Hydrographic survey in Yemen

Fanar Ali

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HYDROGRAPHIC SURVEY IN YEMEN

By

FANAR ALI
Republic of Yemen

A dissertation submitted to the World Maritime University in partial fulfillment of the requirements for the reward of the degree of

MASTER OF SCIENCE
in
MARITIME AFFAIRS

(MARITIME SAFETY & ENVIRONMENTAL ADMINISTRATION)

2020

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Declaration

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

Signature:  

Taner Ali

22 September 2020

Supervised by:  Professor Raphael Baumler

Head of Maritime Safety and Environmental Administration – World Maritime University
Acknowledgements

“To the soul of my dear father, who passed away during this study, for his great role in my life.... “

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Special thanks to Capt. Roy Facey for his support and contributions to data collection of this dissertation.

Last but not least, thanks to my family for their endless support and prayers.
Abstract

Title of Dissertation: **Hydrographic Survey in Yemen**

Degree: **Master of Science**

The dissertation is a study about the history of hydrographic survey in the Republic of Yemen and what are the general techniques and equipment are being used. The level of compliance of International obligations in Yemen was examined and found very weak. After collecting data from experts in Yemen and other related companies, it was necessary to go through International Hydrographic Organization (IHO) publications to extract recommendations and guidelines that should improve the capacity building of Yemen hydrographic services. After assessing the data collected from Yemen, it was clear that the weakness is mainly in training, in addition to logistics, and updating the nautical charts, publications, and maritime safety information.

Researching the modern survey techniques and particularly new Satellite Imagery and Satellite-Derived Bathymetry (SDB) technologies, such services can fill some gaps in updating nautical charts and can provide many benefits to port authorities in Yemen. One of the satellite bathymetry service provider has estimated the price of SDB if used in Port of Aden and explained the options that SDB can perform, such as indicating the depths and characteristics of the water and satellite are able can monitor changes in the sea-floor (such as sandbar migration and sedimentation) in the Port or in any coastal area.

Yemen is not a member of IHO, and mainly there is a shortage of competent staff and awareness of the importance of broadcasting updates and navigational warnings. It is highly recommended for Yemen to be a member in IHO and get the benefit of membership, which includes training and technical assistance.

**KEYWORDS:** Hydrographic survey, Satellite-Derived Bathymetry, Nautical charts, Seafloor survey
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<tbody>
<tr>
<td>IHO</td>
<td>International Hydrographic Organization</td>
</tr>
<tr>
<td>UNCLOS</td>
<td>The United Nations Convention on the Law of the Sea</td>
</tr>
<tr>
<td>IMO</td>
<td>International Maritime Organization</td>
</tr>
<tr>
<td>SOLAS</td>
<td>Safety Of Life At Sea</td>
</tr>
<tr>
<td>U.N</td>
<td>The United Nation</td>
</tr>
<tr>
<td>YGAPC</td>
<td>Yemen Gulf Of Aden Ports Corporation</td>
</tr>
<tr>
<td>NOAA</td>
<td>The National Oceanic and Atmospheric Administration (US agency)</td>
</tr>
<tr>
<td>SBES</td>
<td>Single Beam Echo Sounder</td>
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<tr>
<td>MBES</td>
<td>Multi-Beam Echo Sounder</td>
</tr>
<tr>
<td>SSS</td>
<td>Side Scan Sonar</td>
</tr>
<tr>
<td>LIDAR</td>
<td>Light detection and ranging</td>
</tr>
<tr>
<td>UAV</td>
<td>Unmanned aerial vehicle</td>
</tr>
<tr>
<td>ROV</td>
<td>Remotely operated underwater vehicle</td>
</tr>
<tr>
<td>UKHO</td>
<td>The United Kingdom Hydrographic Office</td>
</tr>
<tr>
<td>SDB</td>
<td>Satellite Derived Bathymetry</td>
</tr>
<tr>
<td>CSPCWG</td>
<td>Chart Standardization and Paper Chart Working Group</td>
</tr>
<tr>
<td>RHCs</td>
<td>Regional Hydrographic Commissions</td>
</tr>
<tr>
<td>LNG</td>
<td>Liquid Natural Gas</td>
</tr>
<tr>
<td>YMAA</td>
<td>Yemen Maritime Affairs Authority</td>
</tr>
<tr>
<td>LORAN</td>
<td>Long Range Navigation</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>DGPS</td>
<td>Differential Global Positioning System</td>
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Chapter 1 - Introduction on hydrography

Almost all human activities that take place on or under the sea need some knowledge of the area’s hydrography, i.e., understanding of the form and nature of the sea-floor, its features, and its dangers (IHO Publication M-2, 2018). Without hydrography, no ship sails safely, no port is constructed, no coastal infrastructure is built, no marine environmental plan is implemented, no coast or island is protected, no maritime search and rescue are attempted, no marine boundaries are specified or enforced.

The United Nations Convention on the Law of the Sea (UNCLOS) was signed in 1982. Certain articles dealing with the determination of baselines, the delimitation of maritime areas such as the territorial sea, the exclusive economic zone, and the continental shelf, the identification of traffic separation schemes, are aspects of the Convention that are of particular interest to hydrographers, identifying sea lanes for transit and innocent passage routes, deploying submarine cables and pipelines, conducting drilling on the sea-floor and conducting marine scientific research (IHO Publication C-51, 2014).

1.1 Obligations to Member States of the International Maritime Organization (IMO)

The hydrographic services to be provided by the contracting governments are defined very clearly in Regulation 9 of SOLAS Chapter V. The provision of these hydrographic services is, in essence, responsible under the International Treaty Law for Contracting Governments. SOLAS Chapter V Regulation 4 puts an obligation on Contracting Governments to ensure that adequate navigational warnings are generated (SOLAS, 1974).

The International Maritime Organization (IMO) and the International Hydrographic Organization (IHO) are collaborating and working on various projects of mutual interest relating to navigational safety and marine environment security. This is achieved mainly under the 1963 IMO Assembly’s resolution A.64 (III). In 1983 both organizations signed a cooperation agreement. The key objectives of the agreement were to co-operate with each other in the provision of technical assistance in the field of hydrography to developing countries and related aspects within the framework of their respective areas
of competence and operation, as set out in their respective conventions (Bermejo, 1998).

1.2 International Hydrographic Organization (IHO)

The Organization was established in 1921 and was known as the International Hydrographic Bureau (IHB) until 1967, after which the name International Hydrographic Organization (IHO) referred to Member States organization (IHO Publication M-10, 2019). In accordance with Article II of the Convention on International Hydrographic Organisations, in (IHO publication M-1, 2017) the main goals of the IHO are defined as following:

- Promoting the use of hydrography for navigational safety and all other maritime purposes and raising global awareness about the importance of hydrography.
- To enhance hydrographic data coverage, availability, and consistency at a global level. Data, products, and services and the facilitation of access to those data.
- To enhance hydrographic capacity, capacity, training, science, and techniques globally.
- To maintain and improve the development of international hydrographic data, information, products, services, and techniques standards and to achieve the greatest possible consistency in the application of these standards.
- Giving states and international organizations authoritative and timely advice on all hydrographic matters.
- To promote the coordination among the Member States of hydrographic activities.
- Increase regional cooperation on hydrographic activities between States.

1.3 Nautical charts

One of the most basic tools available to the mariner is a nautical chart. It is a map which depicts the shoreline and seafloor configuration. It includes water depths, navigational hazard locations, navigational aid positions and characteristics, anchorages, and other features (NOAA, 2020).
Hydrographic surveys are based on nautical charts, considering that surveying is laborious and time-consuming, hydrographic data can be dated and not always accurate for many areas of the sea. Depths are measured in many different ways, the sounding line has been used traditionally while echo sounding is used in modern times for calculating the seabed in the open sea. The minimum depth is tested when measuring the safe depth of water over an entire obstruction, such as a shipwreck.

Ideally, it should be the responsibility of each and every Maritime State to map its maritime areas and to distribute the necessary nautical information. Indeed, several states do not yet have the proper systems and organization needed to manage this role. For historical reasons, some countries (particularly France, Portugal, Spain, the United Kingdom, and the United States) have continued to play this position on behalf of the international community with regard to territories that are now independent. That means they keep maintaining a portfolio of nautical records, which are often the only available guide (Vatsa. et al., 2009).

Nautical charts are provided in many countries through the strength of the national hydrographic offices. In comparison to those made by commercial publishers, these charts are considered “official” via their sales agents, many hydrographic bureaus provide frequent, often weekly, manual updates of their charts. The national chart series and international chart series are created by individual hydrographic offices. The international chart series is organized by the International Hydrographic Organization and is a worldwide chart system (“INT” chart series), which is being established with the intention of unifying as many chart systems as possible. Nautical chart is a final hydrographic survey product. The consistency of the data obtained during the surveys depends on its accuracy and adequacy.

From the outset, the production of nautical charts and additional navigational documents was a national commitment, which in many cases was originally treated as a confidential undertaking, at least the commodity, charts or navigational directions, as confidential documents to be kept away from rivals in the commercial sphere and possible enemies in the military sphere. This closed shop approach gradually resulted in a very confusing set of symbols and abbreviations used on the chart created by different nationality hydrographic offices (Langeraar, 1984. p 534).

Since its establishment, one of the most important tasks of the International Hydrographic Bureau (IHB) has been to promote uniformity on the various national
nautical charts and additional nautical publications through different approaches. Since its inception, IHB has been proposing appropriate charts symbols and abbreviations that a large majority of the member states would agree on (Langeraar, 1984. p 535).

### 1.4 The purpose of this dissertation

The purpose of this dissertation is to review the history of hydrography, to evaluate the present status related to hydrography in The Republic of Yemen, and to research and recommend the best practice in this field.

The hydrographic survey techniques have developed rapidly in recent years, and it was essential to research and introduce the new cheap technology that can fill the gaps in the weak capability of Yemen, which is categorized by the U.N. as a Least Developed Country (UNCTAD, 2020).

Yemen is not an IHO member, nor a member of the North Indian Ocean Regional Hydrographic Commission (NIOHC). It is important to identify the requirements for Yemen to be a member of IHO and explore the benefits that may be gained from this membership, considering that Yemen has long coasts in a high shipping traffic density area.

### 1.5 Methodology

- **Research questions**
  1. What is a Hydrographic survey?
  2. What is Yemen’s history in the hydrographic survey?
  3. What are modern hydrographic survey techniques and their cost?
  4. How can Yemen get advantage from the modern survey technologies?
  5. What is the advantage of IHO membership and how will Yemen benefit from it?

To find answers to the above questions, qualitative research used to explore the traditional and modern hydrographic techniques. Some in-depth information about the cost and performance of hydrography by satellites was collected via email personal communications with Mr. Knut Hartmann from EOMAP, the global service provider of satellite-derived aquatic information in maritime and inland waters.
The documents issued by the International Hydrographic organization have been reviewed to extract the guidelines/recommendations and to explore the advantage of IHO membership and its benefit to Yemen.

To collect data about the status of hydrography in Yemen, an interview was done with Capt. Roy Facey, the IMO senior technical adviser who has extensive experience in the hydrographic survey in Yemeni water and worked closely with Yemen maritime affairs authority, Port of Aden, and the United Kingdom Hydrographic Office.

Other primary source data was collected via personal communications with Eng. Abdulrab Al-Khulaqi, Deputy Chief Executive Chairman of Yemen Gulf of Aden Ports Corporation (YGAPC), about the hydrographic survey status in Port of Aden.

- **Research Limitations and Alternatives**

  It is important to note that during the study of this Master degree dissertation, war is going on in Yemen, and since the war started in 2015, the conflict has caused bad damage to the infrastructure in the maritime sector, and it was complicated to “fully” evaluate the present status of hydrography or to collect a large amount of data. However, the persons who have the greatest knowledge have been approached and questioned to get the maximum possible information.

  To fill the gaps of data, and as an alternative, the best practices recommended by the IHO have been studied and introduced in this dissertation.

**Chapter 2 - Literature review**

**2.1 What is a Hydrographic survey?**

The hydrographic survey is the calculation and explanation of the coastal and water characteristics needed for marine navigation, coastal development, dredging, oil exploration/drilling offshore, and related activities. Substantial attention is given to soundings of depths, shorelines, tides, location, features of the seabed, and obstructions underwater that are important to and impact above mentioned activities.
Three main measurement parameters are used in hydrographic surveys: geodesic location, bathymetric depth, and water level or tide (Xiao et al., 2016). Hydrography is collected under the International Hydrographic Organization (IHO) guidelines and specifications and in compliance with rules that differ according to the needs and approval of the authority. Traditionally conducted by vessels with a sounding line or echo sounding, surveys are increasingly performed in shallow waters with the aid of airplanes and modern digital sensors.

2.2 What is Bathymetry?

Initially, the concept “bathymetry” referred to the depth of the ocean relative to sea level, although it has come to mean “submarine topography,” or underwater terrain depths and shapes.

Bathymetric maps illustrate the land lying underwater in the same way as topographic maps reflect the three-dimensional characteristics (or relief) of overland terrain. Variations in sea-floor relief can be represented by lines of color and contour, called contours of depth or isobaths (See Figure 1).

Bathymetry is the foundation of the hydrographic science, which measures a water body’s physical characteristics. Hydrography requires not only bathymetry, but also the form and characteristics of the shoreline; the features of tides, winds, and waves; and the water itself’s physical and chemical properties (NOAA, 2018).

Figure 1 A bathymetric image of Lake Huron. (Source NOAA 2019)
2.3 Traditional Hydrographic Survey Techniques

- **Hand Lead Line**

Hydrographic surveying goes back as far as sailing history. Early hydrographic surveys included measuring depths with positions determined by three-point sextant fixes for mapped reference points using a hand-held lead line. Ropes, or rods, with graduated depth-markings and a lead weight attached to the end, was lead rods (See Figure 2). Soundings of the lead line were generally taken from a slow-motion vessel. Soundings could only be taken at depths where the leader could heave the lead far enough ahead of the vessel so that the line could be vertical by the time the vessel “caught up.” Depending on the leader’s capacity, this depth limit would vary considerably; under average criteria, the depth limit was approximately 10 fathoms for smaller vessels, and on ships and auxiliary vessels, the limit was approximately 15 fathoms. Collecting hydrographic data using lead lines was a labor-intensive and time-consuming process (NOAA, 2017).

- **Single-Beam Echo Sounder (SBES)**

The traditional echo-sounder (single-beam) consisting of an underwater speaker and a microphone installed in one unit together. The echo-sounder works by transmitting a pulse of sound to the seabed in a way to be reflected and returned. An indication of the double depth of the seabed is the time it takes the sound wave to travel down to the seafloor and back again. (See Figure 3). Thus the half-time is exactly equivalent to the existing depth of water (Danish Geodata Agency, 2020).
- **Multi-Beam Echo Sounder (MBES)**

The multi-beam echo-sounder (multi-beam) emits a sound wave up to 75 degrees vertically in the transverse direction of the direction of sailing (See Figure.4). This gives a total seabed coverage equal to 3-7 times the depth of water. Therefore, Multibeam is much more effective than the single-beam echo-sounder, particularly if a hydrographic survey with a 100 percent seabed cover is required (See Figure.5).

The multi-beam is capable of receiving multiple different beams, unlike the single-beam echo-sounder, which emits a single broad beam on the seabed. These beams (sound waves) are received in a fan-shaped pattern, allowing the system to gather profiles of depth throughout the direction of sailing (Danish Geodata Agency, 2020).

![Figure 4 Multi Beam Echo Sounder (Source: Danish Geodata Agency 2020)](image)

![Figure 5 Coverage Comparison (Source: NOAA 2017)](image)
• **Side-Scan Sonar (SSS)**

A Side Scan Sonar can easily be contrasted with a steel torpedo-like body (towfish) with two sonars mounted to each side that horizontally rather than vertically emit signals. Through a fiber optic cable, the signals are sent to the boat where they are interpreted and registered by a device that then shows the result on a screen in two dimensions (See Figure 6).

The “fish” is controlled and scans in any direction from a boat. Setting the sonar to various frequencies allows users to search selectively, but accurately, or widely and less accurately. Different materials give various powerful echoes on the seabed. For instance, steel gives a strong echo, while soft materials give a lower echo. The sonar’s signals will strike through the bottom a bit depending on the frequency and reveal artifacts hidden in the dune (Divers Community Scandinavia, 2020).

A graphic image can be created as a result of the measurements to determine what is at the bottom (See Figure 7). Side-scan sonar is a type of sonar device that is used to accurately generate an image of large areas of the sea-floor. This method is used to map the seabed for a wide range of purposes, including making nautical charts and detecting and distinguishing underwater artifacts and bathymetric characteristics. Side-scan sonar imaging is also a widely used instrument for detecting debris and other sea-floor obstructions that could be unsafe for ships or for subsea field construction in sea-floor installations. Furthermore, the status of pipelines and cables on the seabed can be explored using Side Scan Sonar. Side-scan data, bathymetric soundings, and sub-bottom profiler data are regularly collected, offering an insight into the shallow structure of the seabed (Bai et al. 2019).
Airborne Lidar Bathymetry

Bathymetric Lidar is a technique used to capture coastline and (shallow) water geospatial data. It is a method that potentially facilitates the effective and rapid hydrographic data production. Lidar, which stands for Light Detection and Ranging, is a remote sensing tool that uses light for measuring ranges (variable distances) to the Earth in the form of a pulsed laser (See Figure 8). These light pulses produce accurate, three-dimensional details about the shape of the Earth and its surface characteristics, together with other data captured by the airborne system. A lidar instrument consists primarily of a laser, a scanner, and a specialized GPS receiver. The most widely used platforms for the acquisition of lidar data over large areas are airplanes and helicopters. Two types of lidar are bathymetric and topographic. Topographic lidar usually uses a near-infrared laser to chart the soil, while bathymetric lidar uses green light that penetrates water to determine sea-floor and riverbed elevations as well (NOAA, 2020).

2.4 Modern Hydrographic survey techniques

New data acquisition technologies such as satellite-derived bathymetry, crowd-sourced data, and the use of Underwater Autonomous and Remotely Operated Vehicles (UAV and ROV) are now actively used as more cost-effective methods in marine regions and depths where existing data are either low or non-existent and where conditions permit the use of those technologies. The development of e-Navigation, a term developed by IMO, encompasses the harmonized selection, integration, sharing, presentation, and review of onboard and ashore maritime knowledge. It does this by electronic means to boost berth to berth navigation and related facilities, for safety and security at sea and marine environment conservation.
Politicians are now taking a much greater interest in the world’s maritime space in terms of its ability to produce economic and socio-economic benefits and optimize that within national territorial sea boundaries. The need for improved access and re-use of hydrography data for emergency response purposes has all been heightened by the recent spate of disasters at sea around the world. (IHO Publication C-17, 2017)

Geospatial data and knowledge are no longer seen as “unique” or “different” as a person. Google, Microsoft, and other global technology firms offering “mash ups” mapping now use such knowledge without even knowing where it came from and any inherent meaning found therein. We now have mobile devices that are able to do in a fraction of the time what a mainframe computer did ten years ago for a fraction of the cost. Recently, the value of geospatial data has dropped by around 80 percent. It is now known to be a resource for commodities. The emergence of Open Data strategies by nations, which enables data to be re-used freely and openly, stimulates the growth of applications produced by business companies (IHO Publication C-17, 2017).

2.5 Hydrography by Satellites

Satellite imagery offers regular repeated coverage of the same area with advantages for examining improvements in diverse seabed areas or areas with little survey data and chart adequacy assessment and survey prioritization applications. Any of the multispectral satellite imagery is also publicly accessible at no cost (Jegat et al., 2016).

![Figure 9 Ship, air, and satellite survey coverage (Source: NOAA, 2017)](image)
Satellite Derivative Bathymetry (SDB) is the new method of surveying shallow waters, unlike other survey methods, no mobilization of individuals or equipment is needed, rapid access to bathymetric data is provided, and costs are saved. Satellite-Derived Bathymetry makes operations more reliable and decreases project risks in shallow water (EOMAP, 2020). SDB is a relatively new hydrographic technique that enables the development of nautical maps and bathymetric maps of shallow waters and coastal regions (Hydro, 2020). The greatest benefit is that a wide area is protected by relatively low investment in time and resources (See Figure 9).

2.6 The Use of Satellite-Derived Bathymetry SDB on Charts.

United Kingdom Hydrographic Office (UKHO) is working with Satellite-Derived Bathymetry (SDB) in chart production and update. Capt. R. Facey (Personal communications, June 16, 2020) has a discussion with C. Brice, who is in charge of the area covering Yemeni waters in the UKHO, mentioning that SDB is similar to the LIDAR used in planes for aerial surveys of water areas.

The effectiveness of SDB depends on the clarity of the water. It only works in clear waters (i.e., without turbidity) such as in the Caribbean and islands in the Indian Ocean. The positional accuracy of SDB is very good, while vertical accuracy is reasonable. This is in contrast with lead line surveys, where horizontal accuracy can be poor, but vertical measurement of the depths accurate. UKHO would not consider that SDB surveys can achieve Category A status, and probably it would be rated as a Category B survey (See Annex 1 - Zones of Confidence Categories Table).

However, if SDB results can be combined with the results of a survey carried out by a survey vessel, the overall results can be excellent. For example, if a survey is being conducted on Male Harbour in the Maldives, and SDB is used with 3-4 passes of a satellite to cover the whole of the Male atoll, then good results can be obtained because the SDB depths can be compared with those of the survey boat and adjusted. For example, if the SDB says that depth is 7.5m and the boat survey records 7.2m, SDB depths can be reduced by 0.3m across the SDB survey results to improve accuracy.
The other very useful application is in areas where there are clear water and coral heads close to the surface, where the survey boat operator does not want to risk striking the coral. SDB survey of the area can be used instead to record the depths over the coral heads.

Chart (2066) had been published with some SDB included. However, the majority of the area of SDB had been ground proved by HMS Protector (British Royal Navy’s Ice Patrol Ship), which was agreed as essential to assist with the validation of the SDB data. Even with the ground proving, there is a note on the chart highlighting the potential inaccuracy of the depths (see Figure. 10).

SDB is very useful in areas that would be very expensive to survey by other methods, and in areas that have not been surveyed for perhaps 150 years (when they were surveyed using lead lines). The U.K. Foreign and Commonwealth Office is interested in doing SDB surveys for some poorer countries where there are clear waters, as the survey costs are very low compared with ship surveys.

In April 2015, at the 11th meeting at the IHO, the U.K. sent a paper to the Chart and Standardization and Paper Chart Working Group (CSPCWG) for consideration. Satellite-Derived Bathymetry (SDB) determined by the UKHO is able to provide reliable information that can be used to make navigational products safer and more accurate. UKHO considered that good quality SDB data, when used properly, could provide reliable information that could be used to make safe navigational products. UKHO has been analyzing SDB accuracy and the most effective approach for representing SDB data on charts. The goal is to be able to control quality and use SDB data as the source data for navigation products. This will allow UKHO to use this technology in areas where there is a lack of modern survey data and where more traditional methods might be too difficult or not cost-effective. The SDB was developed in the late 1970s, but recent advancements in satellite technology have increased its potential as a source of hydrographic data, such as improved resolution and multispectral bands. The use of SDB data as a low-cost source of data is growing throughout the hydrographic industry.

According to UKHO submitted paper, SDB data can offer:
• Good coverage (within depth and image limitations); not as good as Multi-beam echo sounder (MBES), some objects may be missed, but better than single-beam echo sounders (SBES) and lead line.
• Better object detection than a lead line, but not as good as SBES used with side-scan sonar or a MBES.
• Good positional accuracy. Similar to MBES and SBES. Better than the historic lead line. Lesser depth accuracy than MBES, SBES, and lead line.

2.7 Conclusion

Hydrographic data forms the foundation for the building of a maritime data management system (Ponce, 2014). Hydrographic data has historically been used mostly for nautical charts. Hydrographic surveys are expensive, and data should be used beyond navigation. Data may be gathered once and used several times over. Technological developments in the processing of this knowledge give the world a better understanding of the environment.

Chapter 3 - The Role of Hydrographic Offices

3.1 National Hydrographic Services

National Hydrographic Services are usually the organizations with the best experience and knowledge to provide the appropriate baseline information from which to delineate maritime boundaries to determine the territorial areas of the coastal states of the world. The charts of national hydrographic service or the Organization for this information are known as the official source.

The coastal state hydrographic services or authorities make an important contribution to the national maritime infrastructure. They are promoting secure and effective navigation, fostering national maritime management, contributing to the safety of life and property at sea, encouraging the safety of the marine environment, and promoting the management and sustainable development of national maritime zones. The national hydrographic services also support maritime safety and national security.
Some coastal states’ hydrographic services are among the oldest government agencies, many of which were founded in the 18th Century. To date, they have made a major contribution to the growth of world trade. These services have been most effective in their task of improving trade protection and productivity so that they are most frequently taken for granted nowadays, as are other utilities. However, the maritime community is concerned that too few coastal states support hydrography at the national level, considering the fact that many parts of the world still lack sufficient nautical charts and support services. This poses a real and continuing danger to the safety of life at sea and to marine ecosystem well-being. In addition, many coastal state governments are not aware of the significant contribution that hydrography and nautical charting services can bring to their national economic growth. (IHO Publication M-2, 2018)

Investment in a national hydrographic service increases safety at sea, enhances marine environmental protection, and advances national growth. This means more effective and stable maritime transport, which leads to greater foreign and coastal trade. In addition to promoting maritime trade, hydrography underpins nearly every other marine-related activity, including navigational safety, marine environment protection, national infrastructure development, coastal zone management, marine exploration, marine resource extraction (minerals, fishing, etc.), maritime boundary delimitation, maritime defense, and coastal security.

About 50% of the coastal states have no hydrographic capabilities, according to a U.N. report. About 25% still have restricted capabilities. Only the remaining 25 percent have the adequate hydrographic capacity. (Vatsa. et al., 2009)

Therefore, there is enormous scope among the hydrographic offices to conserve/protect coastal regions and build and improve less developed spatial technologies. The Hydrographic Offices of the World are responsible for delivering vital services within the national transport networks to their maritime states. Hydrographic Services promote safer and productive navigation, encourage national maritime development, assist in the protection of marine life and property at sea, facilitate marine environment security and support the administration and sustainable development of national maritime areas.

According to IHO document C-51 (Manual on Technical Aspects of the U.N. Convention on the Law of the Sea), a hydrographic office plays these important roles which can be listed as follows:
1. To collect, with systematic surveys at sea and along the coast, georeferenced data related to:
   - Coastal configuration including man-made maritime navigation infrastructure (Navigation Aids and port configuration)
   - Sea depths in the national interest area (including all possible threats to navigation and other aquatic activities.
   - Composition of the sea bottom
   - Currents, tides
   - Physical properties of the water column
   - Gravity and Magnetic Observations at Sea

2. To process the collected information for the purpose of producing structured databases capable of feeding the development of thematic maps, nautical charts, and other forms of documentation for the most common uses in:
   - Maritime navigation (and traffic control)
   - Naval operations
   - Coastal management and defense
   - Marine environment preservation
   - Sea resource utilization and submarine cable/pipeline laying
   - Description of maritime borders (implementation of the Law of the Sea)
   - Sea-related and near-shore zone research studies

3. To update the databases by re-surveying additional information from other maritime authorities, when and where needed.

4. To ensure that charts and electronic navigational charts are produced, distributed, and updated.

3.2 The hydrographic survey by non-national agencies

In 1983, IMO Resolution A.532(13) adopted on November 17, 1983. The resolution invited Governments to conduct hydrographic surveys and co-operate with other Governments having little or no hydrographic capabilities where necessary.

States may, through bilateral agreements, co-operate with other States advanced in the field of hydrographic surveying in order to undertake, on their behalf, obligations relating
to the execution of hydrographic surveys, the development of charts, and the sharing of maritime safety information (IHO Publication M-2, 2018).

whether the national hydrographic service is a fully operating under government operation or dependent on bilateral agreements or certain levels of commercially contracted services, the national government will still be kept fully responsible for the results of the services rendered. This is because, under Chapter V of the SOLAS Convention, the provision of hydrographic services is an international responsibility.

In order to meet any or all of these foreign commitments themselves, several States do not yet have the necessary mechanisms and organization in place. For historical reasons, some countries (for example France, the Netherlands, Portugal, Spain, the United Kingdom, and the USA) have continued to play this role on behalf of now independent ex-territories or for countries where there is no hydrographic capacity. However, even under these conditions, any coastal state that is a signatory to SOLAS has the overriding duty to ensure that its waters receive a suitable service. This means that the coastal State must take some degree of active participation in hydrographic and MSI service provision (IHO Publication M-2, 2018).

3.3 The hydrographic survey by private organizations

Commercial organizations also carry out hydrographic and geophysical surveys on a large scale, particularly in the dredging, marine construction, oil exploration, and drilling industries.

There are commercial companies that can carry out hydrographic surveys that meet the mandatory IHO nautical charting requirements. These companies actively engage with a variety of national hydrographic services to carry out surveys on their behalf. Nevertheless, the National Hydrographic Service, representing the coastal State, also needs to have the adequate independent experience to determine the survey specifications and assess the contractor’s capacity and the results of the work it conducts.

A number of professional private companies have been established in recent years that offer to conduct both hydrographic surveys and the compilation of nautical charts. This has been taken advantage of by a steadily growing number of hydrographic departments in the IHO Member States, benefiting from private sector expertise through the
outsourcing of surveys and cartographic work. Advantages may include adding industry experience to the public sector, flexibility in program management, minimizing government spending in resources such as staff and training, and enhancing cost-effectiveness (better use of assets and lower costs). The national policy may depend on the decision on which options to adopt (IHO publication M-2, 2018).

3.4 Regional Hydrographic Commissions

The IHO promoted the establishment of Regional Hydrographic Commissions (RHCs). The RHCs cover the globe and operate at the regional level to help further the IHO’s work (See Figure.11). Regional Hydrographic Commissions allow to coordinate in:

- Nautical information.
- Hydrographic surveys.
- The production of nautical charts and documents.
- Technical cooperation.
- Hydrographic capacity building projects, including training and education.

(RHCs, 2020)

Figure 11 Regional Hydrographic Commissions (Source: IHO 2020)
Chapter 4 - The hydrographic survey in Yemen

4.1 Yemeni Waters

The Republic of Yemen is located in the south of the Arabian Peninsula in southwestern Asia. It is bordered to the north by Saudi Arabia and to the east by Oman. It has a southern coast on the Gulf of Aden and the Arabian Sea, and a western coast on the Red Sea (See Figure.12).

The coastline of Yemen is about 2,500 km long, the Gulf of Aden coastline measures 1,550 km from Bab el Mandab, extending eastward to the Oman border, the Red Sea coastline extends 650 km north from Bab el Mandab to the Saudi Arabia border. The Socotra Archipelago, located off the tip of the East African Horn, has a 320 km long coastline (Saeed shaher, 2007).

4.2 Ports in Yemen

Yemen has Ten ports, they are located in Yemen coast of the Red Sea, the Gulf of Aden, and the Arabian Sea,

Seven ports out of 10 are working at present because of the current ongoing conflict. LNG and major oil export operations are suspended since 2015. The summary of the ports in Yemen in following table no.1:
<table>
<thead>
<tr>
<th>Port</th>
<th>Location</th>
<th>Cargo Handling</th>
<th>Main port /Small port</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aden</td>
<td>Gulf of Aden</td>
<td>All types of Cargo</td>
<td>Main</td>
<td>Open</td>
</tr>
<tr>
<td>Hudaida</td>
<td>Red Sea</td>
<td>All types of Cargo</td>
<td>Main</td>
<td>Open</td>
</tr>
<tr>
<td>Mukalla</td>
<td>Arabian Sea</td>
<td>All types of Cargo</td>
<td>Main</td>
<td>Open</td>
</tr>
<tr>
<td>Salif</td>
<td>Red Sea</td>
<td>Dry Bulk</td>
<td>Small Port</td>
<td>Open</td>
</tr>
<tr>
<td>Ash Shihr</td>
<td>Arabian Sea</td>
<td>offshore oil terminal</td>
<td>Small Port</td>
<td>Open</td>
</tr>
<tr>
<td>Ras Isa</td>
<td>Red Sea</td>
<td>Oil</td>
<td>Small Port</td>
<td>Closed</td>
</tr>
<tr>
<td>Balhaf</td>
<td>Gulf of Aden</td>
<td>LNG</td>
<td>Small Port</td>
<td>Closed</td>
</tr>
<tr>
<td>Mokha</td>
<td>Red Sea</td>
<td>Dry Bulk</td>
<td>Small Port</td>
<td>Closed</td>
</tr>
<tr>
<td>Nishton</td>
<td>Arabian Sea</td>
<td>General Cargo</td>
<td>Small Port</td>
<td>Open</td>
</tr>
<tr>
<td>Socotra</td>
<td>Arabian Sea</td>
<td>General Cargo</td>
<td>Small Port</td>
<td>Open</td>
</tr>
</tbody>
</table>

*Table 1 Ports in Yemen*

Source: (Gard, 2020)

4.3 Importance of hydrographic survey in Yemen

Safe and effective navigation is an important prerequisite for the protection of the marine environment. Pollution caused by maritime collisions, wrecks, and oil spills is a major factor of damage, which also has devastating economic consequences. There have been various cases where the economic effects of a single incident have risen to billions of dollars. It is always better to function proactively rather than reactively.

As set out in UNCLOS, good hydrographic data is an important and fundamental prerequisite for maritime boundary delimitation. As the legal principles of maritime boundary delimitation are argued by negotiators, lawyers and judges, it is the hydrographers and the details that help make the nautical charts, based on the agreed legal principles, that specify the exact geographical position of a boundary.

Developing a National Hydrographic Service has a significant variety of benefits for Yemen. Sedimentary coastal and offshore areas may contain mineral deposits, particularly hydrocarbons. Typically, it needs sufficient surveys to confirm this. If the
presence of hydrocarbons or other mineral resources is confirmed, this may lead to the development of offshore production capacity for a coastal country. This, in turn, relies on hydrography to ensure safe navigation for dangerous cargo transportation, the safety of offshore platforms and associated sea-floor transmission systems, and the location and laying of pipelines for production wells. A National Hydrographic Service offers bathymetric, tidal, and other related data as a fundamental element in the growth of an offshore mineral or hydrocarbon industry.

The fisheries sector can be an essential source of national resources. Fishermen need hydrographic information to safely navigate, prevent the loss of fishing gear and fishing vessels on obstructions that are undetected or poorly charted, classify fishing areas by water depth, bottom type, and roughness, ocean and tidal currents, identify areas where fishing is restricted or prohibited. The new science of fisheries pays special attention to the conservation of ecosystems. Hydrographic data and other ocean data are important inputs for the management of ecosystems and organisms.

Navyes are the main users of nautical charting for surface, submarine, anti-submarine, mine-hunting, and air-sea naval operations. In order to ensure freedom of maneuver for warships, to understand where the Navy can operate, and equally importantly, where the enemy can operate, and to monitor marine space when appropriate, the chart coverage must be detailed and precise. A number of products used in naval operations are assisted by hydrographic data and information provided by national hydrographic services (IHO Publication M-2, 2018).

4.4 Hydrographic work in Yemen

At present, the Yemen Maritime Affairs Authority (YMAA) does not have any capacity to do surveys. There is an agreement between YMAA and UKHO to produce and update nautical charts and nautical publications within Yemen territorial waters. UKHO, YMAA, and Port of Aden are having correspondence continuously to share information related to charts and publications update. In case of a new survey needed, YMAA would allow coastal surveys to be done, and then they would allow data to be passed to UKHO, which is Yemen obligation under SOLAS chapter V.

The hydrographic survey can be done by a private company such as, for example, the extensive surveys for the Aden container terminal from 1997 to 1999, and then the
YMAA authorized the collected data to go to the UKHO. Because of course, they want the charts to be updated because the depth in the channel used to be 11 meters, and now it is 15 meters. So they had to update the channel’s depth and also the positions of the sides of the channel. The position of the boys, etc., that is an interests of the national authorities to make sure that charts are up-to-date because it also affects the insurance cost of ships.

It means UKHO does not conduct the survey. UKHO is publishing the information they get from YMAA. But UKHO may involve upon request, for example, in 2001 when Yemen did that large survey by a private company in the southern Red Sea from Bab Al Mandeb to the Hanish Islands using Single Beam Echo Sounder and Side Scan Sonar, in a contract with World Bank, YMAA asked UKHO to work as consultants to make sure that the data was correct. The total cost for surveying (750 square kilometers) in the Red Sea was about two million U.S. dollars. That’s about 2,600 dollars per square kilometer.

Some times UKHO or the French hydrographic office (SHOM) are doing survey work in the southern Red Sea; in such cases, if they want to do any survey work, they have to approach the Yemen Maritime Affairs Authority and ask for permission if it is in Yemen territorial waters. (R. Facey, Personal communications, 2020)

Chapter 5 - Case study of the hydrographic survey in Port of Aden

The Port of Aden is situated on the southern coast of Yemen, in the Gulf of Aden, approximately 95 nm east of the Bab al Mandeb Strait at the southern entrance to the Red Sea. The economy of the Port of Aden depends on its location as a commercial hub for the surrounding regions and a refueling stop for ocean-going vessels.
5.1 History of surveys in Port of Aden

The first complete survey of Port of Aden was undertaken by Captain Haines in 1835 (See Figure 13), using ships and rowing boats and hand lead lines to check the depth, a sextant, and compass for fixing position. Rowing boats from a ship were used to take the soundings, with a navigating officer in charge of each boat. All navigating officers were trained in survey methods and gained experience as ‘midshipmen’ in the Navy. Depths are in fathoms (6 feet). Positions would have been fixed by horizontal sextant angles and compass bearings. Many of the soundings are along straight lines (See Figure 14) as seen in Chart of Shuqra (1837) east of Aden which are common features to other charts from this period. Many surveys carried out later in Port of Aden generally for the purpose of development increasing the seabed depth. The last survey work was done in Port of Aden and Southern Red Sea in 2009, that was done by a private company using echo sounders carried on small boats (Capt. Roy Facey, personal communication, May 2020).
5.2 Responsibilities of port authorities

Regulation 13 of SOLAS Chapter V requires all coastal states to ensure that a sufficient number of navigational aids, such as floating, fixed, and electronic (floating lights, lighthouses), and radio-navigation systems, such as LORAN, GPS, DGPS, beacons, etc., are installed and maintained. The SOLAS Convention states that: Governments contracting to undertake to arrange for information to be made available to all concerned about navigational aids. Changes in the transmission of Position-fixing systems, which can adversely affect the output of receivers mounted in ships, shall be avoided to the extent possible and shall be effected only after prompt and sufficient notice has been given. The port authorities in any coastal State have important responsibilities, including:

- To have in place lights and buoyage in the best position for safe navigation,
- To have surveyed and found the best channel for entrance,
- To monitor periodically the relevant areas to observe changes in the sea-floor (such as sandbar migration and sedimentation) and to relocate the aids to navigation and to re-survey the area as required,
- To publish this information in a timely fashion.

5.3 Assessment of related IMO/IHO requirements for hydrographic office – Case of Port of Aden

The Government in Yemen faced many kinds of troubles during the last 20 years. The economy and security of the country have been badly affected. The maritime sector in Yemen received many hits from terrorism within Yemeni waters and ports, along with piracy in the Gulf of Aden.

At present, and because of the ongoing military conflict in Yemen since 2015, security is a major challenge. Finding a ship who wants to come and survey in Yemen at the moment will not be so easy, some other difficulties are presented even before the war in Yemen.

To evaluate the level of compliance in Yemen of IMO/SOLAS Chapter V and IHO recommendations for hydrographic office, 20 indicators were extracted from IHO
publications C-17 “Spatial Data Infrastructures” Guidance for Hydrographic Offices” and IHO Publication M-2 The Need for National Hydrographic Services. The indicators have been extracted from these two publications because IHO is the best source of standards for hydrography and the most experienced Organization in the field of hydrography, and it is in line with SOLAS Chapter v regulations.

The information about the status of hydrographic services in Yemen was obtained from Capt. R. Facey, who worked as Senior Adviser in Port of Aden and had extensive experience in the hydrographic survey in Yemen, And Eng. A. Alkhulaqui, Deputy Executive Chairman of Yemen Gulf of Aden Ports Corporation - Port of Aden.

The 20 indicators listed in a table (See Table.2), using points score from 0 to 5 for the quantitation process in order to calculate the percentage of compliance are entered in the below table:
<table>
<thead>
<tr>
<th>No</th>
<th>Indicator</th>
<th>Satisfactory 5 points</th>
<th>Fair 3 points</th>
<th>Poor 2 points</th>
<th>None 0 points</th>
<th>Remarks</th>
<th>Source of data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The appropriate governmental authority designated</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td>Maritime Affairs Authority (MAA)</td>
<td>Senior Adviser-Port of Aden</td>
</tr>
<tr>
<td>2</td>
<td>Maritime Safety Information (MSI) Service Broadcasting navigational and meteorological warnings, Search and Rescue information, and other urgent safety-related information.</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td>It is limited at present. The Port can and does respond to distress messages from ships and other sources, such as the Falmouth UK GMDSS Center. The Port expects that re-equipping of its Control Tower with new VTMIS and radio equipment will be completed by the end 2020</td>
<td>Senior Adviser-Port of Aden</td>
</tr>
<tr>
<td>3</td>
<td>Conduct new hydrographic surveys</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>The Port has a hydrographic survey boat</td>
<td>Senior Adviser-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>but limited capacity to use this – training needed</td>
<td>Port of Aden</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Periodical re-surveys</td>
<td>2</td>
<td>Limited, but pilots monitor water depths on ships’ echo sounder arriving and leaving Port</td>
<td>Senior Adviser-Port of Aden</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>The survey in the coastal area where the needs are usually very pressing</td>
<td>2</td>
<td>Not carried out by the Port at present</td>
<td>Senior Adviser-Port of Aden</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Surveys to assure port access and to confirm hazards</td>
<td>2</td>
<td>See Item 4 above</td>
<td>Senior Adviser-Port of Aden</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Qualified personnel</td>
<td>2</td>
<td>Training of younger hydrographic personnel to use the survey boat is urgently required due to the retirement of older qualified staff</td>
<td>Senior Adviser-Port of Aden</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Logistics (buildings, fleet management, communications, funding, etc.)</td>
<td>2</td>
<td>Limited by funding shortages as the Port has much priority</td>
<td>Senior Adviser-Port of Aden</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td></td>
<td></td>
<td>Works to deal with</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>---</td>
<td>-----------------------------------------------------------------------------</td>
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<td>----------------------------------------------------------------------------------</td>
<td>---</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Data management</td>
<td>2</td>
<td>Not formalized at present, but can be addressed</td>
<td>Senior Adviser-Port of Aden</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Organizing the collection and circulation of nautical information, required to maintain and update existing charts and publication</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Charts update</td>
<td>0</td>
<td>Port of Aden normally responds promptly to requests from UKHO for data needed to update charts but has no capacity to do this itself</td>
<td>Senior Adviser-Port of Aden</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Nautical publications update</td>
<td>0</td>
<td>See Item 10</td>
<td>Senior Adviser-Port of Aden</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Chart Production</td>
<td>0</td>
<td>None</td>
<td>Senior Adviser-Port of Aden</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The ability to produce and maintain charts independently.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>The production of nautical publications</td>
<td>0</td>
<td>None</td>
<td>Senior Adviser-Port of Aden</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The ability to produce nautical independently.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Chart Distribution Arrangements</td>
<td>5</td>
<td>Ships on regular calls to</td>
<td>Senior Adviser-Port of Aden</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Aden, such as container feeder vessels, regularly order and receive charts and other UKHO publications through a local ships’ agency (Al Mansoob)</td>
<td>Port of Aden</td>
<td></td>
<td></td>
<td></td>
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<td>---</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Training of Hydrographic Personnel</td>
<td></td>
<td>0</td>
<td>Limited training conducted when the hydrographic survey boat was delivered, but this was not sufficient</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Senior Adviser- Port of Aden</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Training of Cartographic Personnel</td>
<td></td>
<td>0</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Senior Adviser- Port of Aden</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Aids to Navigation (Buoys) in the best position for safe navigation</td>
<td>3</td>
<td>This was done back in 1996/7 when Aden Container Terminal (ACT) was being designed</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Deputy Executive Chairman- Port of Aden</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Port Surveyed and found the best channel for entrance</td>
<td>3</td>
<td>Since Aden port was established, the entrance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Deputy Executive Chairman-</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 2: Assessment of Hydrographic services in Yemen

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Description</th>
<th>Score</th>
<th>Comments</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Port Periodically observe changes in the sea-floor (such as sandbar migration and sedimentation) and to relocate the aids to navigation (Buoys) and to re-survey the area as required</td>
<td>0</td>
<td>We procured a state-of-the-art survey boat yet to be commissioned to do this job</td>
<td>Deputy Executive Chairman-Port of Aden</td>
</tr>
<tr>
<td>20</td>
<td>Publish Survey information in a timely fashion</td>
<td>2</td>
<td>We do get in touch with UKHO but rather late</td>
<td>Deputy Executive Chairman-Port of Aden</td>
</tr>
</tbody>
</table>

**Total of 20 Indicators**

| Score | 10 | 6 | 18 | 0 |

**Total points**

"Maximum is 20 x 5 = 100 points"

\[ 10 + 6 + 18 + 0 = 34 \]

The evaluation score is 34 out of 100 points, Therefore, quantification of the level of compliance = **34%**

**Analysis of the evaluation:**

- From the above quantitation, the result calculated was **34%**, which indicates a very weak overall performance of the hydrographic services.
The absence of chart/nautical publications production independently can be considered as acceptable as long as there is an agreement with UKHO to do the job on behalf of Yemen. (See paragraphs 3.2 and 4.4 above)

The evaluation shows only “satisfactory” performance in only two indicators, which are number 1 Appropriate governmental authority designated, which is YMAA, and number 14 Chart Distribution Arrangements, which is done by a local shipping agent (private sector) in the city of Aden.

Maritime safety information and chart update and survey information reporting are very weak; these function is mandatory obligations under SOLAS chapter V and should be in a timely fashion.

Overall survey capacity is too weak, as well as data management and logistics.

Only two “fair” indicators reported, channel entrance (which is very old) and navigational aids in place (which is also old, 1998).

Training, the qualified personnel, and training on hydrography are absent in Yemen.

The status of hydrographic services in Yemen needs to be reconsidered, there is weakness in mandatory SOLAS requirements which should be the responsibility of IMO member state itself, such as broadcasting MSI, and port periodical survey to check of sandbar migration and sedimentation and reallocate the aids to navigation accordingly.

Yemen needs to improve its capacity in hydrographic service, and the first step for this goal is to be a member of IHO.

Chapter 6 - Recommendations

6.1 Improving Yemen capacity to meet membership requirements at IHO

The ongoing military conflict in Yemen has destroyed and/or affected directly and indirectly most of Yemen Maritime administrative and infrastructures and capabilities. It should be kept in mind that one day, Yemen, will be able to recover and start up again.

Currently, there is a general opinion from Yemeni maritime specialists that the infrastructure of the maritime authority is either weak or non-existent. This is also the
opinion of one of the leaders in Yemen Maritime Authority. Therefore it is best to study and introduce the recommended practice for creating a national hydrographic office, and the best source for such practice is from the IHO, which is the most experienced organization in the world when it comes to hydrography. Some publications issued by IHO contain guidelines for establishing hydrographic services, such as (IHO publication M-2 The need for national hydrographic services. International Hydrographic Organization), which is the best source to start with.

6.2 The Creation of a National Hydrographic Service

Due to economic factors, a shortage of qualified manpower, hydrographic equipment, and other essential prerequisites, national hydrographic service cannot be established immediately. It is typically the result of a project of technical cooperation, either within the framework of international organizations involved, such as the IHO, the IMO or the United Nations or through bilateral agreements between States, in the form of the development of an aid protocol. The first step is the preparation of a Technical Report on Status. The report should provide a summary of the current hydrographic situation in the State. It will include, among other information items, basic statistics such as the length of the coastline, the number of primary and secondary ports, the number of current national waters maps, current navigation aids, the date of the latest hydrographic surveys conducted, and details of those organizations (if any) conducting hydrographic activities in the region. It should also determine the perceived State hydrographic conditions present and potential.

The details provided in the status report will then form the basis upon which an Establishment Project can be published. This, in turn, would describe the different areas of work that should be carried out by national hydrographic service, and what differences exist between the work to be done and the means available for doing so. The development of a National Hydrographic Service is usually achieved in three phases:

Phase 1. The most urgent but simplest to execute is the first step. It involves organizing the compilation and circulation of nautical information, which is necessary to maintain and update existing charts and publications. This process puts all of the organizations involved in maritime activities together. It offers an immediate advantage to foreign shipping and enables a coastal state to be incorporated into the World Navigational Warning Service (WNWS).
Phase 2. The second step is the development of a hydrographic survey capability; first, to survey in the coastal region where the needs are generally very demanding. Generally, a relatively small organization is enough to collect the data needed for most coastal projects; for example, to undertake surveys to ensure port access or to identify hazards and to locate navigational aids accurately. Transferring the information from these surveys through charts and nautical publications by bilateral agreements can also be best done by the historical charting authority.

Phase 3. The third step includes the capacity to independently produce and retain charts and publications. This process cannot be completed easily, but through close collaboration with the historical charting authority, which is UKHO in the Yemen case, it can be made much more accessible. This stage requires not only sufficient human and financial resources but also the capacity to maintain the charts and publications and to deliver the nautical publications and charts to the end-users through a distribution network. Because of scale, economic conditions, or other objectives, this degree of capability might not be feasible for some states. Near liaison and cooperation with a bilateral partner are needed in such cases.

An appropriate governmental authority shall be appointed to be responsible for the proper provision of the hydrographic services, and any national hydrographic service shall report. The organizational structure, including positions and salaries, and the positions resulting from that structure, must be approved by this authority. In certain nations, the National Hydrographic Service is part of the State Navy because of the advantage of providing ample maritime knowledge to personnel to specialize in hydrography. The prospect of operating and sustaining seagoing ships is another significant consideration. Alternatively, it was considered useful for other nations, within the context of the Ministries of Transport or Fisheries or the Port Authority or as part of the Ministry responsible for infrastructure, land surveying, and/or the environment, to improve their hydrographic services. It is also essential to determine the required level of logistics (building, communications, etc.) and to ensure that there is an efficient and reliable long-term financing strategy.
6.3 Training of Hydrographic and Cartographic Personnel

Training is necessary for every newly formed national hydrographic service, whose best approach is to send employees to training and educational programs (such as those recognized by the FIG / IHO / ICA International Board on Standards of Competence), and then contract the services of an experienced hydrographic surveyor to supervise the early stages of the fledgling service.

Training should be in line with IHO publications S-5A and S-5B-Competence Standards for Category “A” and Category “B” Hydrographic Surveyors and S-8A and S-8B-Competency Standards for Category “A” and Category “B” Nautical Cartographers.

- Training centers

A list of hydrography/Cartography educational centers in 30 countries worldwide are listed in “IHO Publication C-47, Training Courses In Hydrography And Nautical Cartography” the study period varies from approximately three months to 4 years depending on the level of qualification and category of certificate required. It is strongly recommended for Yemen to send employees from YMAA and Yemeni ports to these centers, preferable employees with a maritime background such as Arab Maritime Academy graduates.

6.4 Use of low-price modern survey techniques (Satellite services)

- Satellite Imagery

The Earth as a whole is viewed by satellites, gathering data without regard to political restrictions. Very High Resolution (VHR) satellite imagery is rapidly becoming a standard tool in an ever-changing and unpredictable environment for potential forecasting threats, tracking development outcomes, and mitigating risk at all levels of government. As such, more information now needs to be given to policymakers than ever before, and this information is generally time-critical. Satellites provide us with much more knowledge by

Figure 15 Satellite image of Taranto Port, Italy (Source: Geocento 2020)
remotely sensing from their orbits well above the Earth than it would be possible to collect from the ground instead. (Zevenbergen, 2019)

Very High-Resolution satellite images, in particular, provide a unique view of what exists in, on, and around our oceans, seas, and coastlines. They offer a cost-effective and easy way of monitoring large areas across maritime zones globally, and are invaluable tool for managing activities and events affecting maritime safety, security, and sustainability (See Figure.16 for satellite view example of a Port). Anyone can gain insights into ocean bathymetry, ocean color, marine habitats, vessel detection, pollution control, or the updates of navigational charts from this data.

- **Cost of Satellite Imagery**

The cost of imagery is varied depending on the resolution required. See below the example of one of the satellite imagery providers.

<table>
<thead>
<tr>
<th>Resolution</th>
<th>VERY HIGH</th>
<th>HIGH</th>
<th>MEDIUM</th>
<th>LOW</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td>Satellite imagery</td>
<td>Satellite imagery</td>
<td>Satellite imagery</td>
<td>Satellite imagery</td>
</tr>
<tr>
<td><strong>Price per Km²</strong></td>
<td>From $15 per Km²</td>
<td>From $8 per Km²</td>
<td>From $1.42 per Km²</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Minimum Order</strong></td>
<td>From $900</td>
<td>From $800</td>
<td>From $710</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Source: Geocento.com (2020)

- **Satellite Derived Bathymetry (SDB)**

Satellite-Derived Bathymetry (SDB) describes the shallow water bathymetry information using satellite sensors, which record the reflected sunlight of the earth/sea-floor. It allows for mapping and detect the changes in shallow water regions in regular basis, to quantify depth and classify marine habitats. SDB offers various uses, including coastal planning, as input for hydrodynamic modeling or even to update nautical charts and to assess at-risk properties or infrastructure. Using satellite imagery to derive information on the location and depth of shoal complexes and sandbanks is essential to fill these data gaps.
for the shallow water zone, which is the water depth of most significant importance for navigation.

Satellite-derived bathymetry (SDB) is the new method of the survey of shallow waters. Unlike other survey methods, no mobilization of individuals or equipment is needed, rapid access to bathymetric data is provided, and costs are saved. Satellite-Derived Bathymetry makes operations more efficient and reduces project risks in shallow water. Since the 1990s, EOMAP has developed SDB algorithms and applied physics-based, quantitative solutions to transform satellite sensor data collected into bathymetric data used in recent nautical charts, hydrodynamic operational models, and coastal zone management plans. (EOMAP, 2020)

EOMAP offer SDB data in up to very high (1-2 m) spatial resolutions/grid spacing. Turnaround times range from hours (using EOMAP’s bathymetric archives) to a few weeks. Depending on project location and size, EOMAP’s Satellite-Derived Bathymetric data have been used by U.K. and N.Z. charting authorities (typically the national hydrographic office) to update charts in the Caribbean and Pacific.

- **Cost and functionality of Satellite Bathymetry**

For information about the cost of a bathymetric survey using satellite, K. Hartmann from EOMAP (personal communication, September 18, 2020) has estimated the cost of SDB mapping for the entire chart (See figure.17), which is about 150 sq km of shallow waters. EOMAP charge around 14-20 K Euros in 1-2m spatial resolution or 6-9 K Euros if 10m spatial resolution is used, this includes the costs for the commercial satellite image license costs, and turn around is just a couple of days.

However, especially for the use of map and monitor ports and marinas, K. Hartmann advised that to get the perfect match of prices and accuracies, it is recommended to combine SDB with SBES/MBES; this can also be done with an autonomous vehicle; EOMAP works on this solution with an unmanned maritime vehicles company (Syrius project, co-funded by The European Space Agency ESA)
The same applies to use SDB methods using aerial cameras (airborne or drone), which is another way of surveying shallow waters in a much cheaper way than other survey works. It is also a topic of current research in EOMAP. Additionally, considering SDB is not just about data costs. EOMAP offers a software solution that easily allows port and harbor authorities to perform high-quality SDB work - and the combination with acoustic data to do in-house as this solution will be even cheaper when calculate the sq/km costs.

6.5 Donor Agencies

As mentioned in Paragraph 1.4, Yemen is categorized as one of the Least Developed Countries LDCs, Yemen is Oil export dependent country, and since the starting of the ongoing war since 2015, because of the war, the oil export is suspended till moment as well as an extreme damage to the economy. It is known that the government of Yemen is running the country now by very limited income and donor funding in most of the public services. The maritime industry is an essential source of national income, and it is important for this sector to be rebuilt and recovered, Therefor the government of Yemen may consider funding for hydrographic projects which can be obtained from the following donors:

- United Nations (U.N.), World Bank, and Global Environment Facility (GEF)

Projects in developing countries are being considered by the U.N. Development Programme (UNDP) and the Environment Programme (UNEP). Through its U.N. permanent representative or a U.N. regional office, a government planning to set up a national hydrographic service may approach the United Nations. The IHO will facilitate the identification and mobilization of the technical competencies required for the implementation of the project. The kind of assistance available from the U.N. includes consulting services, equipment supply, staff training scholarships, other technical assistance programs, and the Small Grants Programme.

- European Commission

The European Commission can accept regional programs, jointly proposed by two or more countries, for funding under some of the support programs developed for the development of maritime sectors in developing areas. Generally, since hydrographic projects are typically relatively limited in scale, it is recommended that these programs be included in a larger project, such as coastal defense, fisheries, maritime transport.
• Others


USAID - U.S. Agency for International Development. USAID has been the main U.S. agency to provide aid to disaster-recovering nations, seeking to escape poverty, and engaged in democratic reform.

GTZ - Deutsche Gesellschaft fuer Technische Zusammenarbeit. The GTZ is the German Government Department responsible for the Organization and management of all government-funded projects.

NORAD - Norwegian Agency for Development Cooperation. The management of the bilateral portion of this cooperation is the responsibility of the planning and executive body for Norway’s cooperation with developing countries. The geographic areas within which Norwegian bilateral development assistance has been concentrated in recent years are eleven program countries and three regions.

CFTC - The Commonwealth Fund for Technical Cooperation. Has a good reputation for prompt financing of smaller technological projects.

Chapter 7 - Conclusion

The maritime industry is expected to be effective and safe, insufficiently chartered areas and lack of reliable information can cause sailing to be longer than necessary. It can prevent optimum loading of ships, thereby increasing operating costs. Time and cost-savings arising from the use of shorter and deeper routes and the possibility of using larger and deeper ships creating substantial economies for national trade and industry. (IHO publication M-2, 2018).

National Hydrographic Service already exists in several coastal states. Some other Governments may not yet have recognized the benefits to be gained by promoting such a standard of capacity in other countries, however. Governments may also be unaware
of the international obligations to ensure that their waters have sufficient standards of hydrographic and nautical charting services in place. (IHO Publication M-2, 2018)

Yemen government should consider the benefits of membership in IHO, such as technical/advisory assesses and visits, training at no or low cost to enhance the capacity building and Coordination at the regional level RHCs. See annex 2 for more details about the membership procedures and benefits.

Satellite-derived mapping tools and software solutions can map vertical and horizontal changes of shallow water sandbanks. Costs of a bathymetry survey depend on a set of parameters (total area, satellite source), but it’s typically around 1% of acoustic survey work and 5-20% of Airborne Lidar Bathymetry. (K. Hartmann, personal communication, September 18, 2020). It is clear that such cheap modern satellite services are considered as a good option for poor a country, especially when there is a lack of equipment/personnel and difficulties in performing traditional survey techniques in ports or in territorial waters.

Having satellites imagery, SDB and modern survey services at a reasonable price in hand will provide not only essential hydrographic data, additionally, it will also create a better “vision” for decision-makers in port operations, planning and development, coastal management, environmental monitoring, and much more marine-related researches which will make a foundation for building national hydrographic office.

To improve Yemen's hydrographic service capacity, IHO membership will help Yemen government to train personnel, which is the crucial factor for achieving this goal. YMAA and Port authorities in Yemen should recognize that without the qualified human element, nothing will be achieved. Rebuilding of Yemen hydrographic services capability is obviously needed, and IHO membership is the best way to start.
Chapter 8 - References


IMO Resolution A.64 (III) of the IMO Assembly 1963, Section IV, paragraph 18(d) retrieved from: http://www.imo.org/en/KnowledgeCentre/indexofIMOResolutions/Assembly/Documents/A.64(3).pdf


Zones of Confidence (ZOC) Table

Cartographers use Category Zone of Confidence (CATZOC) values to highlight the accuracy of data presented on charts. The following table outlines the position accuracy, depth accuracy and seafloor coverage for each ZOC value to help you manage the level of risk when navigating in a particular geographic area. The information and values used in this table has been taken from the IHO’s Regulations of the IHO for International Charts and chart specifications of the IHO white paper.

<table>
<thead>
<tr>
<th>ZOC</th>
<th>Position Accuracy</th>
<th>Depth Accuracy</th>
<th>Seafloor Coverage</th>
<th>Typical Survey Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>± 5 m + 5% depth</td>
<td>±0.50 + 1%d</td>
<td>Full area search undertaken. Significant seafloor features detected and depths measured.</td>
<td>Controlled, systematic survey high position and depth accuracy achieved using DGPS or a minimum three high quality lines of position (LOP) and a multibeam, channel or mechanical sweep system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Depth (m)</td>
<td>Accuracy (m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>± 0.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>± 0.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>± 1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>± 10.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>± 20 m</td>
<td>± 1.00 + 2%d</td>
<td>Full area search undertaken. Significant seafloor features detected and depths measured.</td>
<td>Controlled, systematic survey achieving position and depth accuracy less than ZOC A1 and using a modern survey echosounder and a sonar or mechanical sweep system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Depth (m)</td>
<td>Accuracy (m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>± 1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>± 1.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>± 3.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>± 21.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>± 50 m</td>
<td>± 1.00 + 2%d</td>
<td>Full area search not achieved; uncharted features, hazardous to surface navigation are not expected but may exist.</td>
<td>Controlled, systematic survey achieving similar depth but lesser position accuracies than ZOC A2, using a modern survey echosounder, but no sonar or mechanical sweep system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Depth (m)</td>
<td>Accuracy (m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>± 1.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>± 1.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>± 3.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>± 21.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>± 500 m</td>
<td>± 2.00 + 5%d</td>
<td>Full area search not achieved, depth anomalies may be expected.</td>
<td>Low accuracy survey or data collected on an opportunity basis such as soundings on passage.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Depth (m)</td>
<td>Accuracy (m)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>± 2.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>± 3.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>± 7.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>± 52.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Worse than ZOC C</td>
<td>Worse than ZOC C</td>
<td>Full search not achieved; large depth anomalies expected.</td>
<td>Poor quality data or data that cannot be quality assessed due to lack of information.</td>
</tr>
<tr>
<td>U</td>
<td>Unassessed</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Explanatory notes quoted in the table:

1. The allocation of a ZOC indicates that particular data meets minimum criteria for position and depth accuracy and seafloor coverage defined in this Table. ZOC categories reflect a charting standard and not just a hydrographic survey standard. Depth and position accuracies specified for each ZOC category refer to the errors of the final depicted soundings and include not only survey errors but also other errors introduced in the chart production process. [Note: the rest of footnote 1 does not apply to paper charts and is therefore omitted from 5-4].

2. Position Accuracy of depicted soundings at 95% CI (2.45 sigma) with respect to the given datum. It is the cumulative error and includes survey, transformation and digitizing errors etc. Position accuracy need not be rigorously computed for ZOCs B, C and D but may be estimated based on type of equipment, calibration regime, historical accuracy etc.

3. Depth accuracy of depicted soundings = a + (bxd)/1 00 at 95% CI (2.00 sigma), where d = depth in metres at the critical depth. Depth accuracy need not be rigorously computed for ZOCs B, C and D but may be estimated based on type of equipment, calibration regime, historical accuracy etc.

4. Significant seafloor features are defined as those rising above depicted depths by more than:
   Depth Significant Feature a. <40 m b. >40 m 10% depth A full seafloor search indicates that a systematic survey was conducted using detection systems, depth measurement systems, procedures, and trained personnel designed to detect and measure depths on significant seafloor features. Significant features are included on the chart as scale allows. It is impossible to guarantee that no significant feature could remain undetected, and significant features may have become present in the area since the time of the survey.

5. Typical Survey Characteristics – These descriptions should be seen as indicative examples only.
   6. Controlled, systematic surveys (ZOC A1, A2 and B) - surveys comprising planned survey lines, on a geodetic datum that can be transformed to WGS 84. 7 Modern survey echosounder - a high precision single beam depth measuring equipment, generally including all survey echosounders designed post 1970.
Annex - 2

IHO Membership Procedures

From IHO Publication M-2

Membership of the International Hydrographic Organization is open to all States. States join the IHO by acceding to the intergovernmental Convention on the IHO as amended. The Government of the Principality of Monaco is the Depositary Government for the Convention on the IHO.

Applications by Member States of the United Nations

Governments of States that are Member States of the United Nations may join the IHO by submitting a Letter of Accession to the Convention on the IHO through diplomatic channels, to the Government of the Principality of Monaco.

A Note verbale for a Member State of the United Nations to submit its letter of accession to the Convention on the IHO. The application should indicate the tonnage of the State’s registered (flag) fleet. The tonnage figure is obtained by adding 6/7 of the displacement tonnage of warships of greater than 100 tons to the gross tonnage of all other vessels greater than 100 tons.

The Department of External Relations and Cooperation of the Government of Monaco, upon receipt of the application, will notify all IHO Member Governments.

Date of Joining the IHO

The State of an acceding Government becomes a Party to the Convention on the IHO and thereby a Member State of the IHO on the date on which its letter of accession is received by the Government of Monaco. If this is during the first six months of the year (before June 30) the full financial contribution for the current year is due. If accession takes place in the second half of the year (between July 1 and December 31) half the current year’s financial contribution is due.

Annual Financial Contribution

Annual financial contributions to the Organization are based upon the shipping tonnages of Member States. These contributions vary between 2 and 27 shares, according to the shipping tonnages of Governments. The table of tonnages and shares is contained in Annex 3 of IHO Publication M-2. The value of a share is decided at every session of the IHO Assembly and can be obtained from the IHO Secretariat. In 2018, the value of one share is 4,024,32€.

Benefits of Membership

Capacity Building by Training. IHO membership provides access to significant training opportunities. Most are at no or minimal cost to the participating
Organization. The full IHO Capacity Building Work Programme (CBWP) for each year is available on the IHO web site.

**Technical Visits and Advice.** Developing IHO Member States, including non-member States, can request a team of experts in a particular discipline to pay an in-country visit. Such a technical/advisory assesses the current situation and propose appropriate solutions for improvement for the respective national hydrographic capacity. For the case of a potential accession the nominated experts may undertake an in-depth evaluation and propose suitable IHO instruments for improvement.

**Regional Coordination.** Coordination at the regional level is achieved through Regional Hydrographic Commissions (RHC). After joining the IHO, the new Member State would automatically become a full member of the relevant RHC, subject the Statues of the RHCs. As such, it would have voting rights and the right to seek to Chair the relevant Commission. Details of the Regional Hydrographic Commissions (RHC) are available on the IHO web site.

**IHO Assembly.** Member States have full voting and rights of participation at the IHO Assembly that is held every three years. In addition to approving the strategy, budget and programme of the IHO, the Assembly elects the Secretary-General and Directors of the IHO.

In addition to their participation and voting rights at the Assembly, Member States of the IHO have a right to participate in all the subordinate bodies of the Organization. Details of the activities of all the IHO Committees, Sub-Committees and Working Groups is available on the IHO web site.
**IHO Council.** Thirty Member States occupy seats on the IHO Council. The Council is appointed by the Assembly coordinate the activities of the Organization during the Inter-Assembly period.

More information: [https://iho.int/en/become-a-member-state](https://iho.int/en/become-a-member-state)