Hydrography in Nigeria and Research Challenges

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SUMMARY

The paper discusses some challenges in the hydrographic profession in developing nations with focus on Nigeria. The enumerated challenges are based on hydrographic operations and researches that have been carried out at selected locations in Nigeria.

Based on available data it is shown that rate of change of mean sea level varies at different points along the coastline and that a coordinated tidal studies along the Nigerian coastline is needed to accurately determine the tidal behaviour. The applications of tidal studies are highlighted as compelling reason for the good knowledge of tidal behaviour within any tidal system. The paper also discusses the existence of a degenerate amphidromic system around Lagos and hence stresses on the need for a full study of tidal system within Lagos as an aid to verifying further courses of recent flooding problems in Lagos and also bearing in mind the impact of amphidromic systems on social life. A tidal study programme at some locations in Imo river near Opobo town, was also briefly discussed. The work revealed an unexpected arrival time of High water relative to Opobo town and Harbour.

Due to the importance of tide in planning for marine based operations, a comprehensive study of the tidal pattern in the surrounding estuarine system is suggested for a full understanding of unexpected phenomenon. Lack of awareness of the hydrographic profession, 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.

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1. INTRODUCTION

The lack of awareness in hydrographic operations has remained a plaguing problem in the developing countries including Nigeria. Consequently, very few studies have been carried out in these nations and the numerous challenges to the hydrogropher remain unattended to. In Nigeria, hydrographic operation 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:

i. Comprehensive charting of the nations 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 frame work for hydrographic education and practise in Nigeria.

The discussions in this paper are however limited to observations encountered in the course of some tidal works in the country and the principal aim is highlight some of the challenges which the Hydrographer in Nigeria should address.

1.1 Study of Tidal Patterns Along Nigerian Coastline

Tidal Studies are employed in everyday life for the following: (Ojinnaka 2004):

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.

Many coastal nations have therefore established functional tidal stations with continuous data collection and analyses.

The Nigerian coastline stretches about eight hundred and fifty three kilometres (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 ,2009). 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.
The Guinea Current transports and deposits large amounts of sand along the coastline resulting in a straight coastline with few good natural harbours that require constant dredging to remove deposited sand. The coastal area is therefore generally shallow with depths rarely getting up to 20m.

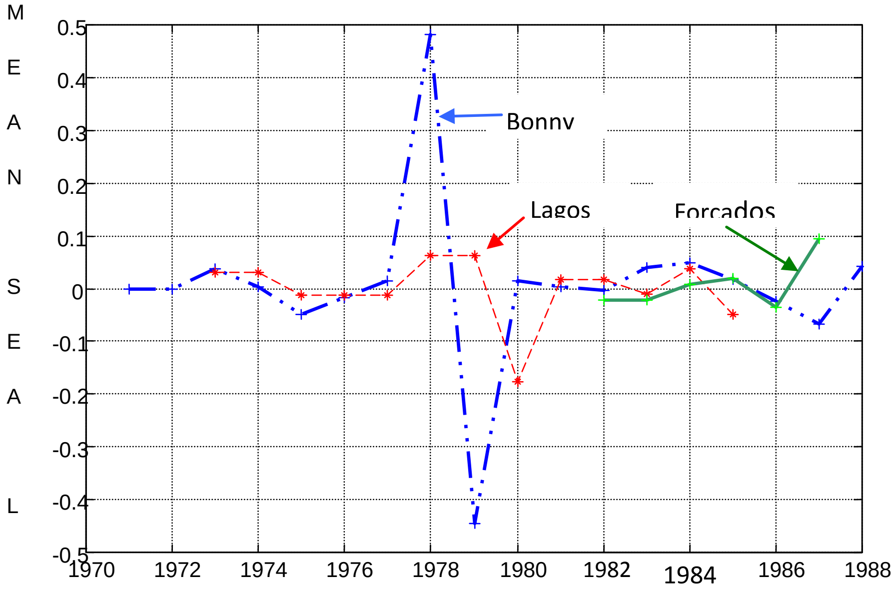
It shoals into the estuaries resulting in serious shallow water distortion of tidal waves as the tide propagates towards the head of estuaries.

Unfortunately, despite apparent preponderance of tidal stations as listed in Easy-Tide, only the Bonny tidal station has so been documented as a standard tide gauge station with verified values of tidal constants obtained from long period observations.. There has been no official confirmation of the tidal constants employed for the published predictions of the other tidal stations. There is therefore no other officially designated standard port apart from Bonny Town. Consequently tide work in Nigeria has remained bedevilled by the following problems:**(** Nigerian Hydrographer of Navy, 2005**)**

i. The occurrence of negative values of predicted tides at some tide stations and the high values of the annual lowest heights at other stations indicate incorrectly established chart datum at these locations.
ii. Absence of reference bench marks at almost all tidal location resulting in arbitrary recovery of gauge zero in event of disturbance.
iii. Lack of correlation between the chart datum at the tide stations resulting in inconsistencies in water level observations and predictions along the coastline. This does not allow for seamless navigation between the stations along the coastline or estuaries.

The rate of mean sea level changes along the Nigeria coast line has been noticed to vary between stations. This is illustrated fiugre1 (Ojinnaka, 2006). From the figure, it is observed that for the period between 1982 and 1983 for which data from the three locations are available, while Bonny showed rise in M.S.L, Lagos showed decrease and Forcados indicated no change.

Figure 1: yearly Mean sea level Changes at some Ports



It may therefore be wrong to adopt one model for any meaningful study that covers the entire Nigerian coastline. To understanding the tidal pattern along the coastline will require the establishment of a network of gauges for tide observations and analysis so that changes within given intervals can be captured. Unfortunately, Bonny has continued to remain the only recognised primary tidal station in Nigeria. Incidentally, for short period observation of tides, Bonny is assumed to cover the secondary ports up to Akassa (see fig 2). Any other secondary port west of Akassa is tied to Takoradi in Ghana.

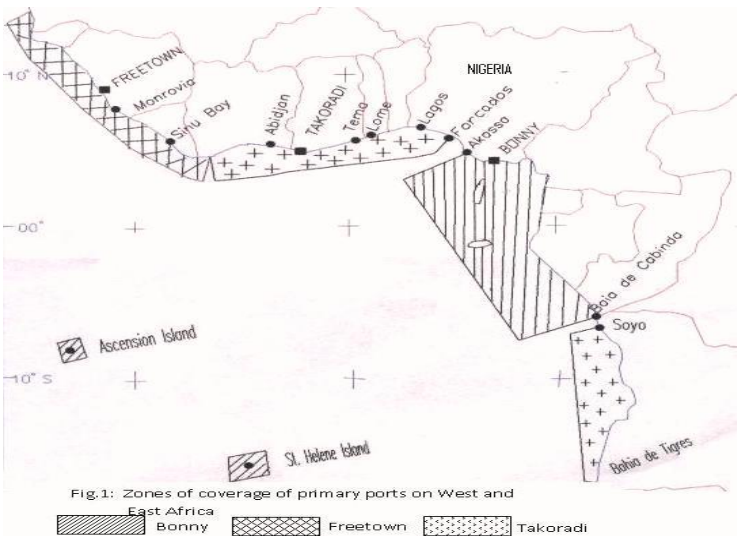
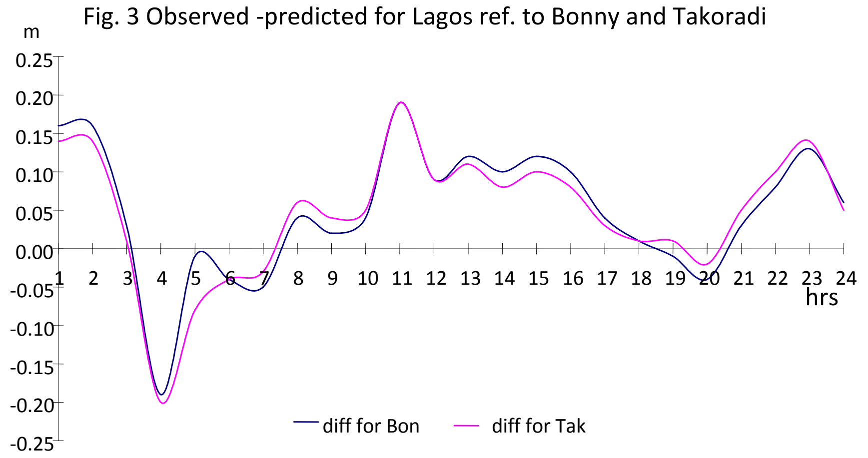


Fig 2.

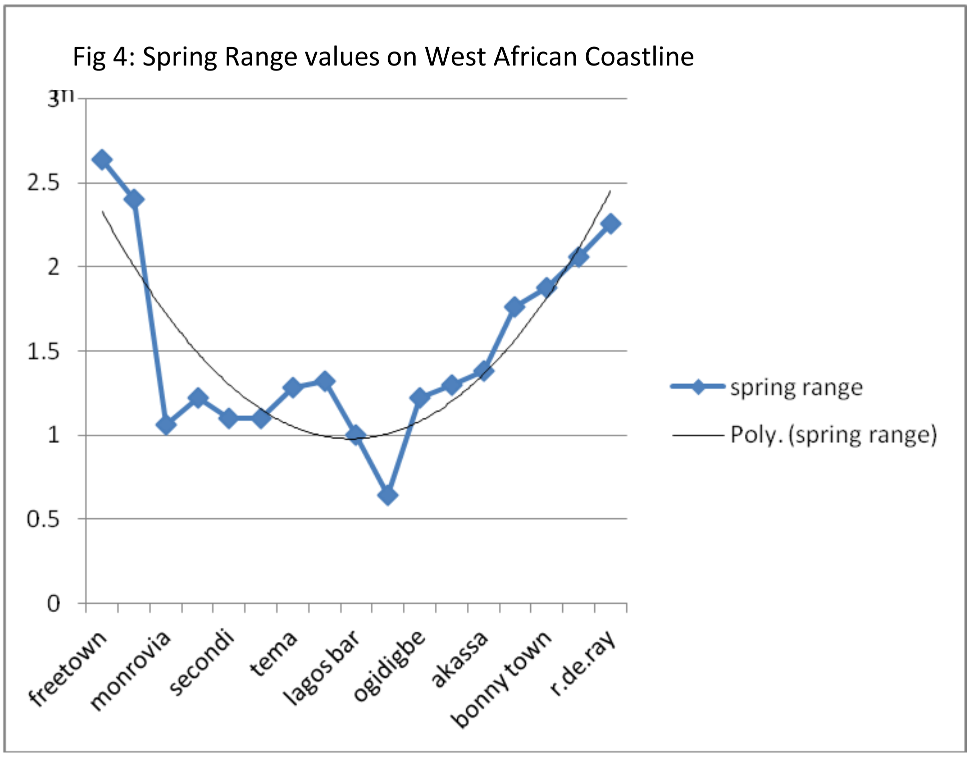
But studies have also shown that all locations along the Nigerian coastline can be referenced to Bonny without any loss in accuracy. Figure 3 shows plot of differences between observed and predicted tides which are referred to Bonny and Takoradi. The application of this new relationship between Bonny and these tidal stations can be possible when there is a correlated study between these locations and Bonny for the purpose of determining the time and height differences between the stations. This is a function of awareness and availability of resources.



1.2 The Degenerate Amphidromic Point at Lagos

Within the previous years, Lagos state in Nigeria has been subjected to serious flooding problems, and the several reasons adduced to this include the following: heavy rainfall, opening of Dam, depletion of sand along the coastline due to wave action, blockage of the drainage systems, etc. *(http://www.unesco.org/csi/act/lagos/flood5.htm*

However, one vital feature of Lagos has been left out in all these speculations. Figure 4 shows plots of ranges for the spring tide along West Africa. The lowest range of tide is at Lagos bar with a range of 1 meter. (H_{m2}=0.37, H_{s2}=0.13). Further in at Apapa the range is lower with a value of 0.64m(H_{m2}=0.25, H_{s2}=0.07) (Admiralty Tide Tables 2000). This suggests the existence of a degenerate amphidrom somewhere within the Lagos town.



An amphidrome is a stationary ocean point around which tides rotate in a counter clockwise (clockwise) sense in the northern (southern) hemisphere, i.e. the point about which the cotidal lines radiate. The vertical range of the tide increases with distance away from the amphidrome. The tidal range at the amphidromic point is almost zero. There is therefore almost no vertical movement of water level at the amphidromic point.

The knowledge of amphidromic systems is of particular interest, given their annually "constant" nature, for the monitoring and understanding of oceanic, climatic, as well as biological variabilities at seasonal to decadal scales, which strongly affect many aspects of the natural and societal activities on the globe. - Chen and Quartly (2005)

Figure 5 shows the amphidromic system of the world's oceans and the co-tidal lines. Figure 6 is the tide energy map superimposed on the amphidromic systems. The figure indicates increasing energy towards west African coastline. An apparent wrong impression on the Nigerian Coastline however suggests a uniform energy across the Nigerian coastline. This is contrary to published tidal studies which show increase in energy east and west of Lagos Bar and a suggested presence of a degenerate amphidromic point located within Lagos. A comprehensive study of the tidal patterns in Lagos state, Nigeria, is therefore essential for a full knowledge of the causes of the recently experienced flooding system in this coastal town. This calls for awareness on the part of the hydrographic community and the availability of human and financial resources.

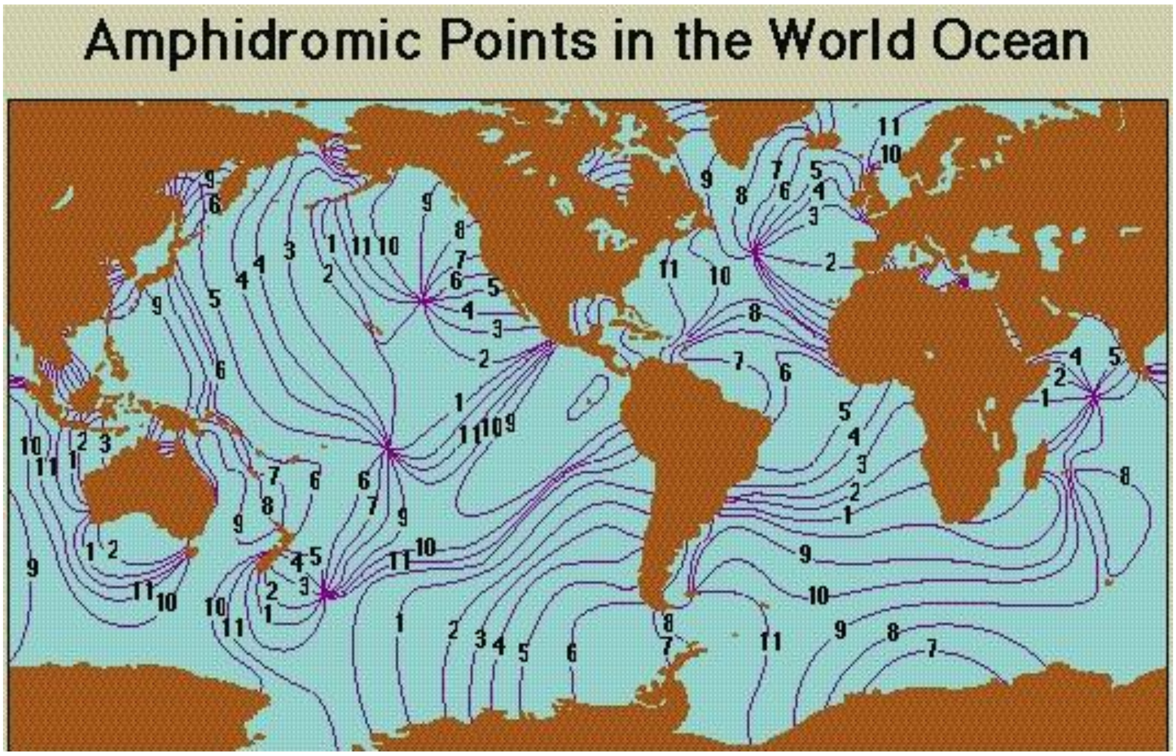


Fig 5 Amphidromic Points in the World Ocean

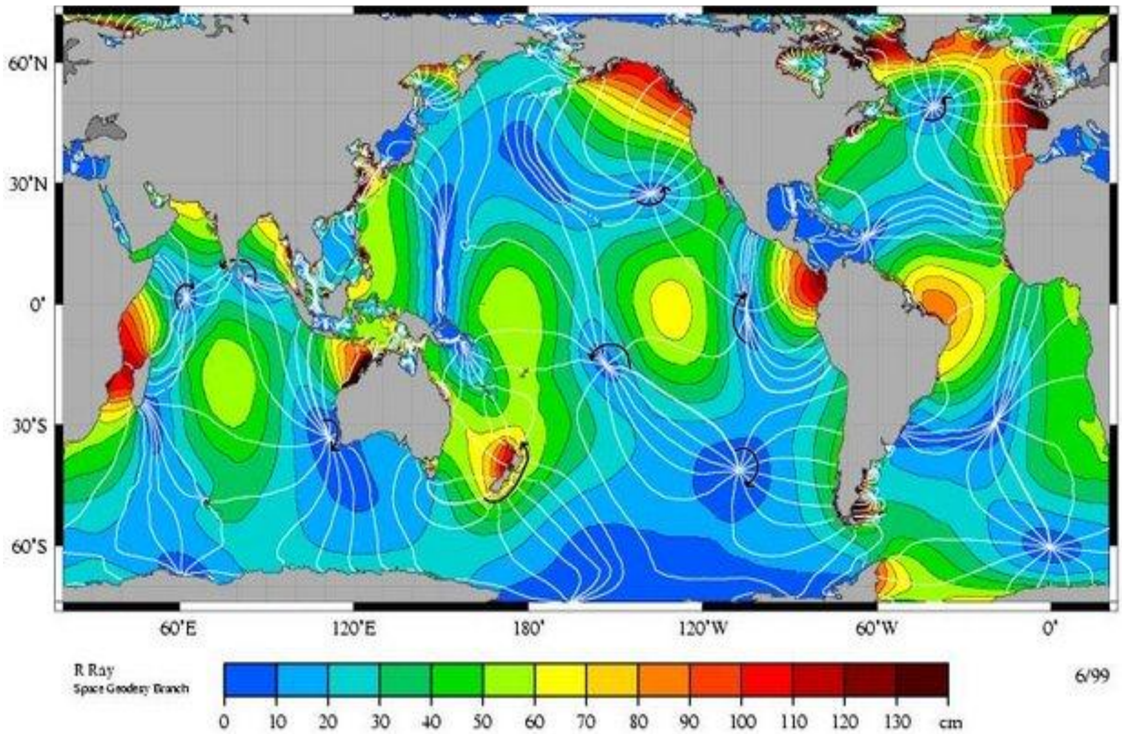


Fig 6: Tidal Energy distribution
http://www.eoearth.org/article/Amphidrome?topic=49523

Patterns of tidal energy played out across the surface of the Earth as lines of force. The colours indicate where tides are strongest, with blues being weaker areas and reds being stronger

1.3 Unusual Tide Arrival Time at Opobo River in Rivers State.

Tides propagate from the ocean towards the estuaries. Consequently, high waters are expected to occur earlier at locations downstream than those upstream. The knowledge of tide is very essential in everyday life and employed for many purposes as already highlighted above. Therefore any strange deviation from expected pattern calls for attention and special studies in other to remove any conflict that may arise from improper application. Such unexpected tidal behaviour was encountered at a study at some locations in Rivers State. Figure 7 shows the locations of the tide gauges for the said project. From available tidal observations, it was noted that the HW at Harbour occurred before that at Opobo town. This created some doubts in the mind of the hydrographic personnel involved in the project.
Tidal observations which covered between 3 and 6 months for the locations were analyses with University of Nigeria Tide Analysis and Prediction Programme(UNITPP)
Table 1 shows listed values of tidal constants for the four principal constituents M_2, S_2 K_1, O_1 for the four tidal stations .

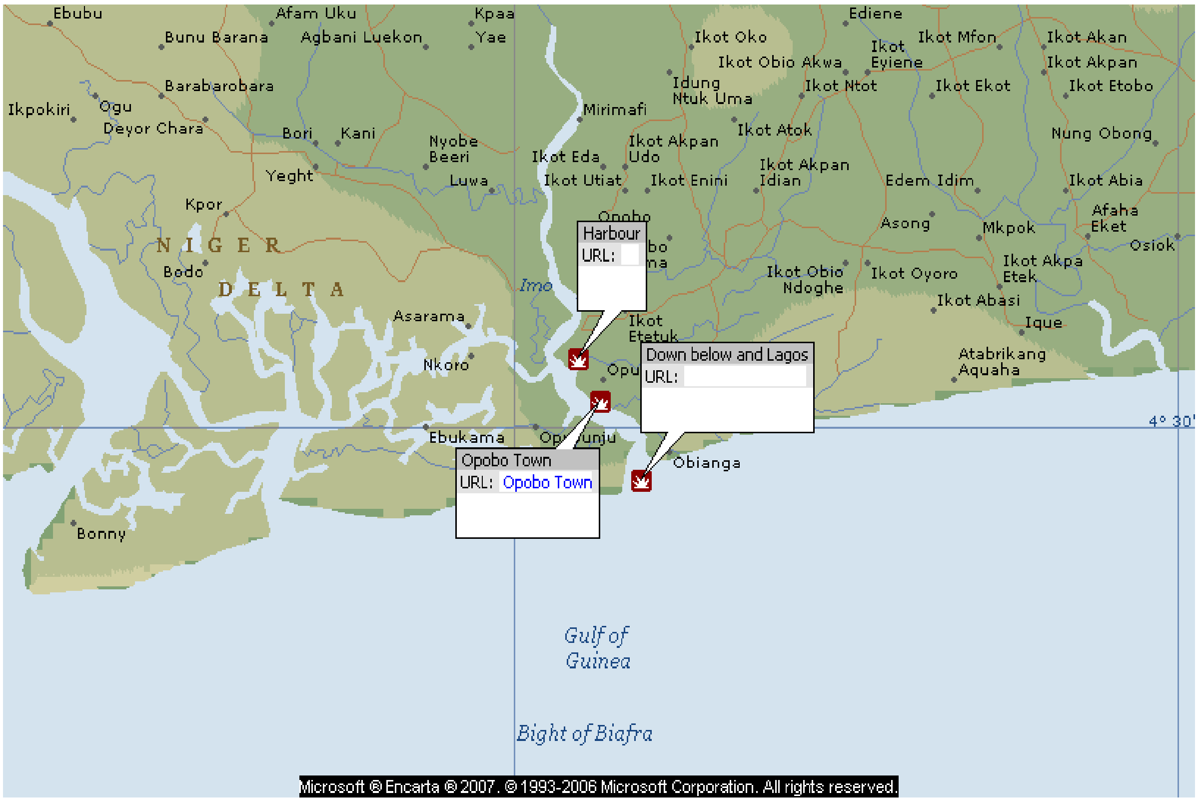


Fig 7: Locations of Tide gauges in study area

Table 1: Tidal constants M_2, S_2 K_1, O_1

	M_2		S_2		K_1		O_1	
	g	H	g	H	g	H	g	H
Harbour	148	0.70	186	0.25	28	0.15	316	0.03
Opobo	147	0.67	185	0.24	24	0.14	312	0.01
Down below	138	0.62	174	0.22	18	0.15	331	0.03
Lagos-Opobo	141	0.62	174	0.22	20	0.11	312	0.02

The age of tide " t" and the mean luni-tidal interval(MHWI) "v" computed from table 1 are given follows and listed in table 2:

$t = \frac{g_{s2} - g_{m2}}{w_{s2} - w_{m2}} \approx g_{s2} - g_{m2}$ hrs $\qquad v = \frac{g_{m2}}{w_{m2}}$ hrs

where w_{s2} and w_{m2} speeds of the S_2 and M_2 constituents given as 30.000^o/hr and 28.984^0/hr respectively.

table 2: age of tide and MHWI

station	Age t hrs	MHWI v hrs
Harbour	38	5.1062
Opobo	38	5.0718
Down below	36	4.7612
Lagos(Opobo)	33	4.8647

Table 2 tends to suggest that while the spring tide occurs at the same time at Harbour and Opobo town, the HW at Opobo occurs about 2 minutes earlier than that at Harbour. Consequently, the arrival time of HW at Opobo and Harbour are almost the same despite the noticeable distance apart. It is therefore very likely that the station at harbour is equally fed by the tides arriving from the creek that feeds the bifurcation from the west of Harbour. Since the importance tidal time cannot be overlooked in planning of marine based projects, a more comprehensive study of this phenomenon is essential especially with the recent effort to develop water transport system in Rivers State.

2. CONCLUSION

The above discussions have only tried to highlight few of the numerous challenges facing the Nigerian Hydrographer. Several nations of the world have not only gone very far in addressing similar problems but have even embarked in complete bathymetric coverage of their water bodies with modern technology. The lack of personnel, the unavailability of funds, or denial of available fund, the absence of modern technology and the gross lack of awareness on the part of the policy makers in the developing nations are serious factors militating against the development of Hydrography in the developing coastal nations. The international community should make coordinated effort to ensure the establishment of functional

Hydrographic offices in all the developing nations as a step towards systematic development of the profession and training of the necessary personnel. A supervised establishment of institutions of learning with modern facilities and defined mission will surely contribute immensely to addressing the various operational challenges confronting the hydrographer in these nations.

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About the Author

Oliver Ojinnaka obtained his B.Sc in Surveying and M.Sc. in Surveying Engineering from University of Nigeria, Nsukka in 1978 and 1985 respectively. He obtained his PG. Diploma in Hydrographic Surveying from Plymouth Polytechnic UK in 1986 and PHD from University of Nigeria, Nsukka in 2001. He worked with Nigerian Ports Authority and later with the International Hydrographic Survey Company, Port-Harcourt, Nigeria as Hydrographer. He is presently a lecturer with University of

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He was responsible for the tidal predictions for Nigerian waters for the Hydrographer of the Navy, Nigerian Navy, from 2000 to 2005 but now produces the *Tide Tables for Nigeria Coastline and Estuaries* under copyright. He has developed a number of tide analysis and prediction software which are currently being used for research and consultancy in the Department of Geoinformatics and Surveying, University of Nigeria. He has carried out several hydrographic projects and acted as consultant in hydrographic surveying to companies and also serves as examiner in Hydrographic Surveying for the Surveyors Council of Nigeria (SURCON). He is the author of the text book on hydrography titled ***Principles of Hydrographic Surveying- From Sextant to Satellite.***

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