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FULL LENGTH ARTICLE

Geological implications of acoustic imagery of the recent seabed textures in the Eastern Harbor, Alexandria

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Abstract Acoustical geophysical devices depend on sound source to transmit sound waves that reflected, diffracted or scattered off the sea bed. The frequency used by each device controls the output information that related to the sea floor properties. The present study aims to get a recent mapping of the seabed texture mostly related to acoustic imagery, sediment analysis, and video images. High resolution side scan sonar has been used for mapping the seafloor of the Eastern Harbor, Alexandria, Egypt. Four different acoustic patterns were recognized: (a) the pattern of strong backscatter related to coarse sand, (b) the pattern of weak backscatter confined to mud and fine sand, (c) patches of strong and weak backscatter and d) the pattern with isolated reflections that belong to rock outcrops and boulders. The various wavelengths of sand ripples are identifiable that depend on their wavelength and amplitude. The presence of mega ripples in the front of the main EL-Boughaz outlet at the middle of Eastern Harbor indicates bed load transport of sediment during high energy conditions (storms). The current action on the sea bottom produced current ripples which are either straight or sinus. They are usually irregular-crested, showing no bifurcation.

Introduction and previous work

The Eastern Harbor had considered the main water basin and port of Alexandria since the Romans times. Its distinct shape, location, geological features and historical background gives the harbor its important status. The Eastern Harbor is located to the west of Alexandria Mediterranean coast at the city center. It is characterized by semi-closed rounded shape with about 2.8 Km^2 total area and it has two outlets (El-Boughaz) along El-Silsila break water to the west of the harbor (Fig. 1).

The main geological feature in the area is the Pleistocene carbonate ridge where the city was built on (Stanley and Bernhardt, 2010). It is parallel to the coast and some of its high relief features occur seaward as Pharos Island, where the ancient light house and the harbor margin were built, while some reef like features submerged in the center of the harbor (Goddio et al., 1998; Torab, 2013). This basin acts as a trap for Holocene sediments that can give a clear archive for human influence in the region even before the recent human

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Figure 1 Aerial map for the Eastern Harbor of Alexandria, including a map of Egypt showing the location of the study area on it.

modifications on the basin in the late Holocene (Hamouda and Awad, 2012; El-Said and El-Sikaily, 2013; Hamouda et al., 2015).

The Eastern Harbor (Fig. 1) is characterized by its physical, chemical, biological attributes as well as the presence of sunken archeological relics, which make this area so important. The average sea surface temperature in the harbor basin is about 22 °C and the mean salinity is about 38.6%. The average water depth in the harbor is about 5 m and the deepest points are at El-Boughaz outlets with 11 m water depth (Massoud and Abdel Wahed, 2006; Hamouda et al., 2014a,b). El-Silsila breakwater protects the harbor from severe storms and waves. The mean wave heights, during the year, are ranging from 0.5 to 1 m while, the current reaches a maximum velocity of 143 cm/s seaward of the harbor break water (Frihy et al., 2004).

The mean tide range in the Mediterranean Sea are relatively low, the tide range in the harbor is about 30 cm (Goiran, 2007; Mostafa et al., 2000a,b; Hamouda and Abdel-Salam, 2010). The water currents sweep the sediments and swash it along the coast "littoral current" and inside the harbor. This motion spreads natural sediments and human introduced materials that shape the sea bed and in suspension that seriously increase the turbidity (Goddio et al., 1998). The wind also transports sediments from the adjacent desert to the harbor (Stanely and Bernasconi, 2006). As the Eastern Harbor has become more enclosed after El-Silsila breakwater was built in 1929, rate of the sediment accumulation increases and the average water depth in the harbor basin decreases (Mostafa et al., 2000; El-Geziry et al., 2007). Recently the sea floor sediments in the harbor are influenced and stressed by natural and anthropogenic pressure (Alves et al., 2015, 2016).

Acoustic sound techniques "SONAR" are the most important to study the water column and the sea floor (Lee et al., 2009). Sea mapping using SONAR system can be categorized into: Single beam echo-sounder, multibeam echo-sounder and side scan sonar. In this study the multibeam system and the sidescan sonar were used. The main target of this paper is to undertake detail mapping of the seafloor of Eastern Harbor using multibeam echo-sounder and sidescan sonars. This high resolution new technology provides detailed information on the rise to get new understanding on the present situation of the bottom sediment texture and seabed characteristics and the accurate distribution of the outcrops and the bed forms. Sidescan sonars images represent clearly the interface boundary between different seabed textures. Moreover its recent applications have expanded beyond this limited purpose. The present study aims to get a recent mapping of the seabed texture mostly read and interpreted by High Resolution Acoustic Imagery, sediment analysis, and video images.

Methodology

Data acquisition and processing

The field survey was carried out in June/July 2014, for 3 working days using a survey boat. The survey grid lines were directed from east to west and from north to south over the study area (Fig. 2). The speed of the survey boat was 4 knots through the water depth of 3 to 20 m, and an average water temperature of 23 °C.

SeaBeam 1185 multibeam

Swath bathymetry data were collected using a SeaBeam SB 1185 multibeam echosounder system. The SeaBeam 1185 multibeam echo sounder collects bathymetric data with narrow beams (1.5° × 1.5°) and 150° swath width, and offers seafloor coverage in excess of 500 meters. Two narrow beam width transducer arrays are transmitting quasi-simultaneously into directed sectors with a high acoustic transmission level. The high operating frequency of 180 kHz in conjunction with small transducers offers high coverage and narrow beam width (Maida et al., 2011).

A multibeam calibration is done before surveying to quantify all residual installation misalignments and to ensure that the subsequent data gathered from the multibeam system is correctly geo-referenced in three dimensions. The multibeam sonar data were relative to true vertical and to heading according to the collected data from motion and heading sensors. The multibeam calibration was done related to alignment offsets of pitch, roll and yaw. Acquisition survey was based on a differ-