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ASSESSMENT OF BATHYMETRIC COMPONENTS OF OGBOGORO SECTION OF NEW CALABAR RIVER, RIVERS STATE, NIGERIA

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ABSTRACT

Bathymetry involves the study of underwater depth of River, Ocean and Lake Floors and taking measurements of depth of water as to ascertain the sea bed topography of any river channel. The need for continuous updating of our navigational charts and maps with data from the Echo sounders is of utmost necessity as it will afford mariners and other individuals the opportunity to have knowledge of the sea bed topography. The essence of this bathymetric survey is to study the water depth of a section of New Calabar River Channel Ogbogoro so as to check the navigability status of the channel. New Calabar River Channel and has been known for a major navigational route for water transportation of goods and services. New Calabar River is located at the Southern part of Nigeria; it is one of the most stressed River in Niger Delta Region of Nigeria. There is need to provide Basic Bathymetric Data of the channel as to examine the navigability status of the channel and to address the likely phobia of wreckage due to unknown depth of the study area. The Study Area stretches to about 3.71km length and about 0.271km average width. This research is aimed at conducting a bathymetric survey along the ogbogoro section of the New Calabar River channel with the objectives of determining the depth values, production of bathymetric chart and digital terrain model (DTM) of the study area. Acoustic method of depth determination was adopted with the use of Single Beam Echo Sounder (south28). Data acquisition was done using south 28D echo sounder equipment mounted with GPS, tidal observations and reductions were done using predicted tide with Port Harcourt port as a reference port. Initial processing performed on observed bathymetric data include spike removal, tidal correction on instrument depth and sorting with south 28D software, further processing was done using microsoft Excel for data arrangement, AutoCAD software for Bathymetric Chart Production and surfer 10 software for production of Digital Terrain Model (DTM) to showcase the seabed profile. A query was performed on acquired data to determine the deepest and shallowest depth of the river, the deepest depth was found to be 19.76m while the shallowest depth was found to be 0.1m respectively. From the results obtained from the channel, there is a clear indication that vast changes have taken place on the seabed which may be as a result of continuous dredging activities along the channel.

Keywords*: Bathymetric, Dredging, Acoustic, Wreckage, Single-Beam*

1. BACKGROUND OF STUDY

Background to the Study:

The bathymetric survey of a river channel involves the study of the topography of the seabed, the types of the vessels that plies the channel and basic marine activities that occur within the channel. The International hydrographic organization (IHO) opined that where under-keel clearance is critical (IHO, S-44, 2008) specifies that navigability assessment should be accomplished to avoid ship wreck. These can be accomplished using method of bathymetry which involves the process of depicting the relief of the seabed including natural and man-made deposited features.

To assess the navigability of a particular channel, depths are usually reckoned to a particular datum (lowest Astronomical Tide LAT or Mean Lower Low Water Spring, MLLWS) and corrections such as vessel motion, tide, SVP and position from GPS are applied.

Hydrographic survey is the science of measurement and description of features which affect maritime navigation, marine construction, dredging, offshore oil exploration/ offshore oil drilling and related activities. Strong emphasis is placed on soundings, shorelines, tides, currents, seabed and submerged obstructions that relate to the previously mentioned activities. The term hydrograph is used synonymously to describe maritime cartography, which in the final stages of the hydrographic process uses the raw data collected through hydrographic survey into information usable by the end user (FIG, 2010).

Bathymetric data, in essence is information about the water depth and underwater topography of oceans, seas and lakes, are important in many aspects of marine and lacustrine research, administration and spatial planning of marine and coastal environments and their resources. In the deep sea, most bathymetric data are collected primarily for such purposes. Even though bathymetric data are still sparse in many regions, significant international efforts are pursued in order to assemble all available data and make these available to the public. Examples of such efforts include the International Bathymetric Chart (IBC) projects, endorsed by the Intergovernmental Oceanographic Commission (IOC), or the General Bathymetric Chart of the Oceans (Hall, 2006).

In the shallow waters and coastal areas of specific states, however, other societal needs are at the forefront: safety of vessel navigation is here the most prioritized rationale for bathymetric mapping close to the coast, around shoals and along shipping routes. This mapping is the basis for the production of nautical charts. In most countries, hydrographic surveying lies within the responsibility of national hydrographic offices or the navies. The detailed bathymetric measurements used for chart production are in some countries considered to be sensitive in bathymetric survey; the important data required are position, tidal reading and depth value. Normally, tidal reading is obtained at tidal section established near the survey area by using instrument like automatic or self –recording tide gauge. Depth of seabed is measured by using single beam or multi beam echo sounder. And the Global positioning system receiver is used for position fixing (Oye, Hart and Sika, 2021).

This study was conducted solely for the purpose of determining the depth of the river and for safe navigation of vessels. The survey comprises of many methods and their various applications in the marine environment, and has important role in coastal management.

1.1 Statement of Problem

The new Calabar River is a busy channel that host shipping, logistics and dredging companies that ply the channel for transportation and company's operations downstream. Up- to-date bathymetry information showing the depth profile of the river and the undulation associated with the river bed which might cause incessant navigational challenge which obstruct the movement of vessel and barge through the river route, therefore need to have a bathymetric chat of the study area for decision support in safe navigation. Thus, with the bathymetric chart of the channel, one can determine the optimal vessel route for safe navigation.

1.2 Aim of the Study

The study is aim at assessing the bathymetric components of a section of the New Calabar River, in Ogbogoro Community of Port Harcourt, Nigeria.

1.3 Objectives of the Study

i. To determine depth of the river by sounding

ii. To provide bathymetric chart of the study area

iii. To produce a digital terrain model (DTM) of the study area

1.4 Significance of the Study

The significance of this study is on the need to enhance safe navigation, and efficient traffic control of vessel sailing on the new Calabar River Ogbogoro. These can be possible by detailed chart of the river, depicting position (latitudinal and longitudinal position); depth, hidden and harmful substance to the vessels kneel well shown on such chart.

The data obtain will also be used by the fisher men as it will help display areas good for fishing, were fishing nets can also be deployed and left for a reasonable length of time without constituting navigational hazard to vessels. In addition, oceanographic charts, compiled and produced by Hydrographic offices, are now being extensively used by the fishing industry.

1.5 Study Area

The study area as shown in figure 1.1 is one of the most stressed River in Niger Delta. Mostly, the Kalabari Kingdoms are based on this river. The New Calabar River is an important water resource for the communities located along its bank, as they depend on the river for recreation, transportation, agriculture and sometimes for domestic water supply. The study area is the Ogbogoro section of the New Calabar River, Nigeria. It is located within a projected coordinate 269876.00m.E, 534740.20m.N and 269863.10m.E, 534725.00m.N. in Zone 32N, (WGS-84) Datum. The channel runs through nearby communities which includes: Aluu, Choba, Egbelu, Ozodo, Rumulumeni, Ogbakiri. The section under study stretches to about 3.71km length and 0.27km average width.

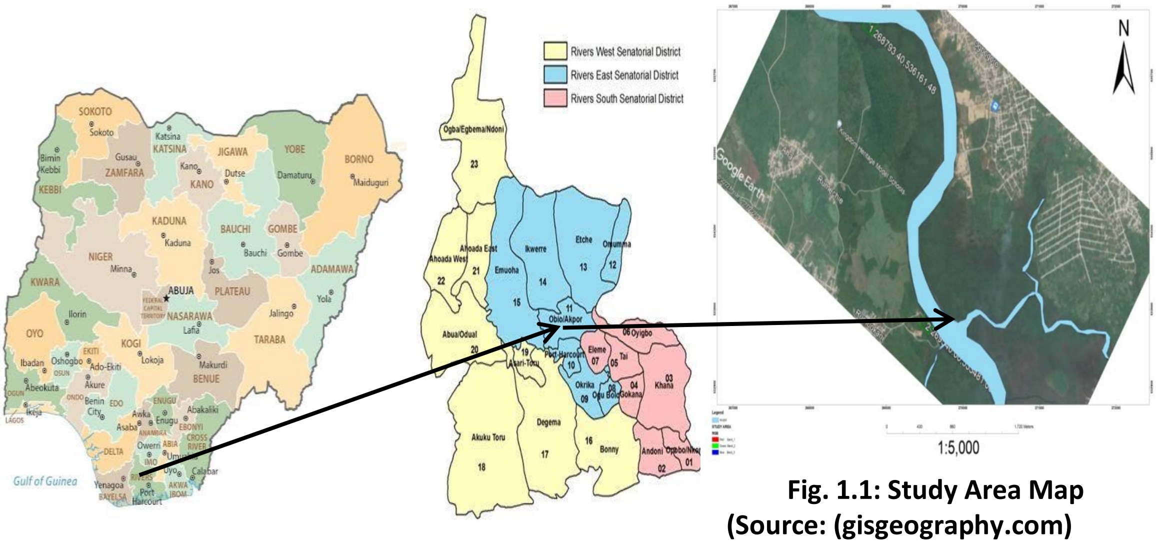


Fig. 1.1: Study Area Map (Source: (gisgeography.com)

2. MATERIALS AND METHODS

2.1 Instrument selections

Hardware: South 28 echo sounder and accessories, Transducer, Leveling staff as temporal tide gauge, Life vest, Survey boat, Bar check plate, 12volts battery, Boat bracket (fixing of transducer), Laptop, Infinix phone camera and Cutlass

Software Used:

1. Microsoft office 2010 (Microsoft Word and Excel)
2. South Single Beam Echo Sounder (28) downloading software
3. PowerNav software
4. AutoCAD 2007 software
5. Surfer 2010 software
6. TideCOMP software

2.2 Research Methodology

The methodology adopted in this study is the principle of acoustic Bathymetry. This is shown using equation as follows:

$$D = \tfrac{1}{2} Vt \qquad ...2.1$$

Where

D → sounded depth
V → speed of sound in water
t → two-way travel time of sound

Research Methods:

Reconnaissance: The study area was visited to take an outlook and firsthand information of the study area which will greatly assist during pre-analysis, planning and execution.

Designing of Sounding Line: AutoCAD 2007 was used to design the sounding lines as represented in figure below. The interval was 10m interval at longitudinal format. The sounding line was designed to run perpendicular to the contour and parallel to each other according to IHO standard .it was also designed to run along the longitudinal section of the creek (perpendicular direction to the coastal lines) see figure 3.2 below

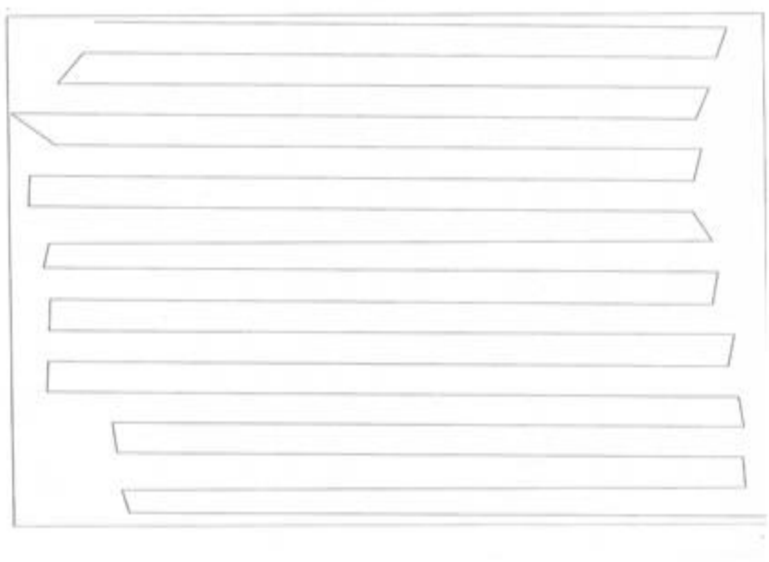


Figure 2.1: Design of Sounding Lines

Bar Check Calibration:

The effect of a varying velocity of sound propagation is measured by performing bar check calibration which is the most common depth calibration technique used for depths about 20- 30 meters (IHO 2008).

Procedure: As shown in figure 2.2, The suspended bar as a bar check apparatus is constructed of flat stainless steel or aluminum plate suspended by two precisely marked lines to a known depth below the water surface and under the transducer. When applying the bar check, method, a reflective bar or plate, is lowered beneath the transducer on marked lines at various depths. A series of depth intervals are observed during a bar check, down to the project depth. The observed depths are compared with the known depths on the lowering bar or plate. Schematic Depiction of Bar Check Calibration, Bar check not only measure the sound velocity errors due to temperature, salinity, or other suspended or dissolved sediment variations, but also static draft fluctuations resulting from varying vessel displacement and instrumental errors-index, mechanical, and electrical (USAGE 2002). The necessary corrections for velocity of sound propagation can be computed by comparing the observed depths.

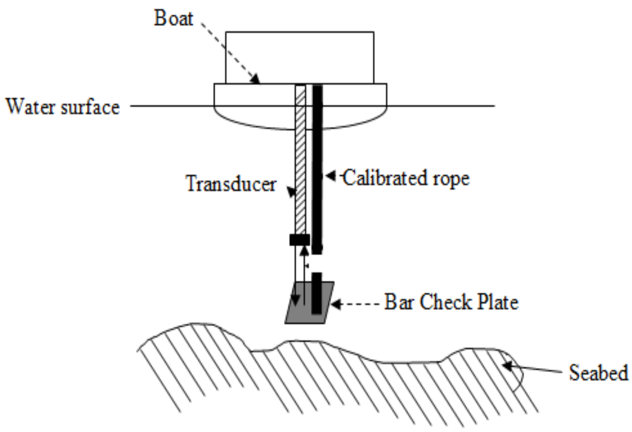


Fig 2.2 Bar Check Calibration, Source: (Ojinnaka, 2007)

2.3 Stages of Data Extraction: The following steps were taking:

Copy the raw file in cabinet form) into a desktop system and confirm it is copied.

Open SDE-28s Software on the desktop

Go to file, from dropdown option and click extract

Save in Comma Separated Values format (excel format), the date, time, fix numbers, northings, eastings, depths, false depths, frequencies will automatically save.

Select excel and it will automatically save details.

South SDE-28s Echo Sounder user Manuel (2017)

2.4 Reduction of Bathymetric Data

With respect to figure 2.3, The Sounded depth is reduced to the reference datum (Mean Tidal Level) by applying the tidal level which was gotten from the tideCOMP predicted tidal table from the start time to the stop time at an interval of 10mins. There was total of 21 main sounding lines, 1 cross line at the centre, 1238 points was fixed at 10m interval averagely considering the wave, operator, tidal, and boat irregularities.

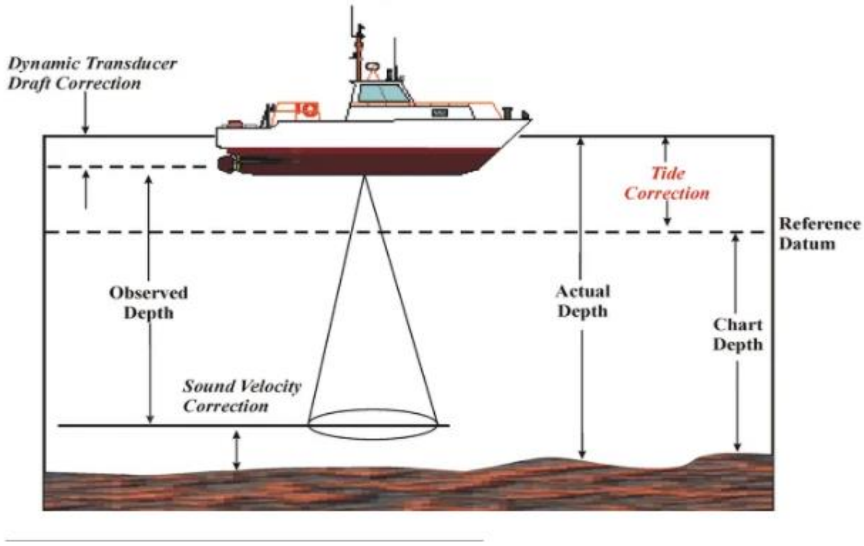


Figure 2.3: Principle of Bathymetric Data Reduction Source: (Ojinnaka, 2007)

The model was adopted for the Sounding reduction,

$D = SD + T - Tp$ (2.2)

Where:

D $\rightarrow$ Final depth above sea bed
SD $\rightarrow$ Sounded depth
T $\rightarrow$ Depth of transducer below water surface(Draft)
Tp $\rightarrow$ Predicted Tide

2.5 Depth Determination

As shown in figure 2.4, Transducer (probe) launches ultrasound, and then measure delta-T between the emission wave and the reflected wave.

Acoustic propagation velocity in water is V, transducer (probe) transmits ultrasound, acoustic emission by the probe to the bottom of the sea, reflected back by the bottom and received by the transducer, then measure the round trip time the acoustic experienced by t,

Therefore; $Z = Vt / 2$ …2.3

At the same time, read the scale on the junction pole to get the value of the draft (draft is the value between the water surface and the bottom of the transducer).

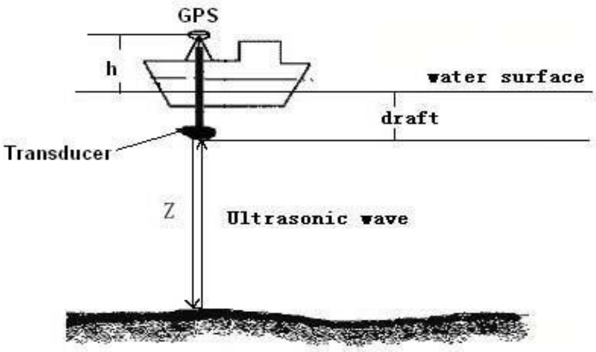


Figure 2.4 Depth Determination, Source: (Ojinnaka, 2007)

The signal frequency of the high-frequency transducer is about 200KHz, that of the low-frequency transducer is about 20KHz. Low frequency signal has a longer wavelength, strong diffraction function, so strong penetration capacity, the general penetrates a certain thickness of silt.

Depth ranging

During the measurement, different water depth measurements adopt different frequencies, the place we worked is salty water so we used a sound velocity of 1480m/s.

2.6 Bathymetric Data Processing:

A project is said to be successful if the data acquired could be processed, analyzed and information given out. This information should meet standards already set before such project could be said to be successful. The field data collected was carefully processed after the successful compilation of all the field records from the bathymetric survey of part of Ogbogoro section of New Calabar River, Nigeria.

Data Analyses:

The data was converted to comma-separated values (CSV) format right there on the field after the sounding was done been within November, 2021 with the aid of south28D Software as follows; double click on the folder were the job was save. Then open the file name click on replay. It will replay the whole job done click on end. To end the replay process, click on file then export to CSV file. You can now view the job in excels format then copy to your laptop. South 28D Echo sounder was used first. Create a folder on the D disk, and we connect the GPS cable to data port so as to make it interfere with the monitor between the traducer and the echo sounder.

2.7 Tidal Reduction:

The tide gauge was established in reference to the predicted tide using the TideCOMP software containing tidal predictions for Nigeria Ports and channels. Port Harcourt Tide gauge located at latitude 04˚ 46' 00" N and longitude 07˚ 00' 00" E was used. The tidal value of the corresponding time of sounding was used for the reduction of the final depth. As shown in the tidal graph of the tideComp software in figure 2.5, the tide is a semi diurnal tide.

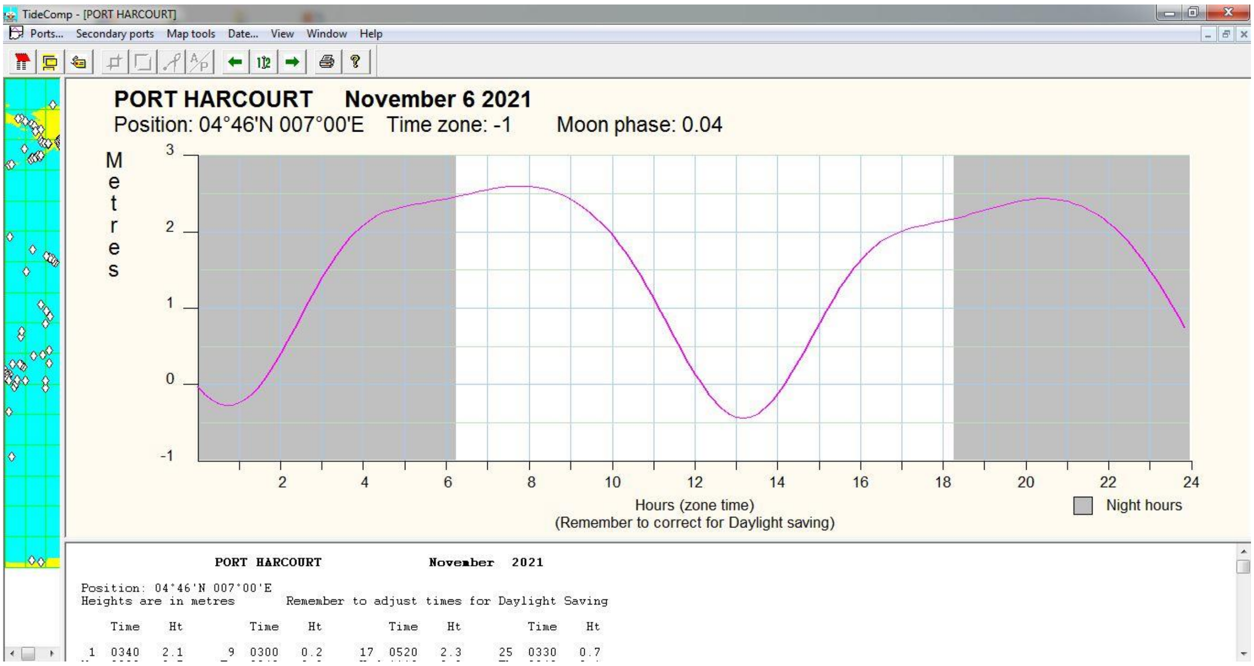


Figure 2.5 Showing Port Harcourt Port Tidal Values
Source: (tideComp software)

3. RESULTS AND DISCUSSIONS

Table 3.1: Bar Check Calibration Result

G1166 fx =E1166-F1166

	A	B	C	D	E	F	G	H	I	J
1	S/N	DATE/TIME	EASTING	NORTHING	RAW DEPTH	TIDE	REDUCED DEPTH			
2	1	11/6/2021 21:03	269516.23	536180.845	7.29	-0.1	7.39			
3	2	11/6/2021 21:03	269508.84	536184.555	9.49	-0.1	9.59			
4	3	11/6/2021 21:03	269499.58	536180.896	12.4	-0.1	12.5			
5	4	11/6/2021 21:03	269488.47	536175.4	14.73	-0.1	14.83			
6	5	11/6/2021 21:04	269479.2	536168.054	14.77	-0.1	14.87			
7	6	11/6/2021 21:04	269468.07	536157.027	16.72	-0.1	16.82			
8	7	11/6/2021 21:04	269458.8	536147.838	17.35	-0.1	17.45			
9	8	11/6/2021 21:04	269449.52	536138.649	18.39	-0.1	18.49			
10	9	11/6/2021 21:04	269442.1	536129.454	18.55	-0.1	18.65			
11	10	11/6/2021 21:04	269432.82	536118.421	12.85	-0.1	12.95			
12	11	11/6/2021 21:04	269427.24	536107.377	8.55	-0.1	8.65			
13	12	11/6/2021 21:04	269421.66	536096.333	4.89	-0.1	4.99			
14	13	11/6/2021 21:04	269419.77	536085.278	3.86	-0.1	3.96			
15	14	11/6/2021 21:04	269425.29	536076.043	3.42	-0.1	3.52			
16	15	11/6/2021 21:05	269434.51	536066.797	3.91	-0.1	4.01			
17	16	11/6/2021 21:05	269445.58	536057.546	3.87	-0.1	3.97			
18	17	11/6/2021 21:05	269456.67	536055.668	4.69	-0.1	4.79			
19	18	11/6/2021 21:05	269469.62	536059.316	8.63	-0.1	8.73			
20	19	11/6/2021 21:05	269484.44	536068.488	13.4	-0.1	13.5			
21	20	11/6/2021 21:05	269495.56	536075.828	16.22	-0.1	16.32			
22	21	11/6/2021 21:05	269508.53	536085.006	16.3	-0.1	16.4			

Calibration Time	Bar Check Depth	Echo sounder Depth Reading 1st Reading	2nd Reading	Mean depth	Difference	Remarks
13:47 Hours	1m	0.98m	1.05m	1.015m	0.015	OK
13:49 Hours	2m	2.07m	2.08m	2.075m	0.075	OK
13:51 Hours	3m	2.98m	3.09m	3.035m	0.35	OK

The data acquired from the sounding operation was extracted into the SDE-28s software for post processing and saved in comma-separated values (CSV) format which is readable in excel.

The post processing involves removal of spikes, false depths and outliers.

3.1 Sounding Values

Table 3.2 : Screen Print of Sounding Values

Table 3.3: Areas of Shallow Depths Varying from 0.1m to 2m

S/n	Eastings (m.E)	Northings (m.N)	Depths (m)
1	269513.88mE	534374.98mN	0.1
2	269894.65mE	536323.14mN	0.52
3	268894.65mE	536326.36mN	1.16
4	269417.35mE	534139.88mN	2.0

Table 3.4: Areas of deep depths varying from 15m to 19m

S/N	Eastings (m.E)	Northigns (m.N)	Depths (m)
1	269420.97mE	534442.79mN	16.93
2	269415.61mE	536161.97mN	15.29
3	268912.77mE	536330.72mN	17.25
4	269701.86mE	535809.729mN	19.76

Result Presentation

After all the data have undergone processing (computation), the processed data were used for plan production. The plans were produced in two 2-Dimensional model (AutoCAD) and 3-Dimensional model (Surfer).

The result from the Bathymetric survey shows the variation in the depth of River bed, figure (3.1) below shows a section of the chart depths reduced to Datum.

There are multiple formats and scales of presenting bathymetric data which is determined by the purpose of the survey. For this study, the bathymetric chart of the study area was plotted using AutoCAD 2007, due to its flexibility.

Surfer 10.0 was used to plot the contour of the river.

2-D Model (AutoCAD):

The coordinates (Northing and Easting) of the shoreline region, sounded Depth, details (natural and artificial features) were used in plotting with the gridded sheet on a suitable scale 1/5000.

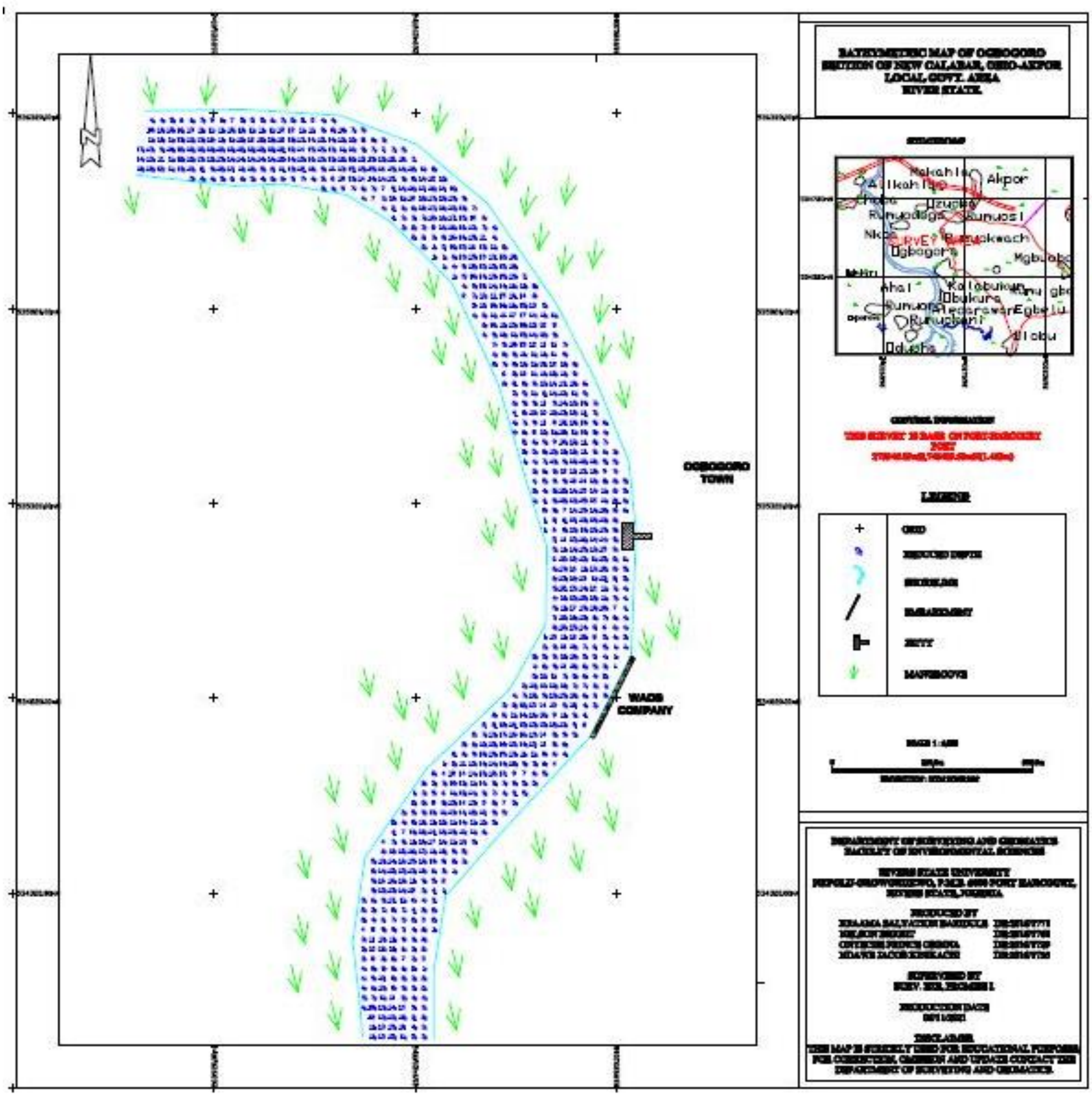
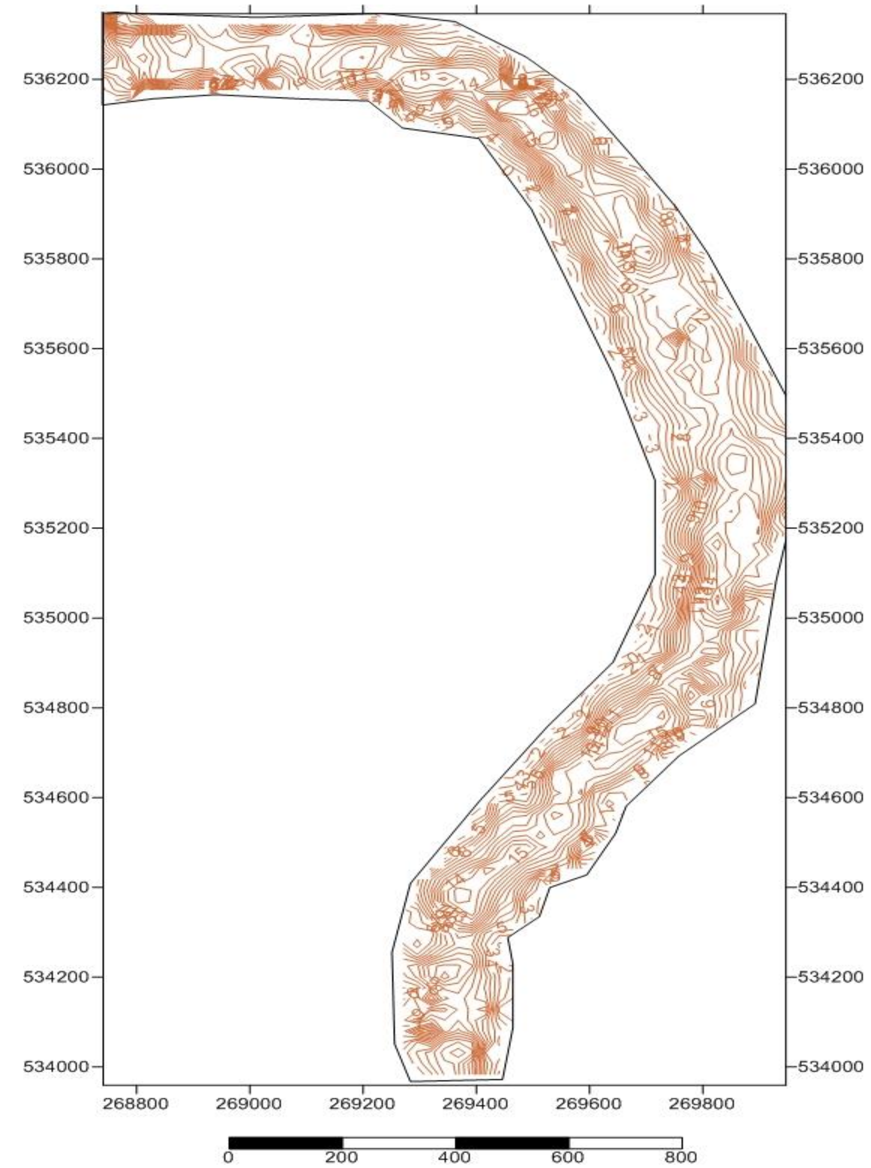


Figure 4.2 Print Screen of the Study Area Bathymetric Chart

The width of the river varies from 165.68m from the beginning (South), 272.38m at the middle and 147.06m towards the ending apart (North) band length about 2.798km.

It was observed that the minimum depth was 0.1m and maximum depth of 19.76m, most of the areas of shallow depths are along the western side of the shorelines, and are usually dry out areas during low tide.

Figure 3.2: Contour Map of the Study Area



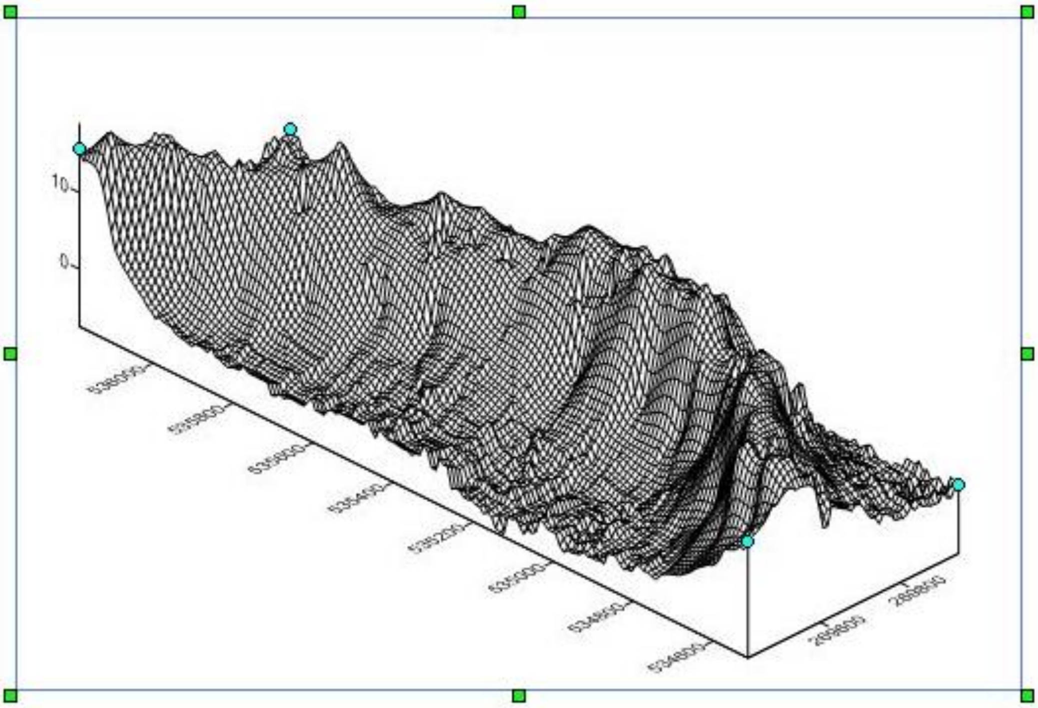


Figure 3.3 Wire Frame Contour Showing the 3D Formation of the seabed topography

4. DISCUSSION

Table 3.1 had shown sounding depth values which were performed with the aid of microsoft excel and table 3.2 and 3.3 shows areas of shallow depth and deep depth respectively. Figure 3.2 shows the bathymetric chart depicting the true nature of the seabed within the study area. Figure 3.3 and 3.4 are contour map and wire frame of the study area plotted using surfer 10 software at one meter interval which showcase the nature of the seabed. Contour are imaginary lines connecting points of equal depth while wire frame is a visual model of the seabed in three dimensions (Easting, Northing and Depth). From figure 3.2, 3.3 and 3.4, it can be inferred that the seabed is at a permissible level of navigation as the presence of hills or rock outcrops are not available. This therefore means that either low or high tide this channel is safe for navigation and also the channel is open and tidal.

5. CONCLUSION

The entire proposed working environment appears relatively very calm with no serious traffic along the channel. The water is salty and the vegetation is light. Finally, the entire survey operation was done successfully without any form of disturbance. The result obtained has clearly justified the necessity of the study. The dynamics of Acoustic method of determining depth adopted was demonstrated to achieve the aim of the study using stated objectives. The obtained depth values varies from 0.7m to 26.8m, this indicates that some section of the sea bed are relatively levelled, fairly undulating and highly undulating.

6. RECOMMENDATIONS

Shoreline protection should be carried out along the rivers so as to protect the river from accretion as a result of solid waste dump, periodic (annual) bathymetric survey and seabed mapping should be carried out to update mariners and other users on the navigational status of the waterways and river channels and Navigational charts should be produced for commercial purposes to guide and direct mariners and other uses of the river channels and waterways of the safety routes. Some few meters from the shoreline is dredged and is harmful to recreational purpose, therefore, awareness should be put in place to avoid loss of lives.

REFERENCES

[1] Abiose, A. (2013). Vanishing Lagos coastline: Dynamics of coastal morphological processes. “the premium time newspaper (December 9,2013)” :http://wiercentreforafrica.com/page/2/.

[2] Afonja, Jimoh, Atagbanza and Opoola, (2016). Bathymetric survey of Five Cowries Creek Lagos, Nigeria

[3] Broman, B., B. Hell, T. Holmqunist, L. Jakobsson, R. Lindgreen, A. Magunnsam and P. Wilberg (2011). A harmonized depth model of the Balticn analysis of demands and required specification. TecheRep. Swedish Marine Administration, Stockholm University.

[4] Chukwu, F. N. and Badejo, O. T. (2015). Bathymetric survey investigation for Lagos Laagoon sea bed topographical changes journal of geosciences and geomatics, 3 (2): 37;43.

[5] Damia Gomis, and Sabastia Monserrat (2012). Mediterranean sea level variability and trends: the climate of the mediterranean region 2012, pages 257-299.

[6] Federation International des Geometrics. (2010). Guidelines for the planning execution and management of hydrographic surveys in pats and harbours. International federation of surveyors (Fig.) Copenhagen. Denmark.

[7] Haiggangs. L. H. Haitaoz, Yongli, Z. (2005) a Fast algorithm of cartographic sounding selection, Geo-spacial information science. 2005:8:262-268.

[8] Hall, J. (2006). GEBCO Continental Special issue-chartering the secret world of the Ocean floor: the GEBCO project 1903-2003. Marine geophysical research.

[9] Hughes, J.E. (2000). Present Day Methods of Depth measurement: In: Continental shelf limit, the scientific and legal interface, eds, cook and carleton, oxford univ. press, page.139-158

[10] International Hydrographic Bureau (June, 2015) “IHO Standard for Hydrographic Surveys.

[11] International Hydrographic Organisation. (2008) IHO Standard for Hydrographic Surveys. Special publication No 44,5th edition: http//www.iho-ohi.net/iho_pubs/standard/s-44_5E.pdf.

[12] Krocker, R.and Schenke, H.W. (2006). Comparison of predicted and measured Bathymetry. Acta Acustica united with Acustica: 92:159-162.

[13] Ojinnaka, O. C. (2007) Principle of hydrographics survey from Sextant to satellite.

[14] Olanrewaju, M. O., Lawrence H. and Sika O. (2021). Bathymetric components towards ensuring navigable channel along a section of lower river Niger, Locoja, Kogi State Nigeria. Volume 5, issue 5, International journal of Hydrology. Pages 231-238. Doi: 10.15406/ijh.2021.05.00285

[15] Plater, A.J. and Kirby, J.R. (2011). Sea level change and Coastal Geomorphic Response: Treatise on estuarine and coastal science volume 3, 2011, pages 39-72.

[16] Quadros, N.D., Collier, P.A. (2008). Bathymetric LIDAR performance in shallow coastal water: Proceedings of the 16th european based Biennial of the LFHS, 4-6 November 2008, Liverpool (uk), 3:1-11.

[17] Quadros, N.D., Collier, P.A., Fraser, C.S. (2008). Integration of bathymetric and topographic LIDAR: A preliminary Investigation proceedings of the XXI congress for the International Society for Photogrammetry and Remote Sensing, 3-4 July 2008, Beijing China,1299-1304.

[18] Ross, D.A. (1995). Introduction to Oceanography. New york, Ny: Harper collins. pp.236-242

[19] Russell C and Minnick (2000). Global seafloor topography from satellite altimetry and ship depth sounding. Volume 277:1956-1962.