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IBCCA Workshop on Data Sources and Map Compilation

Boulder, Colorado, USA, 18-19 July 1988

Unesco

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No.	Title	Publishing Body	Languages
1	CCOP-IOC, 1974. Metallogenesis, Hydrocarbons and Tectonic Patterns in Eastern Asia (Report of the IDOE Workshop on); Bangkok, Thailand 24-29 September 1973 UNDP (CCOP), 138 pp.	Office of the Project Manager UNDP/CCOP c/o ESCAP Sala Santitham Bangkok 2, Thailand	English
2	CICAR Ichthyoplankton Workshop, Mexico City, 16-27 July 1974 (Unesco Technical Paper in Marine Sciences, No. 20).	Division of Marine Sciences, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock) Spanish (out of stock)
3	Report of the IOC/GFCM/ICSEM International Workshop on Marine Pollution in the Mediterranean, Monte Carlo, 9-14 September 1974.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish (out of stock)
4	Report of the Workshop on the Phenomenon known as "El Niño", Guayaquil, Ecuador, 4-12 December 1974.	FAO Via delle Terme di Caracalla 00100 Rome, Italy	English (out of stock) Spanish (out of stock)
5	IDOE International Workshop on Marine Geology and Geophysics of the Caribbean Region and its Resources, Kingston, Jamaica, 17-22 February 1975.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock) Spanish
6	Report of the CCOP/SOPAC-IOC IDOE International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific, Suva, Fiji, 1-6 September 1975.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
7	Report of the Scientific Workshop to Initiate Planning for a Co-operative Investigation in the North and Central Western Indian Ocean, organized within the IDOE under the sponsorship of IOC/FAO (IOFC)/Unesco/EAC, Nairobi, Kenya, 25 March-2 April 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
8	Joint IOC/FAO (IPFC)/UNEP International Workshop on Marine Pollution in East Asian Waters, Penang, 7-13 April 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock)
9	IOC/CMG/SCOR Second International Workshop on Marine Geoscience, Mauritius, 9-13 August 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
10	IOC/WMO Second Workshop on Marine Pollution (Petroleum) Monitoring, Monaco, 14-18 June 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish (out of stock) Russian
11	Report of the IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions, Port of Spain Trinidad, 13-17 December 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish (out of stock)
11 Suppl.	Collected contributions of invited lecturers and authors to the IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions, Port of Spain, Trinidad, 13-17 December 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
12	Report of the IOCARIBE Interdisciplinary Workshop on Scientific Programmes in Support of Fisheries Projects, Fort-de-France, Martinique 28 November-2 December 1977.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish
13	Report of the IOCARIBE Workshop on Environmental Geology of the Caribbean Coastal Area, Port of Spain, Trinidad, 16-18 January 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
14	IOC/FAO/WHO/UNEP International Workshop on Marine Pollution in the Gulf of Guinea and Adjacent Areas, Abidjan, Ivory Coast, 2-9 May 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French
15	CPPS/FAO/IOC/UNEP International Workshop on Marine Pollution in the South-East Pacific, Santiago de Chile, 6-10 November 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock)
16	Workshop on the Western Pacific, Tokyo, 19-20 February 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Russian
17	Joint IOC/WMO Workshop on Oceanographic Products and the IGOSS Data Processing and Services System (IDPSS), Moscow, 9-11 April 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
17 Suppl.	Papers submitted to the Joint IOC/WMO Seminar on Oceanographic Products and the IGOSS Data Processing and Services System, Moscow, 2-6 April 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
18	IOC/Unesco Workshop on Syllabus for Training Marine Technicians, Miami, 22-26 May 1978 (Unesco reports in marine sciences, No. 4)	Division of Marine Sciences, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock) French Spanish (out of stock) Russian
19	IOC Workshop on Marine Science Syllabus for Secondary Schools, Llantwit Major, Wales, U.K., 5-9 June 1978 (Unesco reports in marine sciences, No. 5).	Division of Marine Sciences, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian Arabic
20	Second CCOP-IOC Workshop on IDOE Studies of East Asia Tectonics and Resources, Bandung, Indonesia, 17-21 October 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
21	Second IDOE Symposium on Turbulence in the Ocean, Liège, Belgium, 7-18 May 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
22	Third IOC/WMO Workshop on Marine Pollution Monitoring, New Delhi, 11-15 February 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
23	WESTPAC Workshop on the Marine Geology and Geophysics of the North-West Pacific, Tokyo, 27-31 March 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Russian
24	WESTPAC Workshop on Coastal Transport of Pollutants, Tokyo, 27-31 March 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock)
25	Workshop on the Intercalibration of Sampling Procedures of the IOC/WMO UNEP Pilot Project on Monitoring Background Levels of Selected Pollutants in Open-Ocean Waters, Bermuda, 11-26 January 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (superseded by IOC Technical Series No. 22)
26	IOC Workshop on Coastal Area Management in the Caribbean Region, Mexico City, 24 September-5 October 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
27	CCOP/SOPAC-IOC Second International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific, Nouméa, New Caledonia, 9-15 October 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
28	FAO/IOC Workshop on the effects of environmental variation on the survival of larval pelagic fishes Lima, 20 April-5 May 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
29	WESTPAC Workshop on Marine biological methodology Tokyo, 9-14 February 1981.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
30	International Workshop on Marine Pollution in the South-West Atlantic Montevideo, 10-14 November 1980.	IOC, Unesco Place de Fontenoy, 75700 Paris, France	English (out of stock) Spanish
31	Third International Workshop on Marine Geoscience Heidelberg, 19-24 July 1982	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish
32	UNU/IOC/Unesco Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the context of the New Ocean Regime Paris, 27 September - 1 October 1982	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish

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SUMMARY REPORT

1. OPENING

The IBCCA (International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico) Workshop on Data Sources and Map Compilation was called to order by Dr. Nestor Duch Gary, President of the IBCCA Editorial Board, at 8.30 am on July 18, 1988, at the Holiday Inn in Boulder, Colorado, U.S.A.

Dr. Michael S. Loughridge, Director of World Data Center - A for Marine Geology and Geophysics and Chief of the Marine Geology and Geophysics Division of the U.S. National Geophysical Data Center (NGDC), welcomed the attendees on behalf of NGDC and expressed the expectation that the workshop would be an important step in bathymetric data management for the IBCCA project, and wished attendees a pleasant stay in Boulder, Colorado.

Dr. Nestor Duch Gary welcomed the attendees on behalf of the IOC and the IBCCA project, and thanked the NGDC staff for its efforts in preparing for and hosting the workshop.

Dr. Troy Holcombe, member of the IBCCA Editorial Board and local coordinator for the workshop, introduced the Director of the International Hydrographic Organization, Admiral Alfredo Civetta, the IOC senior assistant secretary, Dr. Viktor Sedov, members of the Editorial Board, invited experts, and guest attendees from NGDC. A list of participants in the workshop is contained an Annex II.

2. ADMINISTRATIVE ARRANGEMENTS

Dr. Troy Holcombe, the local coordinator, submitted the provisional agenda to the workshop for consideration and adoption. The agenda was adopted without amendments. A copy of the agenda comprises Annex I.

3. DATA MANAGEMENT EXPERIENCES FROM THE IBCM PROJECT

Dr. Viktor Sedov of the IOC Secretariat, who was associated with editing and printing of the IBCM (International Bathymetric Chart of the Mediterranean) charts, presented this topic. It is generally agreed that the IBCCA project will benefit from the experiences of the IBCM project. The chart and plotting sheet specifications to be used for IBCCA are largely adapted from IBCM specifications. A copy of this report is included as Annex III.

4. SURVEY OF GULF OF MEXICO - CARIBBEAN DATA AVAILABLE FROM NGDC AND OTHER U.S. SOURCES AND METHODS, USE OF SUPPLEMENTARY DATA FOR MAP COMPILATION

Dr. Troy Holcombe made a presentation on the availability of bathymetric data and strategies for plotting sheet and map compilation.

This report began with a brief history of bathymetric mapping in the Gulf of Mexico and Caribbean region beginning with the 1854 map of the

North Atlantic compiled by Matthew F. Maury; and continuing through the work of Sir John Murray, of the Challenger expedition, several North American geologists, and the U.S. Naval Hydrographic Office; and finally summarizing the work of GEBCO and physiographic portrayals by Bruce Heezen and Marie Tharp. Illustations of many of these historical maps were shown.

Present status of bathymetric mapping was outlined, and graphic examples of this bathymetry were shown. The best bathymetry for the whole Caribbean is the NOAA bathymetry, published in 1980 after being compiled at the U.S. Naval Oceanographic Office. The best bathymetry for the whole Gulf of Mexico is that compiled by Dr. William R. Bryant of Texas A & M University and published in an atlas produced by the Ocean-Margin Drilling Project. In addition, more detailed bathymetry has been compiled for specific areas including the Cayman Trough, the northern Gulf of Mexico, the easternmost Caribbean, and areas adjacent to the island of Hispaniola.

A summary of digital bathymetry data holdings from U.S. sources was presented. Graphics were presented illustrating the data coverage. In addition copies of these graphics were given to workshop attendees for their retention and use. Large volumes of data are held by NGDC in its GEODAS file of trackline bathymetry. This file is an accumulation of data from many sources collected by the marine science institutions of many countries. NGDC also holds survey bathymetry collected by the NOAA National Ocean Service and its predecessor agency, the U.S. Coast and Geodetic Survey; and survey bathymetry collected by the U.S. Defense Mapping Agency through its HYCOOP and other programs. The above data are voluminous and cover all areas of the Gulf of Mexico and the Caribbean.

Other bathymetric data include multiple-beam bathymetric data for specific small areas, collected by French and U.S. institutions principally in the eastern Caribbean, over the West Florida Escarpment, and off Panama; and bathymetric data collected in a cooperative program between the Mexican General Directorate of Naval Oceanography and Oregon State University.

Use of supplementary information was discussed including the use of GLORIA-II imagery (surface-towed scanning sonar images) where it has been collected, and older bathymetric data contained on plotting sheets and survey sheets but not available in digital computer form.

Finally, a discussion of the use of other geophysicl and geological data, including seismic reflection profiles and drillhole stratigraphy in bathymetric mapping, was presented. Methods for the study of these data were outlined. Importance of the use of plate tectonic interpretation and resulting maps of tectonic fabric in interpreting bathymetry was emphasized. Existing geological and tectonic maps of the Caribbean were discussed and examples given. These maps were identified as being of importance for interpreting bathymetry.

5. USE OF GEOLOGICAL STUDIES AND EXISTING GEOLOGICAL AND GEOPHYSICAL MAPS TO IMPROVE BATHYMETRY

Dr. William R. Bryant, Professor of Oceanography, Texas A & M University, presented a summary of the geological history and geomorphology

of the Continental shelf, slope and rise of the northern Gulf of Mexico. The northern Gulf of Mexico is underlain by a wedge of Mesozoic and Cenozoic sediments up to 15 km in thickness and containing extensive evaporite beds and salt diapir provinces. Principal source of sediments is the Mississipi River. Topography is complex over the salt diapirs of the upper continental slope, where topographic depressions have been produced by salt solution. Dr. Bryant is compiling new bathymetry of the western part of the northern Gulf of Mexico at a scale of 1:192,000, using GLORIA imagery and data from the files of industrial companies. This new bathymetry will be incorporated into the U.S. contribution of bathymetry to IBCCA from the northern Gulf of Mexico.

6. USE OF IMAGE ENHANCEMENT TECHNIQUES IN THE INTERPRETATION OF BATHYMETRIC DATA

Dr. Peter W. Sloss, physical scientist and computer graphics specialist for the National Geophysical Data Center, presented this agenda item.

Very striking images can be produced on personal computers equipped with a display of 640 x 480 pixels in 256 colors or gray shades if judicious use is made of the available tones. Three different contrast-computation techniques were applied to images generated from gridded bathymetric data for the IBCCA area to demonstrate the value of emphasizing the topographic features which have only slight slopes. Such features as submarine canyons and small rises are not at all evident under conventional shading methods, but become very prominent in the image if algorithms favoring gentle slopes (shading varying as the square root or logarithm of slope) are used. Many different contrast enhancement schemes can be used for bathymetric data which range numerically from 0 to about 8000 meters below sea level in the IBCCA area, providing up to 8000 possible numeric values for the slope between adjacent points. Color can be used to add quantitative information about absolute elevation/depth to the subjective display of shaded slopes. Data which are available only in processed-image form, such as the 256-shade GLORIA sonar data, cannot be subjected to the same enhanced-contrast algorithms as bathymetric data because the number of computable shades is no greater than the number of displayable shades. To move any shade up or down the brightness scale would require that other shades be bumped off the end of the displayable range, if all 256 displayable levels are still used.

7. MARINE GEOPHYSICS DATA MANAGEMENT AT NGDC

Dan R. Metzger, geophysicist for the National Geophysical Data Center, presented this topic.

The National Geophysical Data Center has developed a data base management system for underway marine geophysics data known at GEODAS. Over 2,900 cruises of bathymetry, magnetics, gravity and seismic reflection data from a diversified group of national and foreign sources have been archived at NGDC. GEODAS is a software system which is based on a series of PCs networked together with a VAX mini-computer which (a) processes digital data into a common format known as MGD77, (b) provides graphic and text

information for searches of the data based on area, dates, data types, etc. and (c) retrieves analog and digital data onto various media for the user.

8. MARINE GEOLOGY DATA AT NGDC

Carla J. Moore, geologist for the National Geophysical Data Center, described the status of marine geology data bases at NGDC in this report.

Marine geology data files at NGDC are global in coverage, including descriptive and analytical information for over 140,000 cores, grabs and dredges. Data are from U.S. and international sources, and range in format from computerized files to reports on paper or microfiche, to well logs on 16-mm microfilm, and ocean floor photographs on 35-mm microfilm. Inventory information for each report or data file, regardless of format, is searchable through the Marine GEOlogy digital INventory "GEOLIN". Searches of GEOLIN typically result in computer listings of available data, page-sized plots of selected sample locations, and a computer-generated order form containing format and price information.

Computerized geology data bases being actively constructed at NGDC include 1) the "Index to Marine Geological Samples" which provides basic lithology and age information for samples physically archived at major U.S. oceanogrphic institutions, 2) the Marine Minerals Data Base and Bibliography containing information on offshore hard mineral resources, and 3) a worldwide data base of grain sized analyses. In addition, many computerized data files compiled outside of NGDC are available. A compact optical disc or "CD-ROM" containing all data from the Deep Sea Drilling Project is in preparation at NGDC and will be available early in 1989.

9. BATHYMETRIC UNITS AND CONVERSION OF ECHO TIME TO DEPTH

LT Robert M. Mandzi of the NOAA Corps, geodesist/hydrographer for the National Geophysical Data Center, presented this topic.

Several corrections must be made in the course of converting raw soundings into final bathymetric values. Four of these corrections are small, and normally are only applied in depths less than 200 meters: settlement and squat correction, sea action correction, tide correction, and tidal datum reduction. Larger and more important are the corrections for transducer draft and sounding velocity. Velocity correctors are usually determined by one of three methods: direct comparisons (such as bar checks), correction tables (such as Matthew's or Carter's) or computation from STD measurements.

Bathymetric data available from the GEODAS marine geophysical data base at the National Geophysical Data Center (NGDC) are in the MGD77 format with bathymetry values given either in two-way travel time or corrected meters. National Ocean Service correctors are derived from the U.S. Naval Oceanographic Office Special Pub. No 68. Data received from the Defense Mapping Agency are corrected using the British Admiralty Tables. Bathymetry derived from SEABEAM center-beam values are corrected by whatever method is chosen by the real-time system operator. Other GEODAS bathymetric data have

usually been corrected using Matthew's or Carter's Tables. NGDC also holds a small amount of analog bathymetry, which may be corrected or uncorrected, in feet, fathoms or meters.

10. THE USE OF RANDOM DATA IN BATHYMETRIC MAPPING

Joseph G. Gilg, retired geologist and former head of the bathymetric charting section of the U.S. Naval Oceanographic Office, described the value of using random data to help with the interpretation aspect of bathymetric mapping in this presentation.

Bathymetric mapping is seldom without its interpretational problems, and it is helpful to use all of the available literature and sounding data. The literature should include bathymetric, geological and geophysical maps and papers. Random data consists of depth soundings taken by non-survey vessels in random passage between ports. Random data are less accurate than survey data, and many workers are reluctant to use it. However, random data can fill in gaps and help with interpretations. One of the most common ways to evaluate random data is to match the depth values along a random sounding line to the related values in survey contours. The accuracy of the random data is determined from the number of points at which it can be favorably correlated to the survey contours. If the fitted random data is perpendicular, or at an angle to the survey lines, the random data can provide additional accurate information in the survey gaps. If the random data reveals bathymetric features between the survey lines, these features can become additional correlation points for incorporating additional random sounding lines. Many of the random sounding lines will fit the initial or subsequent correlation points, but some may require minor adjustments or depth corrections. As additional random data is worked in, a highly accurate network of survey and random data can be developed. In many areas, there is no survey data available for the initial correlation points, and these points must be developed from random data. This is done by first working areas where the topography is relatively simple and the random data is most dense. Normally the soundings will indicate one or more bathymetric features in the area, but they will be distorted in some manner by the data errors. A most likely form and position is interpreted and outlined on a work sheet for each feature. This process can be made more accurate by developing the outlines from contours selected at a gradient change. Most of the gradient changes used are those identified by Bruce Heezen in his work. These changes usually occur over a limited horizontal and vertical distance and can often be delineated between adjacent soundings on a sounding line. The individual sounding lines used to develop the outlines are then fitted back to the outlines. Each sounding line is like a key, and each feature is like a tumbler in a lock. The feature outlines and sounding lines are adjusted to get the best fit. The fitting process is generally a multi-directional process and may involve a number of separate areas of dense data on the work sheet. This produces a surprisingly accurate net of random data to which additional random data can then be tied. The completed worksheet will show feature outlines and the fitted sounding lines. This becomes a guide for selecting both the appropriate lines and density of data for the topography to be contoured. This method, using the outline form, was described in the International Hydrographic Review, Vol. XLVII, No 1, January 1970. This method, and a special version

for complex areas, were used between 1965 and 1977 to efficiently and accurately produce numerous sounding sheets and bathymetric maps for the Indian, Pacific and Atlantic Oceans.

11. CLOSURE

Dr. Nestor Duch Gary congratulated all the participants on the success of the workshop and thanked NGDC for the convenient accomodations and their generous hospitality.

The workshop adjourned at approximately 1:30 p.m. on 19 July 1988.

ANNEX I

AGENDA

FIRST DAY - July 18, 1988 - 8:30 a.m.

1. **OPENING OF WORKSHOP** - Nestor Duch Gary

   a. Welcoming remarks - Michael A. Chinnery, Michael S. Loughridge
   b. Announcements - Troy L. Holcombe

2. **ADMINISTRATIVE ARRANGEMENTS**

3. **DATA MANAGEMENT EXPERIENCES FROM THE IBCM PROJECT** - Viktor Sedov

4. **SURVEY OF GULF OF MEXICO-CARIBBEAN DATA AVAILABLE FROM NGDC AND OTHER U.S. SOURCES AND METHODS, USE OF SUPPLEMENTARY DATA FOR MAP COMPILATION** - Troy L. Holcombe

5. **USE OF GEOLOGICAL STUDY AND EXISTING GEOLOGICAL AND GEOPHYSICAL MAPS TO IMPROVE BATHYMETRY** - William R. Bryant

SECOND DAY - July 19, 1988 - 8:30 a.m.

6. **USE OF IMAGE ENHANCEMENT TECHNIQUES IN THE INTERPRETATION OF BATHYMETRIC DATA** - Peter Sloss

7. **DESCRIPTION OF DIGITAL BATHYMETRIC AND OTHER GEOPHYSICAL DATA BASES AT NGDC** - Dan Metzger

8. **MARINE GEOLOGY DATA AT NGDC** - Carla Moore

9. **BATHYMETRIC UNITS AND CONVERSION OF ECHO TIME TO DEPTH** - Robert M. Mandzi

10. **CONCLUDING REMARKS** - Nestor Duch Gary

ANNEX II

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ANNEX III

DATA MANAGEMENT EXPERIENCES FROM IBCM PROJECT

CONTENTS

1. BACKGROUND

By the 1970s the Mediterranean had become one of the best explored regional seas of the World Oceans. Several bathymetric charts already existed for some parts of this sea on scales of 1:200,000 to 1:1,000,000, and two charts covering the whole Mediterranean : a chart on a scale 1:2,849,300 on Mercator projection (USA) and a chart on a scale 1:4,000,000 on Orthomorphic conical projection (USSR).

However, development of high precision echo-sounding and positioning techniques has made it possible, in recent years, to obtain a large amount of sounding data in a relatively short period. This became an essential premise for preparation of high quality bathymetric charts of the Mediterranean at a relatively large scale.

The existence of good Loran C coverage in the Mediterranean and the presence of well organised and well equipped oceanographic institutions and hydrographic services has greatly simplified the task of compiling the IBCM.

2. RATIONALE

Sea bed topography is to a large degree the result of geological and tectonic processes. For this reason the existence of detailed charts of the topography of the sea bed simplifies understanding of these processes. Furthermore, underwater relief is not influenced by erosion to the same extent as that of the land.

In this respect, the Mediterranean is a particularly interesting area for exploration, as a broad range of processes exists in a relatively small geographical area.

Large scale and high precision charts of the Mediterranean are essential for oceanographic studies. Distribution of temperature, salinity and water mass circulation, migration of near bottom marine organisms and even the distribution of pollution, depend to a great degree on sea bed topography.

3. SPADE-WORK

The IBCM project was initiated by four scientists participating in the joint IOC/ICSEM/FAO Programme of Co-operative Investigations in the Mediterranean (CIM). This proposal was supported by IOC and ICSEM and as a result, a group of experts was formed into, what has become known as, the Editorial Board of IBCM. This group has met annually from 1974 until 1987.

The Chairman and Vice-Chairman, elected by members of the Editorial Board, were responsible for scientific guidance of the project. The Chief Editor was responsible for compilation of the ten sheets of the

chart on the basis of plotting sheets and other data, and for editing the chart, for printing colour-proof copies and for publication of the

International Bathymetric Chart of the Mediterranean (IBCM), on Mercator Projection on a scale of 1:1,000,000 (at 38° N.).

The national Scientific Co-ordinators were responsible for collecting data and for compilation of plotting sheets for national regions of responsibility.

The IOC/ICSEM Operational Unit for the Mediterranean was responsible for technical assistance in the period between the sessions and for co-ordination of effort of the participating countries of the Editorial Board.

Specifications adopted for compilation of the IBCM were improved from time to time and in 1986, they were approved by the IOC Consultative Group on Ocean Mapping as "Specifications for International Bathymetric Charts produced under IOC Regional Mapping Projects".

The main principles adopted for preparation of the IBCM were as follows:

a) Only data received from vessels positioned by satellite or Loran C techniques were used for compilation of the plotting sheets;

b) All echo-sounding depths were corrected by Matthews Tables.

4. COMPILATION

The IBCM Secretary in the IOC/ICSEM Operational Unit collected all the information received from national co-ordinators, Volunteering Hydrographic Offices and individual scientists and despatched this to the scientists responsible for compilation of the 1:250,000 plotting sheets in national regions of responsibility.

The completed plotting sheets were sent to the Chief Editor for editing and compilation on a scale of 1:1,000,000.

Approximately 80% of the data received were supplied from 3 main institutions:

> Osservatorio Geofisico Sperimentale (OGS) of Trieste, in co-operation with the SACLANT ASW Research Centre, La Spezia (329,500 km. of track echo sounding), and the British Department of Geodesy and Geophysics, Cambridge University (220,000 km. of track echo sounding).

Loran C measurements and accuracy of the navigational positioning of the research vessels depended on their location in relation to the transmitting stations; they fluctuated between ± 100 m. and ± 600 m. The spacing of sounding tracks, which varied from 3 km. to 25 km.,

influenced the accuracy of plotted bathymetric contours.

In addition to the above-mentioned sources of data, a considerable contribution was made by oil companies, particularly those with drilling platforms located on continental shelves. Some 25,000 km. of track echo sounding on the margin of Israel was provided by the Geological Survey of Israel.

The bathymetric contours were drawn at 100m intervals, but in certain cases, their density was increased to 50m and even to 10m as data permitted. Transparent overlay sheets of the bathymetric contours were made available, not only for the Chief Editor, but also for the national co-ordinators, in order that necessary adjustments at the edges of the adjacent sheets could be made.

National land maps were used for the topography of the land. The compiled plotting sheets were accompanied by overlay sheets showing source material, tracks, precision of the navigation and echosounding. The coast was taken from existing nautical charts. The Editorial Board did not attach importance to the selection of the geographical co-ordinate system since the maximum difference by of using different systems did not amount to more than 0.2 mm at the scale of the IBCM (1:1,000,000), i.e.: it was within the limits of graphical accuracy. The ellipsoid used had e.081813; a=6,378,295.

On completion of data collection, the participation of different institutions and scientists can be appreciated by study of the following table:

ORIGIN OF DATA COLLECTED FOR THE IBCM

	INSTITUTION or SCIENTIST	DATA	QUANTITY
1.	Scripps Institution of Oceanography (USA)	Plotting sheets	19
		Microfilms	14
2.	Defense Mapping Agency, Hydrographic Center (USA)	Plotting sheets:	
		1:250,000	41
		1:850,000	11
		Magnetic tape	1
3.	National Geophysical and Solar - Terrestrial Data Center (USA)	Microfilms	24
		Magnetic tape	1

4.	Prof. D. J. Stanley (USA)	Plotting sheet	1
5.	Hydrographic Department (UK)	Plotting sheets: 1:1,000,000	15
6.	Dr. Drummond Matthews (UK)	Plotting sheets: 1:250,000	10
7.	Esso Exploration (UK)	Listed depths Plotting sheets	1 book 2
8.	Hydrographic Service (USSR)	Plotting sheets: 1:250,000	101
9.	Istituto Idrografico della Marina (Italy)	Plotting sheets: 1:250,000	72
10.	Empresa Nacional de Petroleos de Aragon, S.A. (Spain)	Plotting sheets: 1:100,000	4
11.	California Oil Company of Spain (Spain)	Maps: 1:50,000	2
12.	ELF AQUITAINE Investigaciones Petroliferas, S.A. (Spain)	Maps: 1:100,000	2
13.	Empresa Auxiliar de la Industria (Spain)	Maps: 1:100,000 1:50,000	 1 1
14.	Deutsches Hydrographisches Institut (FRG)	Plotting sheets: 1:1,000,000	8
15.	Institut Français de Recherche pour l'Exploration de la Mer (IFREMER) (France)	Listed depths	about 20,000km
16.	Mobil Oil Libya Ltd. (Libya)	Plotting sheets: 1:100,000	2

5. EDITION

All the plotting sheets delivered to the Chief Editor were examined carefully for accuracy by comparison with the original source data. Careful attention was then paid to contours at sheet limits to ensure matching with sheets.

The minimum and maximum depths of the undersea features of the sea bed relief were checked, and feature names were cleared with the GEBCO Sub-Committee on Geographical Names and Nomenclature of Ocean Bottom Features before inclusion.

Not more than 2-3 names of cities and towns per square decimetre were shown, and preference was given to ports.

Line drawings of all sheets on a scale of 1:1,000,000, showing bathymetry, depths, ship tracks, topography of the land, names, etc., were printed for consideration by the members of the Editorial Board, and final approval.

Subsequently, after approval by the Editorial Board, the Line drawings were used for preparation of colour proofs and the final production sheets.

However, before printing, the members of the Editorial Board thoroughly checked the colour proofs to ensure that all corrections had been incorporated.

6. DIGITIZATION

After publication of the IBCM, a commercial firm acting for a consosrtium of oil companies, Petroconsultants S.A., offered to digitize the IBCM bathymetry. The Editorial Board of the IBCM, with permission from the Head Department of Navigation and Oceanography, Leningrad, as copyright holder, agreed to accept this offer on the condition that copies of the resulting tapes be supplied to the Secretary IOC for the use of members of the Editorial Board and sponsoring bodies of the programme.

By 1983 this work had been completed, and in June 1987, a magnetic tape of the digital data set was sent to the Chairman of the GEBCO Sub-Committee on Digital Bathymetry for evaluation. This evaluation included reformatting the tape from GEODAT format to the IOC general format GF-3, and preparation of hard copy for comparison with the printed charts. During the evaluation a large number of labelling and digitization errors were discovered.

It may be expected that edited magnetic tapes with these errors corrected will be available to the IBCM Community in early 1989.

7. PREPARATION OF THE GEOLOGICAL/GEOPHYSICAL SERIE

The success of the publication of the International Bathymetric Chart of the Mediterranean (IBCM) inspired the participants of this programme to prepare five separate series of geological/geophysical charts of the Mediterranean on the basis of the IBCM, as follows:

Bouguer Gravity anomalies
Seismicity
Magnetic anomalies
Plio-Quaternary/Messinian Structure
Unconsolidated Sea-Bed Sedimentation

The first series (Bouguer Gravity anomalies) is scheduled to be printed in early 1989 and will subsequently be followed by the publication of one further series each year.

8. UP-DATING BATHYMETRY FOR THE SECOND EDITION

After the publication of the IBCM, the 1:250,000 plotting sheets were, at the request of the IOC, transferred to the International Hydrographic Bureau, Monaco, in its capacity as the World Data Centre for Bathymetry. From there they were despatched to the Volunteering Hydrographic Offices for up-dating and continued maintenance.

New echo-sounding techniques, such as SEABEAM, SEAMARC, Deep Tow and other multibeam systems, providing new methods of improved representation of sea-bed topography, are now coming into more general use.

Results of the first surveys in the Mediterranean using such techniques have recently been received by IHB, for example, a survey south of Cyprus carried out by the Soviet Research Vessel "Academik Nikolai Strakhov".

It is expected that in due course a large area of the Mediterranean will be covered by such surveys and that the data will be used by the Voluteering Hydrographic Offices for up-dating bathymetric data base.

No.	Title	Publishing Body	Languages
32 Suppl.	Papers submitted to the UNU/IOC/Unesco Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the Context of the New Ocean Regime Paris, 27 September-1 October 1982	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
33	Workshop on the IREP Component of the IOC Programme on Ocean Science in Relation to Living Resources (OSLR) Halifax, 26-30 September 1983	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
34	IOC Workshop on Regional Co-operation in Marine Science in the Central Eastern Atlantic (Western Africa) Tenerife 12-17 December 1983	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish
35	CCOP/SOPAC-IOC-UNU Workshop on Basic Geo-scientific Marine Research Required for Assessment of Minerals and Hydrocarbons *in the South Pacific* Suva, Fiji, 3-7 October 1983	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
36	IOC/FAO Workshop on the Improved Uses of Research Vessels Lisbon, 28 May - 2 June 1984	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
36 Suppl.	Papers submitted to the IOC-FAO Workshop on Inproved Uses of Research Vessels Lisbon, 28 May-2 June 1984	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
37	IOC/Unesco Workshop on Regional Co-operation in Marine Science in the Central Indian Ocean and Adjacent Seas and Gulfs Colombo. 8-13 July 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
37 Suppl.	Papers submitted to the IOC/Unesco Workshop on Regional Co-operation in Marine Science in the Central Indian Ocean and Adjacent Seas and Gulfs Colombo, 8-13 July 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
38	IOC/ROPME/UNEP Symposium on Fate and Fluxes of Oil Pollutants in the Kuwait Action Plan Region Basrah, Iraq, 8-12 January 1984	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
39	CCOP (SOPAC)-IOC-IFREMER-ORSTOM Workshop on the Uses of Submersibles and Remotely Operated Vehicles in the South Pacific Suva, Fiji, 24-29 September 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
40	IOC Workshop on the Technical Aspects of Tsunami Analyses, Prediction and Communications Sidney, B.C., Canada, 29-31 July 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
40 Suppl.	IOC Workshop on the Technical Aspects of Tsunami Analyses, Prediction and Communications *Submitted Papers* Sidney, B.C., Canada, 29-31 July 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
41	First Workshop of Participants in the Joint FAO/IOC/WHO/IAEA/UNEP Project on Monitoring of Pollution in the Marine *Environment of the West and Central African* Region (WACAF/2) Dakar, Senegal, 28 October - 1 November 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
42	IOC/UNEP Intercalibration Workshop on Dissolved/Dispersed Hydrocarbons in Seawater Bermuda, USA, 3-14 December 1984 (in press)	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
43	IOC Workshop on the Results of MEDALPEX and Future Oceanographic Programmes in the Western Mediterranean *Venice, Italy, 23-25 October 1985*	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
44	IOC/FAO Workshop on Recruitment in Tropical Coastal Demersal Communities Ciudad del Carmen, Campeche, Mexico, 21-25 April 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock) Spanish
44 Suppl.	IOC/FAO Workshop on Recruitment in Tropical Coastal Demersal Communities - *Submitted Papers* Ciudad del Carmen, Campeche, Mexico, 21-25 April 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
45	IOCARIBE Workshop on Physical Oceanography and Climate Cartagena, Colombia, 19-22 August 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
46	Reunión de Trabajo para Desarrollo del Programa «Ciencia Oceanica en Relación a los Recursos No vivos en la Región del Atlantico Sudoccidental Porto Alegre, Brazil 7-11 de Abril de 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	Spanish
47	IOC Symposium on Marine Science *in the Western Pacific: The Indo-Pacific* Convergence Townsville, 1-6 December 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
48	IOCARIBE Mini-Symposium for the Regional Development of the IOC-UN (OETB) Programme on "Ocean Science in Relation to Non-Living Resources (OSNLR)"	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
49	AGU-IOC-WMO-CPPS Chapman Conference: An International Symposium on "El Niño" Guyaquil, Ecuador, 27-31 October 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
50	CCAMLR-IOC Scientific Seminar on Antarctic Ocean Variability and its Influence on Marine Living Resources, particularly Krill (organized in collaboration with SCAR and SCOR) Paris, France, 2-6 June 1987	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
51	CCOP/SOPAC-IOC Workshop on Coastal Processes in the South Pacific Island Nations, Lae, Papua-New Guinea, 1-8 October 1987	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
52	SCOR-IOC-Unesco Symposium on Vertical Motion in the Equatorial Upper Ocean and its Effects upon Living Resources and the Atmosphere Paris, 6-10 May 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
53	IOC Workshop on the Biological Effects of Pollutants Oslo, 11-29 August 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
54	Workshop on Sea-level Measurements in Hostile Conditions Bidston, UK, 28-31 March 1988	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
55	IBCCA Workshop on Data Sources and Compilation Boulder, Colorado, 18-19 July 1988	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
56	IOC/FAO Workshop on Recruitment of Penaeid Prawns in the Indo-West *Pacific Region (PREP)* Cleveland, Australia, 24-30 July 1988	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
57	IOC Workshop on International Co-operation in the Study of Red Tides and Ocean Blooms Takamatsu, Japan, 16-17 November 1987	IOC, Unesco Place de Fontenoy 75700 Paris, France	English