Surveying 2

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Hydrographic surveying

Fundamentals of Hydrographic Surveying

Hydrography is the branch of applied science which deals with the measurement and description of the physical features of oceans, seas, coastal areas, lakes and rivers, as well as with the prediction of their change over time, for the primary purpose of safety of navigation and in support of all other marine activities, including economic development, security and defense, scientific research, and environmental protection." International Hydrographic Organization – June 2009

1.1 Introduction

More than half of the world's population lives within 100 km of its shores. The effects of denser coastal population and accelerating climate change can be seen in degraded (and even disappearance of) ecosystems, coastal erosion, over-fishing, marine pollution, and higher vulnerability to marine disasters such as tsunami or volcanic activity.

Marine environments (oceans, lake, rivers, swamps, wetlands) cover more than two-thirds of the Earth's surface, and are not easily accessible to direct observations. In the past 20 to 30 years technological advances have allowed us to discover and map much more detailed coastal and ocean bathymetry and to delineate shore boundaries , mostly through acoustic remote sensing.

Hydrography is that branch of physical oceanography that deals with measurement and definition of the configuration of the bottoms and adjacent land area of oceans, lakes, harbors, and other water bodies on Earth. Hydrographic surveying, in the strictest sense, is defined merely as the surveying of a water area; however, in modern usage it may include a wide variety of other objectives such as measurements of tides, currents, gravity, and the determination of physical and chemical properties of water.

The principal objective of most hydrographic surveys that are conducted by large government agencies like the National Oceanic and Atmospheric Administration (NOAA) is to produce nautical charts and mapping. NOAA uses very large vessels to obtain basic data for the compilation of nautical charts with emphasis on features that affect safe navigation. Other objectives of NOAA include acquiring the information necessary to produce related marine navigational products for coastal zone management, engineering, and scientific investigations. Other government agencies such as the US Army Corp of Engineers (USACE), the Naval Oceanographic Office (NAVO), the US Geological Survey (USGS), are tasked with hydrographic surveys for a variety of purposes Some state and local agencies as well as the private sector also have hydrographic survey capabilities

The US Army Corps of Engineers (USACE) is responsible to collect, process, and map hydrographic survey data for federally authorized civil and military navigation channels and shore protection projects throughout the US including Puerto Rico and the Virgin Islands. The main purpose of collecting hydrographic survey data is to be used by engineers and scientists to monitor channel shoaling conditions. Survey results in the form of a bathymetric map become a decision making tool for channel maintenance operations, channel deepening contracts, planning studies,

environmental monitoring, near shore engineering designs, location (and sometimes removal of obstructions such as sunken vessels, sediment transport modeling, and beach nourishment projects. Other objectives include volume computations for fair and equitable payment on dredging contracts. The overarching reason to perform hydrographic surveys is to ensure safe navigation conditions for all commercial and public users within the limits of the federal waterways. Hydrographic surveys are very complex in terms of (electronic) equipment integration, logistics on field operations and costs.

Hydrographic surveys support a variety of activities including:

- **nautical charting,**
- **port and harbor operations (maintenance & dredging),**
- **coastal engineering (beach erosion and replenishment studies)**
- **coastal zone management**
- **offshore resource mapping**

On smaller scale local marine environments, the survey operations can be far less complex. Surveys conducted in shallow waters, lakes and rivers may invoke conventional (manual) surveying procedures.

Nautical Charting: Periodic hydrographic surveys must be performed to determine shipping channel conditions. Minimum controlling depths along with location of shoals and other critical information regarding safe navigation gets documented. Reports of Channel Conditions are accessible to waterway users.

Port and Harbor Operations: Survey data are required for effective management of water resources and harbor estuaries. Operations include maintenance dredging, debris removal for clear passage of vessels, environmental restoration, marine structural design, and many others.

Coastal Geomorphology: Hydrographic surveys provide data for morphodynamic classification of coastal areas from sea state (breaking wave heights), bathymetry, tide regimes (F-factor computed from tide constituents).

Coastal Engineering: Coastal mapping data is required for civil works projects such as revetments, jetties, and beach nourishments. Hydrographic survey data is used to understand various processes that shape the coastlines and human interaction with these processes.

Coastal Zone Management: Hydrographic surveys provide data for coastal hazards and vulnerability assessment of coastal landscapes in relation to climate change, subsidence, glacial rebound, and others. Bathymetric data provide ancillary information on indicators that capture the biophysical conditions and morphodynamic classification.

Offshore Resource Mapping: Offshore energy resources include wind, wave, and geologic mineral (oil, natural gas etc) deposits. Surveys and Geographic Information Systems are invaluable tools to identify the exploitation of these energy resources.

1.2 Disciplines Associated with Hydrographic Surveying

Hydrography relies on a variety of scientific and engineering disciplines. Figure 1 illustrates the core disciplines like Geodesy, Photogrammetry, Cartography, Global Positioning System, Oceanography, Tides, Physics and Mathematics. These are the various disciplines that influence the science and products delivered by hydrographic survey.

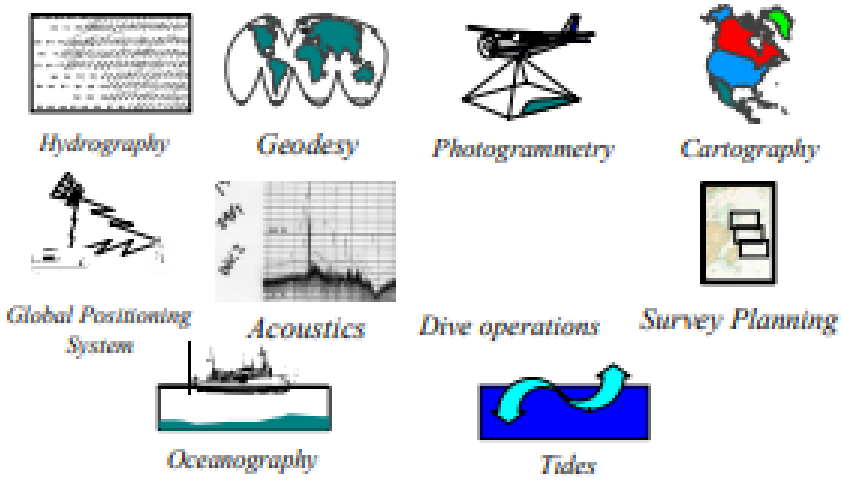

Figure 1. Disciplines that Influence the Science of Hydrography

Geodesy is an interdisciplinary science which uses space-borne and airborne remotely sensed, and ground-based measurements to study the shape and size of the Earth, the planets and their satellites, and their changes; to precisely determine position and velocity of points or objects at the surface or orbiting the planet, within a realized terrestrial reference system, and to apply these knowledge to a variety of scientific and engineering applications, using mathematics, physics, astronomy, and computer science.

Oceanography is the scientific discipline concerned with all aspects of the world's oceans and seas, including their physical and chemical properties, their origin and geologic framework, and the life forms that inhabit the marine environment. Traditionally, oceanography has been divided into four separate but related branches: physical oceanography, chemical oceanography, marine geology, and marine ecology. Physical oceanography deals with the properties of seawater (temperature, density, pressure, and so on), its movement (i.e., waves, currents, tides), and the interactions between the ocean waters and land surface waters (rivers and streams).

1.3.1 Marine Vessel

The size and payload of the marine vessel depends on the extent of the survey project requirements. Surveys can be classified by vessel size -small scale (from wading to small boats), medium scale (using medium size boats and acoustic methods), and regional scale surveys using deep sea research vessels with state-of-the art multi-disciplinary data collection systems. Essential equipment list for each survey is as follows;

A) Small Surveys:

1. Vessel: Oars, Life jackets, Gas tanks (minimum 2), extra oil, and 10 HP engine
2. Depth and Position: 50' leadline, range poles, and plans. Survey equipment may include Total Station Instrument (TSI), compensating level as required, prism pole with extension rods. Deeper water requires a fathometer and transducer installation.
3. Miscellaneous: Radio, 300 ft tape, Navigation chart, staff sheets, Batteries (2), repair kit, tool box

B) Medium Scale Surveys:

1. Vessel: 25-65 ft vessel, licensed operator.
2. Depth and Position: Echosounder with Transducer and aedquate power from batteries or generator, tool box, transducers , GPS or TSI positioning, motion reference units (MRU)
3. Miscellaneous: A small vessel for the near-shore shallow water survey system to perform as rover platform.

C) Regional Scale Surveys:

1. Vehicle: 65 ft and larger research vessels , with competent crew and equipment.
2. Depth and Position: Multi-beam transducer and GPS.
3. Other Equipment: Cameras for stereo imaging (require positioning of frames) Integrated multi-disciplinary data collection systems (e.g., gravity, magnetics), requires accurate in-ship surveys for sensor integration, calibration, and synchronization.
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1.3.2 Positioning equipment

Offshore positioning equipment has been revolutionized due to dramatic evolution in sensor technology and computer science. Traditional offshore equipment includes a sextant, transit, stadia, and an electronic distance measuring (EDM) device. Nowadays, several methods for horizontal positioning include optical, land-based electronic ranging, and space-based positioning. A basic method of positioning is the resection. However, the positioning methodology employed on any project will be evaluated based on site-specific conditions and project specification.

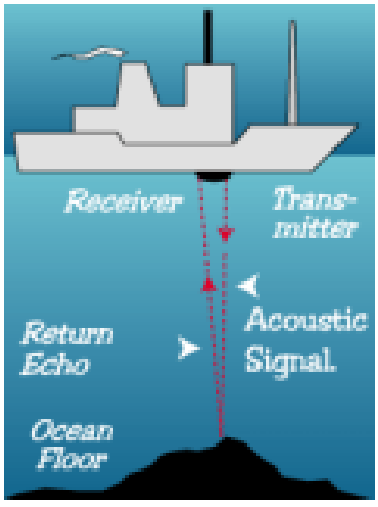

Figure 1.2: Acoustic depth measurement