Development of Marine Information System for Dama Dama Port (Sudan)

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***Abstract*– No doubt that good quality and well managed spatial hydrographic and oceanographic data constitute an essential ingredient to economic and commercial development as well as to marine environmental protection. This research has been oriented towards locating, managing, accessing and manipulating hydrographic data i.e., establishment of marine information system. These data have been collected and applied in Geographical Information System (GIS) package in order to develop marine information system. Collected data are then being easy to analyze, and process for the production of maps charts, and Digital Terrain Models (DTM). Results showed that there is no need to carry out sound calibration in depth less than 12m. Vessels draft more than 14m may cause damage to collide with seabed in the study area. Also, water temperature is considered to be as the major effect on the sound velocity. Study also showed that change in tide is limited to the range of 0.5m - 4.0m in the study area. On the other hand, density and salinity were found to be proportionally increased with depth while temperature decreases.**

***Keywords*– Marine Information System, Marine Database, GPS, Digital Terrain Model and GIS**

I. INTRODUCTION

The Sudan National Survey Authority (SNSA) was established in 1898 by the British colonial authorities under the name (Sudan Survey Department) for map production of Sudan for administrative purposes and exploitation of wealth.

SNSA is the authorized consultant for the government in field of surveying and mapping. So, its mandatory is to provide other agencies working in surveying and mapping fields with control points, base maps and specifications for quality control. Recently, SNSA has established Hydrographic Survey departments [1] to work in cooperation with the existing Military one in order to fill the lack of information in this field.

the long coastline of Sudan in the Red sea is very rich in living and non-living marine recourses. Also Red sea water is one of the busiest areas in the world due to its economical and geographical properties. Sudan has an obligation to monitor the passage of the vessels that sail over the Red sea.

For ideal exploration, exploitation and sustained development of Sudan marine resources, protection of marine life, and strategic naval planning, an accurate hydrographic data is needed. Hence, a comprehensive hydrographic training and promotion of Sudanese skills in hydrographic data acquisition and chart production is needed. This will eventually lead to establish a national marine database for Red sea and other water resources, to supply users and researchers with necessary hydrographic data.

Need for the hydrographic data in applications other than nautical charting, to help in decision making on national, regional and global bases. Exploration and exploitation of marine resources in the Sudan Red Sea territorial waters (life and minerals) constitute a significant offshore asset which, territorial waters include fish, oil, metalliferous mud, and manganese nodule.

For Sustained development and management of the territorial waters and Exclusive Economic Zone (EEZ), hydrographic data has become an integral tool for planning and decision-making processes. Development of ports to meet the recently oil production requirements, will entail rehabilitation of the ports, reclamation of new coastal towns and settlements, fisheries, recreation (boating, surfing), sewage outfall installation plants construction yachting , jet skiing.

Hydrographic data are needed in academic research and education of oceanography, marine biology and development of fish stock, dedicated fish breeding areas, conservation of marine national park and coral reefs.

Also researches for protection of marine environment pollution, spread model, human interference and its impact on the environmental regime required hydrographic data. Delimitation of maritime boundaries, territorial sea, EEZ, continental shelf in accordance with UNCLOS'82 and practicing sovereignty within Sudan water regarding innocent passage, marine research, coast guard activities on smuggling or illegal works. To supervise, control and implement national jurisdiction regarding environmental protection of lakes, rivers, and seas. All these need a good hydrographic data.

Naval strategies and defence plans and operations to look after the national territory waters, require large scale charts within the military sensitive zone. Hydrographic and oceanographic data is necessary for Variety of nautical products used in naval operation such as surface navigation, submarine, mine hunting, air-sea naval operations. Preparation of such products must be available for national investment in defence is to be optimized.

To keep abreast with these nations, Sudan should build its hydrographic capabilities through establishment of its national marine database

Hydrographic departments of the Maritime States provide an invaluable service within the national transport infrastructure. Hydrographic services support safe and efficient navigation, foster for national maritime development, help to safeguard life and property at sea, facilitate the protection of the marine environment and support the administration and sustainable development of the national maritime zones. Yet in the recent years the Member States of the IHO have found it increasingly necessary to justify their existence to the government's intent on reducing activities and expenditure.

At the same time there is concern in the maritime community that many developing coastal states have not yet established hydrographic services, Sudan is one of the in a significant area of the world, the lack of adequate navigation charts is a real threat to safety of life and to the marine environment.

II. MARINE INFORMATION SYSTEM

Map can be defined as a graphical representation of geographical setting. Maps especially designed to serve the needs of navigators are called chards. Geographical Information System (GIS) is a system of computer hardware, software and procedures designed to support the capture, management, manipulation, analysis, modularity and display of spatially referenced data for solving complex planning and management

Marine Information System (MIS) is a new tool to layer the marine data and to provide a seamless surface between land topography and sea bed terrain for any coastal engineering work to be extended to sea, like ports, pipelines and marine cable. It also provides link tool of land sea interface for inundation model.

MIS in the sea therefore is a continuation of the GIS in the land as the sea is a natural extension of the land. The land survey data is static while, the marine data is dynamic (X ,Y ,Z ,T) . Every measurement in the sea is a time tagged data to show the time of the observation. Time of the depth recording is very essential to determine the tidal height to apply to that depth at that instant, and this just one example quoted.

The marine data user can be one of these three categories:

One needs the marine data real time and geographically referenced like the captain navigating across approach channel. Another user or customer may needs and achieved or historical data for decision making like coastal developer.

The last user or the customer may needs both historical and real time data like a hydrographic surveyor and the dredgers. MIS/ GIS are both tools playing one role but on different data nature static and dynamic respectively. MIS is natural extension of GIS toward the sea. The horizontal datum for the positing system is the same for both land and sea, however the vertical datum varies . land surveyors use MSL to reduce the heights while the hydrographer use Chart Datum to reduce the depth measured. To link both and to provide a seamless surface for land /sea interface , the difference between the MSL and CD should be determined.

III. METROLOGICAL DATA AND PHYSICAL PARAMETER AFFECT ON HYDROGRAPHIC MEASUREMENT

The number of parameters that affecting hydrographic measurement these include waves, earthquakes, pressure, weather, salinity, and density. Waves are formed when the sea surface is disturbed. The wave motion when passes over the surface of the water is characteristic by its certain speed, since water itself rises and falls in a symmetrical order. Waves normally arise from the winds, hurricanes; most waves arise from the action of winds on water. Waves might also be created by the action of tides. Furthermore, it can come to being by the effect of earthquakes and volcanism. Waves motion in seas oceans is known to be irregular and disturbed. It is an amalgamation of waves in a group form, or chains that combine together in asymmetrical continuous flow. Wave groups vary according to their origins, how it originates, its speed, direction of flow. Some groups begin to die, some travel for long distances, some of which may reach coastal areas causing turmoil and destruction.

The name tidal waves is given to two different types of waves neither of which has a connection with the tide. The first one originates from earthquakes that occur at the bottom of the ocean. The other type is caused by heavy winds & huge hurricanes.

Most sea earthquakes waves originate from the phenomenon called (TSU- NAMI), a Japanese term for high long wave formed by disturbance of ocean of floor generated in rifts & deep seas trough. In the rifts of Atacama, All china and Japan there arose waves destroyed many lives. Pressure may by define as the force per unit area; thus atmospheric pressure constitutes the pressure falling on an area of one cm^2 of a mercury column 76 cm high. Weather of Sudan is very hot and dry. There are two monsoons in one year. One is the southwest monsoon occurred between July and august and another is the northeast monsoon occurred during November and February.

The average annual rainfall over the 30 years is 110mm a year. Most of the rain falls during the northeast monsoon period with half the annual total falling in November and a quarter December. Occasional heavy falls have been recorded, for example 111.5mm on 21st November 1957.

The prevailing and domination wind direction in coastal area of the Red sea is north and northeast. Extra tropical cyclones are the common storms that occur in temperate latitudes. They consist of a wind rotation around a low pressure centre in a counter-clockwise inward spiral. The diameter of the wind circulation ranges from a minimum of few hundred miles to a maximum of approximately one thousand miles. There is considerable variety in individual storm tracks with relation to area of interest, and in the speed of movement, intensity, and horizontal dimensions of these storms.

Severe thunderstorms occasionally occur over the Red sea. Sometimes associated with hail, sustained winds of 50 mph to 70 mph to short periods, and instantaneous wind gusts in the range of 80 to 100 mph, and spectacular lightning, and static electricity associated with blowing sand and dust may create

hydrocarbon fire hazard conditions in the vicinity of such thunderstorms.

Temperature is considered as one of the most important physical properties of saline water which influence the configuration of the two chemical constituents of water Hydrogen and oxygen. Change in the sea water temperature produces a change in its properties, thus, an affecting water density and dissolved concentration and the ability of sea water to induce electricity. Temperature also affects the acoustic properties of sea water and marine life therein.

Ocean water temperatures rang between -2˚C and +30˚C on the surface, but deep water range from 0˚C to 6˚C. About 50% of oceanic waters have less than 2˚C average temperature.

Salinity is the quantity of the solid particles contained in the sea water, measured in grams as per one kilogram of the water. This is done through the process of converting the carbonates into oxides and replacing the bromide, the iodine and the complete oxidation of all the organic materials by chlorine. It is very rare to find pure water in nature but, such water normally contains some dissolved salts. River waters contain about 0.01% of its weights dissolved salts. Storm waters contain salts and gases dissolved by rains in the atmosphere. Oceanic waters contain about 3.5% of its weight in the form of dissolved salts.

Salinity is then relates to the amount of salt concentration in sea water measured in g/kg defined in ‰ Practical Salinity Unit (PSU). It may also be shown without such units. Because sea water salinity ranges between 34PSU to 38PSU it can quote the mean of 35PSU.

Density is the degree of consistency measured by quantity of mass in unit volume measured in $g.cm^{-3}$. Sea water density depends on the pressure, salinity and temperature inherent in it. In situ density relates to the sea water density measured at a certain depth, when pressure (P) at the temperature (T) and salinity (S) is denoted by (PST).

The average density of oceanic waters is about $1.024789 g.cm^{-3}$ at temperature of 20˚C and salinity of 35 PSU and at instantaneous pressure.

Water column stabilities at sea depend on the vertical density distribution. If the density increases with depth, this implies the stability of the water column. The water column becomes unstable when density decreases with depth.

IV. MEASUREMENT AND RESULTS

In general, one of the important objectives of hydrographic surveying [2], [5] is to determine the depths of water. To achieve this, three elements have to be taken into account; time, position and pressure of water. In order to compute the depth of water, the reference datum plane should be calculated during the echo-sounding measurements. This is so because the rational sea water plane (reference datum) rarely coincides with the measured sea water level.

On the other hand, parameters such as temperature, density and salinity affecting the physical properties of water column, which in turn influence the speed of sound in water and hence the measured depths. This make correction of measured depth depends of some sort of measurement carried out to these parameters.

Alkhair Marine (Dama Dama port) near Portsudan town (Sudan) was selected to carry out this research work. This area is located in the Red sea between 37˚13′ and 37˚14′ longitude and 19˚36′ to 19˚37′ latitude, with one harbor anchor and 25.025 cubic centimeter water density. This sea port was designed to have 14.6m depth that make it capable to receive oil tankers with 2.7 million tones and one million weights.

Dama Dama port is planned to be developed and reconstructed to receive oil tankers with 15.5 million tones and seven million weight. These specifically require a design depth of 17m. This leads to carry out preliminary survey and special measurement. Fig. 1 shows a satellite image of the study area.

Fig. 1: Study area

Three sorts of data were collected in this research work. These are:

i. Oceanographic data including salinity, temperature and density.
ii. Metrological data that consist wind and tide.
iii. Hydrographic data that concentrate on depth observation

Salinity data was collect as a part of oceanographic information. This data was measure by Sound Velocity Probe (SVP). These data were then arranged in an attribute table and represented graphically in GIS. Fig. 2 represents variation in salinity in the study area.

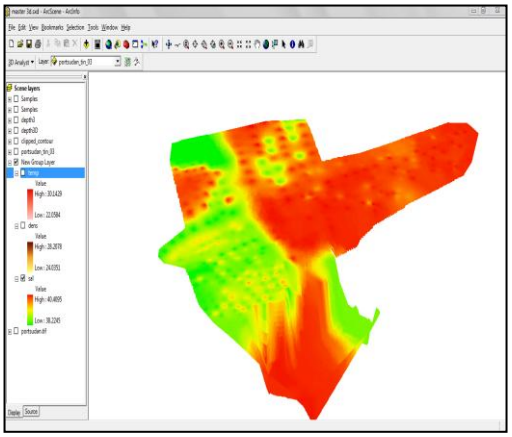

Fig. 2: Salinity Variation Model

In general, for most areas of the ocean, the water temperature degreases from the surface to the bottom, but there are many local variations. In order to know the variation in water temperature of the study area, temperature measurement was carried out by Sound Velocity Probe (SVP). Then, tabulated in attribute table as a part of marine information data base and presented graphically as illustrated in Fig. 3 to show temperature variation.

The last part of oceanographic data collected here in this study was the density. Variation in water density of the study area is shown as a GIS layer in Fig. 4.

The wind information of study area was also collected as a part of metrological data with help of statistical data available in metrological corporation. According to the statistical result the prevailing and dominating wind direction is north and north-east with 36.3% and 28.3% frequency.

The attribute table for wind direction and speed is shown as GIS layer in Fig. 5.

Tidal information of study area is available for a complete year 2012, in meteorological corporation. This data was tabulated in attribute table and also used to correct the observed depth of water. Hydrographic survey measurement covering an area of 840×520 meters was carried out. This area was divided into twenty five parallel lines perpendicular to the coast line. GPS echo–sounding system was used for determination of depths & locations at each observed point along the lines.

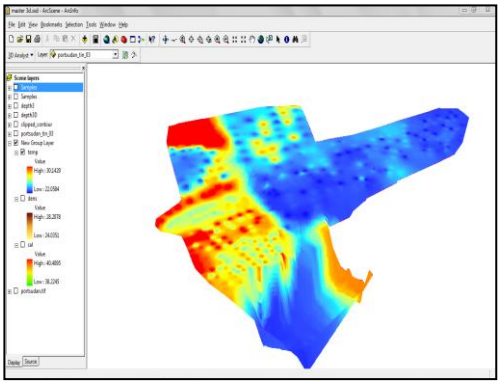

Fig. 3: Temperature Variation Model

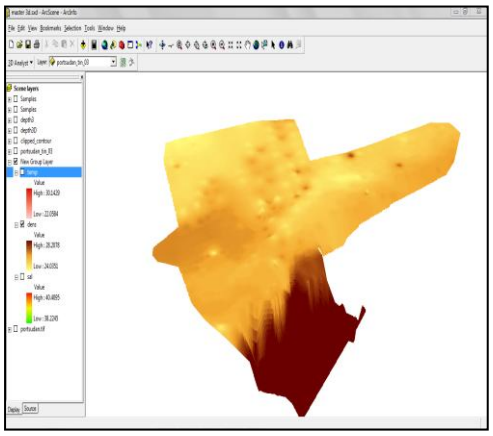

Fig. 4: Density Variation Model

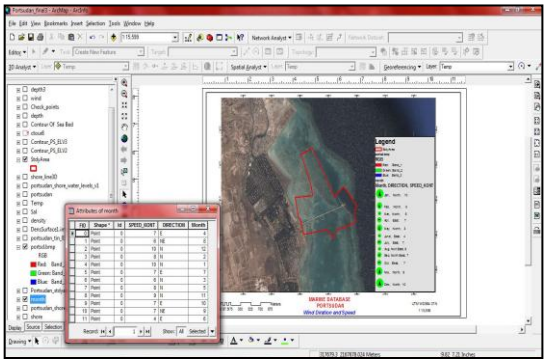

Fig. 5: Wind Direction and Speed

According to the data collected above, depths of water were corrected by the following equation:

$$c = 1449 + 4.6T - 0.055T^2 + 0.0003T^3 + (1.39 - 0.012T)(S - 35) + 0.017Z$$

with the following limits:

$0 \leq t \leq 35°\ C$

$0 \leq S \leq 45\ p.s.u.$

$0 \leq z \leq 1000\ meters$

Where, *c is the speed of sound as a function of temperature, t, depth, z, and salinity, S.*

Then, charted depthes were calculated as:

$$Charted\ depth = observed\ depth + draft - Tide$$

Where, observed depth, represent the vertical distance from the trnsducer to seabed.

Draft, represents the vertical distance from the transducer to the surface of the sea.

Tide, is vertical distance from the chard datum to the surface of the sea at the time of observation. In order to represent the sea bed, the Fig. 6 shows a contour map of sea bed at the study area.

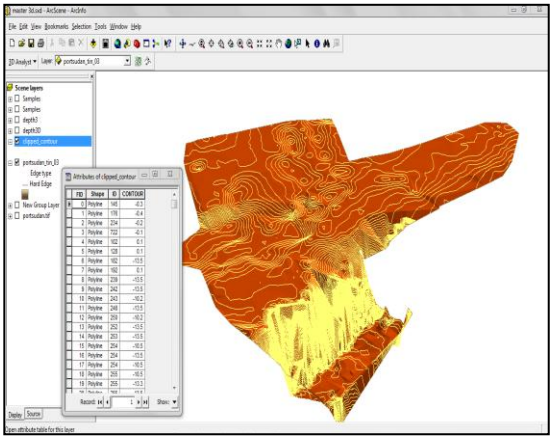

Fig. 6: Contour map of the sea bed

V. CONCLUSIONS

From the measurement carried out and data collected to develop marine information system for the study area of Dama Dama Sea Port (Sudan) it can be concluded with the following:

- The influence of tidal currents in the final results is negligible.
- Northern winds do not affect observation seriously.
- The speed of sound waves in water depends on the degree of change in the physical properties of the water column. Change in temperature proved to be the most factors that affecting the speed of sound waves in water compared to the effects of salinity and pressure.
- Water density stabilizes the water column and has no effect on the speed of sound waves in water.
- Up to 12m depth, the water columns are homogenously mixed and sound velocity is constant throughout the water column. In this case, it is not necessary to carry out sound calibration.
- The changes in the surface of the Red sea water is associated with wind changes in the region.
- Tide range from 0.5m to 4m.
- The water column density, ranges between 24 and 28 $g.cm^{-3}$.

REFERENCES

[1] Admiralty (1969), Manual of hydrographic surveying, volume two, The hydrographer of the navy, Taunton, Somerset, England.

[2] A. E. Ingham, (1975), Sea Surveying, John Wiley and Sons, Inc.

[3] Arthur H. Robinson, (2004), Elements of Cartography, John Wiley and sons, Inc.

[4] A. E. Ingham, (1975), Sea Surveying (Illustrations), John Wiley and Sons , Inc.

[5] A. E. Ingham, (1975), Hydrographic Surveying for Engineers, John Wiley and Sons , Inc.

[6] Amin hamed meshal and Alaa bin mohammed, (2012), Principle of physical oceanography, house of scientific books for publication and distribution.

[7] Omer Elkhidir Elamin (2001), Basic of Hydrographic Survey, Printians corporation, Beirut.

[8] Robert H. Stewart, (2008), Introduction of Physical Oceanography, Department of oceanography Texas A & M University.

[9] Robert ward (2008), Manual of Hydrographic, 1st Edition, International hydrographic Bureau Monaco.

[10] Sherif Fatay (2004), principle of hydrographic survey, House of scientific books for publication and distribution.

[11] Urick M.C. Graw Hill (1983), Principle of Underwater Acoustic, 2end edition.

[12] U.S.A Naval Academy, (1977), Naval operation Analysis, 2nd edition, Fundamentals of naval science series.