. Hydrometric measurements of water level surface elevation ("stage") and/or volumetric discharge (flow) are generally taken and observations of biota and water quality may also be made. From the continuous records obtained at these stations, hydrologists make predictions and decisions concerning water level, flood activity and control, navigation, and the like. There are a lot of different types of gauges in existence worldwide today; an example is a staff gauge, mechanical gauge, pressure gauge etc.

## WATER COMPARED TO LAND

How large is water compared to ordinary land surface? To answer, this let's look at it from two perspectives; The first is the more general about 70% of Earth is water while about 30% island (US Geological Society). The second is the more specific 71% of Earth is water while 29% is land. Both will serve, depending upon your need and aim. The interesting thing is that the percentage of water on Earth does not include only the obvious sources of water, like oceans and lakes, but less obvious sources as well.

The totality of Earth's water is comprised of water in the oceans, water in the air, water in frozen icecaps and glaciers, water in underground aquifers, and water in lakes, rivers and ponds. The largest portion of all this water is found in oceans and seas--being saline water--which hold between 96.5% and 97.5% of all water. That leaves between 3.5% and 2.5% distributed between all Earth's freshwater sources, including water vapor in the air and water in occupants of Earth (US Geological Society). The Earth's hydrologic cycle, the movement of water from Earth to air to Earth's occupants, keeps the water circulating and going through various hydrologic phases, liquid, vapor and frozen forms such as snow and ice.

If the water above ground, *saline and freshwater*, on Earth is measured by volume, the total volume would cover about 1,064 miles in diameter and more than 335,000,000 cubic miles. The third greatest source of water, after (1) oceans and seas and (2) icecaps and glaciers, is ground water, or aquifers. The volume of aquifer water is about 5,614,000 cubic miles. Compare this to the second greatest (icecaps, glaciers) at about 5,773,000 cubic miles. These volumes are surprisingly close while saline ocean water bears no comparison at all, with a volume of 321,000,000 cubic miles. About 30%**,** then, of Earth's total freshwater are ground aquifer water or about one-third the amount frozen is icecaps and glaciers. Rivers constitute the smallest volume of Earth's water--aside from biological water in Earth's occupants--with a volume of 509 cubic miles.

## THE CLASSIFICATION OF WATER MOVEMENT

There are different types of movements of ocean water under the influence of different physical characteristics like temperature, salinity, density, etc. Movements of ocean water are also affected by external forces like the sun, moon and the winds. The major movements of the ocean waters can be classified into three. They are:

1). Waves
2). Tides
3). Ocean Currents

Waves and the ocean currents are horizontal movements of ocean waters while the tide is a kind of vertical movement of the ocean water, (www.ClearIAS.comJuly 20th, 2016).

### 1). Wave

Waves are generated by forces that disturb a body of water. They can result from a wide range of forces - the gravitational pull of the sun and the moon, underwater earthquakes and landslides, the movements of boats and swimmers. The vast majority of ocean waves, however, is generated by wind. Out in the ocean, as the wind blows across a smooth water surface, air molecules push against the water. This friction between the air and water pushes up tiny ridges or ripples on the ocean surface. As the wind continues to blow, these ripples increase in size, eventually growing into waves that may reach many meters in height. (The Coastal Data Information Program publication 2017)

Waves are a kind of horizontal movements of the ocean water. They are actually the energy, not the water as such, which moves across the ocean surface. This energy of the waves is provided by the wind. In a wave, the movement of each water particle is in a

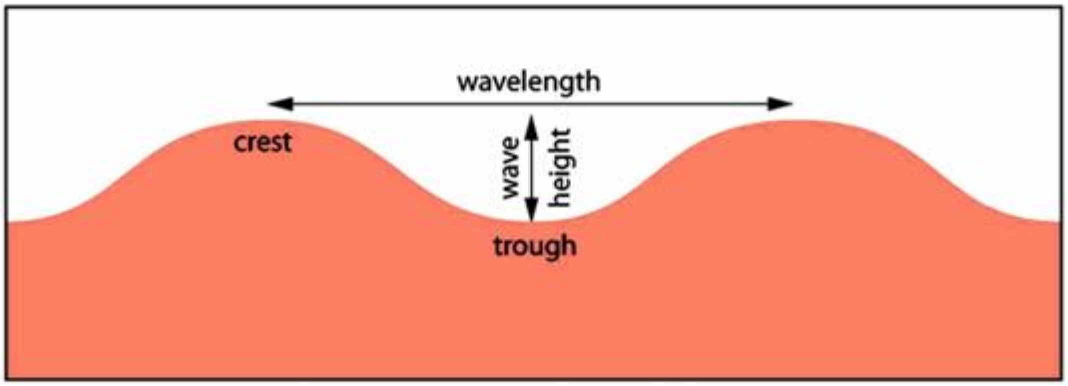


Figure 1. Showing crest, trough and wavelength
**Source:** (www.ClearIAS.com July 20th, 2016)

circular manner. A wave has two major parts: the raised part is called as the crest while the low-point is called as the trough, as described by the diagram in figure 1.

### i). Wave height

For a *sine wave*, the wave height $H$ is twice the amplitude
For a *periodic wave* it is simply the difference between the maximum and minimum of the surface elevation $z = \eta(x - c_p t)$:with $c_p$ the phase speed (or propagation speed) of the wave. The sine wave is a specific case of a periodic wave.

In random waves at sea, when the surface elevations are measured with a wave buoy, the individual wave height$H_m$ of each individual wave with an integer label m, running from 1 to $N$, to denote its position in a sequence of $N$ waves—is the difference in elevation between a wave crest and trough in that wave. For this to be possible, it is necessary to first split the measured time series of the surface elevation into individual waves. Commonly, an individual wave is denoted as the time interval between two successive downward-crossings through the average surface elevation (upward crossings might also be used). Then the individual wave height of each wave is again the difference between maximum and minimum elevation in the time interval of the wave under consideration.

Significant wave height$H_{1/3}$, or $H_s$ or $H_{sig}$, in the time domain, is defined as the average height of the one-third part of the measured waves which are $N$ in number—having the largest wave heights: with $H_m$ the individual wave heights, sorted in such a way that the highest wave has $m$=1 and the lowest wave is for $m$=$N$. Only the highest one-third is used, since this corresponds best with visual observations of experienced mariners: eyes and brain apparently focus on the higher waves seen. Significant wave height $H_{m0}$, defined in the frequency domain, is used both for measured and forecasted wave variance spectra. Most easily, it is defined in terms of the variance$m_0$ or standard deviation $\sigma_\eta$ of the surface elevation: where $m_0$, the zeroth-moment of the variance spectrum, is obtained by integration of the variance spectrum. In case of a measurement, the standard deviation $\sigma_\eta$ is the easiest and most accurate statistic to be used. Another wave-height statistic in common usage is the *root-mean-square wave height* (or *RMS wave height*) $H_{rms}$, defined as: with $H_m$ again denoting the individual wave heights in a certain time series. (Source: Wikipedia 31 March 2016, at 08:35).

### ii). Wave measurement

The wave is measured using some self-recording instruments, example Buoy. Buoys ride on top of the ocean surface. Equipped with accelerometers to record their own movements, buoys rise with the wave crests and fall with the troughs. Since buoys are always floating on the sea surface, by recording their own movements they are in fact recording the movements of the sea surface. Readings from the accelerometers inside the buoys can be used to calculate the buoys' vertical displacements; these values are also a record of sea surface elevation. To determine the direction of the waves and generate a directional spectrum, however, more information is needed. One way to generate a directional spectrum is to measure the same parameter such as pressure at a series of nearby locations. The other way to produce a directional spectrum is by measuring different parameters at the same point. This is the approach used in directional buoys, which measure pitch and roll in addition to vertical heave. Other techniques for directional wave measurement include arrays of surface-piercing wires, triaxial current meters, acoustic doppler current meters, and radars, (www.ClearIAS.com July 20th, 2016)

**2). Tide**

They are a vertical movement of the waters and are different from movements of ocean water caused by meteorological effects like the winds and atmospheric pressure changes. The moon's gravitational pull to a great extent is the major cause of the occurrence of tides (the moon's gravitational attraction is more effective on the earth than that of the sun).Sun's gravitational pull and the centrifugal force due to the rotation of earth are the other forces which act along with the moon's gravitational pull. The regular interval between two high or two low tides is 12 hours 25 minutes.

**The Causes of Tides**

Gravity is one major force that creates tides. In 1687, Sir Isaac Newton explained that ocean tides result from the gravitational attraction of the sun and the moon on the oceans of the earth (Sumich, J.L., 1996).Newton's law of universal gravitation states that the gravitational attraction between two bodies is directly proportional to their masses, and inversely proportional to the square of the distance between the bodies (Sumich, J.L., 1996; Thurman, H.V., 1994).

Therefore, the greater the mass of the objects and the closer they are to each other, the greater the gravitational attraction between them (Ross, D.A. 1995). Tidal forces are based on the gravitational attractive force. With regard to tidal forces on the Earth, the distance between two objects usually is more critical than their masses. Tidal generating forces vary inversely as the cube of the distance from the tide generating object. Gravitational attractive forces only vary inversely with the square of the distance between the objects (Thurman, H.V., 1994).The effect of distance on tidal forces is seen in the relationship between the sun, the moon, and the Earth's waters.

**Flow Tide and Ebb Tide**

A flow tide or a flood tide is a rising tide or incoming tide which results in a high tide. It is thus the time period between a low tide and a high tide (i.e., the rising time).

**Ebb Tide**

Ebb tide is the receding or outgoing tide. It is the period between high tide and low tide during which water flows away from the shore.

**Types of Tides**

**A). Tides based on the frequency**

**i. Semi-diurnal Tide:** They are the most common tidal pattern, featuring two high tides and two low tides each day.
**ii. Diurnal Tides:** Only one high tide and one low tide each day.
**iii. Mixed Tide:** Tides having variations in heights are known as mixed tides.

**B). Tides based on the sun, the moon, and the earth's positions**

**1). Spring Tides**: When the sun, the moon, and the earth are in a straight line, the height of the tide will be higher than normal. These are called a spring tide. They occur twice in a month-one on the full moon and the other on the new moon.

**2). Neap Tides**: Normally after seven days of a spring tide, the sun and the moon become at a right angle to each other with respect to the earth. Thus, the gravitational forces of the sun and the moon tend to counteract one another. The tides during this period will be lower than the normal, which are called as the neap tides. They also occur twice in a month- during the first quarter moon and the last quarter moon.

**Magnitude of Tides**

**Perigee:** When the moon's orbit is closest to the earth, it is called as perigee. During this period, unusually high and low tide occurs.
**Apogee:** When the moon's orbit is farthest from the earth, it is called as apogee. Tidal ranges will be much less than the average during this period.
**Perihelion:** It is the position where the earth is closest to the sun (around January 3$^{rd}$). Unusual high and low tides occur during this time.
**Aphelion:** It is the position where the earth is farthest from the sun (around July 4$^{th}$). Tidal ranges are much less than the average during this period.

**Effects of tides**

a). Tides act as a link between the port and the open sea. Some of the major ports of the world, such as London port on the river Thames and Kolkata port on river Hugli are located on the rivers away from the sea coast.
b). The tidal current clear away the river sediments and slows down the growth of the delta.
c). It increases the depth of water, which helps ships to move safely to the ports.

d). It also acts as a source for producing electricity. (Source: www.ClearIAS.com July 20th, 2016)

**Measurement of Tide**

The sea level has been observed primarily with tide gauges during the last centuries (IOC, 2006). Some of these gauges are self-recording while some require a visit by an operator who records the readings from the device e.g. tide pole. We have another type of gauges which include; pressure gauge, acoustic gauge, radar gauge, GPs gauge, Buoy etc.

## OCEAN CURRENTS

These are the large masses of water moving in a specific direction in open oceans / seas uniformly. The ocean currents are the horizontal flow of a mass of water in a fairly defined direction over great distances. Ocean currents can be formed by the winds, density differences in ocean waters due to differences in temperature and salinity, gravity and events such as earthquakes. The direction of movement of an ocean current is mainly influenced by the rotation of the earth (due to Coriolis force, most ocean currents in northern hemisphere move in clockwise manner and ocean currents in southern hemisphere move in an anti-clockwise manner). This can be measured by the use of water current meter, buoy; it is recorded in meters per second.

**Gyre, Drift, and Stream**

Any large system of rotating ocean current, particularly those involved with large wind movements is called as a Gyre. They are caused by the Coriolis force. When the ocean water moves forward under the influence of prevailing wind, it is called as Drift (The term ‘drift’ is also used to refer to the speed of an ocean current which is measured in knots). E.g. North Atlantic Drift. When a large mass of the ocean water moves in a definite path just like a large river on the continent, it is called as a Stream. They will have greater speed than drifts, E.g. Gulf Stream.

**Types of Ocean Currents**

**Warm Ocean Currents**

Those currents which flow from equatorial regions towards poles, which have a higher surface temperature and are called warm current. They bring warm waters to the cold regions. They are usually observed on the east coast of the continents in the lower and middle latitudes of both hemispheres. In the northern hemisphere, they are also found on the west coast of the continents in the higher latitudes (E.g. Alaska and Norwegian Currents).

**Cold Ocean Currents**

Those currents which flow from Polar Regions towards equator have a lower surface temperature and are called cold currents. They bring cold waters into warmer areas. These currents are usually found on the west coast of the continents in low and middle latitudes of both hemispheres. In the northern hemisphere, they are also found on the east coast in the high latitudes (E.g. Labrador, East Greenland and Oyashio currents).
The ocean currents can be also classified as:

**1). Surface Currents**

They constitute about 10% of all the waters in an ocean. These waters are occupied at the upper 400m of an ocean or the Ekman Layer. It is the layer of the ocean water which moves due to the stress of blowing the wind and this motion is thus called as Ekman Transport.

**2). Deep Water Currents**

They constitute about 90% of the ocean water. They move around the ocean basin due to variations in the density and gravity.

## THE IMPORTANCE OF GAUGE STATIONS ALONG NIGERIAN COASTLINE

Sea level monitoring activities in Nigeria started as far back as the colonial years early in the 20th century. The primary objective of sea level monitoring activities at that time was for safe navigation into the ports of Lagos, Port Harcourt and Calabar. Tidal data were observed at these stations using graduated tidal staff and later upgraded to float types. Tidal predictions at that time were very crude but were sufficient to allow ships to navigate through the shallow estuaries and creeks to the ports, (Source; Omokhomion Catherine, National Report on Sea level Status in Nigeria 2006).

A lot of gains abound when gauge stations are systematically located along the Nigerian coastline. It has the capability of increasing studies concerning marine activities, thereby creating the needed awareness to everyone involved. The following listed points are some of the many important of establishing marine gauge stations along our coastline:

i). Control establishment and study campaigns in coastal zones.

ii). Surge prediction and monitoring.
iii). Marine traffic control.
iv). Reduction of bathymetric data.
v). Industrial and domestic water supply.
vi). Agriculture.
vii). River pollution studies in estuarine and coastal waters.
viii). Analysis of tidal stream.
ix). Determination of Mean Sea Level.
x). Definition of maritime baselines.

The Nigerian coastline stretches about eight hundred and fifty three 6kilometers (853km) and forms of the Atlantic coastline. It is marked by a series of sandbars, backed by lagoons of brackish water that support the growth of mangroves (Encarta, 2017). The Nigerian Coastline lies between the micro-tidal range (0 -2m) from Lagos to Bonny, and the meso-tidal range (2-4m) from East of Bonny to Nigeria/Cameroun coastal boundary. (Ojinnaka, 2006) The Easy-Tide (2012) publishes 26 locations of tidal predictions in Nigeria while the Tide-Forecast publishes data for four stations namely Bonny, Akassa, Lagos bar and Calabar, (Source; Oliver Chinagoro Ojinnaka 2013, Hydrography in Nigeria and Research Challenges).

The coastal area is therefore generally shallow with depths rarely getting up to 20m due to transport sand by sea currents; it shoals into the estuaries resulting in serious shallow water distortion of tidal waves as the tide propagates towards the head of estuaries. Lack of awareness of the hydrographic profession, the absence of modern technology and lack of adequate financial resources are adduced as the main setback in addressing these challenges in Nigeria and in other developing countries, (Ojinnaka 2013).

## THE TIDE GAUGE NETWORK IN NIGERIA

Tide Gauge Station is one of the gauge stations available in the country. According to Omokhomion Catherine, (National Report on Sea level Status in Nigeria 2006).The list of gauge sites in the Nigeria cannot be ascertained because several oil companies maintain tide gauges either at their offshore platforms or at their estuary terminal. However, in the past sixty years, some coastal tide gauge stations supplied data to the Permanent Service for Mean Sea Level (PSMSL). These stations are:

a). Lagos
b). Lagos ii
c). Koko
d). Forcados
e). Port Harcourt
f). Bonny
g. Calabar.

The Lagos tide gauge station is a GLOSS designated station tied to a benchmark BMI. The station is located at the jetty of the Nigerian Institute for Oceanography and Marine Research (NIOMR) Lagos. Initially in 1985 a float type tide gauge was used. In October 1992, this tide gauge station was upgraded to an acoustic type: Next Generation Water Level Measuring System (NGWLMS). The NGWLMS consisted of an acoustic tide gauge device with ancillary sensors to measure the following met ocean parameters:

i). Primary water level (tide)
ii). Backup water level (tide) using a pressure system
iii). Water temperature
iv). Air temperature
v). Wind speed
vi). Wind Direction
vii). Wind Gust
viii). Barometric pressure

Having been able to note that indeed there are a lot to gain from gauge stations, also we have been able to find out that we have some gauge stations on the ground, but not enough, therefore let us buttress some important issues that demand urgent consideration; Establishment of National Hydrographic Service is a necessity that must be funded by agencies in charge of hydrographic matters. There is also the need to formulate policies in Hydrography which will aid all stakeholders involved. These policies, if implemented, will encourage personnel development and encourage the establishment of the necessary infrastructure.

The existing stakeholders in Nigeria like the Nigerian Ports Plc should pioneer charting of Nigerian waters and estuaries. And also help in producing up to date tide tables and other vital information to aid in navigation, mapping and other related matters. The National Emergency Management Agency is a stakeholder and should fundr elated research to discover new information on how to be properly proactive in hydrographic related issues.

The entire Nigerian coastline, which is low-lying, may be adversely affected by sea level rise (SLR). The impacts of SLR on the Nigerian coastal area were well articulated in the Vulnerability Assessment case study of the impacts of SLR on the Nigerian coast, (Awosika *et al.,* 1992, French and Awosika *et al.,* 1995). Therefore, Nigeria being a maritime country needs to start doing the needful to avoid any avoidable emergency that may arise as a result of lack of awareness to marine characteristics, this is important because the coastal zone is low lying and subject to flooding during astronomical high tides and as well as massive flooding during storm surges which are prevalent in the months of April to May and Sept to October annually.

## CONCLUSION

To avoid adverse impact on the Nigeria coastal area due to sea level changes, a continuous collection, analysis, and display of an integrated marine data need to be readily available. Personnel training, availability of funding and policy making must all be put in place. From the above it is apparent that gauge stations be made available, including the personnel capable of monitoring and managing both the gauge stations and the data acquired. While gauge stations are important, we should not forget the importance of datum's along the coastal line, surveyors have to be mobilized to start doing something in making sure that water level datum's be established in other to tie the gauge stations to a reliable reference system.

## REFERENCES

Awosika, L. F., Gregory T. French; Robert J. Nicholls and Ibe, C. E., (1992). The Impacts of Sea Level Rise on the Coastline of Nigeria: In Proc. *IPCC Symposium on the Rising Challenges of the Sea.* Margaritta, Venezuela 14 - 19 March, 1992. p.123-154.

French G. T., Awosika, L. F. and Ibe, C. E. Sea Level rise and Nigeria (1995): Potential impacts and consequences. Journal of Coastal Research Special issue No. 14.

Hydrographer of Navy.2005, Nigerian Navy Tide Tables. Nigerian Navy

Oliver ChinagoroOjinnaka, (2013). Hydrographic Office, Apapa, Lagos. Hydrography in Nigeria and Research Challenges Nigeria, FIG Working Week 2013.

PL Woodworth1*, A Aman2 and T Aarup (2007). Sea level monitoring in Africa