# REPORT ON THE CONDUCT OF THE 2021 WORLD HYDROGRAPHY DAY CELEBRATION IN NIGERIA

1. **Introduction**. In line with the United Nations General Assembly Resolution A/RES/60/30 which set the 21 June of every year as World Hydrography Day (WHD), the Nigerian Navy (NN) being the lead hydrographic agency in Nigeria organised a local event to commemorate the 2021 WHD celebration in Nigeria. The NN adopted the IHO theme of "**One Hundred Years of International Cooperation in Hydrography**," for the local event that was held in 3 phases in Nigeria. The phases involved 2 virtual events and an offline visit to the newly acquired hydrographic survey vessels named Nigerian Navy Ship (NNS) LANA.

2. **Conduct of Online Events**. The First Phase involved the participation of the Nigerian Hydrographic community in the online virtual Opening Ceremony held at Monaco between 1030 – 1130 on 21 June 2021. About 165 participants; comprising the Naval Headquarters (NHQ), NN command headquarters, hydro-related agencies in Nigeria and members of the Nigerian Hydrographic Society (NHS) participated in the online event. The Second Phase, also hosted virtually by the Nigerian Navy Hydrographic Office (NNHO), commenced at about 1130 West African Time. The Session commenced with an opening address delivered by the Chief of the Naval Staff (CNS) at the NHQ Viewing Centre. Thereafter, 2 papers were delivered respectively by seasoned guest speakers. The 2 papers were extensively discussed by 3 distinguished hydrographers comprising Surveyor Ishaya Amos Talmun who is the Assistant General Manager Hydrographic Services and Hydrographer of Nigerian Ports Authority, Commodore AO Olugbode, the Deputy Commandant and Director of Studies Naval War College of Nigeria and Surveyor Denis Osanwuta the CEO of Messrs Marine Laboratory Services Ltd. This was followed by a tour of NNS LANA by invited guests and representatives of media agencies where they were briefed on the various hydrographic capabilities, with a sumptuous lunch to mark the end of the event onboard.

3. **Participants**. The 2021 WHD had 165 virtual participants that comprised NHQ Viewing Centre, command viewing centres, maritime related agencies and invited members of the hydrographic community in Nigeria. A group photograph of the online virtual event is at Enclosure 1.

4. **Paper Presentations**. The 2 paper presented at the 2021 WHD celebrations were entitled "**Advancement and the Future Outlook of Charting Nigerian Waters**" and "**100 Years of International Cooperation in Hydrography - A Look at Interagency Cooperation in Hydrographic Survey in Nigeria.**" The First paper was jointly presented by Surveyors Onyeagoro Franklin Eyinnaya and Onyebuchi Chukwuemeka Chineme. The paper started by defining the concept of hydrography after which it highlighted the aims of hydrographic survey in addition to enumerating modern trend in the conduct of hydrographic surveys. The authors thereafter made some important recommendations that they hope would help redefine the conduct and practice of hydrographic survey operations in Nigeria. These include the adoption of collaborative framework for the conduct of hydrographic surveys and the use of satellite systems in the conduct of shallow water surveys as well as the formation of a body to regulate hydrographic quality control and improved training in Nigeria. A copy of the paper is attached as Enclosure 2. The second paper entitled "**One Hundred Years of International Cooperation in Hydrography: A Look at Interagency Cooperation in Hydrographic Survey in Nigeria**," was presented by Lt UK Erege, the Officer in Charge of the Geospatial Intelligence Data Centre (GSIDC) at NNHO. The paper presented an overview of hydrography in Nigeria, the state of interagency cooperation in the conduct of hydrographic practice in Nigeria and the challenges militating against interagency cooperation to advance hydrographic practice in Nigeria. The speaker thereafter presented a way forward to advance hydrography in Nigeria based on some key priority areas for interagency cooperation that were recommended in the paper. These include the need to create a National Hydrographic Agency (NHA) in Nigeria and the need for the conduct of

regular joint hydrographic training/survey sessions among the various hydrography-related agencies. A copy of the paper is attached as Enclosure 3.

5. **Discussion**. The 3 experts invited to discuss the papers unanimously agreed with the recommendation by the speakers for the institution of a collaborative approach towards the conduct of hydrography in Nigeria as espoused in the 2 lectures. The discussants also agreed that the creation of a NHA to regulate the conduct of hydrographic practice in Nigeria would go a long way to improve the quality of hydrographic surveys and foster synergy among various hydrography-related stakeholders in the country, for improved hydrographic service delivery to mariners.

6. **Visit to NNS LANA**. At the end of the online event, some invited guests and representatives of various media agencies that attended the event at the NNHO were taken to NNS LANA to consolidate their understanding of the importance of hydrography to Nigeria's maritime security and national development. The visiting team was received by the Flag Officer Commanding, Western Naval Command of the NN, who accompanied them on a short tour onboard the newly acquired ship. At the end of the tour the invited guests were treated to a lunch onboard during which the Hydrographer and the ship's company answered questions raised by the visitors. Overall, the visit assisted invited guests to fully understand theoretical issues raised during the lectures, which made them to greatly appreciate the importance of hydrography to Nigeria's maritime security and national development. Some selected pictures of the visit to NNS LANA are at Enclosure 4.

7. **Conclusion**. The 2021 WHD Celebration in Nigeria was conducted in 3 phases that included the Opening Ceremony at Monaco, a local event hosted by the NNHO and a tour of NNS LANA by some invited guests. Participants were connected to the international and local segments of the 2021 WHD virtually. Key features of the local online event included the presentation of 2 papers that were extensively discussed by 3 seasoned hydrographic surveyors. At the end of the 2 virtual events,

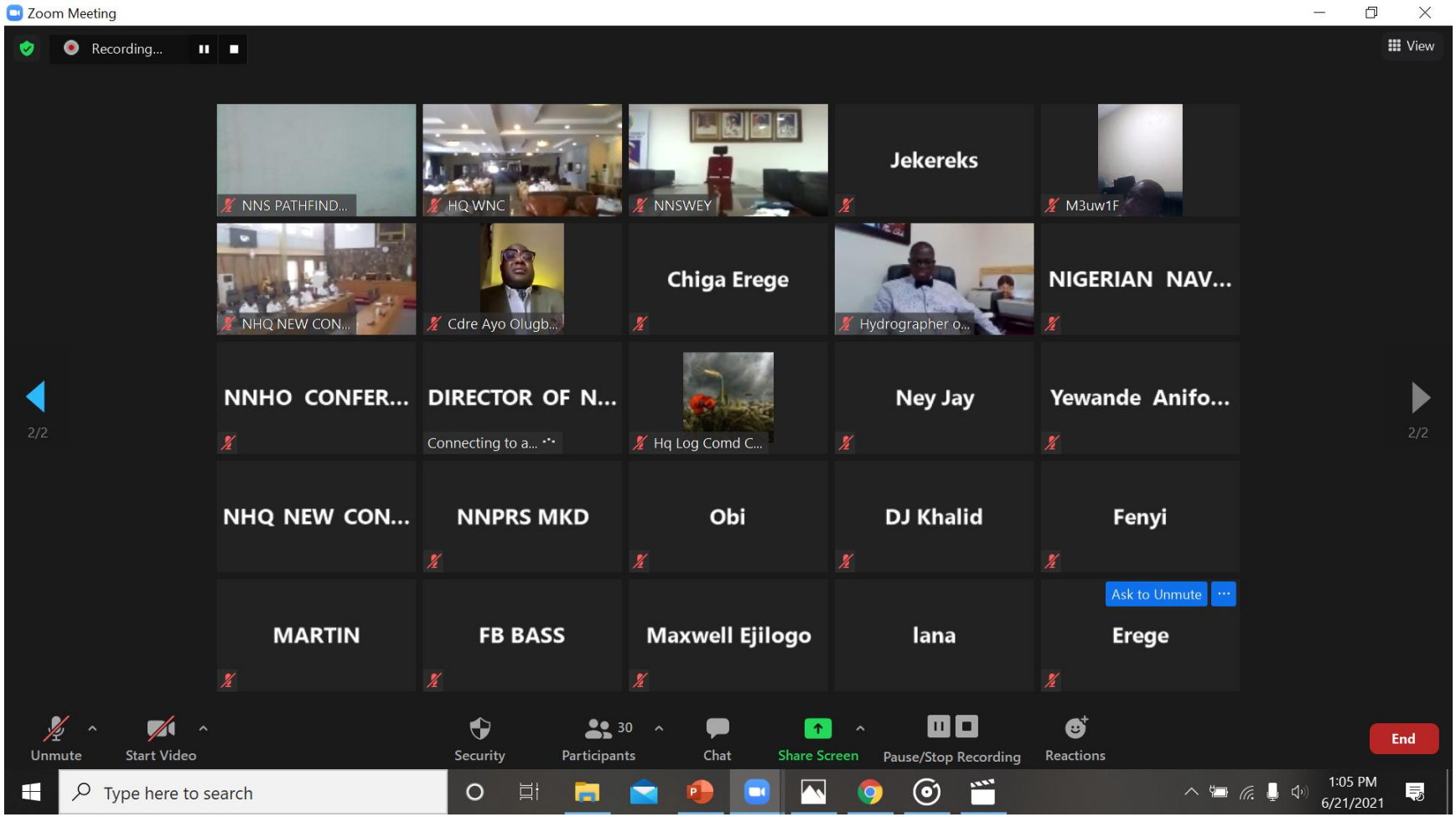
invited guests were taken on a tour of NNS LANA, which ended with a lunch break. The event was adjudged to be a huge success.

**NA ALAO**
Commander
for Hydrographer of the NN

27 Jul 21

**Enclosures**:

1. WHD 2021 Virtual Group Photographs.
2. Copy of paper presented by Surveyors Eyinnaya and OC Chineme titled "Advancement and the Future Outlook of Charting Nigerian Waters".
3. Copy of paper presented by Lt UK Erege titled "One Hundred Years of International Cooperation in Hydrography: A Look at Interagency Cooperation in Hydrographic Survey in Nigeria."
4. Some Selected Pictures of Visitors' Tour Onboard NNS LANA.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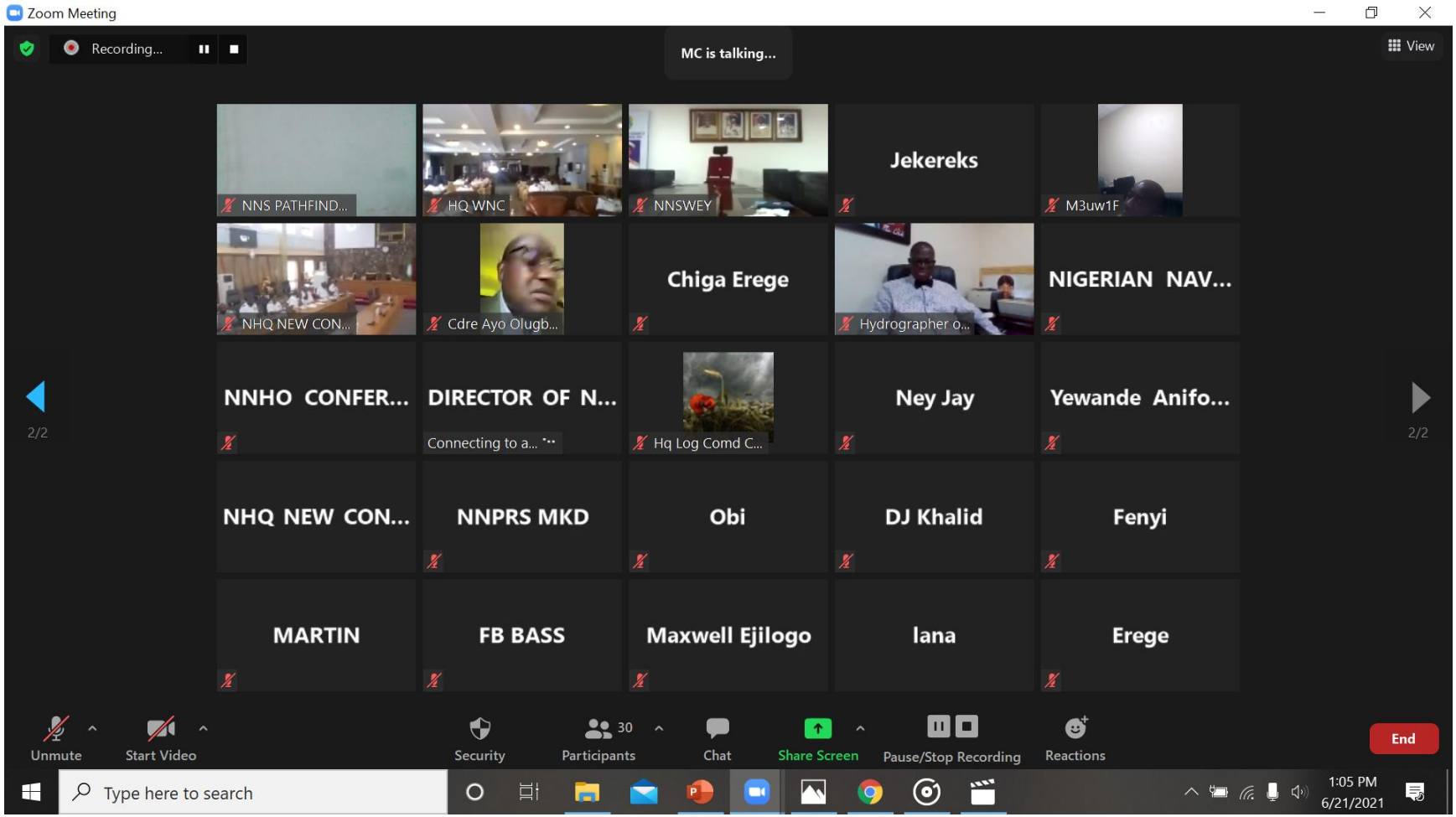
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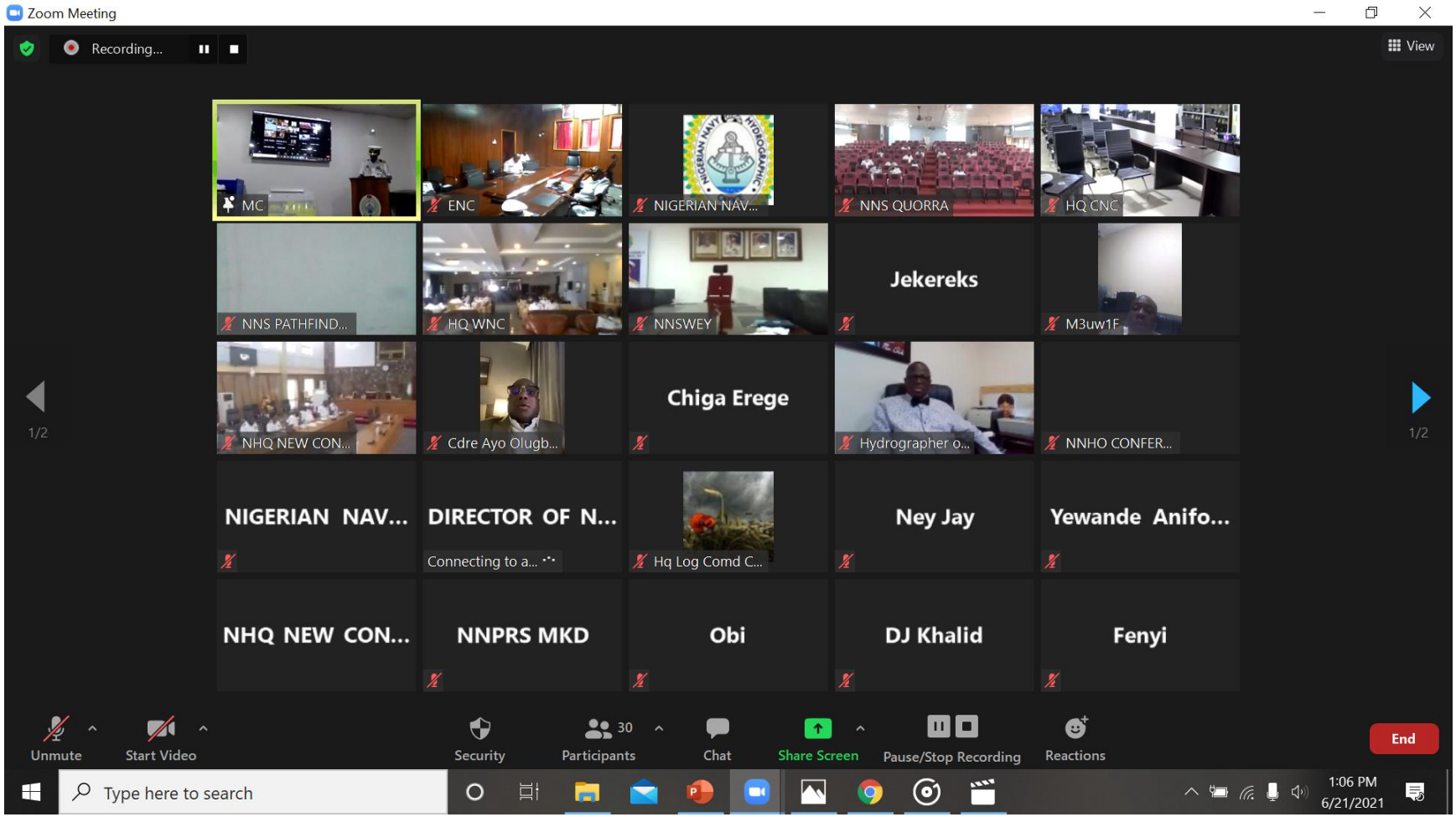
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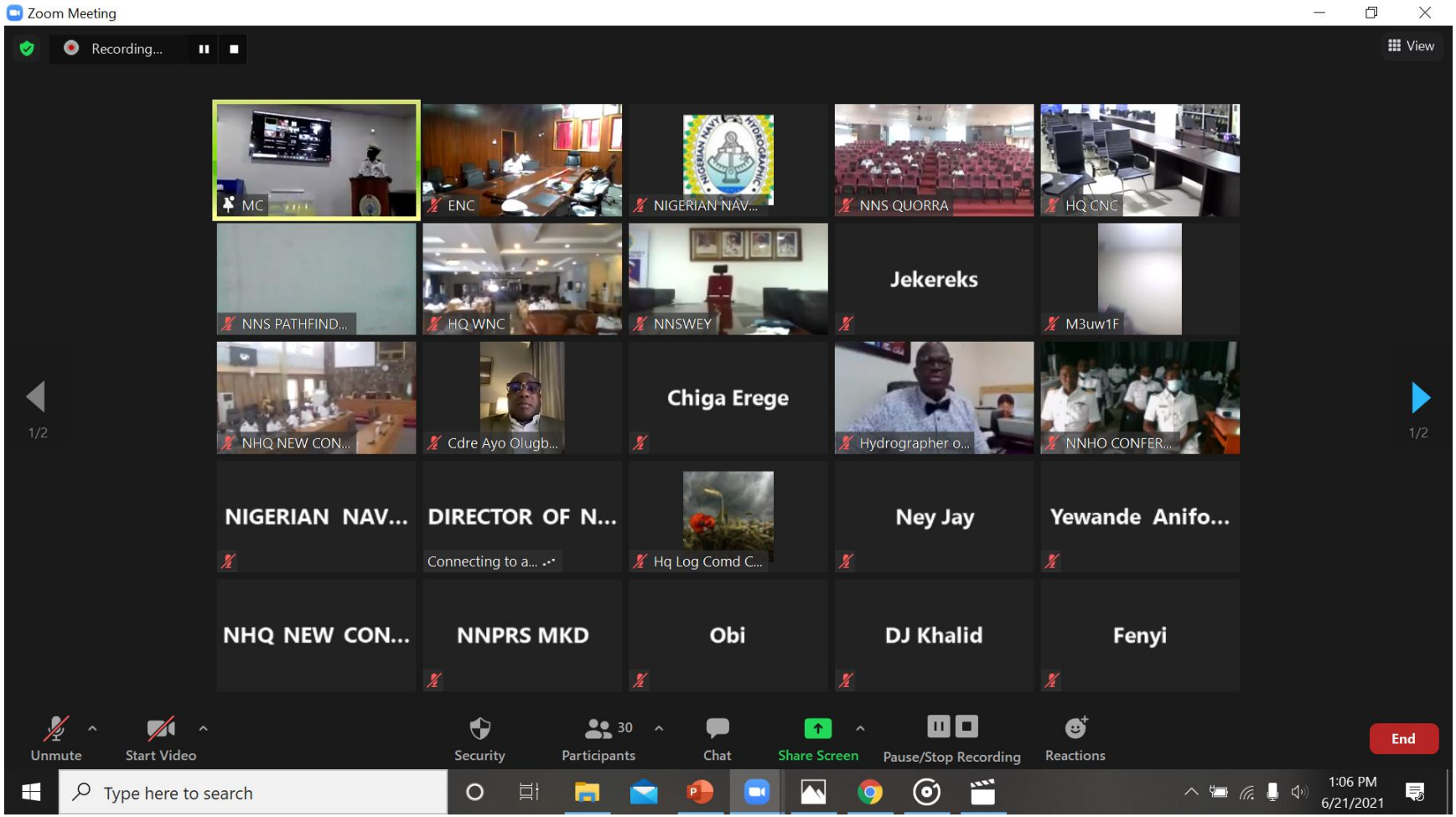
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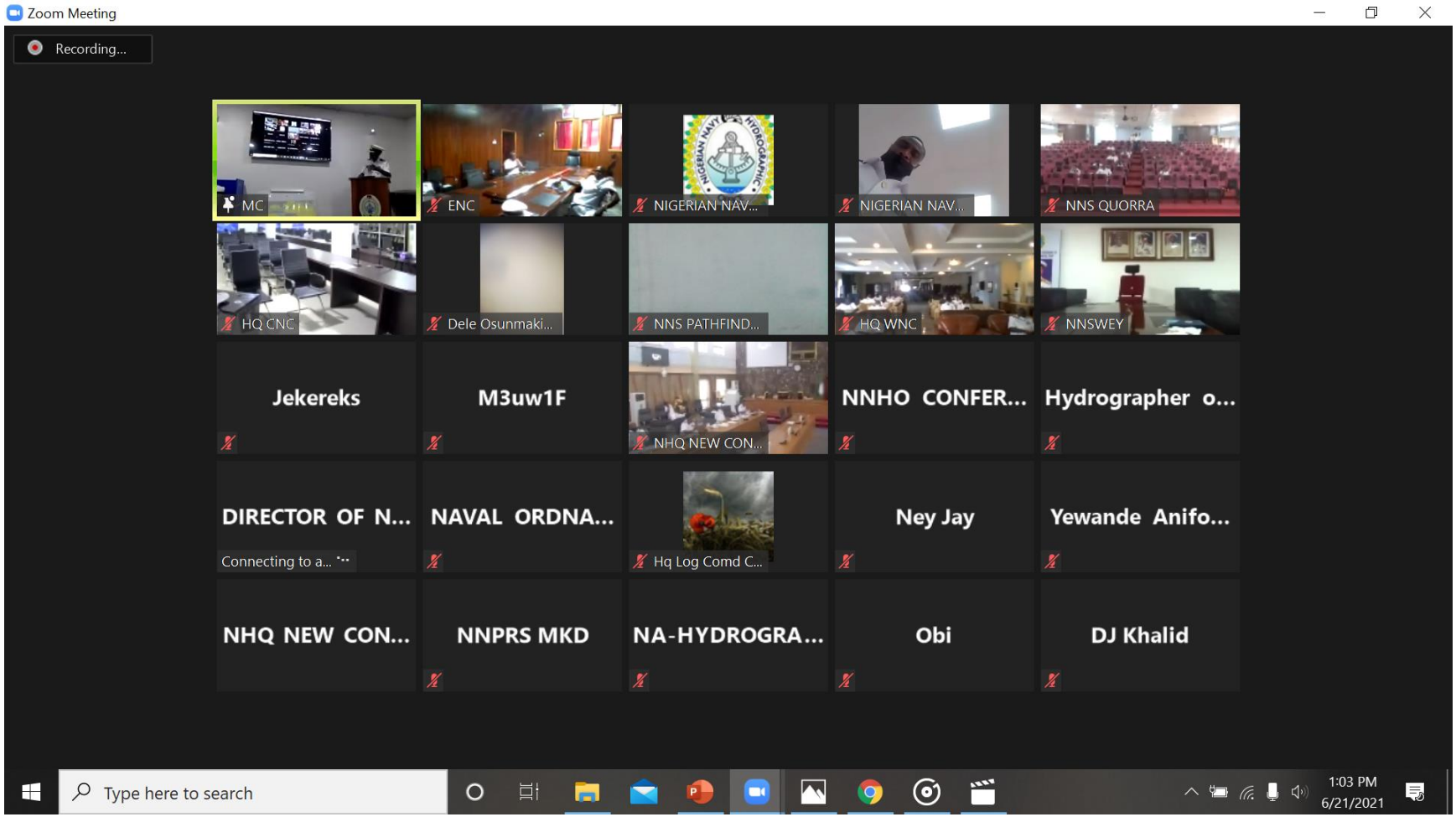
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# Advancements and the Future Outlook of Charting the Nigerian Navigation Channel

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**ABSTRACT**

The need for achieving safe waterways for navigation, engineering, exploration, security and other marine operations cannot be overemphasized and should be attained using precise methods and equipment. The Hydrographic process still remains the only systematic means through which spatial information about our marine environment (oceans, seas, rivers etc.) are acquired for charting purposes so as to aid analysis and decision making. In Nigeria today, most marine operations and mostly the Nigerian Navy is dependent on the Hydrographic process for smooth operations required for security, trading, engineering etc. therefore maintaining the integrity of the hydrographic process is of uttermost importance. To maintain the integrity of the hydrographic process used for charting our navigational channels, the progressive evolution of this process shall be assessed: from the earliest methods that directly sounded navigational channels using weighted lead lines and graduated poles to provide water depths to Wire Drag methods used to identify physical features on the marine environment, then to the 1930s when acoustic waves were applied in the Echo Sounder to indirectly ascertain seabed profile, and the use of instruments like Multi Beam Echo Sounders, Magnetometer, Side Scan Sonar, etc. for detailed Bathymetric and Geophysical Survey Projects, and presently to the use of Remotely Operated Vehicles (ROV) and satellites in space to monitor sea level rise. All these methods are all driven by the insatiable need for more advancements and sophistication in providing information about our marine environment. This paper renders a detailed discourse on the progressive advancements of the hydrographic process used in charting of our marine environment. It also provides recommendations on the future outlook of this process so as to preserve the accuracy in charting our Nigerian navigational channel.

***Keywords****: Hydrographic Survey, Navigation, Trends, Recommendation, Bathymetry, Geophysical.*

**INTRODUCTION**

Hydrography as defined by the National Ocean service "is the science that **measures and describes the physical features** of the navigable portion of the Earth's surface and adjoining coastal areas. Hydrographic Surveyors study these bodies of water to see what the "floor" looks like", were Hydrographic Survey method is the principal means in which this spatial data is collected and the basis for delineating a navigational channel for various economic benefits in: transportation, trading, security, exploration, engineering etc. Furthermore, Hydrography focuses on the deduction of underwater topography from numerous discrete observations of depth. They are also carried out for the following:

1. Provide basic data for nautical charting
2. Obtaining site detail for alongshore or offshore construction
3. Assessing the condition of port and marina facilities
4. Measuring the quantities in dredging projects and
5. Determination of the extent of siltation and for numerous other reasons.

But this paper's focus is on Nautical Chart making.

All marine bodies (Oceans, Seas, Rivers etc.) covering all countries in the world are consequent on hydrographic survey methods for mapping out navigational channels, and Nigerian waters are also being charted too using best survey methods, as the Nigerian Navy Hydrographic Office (NNHO) commenced chart production with the unveiling of Nigeria's first National Chart at the 2019 World Hydrography Day celebration in Lagos (Nigerian Navy Hydrographic Office, n.d.) in a bid to chart all navigable Nigerian waters.

Over the years, these survey methods have advanced steadily from direct methods to the dominant indirect methods of our present day. Where these methods have evolved, the need to preserve and enhance accuracy in the survey methods used in charting these navigation channels has remained insatiable.

This paper aims at pointing out the advancements made in hydrographic surveying from where we were **yesterday**, where we are **today** and the **future** outlook of hydrographic survey methods used in charting the Nigerian navigational channels. This aim is objectively achieved through:

I. Reviewing the progressive trend of Hydrographic Survey methods
II. Providing recommendations the future outlook, in order to maintain accuracy in the practice of Hydrography in Nigeria

**NAUTICAL CHART**

A map/chart is the final product of any survey carried out for any area of interest. It is the visual representation of any specific marine environment in consideration and also the basis for every waterborne operation. Just like a basic survey map/plan, the Nautical Chart presents a graphical spatial relationship of features within any marine environment (oceans, seas, rivers etc.). Information on the Nautical Chart usually includes: areas of varying water depths/tidal information, position of wreck/obstacles (navigational hazards), natural/manmade features, map projection parameters and navigational channels/routes. This information on the nautical chart is represented using signifying colors and symbols according to IHO standards S-4 Regulations and Specifications for IHO International Charts (IHO, 2018).

The Act of Parliament 1964 and the Armed Forces Cap Act A20 LFN of Nigeria empowered the Nigerian Navy to chart all Nigerian waters, while the Nigerian Navy Hydrographic Office (NNHO) a subsidiary of the Nigerian Navy has been invested with the power to produce/issue Nautical Charts (updates, corrections) about Nigerian waters (Nigerian Navy Hydrographic Office n.d.). The NNHO makes this available on demand either via an electronic web link or through a paper sheet, so that end users can have a proper navigational guide in their marine operations. It is important to note that the confidence of a nautical chart is dependent on the accuracy of the survey method employed.

**TRENDS OF HYDROGRAPHIC SURVEY FOR NAUTICAL CHART MAKING**

The constant need for accuracy has remained the driving force in the advancements of the survey methods used in charting navigation channels. As these methods progressed, sophistication of equipment and methodology progressed directly too. These methods are commonly divided into two:

1. Direct Methods

2. Indirect Methods

These methods have been the classification of all past and present survey methods used in charting our marine environment (navigation channels). Conclusively, all hydrographic survey methods have gradually advanced from direct methods which produced incomplete and interpolated information to indirect methods which gave more reliable and comprehensive information on any marine environment of interest.

**1. Direct Methods**

The earliest use of direct methods for hydrographic survey cannot be traced, as there are no official records to its first use and invention. But it is important to note that because there was little or no information (Nautical Charts) for sailing ships on coastal waters, the United States congress in 1790 began authorizing specific and limited surveys of the coast (NOAA, 2017).

The survey methodology involved in Direct Methods includes using of graduated lines, poles, wire and sextant (3-D position fix) to take measurements that determines depth difference and features (wrecks) on the seabed. The earliest charts produced using these methods were comparatively reliable (Ojinnaka, 2007) although not accurate in its totality. This because: the graduated line and pole method, inasmuch as they gave accurate depth readings to the seabed, the method was laborious, time consuming and its area of coverage limited thereby a lot of information on the earliest nautical charts were interpolated. But the invention of the early 1900's Wire Drag method

revolutionized the practice of Hydrographic Survey in that it had a lot of coverage (unlike the graduated pole and lead line method) and the position of wrecks and other navigational hazards could be identified. NOAA associates Nicholas Heck of the Coast Geodetic Survey, a predecessor of the US Coast Survey to its breakthrough (National Ocean Service et al, 2007). The Wire Drag method had the attachment of each edge of a wire net (at a specified depth) to two different vessels (Boat or Ship as seen in ***Fig 1***) and while the vessels moved and encountered an obstruction, it would make a V shape exposing the location and depth of the obstruction (NOAA as cited in Donald and Parnell, 2018). This Wire Drag method as seen in ***Fig 1*** was a major upgrade to the graduated pole and lead line method because a lot of obstacles (wrecks and other navigational hazards) which were missed by the graduated and lead line method could now be identified.

***Fig 1 showing two Vessels carrying out Wire Drag Survey***. *Source: NOAA as cited in Donald and Parnell, 2018*

The United States Coast Survey (USCS) depended so much on the Wire Drag method from the early 1900 to the early 1990 (National Ocean Service et al, 2007) with this method likely accounting a certain percentage in the over 11,600 Hydrographic Surveys carried out by the USCS till date (National Ocean Service et al, 2007). Inasmuch as this method revolutionized the practice of hydrographic survey, its area of coverage was limited.

**2. Indirect Method**

Inasmuch as the Wire Drag method was more reliable than the graduated pole method, in that it provided more details about the seabed, the need for sophistication in equipment and methodology without compromising on accuracy was also needed. This ushered in the dominant use of **sonar enabled equipment(s)** and **remote sensing** techniques to indirectly determine depths and position of physical features which hamper navigational.

**Sonar Systems**

In recent times, the available means of carrying out Hydrographic Survey operation uses Sonar sensors which propagate acoustic waves to carry out underwater measurements. These sensors deployed into the marine environment have the ability to provide seabed profile/depths, positions and images of wrecks and obstacles, in the water body etc. plus they can thrive in both fresh and salt water environment. Single/Multi Beam Echo Sounders, Side Scan Sonars etc. are common instruments employed in this indirect method. The two basic surveys applied in charting navigation channels include; Bathymetric Survey and Physical feature Identification Surveys.

i. **Bathymetric Survey**: Position Fixing and Sounding are the basic features of Bathymetry so as to determine depth variants and the topography of the seafloor from which navigable water channels can be delineated accurately based on bathymetric survey carried out on the marine environment. Echo Sounders are the basic equipment used for sounding to determine depth variants. The Titanic disaster of 1913 was the driving force that led German Physicist Alexander Behm, who in his bid to determine how to detect iceberg, discovered the use of sound pulses to determine depths from the surface to the bottom of the sea (Sana, 2013). But the development and implementation of the Echo Sounder as an equipment can be traced to the 1930's when single beam sound waves were sent out from a transducer directly below a vessel (NOAA, 2017). Nowadays, the Echo Sounder has become a mainstay in Bathymetry, although Multi Beam Echo Sounders (MBES) are much more preferably used as they send out a spread of sound waves in one single ping as seen in ***Fig2*** with a 100%

coverage, unlike the single beam which sends out only one line of sound wave at one ping and leaving various unsounded gaps.

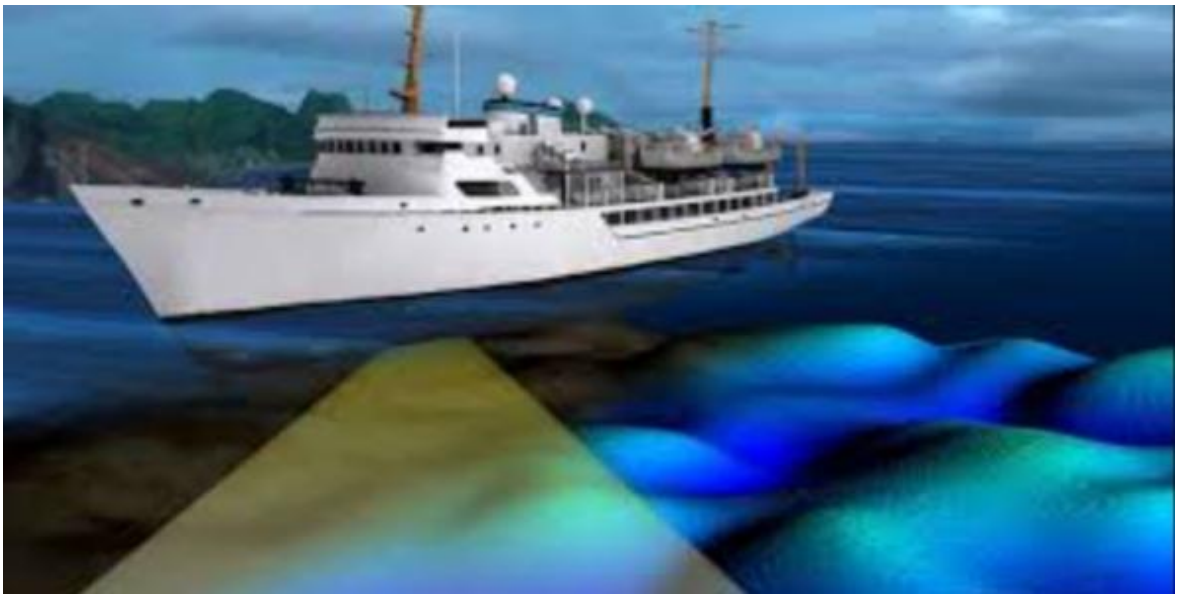

**Fig2 Showing a simulated Multi Beam Echo Sounder sound wave**. *Source Ocean News and Technology Magazine (2019)*

Information about Nigerian water(s) are also being determined using bathymetric surveys, with the existence of various literatures/projects giving credence to that fact. The uniqueness of these existing literatures and projects is the similarity in Equipment, Data Acquisition and Data Processing: (Tata et al, 2019) carried out a Bathymetric Survey on a part of Lagos Lagoon: Data was acquired using an Echo Sounder, Absolute Positioning (Handheld GPS), Moving Vessel (Boat), Transducer, PowerNav for navigation etc. while Hypack, ArcGIS. AutoCAD, Surfer etc. were used for data processing and charting. Also (Badejo and Adewuyi, 2019) carried out a Bathymetric Survey on some parts of Badagry Creek and Yewa River in Lagos State Nigeria: Data was acquired using an Echo Sounder, RTK-GPS (Differential Positioning), while Hypack, ArcGIS were used for mapping/charting,

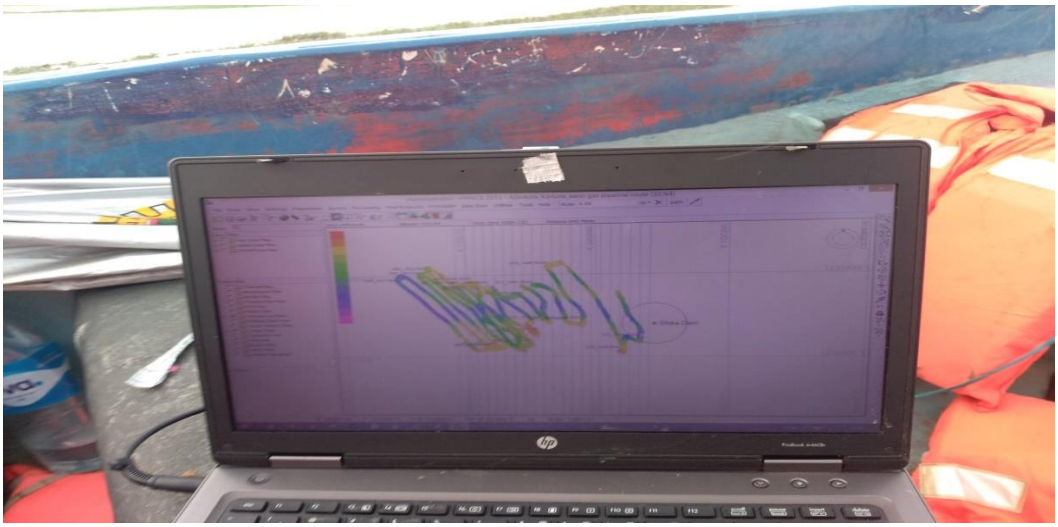

***Fig 3: Bathymetric Survey result on Hypack interface.*** *Source: AKK Project 2020*

The AKK (Ajaokuta Kaduna Kano) is a gas pipeline project managed by NNPC. The proposed gas pipeline route traverses from Ajaokuta in Kogi State, through Niger/Kaduna State and terminates at Kano State. With some water bodies like Chiromawa, Hadejija, Shika, Garnin Jatau, Sarkin Pawa etc. among others found within the over 500km proposed gas pipeline route. The scope of work specified a bathymetric survey using a single beam Echo Sounder, Survey vessel, DGPS system interfaced to a notebook navigation and data logging system, so as to determine the relationship between water levels and ground levels, for the production of a profile map of the Gas Pipeline route. (Nigerian National Petroleum Corporation, 2019). **Fig 3** shows the result of the Bathymetric Survey of Shika River as seen in the Hypack environment which was the navigation and data logging system used during the execution of AKK survey works in 2020, as specified for the project.

It is also significant to note that as Bathymetric survey is important in projects carried out in high elevation Northern Nigeria, so it is of highest important to various individuals and companies who carry out various bathymetric activities in our coastal areas for purposes ranging from research to financial profits: Just as (Tata et al, 2019) cited above carried out a Bathymetric Survey on the Lagos lagoon, (Chukwu and Badejo, 2015) carried out the same bathymetric survey on the same

Lagos lagoon with a different purpose to study seabed topography change over a six year period from 2008-2013: results from the research showed sediment changes in the six year period, while the research recommended more studies on the Lagos lagoon as it affects marine transport.

**ii Physical Feature Identification Survey:** In accessing the progressive evolution of the hydrographic methods used in mapping seafloors, the 1950's to 1970's saw the offering of Side Scan Sonars and Multi Beam Swathe systems in providing a qualitative means of mapping our seafloors and identifying positions of wrecks and features (NOAA, 2017). This on its own solved the problem of incomplete depth determination as encountered in the Single Beam Echo Sounder (SBES) and the limitations in identifying physical features as encountered in the Wire Drag method. These days, in the execution of various marine projects applied in engineering, navigation, research, offshore survey inspections etc., full spread Bathymetric and Geophysical surveys are recommended, as such combination provide a better understanding on the interest marine environment.

Geophysical Survey is **not** basically hydrographic survey, and it is **totally different** in its entirety, but its principles and equipment(s) have applications in most underwater projects including mapping of navigable waters.

The scope of works and equipment(s) involved in Geophysical Survey for charting navigational channels include but are not limited to the following:

a. Bathymetric Survey: To determine variation in water depths, so as to understand the seabed topography. This is achieved by using an Echo Sounder, preferably a Multi Beam Echo Sounder.
b. Determination of geo-hazards: especially ferrous materials underneath the seafloor, this is done using a magnetometer which has the ability to identify any magnetic field (metallic objects) around the marine environment of interest.

c. Identification of debris and wreckages on the seabed: This is achieved using a Side Scan Sonar (SSS) which provides a recorded video/pictorial imagery of inherent positions of debris and wreckages found on the marine environment of interest.
d. Navigation and Positioning using mainly GNSS Satellite Based Augmentation System (SBAS).
e. Survey Vessel as a moving platform which carries all the sensors (equipment)
f. Data processing using software(s) like Hypack, AutoCAD, Surfer etc.

Inasmuch as Geophysical Survey equipment(s) are expensive, it still remains the most **accessible** means of Hydrographic Survey available for charting all navigable waters in Nigeria, as it gives more detailed information on the seabed, as seen in (Egbuh, 2006) who carried out a hydrographic survey in the Lagos Port area for purposes of safe navigation: the equipment deployed for data acquisition included Echo Sounder, Magnetometer, Side Scan Sonar etc. Data was processed using AutoCAD, Hypack, HydroCAD, SurvCAD, GPS Path Finder office, with results showing depth variants from 1.1m to 24m and a total of One hundred and nine (109) wreckages in the entire survey area. The high numbers of wreckages simply shows the significance of detailed bathymetric and geophysical survey in delineating navigational channels. As the results from this survey shows a great number of hazards inherent to safe navigation. Now with this methodology and equipment(s), recommendations could be made for routine dredging of navigational channels, so as to maintain ease in vessel navigation.

**Fig 3 and Fig 4** below shows some equipment(s) employed in identifying Physical features which could impede safe navigation.


***Fig 3: SSS image on display on Topside, and showing a wrecked boat.*** *Source: JW Fishers (undated)*

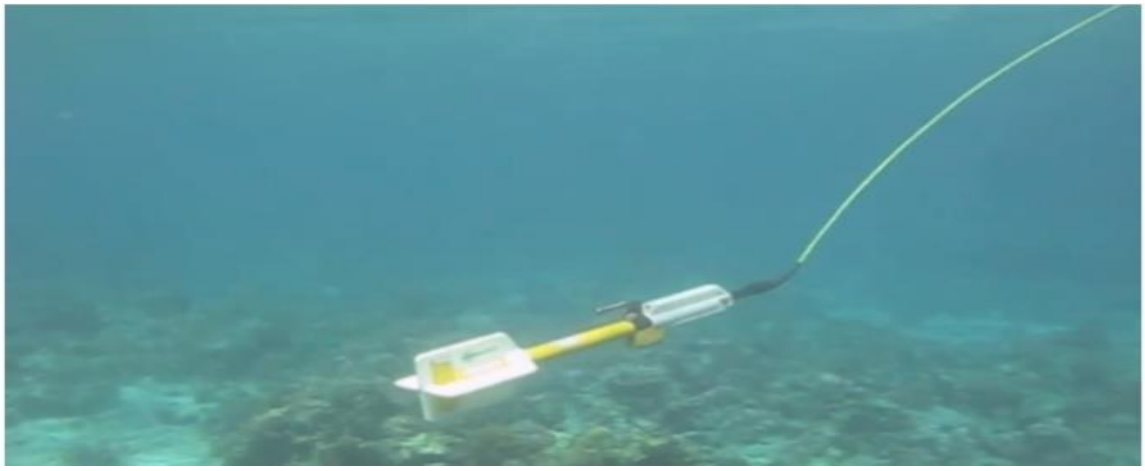

***Fig 5: G-882 Geometrics Magnetometer deployed in Nampula Mozambique.*** *Source: Arqueonates Worldwide (undated)*

## Remote Sensing Techniques

As the quest for improved precision in data acquisition for hydrographic survey has continued, there has been rapid development of modern technologies in remote sensing methods. Some of these new techniques which have been applied in bathymetric data collection have been described as "non-traditional" (Leder *et al*, 2020). They include; Unmanned Underwater Vehicles (UUV), Light Detection and Ranging (LiDAR) platforms and Satellite Derived Bathymetry (SDB)

**i. Unmanned Underwater Vehicles:** UUVs are products of robotic engineering applied in modern day hydrographic survey, either in Remotely Operated Underwater Vehicles (ROV) which requires tethered connecting cables and a human operator for functionality or an Autonomous Underwater Vehicles (AUV)whose operations are automated.

The commercial introduction of ROVs could be traced to the 1970's (Leder et al. 2018) which was a solution to Hydrographic survey in areas inaccessible to survey vessels to deploy sonar systems like the MBES, SSS etc. as described earlier. Currently, hydrographic uses for ROV include object identification (such as navigational hazards), vessel hull inspections and least depth determination (Leder et al 2018) with lighting and sonar cameras which carry out these tasks, thereby providing real time video and pictorial imageries of the interest marine environment.

**ii. LiDAR Platforms:** Several researches have stated that investigations have been carried out on the derivation of bathymetric data from satellite since the 1970s (Mavraeidopoulos *et al*, 2017; Jegat *et al*, 2016). However with the advancements in satellite technology, more work has been carried out on these techniques. An importance of bathymetric surveys in nautical navigation of shallow water is to avoid stranding (Sagawa *et al*. 2019). The traditional techniques such as the sonar systems as earlier described can at an instant measure a width equal to twice the depth of water. However, a shortcoming of this technique is that it cannot measure shallow waters effectively (Smith and Sandwell, 2004). The Lidar platforms have been adopted in hydrographic surveying of recent as can be seen in literatures such as (Sagawa et al, 2019; Irish and Lillycrop, 1999; Leder *et al*, 2020). (Humboldt State university, 2016) highlights that there are three types of Lidar platforms: (i) Ground based (ii) Aerial platform such as the Aerial laser scanning (ALS) and Drone Laser Scanning (DLS) and (iii) Satellite based platforms.

However, (Leatherman, 2003) classifies LiDAR based on two purposes, either Topographic or Bathymetric: were the Topographic LiDAR uses near-infrared beam to map land surfaces, the Bathymetric LiDAR uses infrared and green laser beam.

Bathymetric LiDAR is employed in hydrographic survey to capture geospatial data of the coastline and shallow waters (Leder *et al.,* 2020). A major plus to Bathymetric Lidar is that they are used in areas that are inaccessible to survey vessels (Zhang et al., 2019). A limitation in the use of ALB is that the target area must be in a flight capable area. Another limitation is the extremely high cost of ALB (Sagawa et al., 2019). This means that there will be insufficient data for areas that the survey vessels cannot access or that the airplanes cannot operate.

**Satellite Derived Bathymetry**

Satellite Derived Bathymetry (SDB) is defined as the determination of depth information by analyzing satellite images (Sagawa *et al*, 2019). This is one of the currently used state-of-the –art technologies in the estimation of depth using remote sensing techniques by employing multi-spectral or hyper-spectral sensors (Sagawa *et al*, 2019). Currently, SDB data has potential to become one of the main low cost sources of spatial data especially in hydrographic surveying (Leder *et al,* 2020). Further reads on SDB can be found in (Sagawa *et al,* 2019; Lyzenga *et al,* 2006; Kao *et al*, 2009; Manessa *et al.,* 2016; Mavraeidopoulos *et al*., 2017; Leder *et al.,* 2020; Gao, 2009; Pe'eri *et al.,* 2013).

**Artificial Intelligence (AI)**

Artificial Intelligence is an upcoming advancement in Hydrographic, as there are no dominant records of its use in Hydrographic survey. Artificial Intelligence involves embedding human capacities of logic, understanding, perception, reasoning, creativity etc. into a machine so that it can apply such capacities to any phenomenon of interest. AI has been employed in almost every sector of technology, and Hydrography is not a back bencher to this present advancement, as the Esri

GeoAI has employed machine learning and deep learning tools in ArcGIS to create point feature class containing shipwreck point and also provide charts of marine environment (Snow et al.2020).

**RECOMMENDATIONS ON THE FUTURE OUTLOOK**

To achieve this paper's aim of preserving the precision for mapping the Nigerian navigational channels, the progressive trend in hydrographic survey had to be reviewed from direct to indirect methods, ushering in more sophisticated equipment(s) for a precise and detailed depth determination and mapping of physical features. The following are some recommendations that if implemented could redefine the practice of hydrography in Nigeria with accuracy being the driving force.

1. **Involvement of Key Players**: Inasmuch as the Nigerian Navy is empowered to chart all Nigerian waters and delineate navigable waters, the seamlessness of achieving this is not feasible if all hydrography professionals are not involved. This includes call for all research works on all Nigerian waters and projects carried out by individuals and companies in the past, assessing their results with proper quality checks and compiling them, using it as base information for navigation and mapping of uncharted Nigerian waters.

2. **Satellite Systems**: Satellite systems seem to be the present and future of science and technology. More exploration and utilization of the technologies in satellite systems could be focused in remotely charting Nigerian Waters for the delineation of navigational channels. This might be expensive, considering the cost of building and launching a satellite, but the Nigerian Navy could latch on to the already existing satellites in space which could also be used to provide Satellite Based Augmentation System (SBAS) corrections and provide real time information on Nigerian navigation channels to vessels who have been granted permission to the frequency. This on its own is economically beneficial and guarantees security of our water ways for various offshore projects in trading, security, transportation, Oil and Gas etc.

3. **Exploring Advancements in AI and Programming**: There is a saying that mapping the moon's surface is easier than mapping the water bodies. This implores the Nigerian Navy to explore advancements in Artificial Intelligence and Programming as a means to map Nigerian waters for efficient delineation navigable channels.

4. **Quality Control:** The need for a Quality Control team which regulates hydro survey is important. A team that ensures that all standards for the practice of Hydrographic survey are followed, and also keeps a compilation of charts on Nigerian waters so as to maintain uniformity in practice.

5. **Training:** Because Hydrographic Survey is not as common as the regular onshore surveys, there are very few skilled in this practice. This stresses the need for adequate training or an improvement of the existing curriculum in Nigerian military academies, universities, polytechnics and colleges of education, so as to equip individuals with hands-on practical knowledge in the practice of accurate Hydrographic survey. For the preservation of accuracy in the practice of hydrographic Survey in Nigeria is determinate on the proper framework laid for the future generation.

**CONCLUSION**

The understanding of the progressive trend was crucial to recommending of the future outlook of charting the Nigerian navigational channels. This progressive trend has graduated steadily from the direct methods to the dominant indirect methods. But it is noteworthy to say that all succeeding methods were solutions to the limitations of the previous methods which were driven by the need for better accuracy and sophistication. Inasmuch as this paper has tried to proffer some recommendation, the future still seems unpredictable as it is probable that better methods and equipment(s) are expected to redefine the limitations of the present day dominant methods.

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# ONE HUNDRED YEARS OF INTERNATIONAL COOPERATION IN HYDROGRAPHY: A LOOK AT INTERAGENCY COOPERATION IN HYDROGRAPHIC SURVEY IN NIGERIA

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## INTRODUCTION

1. The link between humans and oceans has been fundamental to the development of civilization. Throughout history, the seas and oceans of the world have been essential for the exchange of goods, people, ideas and religion[1].This is evident today as about 80 per cent of global trade by volume is presently being carried by seas and oceans which cover 75 per cent of the earth's surface.[2] Global maritime trade has effectively permitted an enormous variety of resources to be more widely accessible and has enabled the widespread distribution of our planet's common wealth and to the increase and acceleration of the development of many States[3].This dependence of trade on marine transportation therefore makes having accurate and up-to-date information about the seas crucial. A critical understanding of these waterways towards ensuring their safe and effective utilization by nations and other entities necessitated the development of applied sciences such as hydrography. Hydrography is that branch of applied sciences which deals with the measurement and description of the features of the seas and coastal areas for the primary purpose of navigation and all other marine purposes and activities, including

offshore activities, research and protection of the environment[4]. Hydrography provides such vital information as water depth, hazards, tides and currents among others which enables mariners navigate safely across seas and oceans

2. There are no barriers, boundaries, or borders in the ocean, and although we often list the oceans separately, they are all interconnected to each other, forming one global ocean[5]. This means that coastal nations all over the world are affected by the connectedness of the ocean thus underscoring the international relevance of hydrography. Hydrographic information has typically been published in the form of nautical charts. These charts connected the global oceans across continents and proved critical for providing mariners the world over with the information they needed to navigate ships safely and efficiently. It therefore meant that international cooperation between chart making nations was crucial to ensure standardization of these nautical publications in order to eliminate ambiguity and ensure conformance to universally accepted practices. Additionally, mariners always needed to know the water routes to countries and ports with which they traded. This required the use of charts which had to be interpreted from foreign languages. Hence, there existed a pressing need to achieve international standardization in nautical charts and associated publications in the interest of peaceful trade and the development of better global communications.

3. The need to promote international cooperation and conformity to standards led to the first tangible steps being taken to establish an international organization that would promote the objectives of conformance to standards through coordinated international action. This was achieved through a meeting of hydrographers at a conference held in Washington in 1889 and a second one held in Saint Petersburg in 1912. Furthermore in 1919, a hydrographic conference was held in London and had

24 countries in attendance[6]. It was here that a unanimous decision was taken to establish a permanent coordinating organization to standardize charts and nautical products in aid to safety of navigation within world's seas, oceans and lakes. This move gave birth to the International hydrographic Bureau (IHB). The Bureau commenced its activity in 1921 with headquarters in the Principality of Monaco[7]. On 31 May 1976, Nigeria joined the IHB in order to demonstrate her commitment to providing accurate hydrographic services for international and local shipping and thus promote international cooperation. In a bid to achieve the aforementioned objectives, the federal government instituted several agencies with connected interests in hydrography in relation to coastal waters and inland waterways. These agencies include the Nigerian Navy (NN), Nigerian Port Authority (NPA), Nigerian Maritime Administration and Safety Agency (NIMASA) and National Inland Waterways Authority (NIWA). Over the past decades, these agencies have collaborated in various aspects of hydrography in a bid to provide mariners with up-to-date nautical information in the most standard form in order to aid safe navigation within Nigeria's waters. Notwithstanding this inter-agency cooperation, hydrography in Nigeria still remains fledgling stage.

4. It is against this backdrop that this paper seeks to highlight 100 years of international cooperation in hydrography with emphasis on interagency cooperation in Nigeria. The paper will cover historical development of hydrography, 100 years of international cooperation in hydrography as well as overview of hydrography in Nigeria. The paper will further consider interagency cooperation in hydrography in Nigeria, challenges of interagency cooperation among hydrographic stakeholders in Nigeria and finally a path forward: priority areas for interagency collaboration between maritime stakeholders in Nigeria. It is assumed that the effective synergy between hydrographic stakeholders in Nigeria will aid in the improvement of

international hydrographic cooperation. The paper shall be limited to the last 100 years of international hydrography which is the period of coordinated efforts in the practice of hydrographic survey.

## AIM

5. The aim of this paper is to highlight 100 years of international cooperation in hydrography, while laying emphasis on inter-agency collaboration between hydrographic stakeholders in Nigeria with a view to making recommendations.

## HISTORICAL DEVELOPMENT OF HYDROGRAPHY

6. One of the oldest stories of the sea titled 'The Odyssey' was written by the Greek poet Homer, circa 900 B.C. It tells the story of the mythical sea voyage made by the legendary Greek king Odysseus and mentions a part in it where Odysseus says to his crew 'My friends, east and west mean nothing to us here' referring to when they were lost in the vast seas during the course of their voyage. The first Western civilization known to have developed the art of navigation at sea was the Phoenicians, circa 2000 B.C. During these ancient times, sea voyages were undertaken using sailing directions which were based on the experience and estimates of seafarers. These sailing directions contained important information that was needed to safely sail from one port to the other. In more recent times, nations of the world began to develop the art of hydrography and nautical chart making as a means of facilitating safety of navigation at sea. Early hydrographic surveys consisted of depths measured by sounding pole and hand lead line, with positions determined by three-point sextant fixes to mapped reference points[8]. Lead lines were ropes, or lines, with depth markings and lead weights attached with the lines lowered and read manually to obtain depth values.

7. The nation of Denmark was one of the earliest countries to conduct hydrographic survey and nautical charting on a national scale. The Danish Admiralty first organized and conducted charting of Danish waters in the late 1600s. This included mapping the country's 500 islands and 7000-km long coastline[9]. In 1784, the country had collected relevant navigational details for both Danish and international waters. Thus, reliable and accurate charts were developed for both Danish Navy and Merchant Marine. The USA traces its nautical charting efforts back to 1807 when President Thomas Jefferson founded the agency known as Survey of the Coast to provide nautical charts that would ensure safe shipping, national defense, and maritime boundaries. The agency conducted hydrographic and oceanographic surveys, producing its first set of 6 charts from 1843 to 1845[10]. The agency was renamed Office of Coast Survey and became a department under the National Oceanographic and Atmospheric Administration (NOAA) which was designated as the national hydrographic office of the USA. Other countries such as United Kingdom, Australia and New Zealand also began nautical charting of their waters in the 18th and 19th century thus giving birth to the global use of nautical charts for navigation at sea and improved maritime safety. The Australian Hydrographic Service formerly known as the Royal Navy Hydrographic Service was established by the British Admiralty Hydrographic Office in 1897 to boost hydrographic survey in Australian waters. In 1913, the hydrographic depot was taken over by the Australian government and was renamed the RAN Hydrographic Department. Captain John Robins, RAN was appointed first Hydrographer in 1920 when the RAN Hydrographic Department was established at Navy Office in Melbourne on 01 October 1920. Subsequently, survey activities were performed by Royal Navy vessels until World War I[11]. Surveying operations did not resume in the region until World War II, when it became evident that Age of Sail-era charts of the

South West Pacific desperately needed updating with the RAN designated as the charting authority responsible for supporting Allied operations in the South West Pacific Area.

8. After the First World War, hydrographic efforts of various coastal nations of the world brought about tremendous improvements in the frontiers of the science of hydrography. As technology evolved so also did hydrographic methods as well as techniques, which brought about varying degrees of standards being adopted by different countries. However, the global nature of hydrography and nautical charts making meant that there was an urgent need to harmonize the efforts of these hydrographic and chart producing nations. New Hydrographic Offices were established and those already existing were developed. The Directors of the Hydrographic Offices of France and United Kingdom considered the possibility of holding an International Conference and the French director suggested that London would be the most adequate place to stage such a meeting. In June 1919, at the invitation of the British Admiralty, a hydrographic conference was convened in London, in which 24 nations participated[12]. This marked the beginning of international cooperation in hydrography.

## 100 YEARS OF INTERNATIONAL COOPERATION IN HYDROGRAPHY

9. International cooperation in hydrography truly began with the coordinated efforts of France and United Kingdom at organizing the first international conference in hydrography where various stakeholders from all over the world could come together to discuss hydrography related issues as well as develop a roadmap towards achieving seamlessness in hydrographic operations.. Upon the restoration of peace after the First World War, the French and British Hydrographers came together, and in April 1919 the British Hydrographer submitted his official proposal

to hold the world's first International Hydrographic Conference in London to the Lords Commissioners of the Admiralty. One of the most notable resolutions passed during the meeting was for the establishment of a permanent international bureau. It was agreed at the Conference in London that some form of IHB should be established, and that a longer period of work was necessary to develop this project. To examine this question, a special committee, called the International Hydrographic Conference Committee, was appointed[13]. This committee prepared the first draft Statutes and a set of provisional directions. Its work culminated in 1921, with the adoption of Statutes by the founding States Members, and the election of the first Directing Committee. This body was formed by Vice Admiral Parry from the United Kingdom, Rear Admiral Phaff of the Netherlands and Captain Müller from Norway. Commander Spicer-Simpson from the UK, who had been the Official Interpreter at the London Conference, was appointed as Secretary General. Thus, on 21 June 1921, the IHB was formally established and began its activities with 18 Member States[14]. The Principality of Monaco was selected as the seat of the Bureau, partly for its central location, but largely because of the generous offer of Prince Albert I of Monaco to provide accommodation for this new Organization. This action was the result of the interest of Prince Albert I in the fields of hydrography and oceanography, being himself an eminent marine scientist and explorer. On 22 September 1970, an intergovernmental convention was enforced that officially recognized the Organization as the International Hydrographic Organization and its secretariat became known as the IHB[15].

10. The designation of the IHO as an intergovernmental consultative and technical organization has played a vital role in ensuring international cooperation in hydrography. This has been achieved through the support of safe and eco-friendly marine navigation by providing accurate and timely hydrographic information to the

general public. As at 29 January 2021, the total number of IHO member states was 94[16]. The IHO council which is made up of representatives from member states including Nigeria has also effectively supported IHO objectives. In coordinating global hydrographic survey operations, IHO is saddled with the responsibility of ensuring that all the world's oceans, seas and navigable waters are properly surveyed and charted, through the coordinated endeavors of national Hydrographic Offices that also contribute to the promulgation of Maritime Safety Information (MSI). This is with the vision to 'be the authoritative worldwide hydrographic body which actively engages all coastal and interested states to advance maritime safety and efficiency and which supports the protection and sustainable use of the maritime environment'[17]. The mission of the IHO is to 'create a global environment in which States provide adequate and timely hydrographic data, products and services and ensure their widest possible use and to finally protect by the United Nations Convention on the Law of the Sea as a competent international organization in the field of Hydrography'[18]. For effective and efficient coordination of national hydrographic offices of member states, IHO set specific objectives which are found under Article II of Convention on the IHO. Thus, the IHO continues to influence national practices which countries have sacrificed in the interest of achieving an international goal which would permit mariners of all nationalities the maximum use of nautical publications published in any part of the world.

11. Hydrographic technology has also advanced over the course of 100 years and this has been largely due to cooperation among member states and also the IHO. IHO has been a key driver in these technological advancements through development of standards, guidance, products and services. The IHO develops and adopts standards and guidance that ensure that hydrographic information is available and can be delivered to users through appropriate harmonized and interoperable

products and services. The current maintenance of existing standards and the development of new ones are driven by the need to continue to satisfy the SOLAS requirements of enhancing safety of navigational, and more recently, supporting the implementation of "e-navigation", which is being led by the UN's International Maritime Organization (IMO)[19]. Both elements require easy access to standardized high quality digital geospatial information that can support marine spatial management. . Accordingly, the IHO continued to work on its Standards framework such as S-100, to support the creation and maintenance of interoperable maritime data product specifications compliant with that of the ISO-19100 series of geographic information standards.

12. As result of the work done by IHO, many Member States including Nigeria are making significant efforts to tailor technological advancements and methods in line with IHO as well as utilizing such datasets for national and international coverage. Through its active technical and capacity building programmes conducted in close liaison with other international organizations, notably the International Maritime Organization and the Intergovernmental Oceanographic Commission of UNESCO, the IHO supports the development and improvement of hydrographic and nautical charting standards, products and services, especially in digital formats. These capabilities contribute directly to safe navigation, informed marine spatial planning and coastal management and the prevention of natural disasters. Therefore, the collaborative efforts fostered by the IHO among member states have thus ensured that most of the world's established shipping routes are relatively safe for navigation.

13. In a bid to keep shipping routes within Nigeria's maritime space safe, hydrographic practice and nautical charting in Nigeria have been greatly influenced by the standards and guidelines set out by the IHO. This has largely informed

Nigeria's decisions in the development of methods and technologies utilized during hydrographic data acquisition and the production of Nigeria's indigenous paper charts and electronic navigational charts (ENCs).

## OVERVIEW OF HYDROGRAPHY IN NIGERIA

14. Hydrography in Nigeria dates back to the early eighteenth Century, when the Hydrographic Office of the Admiralty now present day United Kingdom Hydrographic Office (UKHO), surveyed and published charts used for navigation in Nigerian waters. On 18 August 1827, the first chart produced by the Hydrographic Office of the Admiralty covering Nigerian waters was published. That chart was titled Chart 594 - Chart of the West Coast of Africa and it was based on surveys carried out by HM Ships Leven and Barracouta under the direction of Captain W.F.W. Owen. By 1846, most of Nigeria's coastline had been surveyed at a scale of 1:72,000 through the use of leadline method and on 7 February 1861, the first chart of Lagos titled Chart 2812 – Lagos River, was published. The UKHO also conducted hydrographic surveys within Old Calabar River and Akwayafe River using HM Ships Peacock and Beacon. These surveys resulted in the production of fairsheets for the rivers[20].

15. In 1914, the Nigerian Marine Department was established. The Department was controlled by the Director of Marine and was responsible for all maritime matters including hydrographic surveys in the Colony and Protectorate of Nigeria. By October 1928, the first hydrographic survey was carried out by the Department[21]. The areas surveyed included Lagos Harbour, Apapa Crossing and Channel Approaches to Customs to Wharf. The data obtained during the surveys were forwarded to the UKHO for the production and update of their charts. The early 1950s saw extensive modernization of port facilities in Nigeria which had to be

properly managed to ensure productivity. This led to the enactment of the Ports Authority Ordnance of 1954 which created the Nigerian Ports Authority (NPA)[22]. Amongst the numerous roles of the NPA, was to provide hydrographic survey within the port limits of Lagos Harbour and the rivers of Forcados, Warri and Bonny. In November 1954, the first hydrographic survey by NPA was conducted at the Escravos River entrance.

16. The colonial government of Nigeria identified the need for a naval force for maritime security of Nigeria's territorial waters and on 1 June 1956, the Nigerian Naval Service was established and had amongst its obligations, to undertake hydrographic surveys outside port limits as directed by the Federal Government. This Service would later evolve into the Nigerian Navy (NN) through an Act of Parliament passed after Nigeria's independence. The Act of Parliament of 1964 further charged the NN with the responsibility of producing nautical charts and superintend over national hydrographic matters. Accordingly, the NN established the NNHD in 1970 to carry out this responsibility on its behalf. The NNHD was further sub-divided into the Nigerian Navy Hydrographic Office (NNHO), Nigerian Navy Hydrographic School (NNHS) and the NN Hydrographic Ship for ease of operation and administration. These efforts were aimed at building hydrographic capacity for the NN towards meeting its responsibilities to aid in facilitating maritime activities by improving safety of navigation and reliability of our shipping routes. Another objective for the establishment of the NNHD was to foster both local and international cooperation with various stakeholder agencies and organizations in the hydrographic sector.

17. The federal government established other hydrographic related agencies such as Nigerian Inland Waterway Authority (NIWA), Nigerian Maritime Administration

and Safety Agency (NIMASA) and the Nigerian Institute of Oceanography and Marine Research (NIOMR). NIMASA was established to promote safety of Nigeria's waterways. NIMASA undertook hydrographic surveys which was necessary for removal of wrecks and underwater obstructions to facilitate safety of navigation in Nigerian waters[23].In the area of ocean research studies, NIOMR was established to conduct hydrographic and oceanographic survey activities for research into the resources and characteristics of Nigeria's territorial waters[24].

18. Private oil and survey companies also contributed to hydrographic survey operations in Nigeria. With the discovery of crude oil in mainly offshore locations such as Oloibiri, Afam and Bomu in the 1950s, several foreign oil companies including Shell/Darcy Petroleum Development Company and Mobil Exploration Company of Nigeria, began prospecting for oil and gas[25]. In order to conduct these prospecting activities, hydrographic survey was utilized in obtaining critical information about the marine areas that the oil fields were located. Apart from oil exploration related survey operations, hydrographic survey work was also done by some oil companies with respect to environmentally related activities. In 1957, Shell/Darcy Petroleum Development Company in conjunction with local survey authorities, conducted hydrographic surveys in Bonny and Calabar River. The survey was carried out along with oceanographic and meteorological observations to determine the occurrences of bar at the entrance to the Bonny River during heavy rains and the weather that can be expected in Bonny vicinity under the worst conditions which occur during the rains[26].

19. The establishment of the above agencies by the federal government was as a result of the growing understanding of hydrography and hydrographic related activities and how they affected maritime activities both locally and globally. The

need for proper coordination of hydrographic efforts in Nigeria also saw several inter-agency cooperative efforts that would further institutionalize hydrography in Nigeria.

## INTER-AGENCY COOPERATION IN HYDROGRAPHY IN NIGERIA

20. The advancement of hydrography in Nigeria has been due in no small measure to the cooperative efforts of the various hydrographic stakeholders and their contributions towards the improvement of hydrographic knowledge and best practices. Since independence, Nigeria has continued to strive to fulfill her hydrographic obligations under the various international conventions she acceded to. In carrying out these responsibilities, various government agencies charged with hydrographic functions in Nigeria like the NN, NPA, NIMASA, NIWA and NIOMR interface with each other in what is called interagency cooperation, to advance hydrographic practice and nautical charting in order to facilitate safety of navigation within our waters.

21. Accordingly, interagency cooperation in Hydrography in Nigeria dates back to the 1950s and 1960s when the NN was carved out from NPA following an act of parliament. This led to the ceding of some vessels to the NN. Among the ships ceded to the NN by the NPA was a survey vessel named Pathfinder, which was used by the NN, in collaboration with the NPA, for hydrographic survey duties in the 50s. Between 1956 and 1958, NN and NPA conducted the survey of Lagos harbour, Opobo River (Imo River entrance), approaches to Lagos, Escravos River, Forcados River, Nun River, Bimbia River, Burutu and Benin River[27]. These early collaborative efforts in hydrographic surveys between NN and NPA during their formative years was thus very instrumental in obtaining important hydrographic data

that were used during the production and update of nautical charts by the British Admiralty for part of Nigeria's territorial waters.

22. Following the establishment of the Nigerian Navy Hydrographic Office (NNHO) in 1973 to carry out the responsibilities of charting and coordination of all national hydrographic surveys, more collaborative efforts were made with NPA and other relevant stakeholders to ensure that hydrographic practices in Nigeria are in accordance with international standards laid down by the IHO. During this period, the hydrographic offices of the NN and NPA interacted through exchange of ideas during conferences both at local and IHO levels. The interaction also led to the conduct of joint trainings and surveys and above all exchange of hydrographic data and Maritime Safety Information (MSI). These collaborations have facilitated the sustainment of MSI dissemination to mariners all over the world via Nigeria's MSI portal domiciled at the NNHO. It also facilitated the production of Nigeria's national navigational charts covering Lagos harbor and part of Badagry Creek. As at today, NPA shares its quarterly survey data with the NNHO for update of existing navigational charts.

23. Nigeria's maritime boundary delimitation efforts also provided another opportunity for cooperation between hydrographic stakeholder agencies specifically the NN and NIOMR. The federal government identified the western part of the Gulf of Guinea (GoG) as a region over which it could extend its national jurisdiction over the continental shelf beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured. This process required the submission of supporting scientific and technical data on the outer limits of the continental shelf to the Commission on the Limits of the Continental Shelf (CLCS) through the Secretary-General of the United Nations (UN). These key technical data were

obtained through hydrographic and seismic survey activities involving a multiagency survey operation by the NN, National Boundary Commission (NBC) and NIOMR. These agencies conducted joint survey operations in 2009 and 2016 around the identified western region within the GoG. The data collected from these collaborative survey activities have been submitted to the UN CLCS for consideration and possible approval for additional 150nm continental shelf for Nigeria. Nigeria. This joint effort between the NN, NBC and NIOMR in conducting survey operations for the purpose of national interest was largely applauded in all quarters of government. It is hoped that the CLCS would give a positive feedback and subsequently ratify the extension of Nigeria's outer territorial limits to 350nm.

24. There also exist a cooperation arrangement between the NN and NIMASA through executed MOU in area of hydrography. As at today, NN Hydrographic Officer heads the Hydrographic Survey Services Unit (HSSU) of NIMASA. This Unit, which operates under the direct supervision of the Executive Director of Maritime Safety and Shipping Development, was established to provide hydrographic services in areas pertaining to national maritime safety administration. This collaborative effort between the NN and NIMASA has also helped in sustaining MSI dissemination to mariners within Nigerian waters. It has also helped in identification of wrecks dangerous to navigation along Tin-can Ijegun channel, which has cut the attention of Nigerian Government and subsequently led to approval for their removal. It is believed that NIMASA will commence action for the removal of these wrecks in the next few months. It is, therefore, safe to say that the cooperative agreement between the NN and NIMASA has been effective towards ensuring hydrographic surveys foe wreck removals and identification of dangers to navigation towards enhancing safety of navigation with Nigeria's waterways.

25. In addition to collaboration among government agencies, there is also some form of collaboration that exist between private hydrographic practitioners and government agencies in the field of hydrography, primarily for the purpose of ensuring safety of navigation. For instance, the NPA is in a joint venture partnership with Lagos Channel Management and Bonny Channel Company for maintenance of Lagos and Bonny channels respectively. This has ensured safety of ships calling at the ports, with inherent advantage of improved revenue generation for the Government. The NN on the hand, through its Hydrographic Office monitors the activities of private survey companies engaged in any form of hydrographic and seismic surveys, as well as other marine scientific research activities within our waters. This is in accordance with the United Nation Convention on Law of the Sea (UNCLOS), as well as Nigeria's petroleum regulation L.N. 69 of 1969. Through this, companies are meant to conduct their survey and other survey-related activities within the approved limits and also acquire only data for which approval is given. At the end of the survey activities, these companies are meant to submit acquired bathymetric data to the NNHO for archival, as part of the National marine geo-spatial data infrastructure for Nigeria. These data always form the basis for update of existing charts and also provide basic information to surveyors and marine scientists wishing to carry out further studies within same area in future. This is in line with the concept of crowd-sourced bathymetry of the IHO, which is intended to obtain bathymetric data from other sources for various applications, particularly in chart updates. Thus, the cooperation between the NN and private practitioners in hydrographic and other related activities in Nigeria has helped in preventing clandestine survey of our waters for intentions inimical to Nigeria's national security and has also facilitated the development of marine geospatial data for national and other uses.

26. Nigeria has made modest gains in the development of hydrographic capability and standards through interagency cooperation among hydrographic stakeholders. These cooperative efforts have also translated to increased productivity from the individual agencies. Through collaborative efforts with the NN and private stakeholders, NPA has consistently and regularly conducted dredging and hydrographic surveys of all ports and harbour facilities. This has greatly aided shipping activities by ensuring free flow of vessels in and out of the ports and through the channels. NIMASA has also benefitted from interagency collaboration as they have also carried out surveys including bottom profiling surveys which were done to better assess the existence of guyots and other forms of navigational hazards around the Lagos Harbour entrances. Interaction between government agencies and private hydrographic firms also contributed to crowd-sourced bathymetric data that are crucial datasets for international initiative related to hydrography and nautical charting. Notwithstanding the successes achieved through interagency cooperation in Hydrography in Nigeria, there is still room for more improved collaboration among stakeholders in order to fully develop hydrographic practices in Nigeria. It is hoped that the recent induction of a 60-meter hydrographic survey vessel into the NN fleet will stem the tide in this regard.

## CHALLENGES OF INTERAGENCY COOPERATION AMONG HYDROGRAPHIC STAKEHOLDERS IN NIGERIA

27. Establishing a cooperative attitude and close working relationship among industries, and federal as well as state government hydrographic agencies is the best way of ensuring effective hydrographic and charting efforts in Nigeria. However, several challenges exist which have hampered such collaborative efforts. These challenges include lack of proper legislation, lack of joint participation/organization

of interagency hydrographic forums as well as inadequate information and knowledge sharing. These challenges shall be discussed subsequently.

## LACK OF PROPER LEGISLATION

28. The legal frameworks establishing several maritime stakeholders in Nigeria such as NIMASA, NPA and NIWA, could sometimes be a bit unclear with respect to the conduct of hydrographic operations which these agencies undertake regularly. Thus, there exists the potential to duplicate efforts, which leads to wastage of both human and financial resources. A major challenge for these agencies is determining where best to apply their efforts, both in terms of the relative importance of interconnected hydrographic issues and the potential effectiveness of processes and practices that can strengthen interagency coordination. Another challenge that potentially arises is unhealthy rivalry among maritime stakeholders which is due to overlapping and intersecting functions which breeds unnecessary competition. The inability to address these issues in a linked way among these agencies and with the private sector has resulted in significant unintended consequences, duplicative effort (as earlier mentioned), and high economic, environmental, and social costs.

29. The NN and by extension the NNHO is also affected by these interagency overlapping roles and responsibilities. The NNHO derives its functions from the Nigerian Constitution of 1999 and Armed Forces Act Cap A20 Laws of the Federation of the Nation, which vested the responsibility of charting and coordination of all national hydrographic survey in Nigeria to the NN. In spite of this, there still exist several bureaucratic bottlenecks which hamper effective cooperation between the NNHO and other agencies, especially as it relates to the coordination of national hydrographic surveys. . This is largely attributed to deficient legislation, which, although allows the NN to coordinate national survey activities,

but did not explicitly mandate other agencies to partner with the NN during the conduct of any of their routine national hydrographic activities. This makes it difficult for the NN to effectively perform this coordinating function, as most agencies assume that they are not obliged to do so, more so when they have constitutional mandate to decide what to do with data they acquire within their maritime area of jurisdiction. This has and will continue to slow down indigenous hydrographic and nautical chart coverage of Nigeria's waters. There is therefore the need for more improved data sharing among government agencies with hydrographic-related functions in Nigeria.

## LACK OF JOINT PARTICIPATION/ORGANIZATION OF HYDROGRAPHIC FORUMS

30. Public hydrographic forums, including workshops, seminars and capacity building trainings, provide a very useful opportunity for promoting synergy between stakeholders in the hydrographic sector. Most hydrographic related matters that arise are often times interconnected to each other and the various agencies and indeed private sector players experience these issues albeit at varying degrees. Joint conduct and participation in forums and seminars by the stakeholders provide a crucial platform for learning and sharing of experiences that could be valuabe in solving these interrelated problems. However, this has been lacking as most hydrographic agencies conduct trainings and organizes seminars and workshops on parallel lines. This often times prevents the sharing of information, technology and methodologies between agencies which could assist in addressing problems and improving standard.

31. The NNHO organizes sensitization workshops and seminars on diverse range of hydrography related matters including MSI and hydrographic best practices

regularly but the attendance by other stakeholders is often times poor. It is imperative to note that leveraging on various private and government agencies' hydrographic initiative through joint workshops and symposiums can effectively address the myriad of problems that occur in the industry. The various agencies could bring their considerable knowledge, assets and experiences to bear by engaging in constant dialogues over their agency goals, actions and objectives. This could result in significant multiplication of both government and private sector hydrographic stakeholders' actions and also help in building healthy interpersonal networks that could facilitate interagency relationships.

## INADEQUATE INFORMATION AND KNOWLEDGE SHARING

32. Inter-organizational collaboration among hydrographic stakeholders provides some important outcomes for the partnered organizations. One of such collaborative efforts is critical hydrographic information sharing and knowledge transfer. Collaboration between these hydrographic agencies not only transfers current knowledge among them but also paves the way for the creation of new knowledge bases and produces synergistic solutions. Each of these stakeholders possesses vast sea experiences and work force that is specialized in different aspects of hydrography. For instance, NNHO possesses practical experiences as the national authority for hydrographic survey and charting activities in Nigeria, while NPA which is in charge of the nation's ports and habours, conducts frequent surveys of these areas. Effective information and sharing between them in recent time facilitated the production of Nigeria's first indigenous navigational charts, which placed Nigeria on the map of chart producing nations of the world.

33. There is therefore an urgent need for other agencies like NIWA, NIMASA, NIOMR among others to volunteer navigational information within their area of

jurisdiction to the NNHO for improved nautical chart coverage of Nigeria's waters. Accordingly, effective collaboration could be encouraged between the aforementioned agencies which would pave the way to share resources, transfer knowledge and produce the synergy that is required for the development of hydrography in Nigeria. In achieving the desired outcome, these organizations need to be well embedded and actively involved in the process of collaboration by understanding the national imperatives of indigenously charting our entire maritime space.

## A PATH FORWARD: PRIORITY AREAS FOR INTERAGENCY COLLABORATION BETWEEN MARITIME STAKEHOLDERS IN NIGERIA

34. Several priority areas have been identified as ways of bolstering collaboration and cooperation between hydrographic agencies in both the public and private sectors. These strategies are targeted at mitigating the problems associated with synergizing hydrographic survey capabilities and operations between these relevant stakeholders including the NN. These measures include enactment of a National Hydrographic Law (NHL), and conduct of joint hydrographic trainings/exercises. . These will be discussed accordingly.

## ENACTMENT OF A NATIONAL HYDROGRAPHIC LAW

35. Enactment of a NHL would overcome the challenge of lack of legislation for coordination of national hydrographic activities. The NHL would provide the legal backing for the establishment of a National Hydrographic Office (NHO) to facilitate the coordination of all the stakeholders responsible for hydrography in Nigeria. The NHO could be headed by a serving professional hydrographer, designated as the Hydrographer of the Nation (HoN), from the NN, while representatives from MOD,

Ministry of Transport, Ministry of Finance, the NPA, NIWA and NIMASA could form the Board of the NHO.

36. The NHO could encompass liaison desks of other public and private sector hydrographic agencies. These liaison desks could act as interfaces between the various agencies thereby ensuring coordination by building mutual trust and understanding between relevant bodies. This coordination centre could create opportunities for joint trainings, seminars as well as other capacity building and technology transfer efforts. This will ensure that uniform hydrographic procedure that meets IHO standards is maintained in all agencies, thereby facilitating the production of national hydrographic charts and publications to support maritime trade towards enhancing national development in Nigeria. Therefore, there is the need to enact a NHL.

## CONDUCT OF JOINT TRAINING/EXERCISES

37. Opportunities to better identify and address collaborative efforts between hydrographic agencies and organizations are extensive. One of such opportunities is through the conduct of regular multi-agency training exercises, seminars and forums. As you are all aware, most hydrographic issues are interconnected and impact both public and private sector stakeholders. In order to effectively address these issues, the conduct of joint trainings and technical workshops is necessary as this involves all relevant stakeholders working together. This ensures that they all leverage each other's considerable knowledge, assets and experience. It also ensures that they engage each other in dialogues over goals and actions, which could result in significant multiplication of governmental actions to the benefit of the nation.

38. There is therefore the need to organize and conduct periodic exercises and capacity building trainings where the various stakeholders in the hydrographic sector can interface. These efforts would potentially result in more effective and efficient outcomes with positive return on investment. For issues that border on hydrographic matters, applying this framework can significantly reduce duplication of effort and therefore potentially result in cost savings, considering the high cost of conducting hydrographic operations. Furthermore, these joint trainings/exercises could reduce unintended consequences in which actions taken to address one stakeholder's domain without consideration other closely connected stakeholders can result in negative outcomes in these connected domains. Applying this criterion can help focus attention on those issues in which many agencies have overlapping jurisdictions and in which the potential for unintended consequences is high.

## CONCLUSION

39. The conclusion of the First World War in 1918 brought about significant progress in hydrography due to the effort of various coastal nations including the USA, Denmark, UK and France. The individual hydrographic efforts by these countries meant variances in standards and methods employed. However, the global nature of hydrography and nautical chart production necessitated the harmonization of efforts of the various national hydrographic offices. The IHO was established following an international conference of hydrography held in June 1919 in London, with a mandate of promoting international cooperation between hydrographic offices for safety of navigation and other maritime related activities. The designation of the IHO as an intergovernmental consultative and technical organization was instrumental towards ensuring the adherence to standards and best practices by member states including Nigeria. This ultimately streamlined the hydrographic

efforts of all member states and the creation of nautical products and related datasets that had both national and international coverage.

40. The early Eighteenth century and prior to Nigeria's independence saw a total reliance on the UKHO by Nigeria for hydrographic surveys and publication of nautical charts covering Nigerian waters. However, after Nigeria's independence in 1960 and establishment of government agencies including NN, NPA, NIWA, NIMASA and NIOMR, the total dependence on the UKHO reduced. This was as a result of hydrographic related operations being conducted by the aforementioned agencies as mandated by the Federal Government. Although, the UKHO still produced Nigeria's charts, the various government agencies began to develop hydrographic capacities. Nigeria formally joined the IHO in May 1976 with the NN designated as the national hydrographic agency as a result of her constitutional mandate. This move by Nigeria in joining the IHO, meant a development of a framework to guide the practice of hydrography in the country. As a result, the various government hydrographic stakeholders commenced the setting up of hydrographic departments that would ultimately contribute to the coordination of national hydrographic related operations for improved maritime activities.

39. Interagency cooperation among the various hydrographic stakeholders in Nigeria has contributed to the development of capacity, standards and industry best practices in Nigeria. The collaboration between the NN and other relevant hydrographic agencies has given rise to productivity in their operational outputs. These outputs range from the regular maintenance dredging and conduct of hydrographic surveys of harbours and port facilities by the NPA to the timely clearance of wrecks and other dangers to navigation by NIMASA. The NN through the NNHD has taken the lead role by conducting hydrographic surveys and

subsequent production of IHO approved paper and electronic nautical charts that are now being used for navigation by mariners. The NNHD has also taken the initiative towards contributing to crowd-sourced bathymetric data to IHO projects, through cooperative efforts with private oil/survey companies. All these have been instrumental in placing Nigeria among the on the international hydrography map.

40. As with various other endeavours, several challenges still exist which have impeded the collaborative efforts among maritime stakeholders and thus limited the growth of hydrography in Nigeria. Some of the challenges identified include lack of legislation, lack of joint participation/organization of hydrographic forums and inadequate information and knowledge sharing. These challenges were recognized as impediments to national hydrographic growth. There was thus an urgent need to address these challenges through strategies including the enactment of a national hydrographic law, greater multi-agency coordination and conduct of joint trainings/exercises. It is believed that the adoption of these strategies would positively affect inter-agency cooperation among hydrographic agencies on a national scale as well as promote international cooperation among coastal nations of the world.

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