Intergovernmental Oceanographic Commission
Reports of Meetings of Experts and Equivalent Bodies

IOC Consultative Group on Ocean Mapping

Third Session

Bremerhaven, 7-9 December 1988

Unesco

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IOC/CGOM-III/3
Paris, 7 February 1989
English only

In this Series, entitled

Reports of Meetings of Experts and Equivalent Bodies, which was initiated in 1984 and which is published in English only, unless otherwise specified, the reports of the following meetings have already been issued:

1. Third Meeting of the Central Editorial Board for the Geological/Geophysical Atlases of the Atlantic and Pacific Oceans
2. Fourth Meeting of the Central Editorial Board for the Geological/Geophysical Atlases of the Atlantic and Pacific Oceans
3. Fourth Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of «El Niño» *(Also printed in Spanish)*
4. First Session of the IOC-FAO Guiding Group of Experts on the Programme of Ocean Science in relation to Living Resources
5. First Session of the IOC-UN(OETB) Guiding Group of Experts on the Programme of Ocean Science in relation to Non-Living Resources
6. First Session of the Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
7. First Session of the Joint CCOP (SOPAC)-IOC Working Group on South Pacific Tectonics and Resources
8. First Session of the IODE Group of Experts on Marine Information Management
9. Tenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies in East Asian Tectonics and Resources
10. Sixth Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
11. First Session of the IOC Consultative Group on Ocean Mapping *(Also printed in French and Spanish)*
12. Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ships-of-Opportunity Programmes
13. Second Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
14. Third Session of the Group of Experts on Format Development
15. Eleventh Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of South-East Asian Tectonics and Resources
16. Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
17. Seventh Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
18. Second Session of the IOC Group of Experts on Effects of Pollutants
19. Primera Reunión del Comité Editorial de la COI para la Carta Batimétrica Internacional del Mar Caribe y Parte del Océano Pacífico frente a Centroamérica *(Spanish only)*
20. Third Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
21. Twelfth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of South-East Asian Tectonics and Resources
22. Second Session of the IODE Group of Experts on Marine Information Management
23. First Session of the IOC Group of Experts on Marine Geology and Geophysics in the Western Pacific
24. Second Session of the IOC-UN(OETB) Guiding Group of Experts on the Programme of Ocean Science in relation to Non-Living Resources *(Also printed in French and Spanish)*
25. Third Session of the IOC Group of Experts on Effects of Pollutants
26. Eighth Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
27. Eleventh Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans *(Also printed in French)*
28. Second Session of the IOC-FAO Guiding Group of Experts on the Programme of Ocean Science in Relation to Living Resources
29. First Session of the IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials
30. First Session of the IOCARIBE Group of Experts on Recruitment in Tropical Coastal Demersal Communities *(Also printed in Spanish)*
31. Second IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
32. Thirteenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of East Asia Tectonics and Resources
33. Second Session of the IOC Task Team on the Global Sea-Level Observing System
34. Third Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
35. Fourth Session of the IOC-UNEP-IMO Group of Experts on Effects of Pollutants
36. First Consultative Meetings on RNODCs and Climate Data Services
37. Second Joint IOC-WMO Meeting of Experts on IGOSS-IODE Data Flow
38. Fourth Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
39. Fourth Session of the IODE Group of Experts on Technical Aspects of Data Exchange
40. Fourth Session of the Joint CCOP-IOC Working Group on Post IDOE Studies of East Asian Tectonics and Resources
41. Third Session of the IOC Consultative Group on Ocean Mapping

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1. OPENING OF THE SESSION

The Chairman, Mr Desmond P.D.Scott, opened the Third Session of the IOC Consultative Group on Ocean Mapping at the Alfred-Wegener-Institut, Bremerhaven, Federal Republic of Germany, at 09.30 on Wednesday 7 December 1988. 1.

Dr Dieter Fütterer welcomed the participants on behalf of the Director of the Institute, Dr Gotthilf Hempel. 2.

Apologies were received from Professor Michel Vigneaux and Dr Nestor Duch Gary. 3.

A full List of Participants is given in Annex V. 4.

2. ADOPTION OF THE AGENDA

The Agenda was adopted without any changes (see Annex I). 5.

3. CONDUCT OF THE SESSION; DOCUMENTATION

The Chairman announced the arrangements for the session. Dr Viktor Sedov in his capacity as Technical Secretary for the session presented the documentation and drew attention to certain documents which had been prepared for the information of the members of the Consultative Group. 6.

4. INTERSESSIONAL OCEAN MAPPING ACTIVITIES

The reviews given under this item were based on the reports of meetings of Ocean Mapping Editorial Boards. 7.

A List of Meetings of IOC Ocean Mapping Projects and their Summary Reports is given in Annex II. 8.

4.1 REPORT FROM THE JOINT IOC-IHO GUIDING COMMITTEE FOR THE GENERAL BATHYMETRIC CHART OF THE OCEANS (GEBCO)

4.1.1 Introduction

The Chairman of the Joint IOC-IHO Guiding Committee for GEBCO, Sir Anthony Laughton, provided information on the activities of the Guiding Committee during the intersessional period. 9.

4.1.2 Meetings held

The Guiding Committee had met 28-30 April 1987 in Paris and the GEBCO Officers had met 14-18 April 1988 in Wormley, United Kingdom. 10.

4.1.3 Membership

11. Sir Anthony reported on changes in the membership of the Guiding Committee:

(i) Rear Admiral V.K.Singh, Chief Hydrographer to the Government of India, replaced Rear Admiral A. Gerald Moraes (India).

(ii) Ingénieur en chef de l'Armement (hydrographe) Jean Laporte (France) replaced Ingénieur Général de l'Armement André Roubertou (France), Vice-Chairman GEBCO, on his retirement from the Service Hydrographique et Océanographique de la Marine.

12. New Scientific Advisers were appointed as follows:

(i) Dr.Ing.Hans-Werner Schenke, Alfred-Wegener-Institut für Polar- und Meeresforschung, Bremerhaven, Federal Republic of Germany.

(ii) Mr Nigel R.L.Gooding, Hydrographic Department, Taunton, United Kingdom, replaced Mr William Huddy.

13. New members of the GEBCO Sub-Committee on Digital Bathymetry:

(i) Dr Andrey Popov, Head Department of Navigation and Oceanography, Leningrad, U.S.S.R.

(ii) Dr.Ing.Hans-Werner Schenke, Alfred-Wegener-Institut für Polar- und Meeresforschung, Bremerhaven, Federal Republic of Germany.

14. New members of the GEBCO Sub-Committee on Geographical Names and Nomenclature of Ocean Bottom Features:

(i) Rear Admiral Alfredo Civetta (IHB) replaced Vice Admiral Orlando A.A.Affonso.

(ii) Ingénieur en Chef de l'Armement Jean Laporte, Service Hydrographique et Océanographique de la Marine, France, replaced Ingénieur Général André Roubertou.

4.1.4 Sub-Committee on Geographical Names and Nomenclature of Ocean Bottom Features

15. The Sub-Committee on Geographical Names and Nomenclature of Ocean Bottom Features held its seventh meeting in late April 1987, at IHB, Monaco, and since then has worked by correspondence.

16. The Chairman GEBCO reported that he had sent more than 70 letters to the editors of international scientific periodicals, inviting them to "consider the inclusion in their notes for authors of a clause requiring close scrutiny, and preferably referral of any new names used to the GEBCO Sub-Committee or to an appropriate national body, before new or controversial names are allowed into print".

17. The 'Gazetteer of Geographical Names of Undersea Features shown (or which might be added) on the GEBCO and on the IHO small-scale International Chart Series', together with a revised version of the English/French version of the publication 'Standardization of Undersea Feature Names', had been completed and published as IHB Publication no.BP-0008. The Representative of the IHO reported that the Gazetteer had been distributed to the Hydrographic Offices of all IHO Member States and would shortly be sent out on a list provided by the Permanent Secretary GEBCO, which included all persons whose names appear on the current GEBCO Personality List.

4.1.5 Sub-Committee on Digital Bathymetry

18. The GEBCO Sub-Committee on Digital Bathymetry held its Fifth Meeting, 12-13 April 1988, in Wormley, United Kingdom. By the end of 1988, digitization by the Bureau Gravimetrique International of the following sheets of the GEBCO (5th Edition) will have been completed:
5.13, 5.14, 5.15, 5.16 and 5.18 (Antarctic); and
5.01, 5.04, 5.08 and 5.17 (North Atlantic and Arctic).

19. Priorities for digitization during 1989 are as follows:
(i) 5.12 South Atlantic (coastline only);
(ii) 5.05 North Indian Ocean only, omitting the Mediterranean and Black Seas (already digitized as IBCM) and the area east of 90°E. (overlap with sheet 5.06);
(iii) 5.06 west of 100°E. (overlap with sheet 5.05);
(iv) 5.09 South Indian Ocean;
(v) 5.10 Australian and New Zealand waters;
(vi) Remainder of 5.06 Western North Pacific;
(vii) 5.03, 5.07 and 5.11 Eastern Pacific.

20. The Head Department of Navigation and Oceanography (USSR) will complete digitization of sheet 5.02 North-west Pacific, including ship tracks and geographical names, by April 1989.

21. Sheet 5.12 South Atlantic is being revised and will be digitized when the new edition becomes available.

22. A small Task Team has been created to investigate the usage of digitized maps and of Digital Terrain Models (DTMs).

4.1.6 GEBCO Reviewers

23. The Chairman GEBCO recalled that GEBCO Reviewers were being appointed as and when digitization of appropriate blocks of GEBCO (5th Edition) contours became available on magnetic tape, and it was planned that eventually these would cover the world's oceans. He reported that he and the Permanent Secretary GEBCO had prepared a Job Description for GEBCO Reviewers which was awaiting final adoption by the GEBCO Guiding Committee.

24. It was noted in discussion that Quality Control of new blocks of contours for inclusion in the GEBCO World Bathymetric Digital Database would be the responsibility of the compilers, together with the relevant GEBCO Reviewers, not of the U.S. National Geophysical Data Center or of the IHO Centre for Digital Bathymetry. This matter would be discussed further at the next session of the GEBCO Guiding Committee.

4.2 REPORT FROM THE CENTRAL EDITORIAL BOARD FOR THE INTERNATIONAL GEOLOGICAL/GEOPHYSICAL ATLASES OF THE ATLANTIC AND PACIFIC OCEANS (GAPA)

25. The Chief Editor GAPA, Dr Gleb B.Udintsev, reported on the state of preparation of the Atlases for printing.

26. The Atlantic Atlas is close to publication and the completed atlas is expected to be displayed during the International Geological Congress in Washington DC, 9-14 July 1989, and at the XVth Session of the IOC Assembly, 4-19 July 1989, when orders will be accepted. The Pacific Atlas is due for publication about two years later (in 1991).

27. The Chief Editor GAPA stated that the Soviet authorities expect to receive 36 roubles for each atlas through the Soviet sales agency 'Sojuzkarta'. However the sales price if purchased outside the Soviet Union will be higher and will depend on the mark-up by the sales agent.

4.3 REPORT FROM THE EDITORIAL BOARD FOR THE INTERNATIONAL BATHYMETRIC CHART OF THE MEDITERRANEAN AND ITS GEOLOGICAL/GEOPHYSICAL SERIES (IBCM)

28. The Chairman IBCM, Professor Carlo Morelli, reported that the Editorial Board had held its third session in Unesco House, Paris, 30 November-4 December 1987 and ad hoc consultations between members of the Board in Athens, Greece, during the XXXIst ICSEM Congress, 17-21 October 1988.

29. He then reported on progress with the preparation of the IBCM geological/geophysical series. It is expected that the Bouguer Gravity Anomalies series will be published in mid-1989

and the Seismicity series before the end of the year. They will both be accompanied by explanatory texts which will eventually form part of a Supporting Volume.

Preparation of the Magnetic Anomalies series, the Plio-Quaternary/Messinian Sediments series and the Unconsolidated Sea-Bed Surface Sediments series is at an advanced stage, in spite of a lack of data from some regions. *30.*

The IBCM (bathymetry) and its Geological/Geophysical series, with the Supporting Volume, will eventually be issued in the form of Boxed Sets for library use. *31.*

It was recalled that it had been agreed that archiving of digital data and maintenance of 1:1 million or 1:250,000 plotting sheets would have to exist in parallel for the foreseeable future, until such time that all Volunteering Hydrographic Offices could handle Digital Data. Responsibility for maintenance of the IBCM 1:250,000 Plotting Sheets had been allocated to, and accepted by, appropriate Hydrographic Offices but no Hydrographic Office had, as yet, accepted responsibility for the Black Sea. The Representative of the IHO was asked to approach the Hydrographic Offices of the U.S.S.R. and Turkey, and to try to get the problem resolved. *32.*

4.4 REPORT FROM THE EDITORIAL BOARD FOR THE INTERNATIONAL BATHYMETRIC CHART OF THE CARIBBEAN SEA AND GULF OF MEXICO (IBCCA)

In the absence of the Chairman IBCCA, Dr Nestor Duch Gary, Dr Viktor Sedov provided information on progress with the IBCCA. *33.*

Following a recommendation of the XIVth Session of the IOC Assembly, the title of the Chart had been changed to 'International Bathymetric Chart of the Caribbean Sea and Gulf of Mexico'. A new Assembly Diagram of the sheets had been adopted (see Annex III). *34.*

Priorities for compilation of sheets were determined: sheets 1-01 to 1-10 (i.e. the whole region north of 15°N.) are expected to be compiled in time for presentation to the next session of the Editorial Board in 1990. *35.*

4.5 STATE OF PREPARATION FOR THE FIRST SESSIONS OF THE EDITORIAL BOARDS OF THE INTERNATIONAL BATHYMETRIC CHART OF THE WESTERN INDIAN OCEAN (IBCWIO) AND THE INTERNATIONAL BATHYMETRIC CHART OF THE CENTRAL EASTERN ATLANTIC (IBCEA)

The Chief Editor IBCWIO, Dr Werner Bettac, informed the Consultative Group that nominations for membership of the Editorial Board had been received from eight countries. *36.*

37. Selection and appointment of the Board would be completed shortly. The first session of the Editorial Board is expected to be held in Antananarivo, Madagascar, in early-April 1989.

38. The Tech.Sec. provided information on the state of preparation for the first session of EB/IBCEA. Only five nominations from the countries of the region had as yet been received. A Circular Letter had been sent out more than a year ago, and a second request for nominations had been sent recently to countries which had not responded to the original letter, but no further nominations had as yet been received. The first session of the EB/IBCEA is planned for June 1989 in Dakar, Senegal.

39. Dr Sedov reported that he had attended the second session of the Hydrographic Commission for the Eastern Atlantic (Cadiz, Spain, September 1988) and had taken the opportunity to provide that group with details of the IBCEA project. Delegates from some countries had agreed to consider future involvement in the IBCEA.

40. The Consultative Group noted that no firm agreement had as yet been reached with any country regarding printing and publication of this series. It was considered that this was an essential preliminary before any compilation work was started; the Secretary IOC was therefore requested to formalise the verbal agreement that it was understood had already been reached with the Service Hydrographique et Océanographique de la Marine, France, if possible before the first session of the Editorial Board.

5. CONSIDERATION OF CLOSER COLLABORATION BETWEEN IOC AND IHO IN THE DEVELOPMENT OF THE REGIONAL OCEAN MAPPING PROJECTS

41. The Chairman introduced the item and referred to a letter dated 14 June 1988 from Rear Admiral Alfredo Civetta, Director IHO, to the Secretary IOC, in which he had noted that "the experience gained during the compilation of the IBCM and the problems encountered, mainly due to the lack of involvement from the outset of the IHO Hydrographic Offices in the preparation and maintenance of the plotting sheets, had led (the IHB) to the conviction that it is essential to establish, in the early stages of each future IOC project, a more active participation amongst the hydrographic community."

42. Admiral Civetta said that IHB was seeking a more formal collaboration between IHO and IOC in the Editorial Boards of the IOC Regional Ocean Mapping projects, bearing in mind the important roles of Hydrographic Offices in assisting in compilation of data and in printing of the charts, as well as of IHO as the World Data Centre for Bathymetry.

43. The Group concurred fully and after consideration, and in agreement with the Representative of the IHB, decided to inform the Secretary IOC that it was the considered opinion of the CGOM that:

(i) strengthening of the close collaboration between IOC and IHO would be beneficial for both organizations;
(ii) it would be undesirable to establish a new joint IOC/IHO Sub-Committee for the regional International Bathymetric Chart series;
(iii) IHB should be invited to nominate (at their own expense) a full member for:
a) the IOC Consultative Group on Ocean Mapping (CGOM);
and b) each of the IOC Editorial Boards for regional International Bathymetric Charts; and
(iv) IHB should be approached to invite an IOC observer to participate in sessions of appropriate IHO Regional Hydrographic Commissions, subject to the prior approval of each Hydrographic Commission.

44. It was noted (doc. IOC/INF-781) that, besides IHO, closer collaboration with the International Commission for the Scientific Exploration of the Mediterranean Sea (ICSEM) in the IBCM project was also considered desirable. The Secretary IOC was therefore asked to approach the Secretary-General ICSEM with an invitation to co-operate in the project and to nominate a full member (at their own expense) to the IBCM Editorial Board.

6. COPYRIGHT OF DIGITIZED BATHYMETRIC CONTOURS FROM THE GEBCO AND IOC'S REGIONAL INTERNATIONAL BATHYMETRIC CHART SERIES

45. The Chairman recalled that the contours of the International Bathymetric Chart of the Mediterranean (IBCM) had been digitized by Petroconsultants S.A. which firm had placed the tapes on sale at a high price, with a number of statements regarding copyright in their sales/publicity brochure that are not acceptable to IOC.

46. He reported that, at the request of the Secretary IOC, he had investigated the matter and had discovered that at no time had any approach been made by Petroconsultants to either the IOC (as sponsor of the IBCM) or to the copyright holder, the Head Department of Navigation and Oceanography, Leningrad, USSR (as stated on each sheet of the printed map series), to obtain permission to digitize the IBCM contours.

47. It appeared that a verbal discussion had been held in September 1980 between a representative of Shell Internationale Petroleum Maatschappij B.V. and a former Director IHO who had duly reported on this approach to the IBCM Disciplinary Group on Overlay Sheets in Marine Geology and Geophysics at its Third Session in June 1982. On the strength of this information the Secretary IOC had written to the Chief Editor IBCM, Dr V.Faleev, (letter dated 16 July 1982) on the subject but Dr Faleev was very ill at the time (he died shortly thereafter)

and no reply had ever been received. It appears that the correspondence then lapsed and permission to digitize the IBCM contours was never either formally requested by, or granted to, Petroconsultants S.A.

48. The Chairman said he had laid these facts before the Copyright Division of UNESCO and they had stated that, in their opinion, "digitization without such permission would be an infringement of copyright". From this it follows that if Petroconsultants infringed copyright in digitizing the IBCM contours, then, despite the statements in their sales/publicity brochure, they can have no legal right to any copyright on their product (the magnetic tapes in GEODAT format containing the IBCM digitized contours).

49. Whilst there is no intention of taking action against Petroconsultants S.A. regarding infringement of copyright, which it is accepted might have been done in good faith, it is clear that Petroconsultants can have no legal grounds for objection if IOC (or the copyright holders) were to sell their magnetic tapes of the digitized IBCM contours, which are an improvement (value added) on the Petroconsultants original and in a different (the international GF3) format.

50. At the request of IOC, the Marine Information and Advisory Service (MIAS), United Kingdom, has taken the Petroconsultants tape, modified it to a considerable extent for discrepancies and ambiguities by going back to the original compilers when in doubt [Petroconsultants have stated that "we made no attempt to reconcile the sometimes serious discrepancies that were to be found in the compiled maps" (letter dated 25 June 1986)], and produced a final clean tape in international GF3 format for scientific use and, if appropriate, for sale to both scientific and commercial users. It will also be incorporated into the GEBCO World Bathymetric Digital Database in lieu of contours from GEBCO sheet 5.05.

51. It was also noted that:

(i) the Head Department of Navigation and Oceanography, Leningrad, is also digitizing the IBCM contours (in GF3 format) and that a comparison of the two products will in due course be carried out as a quality control exercise; and

(ii) that copyright of the magnetic tapes of the GEBCO (5th Edition) contours, being digitized by IGN/BGI in agreement with the Canadian Hydrographic Service (as copyright holders of the printed map series), will remain with IGN, which institute has agreed to charge only a 'symbolic' royalty to scientific users. These tapes, which will form the basis of the GEBCO World Bathymetric Digital Database, are being checked and edited by the Marine Information and Advisory Service (MIAS), United Kingdom, and copies will be placed on sale at a price to cover royalty and reproduction/ despatch costs.

7. USAGE OF DIGITIZED MAPS AND POSSIBLE DEVELOPMENT OF DIGITAL TERRAIN MODELS (DTMs)

52. Dr Hans-Werner Schenke introduced this subject and made a lengthy presentation to the Group on his experience with Digital Terrain Models (DTMs). A resume of his paper is attached as Annex IV.

53. After discussion, the Group agreed that development of DTMs will be very valuable, not only for the large variety of DTM products of direct relevance to users, but also for their potential use in quality control and, in particular, for improving the quality of bathymetric contouring.

54. The Group recommended that copies of both the report in Annex V and the report of the GEBCO Task Team on the Usage of Digitized Maps and DTMs (paragraph 22 above) be sent to all members of IOC Editorial Boards for their information.

8. CONTRIBUTION BY CGOM TO THE WORLD DIGITAL DATABASE FOR ENVIRONMENTAL SCIENCE (WDDES), IN THE CONTEXT OF ICSU's INTERNATIONAL GEOSPHERE/BIOSPHERE PROGRAMME (IGBP)

55. The Secretary reported on the development of ICSU's International Geosphere/Biosphere Programme (IGBP) which has as its main objective:

> "to describe and understand the interactive physical, chemical and biological processes that regulate the total earth system, the unique environment that it provides for life, the changes that are occurring in this system and the manner in which they are influenced by human actions."

56. One step in support of the development of the IGBP was the creation by the International Geographical Union (IGU) and the International Cartographic Association (ICA) of a joint Working Group on Environmental Atlases and Maps, with the task of exploring the feasibility of developing a standard global dataset in a modern topologically structured form. This project has been entitled the World Digital Database for Environmental Science (WDDES).

57. The above Working Group has decided that, so far as possible, the scale should be 1:1 million (about 1km resolution), and that the following should be portrayed:

(i) Coastlines;
(ii) Drainage networks (rivers, lakes, etc.);
(iii) Land relief (contours at c.300m interval; spot heights);
(iv) Bathymetry (contours at 100m interval; depth values);
(v) Statistical (e.g. provincial) boundaries;
(vi) Built-up areas;
(vii) Place names of the above.

The estimated size of such a database is about 3 gigabytes (January 1988).

58. The CGOM queried the contour interval proposed above for bathymetry and recommended that the GEBCO standard, which provides for contours at 200m, 500m, 1,000m and thence at 1,000m intervals [viz.: Specifications for the GEBCO (5th Edition), item 403], be adopted. Additional contours at regular intervals might be portrayed where the density of data permits.

59. It is planned that the following sources will be used in the preparation of the WDDES:

(i) Operational Navigational Chart (ONC) series, scale 1:1M. (for the land);
(ii) General Bathymetric Chart of the Oceans (GEBCO), scale 1:10M. (for the oceans);
(iii) Direct digital processing by the Scott Polar Research Institute (SPRI), Cambridge, U.K. (for Antarctica);
(iv) A digital database, scale 1:1M., being produced by the National Mapping Agency, Australia.

60. The CGOM recommended that the GEBCO World Bathymetric Digital Database be used, as this will incorporate blocks of data (e.g. the Mediterranean and Black Seas from the IBCM) which have been digitized on a considerably larger scale than the GEBCO (5th Edition).

61. It was noted that most of the GEBCO (5th Edition) was compiled from contoured plotting sheets on scales of 1:1M. (and larger), though there are no plans to digitize the contours at this scale.

62. It now appears that future development of the WDDES will be co-ordinated and funded by Pergamon Press, with a quality control group, on which the CGOM will be represented, to be set up by ICSU.

63. The volume of digitized information required from GEBCO is estimated to be about 5% of the total, although CGOM believes that the expressed need for greater detail would require more than this.

64. A magnetic tape of one digitized GEBCO sheet (5.14 - Antarctic waters south of Australia & New Zealand) was provided to the Chairman of the Joint IGU/ICA Working Group in April 1988, 'for a trial and to ascertain the feasibility of incorporation of all the GEBCO tapes into the WDDES'. None of the 'shortcomings' listed on 4 May 1988 were unexpected or of particular concern to MIAS, though some will require additional work and therefore funding.

65. However one stated 'shortcoming' reads as follows: "Reliability indications are specially important in the bathymetry and methods of representing this need discussion with

oceanographers". The CGOM decided that the Chairman of the Joint Working Group should be asked:
(i) What technology would he suggest be shown on the face of the chart, or on any system giving a visual indication of bathymetry, e.g. DTMs?
(ii) Could he provide concrete examples of options? and
(iii) How does he 'tag' reliability'?

66. Another 'shortcoming' states "I am assuming that the ONC coastlines will be superior to the GEBCO one ...". The CGOM recalled that the GEBCO coastline, apart from Antarctica, had been taken from IGN's Carte Generale du Monde, whereas it was understood that the ONC coastline came from a number of different sources and varied in accuracy in different areas. All the discrepancy referred to (e.g. in Sumatra) indicates that the coastlines in that area shown on the ONC map and on the GEBCO are different, not that one of them is superior to the other.

67. It was decided to carry out an investigation to find out what is the best world coastline in existence at the present time, using such criteria as its source (e.g. from satellite data) and the number of points per kilometre on the coast. The Representative of the IHO was asked to approach the United States Defense Mapping Agency; other enquiries would be made to the U.S. National Geophysical Data Center (NGDC), the Central Intelligence Agency (CIA), the NERC Unit for Thematic Information Systems (NUTIS), United Kingdom, and the Institut Geographique National (IGN), France.

68. It was noted that it might be feasible to incorporate the digitized land material from the ONC series into IOC's regional International Bathymetric Chart series.

69. The CGOM was also informed of a United Nations Environment Programme (UNEP) project to produce a global data base, the coastline having been digitized at GRID. It is understood that this project may be sponsored by IBM.

70. Since both the WDDES and the UNEP GRID project are commercial operations, CGOM recommended that a careful estimate should be made of the value of the GEBCO World Bathymetric Digital Database, and that this should be taken into account in any negotiations for its incorporation into a larger database, bearing in mind the situation regarding copyright (item 6 above).

9. REPORT ON IOC's OCEAN MAPPING ACTIVITIES FOR SUBMISSION TO THE FIFTEENTH SESSION OF THE IOC ASSEMBLY

71. The Chairman presented the draft of a report by the Chairman GEBCO, which had been prepared for inclusion in the

1988 Annual Report of the IHB. This report (with any updating considered necessary) will form the first part of the biennial report of CGOM on IOC's Ocean Mapping Activities, for submission to the XVth session of the IOC Assembly, 4-19 July 1989.

72. The Chairmen of all the other IOC Ocean Mapping subsidiary bodies were invited to submit short reports on their activities since IOC-XIV (1 April 1987), by a deadline of end-March 1989, for incorporation in the biennial report. The Tech.Sec. was instructed to transmit this requirement to the Chairman IBCCA and to prepare a short report himself on the IBCEA, if by then no Chairman had been appointed.

10. SALES AND PUBLICITY

73. The Chairman GEBCO reported that sales and free distribution of the GEBCO now amounted to over 40,000 flat sheets and nearly 700 Boxed Sets.

74. Two GEBCO publicity exhibits showing the results of the digitization work have been prepared and were displayed at the Joint Oceanographic Assembly, Acapulco, Mexico, 23-31 August 1988, and at the Sixth Biennial International Symposium of the Hydrographic Society, Amsterdam, 5-17 November 1988, where they attracted a considerable amount of interest.

75. One of the GEBCO exhibits, and also the GAPA Atlantic Ocean Atlas, will be displayed at the 28th International Geological Congress, Washington DC, 9-14 July 1989, and at the XVth session of the IOC Assembly, 4-19 July 1989.

76. It was suggested that the same exhibits could be displayed at the next session of the Central Editorial Board for GAPA, together with its accompanying Symposium on Geological/ Geophysical Mapping of the Pacific Ocean, Yuzhno-Sakhalinsk, 11-16 September 1989, and another at the next meeting of the Antarctic Treaty countries also in September 1989.

77. The Chairman IBCM reported that the IBCM had been displayed at the Mediterranean Basins Conference of the American Association of Petroleum Geologists (AAPG), Nice, France, 25-28 September 1988 and also, together with proofs/computer printouts of the Bouguer Gravity and Seismicity maps of the IBCM Geological/ Geophysical series, at the XXXIst Congress of ICSEM, Athens, 17-21 October 1988. He distributed copies of IBCM postcards which had been printed for publicity purposes.

78. The Chairman IBCM was asked to include in his short report for incorporation in the CGOM biennial report to the IOC Assembly (para. 72 above) some details of sales of the IBCM since publication in 1982.

11. DATE AND PLACE OF THE NEXT SESSION

79. It was tentatively agreed that the next (fourth) session of the Group would be held 5-8 December 1989 at a place to be decided later.

12. ADOPTION OF THE SUMMARY REPORT

80. The Summary Report was adopted before closure of the session but the Secretary was instructed to clear appropriate parts with participants who had had to leave early.

13. CLOSURE OF THE SESSION

81. The Chairman closed the session at 16.00 on Friday 9 December 1989, and in so doing thanked the Director AWI and his staff for the hospitality and administrative support that had been provided.

ANNEX I

AGENDA

1. OPENING OF THE SESSION

2. ADOPTION OF THE AGENDA

3. CONDUCT OF THE SESSION; DOCUMENTATION

4. INTERSESSIONAL OCEAN MAPPING ACTIVITIES
   - 4.1 Report from the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans (GEBCO)
   - 4.2 Report from the Central Editorial Board for the Geological/Geophysical Atlases of the Atlantic and Pacific Oceans (GAPA)
   - 4.3 Report from the Editorial Board for the International Bathymetric Chart of the Mediterranean and its Geological/Geophysical Series (IBCM)
   - 4.4 Report from the Editorial Board for the International Bathymetric Chart of the Caribbean Sea and Gulf of Mexico (IBCCA)
   - 4.5 State of Preparation for the First Sessions of the Editorial Boards for the International Bathymetric Chart of the Western Indian Ocean (IBCWIO) and the International Bathymetric Chart of the Central Eastern Atlantic (IBCEA)

5. CONSIDERATION OF CLOSER COLLABORATION BETWEEN IOC AND IHO IN THE DEVELOPMENT OF THE REGIONAL OCEAN MAPPING PROJECTS

6. COPYRIGHT OF DIGITIZED BATHYMETRIC CONTOURS FROM THE GEBCO AND IOC'S REGIONAL INTERNATIONAL BATHYMETRIC CHART SERIES

7. USAGE OF DIGITIZED MAPS AND POSSIBLE DEVELOPMENT OF DIGITAL TERRAIN MODELS (DTMs)

8. CONTRIBUTION BY CGOM TO THE WORLD DIGITAL DATABASE FOR ENVIRONMENTAL SCIENCE (WDDES), IN THE CONTEXT OF ICSU'S INTERNATIONAL GEOSPHERE/BIOSPHERE PROGRAMME (IGBP)

9. REPORT ON IOC'S OCEAN MAPPING ACTIVITIES FOR SUBMISSION TO THE FIFTEENTH SESSION OF THE IOC ASSEMBLY

10. SALES AND PUBLICITY

11. DATE AND PLACE OF THE NEXT SESSION

12. ADOPTION OF THE SUMMARY REPORT

13. CLOSURE OF THE SESSION

ANNEX II

LIST OF MEETINGS OF IOC OCEAN MAPPING PROJECTS AND THEIR SUMMARY REPORTS

Second Session of the IOC Consultative Group on Ocean Mapping (CGOM), Paris, 12-13 February 1987 (doc. IOC/CGOM-II/3);

Fourth Meeting of the GEBCO Sub-Committee on Digital Bathymetry, Boulder, Colorado (USA), 18-20 March 1987 (doc. IOC-IHO/GEBCO SCDB-IV/3);

Seventh Meeting of the GEBCO Sub-Committee on Geographical Names and Nomenclature of Ocean Bottom Features, Monaco, 25-27 April 1987 (doc. IOC-IHO/GEBCO SCGN-VII/3);

Eleventh Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans (GEBCO), Paris, 28-30 April 1987 (doc. IOC-IHO/GEBCO-XI/3);

Seventh Session of the Central Editorial Board for the International Geological/Geophysical Atlases of the Atlantic and Pacific Oceans (GAPA), Moscow, 5-9 October 1987;

Third Session of the Editorial Board for the International Bathymetric Chart of the Mediterranean and its Geological/ Geophysical Series (IBCM), Paris, 30 November-4 December 1987 (doc. IOC/EB-IBCM-III/3);

Ad hoc Informal Consultations between Members of the Editorial Board for the IBCM and other Experts, Paris, 7-10 March 1988 (doc. IOC/INF-696);

Fifth Meeting of the GEBCO Sub-Committee on Digital Bathymetry, Wormley (UK), 12-13 April 1988 (doc. IOC-IHO/GEBCO SCDB-V/3);

Sixth Meeting of the GEBCO Officers, Wormley (UK), 14-15 April 1988 (doc. IOC-IHO/GEBCO Officers-VI/3);

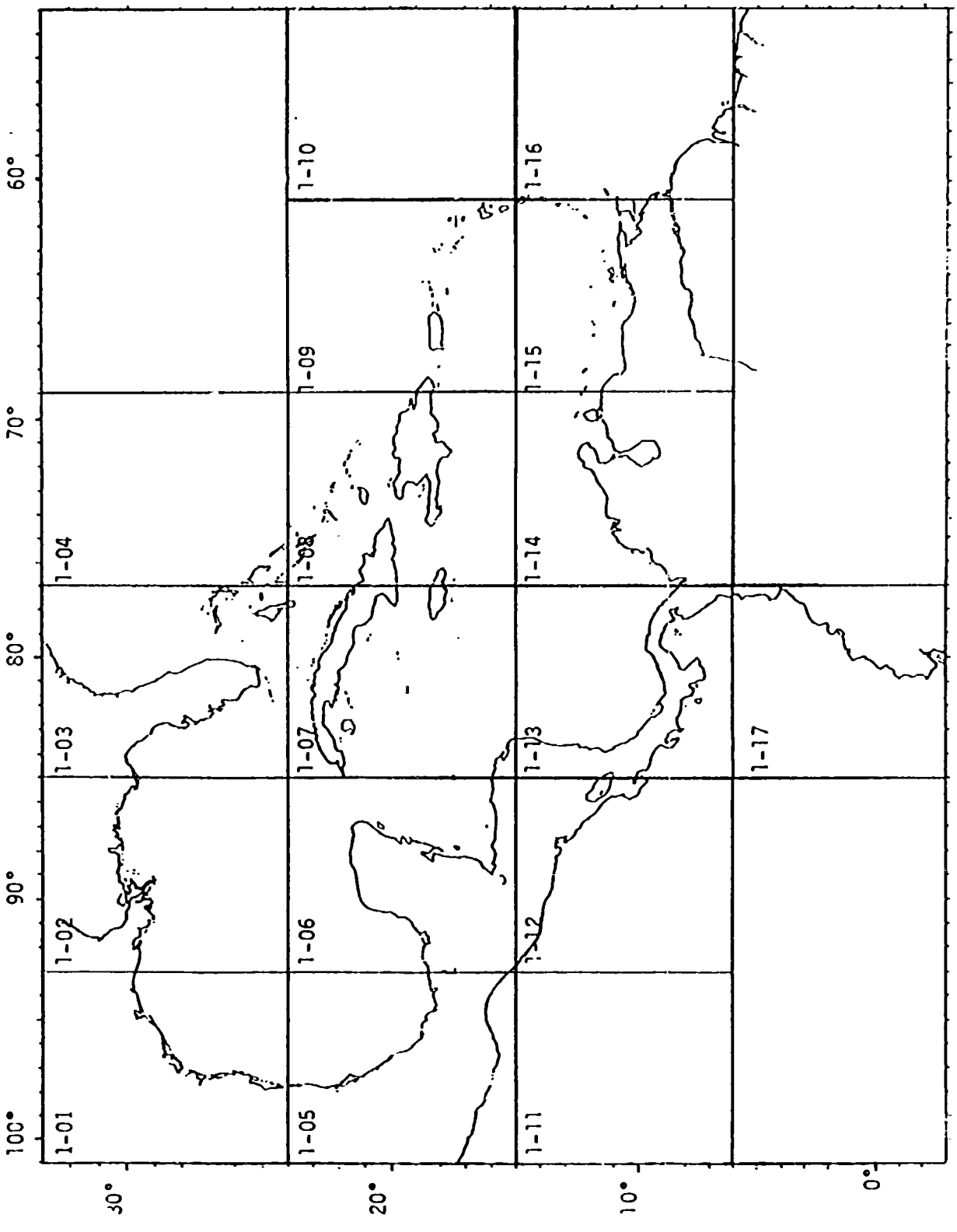
Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and Gulf of Mexico (IBCCA), Boulder, Colorado (USA), 20-22 July 1988 (doc. IOC/EB-IBCCA-II/3);

Eighth Session of the Central Editorial Board for the International Geological/Geophysical Atlases of the Atlantic and Pacific Oceans (GAPA), Kishinev (USSR), 12-16 September 1988;

Ad hoc Informal Consultations between Members of the Editorial Board for the IBCM and other Experts, Athens, 17-22 October 1988 (doc. IOC/INF-781);

ANNEX III

ASSEMBLY DIAGRAM FOR THE INTERNATIONAL BATHYMETRIC CHART OF THE CARIBBEAN SEA AND GULF OF MEXICO (IBCCA)
Scale: 1:1,000,000 at 15°N.



ANNEX IV

DIGITAL TERRAIN MODELS IN MARINE CARTOGRAPHY

by Dr H.-W.Schenke
Alfred-Wegener-Institut für Polar- und Meeresforschung
Bremerhaven, Federal Republic of Germany

Introduction

Digital Terrain Models are increasingly becoming important as a source for geographical and morphological analysis and digital mapping.

In the wake of the fast-developing computer technology DTMs are becoming more and more useful. DTMs are used nowadays not only in Geographical Information Systems, Remote Sensing and the Geosciences, but also in Geography, Oceanography, etc. Possible application areas include terrain analysis (e.g. slope, aspect, visibility) and erosion studies. Various display products (e.g. contour lines, shaded relief, profiles, three-dimensional perspective views) can be derived from DTMs.

Since the 1970s, intensive research has been carried out to improve interpolation techniques and the algorithm used, especially for the study of morphology and the identification of significant structural trends for interpolation purposes. The automatic determination of morphological or surface structure lines is today an important objective.

Furthermore the determination of derived DTM products and their quality analysis, one of the most serious possibilities for bathymetry, is of high interest. Because the seabed is not visible, DTMs are fundamental elements for the development of marine cartographic databases. With smoothing techniques, small-scale charts may be developed from DTMs and last (but certainly not least) DTMs will become the main component and basis for automatic nautical charts (the so-called electronic chart).

Definition of DTMs

A Digital Terrain Model (DTM) can be defined as any machine-readable representation of the topography from the earth's surface as well as from the seabed. In the field of marine cartography two different types of DTMs are of interest:

- the model with direct digitized contour lines; and
- the universal Digital Terrain Model (DTM).

The DTM is a simplification of the real world, derived by computing a matrix of discrete depth values from all available data in the area. It is prepared by computer processing and systematic modelling, and may be seen as a variable scale map, the maximum accuracy of which is only limited by the accuracy

of the basic measured data. A general bathymetric DTM is substantially nothing more than a matrix containing the water depths of the grid cells. Each DTM contains a header line with the number of rows and columns of the matrix and the co-ordinates of the area corner points. In addition for each grid element a quality or accuracy value can be given as well as information about the interpolation algorithm and morphological structure lines. An important advantage of DTMs is that they can be stored easily on computer disks.

Types of Digital Terrain Models

1. Model with Direct Digitized Contours

Digitization is conversion of analogue cartographic material to digital computer representation by means of electronic, optical, laser, solid state or mechanical processes. The most common forms of digitization are manual, automatic, line-following and raster scanning.

Digitization is usually carried out at constant time- or distance-intervals. Time-constant digitizing is to be preferred because of a closer point sequence on the curves, due to slower manual line following.

Advantages: Faster plotting of contour lines; easy and quick smoothing for smaller scales.

Disadvantages: For bathymetric charts covering different and heterogeneous morphology of the continental slope and abyssal plains, DTM determination is very computer time-consuming, especially transfer from digitized isolines to a gridded DTM, and interpolation is more complex. Only with a DTM would it be possible to combine new data with a digitized chart.

2. The Universal Digital Terrain Model

The Universal Digital Terrain Model contains the mean or discrete depths of a regular raster, the co-ordinates of the corner points, the number of rows and columns of the model, and additional information such as structure lines, fault lines, break lines, significant terrain points, holes, etc., and, also in the form of a regular raster, corresponding estimates of the accuracies, if available.

The grid or raster width needs to be chosen so that linear interpolation between adjacent points on the grid or along the morphological structure lines is possible.

Problems with DTM-determination for Bathymetry

The seabed is very heterogeneous. For the determination of DTMs of the seafloor, standard values for the various model parameters, such as grid width, search radius, fitting surface, etc., cannot be given, especially when the sample point data distribution is not regular.

The main problem with DTM-determination for bathymetry is the task of determining a regular gridded base from irregularly distributed data. The assumption of normal distribution of the measurements is not valid for bathymetry.

With bathymetry, maximum data distribution is along the profiles. A reduction of this influence on the DTM-determination can only be achieved by special search and selection procedures for the used sample points. With multi-beam surveys, the problem is easier to solve using a moving averaging technique along track. Considerable experience is required for the modelling and determination of DTMs.

Bathymetric Data of different Origin and Quality

Bathymetric surveying has a long history. Systematic echo-sounding surveys have been carried out for more than half a century. The accuracy of the isolines depends directly on the accuracy of the depth measurement combined with positional accuracy. Over the last 50 years positional accuracy has improved from ±5km to ±500m (with Integrated Navigation System), to better than ±50m (with GPS). In nearshore areas, ±5m accuracies are possible with radio navigational systems. This shows clearly the difference in quality of so-called 'old' bathymetric data, as used to compile most nautical charts, and data from modern precision surveys.

As it is not feasible to discard all the 'old' data, it is necessary to combine it with newer measurements, taking into account both positional and depth measurement accuracies. This is a difficult problem which cannot be solved with the help of software alone; human intelligence is also needed to compile new bathymetric maps from these different data sources. This is where scientists, working as interactive computer graphics editors, become a necessity.

Variation in the Accuracy of Multi-beam Systems

Spurious and erroneous measurements must be edited out from single- and multi-beam sonar data. Incorrect data will show up in the DTM and produce artifacts. Data 'snooping' should be carried out in near-real-time which means at sea whilst the

survey is in progress. With multi-beam systems the size of the reflected sea bottom area increases with larger beam fan centre angles; this has to be taken into account when defining parameters such as grid widths, search radius, etc. for the DTM determination.

The Use and Determination of DTMs

One very important result of a DTM determination is the listing of values for Standard Deviations, for the entire DTM or for single elements. Highly sophisticated post-processing techniques running on large Main Frame computers can be used for final map compilation, or fast programs for a quick look and data check on low cost PCs.

"KRIGING"

"Kriging", as a computer technique for DTM determination and for plotting the cartography of the sea floor, was first introduced more than ten years ago in an article in the International Hydrographic Review, which showed some results and presented a number of computation procedures. This technique, which takes into account the surrounding relief structure, was developed by Professor G.Matheron from the French Institut de Geostatistique in Fontainebleau; it was named after D.G.Krige, a mining specialist.

The problems associated with the determination and plotting of isolines is not new; various methods have been developed by way of solution, e.g. Least Squares Adjustment, bi-cubic spline functions, moving polynomial surfaces, etc. But all these models lead to solutions which take only small account of the spatial structure of the variable. They are, moreover, not even capable of analysing this structure. As a result the same estimations will be given whether the variable is regular, such as the bathymetry of an abyssal plain, or chaotic, as with a fracture zone.

The "Kriging" technique does however take into account the structure of the phenomenon by employing a 'structural function': the Semi-Variogram, which is determined on the basis of sample points. "Kriging" is in fact very similar to Least Squares Prediction, the main difference being that "Kriging" uses the morphological structures for interpolation and for this reason is the best technique that can be used for marine cartography.

However, the quality of the Semi-Variogram determination is most important and directly influences the quality of interpolation; it is therefore responsible for the

cartographic results. Determination and fitting of the Semi-Variogram cannot be automated; a fundamental knowledge of the geomorphological environment and the data structure is essential. The geomathematical approach to this problem provides a distinct advantage for "Kriging" over other techniques.

The "Kriging" technique has in addition other advantages:
i. minimum variability of the estimator; and
ii. explicit output of estimation errors.

Scientific and Technical Uses of DTMs

DTMs are used today in many different scientific disciplines. Besides isoline determination, DTMs are also used for the determination of derived products such as 3-dimensional perspective views, profile determination, mass determination, difference-DTMs, slope and aspect maps, etc.

Cartography

DTMs are here used as the fundamental basis for isoline determination, and as a tool for automated shading, determination of slope and aspect values of the terrain.

Geography

DTMs are basic and fundamental components of Geographical or Land Information Systems. In addition some derived products may also be incorporated therein.

Products from DTMs

Isolines

Determination and plotting of isolines is an important application and use for DTMs. Smoothing of isolines can be carried out thus allowing for scale changes.

Along-track and cross profiles

These are used, for instance, for survey engineering, for river dredging, for mass determinations in connection with dredging, volume determination of rivers and lakes, or for determination of water masses flowing through deep sea channels.

Slope and Aspect Maps

Terrain slope is determined for each point on the DTM. A DTM can then be determined for slope groups which can be plotted in colour. Instead of water depth, the slopes are shown and colour coded. This technique is used by geologists and oceanographers for erosion and current analysis.

A very interesting marine application is slope aspect. A vector field is determined with aspect directions, the thickness or length of the vector indicating the main slope in the grid cell.

Determination of Volumes and Volume Differences

Volume differences can be determined by additional analysis from two DTMs of the same area.

Determination of Spot Heights

This is very important for terrain analysis, i.e. terrain maxima and minima for presentation and interpretation.

The Value of DTMs to Commercial and Scientific Users compared with traditional line contouring.

From the operational point of view the main steps for making maps are: data acquisition, processing, editing and drafting. In contouring with DTMs, working phases are: data acquisition and analysis, interpolation of contours, editing and plotting of contours.

Contouring by interpolation with DTMs is becoming increasingly popular, particularly with modern sonar survey techniques such as multi-beam systems. Small digital computers and even some enhanced PCs have become more and more powerful and now allow efficient collection, storage and processing of DTM data. The digital method has many advantages in comparison with direct digitizing or manual plotting of contours.

Conventional Method of Contouring

With the conventional method, isolines are directly interpolated and drawn. Further processing may or may not be carried out manually. The result is a single product, a contour map. The advantage of this method lies with the freedom of interpretation accorded to the cartographer. Based on his professional knowledge, he can represent contours as smoother or rougher, thus allowing the map to show additional information about the topography and characteristics of the sea floor.

Contouring using a DTM

For the interpolation method, the first step is to create a DTM. Contours are then derived as one of a number of DTM products. As contours are the result of an interpolation process, their quality depends on the right choice of reference points and the algorithm to be used therein. However, the way in which the morphology of the seabed is handled is probably the most important factor for the interpolation. Parameters describing the morphology are the cartographer's, especially the marine cartographer's, interpretation tools. Non-availability of the terrain-describing parameters results in a poor 'automatically generated' looking contour map, even when the contours fall within accepted height or position tolerances.

ANNEX V

LIST OF PARTICIPANTS

1. MEMBERS

Mr Desmond P.D.Scott (Permanent Secretary GEBCO
Chairman CGOM Deputy Editor GAPA)
Cumbers
Mill Lane
Sidlesham, Chichester
West Sussex PO20 7LX
UNITED KINGDOM
Telex: 858833 OCEANS G Fax: (428) 79 3066
Telmail: IOS.WORMLEY Tel: (243) 56222
Time Zone: GMT (Summer +1)

Professor Carlo Morelli (Chairman IBCM)
Vice Chairman CGOM
Istituto di Miniere e Geofisica Applicata
Facoltà d'Ingegneria dell'Università
Piazzale Europa, 1
I - 34127 Trieste
ITALY
Telex: 460014 FISICA I
Tel: (40) 52465
Time Zone: +1 (Summer +2)

Dr Werner Bettac (Chief Editor IBCWIO)
Deutsches Hydrographisches Institut
Postfach 2 20
Bernhard-Nocht-Str. 78
D - 2000 Hamburg 4
FEDERAL REPUBLIC OF GERMANY
Telex: 211 138 bmvhh d
Tel: (40) 3190 5206
Time Zone: +1 (Summer +2)

Sir Anthony Laughton PhD FRS (Chairman GEBCO)
Institute of Oceanographic Sciences
Deacon Laboratory
Brook Road
Wormley, Godalming
Surrey GU8 5UB
UNITED KINGDOM
Telex: 858833 OCEANS G Fax: (428) 79 3066
Telemail: IOS.WORMLEY Tel: (428) 79 4141
Time Zone: GMT (Summer +1)

Dr Gleb B.Udintsev (Chief Editor GAPA)
c/o Soviet Geophysical Committee
Molodezhnaya, 3
117296 Moscow
U.S.S.R.
Telex: 411478 SGC SU
Tel: (095) 930 5609 (leave message or
Time Zone: +3 (Summer +4) ask to return call)

2. BY INVITATION

Rear Admiral Alfredo Civetta
Director
International Hydrographic Organization (IHO)
7, avenue Président J.F.Kennedy
B.P.445 - MC 98011 Monaco Cédex
PRINCIPALITY OF MONACO
Telex: 479164 MC INHORG
Tel: 93 50 65 87
Time Zone: +1 (Summer +2)

Dr.Ing. Hans-Werner Schenke
Alfred-Wegener-Institut für Polar- und Meeresforschung
Postfach 120161
D-2850 Bremerhaven
FEDERAL REPUBLIC OF GERMANY
Telex: 238695 POLAR Fax: (471) 4831 149
Telemail: Alfred.Wegener Tel: (471) 4831 152
Time Zone: +1 (Summer +2)

3. IOC SECRETARIAT

Dr Viktor Sedov
Intergovernmental Oceanographic Commission
UNESCO
Place de Fontenoy
75700 Paris
FRANCE
Telex: 204461 Paris Fax: (1) 43 06 11 22
Tel: (1) 45 68 40 13
Time Zone: +1 (Summer +2)