

PROGRESS IN PRODUCING BATHYMETRIC CHARTS AT A GLOBAL AND REGIONAL LEVEL

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Introduction

This paper describes the progress of work to advance the production of bathymetric charts. This includes the IHO's present and historical role relating to the General Bathymetric Chart of the Oceans (GEBCO), and the work of the Intergovernmental Oceanographic Commission (IOC), in cooperation with the IHO and in developing regional bathymetric maps. Inspired originally by Prince Albert I of Monaco, the GEBCO world series of bathymetric charts is now in its Fifth Edition. This edition is now available in digital form on CD-ROM as the GEBCO Digital Atlas.

This latest edition, printed and distributed in hard copy by the Canadian Hydrographic Service, has recently been digitized through an effort of the British Oceanographic Data Centre at Bidston, U.K. Considerations are now being given for updating of the digital data and the possibilities for a printed Sixth Edition. In recent years, the IHO designated the U.S.-NOAA's National Geophysical Data Center at Boulder, Colorado, as the IHO Data Centre for Digital Bathymetry. This Centre now provides a central depository for all ocean bathymetry greater than 100 meters in depth.

The GEBCO series is published at a scale of 1:10 million to provide for total world coverage. The need for increasingly larger scales has most recently been addressed by the IOC's Regional Ocean Mapping Project at 1:1 million scale. Started in the Mediterranean, there are now several regional bathymetric mapping projects underway. Bathymetric maps at these small and medium scales provide a good basis for planning and support a wide variety of scientific activities in the oceans.

One of the many problems being faced in these bathymetric mapping activities is the handling of the very dense data sets resulting from the deep ocean multibeam mapping systems. Another is to develop a rational system for naming the many new ocean features that are being discovered.

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BACKGROUND

Historically, as nations began to explore the world's oceans, nations held secret the information collected by their mariners for commercial and military advantage. About the turn of the century, as nations had become involved in world maritime trade, this attitude began to change. In 1899, during the Seventh International Geographic Congress in Berlin, Germany, a Commission was set up to study the naming of ocean relief features and to draw up plans for a general chart of the oceans. The Commission was composed of ten leading geographers and scientists of the day: H.S.H. Prince Albert I of Monaco, Professor O. KRUMMEL, Admiral S.O. MAKAROW, Dr. H.R. MILL, Sir John MURRAY, Dr. Fridtjof NANSEN, Professor O. PETERSSON, Baron RICHTOFEN, Professor A. SUPAN and Professor J. THOULET.

The Commission next met in Wiesbaden, Germany, in 1903 under the Chairmanship of Prince Albert I. At this meeting, the Prince's offer to organize and finance the production of a new series to be designated "The General Bathymetric Chart of the Oceans (GEBCO)" was accepted. The series, at a scale of 1:10 million, was to be composed of 16 sheets on the Mercator projection, together with 8 sheets on gnomonic projection to cover the polar regions.

Work began in 1903 on the First Edition and a team of seven draftsmen completed it in only 7 months. It included over 18,000 soundings and was presented to the Paris Academy of Sciences in 1904 and, later that year, to the Eighth International Geographical Congress at Washington, D.C.

At the opening of the Oceanographic Museum at Monaco, in 1910, Prince Albert I called for experts to discuss the production of a Second Edition of GEBCO. The first sheets of the Second Edition were published in 1912, but because of the disruption of World War I, the Edition was not completed until 1930. This Edition was compiled from over 30,000 soundings. Through the time when this edition was compiled, available sounding data only consisted of point depths. Soundings in the deep ocean were taken at great effort, and only a few ships could actually take the time to stop and expend the time to lower a weighted wire to determine a single ocean depth. Because of this, only a few deep ocean soundings became available each year and updating of the data base could be done simply by publishing listings of the information collected by national Hydrographic Offices.

Following the death of Prince Albert I, in 1922, and after the completion of the Second Edition, his team of scientists working on GEBCO was disbanded and the International Hydrographic Bureau (now the International Hydrographic Organization) was invited to take over the GEBCO project. In 1929, IHO took on the task of keeping the series up-to-date and collating the needed data.

Data for a Third Edition were compiled by the IHB staff, and Hydrographic Offices of the IHO Member States were requested to supply available ocean soundings to the IHB. To collect and archive these data, the IHB established a series of 1001 plotting sheets (now 655 sheets) on the Mercator projection at a scale of 1:1

million. As a result of this global effort, when the International Council of Scientific Unions (ICSU) established the World Data Center network for the International Geophysical Year in 1957, the IHO was designated as the World Data Center for Bathymetry. From these 1:1 million scale plotting sheets, which formed a unique data base, the 1:10 million scale GEBCO series was derived. Although publication began in 1932, the outbreak of World War II disrupted the effort and the Third Edition was never completed. Due to the delay, significant new data had become available necessitating a renewed effort.

The echo sounder had come into use prior to the war (about 1930) and the amount of available bathymetric data was increasing rapidly. The VIth International Hydrographic Conference, in 1952, initiated work on a Fourth Edition. Two sheets were published in 1958-61 based on compilations by the IHB staff, but the amount of data becoming available is now beyond the capability of the small IHB staff.

As a result, based on a decision of the 1962 International Hydrographic Conference, the maintenance of the 1:1 million plotting sheets covering the world's oceans was assumed by 18 "Volunteering Hydrographic Offices" (VHO's) of the IHO Member States. The allocation of the plotting sheets among the VHO's is given in IHO Publication B-2, "Catalogue of Bathymetric Plotting Sheets". By 1965, an agreement was made between the French Institut Géographique National (IGN) for the production of the GEBCO Fourth Edition. The IHO then coordinated the effort wherein Volunteering Hydrographic Offices provided updated sounding sheets which were used by IGN for compilation, with the French Hydrographic Office verifying the work. The overall project was overseen by the GEBCO Committee, which was drawn from IHO national Hydrographic Offices, the Scientific Committee on Oceanic Research (SCOR) and the International Association for the Physical Sciences of the Oceans (IAPSO). An Editorial Board of the Committee was responsible for the verification and correction of geomorphological details.

Fifth Edition of GEBCO

In 1972, the IHO and Intergovernmental Oceanographic Commission (IOC) of UNESCO entered an arrangement for co-sponsorship of a new edition of GEBCO. With the theory of plate tectonics having been developed and significant advances in marine science having been made, it was decided that a scientific approach should be taken for the compilation of a GEBCO Fifth Edition. This involved scientific analysis of data types other than bathymetry to provide inferences as to the major linear trends of seafloor features. This approach provided for a better compilation of bathymetric features than sparse bathymetric data alone could provide. This new approach took advantage of the strengths of the two organizations by employing experts for the IHO Hydrographic Offices and eminent marine geologists and geophysicists from IOC nominated after consultation with SCOR, IAPSO and the Commission for Marine Geology.

The IHO retained its responsibility for maintaining the collected 1:1 million scale sounding sheets, a role of providing cartographic advice and supervision over the final GEBCO product. IOC provided the scientific input, essential for improved contouring of the bathymetric data and scientific peer review. Through close

collaboration between members of the two organizations a product of improved quality resulted.

As with any major project, financing became a major issue. The Chairman of GEBCO at the time was Mr. Gerald H. EWING, Assistant Deputy, Minister of Fisheries and Oceans and former Dominion Hydrographer. Through his initiative, the Canadian Government agreed to fund the scribing and printing of the GEBCO Fifth Edition through the Canadian Hydrographic Service (CHS). Over the 1975-1982 time period, CHS completed the entire series of 18 Fifth Edition sheets. The Fifth Edition consists of 16 sheets on Mercator Projection at 1:10 million (at the Equator) and 2 sheets on Polar Stereographic Projection at 1:6 million scale (at 75 degrees latitude) (Fig. 1). Upon completion, CHS also produced a World Sheet giving global coverage at 1:35 million and 1:25 million (Polar regions) using the projections of the basic series. Bathymetry was depicted at 200 metres, 500 metres and at 500 metre intervals thereafter, with the contours displayed varying slightly because some sheets included intermediate contours to better delineate features.

An important innovation with the Fifth Edition was the inclusion of information about the source data on each of the sheets. Discrete soundings appear as grey dots and echo sounding tracks as grey lines in the background to the contours. Areas that would appear saturated and dense areas of high quality surveys are shown as boxes or brackets, and cross-referenced to notations about the data source in the border area. Thus, for the first time the user had some measure of the quality of the contour data. The Canadian Hydrographic Service has recently produced a new proof of GEBCO Sheet 5.12 in the South Atlantic because the original version had been based on rather sparse data and new data to significantly improve the sheet had become available. The sheet is to be published in 1994. The Canadian Hydrographic Service deserves great credit for having carried out the very significant task.

Geographic Undersea Feature Names

To provide for standardization between sheets prepared by individuals of differing nationalities and languages, and to avoid, as far as possible differences of opinion, the names shown and nomenclature used for ocean bottom features are carefully scrutinized by the GEBCO Sub-Committee for Undersea Feature Names (SCUFN), (formerly Sub-Committee on Geographical Names and Nomenclature of Ocean Bottom Features). The submission of names to the GEBCO-SCUFN is standardized through IHO-IOC Publication B-6 (actually a series of various languages publications) which was developed in accordance with provisions of resolutions of the United Nations Conferences on Geographical Names. At present, Publication B-6 "Standardization of Undersea Feature Names" is published in English/French, English/Spanish, English/Japanese, English/Russian and English/Chinese. English/German and English/Portuguese versions are in preparation. For land features, the national versions of geographic names are used in conformance with those used by the IHO for the INTERNATIONAL Chart series of nautical charts, with the names transliterated to the Roman alphabet as appropriate.

The Secretariat for the GEBCO-SCUFN is provided by the IHB. IHO-IOC Publication B-8 "Gazetteer of Geographic Names" provides the approved names and the positions of the features named. This publication includes the undersea feature

TABLEAU D'ASSEMBLAGE
DES FEUILLES DE LA GEBCO
(5e édition)

ASSEMBLY DIAGRAM
FOR GEBCO SHEETS
(5th Edition)

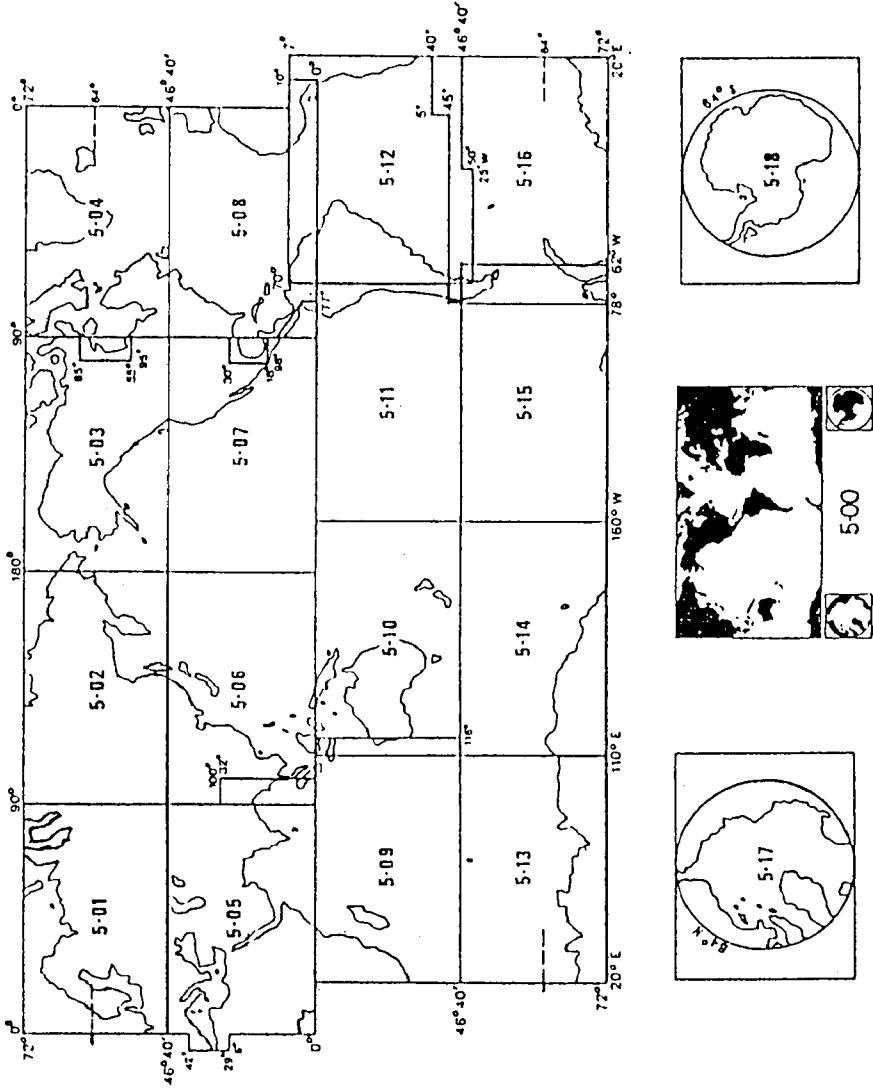


FIG. 1. GEBCO Fifth Edition.

names used for GEBCO and names for the IHO Small-scale International Chart Series (1:2.5 million and smaller). The information in this publication is continuously under review with undersea feature names being added or amended. As a result of the availability of high resolution multibeam mapping systems there has been a move toward larger scale maps, which has caused a significant increase in naming activity. The seemingly simple shift from 1:10 million scale maps to 1:1 million scale maps actually opens the possibility for a 100 fold increase in naming. In 1994, the IHB will produce a digital version Publication B-8, which includes a program to allow display and printing of the information but without provision for altering the data. IHO-IOC Publication B-8 will then no longer be made available in hard copy format. Since the availability of undersea feature names is important to anyone considering the possibility of whether or not to name a feature and should be readily available to all users, it is planned that the "Gazetteer of Geographic Names" in digital format will be made available "gratis" on a wide-area network such as InterNet. IHB would continue to recover the costs associated with production and distribution of disks requested directly from the Bureau.

GEBCO Digital Bathymetry

In May 1977, the GEBCO Guiding Committee formed a Sub-Committee on Digital Bathymetry (SCDB). Tasks assigned to the SCDB were to look into issues related to digitization of the GEBCO Fifth Edition and the establishment of a system using digital techniques for the maintenance and updating of the data stored on the IHO plotting sheets.

Digitization of the GEBCO Fifth Edition is now complete and available on CD-ROM, with a support booklet and floppy disk containing the GEBCO Digital Atlas interface software. This effort was a major task and took most of the ten year period 1984-1993 to complete. Digitization was carried out at four laboratories on a sheet by sheet basis; i.e., Bureau Gravimétrique International, Toulouse, France - 11 sheets; Natural Environment Research Council, Unit for Thematic Information Systems, Reading, U.K. - 4 sheets; and British Oceanographic Data Centre, Bidston, U.K. - 2 sheets. Quality control, final editing and reformatting of these data into a uniform data set was carried out by the British Oceanographic Data Centre (BODC). Stable base transparencies provided by the Canadian Hydrographic Service were used for digitizing. Gaps due to labelling of contours were closed to provide for enclosed polygons. The digitized contour segments, which included about 95,000 segments, were checked by BODC and confirmed to be within the line thickness of contours on the published sheets. Where sheets overlapped, the most up-to-date data was digitized to construct a seamless data base. For sheet 5.06 in the Western Pacific, the source data came from a digital data base maintained by the Japan Oceanographic Data Centre, Tokyo. An earlier version of this data base had formed the basis for the published sheet. The updating of sheet 5.12 involved a combined effort by scientists from U.S.A., Russia, New Zealand and the U.K., with the BODC digitizing the final contours and the Canadian Hydrographic Service using the digitized file as a basis for publishing the revised sheet.

The background information about source data, i.e., tracklines and survey boxes (not isolated spot soundings), were also digitized by BODC, Bidston, U.K. - 13 sheets; Head Department of Navigation and Oceanography, St. Petersburg, Russia

- 3 sheets; and Alfred-Wegener-Institute, Bremerhaven, Germany - 2 sheets. Quality control was again carried out by BODC.

Content of the GEBCO Digital Atlas

The GEBCO Digital Atlas (GDA) has been produced on a CD-ROM disk containing the following data sets:

- digitized bathymetric contours, coastlines and the trackline control from the GEBCO Fifth Edition
- digitized bathymetric contours and coastlines from the IBCM (International Bathymetric Chart of the Mediterranean) First Edition
- digital global coastlines from the World Vector Shoreline (U.S.-Defense Mapping Agency) at a range of scales from 1:43 million up to 1:250,000
- trackline inventory of the digital echo-sounding data held at the IHO Data Centre for Digital Bathymetry up to December 1993
- a digital set of geographically referenced feature names including the IHO-IOC Gazetteer of Geographical Names of Undersea Features, a list of the ports/cities and Antarctic islands portrayed on the printed sheets of the GEBCO Fifth Edition, a list of Antarctic stations and a specially prepared list of oceanic islands
- a digital version of the Third Edition of the Echo-Sounding Correction Tables (Carter's Tables)
- a set of supporting documents describing each of the data sets included on the CD-ROM.

The software interface included on floppy disk provides users with the facility to display the GDA charts on an IBM compatible PC screen and to extract data from the GDA into one's own files; system requirements are 640K RAM (500K free), a VGA monitor, a CD-ROM drive, and a hard disk with at least one Megabyte of free space. Software may be installed for multi-user operation on a LAN (Local Area Network). The system is controlled by a series of "pull down" menus and has a context sensitive help system. This provides for a "user friendly" interface and allows the novice user to begin operation of the GDA immediately.

The GDA software interface is functionally divided into two sections between which the user may move freely. One is an area selection screen which displays the land/sea map of the entire area covered by the dataset. This allows the user to select the area of data to be used before the system must call-up the data, thereby avoiding time delays associated with unnecessary data processing. The second section is the Main Display Screen, which displays the detailed bathymetric contour, coastline, trackline and feature data for the specific area.

The GDA software interface offers a number of options for controlling the manner in which information is presented.

Geographic area selection from the CD-ROM data can be made by chart number, geographic latitude and longitude limits or by a user controlled zoom box. One can pan and zoom, even across adjacent areas, can backtrack, and use "where am I" to highlight the chosen area on a smaller scale display. As one zooms, the World Vector Shoreline displayed automatically is shifted to higher resolution versions. The system informs the user of the depth values of contours available within any chosen area, provides for selection of which ones to be displayed and for assigning colours to them. A cursor can be used to query the value of any displayed contour.

Within the GDA, there is a choice of five projections for chart display: Equidistant Cylindrical, Mercator (default), Miller Cylindrical, Lambert Cylindrical Equal-Area and Peters Equal-Area. A geographic grid optionally can be overlaid for reference, the interval being set automatically based on the field of view.

The position of the cursor is constantly displayed in geographic coordinates, the echo-sounding correction at the position can also be displayed and there is a capability for multi-point distance measuring in miles, nautical miles or kilometers. Cursor initiated queries within a survey box outlining source data will result in details of the source survey being displayed. Alternatively, the display can be overlaid with tracklines from the IHB DCDB rather than the tracklines used to compile the Fifth Edition, illustrating what data has since become available. One can also list or display outlines of the source charts contributing to the user's display screen.

Displays can also be overlaid with symbols indicating the locations of undersea features, oceanic islands, port/cities, and Antarctic islands and stations. Cursor controlled queries will cause display of the feature name/type.

Data can be exported to one's own files, either in DXF format or in a simple flat ASCII format. Maps and text can be copied to a printer. Also, the current screen display can be stored as a PCX or GEM image for use in desktop publishing or wordprocessing software, and for display as "slides".

Regional Ocean Mapping Projects

To respond to the increasing needs of the scientific community for bathymetric and geologic-geophysical data at larger scales, the IOC has begun a series of Regional Ocean Mapping Projects to produce bathymetric charts at a scale of 1:1 million for specific regional areas of the world's oceans. At present, there are five such projects: 1) International Bathymetric Chart of the Mediterranean and its Geological-Geophysical series (IBCM); 2) International Bathymetric Chart of the Caribbean Sea and Gulf of Mexico (IBCCA); 3) International Bathymetric Chart of the Central Eastern Atlantic (IBCEA); 4) International Bathymetric Chart of the Western Indian Ocean (IBCWIO); 5) and International Bathymetric Chart of the Western Pacific (IBCWP).

Of these projects, the IBCM is the most advanced with its series of 10 sheets having been published in 1981 by the Head Department of Navigation and Oceanography, St. Petersburg, Russia. It is this series of sheets that is included on

the GDA CD-ROM (Fig. 2). Although the IHO does not formally participate in the Regional Mapping Projects with IOC, several IHO Member States, called Volunteering Hydrographic Offices (VHO's), participate in the effort and provide for updating of the 1:250,000 scale plotting sheets used for compilation of the 1:1 million scale bathymetric series. For the IBCM, sheets are maintained by VHO's of 7 IHO Member States. Due to the involvement of the IHO Member States and the usefulness of the data as a source for GEBCO, IHB maintains a coordination role related to the scheme. The IBCM includes the development of six series of charts, i.e., Bathymetry Bouguer Gravity anomalies, Seismicity, Thickness of Plio-Quaternary Sediments, Unconsolidated Bottom Surface Sediments, and Magnetic Anomalies (scheduled for publication in 1996). A second edition of the Bathymetry of IBCM is now being compiled. Several IBCCA bathymetric sheets are now being published and sheets of the IBCEA are well underway. The IBCWIO and IBCWP projects have been moving slowly due to resource problems. It is intended that these compilations eventually provide a source of updating material for the GDA.

A number of VHO's, as with the IBCM project, participate in these other IOC Regional Ocean Mapping projects. Also, the IHO DCDB provides bathymetric data used for compilation of the 1:1 million scale bathymetric charts. As an acknowledgement of the IHO effort in the IOC projects, it has been agreed that the IHO logo will appear on all future bathymetric sheets of IOC Regional Ocean Mapping projects, in addition to the IOC logo.

Updating Bathymetry

As was noted above in the Background section, IHO Volunteer Hydrographic Offices maintained a series of 1:1 million plotting sheets covering the world's oceans and IHO was designated by ICSU as the World Data Centre for Bathymetry. Annually, the IHB calls for information about recently collected bathymetric data and compiles a series of listings of the responses. IHO Publication B-4, "Information concerning Recent Bathymetric Data" List No. 23 has been produced by IHB in 1994 (Fig. 3).

In 1987, the United States submitted a proposal to the XIIIth International Hydrographic Conference for the establishment of an IHO Data Centre for Digital Bathymetry (DCDB) to be operated by the U.S.-NOAA's National Geophysical Data Center at Boulder, Colorado on behalf of the IHO. This was initiated from GEBCO meetings in 1985 and 1986. The proposal was accepted and, in 1990, the IHO DCDB was officially established and IHO Member States were encouraged to submit data to the DCDB. As a result of this, the IHO Publication B-4, which incrementally provides information about survey data that has become available since the previous Listing, was modified to include two Parts, Part I analogue Data (and digital data not held by the DCDB) and Part II Digital Data held by the DCDB. This modification was first done with the publications of List No. 22. Eventually, it is anticipated that Part I will be phased out and Part II will compass the entire publication. An additional Part III giving an inventory of the holdings of the IHO DCDB, has now been added to publication B-4 with the issuance of the 1994 List No. 23.

In just 3½ years of existence, through the end of 1993, the IHO DCDB accumulated 8 million soundings which are jointly held within NGDC's GEODAS database of worldwide underway geophysics data. In total the GEODAS database

INTERNATIONAL BATHYMETRIC CHART OF THE MEDITERRANEAN
(IBCM) - PLOTTING SHEETS AT 1:250 000
CARTE BATHYMETRIQUE INTERNATIONALE DE LA MEDITERRANÉE
(CBIM) - MINUTES DE REDACTION A 1:250 000

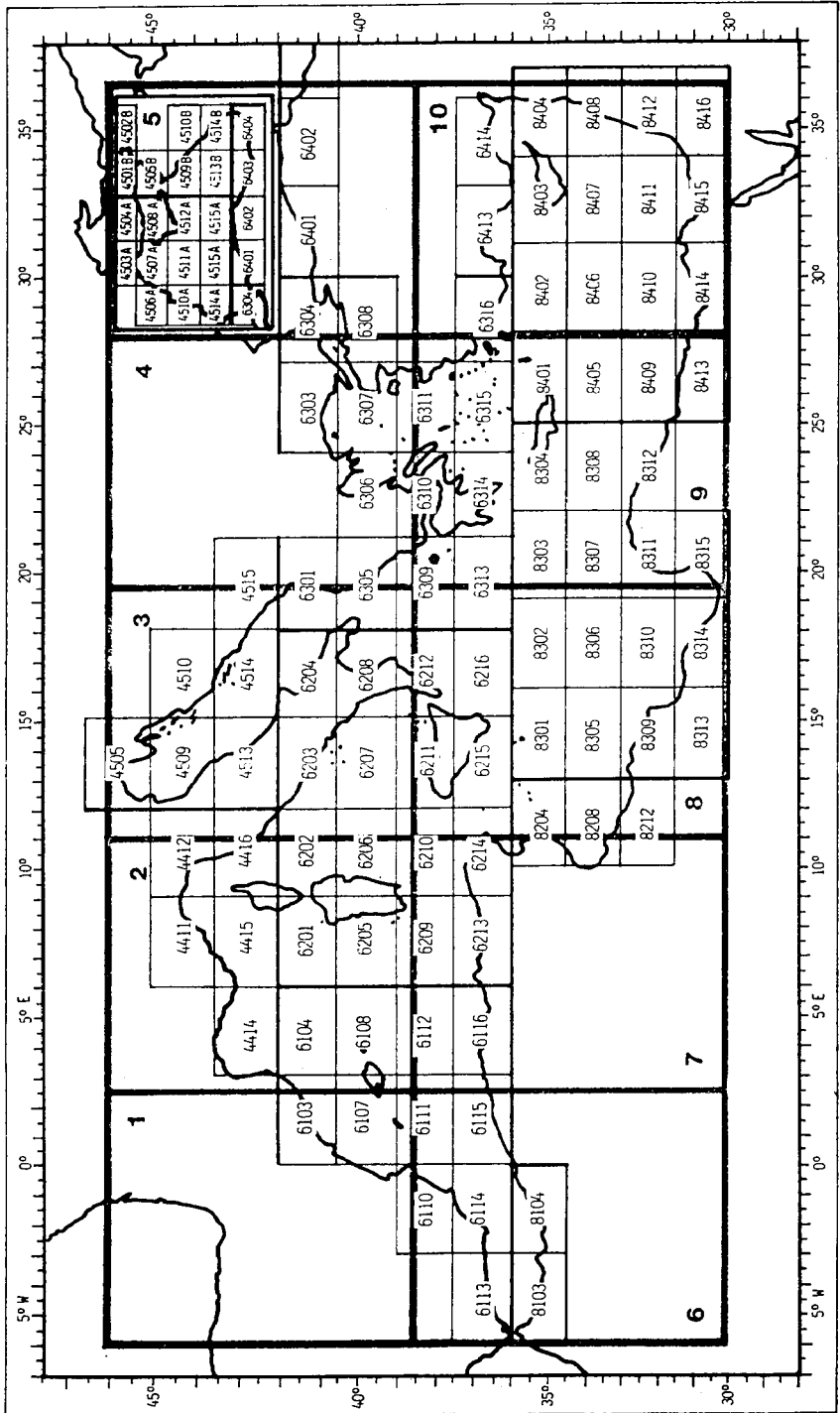


FIG. 2. International Bathymetric Chart of the Mediterranean.

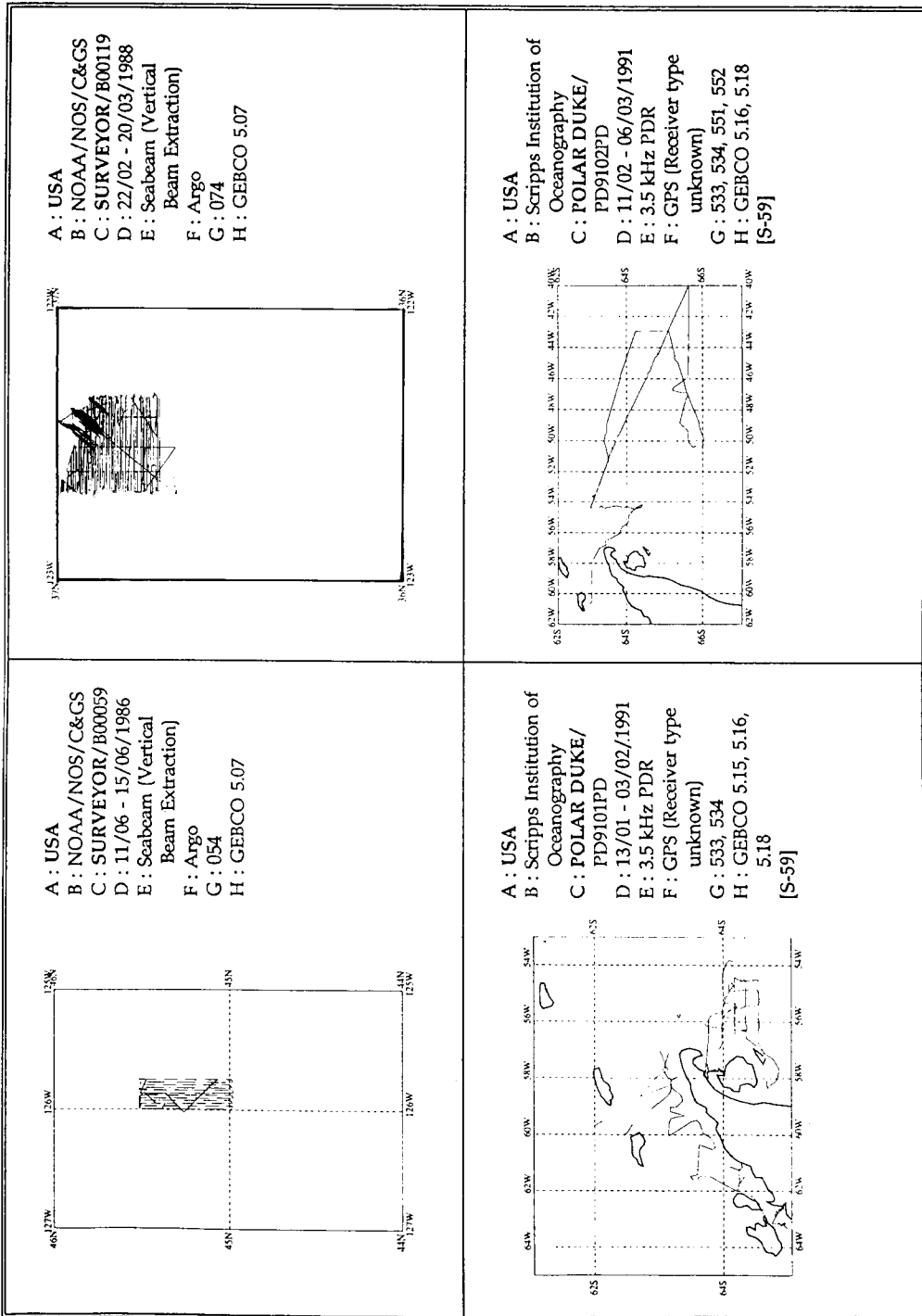


FIG. 3. IHO Publication B-4 "Information Concerning Recent Bathymetric Data", List No. 23.

now includes over 28 million soundings covering 12 million miles of trackline. Despite this there are still many areas of the ocean with sparse data coverage or with data coverage which is of questionable quality.

A two volume CD-ROM of the complete GEODAS data holdings as of the end of 1992 accompanied by a user friendly software interface was issued by the Data Center in 1993. These data are available as a source for updating of the bathymetric charts. Despite the great progress being made in accumulating digital data, it is expected that the BHI system of 1/1 million sounding sheets will continue for some time; These sheets contain much of the older data not yet digitized and there is a need for cooperation between VHO's and the DCDB such that as this data is digitized with care being taken to avoid duplication where data has already been digitized; techniques for production of bathymetric map products using the DCDB need to be developed such that use of the data becomes more "user friendly", proper quality control techniques are applied and necessary meta data are recorded and available so that such techniques can be applied.

At present, the IHO DCDB maintains a record of only the vertical beam of multibeam data. The possibility of incorporating the full multibeam data sets into the IHO DCDB is being investigated and the GEBCO Sub-Committee for Digital Bathymetry is attempting to develop a standard format for multibeam data. This latter item is quite difficult in that operators have a variety of parameters they collect for various scientific purposes, have varying capabilities depending on the system in use, and are understandably reluctant to reprocess the large amounts of data collected. Also, some users want the raw data for analysis whereas others want just position and depth for ease of processing. Certainly work needs to be done to insure that data are categorized according to quality levels within the data base.

As noted above, the 1:1 million scale Regional Ocean Mapping Projects are intended to become a source of updating material for the GDA, however, the pace of progress is rather slow due to resource constraints and GEBCO is faced with similar resource problems as related to the possibility of a Sixth Edition and a system of updating. Many of the IHO Hydrographic Offices have had budget reductions limiting their capacity to support bathymetric charting. At the same time, Hydrographic Offices must continue to maintain and produce their hard copy nautical chart series in support of marine navigation, but must also find resources to acquire digital production methods and digitize their existing chart data bases. Resources have become limited both in terms of ship operations and the capability for chart production has become competitive due to the many demands in times of shrinking resources.

Possibilities for the Future of Bathymetric Mapping

The problems concerning resources needed for IHO-IOC updating of bathymetric mapping (both GEBCO and the Regional Mapping programs) are serious issues to consider in these times of limited funding for ocean science and mapping. Advances in remote sensing for land mapping, mapping of planets and satellite mapping of the surface of the ocean have left an impression with many people, other than those most knowledgeable on the subject, that mapping of the oceans is a simple task, and since ocean mapping has been conducted for many

decades, the job must have been completed by now. These are very false impressions and they need to be overcome!

Although ships have been surveying for many decades, one must recognize that only point depths were acquired up until the 1930's and accurate offshore positioning using electronic methods was not available for ship surveys until the 1960's. The historic bathymetric data acquired is generally of poor quality in comparison to data acquired by present methods using very accurate GPS satellite positioning and high resolution sonars with multiple beam arrays capable of mapping wide areas of the seafloor along a ship's trackline; It is only in the last decade that efficient methods have been developed and that data to accurately delineate the deep ocean bathymetry (greater than 100 metres) have begun to be acquired.

Possibilities for the future of the bathymetric charting are to: 1) ignore the program and leave the shape of the seafloor as an unknown, 2) find adequate sources of funding to support map compilation on a reasonable cycle such as 5-years, or 3) find a new approach that diverts effort to the bathymetric program.

Ignoring the program would mean an abandonment of ocean science and technology at a time when supercomputers are making it possible to better understand the workings of our planet as a whole. There is a growing need for improved bathymetry particularly amongst modelers studying the role of the oceans in the climate system and sea floor bathymetry has been recognized as an essential component for the Global Ocean Observing System (GOOS). Marine technology has advanced significantly in the last decade making it now possible to conduct accurate high resolution surveys of the world's oceans without it being the daunting task of the past. Our understanding of geologic processes, our ability to find and manage ocean resources, our ability to model scientific processes and make marine predictions all depend on a detailed knowledge of the oceans. The dynamics of ocean modelling, to reliably understand the transport and storage capacities of the deep ocean will require a knowledge of ocean currents and their response to seafloor topography, and this is very likely to be a focal point of oceanography in the coming decade. In the future, as fisheries biologists and oceanographers focus more on habitat management and study "why" living resources aggregate in certain areas, detailed bathymetry will become an important factor.

From an applied, industry standpoint, fishermen are major users of bathymetric products and gain efficiencies in their operation from detailed bathymetry. Deep trawlers work to depths of as much as 1,000 metres with gear that is very expensive. Bathymetry provides the foundation layer of information upon which other layers of the "marine Geographic Information System or GIS" depend. It is essential that ocean surveys continue in order to improve the quality of the bathymetric data base which at present is all too often based on soundings from the era of sailing ships and exploration in the age of Captain COOK. Science and industry need good bathymetry.

Finding adequate resources to support the GEBCO effort is necessary, but in these times of budget reductions seems unlikely to result from direct Government sponsorship. Increased funding to support the few scientists and hydrographers who are working hard to improve our understanding of the oceans in a physical sense

would go a long way towards accomplishing the goal. Despite the decline in sources of data, much data is being acquired and there is need to support these few individuals who are capable of making application of the data to improve the GEBCO product. As increasing amounts of data becomes available, larger and larger scale bathymetric products become a requirement of the user community. A limited amount of funding from private donors or multinational sources, intergovernmental or otherwise, to support the travel of compilers and reviewers is minimally necessary.

While adequate sources of funding to support scientific interpretation are essential, there also may be new approaches to the problem, particularly as high resolution data become available. An approach is needed which can increase the involvement of the national Hydrographic Offices. Hydrographic Offices have a mandate to collect and review data for compilation of traditional nautical charts and to varying degrees have supported the compilation of ocean bathymetry. Hydrographic offices are collecting significant amounts of deep water bathymetry as are the oceanographic research fleets. Some countries are collecting information to justify continental shelf claims related to the United Nations Convention on Law of the Sea, which will enter into force in November 1994. The question becomes one of how to provide for increased involvement by national Hydrographic Offices in bathymetric charting without overly increasing their burden of work and how to possibly increase their interest in producing bathymetry as part of a basic product with the possibility of a broader sales market.

One possibility would be to phase out the traditional compilation of nautical charts in waters deeper than 100-200 metres and compile bathymetry instead. Historically, it is understandable why charts have been constructed the way they are. Little was known about the ocean deeps, so addition of the few point soundings being acquired was a simple task, the sparse information available would not support compilation of detailed bathymetry even if this had been a goal, and mariners navigating on the paper chart needed lots of white background for the plotting of navigational fixes. Today the situation is changing. High resolution data are being acquired for many ocean areas; navigators are about to shift to electronic chart navigation, where depiction of bathymetry is feasible; and there is need for increased efficiency in the overall system of bathymetric and nautical chart compilation.

Under such a modification, Hydrographic Offices could phase out their traditional compilation effort of searching for shoal biased depths in deep water and, as new data becomes available sufficient to support recom compilations in the deep water, begin compilation of bathymetry only beyond 100 meters depth. Some will argue that this entails liability, but certainly they fail to recognize the inadequacies of compilations from the historically sparse and poorly positioned data. Others will argue that the lines of soundings on charts provide the navigator with an indication of the data available at the time of chart compilation, providing a warning as to when the navigator should be cautious. While it is true that bathymetric contours do not provide this indication, bathymetric compilations now include depiction of the underlying tracklines or an indication of source where data are dense. It could therefore be argued that the bathymetric depiction would be an improvement. How many navigators actually know enough to look for lines of soundings that give an indication of sparse data?

Hydrographic Offices might consider the possibility for increased utility of their nautical chart product with bathymetry combined in the offshore areas. Fishermen and scientific investigators are likely to find the product significantly more useful making the product more saleable. If Hydrographic Offices would agree to begin the transition to implement such a change, the chart products could become large scale source data sets, which would have gone through a quality review process, for use in the compilation of small and medium scale bathymetric charts. Such a proposal is planned for inclusion in the Draft IHO Strategic Plan being developed at the International Hydrographic Bureau for the consideration of the IHO Member States.

Bathymetric Product Sources

GEBCO Fifth Edition sheets:

The Hydrographic Chart Distribution Office
 Department of Fisheries and Oceans
 *1675 Russell Road
 P.O. Box 8080
 Ottawa, Ontario K1G 3H6
 Canada

Fax: 1-(613) 998 1217

GEODAS CD-ROM

National Geophysical Data Center
 NOAA E/GC4, Dept. 915
 325 Broadway
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