

**THE INTERNATIONAL HYDROGRAPHIC ORGANISATION EFFORT
ON THE NEED TO PROMOTE NATIONAL AND
INTERNATIONAL AWARENESS TO CONSTITUTE
ADEQUATE NATIONAL HYDROGRAPHIC SERVICES
ABLE TO PROVIDE RELIABLE NAUTICAL CHARTS
TO THE MARINERS AND TO THE ADMINISTRATORS**

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ABSTRACT

*The International Hydrographic Organisation (IHO) approved in March 2000 its new strategic plan. One of the most important strategic issues listed in that plan is **achievement of an adequate global hydrographic data coverage**.*

As known the quality of the hydrographic data is reported on each nautical chart (paper and electronic) in diagrams which show, for each zone represented on that particular chart, the degree of confidence of the information provided.

In particular for the electronic charts, the IHO has approved a data exchange standard format (S-57) which prescribes that the Hydrographic Office identifies on the chart, the so-called zones of confidence (ZOC). This is essential information for all users and in particular for the mariners.

The IHO is aware that in many sea areas of the world the hydrographic survey data (at present available to the cartographers) is not of the quality requested by the modern standards and in some cases the information displayed on the charts is more than one century old. This is due to many reasons: the non existence of a national hydrographic service in several coastal states, the in-adequacy of funds for the existing hydrographic service and the non awareness of some governments and institutions about the necessity to explore and chart the seas under their responsibility.

The IHO has therefore initiated a series of actions aimed at promoting the constitution of the hydrographic services (in the maritime nations where those services do not yet exist) and/or their reinforcement. We hope that those actions may accelerate the process of providing more reliable charts worldwide and also adequate geographic information to support activities at sea.

The IHO has elaborated a comprehensive situation of the hydrographic services world-wide and has initiated actions towards the International Organisations like the United Nations (and its agencies), the European Union, the Asia Development Bank, and towards the national donor institutions (like NORAD, JICA, Italian MOFA etc.)

The paper illustrates the actions carried out and the intentions for the future.

1. The International Hydrographic Organisation's strategy

The IHO is an intergovernmental organisation established in 1921 that brings about:

- The coordination of the activities of the national hydrographic services.
- The maximum possible uniformity of nautical charts
- The effective and reliable methods for carrying out hydrographic surveys.
- The development of the hydrographic science and of descriptive oceanography.

The present situation of the IHO member states is displayed in the picture below:

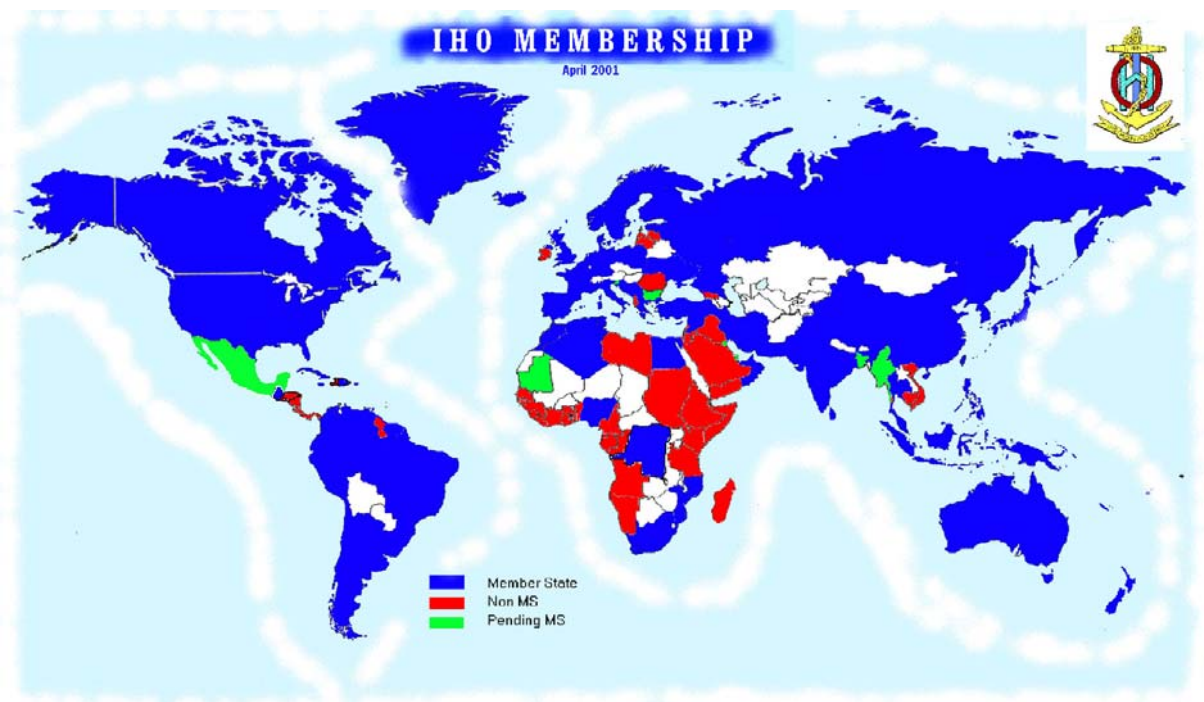


Figure 1: the situation of the IHO Member States at April 2001

In the year 2000 the IHO approved its Strategic Plan and the associated Work Programme.

The Strategic Plan is based on the following main strategic issues:

- *Achievement of global coverage of reliable hydrographic data*
- *Capacity building*
- *Provide services other than for navigation*
- *Transition to the digital era*
- *Responding to the external environment*
- *Achievement of adequate funding*

It is evident that of the six above-mentioned strategic issues the first one is the most important: without data, cartographic and GIS products can not be provided.

But hydrographic data, even if referred to an environment that changes less rapidly than the terrestrial one, is not easy to achieve. An authoritative representative of the UK Hydrographic Office, when addressing the hydrographic issue to the attendees of the ICA Conference that was held in Stresa Italy in 1969, said:

*“For evaluating the difficulties of the hydrographic labour you should consider the fact that we hydrographers are **blind**. We can **only hear** the echo of an ultra sonic pulse reflected by the bottom or by something else, which was hit by that pulse.”*

Nowadays the situation is not very much different from the one described in Stresa: the basic principle of the hydrographic survey operation still resides on the measurement of the time interval between the emission of a pulse and the first return-echo of it. The pulse may be emitted by sophisticated acoustic transducers, that now can sweep an area instead of a line (multi-beam technique), or it may be a *laser* pulse that can also explore an area and may be mounted on an aircraft (fixed or rotating wing). This latter technique which is dependent from the transparency of the waters, may penetrate to a maximum depth of 60m and is much faster than the echosounder, hull mounted on a ship. The two techniques can be used in combination thus reducing the survey time. Figure below illustrates the present practice to collect and use hydrographic data.

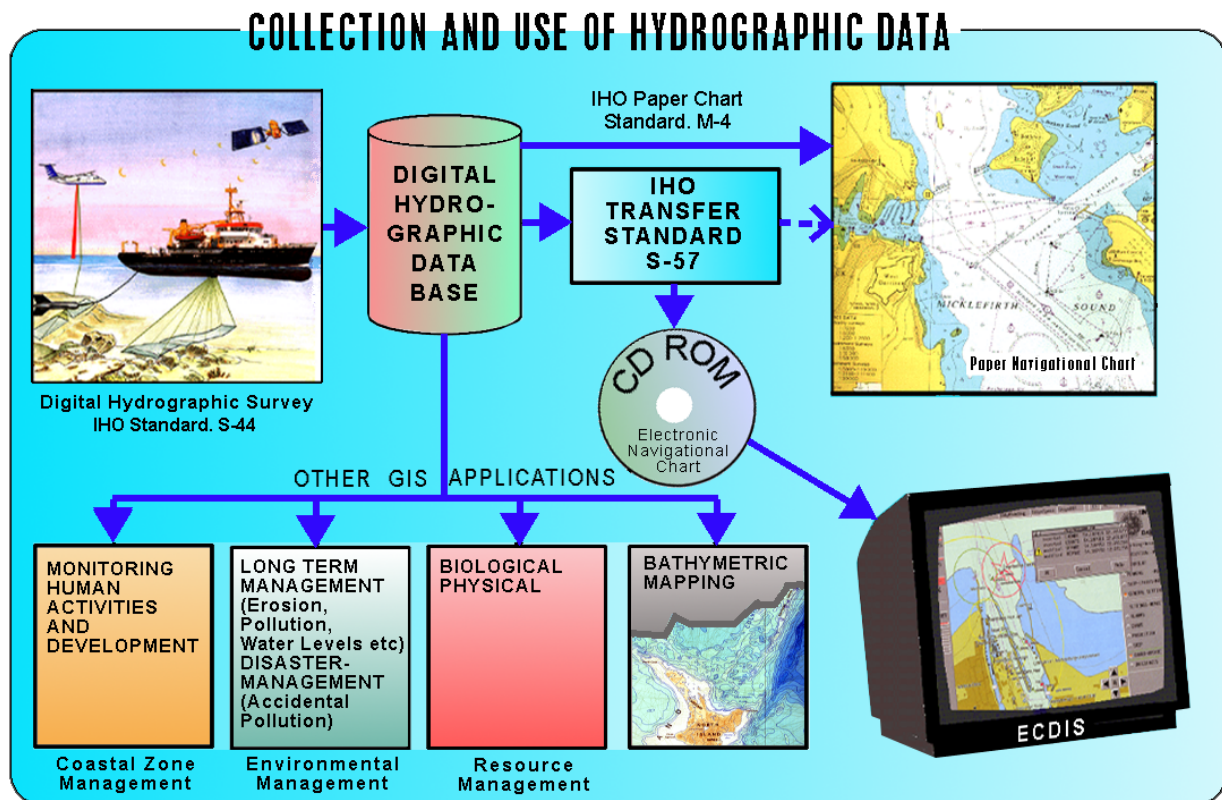


Figure 2: present status of the collection and use of the hydrographic data

But if we want to cover all the navigable waters worldwide with this type of reliable data, the task is immense because in many areas of the world we are far from this ideal result. Do we really have to make this effort? Why do we not simply explore the immediate vicinities of the ports, put only that information on the nautical chart and leave blank the rest of the sea area with the warning inscription: *hic sunt leones?* (*here are lions*).

The reasons why we can not do this are obvious and well rooted in the history of navigation and of the scientific explorations, which led to the necessity of carrying out hydrographic surveys and nautical charting. The desire of the human kind to know, and in particular to explore the globe by navigating the seas, is well expressed by the Italian Poet Dante Alighieri in the Divine Comedy when Ulysses, addressing to his frightened crew, says:

*Considerate la vostra semenza
Fatti non foste a viver come bruti
ma per seguir virtute e conoscenza*

(Inferno Canto XXVI 118- 120).

Translation:

*Consider ye the seed from which ye sprang;
Ye were not made to live like unto brutes,
But for pursuit of virtue and of knowledge*

This brief quotation is one of the possible examples of the necessity of the human kind to know the sea and we hydrographers have been doing this for a long time.

But this necessity had never been clearly inserted into the international conventions until presently.

In fact the International Hydrographic Organisation, only recently, was able to propose to the United Nations and to the International Maritime Organisation recommendations that are now inserted into the appropriate UN resolutions and IMO regulations thus constituting respectively a clear indication and a contracting obligation for the coastal states.

2. The obligations of the coastal states

Until 1998 there was not, in the international conventions, any statement by which a coastal state could be considered responsible to provide hydrographic services.

As a first step the IHO promoted the following paragraph (21) that was inserted in the resolution 32 of the 53rd United Nation Assembly:

UN Assembly Resolution A/53/32 (1998)
Paragraph 21

(The Assembly) Invites States to co-operate in carrying out hydrographic surveys and in providing nautical services for the purpose of ensuring safe navigation as well as to ensure the greatest uniformity in charts and nautical publications and to co-ordinate their activities so that hydrographic and nautical information is made available on a world-wide scale.

Subsequently, in December 2000, following a proposal of the IHO, the Maritime Safety Committee of the International Maritime Organisation approved the following regulations in the new edition of the International Convention for the Safety of Life at Sea (SOLAS)

Safety of Life at Sea Convention (SOLAS)
Chapter V, Regulation 2.2
Definitions

Nautical chart or nautical publication is a special-purpose map or book, or a specially compiled database from which such a map or book is derived, that is issued officially by or on the authority of a Government, authorized Hydrographic office or other relevant government institution and is designed to meet the requirements of marine navigation. *

*Refer to appropriate resolutions and recommendations of the International Hydrographic Organization concerning the authority and responsibilities of coastal States in the provision of charting in accordance with regulation 9.

SOLAS Chapter V, Regulation 9
Hydrographic Services

- 1) Contracting Governments undertake to arrange for the collection and compilation of hydrographic data and the publication, dissemination and keeping up to date of all nautical information necessary for safe navigation.
 - 2) In particular, Contracting Governments undertake to co-operate in carrying out, as far as possible, the following nautical and hydrographic services, in the manner most suitable for the purpose of aiding navigation:
 - .1 to ensure that hydrographic surveying is carried out, as far as possible, adequate to the requirements of safe navigation;
 - .2 to prepare and issue nautical charts, sailing directions, lists of lights, tide tables and other nautical publications, where applicable, satisfying the needs of safe navigation;
 - .3 to promulgate notices to mariners in order that nautical charts and publications are kept, as far as possible, up to date;
 - .4 to provide data management arrangements to support these services.
 - 3) Contracting Governments undertake to ensure the greatest possible uniformity in charts and nautical publications and to take into account, whenever possible, relevant international resolutions and recommendations. *
 - 4) Contracting Governments undertake to co-ordinate their activities to the greatest possible degree in order to ensure that hydrographic and nautical information is made available on a world-wide scale as timely, reliably, and unambiguously as possible.
- * Refer to the appropriate resolutions and recommendations adopted by the International Hydrographic Organization.

Note:

The new edition of SOLAS chapter V that contains the mentioned regulations 2.2 and 9 will enter into force in July 2002.

The cited resolution and regulations are useful tools for promoting the awareness of the governments to allocate resources for hydrographic services at the requested level. There are, however, areas in the world where the governments can not allocate sufficient national resources to carry out the hydrographic activities and to manage and publish the related data.

The following paragraphs illustrate the standards to carry out hydrographic surveys and the standard ways to display the degree of confidence of nautical charts.

3. The IHO standards for hydrographic surveys (publication S-44)

The degree of confidence of a chart depends on the accuracy according to which the hydrographic surveys were executed. The standard for the hydrographic surveys is contained in the IHO publication S-44.

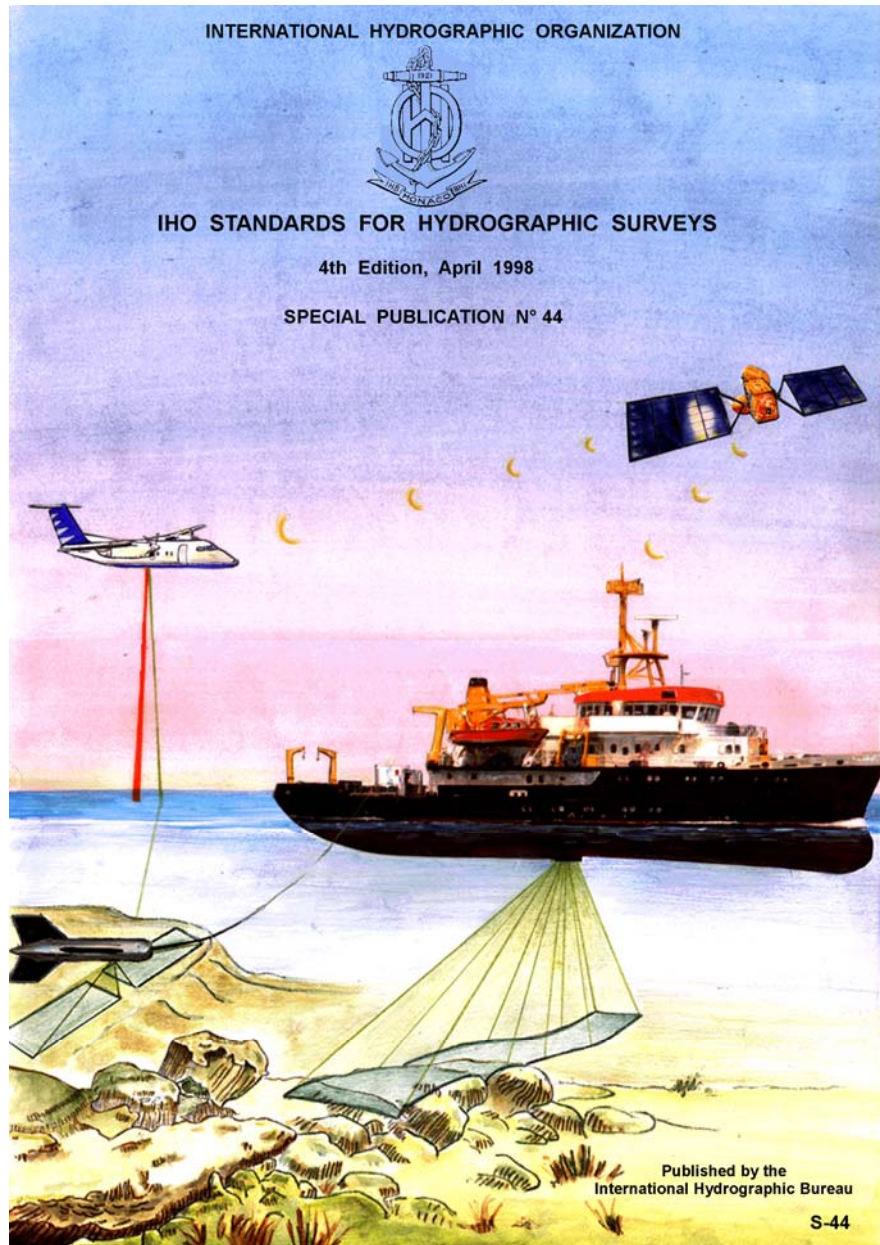


Figure 3: Cover of the IHO publication S-44

The hydrographic survey required accuracy is related to the importance of the area to be charted. The IHO has identified four orders of surveys associated to the marine navigation needs (*harbours and critical channels – harbours approaches and coastal areas – areas up to 200 m water depth – offshore areas*).

Summary of Minimum Standards for Hydrographic Surveys
Table 1: Reproduction of table 1 of the IHO Publication S-44

ORDER	Special	1	2	3
Examples of Typical Areas	Harbours, berthing areas, and associated critical channels with minimum underkeel clearances	Harbours, harbour approach channels, recommended tracks and some coastal areas with depths up to 100 m	Areas not described in Special Order and Order 1, or areas up to 200 m water depth	Offshore areas not described in Special Order, and Orders 1 and 2
Horizontal Accuracy (95% Confidence Level)	2 m	5 m + 5% of depth	20 m + 5% of depth	150 m + 5% of depth
Depth Accuracy for Reduced Depths (95% Confidence Level) ⁽¹⁾	a = 0.25 m b = 0.0075	a = 0.5 m b = 0.013	a = 1.0 m b = 0.023	Same as Order 2
100% Bottom Search	Compulsory ⁽²⁾	Required in selected areas ⁽²⁾	May be required in selected areas	Not applicable
System Detection Capability	Cubic features > 1 m	Cubic features > 2 m in depths up to 40 m; 10% of depth beyond 40 m ⁽³⁾	Same as Order 1	Not applicable
Maximum Line Spacing ⁽⁴⁾	Not applicable, as 100% search compulsory	3 x average depth or 25 m, whichever is greater	3-4 x average depth or 200 m, whichever is greater	4 x average depth

- (1) To calculate the error limits for depth accuracy the corresponding values of a and b listed in Table 1 have to be introduced into the formula

$$\pm \sqrt{[a^2+(b*d)^2]}$$

with

- a constant depth error, i.e. the sum of all constant errors
- b*d depth dependent error, i.e. the sum of all depth dependent errors
- b factor of depth dependent error
- d depth

- (2) For safety of navigation purposes, the use of an accurately specified mechanical sweep to guarantee a minimum safe clearance depth throughout an area may be considered sufficient for Special Order and Order 1 surveys.
- (3) The value of 40 m has been chosen considering the maximum expected draught of vessels.
- (4) The line spacing can be expanded if procedures for ensuring an adequate sounding density are used (see 3.4.2)

4. The reliability of the charts

The surveys accuracy parameters indicated above make it possible to produce reliable nautical charts. At the same time, the data collected in the prescribed systematic way is also valid to be used for scientific, industrial and coastal management purposes.

4.1 Paper charts

The degree of confidence of a paper chart can be depicted in form of source diagram of the hydrographic data. In general one can say that all data collected before the 1970's does not have an adequate reliability. Even worst is the case of the data collected before the 1930's when the soundings were obtained with led-line. Below are two examples of source diagrams (figure 4 and 5). By examining them one can easily understand that the degree of confidence of the two charts is totally different.

Mediterranean Sea, Libya

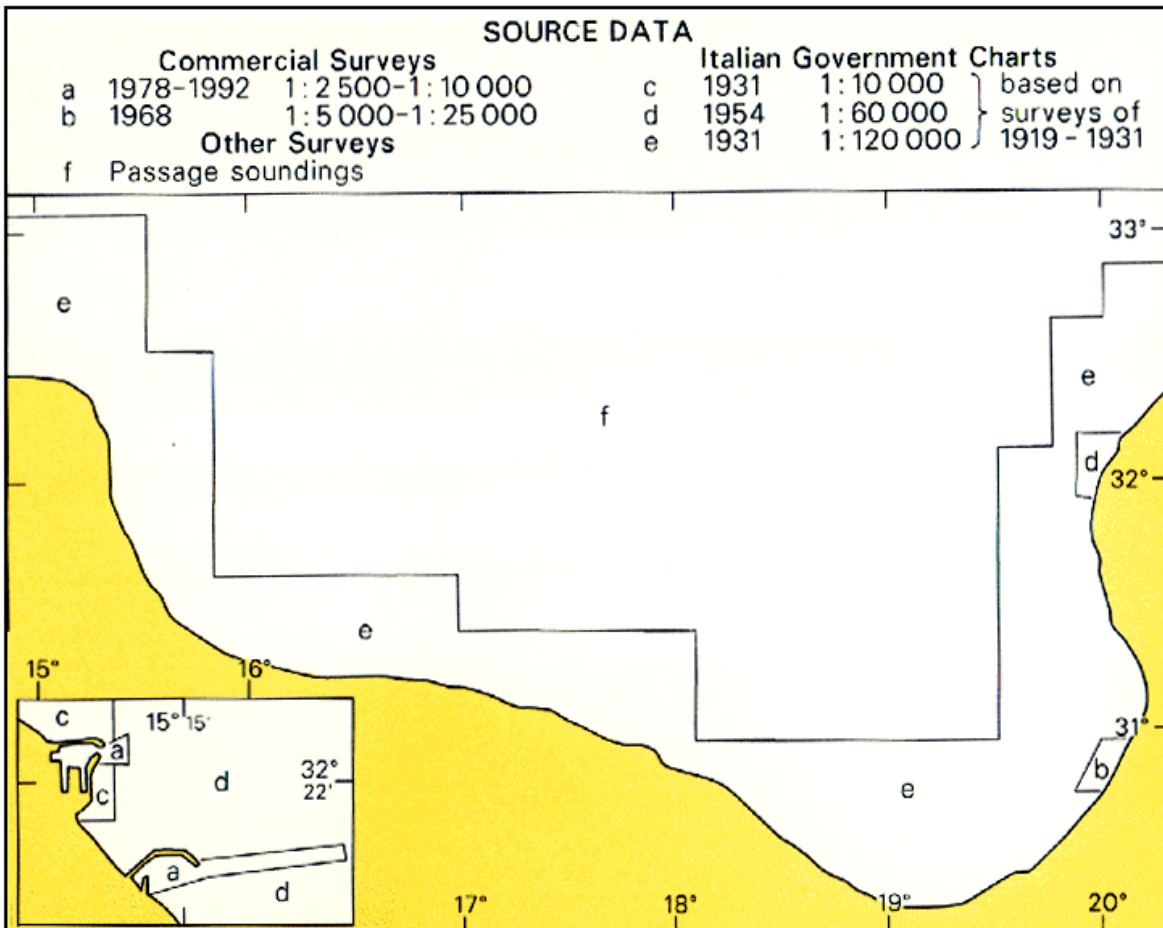


Figure 4: source diagram of a nautical chart of the coasts of Libya

China, Hong Kong Harbour

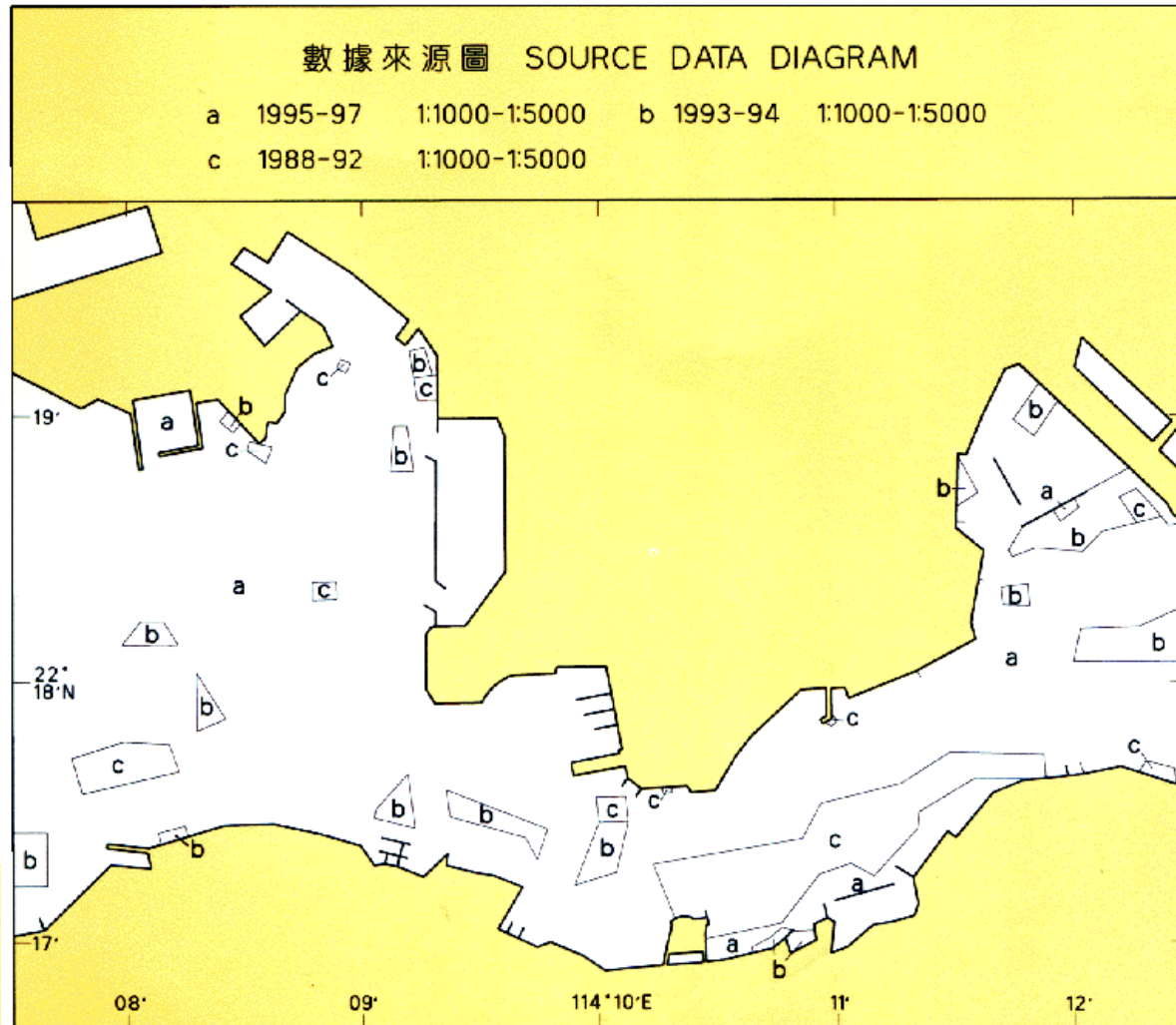


Figure 5: Source diagram of a nautical chart of the Hong Kong Harbour

Another more explicit way to indicate the degree of confidence of a paper chart, reported in the publication M-4 Chart Specification of the IHO is shown in the diagram below:

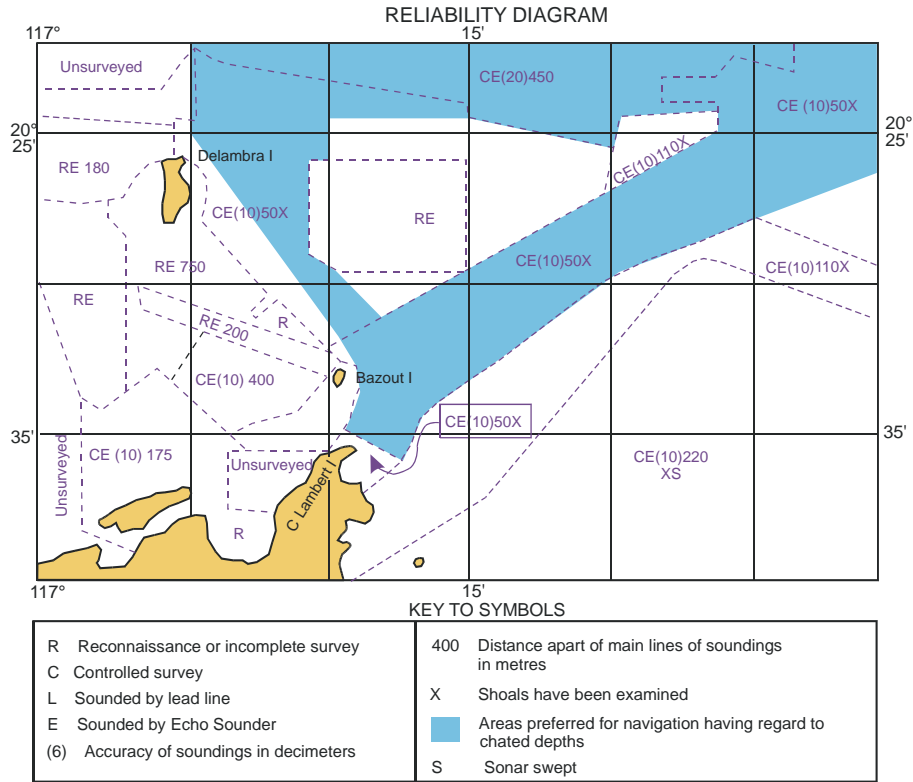


Figure 6: Reliability Diagram of an Australian paper nautical chart

4.2 Electronic Charts

The accuracy standard for hydrographic surveys is taken into account in the construction of the Electronic Navigational Charts (ENC). To do this, the IHO has established a special coding system in the Transfer Standard for Digital Hydrographic Data (IHO publication S-57). The way the cartographer has to follow to attribute the right code to the *Zones Of Confidence (ZOC)*, on the ENC, is illustrated in the table below:

1	2	3		4	5
ZOC	Position Accuracy	Depth Accuracy		Seafloor Coverage	Typical Survey Characteristics
A1	± 5 m	=0.50 + 1%d		Full area search undertaken. All significant seafloor features detected ^{and} depths measured.	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.
		Depth (m)	Accuracy (m)		
		10	± 0.6		
		30	± 0.8		
		100	± 1.5		
		1000	± 10.5		
A2	± 20 m	= 1.00 + 2%d		Full area search undertaken. All significant seafloor features detected and depths measured.	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.
		Depth (m)	Accuracy (m)		
		10	± 1.2		
		30	± 1.6		
		100	± 3.0		
		1000	± 21.0		
B	± 50 m	= 1.00 + 2%d		Full area search not achieved; uncharted features, hazardous to surface navigation are not expected but may exist.	Controlled, Systematic survey achieving similar depth but lesser position accuracies than ZOCA2, using a modern survey echosounder, but no sonar or mechanical sweep system.
		Depth (m)	Accuracy (m)		
		10	± 1.2		
		30	± 1.6		
		100	± 3.0		
		1000	± 21.0		
C	± 500 m	= 2.00 + 5%d		Full area search not achieved, depth anomalies may be expected.	Low accuracy survey or data collected on an opportunity basis such as soundings on passage.
		Depth (m)	Accuracy (m)		
		10	± 2.5		
		30	± 3.5		
		100	± 7.0		
		1000	± 52.0		
D	worse than ZOC C	Worse Than ZOC C		Full area search not achieved, large depth anomalies may be expected.	Poor quality data or data that cannot be quality assessed due to lack of information.
U	Unassessed - The quality of the bathymetric data has yet to be assessed				

**Table 2. Zones of Confidence (ZOCs) displayed on the electronic charts
(From IHO publication S-57)**

The figure below illustrates the Zone of Confidence on an Electronic Navigational Chart (ENC)

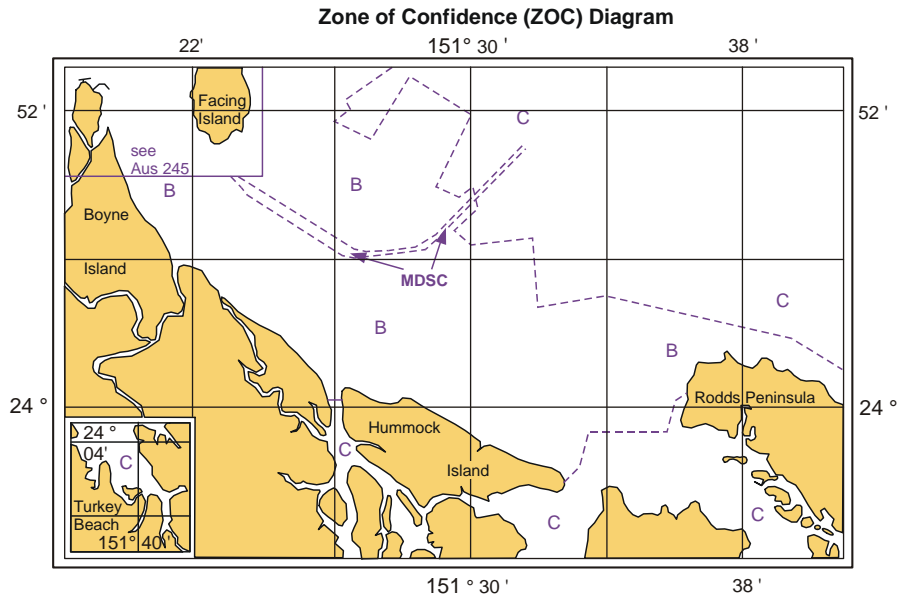


Figure 7: Zone of Confidence diagram for use on the electronic charts

5. The IHO task to provide reliable hydrographic data and reliable nautical charts world-wide

From what was stated in the above paragraphs, it is easy to understand that:

- a. The UN resolution A/53/32 and the IMO regulation 9 included in the Chapter V of the SOLAS Convention have to be implemented.
- b. The task to survey, at the present requested level of accuracy, all the seas of the globe, which were previously surveyed with a much lesser degree of precision or not surveyed at all, is immense.

The challenge is such that the IHO is now deeply committed to provide good hydrographic data and reliable charts. The task is easier to execute, but not within a brief delay, in the sea areas under the responsibility of developed countries. It is much more difficult in the sea areas where the coastal nation has not a well-established hydrographic service. Some of these areas are:

- Waters adjacent to the African continent and islands Black Sea, Red Sea, Gulf of Aden, Bay of Bengal, South China Sea, Solomon Sea, Bismarck Sea, Southern Ocean (Antarctica), Central American waters, part of the Caribbean Sea, part of South American waters etc. See figure 8 below.

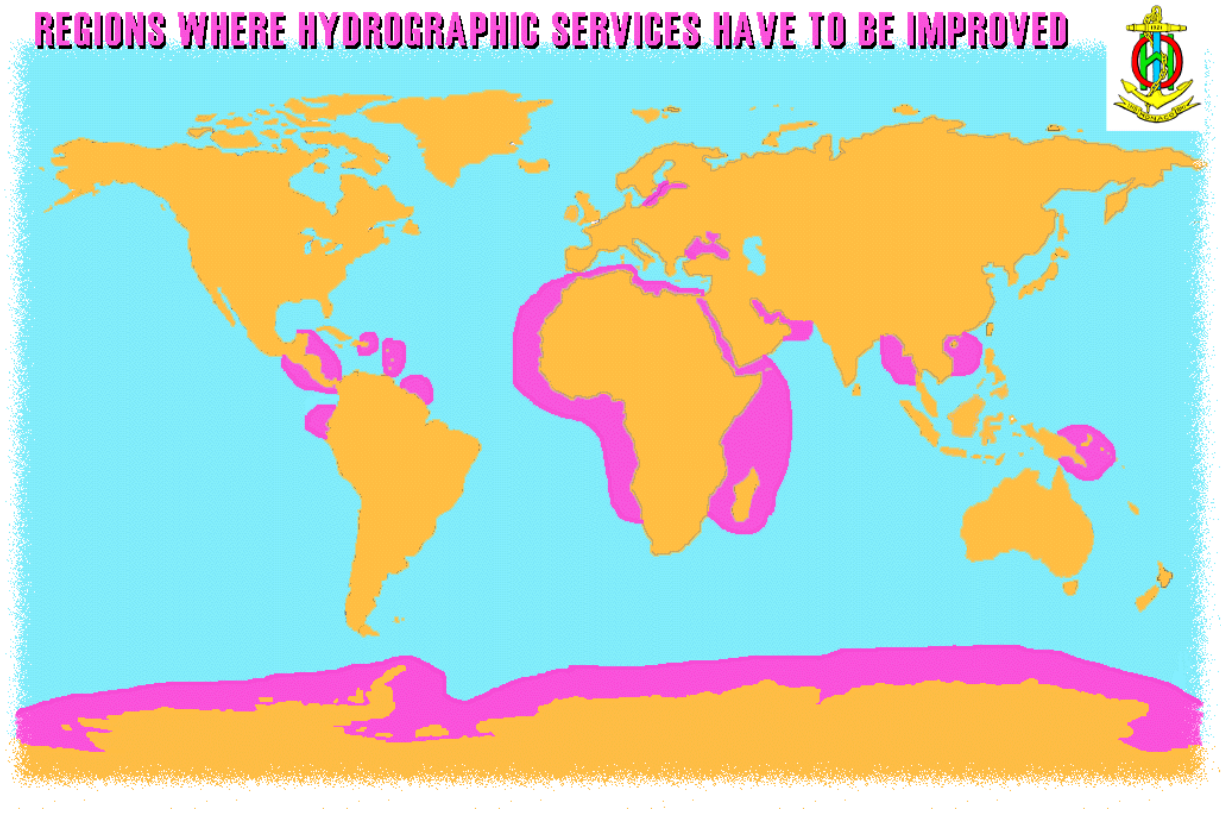


Figure 8 Regions where hydrographic services have to be improved

To carry out this task, the help of national and international agencies capable of providing financial help is necessary.

The economic value of the hydrographic services can be demonstrated and affects directly the maritime transport, the sea resources exploitation and the management and protection of the marine environment.

The IHO, through its permanent secretariat based in the Principality of Monaco, its Member States and its Regional Hydrographic Commissions initiated since some years ago a series of actions of Technical Co-operation. These actions are briefly illustrated in the paragraphs below.

6. IHO actions to promote the awareness of the national governments and international agencies on the need to provide hydrographic services

The IHO has now joined forces with the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA), the International Maritime Organisation (IMO) and with the International Association of Ports and Harbours (IAPH), in order to make the actions aimed at promoting hydrography more effective. The four organisations IMO, IHO, IALA and IAPH, in co-operation with the donor agencies, can assess the state of the maritime services in a particular area and draft a development plan, which would basically contain the following:

- National organisations and authorities involved
- Educational and training requirements.
- Equipment and other material requirements.

Promotion of hydrography was done through conferences and visits such as:

- Conference on the maritime safety held in Maputo (Mozambique) in 1995 during which the shortcomings in the maritime development in Southern Africa, the South Atlantic Ocean and Southern Indian Ocean and Islands were highlighted.
- Series of visits to African countries since 1995.
- Series of visits to East Asia countries since 1997
- Visit (1997) to the Italian Foreign affairs officials to encourage Italy to continue to offer hydrographic scholarships to the International Maritime Academy in Trieste.
- Letters to the Japanese Ministry of Foreign Affairs to encourage them to continue to include training and hydrographic assistance into the JICA co-operation programmes.
- Advertisement of the hydrographic courses offered by India.
- Joint visit by IMO, IHO, IALA and Norwegian Hydrographic Service, to Ms. Tove Strand Director General of the Norwegian Agency for Development and Co-operation (NORAD) in September 2000. During that visit appreciation was expressed for the assistance NORAD had provided in the holding of the conference in Maputo in 1995. The work undertaken by NORAD in Tanzania, Kenya, Uganda and Namibia as well as that of the Norwegian Hydrographic Service and NORAD's support in Mozambique and Angola were noted.
- The workshop on the hydrographic activities held in KUWAIT in October 1999 and jointly organised by the IHO, PERSGA and ROPME.
- Visit in May 2000 to the European Commission's Vice President Ms Loyola de Palacio, who stated that she considers important the provision of adequate hydrographic services and up-to-date charts to the mariners. She stressed that the provision of adequate charts is and should remain the responsibility of the coastal states.
- Visits (December 2000) to the Central American countries to support a regional programme aimed at reinforcing the hydrographic capabilities of the seven countries of that region.
- Establishment of points of contacts with the World Bank, the Global Environment Facility (GEF), the Asian Development Bank, the Inter-American Development Bank, the European Commission.

7. Examples of hydrographic development projects

In the following sub-paragraph some examples of possible projects aimed at the provision of hydrographic services will be given.

7.1 The MEDA Project 7

This project, sponsored by the European Union, was initiated by the International Maritime Academy (Trieste Italy) jointly with the IHO in 1996 and comprises: technical visits, meetings, two hydrographic courses, a cartographic course and the release of hydrographic and cartographic equipment. 12 Countries of the Southern and Eastern Mediterranean are beneficiaries of this project. See figure 9 below.

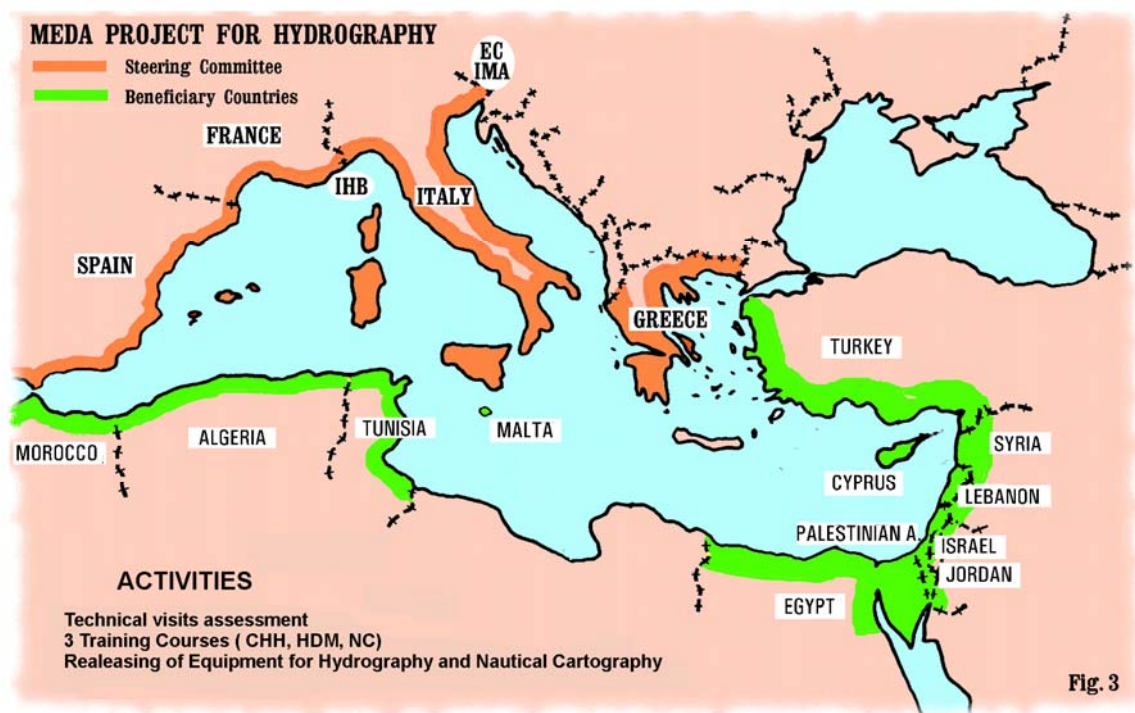


Figure 9: MEDA project 7 for Southern and Eastern Mediterranean

7.2. The Black Sea Initiative

This initiative was launched by the Head of the Hydrographic Service of Turkey in 1997 and received the consensus of the nations bordering the Black Sea:

Bulgaria, Georgia, Romania, Russian Federation, Ukraine and Turkey. The International Association for Aids to Navigation and Lighthouses Authorities (IALA) and the IHO assisted in formulating the basic structure of a project that has the following objectives:

To contribute to the effectiveness of the maritime transport, to the safety of navigation (including fishing and recreational navigation) and to the protection of the marine environment in the Black Sea, through the provision of:

- * *Adequate series of national and international nautical charts (paper and electronic) based on hydrographic surveys executed in conformity with the IHO standards.*
- * *Adequate network of aids to navigation (including fixed and floating aids and electronic positioning systems like GNSS and their terrestrial based differential applications).*
- * *Control of the adequacy and effectiveness of the Vessel Traffic Management and Information Systems in the main ports of the BS.*
- * *A study on the possibility to establish a ship reporting system for the entire Black Sea.*
- * *Adequate communication systems for the Maritime Safety Information (MSI) collection and dissemination in order to implement the Global Maritime Distress and Safety System (GMDSS).*
- * *Adequately trained personnel to carry out the operations described above.*

It is hoped that the States bordering the region endorse the need to develop the project.

7.3 The Regional Project for the implementation of the Strategic Action Programme for the Red Sea and the Gulf of Aden

This project, aimed at improving coastal and marine environments of the Red Sea and Gulf of Aden, was proposed by the governments of Djibouti, Egypt, Jordan, Somalia, Sudan and Yemen. It was approved by the UN Global Environment Facility (GEF) for a total cost of 19 Million USD.

The project includes 8 components:

- Component 1: Institutional strengthening to facilitate regional co-operation- UNEP
- Component 2: Reduction of navigational risk and marine pollution World-Bank;
- Component 3: Habitat and biodiversity conservation – UN
- Component 4: Sustainable use and management of living marine resources – UNDP
- Component 5: Development of a regional network of Marine Protected Areas (MPAs) - UNDP
- Component 6: Support for Integrated Coastal Zone Management (ICZM) –WB
- Component 7: Enhancement of public awareness and participation –UNDP;
- Component 8: Monitoring and evaluation of programme impacts -UNDP

The component 2 is going to be supported by a budget allocation of about 3.5 Million USD and will be administered by the World Bank. In this component 1.9 million USD is going to be spent on carrying out hydrographic surveys under the superintendence of the UK Hydrographic Office. The UK HO provides support for the planning, overseeing and appraisal of the surveys. The area where the surveys are being carried out is shown in the figure 10 below.

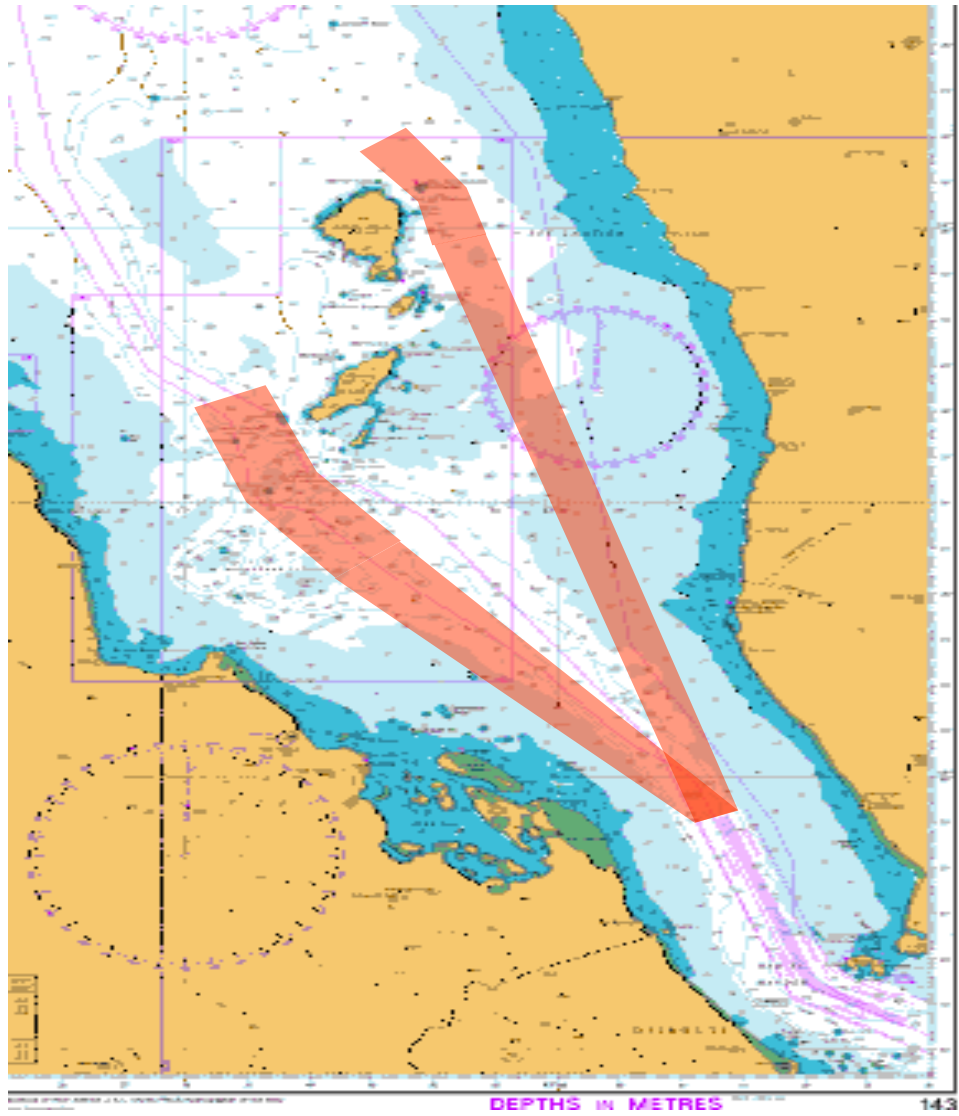


Figure 10 Area of the Traffic Separation Schemes in the Southern Red Sea being surveyed

7.4 Asian Development Bank (ADB) project for the rehabilitation of the Maritime Navigation Aids in Papua New Guinea

The IHO is in contact with the ADB for the implementation of a project which includes the establishment of hydrographic services and the execution of hydrographic surveys. The area concerned is represented below in Figure 11.



Figure 11: Areas where hydrographic surveys are to be conducted

The prospective loan that the ADB proposes to award to PNG is aimed at developing the maritime transport in order to contribute to the economic growth and development of PNG. The project comprises the establishment of Hydrographic Services because of the 1.7 million km² of sea area only 10% has been adequately surveyed. Production of Electronic Navigational Charts is also envisaged.

7.5 The project for Central America

This project was jointly put forward by the Central American Commission for the Maritime Transport and by the IHO. It is the first project in which it is envisaged to establish a regional hydrographic organisation by putting together the present (limited) national hydrographic capabilities and by creating a regional nautical cartography centre.

The project also includes the acquisition of a regional hydrographic vessel.

7.6 The initiative for Western Africa

This initiative was taken as the result of an ad hoc meeting held in Lisbon in March 2001, within the frame of the IHO Regional Hydrographic Commission for the Eastern Atlantic (EAtHC). The project will comprise technical visits, training and the execution of hydrographic surveys. An action team that will draft regional and national plans will visit coastal states that have been requested to agree on the initiative.

8. Conclusions

The above are merely examples of what must be done and what we at the IHO are at present doing. It should not be taken as an exhaustive and complete situation report, but instead, should be taken as an example of the amplitude of the hydrographic task.

To summarise, we can say that the way to obtain the suitable global coverage of hydrographic data is arduous, expensive and time consuming. It can be achieved if governments and international organisations provide adequate funding. The IHO hydrographic services of developed countries have the skill to co-operate with the less developed coastal states. The IHO secretariat is fully committed to act as a catalytic factor to obtain that hydrography be considered at government's decision level, an essential element for the protection of the marine environment and the navigation safety.