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Monitoring of bathymetric changes in the Commodore Channel, Lagos State Nigeria

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ABSTRACT

The Commodore Channel in Lagos State is located at the seaside entrance into the Lagos Harbour thus exposing it to the action of dynamic coastal forces such as high waves, tidal currents, and storm surges. The combined effects of these forces affect the stability of the sediments on the channel's seabed. This study assessed changes in the channel's bathymetry using data on water depth from a time series of bathymetric charts covering the channel at the following periods: 2008, 2010, 2012, 2014, 2016 and 2018. The charts were acquired from the Nigerian Navy Hydrographic Office (NNHO), scanned and georeferenced. The depths were digitized within the ArcGIS 10.4.1 software environment. Using Kriging interpolation, bathymetric surfaces were produced, and coincident points for depth comparison were extracted. There was an average decrease of 0.02m in depth values from 2008 to 2010 and an average decrease of 0.03m between 2010 to 2012. From 2012 to 2018, the average depth increased consistently. There was also a rapid increase in surface volume from 2008 – 2014, and a slight decrease in volume in 2016. Continuous monitoring of channel bathymetry is essential for safe navigation.

1. Introduction

Seafloor data are primarily collected by measuring the time that laser light, or an acoustic sonar pulse, takes to travel through the water column to the seafloor and back, based on the speed of sound in water, sensor characteristics, time and other variables (Kearns et al., 2010). Monitoring the changes in riverbed topography is important because they provide data from which morphological parameters are estimated. Bathymetric surveys involve the measurement of the depth of water bodies as well as the mapping of underwater features. Several methods can be used for bathymetric surveys including multi-beam and single beam echo sounder surveys, and remote sensing methods. Bathymetric surveys are important for many purposes such as sedimentation purposes to check for accretion or erosion, and pre/post dredge bathymetry to determine the status of the water body or ascertain the dredged volume (Chukwu and Badejo, 2015). Bathymetric information is vital in navigation safety, water volume computation, pollution control, underwater engineering construction and maintenance (Temitope and Kehinde, 2019). In bathymetric surveys, charts are produced to support safety of surface or sub-surface navigations which usually shows seafloor relief, and such charts provides surface navigational information (Temitope and Kehinde, 2019). The regular updating of bathymetric charts is a daunting task that cannot be ignored due to its importance in estimating or determining temporal changes in an ocean floor which provides accurate information in terms of planning, engineering design, and regulation of navigation, flood control and coastal engineering projects (Chukwu and Badejo, 2015). Comparison of digital bathymetric data for the same region but at different time periods enables the estimation of net movement of sediments in (accretion) and out (erosion) of the Commodore channel in Lagos State (Temitope and Kehinde, 2019).

This study aims to monitor and visualize the bathymetric changes in the Commodore Channel of Lagos State (shown in Figure 1) using a time series of

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bathymetric data for the following periods - 2008, 2010, 2012, 2014, 2016 and 2018. We also assess the changes in channel volume that have occurred over time and infer the causative factors for observed changes in the Commodore Channel and its implications for safe navigation.

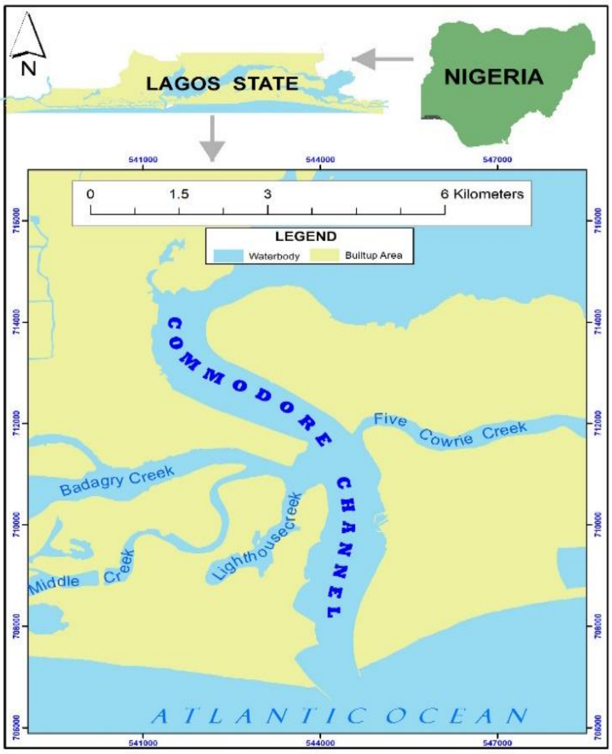

Figure 1. Map showing the location of Commodore Channel

2. Methods

2.1. Data acquisition

Bathymetric charts published by the Lagos Channel Management (LCM) for 6 epochs (2008, 2010, 2012, 2014, 2016 and 2018) were acquired from the Nigerian Navy Hydrographic Office (NNHO).

2.2. Data conversion

The bathymetric charts were scanned, georeferenced and referenced to the WGS84 datum. The study area falls within Zone 31N of the UTM zone. Vectorization of the charts was done in ArcGIS software.

2.3 Kriging and quantitative analysis

Using kriging interpolation in ArcGIS, bathymetric models for the six epochs were generated from the depth points. The changes in depth were computed using the ArcGIS raster calculator. The calculation of the depth change was done using raster calculator expressed as "depth map of the more recent year – depth map of the preceding year". The surface volume tool in ArcGIS was used to calculate the surface volume at each epoch.

3. Results

Table 1 shows the statistics of sampled depths. There was an average decrease of 0.02m in depth values from 2008 to 2010 and an average decrease of 0.03m between 2010 to 2012. From 2012 to 2018, the average depth increased consistently.

Table 1. Statistics of the sampled depths

Statistics	Chart depths (m)					
	2008	2010	2012	2014	2016	2018
Min	22.1	21.65	21.89	21.85	21.67	32.59
Max	3.2	1.47	1.50	1.43	1.61	2.01
Range	18.9	20.18	20.39	20.43	20.06	30.57
Mean	11.3	11.28	11.25	11.81	12.02	12.33
Std. Dev.	3.4	3.646	3.781	3.840	3.796	4.053

The descriptive statistics of depth changes are presented in Table 2. Positive values indicate an increase in depth while negative values indicate a decrease.

Table 3 presents the surface volumes computed for the six periods. There is a rapid increase in volume from 2008 – 2014. However, there is a slight decrease in volume in 2016.

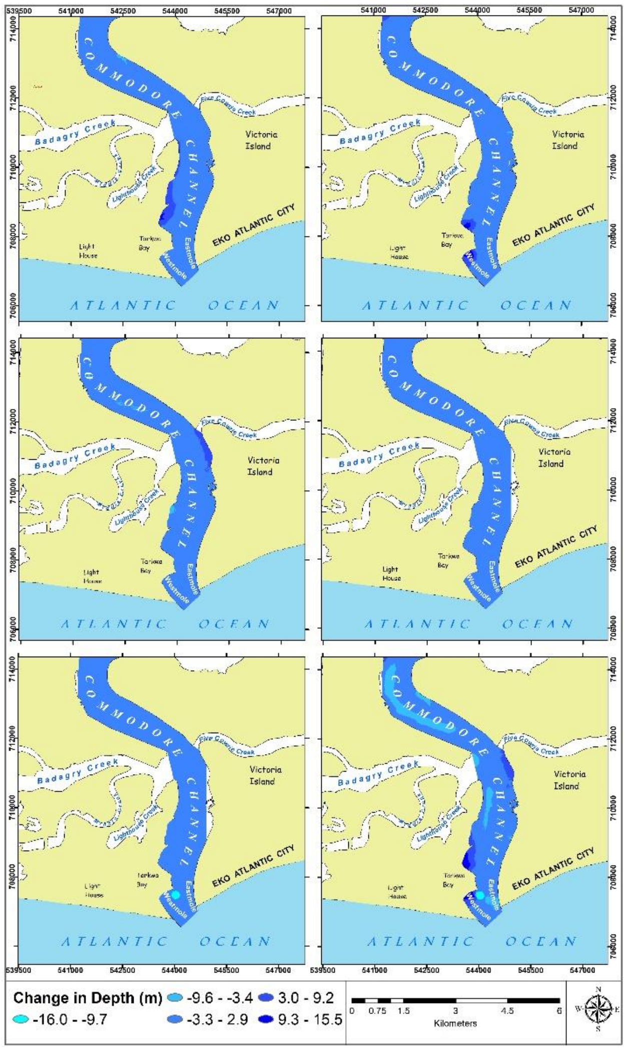

Figure 2. Maps showing changes in depth (ΔH) – (a) 2008-2010 (b) 2010-2012 (c) 2012-2014 (d) 2014-2016 (e) 2016-2018 (f) 2008-2018

Table 2. Statistics of depth changes (ΔH) in metres

	2008-2010	2010-2012	2012-2014	2014-2016	2016-2018	2008-2018
Max (-ve)	4.01	4.51	4.91	3.58	16.40	15.96
Max (+ve)	10.34	15.06	8.25	2.61	2.87	15.51
Range	14.35	10.55	13.16	6.18	19.27	31.47
Mean	+0.08	-0.02	-0.57	-0.15	-0.36	-0.97
Std. Dev.	1.44	1.59	1.29	0.66	1.10	2.87

Table 3. Statistics of surface volume

Year	Volume (m^3)
2008	69,238,215.866
2010	83,783,538.873
2012	83,404,963.764
2014	88,842,339.010
2016	86,655,377.418
2018	88,152,424.554

4. Discussion

The historical archive from the bathymetric charts (2008 – 2018) offers added advantages for monitoring changes over a lengthy period or since the last hydrographic survey of the channel was done. These products can serve as stand-alone information in inaccessible areas or can be used in combination with ancillary data to give informed perspectives on river channel morphology.

5. Conclusion

Historical bathymetric data is a valuable resource for monitoring the changes in the underwater topography of rivers and creeks. The digital bathymetric models produced provide a layer for the development of a coastal characterization procedure of the local coastal habitats. The results of this study clearly show the relevance of digital bathymetric data in urban planning which is primarily concerned with the control of the use of land and design of the urban environment, to guide and ensure the orderly development of settlements and communities. Integrating such data enables us create more comprehensive and strategic plans for development and fosters more sustainable cities.

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