SPATIAL DATA BASELINE STUDIES OF A SECTION OF SOMBEIRO RIVER; ADJOINING THE DEGEMA HULK JETTY

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ABSTRACT

The study of under water depth of lake and ocean floors and accurate data for production of nautical chart is the main objective of bathymetric survey. This research work was conducted to investigate changes in the topography of a section of the Sombeiro river adjoining the Degema hulk jetty. Data acquisition was done using satellite imagery, tidal observation and reduction, depth sounding with echo sounder and GPS. Initial processing performed on observed bathymetric data includes tidal correction on instantaneous depth and sorting with HYPACK 2008 software. Further processing was done using ArcGIS 10.0 software. The processed depth was analyzed and presented in form of charts and graphs. From the analysis conducted, there is an accreted sediment volume and perhaps could have been influenced by the adjoining tributaries of the sombiero river. For further studies, the need to investigate the stretch of the sombiero river starting from Obuama through Degema to Abonnema is recommended.

Keywords: Bathymetric survey, Spatial data, Sombeiro river, Shoreline, Topographical changes.

INTRODUCTION

Hydrographic surveying deals with the mapping of large water bodies for the purpose of navigation, construction of harbour works, and prediction of tides and determination of mean sea level. It consists of preparation of topographical maps of the seabed. The survey must be repeated periodically as both natural currents and large storms are continually shifting silt on the sea floor – which may accumulate and cause dangerous conditions or obstructions. Hydrographic survey must be utilized to have an acceptable knowledge on the periodic happenings on the seabed along the shoreline.

Apparently shoreline engineering measures depends on proper and studied evaluation of the shoreline involvement; such evaluation will invariably require an appropriate spatial data set for the targeted shoreline. This would include the identification of the land - sea interface in addition to the understanding of the physical regime within the shoreline. The provision of this spatial data set for initial studies, assessment and design is the role and responsibility of Surveyors. However, the Surveyors role does not end with the provision of the initial spatial dataset.

One of the measures to monitor the impact of shoreline engineering works is the implementation of shoreline monitoring programme for certain marine engineering projects. This programme included initial or baseline survey, shoreline monitoring survey during the construction works period and thereafter for a further post construction period.

Initial or Baseline survey

A comprehensive land and hydrographic survey is undertaken for the designated shoreline and the results of the survey forming the initial or baseline survey is normally utilized for initial engineering and hydraulic studies, assessment of design alternatives as well as detail engineering design. Hence, the scope of the work has to be carefully determined to ensure "fit-for purpose". The survey will cover both the land and the adjoining sea.

During the construction period or implementation stage

Shoreline monitoring surveys over selected section of the designated shoreline are carried out, normally at three or four monthly intervals hence three or four surveys per annum. The results of the survey are compiled and the impact of the ongoing operation on the adjacent shoreline monitored.

Post – construction period

After the completion of the engineering works, shoreline monitoring continues for up to three years and survey are carried out at six monthly intervals. The results of the survey are compiled and continue to be monitored.

It brings in fore the role and essentiality of spatial dataset. A surveyor's involvement begins at the study, assessment and design stage but do not need to end there, as it was in previous occasions. The survey's involvement and contribution continues for a few more years afte the end of the end of the construction works, after all the construction plants and machineries have long being demobilized from site.

In addition, the surveyor is called upon to review the results of it's survey, to compute quantities and volumes and to provide hard facts of the physical situation at site. This allows planners, engineers and decision makers' data to access the coastal works in an objective manner, to ascertain whether project objectives and intent has been met and whether the project provides the necessary returns.

STATEMENT OF THE RESEARCH PROBLEM

The shoreline is a highly dynamic environment with many physical processes such as tidal fluctuations, flow pattern, wave and shore current etc. These processes in modifying the shoreline changes, rate of positional change and future prediction play an important role in any shoreline development studies, marine transport, sediment budget.

In Nigeria, there are many developments taken place in the marine environment such as construction of jetties, land reclamation, dredging, shoreline embankment to mention but a few without a long-term baseline study, investigating the spatial data of the seabed environment as a basis for physical planning design, construction and post development management.

The section covered by the study, the sombeiro river adjoining the Degema hulk jetty do not have any spatial information for baseline studies.

THE STUDY AREA

Degema is the headquarters of Degema Local Government Area of Rivers State with a land area of 1,011km2 and a population of 249,773 at the 2006 census

Degema, a town and village port in Rivers State, Southern Nigeria on the Sombreiro River (an outlet of the Niger). A traditional market centre of the Ijaw people, became a major exporter of palm oil and kernels after the decline of the slave trade in the early 19th century. The Degema – Abonnema port has been eclipsed by the success of Port Harcourt 17 miles (27km) east but vessels of 16-foot (5meters) drift still navigate the 42 miles (68 km) to the port from Bonny in the Boler creek, the new calabar river and the kra-kra creek. Degema is located latitude $7^0 21^{'} 15^{''}$N and longitude $8^0 17^{'} 54^{''}$E in an area of swamps, mangroves and tropical rainforests.

Degema climate is classified as tropical. During most months of the year, there is significant rainfall and only a short dry season. The average annual temperature is 26.8^0C and precipitation average 2610m.

The study was carried out for a period of two years (2013-2015) with two separate observations each for 2013 and 2015 in the sombreiro river in the Niger Delta of Nigeria. It is one of the rivers that drain the western part of Rivers State. The river provides nursery and breeding grounds for a large variety of fish species (Ezekiel et al.2002).Sombreiro river is located in three Local Government Area – Degema , Akuku-toru and Asari-toru between latitude $6^0 30^1$ and 7^0N and longitude $4^0 12^1$ and $6^0$17'E. It is a tributary of the River Niger which arises Northern boundary of Rivers State and Imo State connecting other rivers via creeks and drains into the Atlantic Ocean.

METHODOLOGY

Processes

The following steps were taken to effectively carry out a standard bathymetric survey of a section of Sombriero river adjoining the Degema Hulk Jetty.

(i) This survey covers the section of the adjoining jetty measuring 800m along the jetty area and 600m breadth from the jetty into the river.

(ii) The Sounding was carried out using Multi-Beam Echo Sounder.

(iii) Sounding was taken at 25 meters interval.

(iv) Sounding shall be reduced to the same common datum as indicated in the control information.

(v) Tide gauge was erected and read throughout the duration of the sounding and the values are related to the datum.

(vi) Soundings are measured in meters to the nearest decimeter.

(vii) Depths are measured by means of a precise depth recorder (PDR) Echo Sounder with Full GPS Navigational Package of approved make and pattern.

(viii) The echo sounder system was calibrated in the survey area, both before and after measurements by means of bar-check lowered to set depths as far as possible.

Reconnaissance

Reconnaissance was conducted in office and field to ascertain the condition of equipment, available maps, provides data and suitable location for the tide gauge installation for the area under investigation. The collected data include 2013 and 2015 bathymetric survey dataset and map covering the Degema jetty area of the Sombeiro river and major equipment used were SDE-28S south single frequency echo sounder and 62sc Garmin hand held GPS labeled by the manufacturers as most accurate and reliable GPS tested so far; best used for boating, mountaineering and hunting services. Odom ES3 – M25 multi-beam echo-sounder and MK11 single-beam echo-sounder run on windows XP operating system, user-friendly interface, integrated with both computer and echo sounder at industrial level, with low power consumption.

Measurement accuracy and operation range might vary due to atmospheric conditions, signal multipath, obstructions, observation time, temperature, signal geometry and number of tracked satellites.

All maps were converted to digital form using Arcmap ArcGIS 10.0 and all the available data were referenced to WGS 84 datum. A temporary tide gauge was established at a point where water level hardly goes below zero mark of the leveling staff supported by two poles laid vertically to one another and tidal observation commenced seven day consecutively before the depth sounding. The boat was deployed into the water and its accessories installed. Having fixed the boat engine however, the boat was tested before all other equipments were transferred in, with the aid of the metal support; the transducer was anchored at one side of the boat. The depth of the transducer below waterline was measured and fed in during the initial settings. It was ensured that ten(10) to eleven (11) satellites were visible on the sky point for better geometry and 95% clear visibility with a Position Dilution of Precision(PDOP) within 0.8 to 1.0 was ensured. To ensure best fit vertical positioning, depth measurements were taken at a mini second time interval along navigational routes and reliable depth measurement was achieved. HYPACK navigation software also computes vessel positions.

A test on the instrument was performed by taking redundant observations of water depth in comparison with bar check measurement. The result of the test was in conformity to IHO standard for all depth measurement acquired. Subsequently, data acquired during reconnaissance was set on display unit of the echo sounder and cruise was set to tour round the study site to ensure that all the equipment are in good working condition and properly integrated. Sounding (depth measurement) of points were done perpendicular to the jetty shoreline.The entire survey was based on the following control pillars.

Table 1: CONTROL STATIONS

POINT ID	EASTINGS (M)	NORTHINGS (M)	HEIGHT
PGH 05	252770.428	526960.446	13.462
PGH 06	252364.821	526982.750	13.430

Equipment

The following equipment was deployed for the Project:

S/N	ITEM	Serial No.	QTY
1	One Set of Teledyne Odom ES3-M25 Multi Beam Echo Sounder with in-built TSS DMS-25 Motion Sensor and ES3-M Transducer Fairing – interfaced with "HYPACK" & "HYSWEEP"	003185(Data Interface)/ 003182(Transducer Interface)	1 set
2	Total Station (Tc307) C/W Accessories	677120	1 No.
3	Levelling instrument (Sokkia C330) + accessories	399137	1 set
4	Odom MK111 Single-Beam Echo-sounder C/W Accessories	003039	1 set
5	Two sets of Computers (Control P.C. & Data Acquisition P.C.) for Multi-Beam sounding		2 sets
6	One Bar Check and one clamp		1 No.
7	TWO (2) Units of Leica Dual frequency GPS receivers (500 series)	0131507/ 0039898	3 No
8	One Set of Pacific Crest RTK radios (PDLGFU6/RFM9645P)	02266544, 01246980	2Nos
Os	Basic survey equipment (Tripods,tape,survey umbrella, ranging poles)		1 set
10	Tide Gauge Pole		1 No.
11	Tripods		3No.
12	Laptop		1 No.
13	Telephones (GSM) Hand Sets		4 Nos.

14	Battery + Current Inverter Charger / Generator		5 / 1 No.
15	C-Nav Dgps C/W Accessories		
16	Boat (GSL 8 with Audit Exp. Date: July 2012)		1 No.
17	Vehicle (GA 319 LND with Audit Exp. Date:31/05/12)		1 No.
18	Personal Protective Equipment / Life Jackets		As required
19	Battery charger		1 No

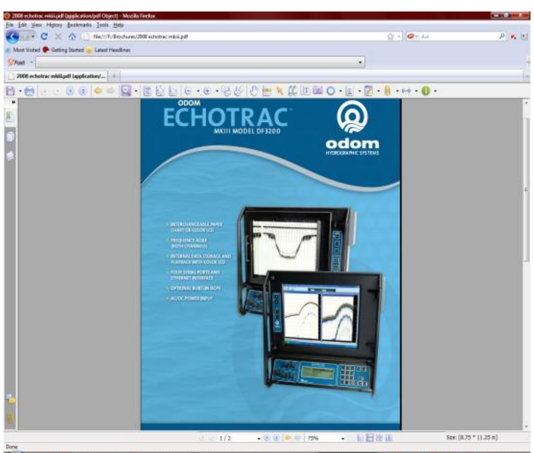
Single Beam Equipment Calibration

The single beam echo-sounder was calibrated using the bar-check method. The bar plate was lowered below the transducer at intervals of 1m,2m,3m.The online result was satisfactory and was certified before commencement of the survey. For the MK111 that has an echo roll, the result was marked on the echo roll.

Odom Echo-track MK111

The Odom Echo track MK111 is a professional grade Echo-sounder. Recorder, Digitizer, Transceiver and utilizes multiple processors including two dedicated Digital signal processors working in concert to accomplish specific analysis tasks while communicating effectively on a real time basis in order to assure accurate measurements under difficult sea conditions and over all type of Sea bed. It has dual frequency operations. Two simultaneous transmitted frequencies are selectable in 100HZ steps in the following bands. High Band-from 100khz to 1000khz and in the Low Band-from 10 to 50 KHz.

The Odom Echotrack MK111 was interfaced with the Hypack 2009a Navigational software. All the acquired data was outputted in the processing computer running the Hypack software and stored in Raw format. Also the Leica 500GPS was interfaced with Odom Echotrack to give position to the Echo-sounder. All data was acquired real-time.



PIC04:OdomEchotrackMK111

Odom Echotrack MK111 during Data Acquisition

GENERAL SPECIFICATIONS OF THE MK111 SINGLE BEAM-BEAM ECHO SOUNDER

Frequency
• High band: 100 kHz – 1 MHz
• Low band: 3.5 kHz – 50 kHz
Output Power
• High: 100 kHz – 1 kW RMS max 200 kHz – 900 W RMS max, 750 kHz – 300 W RMS max
• Low: 3.5 kHz – 2 kW RMS max, 50 kHz – 2 kW RMS max
Input Power
• 110 or 220 V AC / 24 V DC 50 watts
Resolution
• 0.01m / 0.10 ft.
Accuracy
• 0.01m / 0.10 ft. +/- 0.1% of depth @ 200 kHz
• 0.10m / 0.30 ft. +/- 0.1% of depth @ 33 kHz
• 0.18m / 0.60 ft. +/- 0.1% of depth @12 kHz
(Corrected for sound velocity)
Depth Range
• 0.2 – 200 m / 1.0 – 600 ft. @ 200 kHz
• 0.5 – 1500 m / 1.5 – 4500 ft. @ 33 kHz
• 1.0 – 6000 m / 3.0 – 20,000 ft. @ 12 kHz
Phasing
• Automatic scale change, 10%, 20%, 30% overlap or Manual
Printer
• High resolution 8 dot/mm (203 dpi), 16 gray shades
• 216mm (8.5 in) wide thermal paper or _lm
• External ON/OFF switch
• Paper advance control
Paper Speed
• 1cm/min. (0.5 in/min.) to 22 cm/mm (8.5 in/min.), Auto = one dot row advance for each Ping
Sound Velocity
• 1370 – 1700 m/s
• Resolution 1 m/s
Transducer Draft Setting
• 0 – 15 m (0 – 50 ft.)

Multi Beam Equipment Calibration

The Odom ES3-M25 Multi-beam Echo sounder used has all its sensors incorporated as one whole unit. Motion Sensor is built into the Transducer Fairing of the ES3-M25. The motion sensor has in-built Gyroscope and Accelerometer Systems that detect variations in HEAVE, ROLL and PITCH. Angular variation of Transducer and Motion Sensor was set as 0.0000 in HYSWEEP®.
The Patch test was carried out using the North/South, East/West line and the results of -0.1 was determined for the roll which was applied during processing. The origin for applicable HEAVE, ROLL and PITCH corrections was set during calm water. "DigiBar" (sound velocity system) offset was also set as 0.000; velocity correction was applied during post processing.

The Depth Calibration of the Multi-beam Echo-Sounder was done by comparing the Data Captured with Odom Mk111 (Single beam) Echo-Sounder. The Single Beam Echo-Sounder depth was checked by conventional Bar-Check. The Multi Beam Data compared accurately with the single beam depth.
System alignment (x,y) for the peripheral equipment (GPS) was set at 0.000, 0.000 – since the GPS was mounted directly above the Multi-Beam Transducer.

GENERAL SPECIFICATIONS OF THE ES3-M25 MULTI-BEAM ECHOSOUNDER

Frequency
- 240khz

Swath Width (Nominal Beam Width)
- 120° x 3° Transmit
- 120° x 3° Receive

Effective Beam Width
- Narrow-0.75°
- Medium-1.5°
- Wide-3°

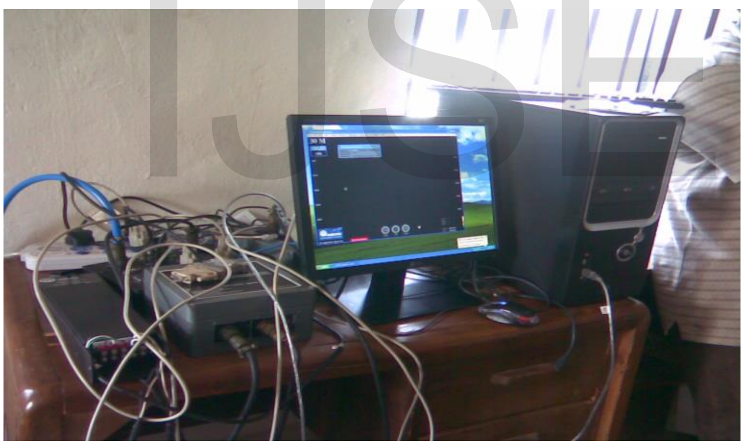
Minimum Detectable Range
0.5m below transducer

Number of Beams
- Default-480
- Selectable-240, 120

Range Resolution
- 0.02% of Range

Range
- 60m (197ft) water depth
- 100m (328ft) slant range

Ping Rate (PRF)
- 12 Hz at 20m range (processor and # of real time beams selectable dependent)

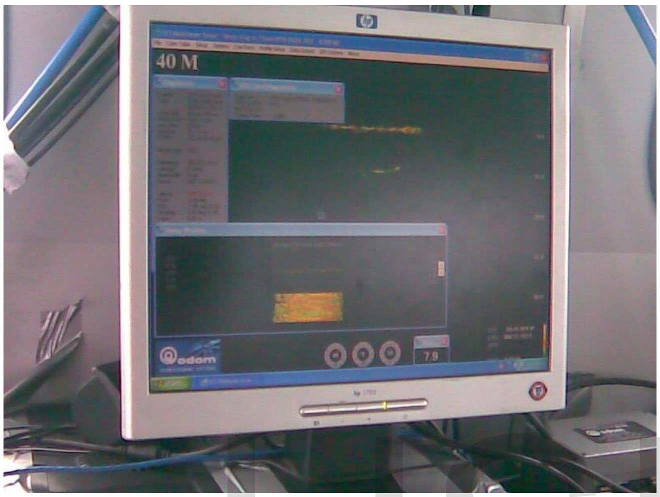


-M25 Multi-Beam Test-Run Systems are to the left side of the picture. The Monitor shows the HYSWEEP window.

Two computers were used to monitor the Data Collection of the Multi Beam Bathymetry. The Data Acquisition computer was used to run the HYSWEEP®/ HYPACK® software, a second computer was used to run ES3 MULTIBEAM Sonar for windows XP version 1.02.78h, both computers communicated with each other through an Ethernet Cable.
The "ES3 MULTIBEAM computer" performed data collection/logging, time tagging and real-time visualization of bottom coverage. It was also used to monitor signal window and general quality of data being captured.
ES3 MULTIBEAM data collected include: Beam Depth in meters; Time and Event Number for each depth; Heave Correction in meters – upward movement is positive; Roll Correction in degrees – port side up is positive; Pitch Correction in degrees – bow up is positive; Vessel Heading and Grid

Position of each depth – logged from HYPACK®. Draft corrections were obtained by HYSWEEP® from its squat and settlement table. Tide corrections were not captured real time.

The "HYSWEEP®/ HYPACK® Computer" was used to ensure that the Survey Vessel maintained its course along the pre-planned lines and for the processing of bathymetric data which is stored as- .HSX/.LOG FORMAT in HYPACK. It also provided general navigation information on the speed and heading of the Survey Vessel. The HYPACK® monitor was placed close to the quarter master for easy usage in following the pre-planned lines.



PIC.05: THE ES3® Monitor during Multi Beam Bathymetric Survey

Complete Set of Surface Control Systems of the Bathymetric Survey equipments inside survey boat.

Traversing

Traverse was carried out from the lease controls of PGH 05 and PGH 06 to the jetty area to establish an extension JETTY 01(Easting = 252099.585mE, Northing = 526982.803mN) with the aid of a Total Station Leica TS 06 Total Station. The instrument was used in the Tachy mode hence enabling data capture in Eastings, Northings and Heights.

The equipment was earlier calibrated in SPDC.

Bench Mark

The reference Bench Mark for the Project was the Lease pillar PGH 05 and PGH 06 with heights 20.462m, 20.430m. All heights were referenced to the lease pillar PGH O6 and PGH 05 with Minna datum.

: Lease pillar control

Tide Gauge and Height Transfer

The tide changes throughout the day, with two high tides and two low tides occurring daily. The sea level rises over several hours as the flood tide comes in until the water reaches high tide. Then, the sea level falls over several hours as the water recedes during ebb tide until the water reaches low tide.

Tide gauge established within the ramp area was calibrated using tachy from the control pillar and the result was within allowable tolerance. It is worthy of note that the tide correction was carried out in real time.

Current Flow

The current flow of the river was done by dropping a floater in the flowing water at one end of the measured distance. The level of flow was monitored with the aid of a stop watch, when the floater was dropped at one end and the time it took it to reach the other end of the measured distance.

DATA ANALYSIS & RESULT PRESENTATION

Tidal Readings

DAY	DAILY AVERAGE TIDE READING
1	1.301
2	1.319
3	1.335
4	1.351
5	1.367
6	1.383
7	1.361
8	1.345
9	1.431
10	1.417
11	1.403
12	1.419
13	1.33
14	1.448
15	1.464
16	1.478
17	1.493
18	1.484
19	1.475

20	1.466
21	1.456
22	1.445
23	1.431
24	1.415
25	1.43
26	1.444
27	1.453
28	1.463
29	1.471
30	1.481

Current Flow

Flood Tide

DISTANCE(meters)	FLOAT MEASUREMENT (Time)
20	1 minute 42 seconds
50	4 minutes 07 seconds
100	7 minutes, 11 seconds

Ebb Tide

DISTANCE (meters)	FLOAT MEASUREMENT (Time)
20	2 minutes, 8 seconds
50	4 minutes, 57 seconds
100	7 minutes, 59 seconds

Sounding Readings

Results presented are in form of tables, charts, and graph of relevance which depicts processed dataset aiding analysis tasks. The results for this study were Sombierio river adjoining the Degema

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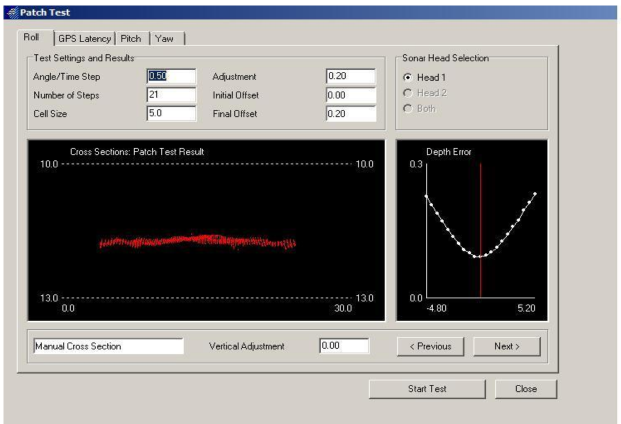
jetty bathymetric survey dataset for 2013 and 015 dataset covering the same area. The coordinate listing of the 2013 bathymetric survey and 2015 bathymetric project is as shown.

DATA PROCESSING

Patch Test

Roll calibration was carried out at this initial phase of data editing on the first set of data being processed and the value obtained was applied to all the data sets processed to remove roll artefact.



PIC 08: Patch Test Display in HYSWEEP®

Data Processing Flow

Data processing consisted of Tidal and Sound Velocity corrections, Filtering and Spike removal and Export to x,y,z Format.

Data processing underwent three (3) editing phases to remove noise and also remove data outliers and Roll artefacts.

Phase I

This phase of data processing involved applying tidal and sound velocity corrections. The Track lines, Heave, Pitch, Roll and Heading were graphically viewed and edited. Raw data was converted to correct sounding data.

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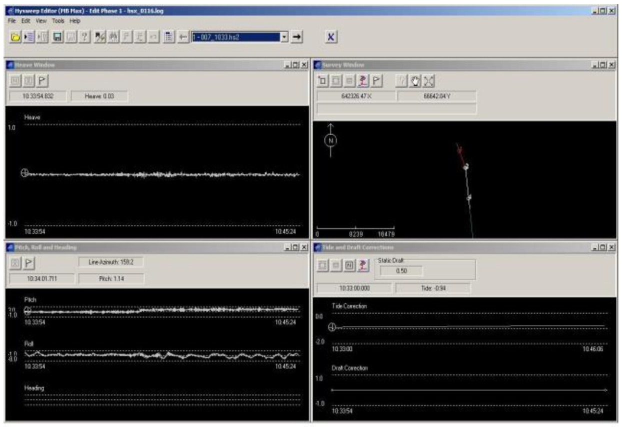
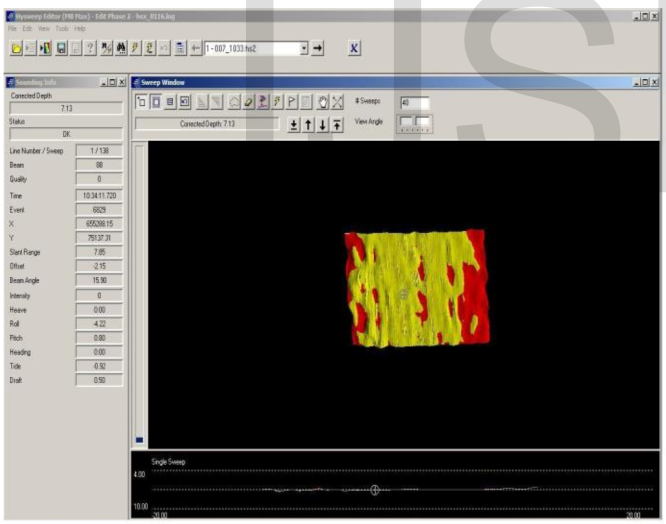


PIC 09: HYSWEEP® Processing software Phase I Display

Phase II

This phase involved graphically viewing the corrected sounding. The filter limits within for all data were set and any data that fell outside these limits were removed. For quality control, different filter limit options were used on the data to know the best filters that will not remove good data while dealing with noisy data. The data was gridded and the third phase of editing was started.

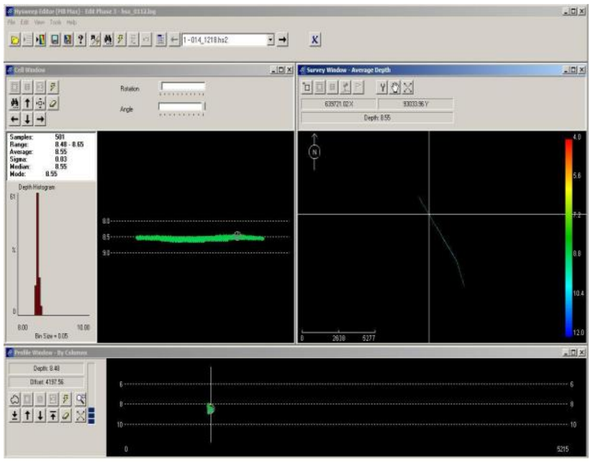


PIC 10: HYSWEEP® Processing software Phase II Display

Phase III

During this phase of data editing, the filter option was re-evaluated to view any data point that was left out during the second phase of data editing.

At the end of the third phase, data were exported to x,y,z format for further data presentation.



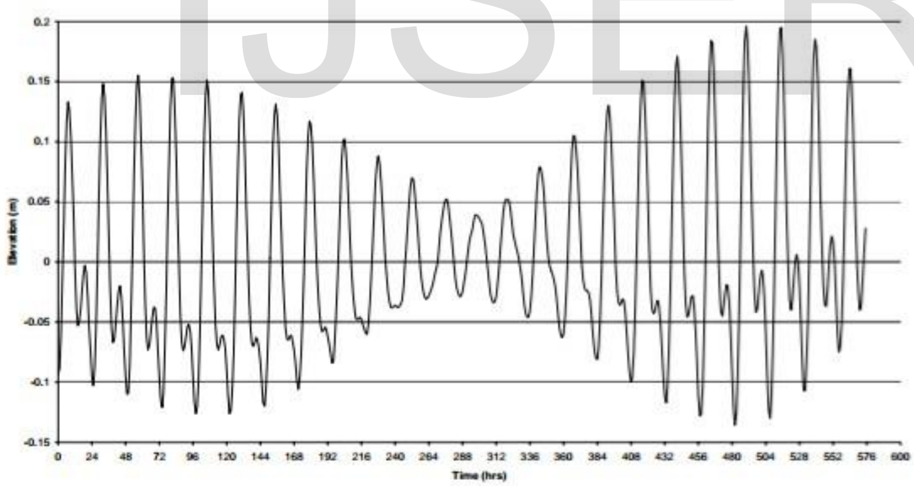
PIC 11: Hysweep® Processing Software Phase III Display

4.3.5 Filtering

The x,y,z file was uploaded into HYPACK® and the data filtered to 5metres spacing and checked for readability on the scale of 1:1000.

RESULTS PRESENTATION AND INTERPRETATION

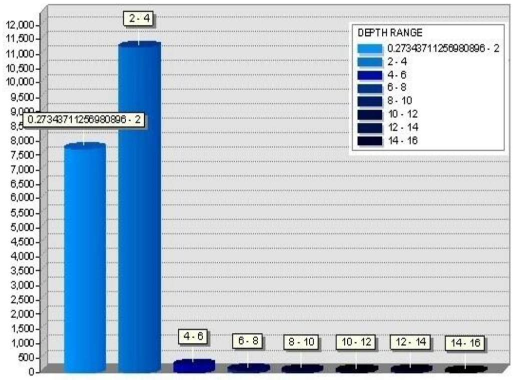
Tidal Observation

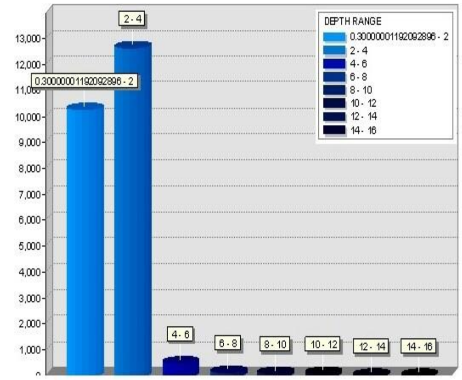


SOUNDING RESULTS IN HISTOGRAM

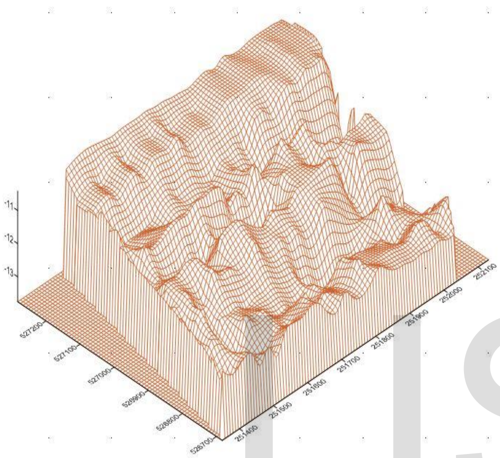
Presentation of 2013 Sounding

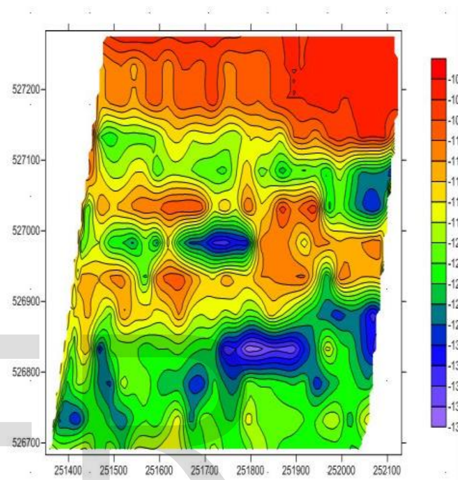
Presentation of 2015 Sounding



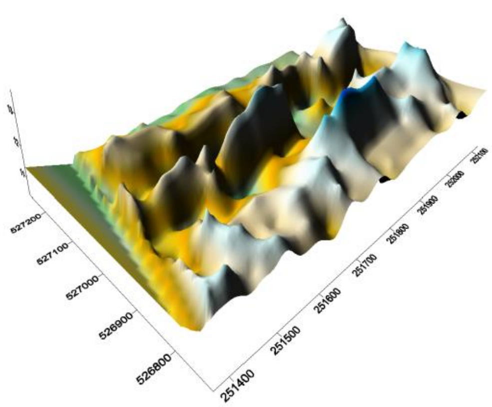


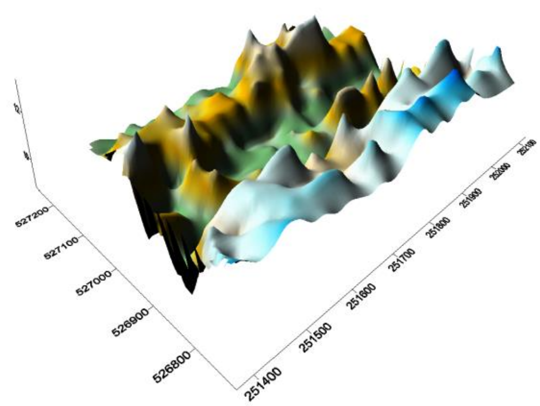
All the data from the single beam and Multi-beam Echo-Sounder were imported into Surfer for plotting at the scale 1:1000.





Surfer Plotting





Topography of the seabed 2013 Topography of the seabed 2015

From the tin map above one can deduce that there is an easterly curving of land.
Red represents the land section
Yellow represent shallow land areas
Blue represents deep water channel

The legend shows the scaling where negative represent the topography area i.e. the land section while the positive represents the bed elevations.
From the Chart it is obvious that with time the land section will continue to erode. Also from physical observations we noticed that the bank is eroding heavily.
The CPF jetty lies on the edge of a very long concave bend of the river Nun. As such, every season, the fast currents will erode sediments from the concave bank of the river Nun and deposit them on the opposite bank.

CONCLUSION AND RECOMMENDATION

Conclusion

The paper investigating the seabed topographical changes of the Sombeiro river. The stages of this exercise includes; planning, data acquisition, processing analysis and documentation.

However, spatial changes were confirmed to have taken place in the study area within the time frame, more especially in area of sediment deposits.

Recommendations

1. An integrated shoreline management plan should be embraced.
2. Environmental impact analysis should be strictly adhered to, and legislation fully enforced.
3. Adopting a good coastal management policy; coastal education will be a useful tool in educating the involved communities on their impact on coastal waters and consequences in terms of flooding, disease, spread and use of contaminated water in focus.
4. The study should be extended to the entire length of the Degema shoreline of the Sombeiro river.
5. Tidal correction is compulsory for reduction of sounding depth and its observation process laborious, therefore government should intensify effort in establishing automatic tide gauge for her waterways, this will encourage researchers in extending their study to other parts of the country as w are currently witnessing flooding in many states of the country.

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