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ACOUSTIC IMAGING APPLIED IN NEAR-SEABED RECONNAISSANCE SURVEY OF THE LOWER IMO RIVER, NIGER DELTA

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ABSTRACT

Multi Beam Echo sounding, Side Scan Sonar and Sub-Bottom Profiling of the Lower Imo River, Niger Delta was carried out. It is aimed at determining the water depth, topography, detecting buried features like pipelines, cables and debris, thickness and lithology of the sediments beneath the study area. The corrected Multi Beam Echo sound data showed the water depth approximately range from 0.2m – 17.1m with no significant change in the topography. Result from the Side Scan Sonar showed that the seabed is mostly composed of very soft strata, it also showed the presence of features like drag marks, scours, and debris together with partially buried pipeline across the channel which was confirmed by the strong deflection of the marine magnetometer. The Edgetech SB-424 Sub Bottom Profiler which was set at a frequency range of 2 kHz – 16 kHz was used to achieve maximum penetration of 40m and delineated 3 relatively uniform subsurface layers. The 32 Grab samples taken at 500m interval for physical examination of the top soil showed that the top layer is dominantly mud-clay and silty-sand. The integrated results interpreted within the vicinity of the study area show that the sediment can support the construction of the proposed jetty, however care must be taken to avoid contact with the detected pipeline. Also, the observed rate of siltation at the estuary is very high, hence requires frequent maintenance dredging to keep the channel navigable all year round.

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INTRODUCTION

Many engineering construction work within the shallow areas of the sea bed has failed, a lot of river channels have been abandoned and left un-navigable due to lack of, or inadequate hazard surveys and investigations to understand the condition of the seabed, its depth, underlying features and the complexities of the stratigraphy and geomorphological features. But the advent of Geophysical sea bed survey has to no extent stymied these failures and improved the competency of most shallow marine construction works. Also wreckages from ships and air plane has successfully been detected via this method (Chaubey, 2012). The approach used in this study is basically that of acoustic principles of seismic to obtain information on the depth, images of the river bed to detect features and a sub bottom profile of the channel to determine the shallow geology. Acoustic imaging which is also known as the High- Resolution Reflection System, is a geophysical survey system involving equipment that use sound (acoustic energy) and to measure where the energy is 'reflected' from a geological horizon or seabed (Danson, 2005). According to Damuth (1980), it is one of the most preferable geophysical method for offshore and near-shore reconnaissance survey or hazard identification. This springs from its flexibility and cost effectiveness in collecting site investigation data for offshore and near-shore structures and navigation. This approach was complemented with the marine magnetometer to detect metallic features and the grab sampler to obtain soil samples for physical examination of the underlying sediments. The motivation of this study sprang from the need to carry out a good site reconnaissance survey prior to the construction of jetty and navigation. Knowledge of seabed soils and rocks is essential if offshore and near-shore structures are to be

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properly and safely designed and built. Researches show that several hazards involved in the A large part of the commercial and operational risk involved in these works relates to uncertainties about the properties of soils at the site, nature of underlying features like pipelines, cables, ship wrecks, etc. It is therefore necessary to perform sufficient investigations to evaluate these risks thoroughly (Campbell and Hough, 1986). It is of great importance to study the depth profile of the channel for safe navigation, owing to the turbulent sediments at the estuary. Activities carried out in the area are basically local fishing, local mining by the communities and transportation, economic activities like oil exploration and aluminum smelting. Poor navigability and accessibility has hindered the utilization of the embedded potentials of the channel. However, its development can contribute to the economic growth of the nation because it can serve as a major sea port in the country (Ezeugwu et al., 2015). In addition, there is need for continuous study and update of hydro-morphological characteristics within the channel and especially around the estuary, (Ezeugwu, et al., 2015).

Location of study area: The study area is the southern part of the Imo River located in Niger Delta, it is a channel and a boundary between two coastal towns; Ikot Abasi and Opobo, South-South region of Nigeria. It covers a distance of 16km from Ikot Abasi to the estuary which opens into the Atlantic Ocean. It lies between latitude 04^0 35^1N to 04^0 27^1N and longitude 07^0 32^1E to 07^0 35^1E, Figure 1. The climatic seasons of the study area are distinctly the rainy and the dry seasons. The rainy season lasts from April to October and the dry season lasts from November to March. The total annual rainfall varies from 4000mm along the coast to 2000mm inland.

Geology: The study area as shown in Figure 2, is one of the distributaries in the Niger Delta. It is underlain by sedimentary formations of Late Tertiary and Holocene ages. Deposits of recent alluvium and beach ridge sands occur along the coast and the estuary of the Imo River, and also along the flood-plains of the creeks (Nwajide, 2013).

MATERIALS AND METHODS

The geophysical survey method employed in the field basically utilized equipment that have been designed to use the principle of acoustics (seismic) to obtain required data of the study area complemented with the marine magnetometer and the grab sampler. This was carried out in accordance with the International Hydrographic Organization (IHO) SP-44 acceptable standard. The equipment used are the Multi Beam Echo Sounder, the Side Scan Sonar, Sub-Bottom profiling. Also the Marine Magnetometer was used to detect metallic objects in the channel. All the equipment were synchronized with a Differential Global Positioning System for proper recording of data positions in terms of longitude and latitude. Longitudinal and transverse survey lines were generated in AutoCAD and imported into the HYPACK navigation system. The survey main lines were planned to cover 16km distance of the channel from the estuary at 100m lines spacing while the cross lines were at 300m spacing. All the transducers were mounted on the survey vessel in their respective positions. Acoustic pulses were sent and received at 25m distance interval along a planned line. All the data acquired were processed using a combination of SONARWIZ 5 and HYPACK/ HYSWEEP processing Module. The raw swath data were filtered to remove outliers.

Figure 1. Aerial View of the Study Area (shown in red line), (Google, 2016).

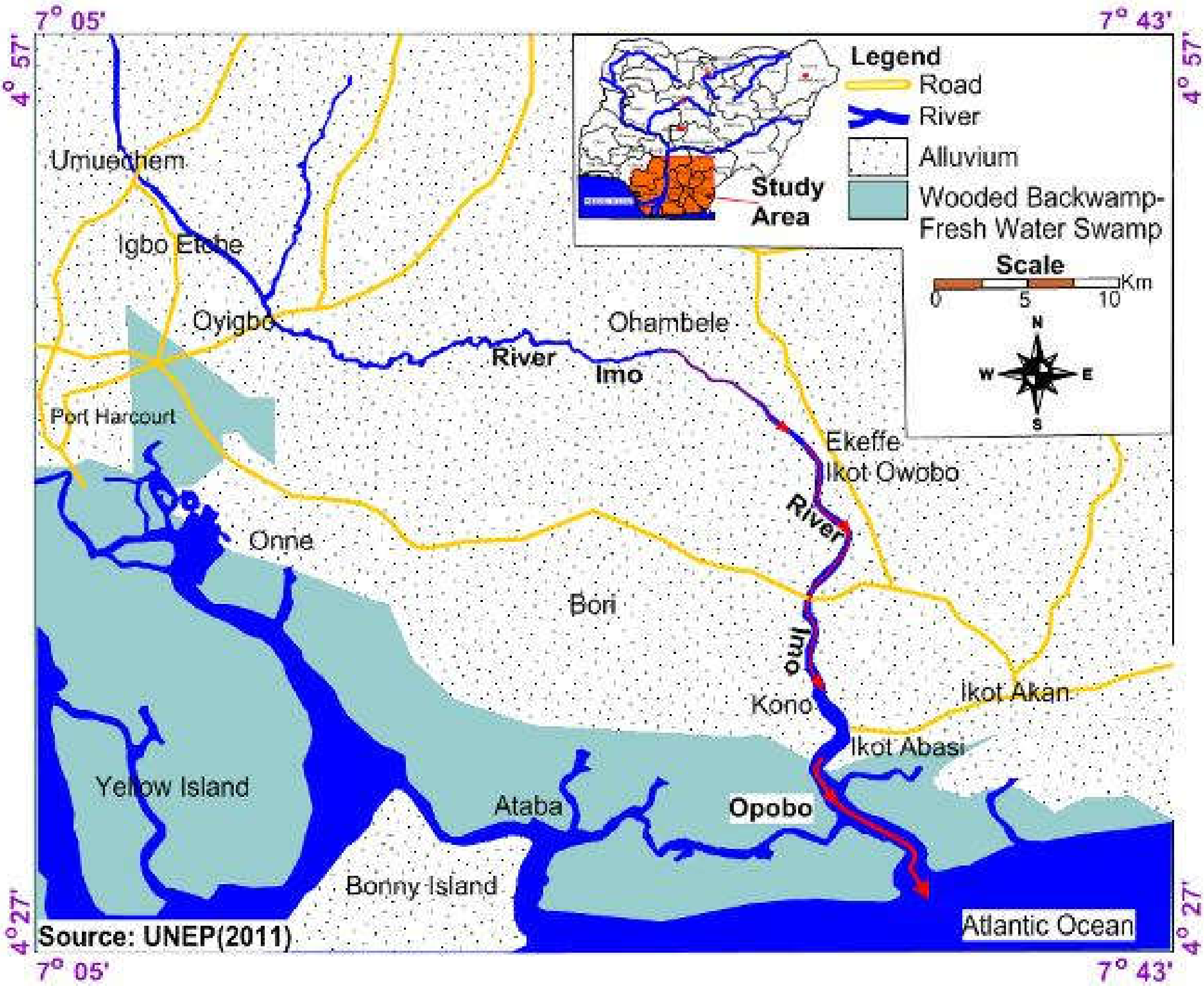

Figure 2. Geologic Map of the Study Area showing the River Channel (Red Arrow Shows the Surveyed Channel)

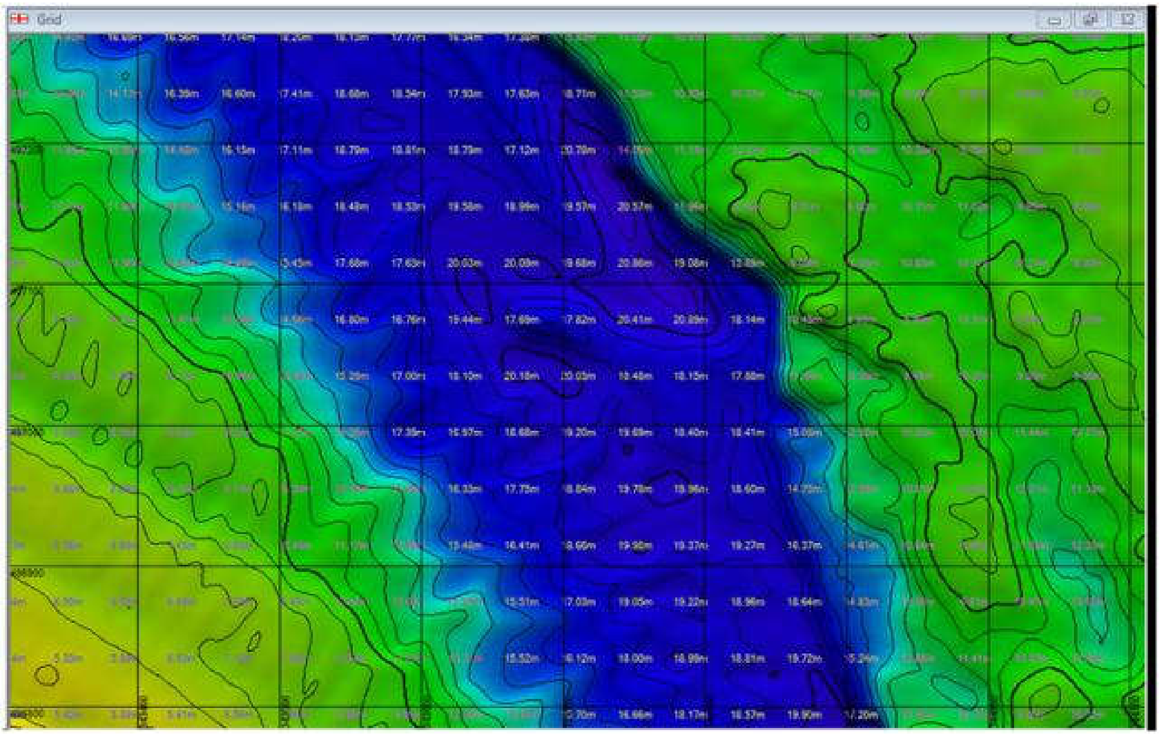

Figure 3. The Multi Beam Depth values in Grids.

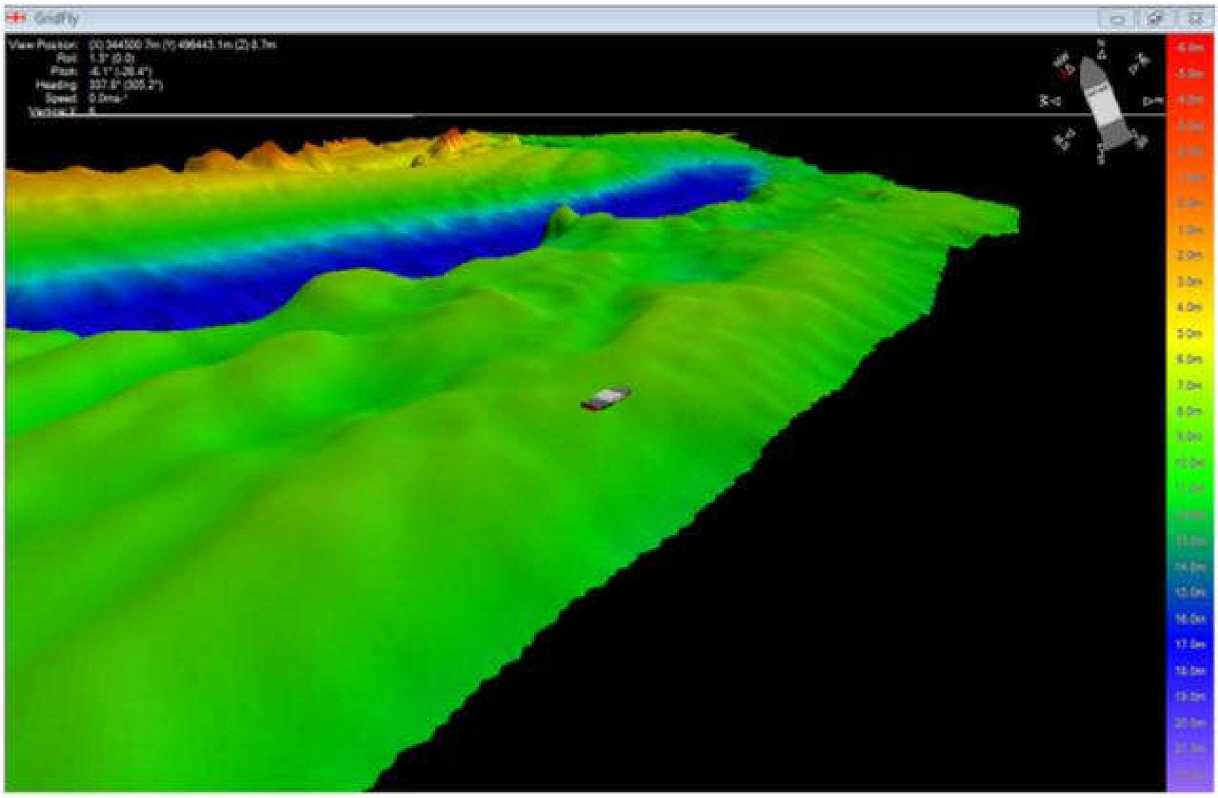

Figure 4. A 3D View of a Part of the Channel around the Estuary (From Figure 3)

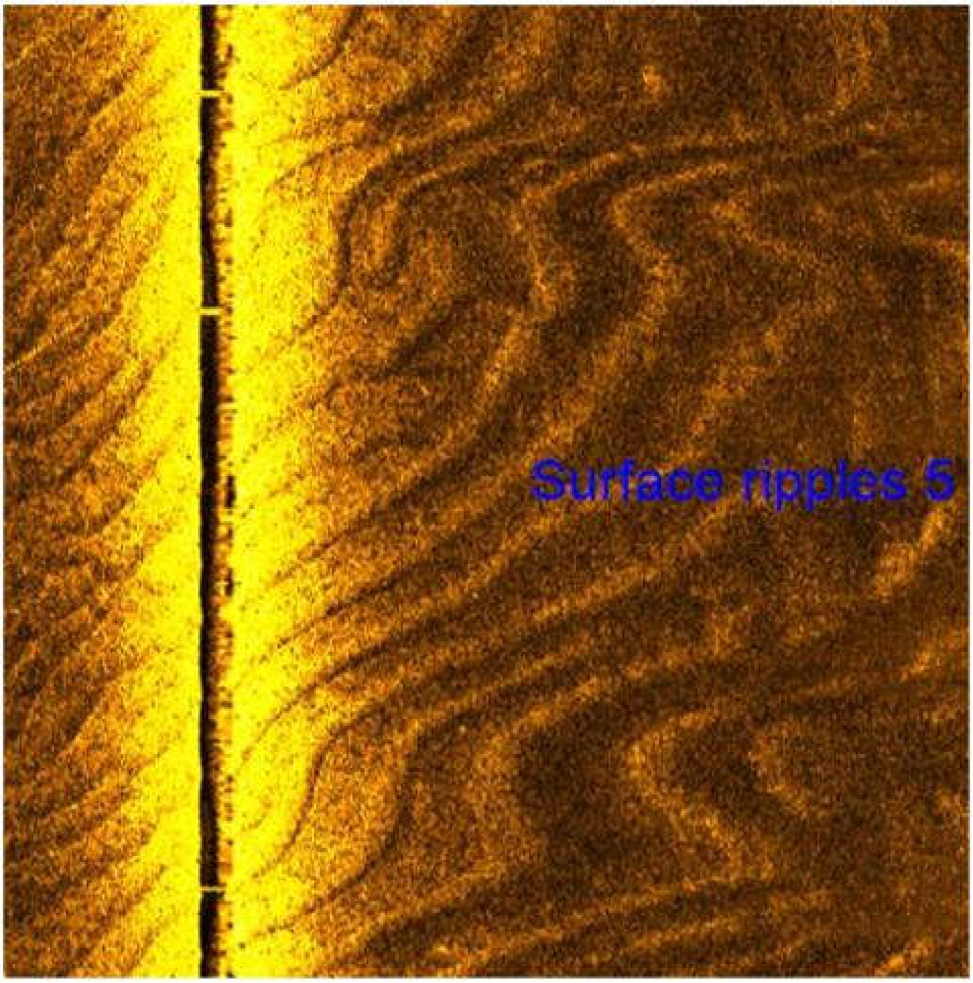

Figure 5. Sand ripples along the channel

Figure 6. Image of Scours along the Channel

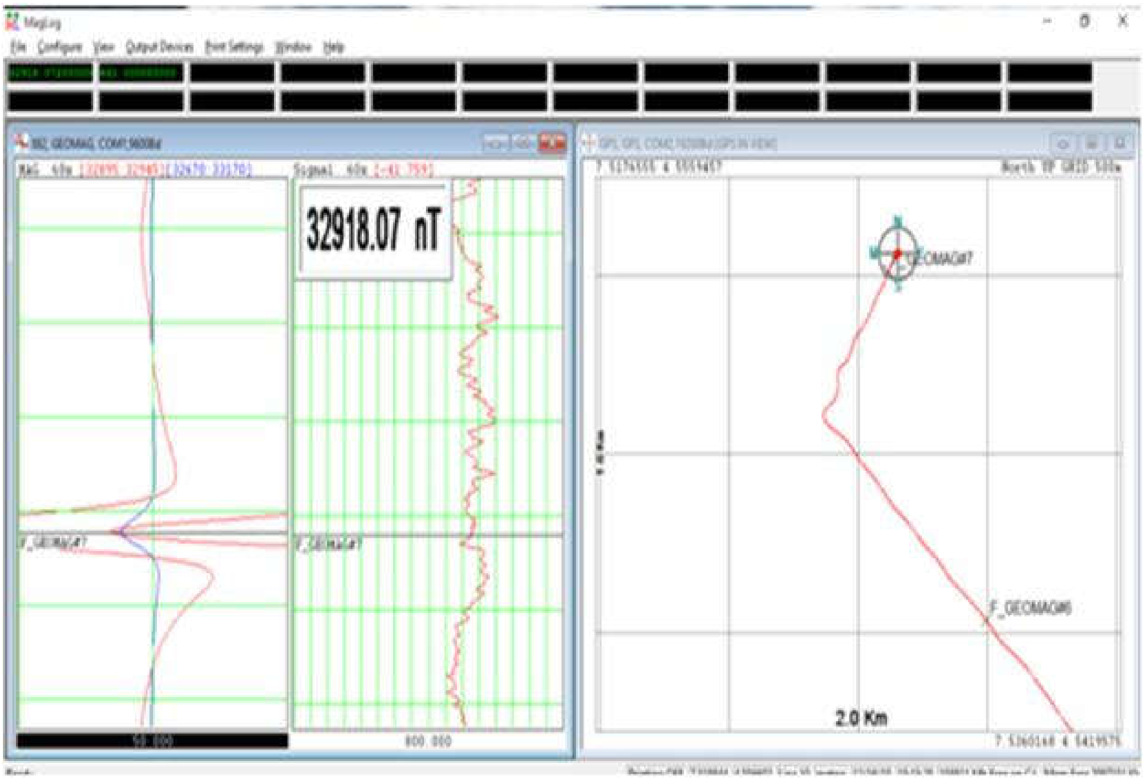

Figure 7. Deflection of Magnetic Signal indicate anomaly

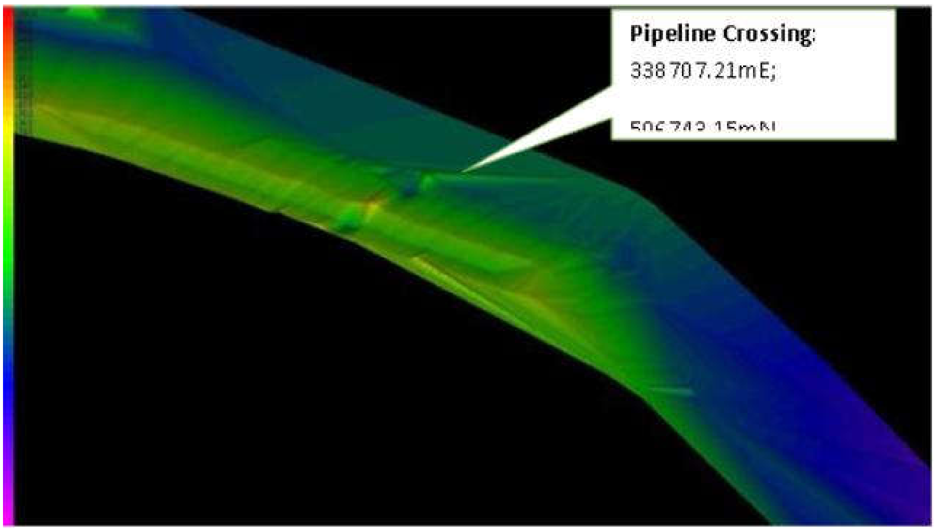

Figure 8. Magnetic data in 3D showing Pipeline lying across the Survey Route

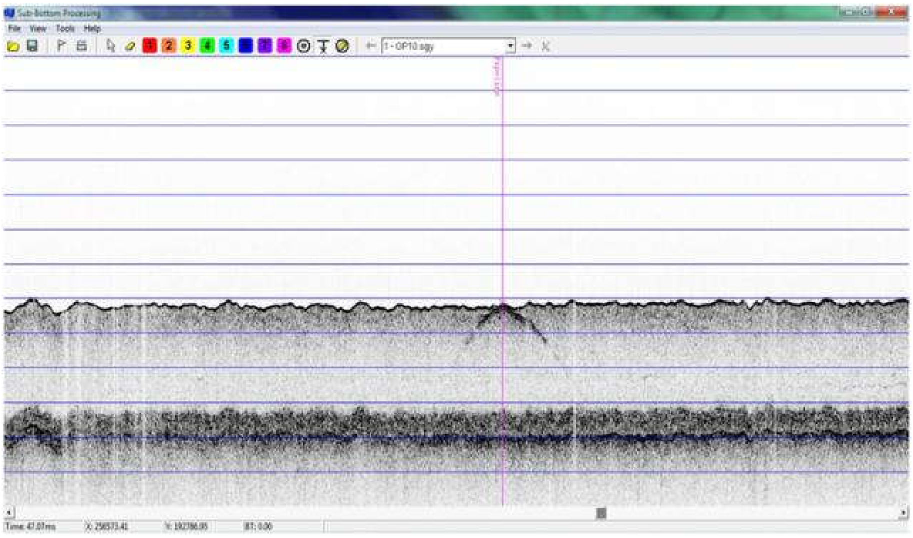

Figure 9. A portion of the Sub Bottom Profiler data showing partially buried pipeline indicated by the parabolic shape

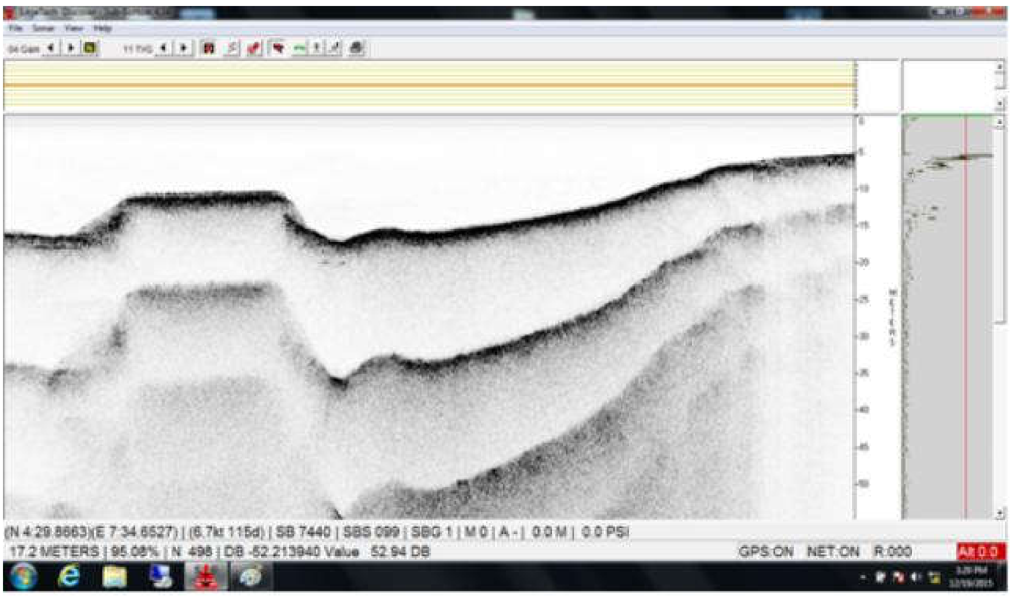

Figure 10a. Images showing uniform Sub surface layers

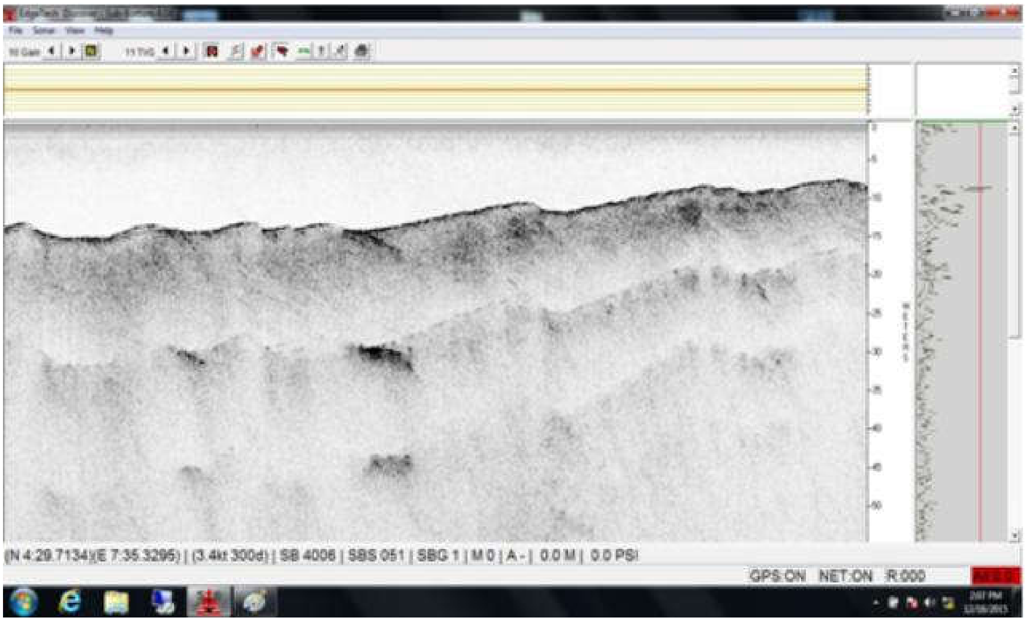

Figure 10b. Images showing uniform Sub surface layers

The filtering consists of limiting the swath width, a low amplitude filter to remove water column noise points, and rejection of outliers. The navigation data was checked and edited using the GEOSWATH software. The calibration parameters, tide readings and the sound velocity data were inputted for data corrections. This gave geo – referenced, calibrated data file on a line-by-line basis.

RESULTS

The Depth Data: The depth values obtained from the Multi Beam Echo Sounding, Figures 3 and 4, revealed that the average deeper part of the channel is from the Alscon turning basin to the Estuary (9.1 to 17.1m). This is because of the local sand mining activity by the community in the area. The water depths were reduced to the Mean Sea Level of the observed tide gauge values installed at the Imo River.

Table 1. Showing Depth Ranges obtained along the channel

Location	Depth Range (m)
Essene Creek to Alscon Turning Basin	0.2 to 17.1
Turning Basin to Estuary	9.1 to 17.1
Within the proposed Jetty	0.6 to 9.6
Estuary to Opobo Platform	4.3 to 13.4

The Side Scan Sonar: The objects detected and seabed features observed were clearly imaged by the side scan sonar as shown in the Figures 5 and 6 below. Geological features such as sand ripples were observed along the survey route with no valleys or acute depressions. Current related features like the scours and ripples observed within the channel indicate that sediments along this path will be mobile with time. Therefore, the legs of the proposed jetty requires a deep seating to withstand the energy of the current.

The Magnetic Anomalies: Strong deflections of the magnetic signals, Figure 7, indicate magnetic anomalies as a result of the presence of some metallic features and a partially-buried pipeline lying across the channel. The Magnetic data in 3D showing pipeline lying across the survey route is shown in Figure 8.

The Shallow Geology: The shallow geology profile shows 3 layers underlying the survey area, Figures 10a and 10b. The riverbed is mostly composed of very soft silty-clay and silty-sand with no significant change in the formation The profile within the survey route shows a top layer thickness of between 2m to 4m, while the underlying stratum has a layer thickness of between 4m to 8m.With the Sub Bottom Profiler, a penetration of about 40m from the riverbed was achieved. From the data, there were no faults, acute depression, outcrop or geological features. However, the presence of the partially buried pipeline was detected by the Sub Bottom Profiler and is shown in the Figure 9 below.

Conclusion

The acoustic imaging of the channel has shown that the proposed jetty construction and other shallow or minor marine constructions can be successfully carried out in the site away from the vicinity of the detected underlying pipeline. Large vessel navigation with less than 17m draft is safe to navigate the deeper parts of the channel. Observed scours in the area indicate that the sediments along the channel will be mobile overtime hence, the jetty legs require a deeper seating to withstand the energy of the current. Due to high rate of siltation at the estuary, further maintenance dredging should be done to keep the channel navigable all year round. This study has confirmed that the acoustic imaging of the geophysical seabed survey is an efficient and cost-effective method for a reconnaissance seabed survey.

The limitations of the acoustic imaging, demands further geotechnical investigation of the site to be carried out so as to determine the condition of the deeper layers and underlying rocks using the penetration tests methods. In addition, there is need for continuous study and update of hydro-morphological characteristics within the channel and especially around the estuary, which has more sedimentation dynamics. With this continuous information, an updated co-ordinate listing that defines safe route will be made available to mariners/vessels arriving the channel.

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