Distribution: limited

IOC-IHO/GEBCO SCDB-XII/3
Bidston, 8 January 1996
English only

INTERGOVERNMENTAL OCEANOGRAPHIC
COMMISSION
(of Unesco)

INTERNATIONAL HYDROGRAPHIC
ORGANIZATION

Twelfth Meeting of the GEBCO Sub-Committee on Digital Bathymetry

SACLANT Undersea Research Centre
La Spezia, Italy

9-12 May 1995

SUMMARY REPORT

TABLE OF CONTENTS

ANNEXES

1. OPENING OF THE MEETING

1 The Chairman, Dr. Meirion T. Jones, opened the meeting at 1400 hrs on Tuesday 9 May 1995.

2 In his opening address he commented that it was the first time that the Sub-Committee had met on the shores of the Mediterranean and that it was a particular pleasure to be invited to SACLANTCEN. He recalled that the SACLANTCEN had been involved in much of the early bathymetric surveying of the Mediterranean and he expressed his thanks to Dr. Michael D. Max for organising the meeting - the first of its kind at the centre.

3 Mr. David L. Bradley, Director of SACLANTCEN, welcomed the participants to the Research Centre. He and his colleagues were interested in the work of GEBCO, particularly where shared interests pointed to the Information Highway and the standardisation of data bases. He added that he was keen to establish a dialogue with the Sub-Committee, hopefully leading to future meetings between the two groups with SACLANTCEN taking a more pro-active role.

4 A list of participants is given in Annex XIII. Apologies for absence were received from: Robin Falconer, Hugo Gorziglia, Alexis Hadjiantoniou, Larry Mayer, Ron Macnab, David Monahan, Andrey Popov, Alf Simpson and Kunio Yashima.

2. CONDUCT OF THE MEETING

2.1 ADOPTION OF THE AGENDA

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

2.2 DOCUMENTATION

6 The following documents and maps were tabled for the consideration of the meeting:

Papers

- 'Guidelines for the GEBCO, Part 4 - Digital Bathymetric Data (Multibeam Echo-sounders)', revised draft prepared by George Sharman (NGDC) and Stuart Smith (SIO), April 1995.
- 'Requirements for Improved Regional and Global Bathymetric Data', submitted by Philip Woodworth, Director PSMSL, January 1995 (see Annex IV).
- 'Promotion and Sales of the GEBCO Digital Atlas up to May 1995', Meirion T. Jones.
- 'SHOM Report to the GEBCO SCDB', April 1995.
- 'Review of related activities of other international and national groups (1994-95)', compilation by Peter Hunter, GEBCO Bathymetric Editor, May 1995.
- Annex II of the Report of the Informal Consultation of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean and its Geological/Geophysical Series, held 28-29 March 1995 in La Valletta, Malta - Remarks by Dr. John K. Hall concerning his ideas about the Second Edition of the IBCM.
- Executive Summary of the fifth session of the Consultative Group on Ocean Mapping (CGOM) held in Bremerhaven, April 1995.
- 'Report on Bathymetric Mapping at the SOPAC Secretariat in the Pacific Region', James V. Eade, May 1995 (see Annex III).

- Indexes of Maps and Surveys in the SOPAC Region, James V. Eade, May 1995.
- 'Updating schedule for the IOSDL North-east Atlantic Bathymetry 1995-1998', Peter Hunter.
- 'Notes to the 1995 GEBCO SCDB meeting comparing gridded bathymetry solutions from Walter Smith and Gary Robinson for GEBCO Sheet 5.12', Walter Smith, April 1995.
- 'Remarks to 1995 GEBCO SCDB concerning production of a gridded data set from the GEBCO Fifth Edition contours', Walter Smith, May 1995.
- 'Histograms of GEBCO Sheet 5.12 DEM and coloured DEM plot', Gary Robinson, May 1995.
- 'Report of IHO-DCDB and related activities of NGDC (1994-95)', Michael S. Loughridge, NGDC.
- 'Report of the GEBCO Digital Atlas Manager (1994-1995)', Pauline Weatherall, BODC.
- 'Progress report on the Circum-Atlantic Project CD-ROM', Norman Z. Cherkis, May 1995.
- 'Inventory of Multibeam Equipped Ships', Norman Z. Cherkis, April 1995 (see Annex VIII).
- 'Report on bathymetric mapping activities at Servicio Hidrografico y Oceanografico de la Armada de Chile', Captain Hugo Gorziglia, April 1995.
- 'Digital map and linked data (DMap) implementation at SACLANTCEN, as an aid to sea-going research', Dr. Michael D. Max, May 1995.

Charts

- Bathymetric chart BCWS 567, part of Weddell Sea Series @ 1:1 million, AWI.
- Bathymetric chart of the Weddell Sea @ 1:3 million, working copy, AWI.
- Track coverage of South Atlantic and Antarctic cruises by RV *Polarstern* during 12 year period.
- Topographic map of sub-glacial and seabed topography of the Southern Part of the Weddell Sea, published by the Applied Geodesy Institute of Frankfurt - a joint project by six institutes.
- Preliminary plot of contours digitized by Pauline Weatherall from Robert L. Fisher's Indian Ocean compilations.
- 5-minute gridding solutions for GEBCO Sheet 5.12, Walter Smith and Gary Robinson, April 1995.
- Four colour plots showing DTMs for GEBCO Sheet 5.12 from ETOPO5, GDA and various combinations, Larry Mayer, 1995.
- SOPAC Pacific index map for 200 nautical miles EEZ @ 1:25 million for each SOPAC Region.
- Samples of four SOPAC Bathymetric maps @ 1:250,000 and 1:500,000 for Multibeam Project in New Georgia Sound (Solomon Is) and Malaita.
- South Pacific Sea Floor Atlas (co-operative study Japan/SOPAC, 1995).
- Bathymetric map of Apolima Strait, Western Samoa, sheet 16 @ 1:20,000, SOPAC.
- Bathymetric chart of Eastern Mediterranean @ 1:625,000, 1980 - reprinted 1994.

3. REVIEW OF BATHYMETRIC MAPPING WORLDWIDE

(Written contributions submitted to the GEBCO Bathymetric Editor by organisations not represented at the meeting are shown in italics)

7 The Chairman commented that the Sub-Committee was the only forum to discuss bathymetric mapping activities on a global basis. Although the GDA had made quite an impact around the world, it was in need of updating. The target for the Sub-Committee over the next five years would be to completely revise the GDA, and it was important therefore to keep bathymetric mapping activities under review on a worldwide basis and to identify suitable material for feeding into the GDA.

3.1 ARCTIC REGION

3.1.1 NRL Activities in the Arctic

8 Mr. Norman Cherkis reported that the Naval Research Laboratory (NRL) was aiming to complete a recompilation of its 1986 map "Bathymetry of the Arctic Ocean" at a scale of 1:4 million, with a view to publication in 1997. Sounding data were being actively sought and digitized in readiness for contouring. Recent data collected on the Arctic Ocean crossing by a joint US/Canada programme was about to be digitized. Other data sets recently digitized included echograms from expeditions over the Northwind Ridge and vicinity (Chukchi Sea) by the USGS in 1988, 1989, 1992 and 1993.

9 Mr. Cherkis added that bathymetric compilation work in the Barents Sea was continuing and that recent Russian data had been digitized, including two nautical charts and a set of contours in the south-eastern area. The latter was the work of a Russian marine geologist who had spent three weeks at NRL digitizing data taken from seismic profiling records obtained in past years by the Ministry of Oil and Gas and the Ministry of Geology. He added that an NRL sedimentologist had participated in a cruise over Svyataya Anna Trough in late 1994 and that bathymetric data from the cruise would be forthcoming.

10 Mr. Cherkis further reported that the radionuclide studies in the Kara Sea were in decline owing to a shortage of funding. However, new bathymetric data continued to be located but negotiations for their release had not yet been completed.

11 Mr. Cherkis concluded by announcing that the Bathymetric Map of the Franz Josef Land Area (79°15'N to 82°15'N; 43°E to 67°E) was in its final edit stages and would be published in October 1995. Copies of the final edited contours would be made available to GEBCO.

3.1.2 AWI Activities in the Arctic

12 Dr. Hans-Werner Schenke reported that RV *Polarstern* had recently made two cruises to the Greenland Sea region and the single beam data from these cruises would be transferred to the IHO DCDB. He added that, later in 1995, a multibeam survey would be carried out in the Fram Strait and these data would contribute to the series of four maps covering an area of 250 x 140 miles - all the digitized contours (100m intervals) would be made available for the GDA. Plans had been made to increase the area of survey when ice cover permitted.

3.1.3 AGC Activities in the Arctic

13 *Dr. Ron Macnab, reporting for the Atlantic Geoscience Centre (AGC), drew attention to the recovery and preservation of Russian seismic data in digital form. Geoscience Centre A (GSC-A) investigators had been awarded a NATO Linkage Grant to help plan and implement a co-operative project with their Russian counterparts for recovering, cataloguing, and digitizing key sets of Russian seismic observations that had been collected in the Arctic over the past several decades. Where feasible, bathymetric information would be recovered from these records as well; this information could significantly enhance the existing bathymetric data base in the central basins of the Arctic Ocean. It was proposed to place all results of this project in the public domain for unrestricted use in scientific and mapping applications. A June 1995 meeting was scheduled in St. Petersburg, where prospective Russian and Western participants would identify data sets for the project and develop a detailed work plan.*

14 *Dr. Macnab provided information on the Second Edition of the GSC(A) Bathymetric & Topographic shaded relief map of the Arctic north of 64°N. The First Edition featured a combination of topography derived from the ETOPO5 grid, and bathymetry developed from a partial set of depth contours that had been digitized from GEBCO Sheet 5.17. In November 1994, a Second Edition had been produced with an improved bathymetric grid based on depth contours taken from the GDA. The new map was available in digital or hardcopy form through the Open File system of the Geological Survey of Canada (for more information, see the GSC(A) WWW server at http://agcwww@agc.bio.ns.ca).*

15 *Dr. Macnab concluded by announcing that the International Arctic Science Committee's (IASC) Working Group for Geophysical Compilation and Mapping had established an Internet Mailing List to promote the exchange of information on activities involving bathymetric and geophysical data sets from the Arctic. Persons wishing to subscribe should send an email message to majordomo@agc.bio.ns.ca containing the command 'subscribe arcticgp'.*

3.1.4 Other Activities in the Arctic

16 Questions were raised by Dr. Hall about the ice drift data held by Yuri Kiselev - these were estimated to contain about 15,000 data points. In reply, Dr. Loughridge stated that, fearing the data might be lost forever, NGDC had tried to get micro copies and despite generous offers of guaranteed publication, co-operation had not been forthcoming.

17 The meeting regretted that Andrey Popov had been unable to attend the meeting and to report on the activities of the HDNO in the Arctic. The Chairman was requested to convey participants' best wishes to Dr. Popov.

3.2 ATLANTIC OCEAN INCLUDING MEDITERRANEAN AND CARIBBEAN SEAS

3.2.1 International Bathymetric Chart of the Mediterranean and its Geological/Geophysical Series (IBCM)

18 Professor Carlo Morelli observed that the IBCM project, begun in 1970, was now 25 years old. He recalled the early help of SACLANTCEN and many others in providing invaluable data for the 1:250,000 Plotting Sheets and for the publication and printing of the First Edition undertaken by the Head Department of Navigation and Oceanography, Leningrad, on behalf of the IOC, in 1982. He stated that plans were in hand to publish a Second Edition of the IBCM.

19 At present, a full cover of 1:250,000 Plotting Sheets for the region was being maintained by a network of Hydrographic Offices. The policy of the IHO was that these plotting sheets would be phased out (by 1996 at the latest) and replaced by digital datasets. Furthermore, it was clear that there was a growing amount of swath data being collected in the Mediterranean, both by IFREMER and commercial companies. By the time the IBCM Second Edition was produced, these data might well become available. For these reasons, further consideration was being given to future action on this series, as pressing ahead with traditional methods might well consume a great deal of time and effort for the production of an obsolete and inferior product. These issues would be discussed at the next meeting of the Mediterranean and Black Sea Hydrographic Commission, to be held in Cadiz, June 1995.

20 Dr. Hall drew the participants' attention to Annex II of the Report of the informal consultation of the Editorial Board for the IBCM held 28-29 March 1995 in La Valletta, Malta (doc. IOC/INF-997). In this paper he had outlined what he saw as the drawbacks of using vector data and contour lines for increasingly complex mapping and he described how raster imaging and new printing technologies could be effectively and cheaply combined to produce a new form of mapping display. He promised to present these ideas at some stage using a prototype based on sheet 10 of the IBCM Series (South-east Mediterranean).

21 The Chairman enquired about the position of the Italian and Spanish Hydrographic Offices regarding their intentions to disseminate only contours from their Plotting Sheets. Rear Admiral Andreasen, speaking for the IHO, stated that, following discussions, the two Hydrographic Offices had indicated their intentions to revert to the provision of point data; a decision which came as a result of an offer by NGDC to digitize the relevant Plotting Sheets.

22 Mr. Huet reported that the IHB had sent all their Mediterranean Plotting Sheets to HDNO for digitizing - no news was available from St. Petersburg on the progress of this work.

23 Finally, Professor Morelli reported on progress with the Geological/Geophysical Series of the IBCM. The full series of the 'Thickness of Plio-Quaternary Sediments' sheets had been published in 1994 and progress with the 'Unconsolidated Bottom Surface Sediments' sheets was well advanced, with the hope of publishing the series in late 1995/early 1996. Unfortunately, the 'Magnetic Anomalies' series had been beset with problems, including the loss of a complete data set in a computer accident. At present, it was difficult to predict when the series would be published, although the importance of the series was well recognised by the Editorial Board.

3.2.2 International Bathymetric Chart of the Central Eastern Atlantic (IBCEA)

24 *The Chairman furnished a report by SHOM on the status of the various 1:1 million sheets of the IBCEA being compiled by the Hydrographic Offices of Portugal, Spain and France.*

- *Portugal (sheets 1.01, 1.02, 1.03, 1.07): sheet 1.01 was due to be printed shortly and the compilation of material for sheet 1.03 was underway. Sheets 1.02 and 1.07 had not been started.*
- *Spain (sheets 1.04, 1.05): no schedule for these sheets was available.*
- *France (sheets 1.06, 1.08, 1.09, 1.10, 1.11, 1.12): SHOM had resumed the compilation of sheet 1.08 to include new surveys which had been identified during the review of the first draft in 1994. The response of the Chairman of the Editorial Board to comments raised during the review had not given rise to any new comments. The printing of sheets 1.06, 1.08 and 1.09 was scheduled for 1995 and proof copies of these sheets had been circulated at the Fifth Session of the Consultative Group on Ocean Mapping, held in Bremerhaven, 25-26 April 1995. The compilation of sheets 1.10 and 1.11 would be completed before the end of the year and both sheets would be printed in 1996. The publication of sheet 1.12 was scheduled for 1997.*

25 Mr. Hunter reported that he had examined a proof copy of sheet 1.09 and was of the view that the criticisms raised about sheet 1.08 were equally valid for this sheet, e.g. concerning the presentation of bathymetric contours in certain key areas. Notwithstanding the lengthy and detailed response from SHOM about sheet 1.08, he was still not convinced about the validity of the contour presentation. He added, however, that examination of a proof of sheet 1.06 had revealed a more satisfactory solution.

26 A discussion followed about the likelihood of updating the GDA from the IBCEA chart series. The participants came to no firm conclusion except to reiterate their views expressed at last year's Sub-Committee meeting that automated contouring was not a substitute for a proper scientific interpretation of the available sounding data.

3.2.3 International Bathymetric Chart of the Caribbean Sea and Gulf of Mexico (IBCCA)

27 Lic. José Frias Salazar reported that the Fifth Meeting of the Editorial Board of the IBCCA, had taken place in San Jose, Costa Rica, during November 1994. Ing. Juan Lobo Zertuche had been voted in as Chairman and Chief Editor for IBCCA taking the place of Lic. Nestor Duch Gary who had resigned the position early in 1994.

28 Considerable progress had been made with some of the IBCCA sheets. Thus, the bathymetry was complete for sheet 1.01 (USA), 1.05 and 1.06 (Mexico) and nearly complete for sheets 1.02, 1.03 (USA) and 1.11 (Mexico). Considerable work had also been done on sheet 1.13 (Colombia) while sheets 1.07 and 1.08 (Cuba) were undergoing major revisions after being extensively reviewed. Sheet 1.15 and part of 1.14 had already been digitized by Venezuela and submitted to INEGI, Mexico, in Arc/Info format, although there were problems concerning the resolution of the digitization. No progress had been reported for sheets 1.12 or 1.17 and SHOM had offered to compile sheets 1.10 and 1.16 once they had completed their commitment to IBCEA.

29 Lic. José Frias further reported that sheet 1.09 had been printed, and that 600 copies of sheet 1.04 had also been printed but were being held back because of problems with one of the colours. The final printing of this sheet had been delayed because the main press at INEGI was in need of repair and alternative means of printing were being discussed by the Editorial Board. Sheet 1.06 was almost ready for printing and this would be the first sheet to be produced using a new automated system at INEGI for producing colour separates.

30 Lic. José Frias concluded his report by noting that the Editorial Board had reviewed the proposal by the Hydrographic Institute of Cuba to digitize the IBCCA bathymetric contours. It had been decided that Cuba should proceed with digitizing the sheets that had already been compiled and submitted to INEGI, but that each country would be encouraged to submit their future sheets to INEGI in digital form.

3.2.4 SOC Activities in the NE Atlantic

31 Mr. Peter Hunter reminded the meeting that the IOS Deacon Laboratory would move and be incorporated within the new Southampton Oceanography Centre in autumn 1995. He reported that the revision of the IOSDL 1:1 million scale bathymetry of the North-east Atlantic had continued, using data from a variety of sources including single-beam bathymetry from IOSDL and the NGDC GEODAS CD-ROM, multibeam bathymetry and sidescan sonar images. Over many years, the IOSDL had maintained a set of charts covering the region from 12°N to 72°N and from the European and African coast out to 40°W/50°W. These charts were now being brought up to date and would be fed into the GEBCO Digital Atlas over the next three years.

3.2.5 Circum-Atlantic Project (CAP)

32 Mr. Cherkis reported that the Circum-Atlantic Project (CAP) was nearing the completion of a CD-ROM featuring a GIS-type stack of data from various sources, to serve as a basic reference for the North Atlantic region. Data were still being added, but currently the compendium included: GEBCO bathymetry, with additional data obtained for the Kara-Barents Seas region; World Vector Shoreline; DMA topography for the land areas; a digitized version of the recently compiled DNAG geologic map of the US; several US geophysical data sets; and digitized versions of published coastal-erosion maps. The full disk was expected to be available in late 1995.

3.2.6 Other Activities in the Atlantic

33 Dr. John Hall reported that the University of Rhode Island was assembling Russian multibeam data collected in the Atlantic. *The SHOM report mentioned that multibeam surveys had been continued in the Azores area.*

3.3 INDIAN OCEAN

3.3.1 International Bathymetric Chart of the Western Indian Ocean (IBCWIO)

34 Mr. Hunter reported that the Third Session of the Editorial Board for the IBCWIO was held in Zanzibar, Tanzania, during October 1994. Since the Second Session in 1990, there had been a significant change in the ability of most member states to handle digital source data. The Chief Editor of IBCWIO would be working with the Sheet Co-ordinators to identify their capabilities and computing facilities prior to liaising with NGDC concerning the supply of digital sounding data for their sheet areas.

3.3.2 SIO Activities in the Indian Ocean

35 The meeting noted with great interest the major bathymetric mapping work being carried out by Dr. Robert L. Fisher of the Scripps Institution of Oceanography in the area of the Indian Ocean. As part of the "Alliance Exotique" undertaking, Dr. Fisher was compiling a coherent bathymetric chart from 10°W to 166°E, 25°S to Antarctica in both the South Atlantic and Tasman Sea, and from Africa-Asia-South-east Asia-Australia to Antarctica between 20°E and 150°E. The chart was being contoured on Mercator projection at a scale of 4 inches per degree longitude and involved 240 or so individual sheets.

36 As each set of Dr. Fisher's sheets was completed, copies of both the tracklines and the contours were being sent to BODC for digitizing and edge matching. Miss Pauline Weatherall reported that the whole area from 10°W to 100°E had now been digitized, although work still remained to complete the quality control and geographic registration of the digitized data and to incorporate some recent updates. She added that Dr. Fisher was now contouring the region between 100°E and 120°E (see also paragraph 78 and Annex IX).

3.3.3 Arabian (Persian) Gulf

37 Mr. Norman Cherkis reported that work had been completed at NRL in compiling and digitizing all the echo-sounding data gathered in the Arabian Gulf area by USNOO, Defense Mapping Agency and British Hydrographic Office between 1960 and 1993. Approximately 80% of the data had been contoured, and this work was continuing. The final product would be a new bathymetric contour map of the Arabian Gulf, at a 5m contour interval from the coasts to 50m, with a 10m contour interval from 50m to 100m, and a 20m contour interval thereafter. He hoped that this chart would be available for incorporating into the GDA.

3.4 PACIFIC OCEAN

3.4.1 International Bathymetric Chart of the Western Pacific (IBCWP)

38 *Mr. Peter Hunter reported that the First Session of the IBCWP Editorial Board had been held in Tianjin, China, in October 1994 and that good progress had been made in setting up the organisational framework for the project. Some progress had also been made in the compilation of sheets. Thus, the data for the first sheet in Subregion 1 (Sea of Okhotsk and SE Kamchatka) had already been compiled by HDNO, St. Petersburg, and it was understood that Japan was actively engaged in compiling the data for Subregion 2 (Japan Sea and waters surrounding Japan). Within Subregion 3 (Central Western Pacific), Malaysia had compiled a sample plotting sheet within their waters, and China was known to be collecting data in the East and South China Seas.*

3.4.2 South Pacific Applied Geoscience Commission (SOPAC)

39 Dr. James Eade explained that he had recently completed his contract with SOPAC and was attending the meeting in lieu of his successor, Alfred Simpson, Deputy Director of SOPAC. He gave a comprehensive account of SOPAC and its bathymetric mapping activities (see Annex III). He commented that the rate of surveying of the plate margin areas, by visiting research vessels using multibeam, was increasing and that this technology allied to GPS was making a major contribution to the mapping of the region. He added that the requirement for Island States to lodge claims for their EEZ boundaries before 2004 was of primary importance. However, although many of the Island States' waters had been mapped, there was no coherent digital data set of the bathymetry and funding to support this work was not seen of prime importance by fund donors.

3.4.3 Other Activities in the Pacific

40 *Captain Hugo Gorziglia of the Chilean Hydrographic Service reported that they were digitizing the collected soundings on GEBCO Bathymetric Plotting Sheets 454 and 484 in a similar fashion to sheets 365, 395 and 424 completed last year.*

41 *SHOM reported that, in 1994, some bathymetric anomalies in the French Polynesia EEZ, derived from altimetry data, had been confirmed through echo-sounding investigations.*

42 Mr. Norman Cherkis reported that NRL were starting a new mapping project in the Sea of Japan and the Yellow Sea, as a joint programme with two Korean Institutes. Data sets collected between 1989-1992 had been identified and plans were in hand for joint cruises in 1996 with personnel exchange. It was hoped that the data would be in the public domain by 1998.

3.5 SOUTHERN OCEANS

3.5.1 AWI Activities in the Antarctic

43 Dr. Hans-Werner Schenke reported on bathymetric mapping activities at the Alfred Wegener Institute in the region of the Weddell Sea. He tabled a prototype copy of the first sheet (sheet 567) of the AWI "Bathymetric Chart of the Weddell Sea" - the chart would eventually cover 13 sheets at a scale of 1:1 million. This generated considerable discussion on the contour steps and colour coding used and also on the difficult specialist problem of how to display the edge of floating ice. Comments were aired about the portrayal of tracklines and, in particular, about the representation of multibeam tracks. The meeting was impressed by the quality of the prototype and welcomed Dr. Schenke's offer to make the digital version of the map available for the GDA.

44 Dr. Schenke also presented a new 'Topographic map of Sub-Glacial and Seabed Topography of the Southern Part of the Weddell Sea' representing the combined effort of six institutions. He also reported that a meeting had been held with the British Antarctic Survey (BAS) at which AWI and BAS had agreed to exchange their bathymetric data and contours, although no fixed time had been set for the conclusion of this co-operative effort.

45 Dr. Schenke concluded by reporting recent expeditions to the Antarctic and, in particular, a combined Russian-AWI expedition. A network of 15 GPS stations had been established which in turn was linked to 30 other stations, thus forming a geodetic reference system for Antarctica. These were also linked to tidal stations including those of the UK and Palmer Point (US). He showed the track plot of a recent cruise by *RV Boris Petrov* on the west side of the Antarctic Peninsula and other multibeam survey areas near the South Sandwich Trench, South Orkney and Elephant Island. At the same time *RV Polarstern* had been active in the Weddell Sea area, and from the last two cruises some 25,000 kms of multibeam data had been collected. Dr. Schenke reported that *RV Polarstern* was now fitted with an improved 120° multibeam echo-sounder, having 3.5 times the vertical coverage with improved sonar imaging - he showed some remarkable examples of iceberg marks on the bottom.

3.5.2 Meetings on Antarctic Issues

46 Dr. Schenke reported on the activities of the IHO Permanent Working Group for Co-operation in Antarctica (PWGCA) and on its last meeting which took place 1-7 July 1994, in Buenos Aires. The INT Chart Scheme for scales 1:10 million, 1:2 million, 1:1 million and larger miscellaneous scale approach charts was agreed. Dr. Schenke also reported on a SCAR meeting held 28 July - 3 August 1994, in Rome, which he had attended as an observer. A joint IHO/PWGCA/SCAR Working Group was set up to examine data exchanges and other issues. It had been agreed with SCAR that IHO DCDB should be the repository for echo-sounding data, that GEBCO Sub-Committee on Undersea Feature Names should be the authority for undersea feature names and that cruises would be advertised through IHB publication B-4.

47 Rear Admiral Andreasen said the PWGCA had been a remarkable success in getting (almost) total co-operation between the chart producing nations. Future meetings were rescheduled from an annual basis to once every two years.

48 The Chairman raised the question of whether NGDC had been informed of all Antarctic data collecting activities and if the centre actively sought such data. Dr. Loughridge in reply said that NGDC asked for data when it was known to exist but no pressure was applied. Rear Admiral Andreasen commented that it was likely that other nations would be enjoined to co-operate - they may not wish to be seen as the odd one out.

4. REVIEW OF RELATED ACTIVITIES IN OTHER INTERNATIONAL/ NATIONAL GROUPS

4.1 IHO ACTIVITIES

49 Rear Admiral Christian Andreasen brought the meeting's attention to a variety of activities and publications being worked upon within the IHO. He announced the publication of *S-60 Data Transformation Formulas* which provided algorithms for converting all known horizontal datums to the WGS 84; a French translation of the publication would be available shortly. The IHO was also considering the question of vertical datums and the ECDIS issue was beginning to show the need for the adoption of a single datum. This would be a subject of discussion at the 1997 IHO Conference. He added that the geoid/ellipsoid debate was showing signs of moving towards the adoption of the ellipsoid.

50 Rear Admiral Andreasen reported on ongoing work in revising *S-44 IHO Standards for Hydrographic Surveys*. Once drafted, the revised document would be distributed for comment and the Sub-Committee would also be invited to comment. He regretted delays in the publication of *B-4 Information Concerning Recent Bathymetric Data* and stated that the 1995 edition would include 300 plates of trackline inventories of data acquired during the past year by IHO DCDB. Dr. Loughridge reported that the NGDC was currently experimenting on how best to present information about data holdings, with the hope that this could be made an automated process. The meeting welcomed these developments.

51 Rear Admiral Andreasen announced that plans were in hand to prepare a *Digital Gazetteer of Geographical Names of Undersea Features (B-8)* and that a student would be engaged in summer 1995 to load the database from the existing B-8 publication and to check on the accuracy of the available information.

52 Rear Admiral Andreasen spoke of a meeting in Maputo attended by many of the African littoral states where the subject of training for Hydrographic Surveyors was a major topic. About a half of the training funds would be met by the IHO, while EU grants were being actively pursued for some of the remainder. There was now a database on all training projects underway worldwide. The Chairman asked if there was any feedback on the effect of training and suggested the database could be extended to include details of employment patterns of ex-trainees.

53 In conclusion, Rear Admiral Andreasen raised the issue of copyright of charts, observing that there was a trend in Europe for increasing copyright while the USA was tending to step back from the issue. He reported that the IHB was seeking legal advice on the copyright issue with a view to preparing a series of reports on the problem. They were also developing a document to guide the exchange of data between Hydrographic Offices. The Sub-Committee noted the relevance of these deliberations to the publication of the GEBCO Digital Atlas, and looked forward to being advised on the issue.

4.2 IOC CONSULTATIVE GROUP ON OCEAN MAPPING (CGOM)

54 Dr. Hans-Werner Schenke informed participants on a recent meeting of the IOC CGOM, held at the Alfred-Wegener Institute in April 1995. The CGOM had recognised that the scientific demands for an authoritative global bathymetry had increased beyond the requirements of marine geologists and geophysicists and that there was now a demand from physical and biological oceanographers involved in modelling the ocean environment and predicting changes in global circulation. Furthermore, with the coming into force of the UNCLOS in November 1994, there was a need for coastal states to define and claim resources within national jurisdiction which, in turn, highlighted the need for detailed and accurate bathymetry of the margins. Likewise, global bathymetry was an essential framework for observations with the IOC Global Ocean Observing System. The Sub-Committee welcomed these developments and looked forward to receiving detailed statements on the specific requirements of the various interested parties for an improved global bathymetry. The Chairman reported that he had already invited the Director of the Permanent Service for Mean Sea Level to provide such a statement and his response is to be found in Annex IV.

4.3 INTERNATIONAL GEOLOGICAL-GEOPHYSICAL ATLASES OF THE ATLANTIC AND PACIFIC OCEANS (GAPA)

55 Reporting on the activities of GAPA, Mr. Hunter noted that the Atlantic Ocean Atlas had been published in 1991 and had now been fully distributed to contributors and to IOC Depository Libraries, and placed on sale. Its sales had been satisfactory but large stocks still remained unsold. It now sold for sterling £100 ($165).

56 The main atlas sections, consisting of maps on both 1:30 million and 1:10 million scales, covered bottom topography, magnetic total intensity anomalies, free-air gravity anomalies, sea surface heights, geothermal data, earthquake epicentres and thickness of sedimentary cover. Larger scale maps were provided for certain regions, e.g. Mid-Atlantic Ridge, Caribbean Sea, and for particular themes (usually bottom topography, magnetic and gravity anomalies, and thickness of sediments).

57 The companion atlas for the Pacific Ocean was now nearing completion and it was expected that it would be published in 1996. The Russian Academy of Sciences was responsible for its compilation, printing and publication. Delay in the production of this atlas had been caused by financial difficulties which had now been overcome thanks to generous support from the Houston Advanced Research Center (HARC), and the National Geophysical Data Center (NGDC), USA. The introduction and main sections of this atlas would be similar to those provided in the Atlantic Ocean Atlas. The Pacific Ocean regions selected for detailed study, for which larger scale maps would be provided, were the Okinawa Trough, Gulf of Alaska, East Pacific Rise, South China Sea, Japan Sea, Japan Trench, Sea of Okhotsk and the Bering Sea.

58 A final meeting of the GAPA Editorial Board was scheduled to be held in September 1995. After this meeting the project would be terminated, apart from printing, publication, distribution and sales.

4.4 ICA WORKING GROUP ON MARINE CARTOGRAPHY

59 The Chairman reported that he had received notification that there was a proposal to change the status of the ICA Working Group on Marine Cartography to a Commission, with the main aims of promoting marine cartography and of encouraging publications in relation to the coastal zone. The meeting noted with interest that the group was planning to prepare a multi-lingual gazetteer of ocean names.

4.5 NATIONAL OCEAN SERVICE (NOS), WASHINGTON DC, USA

60 Mr. Donald Pryor reviewed some of the recent hydrographic activities within NOAA and commented that effort was tending to be focused on shallow water (<30m) multibeam/sidescan surveying. He reported that a new AGOR-24 class ship, to be named *Researcher*, was under construction and would be equipped with a SeaBeam 2000 system. The two surveying ships, *Surveyor* and *Mt. Mitchell*, would be laid up in 1996 and a medium depth multibeam system, HYDROCHART, would be installed on the *Rainier* for work in Alaskan waters. Mr. Pryor further reported that the US had adopted the Spatial Data Transfer Standard (SDTS) as a Federal Information Processing Standard, and that the IHO's S-57 (DX-90) was being proposed as being compliant with SDTS. He noted that metadata standards had been proposed under SDTS and that a "clearing house" was being established to enable data searches to be conducted on metadata submitted by originating agencies. He suggested that this could be a useful aid to the work of GEBCO.

61 Dr. Walter Smith gave a comprehensive account of his activities at NOS since the last meeting and of other related activities in the field of satellite altimetry (for full details see Annex V). He drew special attention to the difficult decision taken, in December 1994, by Dr. Guy Duchossois of ESA to meet a request made by Dr. Smith and other scientists to extend the ERS-1 mission for 35 days to complete a uniform and high-resolution altimetric data set for mapping purposes. The meeting acknowledged the value of this data set for the GEBCO community and agreed that the Chairman should invite the Chairman GEBCO to send a letter of thanks to Dr Duchossois.

4.6 NAVAL RESEARCH LABORATORY (NRL), WASHINGTON DC, USA

62 Having already described the current mapping activities at NRL, Mr. Cherkis briefly introduced participants to the NRL software package ECONT (Edit CONTours) underlying this work. The package had been written in-house for use on Silicon Graphics workstations and had been developed using the SGI graphics language - as such it was not portable to other platforms. Using the software, the operator was able to smooth contours and compare them with actual soundings on the editing screen. Contours and echo-soundings could be manually edited on screen, questionable data could be flagged and obviously erroneous data could be removed from the data set. Line breaks still had to be located by eye, but this was facilitated by an ability to zoom-in on the contours. A software upgrade was currently being developed to more quickly identify spurious depths within a composite area. The upgrade would colour identify soundings by operator-determined intervals (e.g. 5m, 50m, 100m) and would greatly facilitate the blunder-checking of data.

63 Mr. Cherkis concluded by informing the meeting that NRL continued to maintain an international inventory of platforms equipped with multibeam systems (see Annex VIII).

4.7 SOUTHAMPTON OCEANOGRAPHY CENTRE (SOC), UNITED KINGDOM

64 Having reminded participants that the IOS Deacon Laboratory would be incorporated into SOC in autumn 1995, Mr. Hunter went on to describe the digitally based systems he had been developing at IOSDL to facilitate his bathymetric mapping work. Data from a variety of sources went into the mapping system, including single beam bathymetry, multibeam data and sidescan sonar images. The PC software package, Surfer for Windows, was used to check for bad data and to produce quick-look images of the shape of the seafloor; thereafter contours were created and edited by hand, with the final contours being produced in digital form. An A0 size, colour Hewlett-Packard inkjet plotter was used to make plots. Mr. Hunter reported that the 80 compilation maps maintained at IOSDL as hand drawn 1:1 million sheets had recently been scanned and written to a CD-ROM for use as a library source. The PC software, CadCore/Tracer by Hitachi, had been purchased to convert these raster images to vector lines.

65 The ability of all the above software (and the GDA) to produce AutoCAD compatible DXF exchange format files fitted in with an earlier decision at IOSDL to use AutoCAD or AutoCAD LT CAD software to edit contours and create final maps. Another available route was to transfer the edited files to a UNIX workstation and to use the GMT software to create a publication quality map.

66 Mr. Hunter concluded by reporting that the procedure set up at IOSDL last year to process the UK research community's geophysical cruise data continued to function well. Clean depth files of 92 cruises had been deposited in the IHO DCDB and these data now formed part of the NGDC's GEODAS CD-ROM.

4.8 BUNDESAMT FUR SEESCHIFFAHRT UND HYDROGRAPHIE (BSH), ROSTOCK, GERMANY

67 Dr. Schenke, reporting on behalf of the German Bathymetric Data Centre at the BSH, Rostock, commented that although the centre was actively supported by BSH, Hamburg, funding was an increasing problem. Staff resources had been reduced from four to three. However, most of the data from German research vessels had now been collected and were being quality controlled - in due course they would be passed on to the IHO DCDB.

4.9 SERVICE HYDROGRAPHIQUE ET OCEANOGRAPHIQUE DE LA MARINE (SHOM), BREST, FRANCE

68 *SHOM continued to be responsible for 80 bathymetric plotting sheets at a scale of 1:1,000,000 in the Atlantic, 51 sheets in the Pacific and 10 sheets at a scale of 1:250,000 in the Mediterranean. All these data were held in digital form in the SHOM bathymetric database and, as of 31 December 1994, the GEBCO sub-database contained 1,573,642 soundings. New surveys or new soundings along tracks were routinely included in the sub-database. Coherency with existing data in the same area was checked and less reliable data were discarded.*

69 *A new semi-automatic software system based on an optical character recognition algorithm was implemented in February 1994 to digitize analogue survey sheets. It was mainly used to digitize coastal surveys conducted before automatic logging systems were available on SHOM's vessels.*

70 *SHOM was also involved in the IBCEA and IBCCA projects (see 3.2.2 and 3.2.3).*

5. THE GEBCO DIGITAL ATLAS (GDA)

5.1 THE GDA CD-ROM PUBLICATION

71 Dr. Meirion Jones tabled a paper (see Annex XII) reviewing the sales and promotion of the GEBCO Digital Atlas since its publication in Spring 1994. He was pleased to report that, up to 1 May 1995, some 374 copies of the GDA had been sold or distributed as complementary copies to organizations in 45 countries. There had been widespread interest in the product from around the world and BODC had received many unsolicited congratulatory comments on the quality of the Digital Atlas.

72 Dr. Jones reported that a User Registration Form was being distributed with each copy of the GDA in order to maintain contact with users so that they could be kept informed of developments in updating the GDA and notified of new software releases as they became available. By May 1995, some 233 users (62%) had registered their copies with BODC. A Problem Report Sheet was also being distributed with the package. To date, only five minor software bugs in the GDA user interface had been reported to BODC and these had been corrected, with updated releases of the software distributed on floppy disk to all recipients of the GDA. All recipients had also been sent notification of an error in one of the data files together with instructions on how to overcome it. A minor modification had been made to allow users to output screen plots on a white background and this was included on the latest software release (version 1.06) which had been distributed to all GDA recipients.

73 In order to ensure as widespread a distribution of the GDA as possible, Dr. Jones announced his intention to produce a steady stream of adverts and articles on the product - a number had already been produced as listed in Annex XII. He thanked Dr. Loughridge for his help in distributing 40,000 GDA fliers to the NGDC mailing list and noted that the marked rise in sales for February/March 1995 was probably due to that initiative. The meeting discussed ways in which the GDA could be further promoted. Suggestions included: major universities, University National Oceanographic Libraries System (UNOLS), EOS, SOPAC and EEZ Newsletters. Dr. Smith suggested that a World Wide Web News item would demonstrate that the GDA was an evolving product that was being continually improved. Dr. Loughridge offered NGDC news services to announce improvements to the GDA. Dr. Jones reported that the four page coloured brochure on the GDA was being reprinted and requested that participants should let him know if they wished to receive copies for distribution to their own network of contacts

5.2 PROGRESS ON UPDATING THE GDA

74 The Chairman reminded the meeting that, with the exception of revised Sheet 5.12, the bulk of the bathymetry published on the GDA was based on soundings collected up to the mid-1970s and that almost two additional decades of data were now available for use in revising the GEBCO bathymetry. In addition, important satellite altimetry data sets were available to assist in the compilation of bathymetry contours in areas sparse in echo-sounding coverage. If GEBCO was to maintain its reputation as the authoritative bathymetric chart of the oceans, then there was an urgent need to make use of these new data in compiling revised charts and in updating the GDA.

75 Without the scale constraints of the printed chart, it was envisaged that improved bathymetric compilations would be merged into the GDA at scales ranging from 1:10 million up to 1:500,000 (or even larger in isolated cases). The Chairman noted that, because of the digital nature of the GDA, many users were attempting to blow the bathymetry up to scales much larger than the 1:10 million scale of its base data and were commenting on its reduced quality at these larger scales. This was becoming increasingly apparent when the blown up bathymetry was being compared with the much higher resolution World Vector Shoreline (WVS). Indeed, in some areas there were shifts of up to 5-7 kms

between the GDA coastline (based on the old French Carte Generale du Monde) and the WVS - this was particularly apparent around oceanic islands. It was important to remind users of the scale on which the bathymetry included on the GDA was compiled but, more importantly, it stressed the urgent need for updating the GDA with improved compilations.

76 The Chairman reminded the meeting that, in updating the GDA, the coastline would be standardised on the WVS and that this had already been used for revised Sheet 5.12. However, despite the excellent resolution of WVS across the globe, it was known to be of lower accuracy around Antarctica. At the last meeting of the Sub-Committee, Dr. Hans Schenke had advised that the best circum-Antarctic coastline available at present was that published on CD-ROM by the British Antarctic Survey in 1994 on behalf of SCAR. Dr. Jones was pleased to report that BODC had already received a copy of the CD-ROM and that, through an exchange of letters with the Secretary of SCAR in November 1994, he had obtained permission for the SCAR coastline to be used by GEBCO in the GDA. The meeting agreed that, in the updating of the GDA, the SCAR coastline would be used in the area around Antarctica instead of WVS. Thanks were expressed to SCAR for their generous contribution.

77 Miss Pauline Weatherall, GDA Manager, reported that she had extracted the Antarctic coastlines from the SCAR CD-ROM for use in the GDA. The CD-ROM contained five coastline data sets - the first comprised data at the original scale of the source material while the others were generalised versions at scales of 1:1 million, 1:3 million, 1:10 million and 1:30 million respectively. She explained that the coastline was divided into a number of different feature types, viz:

Ice coastline (definite)
Rock coastline (definite)
Grounding Line (definite)
Rock against ice shelf (definite)
Ice Wall (approximate)
Rock coastline (approximate)
Grounding line (approximate)
Rock against ice shelf (approximate)
Iceberg tongue
Floating glacier tongue
Ice shelf front
Ice rumples (distinct)
Ice rumples (indistinct)

Each of these features would be included in the GDA with accompanying feature codes.

78 Miss Weatherall then reported that she had continued to collaborate closely with Dr. Robert L. Fisher of the Scripps Institution of Oceanography in the area of the Indian Ocean. As part of the "Alliance Exotique" undertaking, Dr. Fisher was compiling a coherent bathymetric chart from 10°W to 166°E, 25°S to Antarctica in both the South Atlantic and Tasman Sea, and from Africa-Asia-South-east Asia-Australia to Antarctica between 20°E and 150°E (see Annex IX). The chart was being contoured on Mercator Projection at a scale of four inches per degree longitude and involved 240 or so individual sheets (see also paragraph 36).

79 Miss Weatherall explained that, as each set of Dr. Fisher's sheets was completed, copies of both the contours and tracklines were sent to BODC for digitization. During the past intersessional period a further 150 sheets had been digitized at BODC thus completing the area between 20°E and 100°E and from 29°N to Antarctica. Work was continuing on edge matching the contours across these sheets and on correcting the registration of the sheet grids for paper distortion. In addition, a number of updated sections were being incorporated into the sheets based on revisions compiled by Dr. Fisher from recently obtained data. Miss Weatherall informed the meeting that BODC had now received the majority of the bathymetric contour and trackline control data digitized at Scripps for the area 10°W to 20°E, 23°S to Antarctica. These were being incorporated with the other data already digitized at BODC.

80 Since the last meeting, BODC had received two further sets of digitized contours for inclusion in the GDA, viz:

81 a) From New Zealand Oceanographic Institute: digitized bathymetry for the area 178°E to 165°W; 25°S to 45°S (Kermadec Trench and Southwest Pacific Basin Area). The data were digitized from charts at a scale of 1:1 million, with digitized contours at 1000m and at 1000m intervals down to 9000m.

82 b) From HDNO, St. Petersburg: digitized bathymetry for the area 78°E to 128°E; 72°N to 78°N (Kara and Laptev Seas Area). The data set consisted of contours at the following depths: 5m, 10m, 20m, 50m, 100m and 200m.

83 Because of the Indian Ocean work, BODC had not yet had the opportunity to evaluate these data sets. The meeting noted that the NZOI data set only contained contours at 1000m intervals and invited the GEBCO Bathymetric Editor, Mr. Peter Hunter, to enquire whether more detailed bathymetry was available from NZOI with closer spaced contours.

84 Miss Weatherall concluded her report by identifying certain information she would like to see accompany any new digital data sent for inclusion in the GDA. Firstly, in respect of data registration she asked that digitized contours should be accompanied by:

- information on the geographic control points used in the digitization and on the method used to correct for paper distortion and alignment;
- a copy of the original source material from which the data were digitized so as to be able to compare any plots of the digital data with the original; and
- a statement on the accuracy of the digitization.

85 Secondly, it would also be useful to be provided with:

- a listing of the number of points and line segments in the data file - this would help to check that any conversions between data formats had worked successfully; and
- information on the original source material - such as scale, etc.

86 After some discussion the meeting agreed that there was an urgent need for a set of guidelines to cover the digitization of bathymetric contours and the specification of supporting documentation to accompany such data. It was recalled that the IBCCA community had already reported difficulties in producing standardised digital bathymetric contour data sets without an agreed specification for digitizing charts. It was felt that the GEBCO Guidelines would provide an appropriate mechanism for publishing such guidelines and that these could be combined with relevant information already agreed by the Sub-Committee on procedures for updating the GDA (see Annex XI). The GEBCO Bathymetric Editor and the GDA Manager were invited to prepare an initial draft for consideration by the Chairman in the first instance. Some research would first be required to ascertain whether appropriate material was already available from other sources and Dr. Gary Robinson was invited to assist in this task. It was agreed that if a sufficiently mature document could be prepared in the intersessional period then comments should be sought from relevant experts with a view to submitting a further draft for consideration by the Sub-Committee at its next meeting.

5.3 FUTURE UPDATING OF THE GDA

87 Mr. Peter Hunter, the GEBCO Bathymetric Editor, reported on the maps and mapping programmes that he had identified as being suitable for updating the GDA (a world map is shown as Annex X which locates these maps).

88 The principal sources were the IOC's International Bathymetric Chart Projects and the major work being carried out by Dr. Fisher in the Indian Ocean. High levels of activity were also apparent in the Arctic, the Southern Oceans, the West & Central Pacific and the North-east Atlantic.

5.3.1 Arctic Ocean

89 The Naval Research Laboratory had already published three charts; the Bathymetry of the Norwegian and Greenland Seas, the Bathymetry of the Barents and Kara Seas and the Bathymetry of Franz Josef Land. The charts were currently being digitized although problems might arise because the contours were in uncorrected metres rather than corrected metres.

90 HDNO, St. Petersburg, were compiling maps for the 1:1 million plotting sheet areas in the Kara and Laptev Seas - two sheets, 593 and 594, had already been completed and digitized versions of these sheets had been submitted to BODC.

91 During the meeting, information was provided on a new map by Dr. H.M. Kassens of GEOMAR in the Laptev Sea and Mr. Hunter agreed to contact Dr. Kassens.

5.3.2 Southern Oceans

92 Apart from the coverage of Dr. Fisher's Indian Ocean work which stretched down to Antarctica from 10°W to 166°E, the main mapping programme was taking place at the Alfred-Wegener-Institut, Bremerhaven. Dr. Hans Schenke was actively involved in preparing a set of 'Bathymetric Charts of the Weddell Sea' at a scale of 1:1 million and, in collaboration with his colleague, Dr. Heinrich Hinze, had virtually completed work on the first sheet (567). Dr. Schenke offered to supply a digital version of this sheet for incorporation in the GDA.

5.3.3 West & Central Pacific Ocean

93 There were five principal mapping activities in the West & Central Pacific Ocean: a gridded bathymetry by Dr. Barbara Keating of the Hawaii Institute of Geophysics, a Bathymetry of the Southcentral Pacific published in EOS by Dr. Jacqueline Mammerickx of Scripps, various maps by the New Zealand Oceanographic Institute, the Offshore Resource Map Series (ORMS) being prepared by the Australian Geological Survey Organisation and various large scale maps in the SOPAC region.

94 The HIG gridded bathymetry had been promised to the GEBCO over a year ago. However, nothing had been heard from Dr. Keating since then and Mr. Hunter agreed to follow this up.

95 Dr. Mammerickx's bathymetry was published in 1992. It covered the area from 3°N to 53°S between 120°W and 180°W on a Mercator projection. Its scale was 1:6.4 million at the Equator and the contour interval was mainly 100 metres although in some areas this dropped to 500 metres. It was based on a great deal of Seabeam data and the track control was printed on the back of the map.

96 NZOI had already passed digital files of two of their bathymetric maps to Mr. Hunter. The area covered was from 25°S to 45°S between 178°E and 165°W. The contour interval was 1000 metres although the interval on previously published 1:1,000,000 maps had been 100 metres. BODC had successfully displayed the contours, the files having been brought over from New Zealand via the Internet.

97 AGSO had agreed to release the bathymetry from their Offshore Resource Map Series for use in GEBCO and Mr. Hunter agreed that he would contact Chris Johnston of AGSO to discuss the transfer of the contours to the GDA.

98 SOPAC had compiled various large scale maps produced through multibeam surveys. Although of limited geographical coverage on their own, they did cover an appreciable area when combined but there were still major gaps which needed to be filled using single-beam echo-sounding data. Mr. Hunter would be having discussions during June with Jim Eade and the new deputy director of SOPAC, Alf Simpson, on the best way to include these surveys.

5.3.4 North-east Atlantic Ocean

99 The major activity in this region was being carried out by Mr. Hunter at the Southampton Oceanography Centre with the assistance of Mr. Jeremy Evans. Two areas were being concentrated on: Rockall Bank (48°N to 60°N; 24°W to 6°W) and the Madeira Abyssal Plain (24°N to 36°N; 28°W to 6°W).

100 A new bathymetric chart of the Bay of Biscay had been published by IFREMER, Brest. It was published at a scale of 1:2 million on Mercator projection covering the area 43°N to 49°N; 18°W to 1°W and with a contour interval of 200m. Mr. Hunter agreed to investigate whether the chart could be included in the GDA.

5.3.5 Updating the GDA for Bathymetry of the World's Largest Lakes

101 Dr. Loughridge asked if there was any intention to incorporate bathymetric data for the largest world's lakes. Noting that there was a number of projects in hand to map several of these features, it was agreed that there was no reason not to include such data in the GDA even where the depths were less than 200m.

6. MANAGEMENT OF ECHO-SOUNDING DATA

6.1 IHO DATA CENTRE FOR DIGITAL BATHYMETRY (IHO DCDB), BOULDER

102 Dr. Mike Loughridge reported on the intersessional activities of the National Geophysical Data Center (NGDC) and the co-located IHO DCDB. He stated that, since the Eleventh Meeting of the Sub-Committee in May 1994, the NGDC had responded to 133 requests for bathymetric data or information from 21 countries, of which 19 were IHO Member States. Also, a total of 180 cruises/legs of data had been assimilated into the global marine geophysical data base (GEODAS), including almost 2 million soundings from 13 agencies located in 7 countries. A statistical breakdown of the total holding, and of data assimilated since May 1994, may be found in Annex VII.

103 Dr. Loughridge was pleased to announce that a new GEODAS CD-ROM data set (Version 3.1) had been released in March 1995 containing all the underway bathymetry, magnetics and gravity data assimilated into GEODAS up to the end of 1994. The CD-ROM now contained over 12.7 million nautical miles of echo-sounding data from 3641 cruises with 29.5 million digital records.

104 Dr. Loughridge added that NGDC had been further developing its GEODAS system. Originally designed to manage underway marine geophysical trackline data, the GEODAS software had now been enhanced so as to cover data compiled on survey sheets. GEODAS now had two distinct components, GEODAS/TRKDAS for marine geophysical trackline data and GEODAS/HYDDAS for hydrographic (bathymetric) survey data. At the present time, a working version of the GEODAS/HYDDAS software was in use and the data base was being populated; currently about 1300 surveys had been inventoried in the GEODAS/HYDDAS system. Data base population was continuing and a CD-ROM version was expected to be released to the public in late 1995.

105 Rear Admiral Andreasen said the IHB would send circular letters to Member States asking about the progress they were making in digital data capture from plotting sheets and draw their attention to the GEODAS/HYDDAS application which provided a means to capture data from such sheets where cruise extraction was not possible. Dr. Loughridge reiterated that it was NGDC policy to ensure that all data contributors were named in the header records accompanying data held on NGDC databases.

106 Dr. Loughridge announced that the multibeam data from NOS, Scripps and the New England Consortium at Rhode Island had almost been fully integrated into the NGDC system. It had been decided to store these data in their native format.

107 In its role as IHO DCDB, NGDC had provided information on cruise data holdings for inclusion in the *IHO B-4 Information Concerning Recent Bathymetric Data Holdings*.

108 NGDC had also continued to be an active participant in the US/Japan Cooperative Program in Natural Resources (UJNR) in the Sea-Bottom Surveys Panel (SBSP). This panel had become one of the principal mechanisms by which Japan and NGDC exchanged marine geophysical data, including bathymetry. Recent discussions had included the latest techniques in the acquisition, processing, and display of multibeam sounding data. Dr. Loughridge had attended the Fourth Meeting of the People's

Republic of China - United States Joint Co-ordination Panel for Data and Information Co-operation, in Tianjin, China, September 1994. On his return trip he had paid a courtesy call on the Japan Hydrographic Department and the Japan Oceanographic Data Center of the Maritime Safety Agency.

109 Dr. Loughridge reported that, in July 1994, Commander Maureen Kenny had participated in the IHO Permanent Working Group on Co-operation in Antarctica meeting held in Buenos Aires, Argentina. Discussions included the submission of Antarctic bathymetric data to the DCDB, and the provision of assistance by the DCDB to countries compiling international charts of the Antarctic region. He was pleased to report that Commander Kenny had now taken up her first command and her replacement, promised as a permanent post, would be Lt. Tom Niichel. The meeting expressed its thanks to Maureen Kenny and wished her well on her new assignment.

110 In addition to participation in GEBCO, Dr. Loughridge stated that NGDC staff had continued to take an active role in the IOC regional bathymetric mapping projects. Dr. Troy Holcombe served on the Editorial Board of IBCCA, IBCEA, and IBCWIO, and in October 1994 he had attended a meeting of the IBCWIO officers in Zanzibar, Tanzania. Dr. Holcombe had also participated in the March 1995 Informal Consultation meeting of the IBCM held in Malta. Dr. George Sharman continued as an active member of the Editorial Board of the IBCWP while in November 1994, Ms. Lisa Taylor, the member of NGDC's staff responsible for the compilation of bathymetry for IBCCA sheets, had attended an IBCCA Editorial Board meeting in San Jose, Costa Rica.

111 Dr. Loughridge reminded participants that, in December 1993, NGDC had been officially named as a Data Assembly Center for bathymetric data acquired on World Ocean Circulation Experiment (WOCE) cruises. During 1994, procedures had been established for data submission and for data exchange with WOCE participants. To date, data had been received from seventeen WOCE cruises and these had been added to the DCDB bathymetric data holdings.

112 Dr. Loughridge concluded his report by informing participants of a number of new NGDC products:

a new colour image of global relief was released by NGDC in 1994. The image, "Views of the Globe", portrayed fourteen images of hemispheric global relief which had been computer-generated from NGDC's digital elevation data combined into a 24" x 24" full-colour poster. Views were spaced every 90° of longitude and 45° of latitude. The resolution of the gridded data used varied from true 5-minute for the ocean floors, the USA, Europe, Africa, Japan, and Australia to 1 degree in data-deficient areas of Asia, South America, northern Canada, and the Arabian subcontinent;

a new poster displaying the relief of the ocean floor and continents had been published. The "Surface of the Earth" poster was approximately 42" x 32" (106 x 82 cm) and showed the colour-shaded relief in a Mercator projection covering 80° of latitude and 390° of longitude (the overlap minimized cutting of ocean basins). The represented data included ETOPO5 with several updates to land areas such as Africa, South America, Great Britain, and Italy. Since its release in mid-summer 1994, over 1,100 copies of the poster had been distributed. The updated data had been released and were available from NGDC on the CD-ROM known as "Terrainbase";

NGDC was distributing a colour image "Predicted Seafloor Topography" produced by Dr. Walter H. F. Smith of the Geosciences Laboratory, NOS, and Dr. David T. Sandwell of Scripps Institution of Oceanography. This image displayed predicted seafloor topography in the sparsely sounded circum-Antarctic region south of 30°S. Using gravity field information derived from GEOSAT altimetry data, and available depth measurements acquired during ship transits to determine a correlation between gravity and the known seafloor topography, the seafloor topography had been predicted in areas where no actual depth measurements had been acquired. The results indicated many new features and were estimated by Smith and Sandwell to be within 100m of actual depths in most areas. The digital data sets used in this project, including Predicted Seafloor Topography, Free-Air Gravity, Total Sediment Thickness and Magnetic Lineations were also available on CD-ROM from NGDC.

113 The Chairman thanked Dr. Loughridge for his comprehensive report and, in particular, for the help that NGDC had given in distributing the GDA brochure to its mass mailing list.

6.2 GEBCO GUIDELINES, PART 4, 'DIGITAL BATHYMETRIC DATA (MULTIBEAM ECHO-SOUNDERS)'

114 The Chairman recalled that, following the last meeting of the Sub-Committee, Dr. George Sharman of NGDC and Mr. Stuart Smith of the Scripps Institution of Oceanography had been invited to develop further their draft document for Part 4 of the GEBCO Guidelines (B-7) concerning the handling of multibeam data. During the intersessional period, extensive discussions had been held involving, amongst others, George Sharman, Mike Loughridge, Larry Mayer, Walter Smith, Dale Chayes, Stuart Smith and Jim Charters. As a result, a revised draft had been prepared by Dr. Sharman and this had been circulated to participants just prior to the meeting.

115 The general consensus of the participants was that the latest draft was a well thought out document which incorporated the overall views of the Sub-Committee. Several important points were noted: the draft affirmed the importance of maintaining cleaned up/quality controlled multibeam data in a time sequenced form reflecting the original data. It also recognised the value of maintaining cleaned up gridded data from multibeam surveys but stressed that these should not be a substitute for the original time sequenced data. In all cases, comprehensive metadata (i.e. documentation) was required as an essential component of multibeam data. It was agreed by the participants that any attempt to draft a specification for a generic format for multibeam data at this stage, would be premature. Some minor modifications were proposed together with an invitation to Dr. Sharman to append a set of documentation forms to his amended paper similar to those already included in GEBCO Guidelines Parts 3 and 5. Rear Admiral Andreasen suggested that the document should avoid any involvement with gridded data; the Chairman agreed with this view. It was additionally suggested that a statement setting out the document's aims - particularly in respect of the requirement for time series data - might be beneficial.

116 Michel Huet said IHO was interested in this document for two reasons. Firstly, as it would be published in B-7, he reminded the meeting that the normal procedure required a draft to be sent to Member States and to IOC for comments. He proposed that Dr. Sharman should analyze any replies from these circulations and incorporate changes as necessary to his final draft for presentation to the next meeting of the Sub-Committee. Secondly, he explained that, in 1994, the IHO Data Base Working Group (DBWG) - which works on the IHO Standard *S-57 Transfer Standards for Digital Hydrographic Data* had set up a study group tasked to extend the capabilities of S-57 so as to cover multibeam data. It was agreed that contact should be established between the study group Chairman, Mr. George Spoelstra, and Dr. Sharman. The next meeting of the DBWG would be in late May 1995.

117 The meeting agreed that, with some minor editorial modification, the paper had reached a sufficient level of maturity for it to be distributed widely for review and comments from a) IHO Member States, b) manufacturers and users of multibeam equipment and c) a wider community to be contacted over the Internet. It was agreed that the final draft should be reviewed at the next meeting of the Sub-Committee and Dr. Sharman was thanked for the excellent progress made to date.

6.3 EXCHANGE FORMATS FOR BATHYMETRIC DATA

118 The Chairman reminded the participants of the 'Discussion Paper on Bathymetric Exchange Formats', written by Mr. I.W. Halls of the Royal Australian Navy, which was discussed at last year's meeting. He reported that, as requested, he had responded to Mr. Halls' paper but unfortunately Halls was no longer at RAN; a copy of the letter had been sent to the President of the IHO Directing Committee. It was generally agreed that further liaison should await the production of S-57 geared to bathymetric data, at which time the Sub-Committee would be invited to submit comments.

119 The meeting was informed of two format specification initiatives for multibeam data: firstly, the IHB announced their intention to draft a specification within S-57, and secondly, Dr. John Hall reported that the University of Rhode Island had prepared a study paper on format/s for multibeam data. The Sub-

Committee had already identified difficulties in preparing a generic format for multibeam data, and requested that it should be kept informed of all developments in this area. Dr. Loughridge reported that NGDC had decided to store the multibeam data in its archives in the native format used by the data originators and that there were no plans at this stage to develop a common format.

120 Mr. Hunter reported that the NERC BRIDGE community had held a workshop on "Sonar Processing in the UK" during June 1994. Amongst the items discussed were the most efficient short- and long-term solutions for the archiving, management and distribution of multibeam data. They had noted the discussions already taking place within GEBCO on this subject.

121 In conclusion, Rear Admiral Andreasen informed the meeting of work underway concerning the revision of *S-44 IHO Standards for Hydrographic Surveys*. A consensus had not yet been arrived at in reviewing S-44 but the Sub-Committee would be invited to comment once a more formal draft became available.

7. FUTURE DEVELOPMENT OF GEBCO PRODUCTS

7.1 DEVELOPMENT OF A GEBCO GRIDDED DATA SET

122 The Chairman recalled the brainstorming session held at last year's meeting, during which the Sub-Committee had recognised the need to develop a gridded version of GEBCO and had identified a number of key issues that would need to be addressed before such a gridded dataset could be produced. It had been agreed that the area of GEBCO Sheet 5.12 (revised) in the South Atlantic should be used as a test bed for comparing the various techniques available and that a small team of experts (Peter Hunter, Ron Macnab, Larry Mayer, William Rankin, Gary Robinson and Walter Smith) should work intersessionally to study the problem. It had been further agreed that, in the first instance, the aim should be to develop a 5-minute gridded bathymetric dataset for the area so that it could be used to update DBDB5.

123 Dr. Walter Smith explained the methodology he had chosen to explore, and reviewed some of the problems of constructing grids from contours (see Annex VI). His method involved treating the individual co-ordinate pairs in the contour vector streams as data points, averaging them into 5-minute cells and then gridding using a spline under tension. He showed colour plots of his gridding solutions.

124 Dr. Gary Robinson had chosen to explore the use of a Delaunay triangular technique. He demonstrated his solution with a colour plot and explained how the technique tended to produce artificial terraces and then larger than true slopes between the terraces. He also showed that this led to an abnormal histogram of grid values, with contour values more common in the grid than they should be.

125 Dr. Smith then produced a set of grey shaded images comparing in turn the values and slopes given in DBDB5, Dr. Robinson's solution and his solution for the area of Sheet 5.12. The differences between the three solutions were quite illuminating and served to illustrate two key problems that would need to be addressed in the gridding process viz. a) what to do in the large areas between contours (e.g. on abyssal plains) and b) what to do when contour detail was more dense than the grid could reproduce.

126 Peter Hunter reported that he had experimented with the gridding of a number of representative areas of 5.12 using three methods: a) kriging, b) minimum tension and c) residual based functions, but had been unable to produce a satisfactory solution. In particular, he had attempted to mix GEODAS echo-sounding data with GDA contours but found this to be impossible due to large cross-over errors in the GEODAS data. This again served to illustrate the value-added component of the GEBCO contours in ironing out and reconciling apparently inconsistent trackline data.

127 Dr. John Hall said he favoured tackling this problem from a radically different viewpoint in which contours were treated as form lines and the grid size was set at no larger than 0.1 mile. Dr. Hall was invited to construct a sample grid from Sheet 5.12 to be presented at the next SCDB meeting.

128 There was a considerable debate during which many of the participants offered their views and experiences. Doubts were expressed about whether the construction of a grid that then reproduces the

contours was necessarily the best solution, although this was an obvious way of checking the gridding process. Furthermore, one had to be aware of the aspects of the topographic surface that one wished to reproduce within the grid - different solutions might be needed to deal with different properties and it was important to decide what aspects should be preserved within the grid. It was agreed that it might be difficult to develop a gridded data set without the use of extra form lines or of additional information.

129 The Chairman summarised the debate by highlighting three points:

- there was a need to document the problems surrounding the development of a GEBCO gridded data set, to describe how these could be resolved and to illustrate the properties of different techniques;
- there was a requirement for some market analysis to determine the community of users and their needs for models and data sets; and
- in recognition that DBDB5 was not being maintained, it was important that a successful gridded version of Sheet 5.12 be made available to the international scientific community.

130 Whatever method was chosen for the publication of the new data set it was agreed that it must carry information about the quality of the data and the attributes of the product; modellers must understand the constraints of the product including its pitfalls. The Chairman asked Walter Smith, Gary Robinson, Peter Hunter, Mike Carron, Ron Macnab, Larry Mayer and Bill Rankin to prepare a joint paper addressing the problem, and to continue with their search for a successful solution to the production of a gridded data set for Sheet 5.12. He invited Dr. Smith to lead the group and to report back to the next meeting of the Sub-Committee.

7.2 DIGITAL TECHNIQUES FOR LABELLING FEATURES

131 Dr. Gary Robinson demonstrated a simple prototype version of a PC-based program for automatically labelling features with their names overlaying contours from the GDA in a cartographically acceptable manner, given user selected viewing scales and windows. Feature names were derived from the IHB Gazetteer of Undersea Feature Names.

132 He explained that, to facilitate the positioning of labels, one or more rough circles delineating the extent of each feature had been drawn on the 1:10 million paper charts and their centres and radii (kms) had been measured and stored in a simple ASCII file. Whether text labels appeared depended upon the current scale and their height at 1:10 million so that smaller features were not labelled at small scales and vice-versa. He added that the program also had an option to scale text non-linearly, enabling it to remain legible over a wider scale range. The program currently did not cope with labels falling off the edge of the display, or overlapping names. Methods to resolve these problems would be developed in the next few months, as well as techniques for positioning text to minimise obscuration of detail in contours. He concluded by saying that the delineation of the boundaries of features listed in the Gazetteer of Undersea Feature Names would have to be addressed - this requirement was purely for the purposes of labelling and not to identify the extent of any feature.

133 The Chairman thanked Gary Robinson for his most interesting demonstration and looked forward to seeing a more developed version in 12 months time.

8. ANY OTHER BUSINESS

8.1 VISIT TO *NRV ALLIANCE*

134 Participants were warmly welcomed to the *NRV Alliance* by Captain Chris Gobey who, in the short time available before sailing, conducted a very interesting tour of particular areas of interest; these included the scientific laboratories, Chart Room, Bridge and Deck Work Areas. Several experienced data gatherers in the party expressed an undisguised envy for the excellent data collecting and handling facilities displayed. The Chairman thanked Captain Gobey for a most interesting visit.

8.2 VISIT TO SACLANTCEN MAPPING UNIT

135 Dr. Michael Max conducted a tour of the mapping unit where he demonstrated the DMap (Digital Data Map) facility. He explained that the maps were composed of a Geographical Information System (GIS) linked to numerical data, text, image and graphics of marine information, and were being implemented at SACLANTCEN using relatively inexpensive transportable computers and commercial software. He said that DMaps had been used to support planning and at-sea exercises and experiments, as well as providing a relational archive for the linked data/information.

136 The DMap was an editable, expandable geographically referenced data set. Each marine DMap (which may include considerable information from land adjacent to the sea) must first be prepared. The complexity and size of a DMap depended on its purpose. A simple map containing only bathymetry could be assembled in minutes to hours from existing digital bathymetry. More high-resolution information could be added to the map through a number of input modes. Environmental data, such as bathymetry, bottom and water character, and positions of artifacts such as wrecks, pipelines, and cables, were input and geographically linked in a common co-ordinate system whose positions were visualized on the digital chart. The map image was used directly to input, locate, and retrieve data and other information.

137 Used at sea, the DMap functioned as the repository for newly input real-time location and sensor information such as GPS position, radar, and experiment position data such as sonar contacts. New map overlays, for instance of bottom-reverberation character and bottom softness, could be compiled and edited in virtual real-time as the information became available. The post-cruise analysis overhead could often be cut to nothing by using DMap technology.

138 The DMap also allowed complex geographically referenced information to be shared rapidly. New map layers of positions, areas, and lines, as well as numerical data related to positions, had been electronically communicated and merged with duplicate copies of the DMap at remote locations. New versions of DMaps were being archived on CD-ROM at SACLANTCEN, providing a stable media for both archiving and secure dissemination.

8.3 BIBLIOGRAPHY FOR SWATH MAPPING

139 The meeting was informed that a Bibliography for SWATH Mapping had been started by Stephen P. Miller and Stephanie D. Barber of Santa Barbara. It was agreed that this difficult task was probably best carried out by a team of information management experts and that the Sub-Committee could not usefully contribute to the project.

8.4 DATES AND PLACES OF NEXT TWO MEETINGS

140 The Chairman stated that he was anxious to extend the message of GEBCO towards the Pacific rim countries and to encourage them to participate in the next meeting of the Sub-Committee. To this end, he was hoping to secure an invitation from Hawaii for a meeting some time in the spring/early summer 1996.

141 The 1997 GEBCO Guiding Committee session (GEBCO-XVI) was scheduled to take place in June 1997 at the new Southampton Oceanography Centre. The UK venue for the Sub-Committee, which would precede this meeting, had yet to be decided.

9. CLOSURE OF THE MEETING

142 In closing the meeting the Chairman once again paid tribute to the participants for their active work for the Sub-Committee, not only at the meeting but also during the intersessional period. He said he was very encouraged to observe that yet again, despite several notable absences, the number attending the meeting had broken the previous record; it was evidence of the continued healthy growth of GEBCO, and augured well for the future.

143 The meeting was then addressed by the Director of SACLANTCEN, Mr. David L. Bradley. In thanking the Sub-Committee for holding their meeting at the centre he reiterated his remarks of his opening address that SACLANTCEN would be interested in future communications with GEBCO when the Centre could take a more pro-active role, perhaps leading to a more formal connection. He said that SACLANTCEN needed to remove the sense of being an island and, in helping to achieve this, he cordially welcomed the Sub-Committee for a return visit.

144 With the unanimous support of the meeting, the Chairman thanked Mr. David Bradley, Dr. Michael Max and Ms. Anna Bizzarri and their colleagues for the warm hospitality, excellent arrangements and support given for the meeting.

145 The meeting closed at 1300 hours on Friday 12 May 1995.

Meirion T. Jones (Chairman)

ANNEX I

AGENDA

1. Opening of the Meeting

2. Conduct of the Meeting and tabling of documents

3. Review of bathymetric activities worldwide

   3.1 Arctic region

   3.2 Atlantic Ocean including Mediterranean & Caribbean Seas

   3.3 Indian Ocean

   3.4 Pacific Ocean

   3.5 Southern Oceans

4. Review of related activities in other international/national groups

5. The GEBCO Digital Atlas (GDA)

   5.1 The GDA CD-ROM publication

   5.2 Progress report on updating the GDA

   5.3 Future updating of the GDA

6. Management of echo-sounding data

   6.1 IHO Data Centre for Digital Bathymetry

   6.2 GEBCO Guidelines, Part 4, Multibeam Echo-sounding Data

   6.3 Exchange formats for bathymetric data

7. Future Development of GEBCO Products

   7.1 Development of a GEBCO Gridded Data Set

   7.2 Digital techniques for labelling features

8. Any other business

9. Closure of the Meeting

ANNEX II

TERMS OF REFERENCE
OF THE
GEBCO SUB-COMMITTEE ON DIGITAL BATHYMETRY (SCDB)

(Adopted by the GEBCO Guiding Committee, May 1993)

The Sub-Committee on Digital Bathymetry shall:

1. Maintain a watching brief on developments in deep sea bathymetric mapping and related activities, and on the evolving technologies used to support such work.

2. Keep under review, and provide advice on, standards and procedures for ensuring the continued and effective management, availability and depiction of digital bathymetric data.

3. Maintain, routinely update and further improve the GEBCO Digital Atlas (GDA) by:

   i) developing procedures for incorporating new compilations of bathymetry;

   ii) advising on standards and methodology;

   iii) generating and developing a supplementary file containing shiptracks, for the purpose of providing graphic presentation for quality assurance related to interpreted bathymetric information;

   iv) integrating in an appropriate way the geographical names of undersea features; and

   v) investigating the best medium and software for the effective use of the GDA by all users.

4. Explore the potential, for the better interpretation of oceanic bathymetry, of techniques such as acoustic imagery and satellite observations which do not produce precise sounding data.

5. Investigate and recommend ways and means by which digital methods may be used to expedite production of the GEBCO (6th Edition).

6. Advise, through the Guiding Committee, the International Hydrographic Organization (in its capacity as the World Data Centre for Bathymetry) on matters connected with the collection and exchange of bathymetric data, including the development of automatic data assimilation, archival, retrieval and distribution methods, soliciting the advice and assistance of the IOC Committee on International Oceanographic Data and Information Exchange (IODE), and others as necessary.

7. Stimulate the flow of data relevant to GEBCO by actively identifying sources of new data and encouraging release of data to appropriate data banks, with the object of ensuring that maximum available data are provided to the World Data Centre for Bathymetry and its IHO Data Centre for Digital Bathymetry.

8. Interact with the IHO Committee on Exchange of Digital Data (CEDD) and with other relevant committees and working groups to bring about, to the extent possible, uniformity and compatibility with IODE developments and also with IHO Classification Criteria for Deep Sea Soundings (IHO Special Publication No. 44, Book 2).

ANNEX III

BATHYMETRIC MAPPING AT THE SOUTH PACIFIC APPLIED GEOSCIENCE COMMISSION (SOPAC)

James V. Eade (May 1995)

1. INTRODUCTION

SOPAC began in 1972 as CCOP/SOPAC (Committee for the Co-ordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas) with ESCAP support and as a UNDP project. It became an independent, inter-governmental regional organisation in 1984, and changed its name to South Pacific Applied Geoscience Commission (SOPAC) in 1989. SOPAC aims to improve the well-being of peoples of the Pacific through the application of geo-scientific knowledge, especially relating to non-living resources (minerals, hydrocarbons, energy) and environmental geoscience (coastal management & development, water & sanitation, EEZ information services).

There are 17 members of SOPAC, 15 full members and 2 associate members.

Australia	Marshall Islands	Tahiti (Associate)
Cook Islands	New Caledonia (Associate)	Tonga
Fed. States of Micronesia	New Zealand	Tuvalu
Fiji	Niue	Vanuatu
Guam	Papua New Guinea	Western Samoa
Kiribati	Solomon Islands	

The SOPAC Governing Council of member country National Representatives oversee a Secretariat managed by a council-appointed Director and Deputy Director. The Work Programme of the Secretariat has been established by members to provide assistance and support to applied geo-scientific work that governments are endeavouring to carry out. Annual activities are set and approved, along with an annual budget, by the Governing Council each year at the Annual Session, held usually in September or October. The emphasis of SOPAC is on field work and data collection, processing, storage and retrieval, and in-country institutional capacity-building and in-country-support. Practical training at the Secretariat for island country professional staff is a major on-going activity.

The SOPAC Secretariat carries out its work from its offices in Suva, Fiji, where an international staff totalling 40-50 people work. Funds come from member countries (an annual compulsory membership fee) and aid funds. The work being carried out at any time is dependent on resources available which are largely dependent on SOPAC management's abilities to sell its work programmes to foreign aid donors. Funds are sought primarily for staff positions - people to do the work, so maintaining a competent and active Secretariat, located alongside Fiji's Mineral Resources Department in Suva's Nabua. Consultants are used sparingly as necessary and when staff positions cannot be filled.

SOPAC is currently seeking funds for a person to take the lead in its bathymetric (regional) mapping programme. While preference is for a staff position (minimum of two years), the possibility of using shorter term consultants is also being explored. The Deputy Director of SOPAC (Mr. Alf Simpson) is responsible for overall management of this programme.

Present facilities at the SOPAC Secretariat include traditional map drafting and map copying facilities. Maps are stored in a catalogued map collection and in most instances these are copied to the relevant member country. These are being managed by the Chief Cartographer.

SOPAC has growing computer power. This includes 486 PC networked system with an AO plotter. SOPAC is currently (with DMA assistance) developing, improving, and upgrading its digital databases, not only for indexing but also for data storage. SOPAC now has CD-ROM making capability for copying large datasets to its members (who now almost all have CD-ROM readers). SOPAC has a single Sun workstation operating under Unix. Current staff include a Computer Systems Manager and a Database Development Officer. SOPAC hopes to have and be able to make available digital bathymetric files from multibeam surveys.

2. MAPPING PROGRAM

SOPAC is responsible for assisting island countries map the seabed in their EEZs. It collects, compiles, and stores bathymetric data and produces map products covering much of the South and Central Pacific. This is of growing importance to member states now that the UN Convention on the Law of the Sea, which will approve EEZ boundaries, has come into force. SOPAC's clients for results produced by the Mapping Programme are the Geological, Lands, Hydrographic, Environmental, and Fisheries Departments of the Pacific Island states.

Bathymetric studies at SOPAC involve data collection, compilation, storage (both in sheet form and digitally), plotting, contouring, and map production. While production of maps is an ongoing activity, much of SOPAC's bathymetric data is generated from studies done for reasons other than establishing bathymetry, and mostly in coastal areas. Some of these data have been compiled with existing data to produce published maps such as lagoon bathymetric maps, and nearshore maps from shore to about 1,000 metres. Data from many surveys are contoured and presented as figures in reports. SOPAC maintains a pool of bathymetric surveying and position fixing equipment, mostly suitable for use from small boats, and maintains a strong data collecting ability.

SOPAC is currently giving emphasis to multibeam data collected with GPS navigation. Much of this kind of work in the SOPAC area in recent years has been done by visiting research vessels such as the *Sonne*, *Thomas Washington*, *Moana Wave*, *Kaiyo*, and *Jean Charcot*.

In recent years SOPAC has been carrying out its own multibeam surveys. Of note are the SOPACMAPS survey of the Solomon Islands and Northern Melanesian Borderland, funded for SOPAC by the European Union (under Lome III) and carried out under contract to SOPAC by IFREMER using the *L'Atalante*, and the Joint SOPAC/Japan survey of member countries EEZs for mineral resources using the *Hakurei Maru No* 2. Maps from these surveys have been produced by SOPAC at scales of 1:500,000, 1:250,000, and other more detailed scales. There has been an emphasis of this work in the plate boundary region where Pacific and Indo-Australian plates meet. Back Arc basins - Manus, Woodlark, North Fiji, and Lau have received the most attention. Bathymetric summary maps, made from compiled data have been produced for the Lau and North Fiji basins. But wherever possible work continues in the Pacific plate areas.

Much of the data is in map form at a variety of scales and sometimes in different digital forms incompatible with each other and very difficult to merge. Atlases have now been produced for SOPAC by the Hawaiian Institute of Geophysics, and Japan (JICA/MMAJ).

SOPAC has no funds at present for further work and will rely on visiting research vessels for new data. However SOPAC is working with the Territory of New Caledonia on a proposal to continue work in the SOPAC region including New Caledonia, for European Union (Lome IV) funds to continue the work of the *L'Atalante*.

3. REGIONAL BATHYMETRY

The SOPAC Secretariat is maintaining the resources to produce small scale bathymetric maps of the seafloor. Maps produced cover the SOPAC region or part of the region, or individual country EEZs. Depth data in paper copy and digital form are collected, stored and processed at the Secretariat. For digital bathymetry, SOPAC is using almost exclusively the GEBCO Digital Atlas CD-ROM.

The GEBCO digital bathymetry is proving to be a most useful tool. However it is the GEBCO Fifth Edition contours which are more than 15 years old and therefore similar in age to the SOPAC regional bathymetry. The Secretariat believes that by co-operating with GEBCO, especially its Sub-Committee on Digital Bathymetry, then SOPAC may be able to update the GEBCO digital file and lead to the production of a new regional bathymetry and better country EEZ maps. While some of this work will be carried out by present staff - the Chief Cartographer - SOPAC will need additional assistance at its Secretariat to work effectively with GEBCO.

SOPAC cannot do this work alone and is relying on an exchange of information and collaborative assistance. The Secretariat is maintaining active contact with the US National Geophysical Data Center (NGDC) in Colorado, the IOC/IHO GEBCO Digital Atlas (GDA) at the British Oceanographic Data Centre (BODC) in UK, IFREMER Brest, and the Japan Oceanographic Data Center (JODC). With US State Department and DMA funds SOPAC is improving its digital databases and ability to electronically exchange data. SOPAC is an observer in the IOC's International Bathymetric Chart of the Western Pacific (IBCWP).

ANNEX IV

AN OCEANOGRAPHER'S VIEW OF THE NEED FOR IMPROVED REGIONAL AND GLOBAL BATHYMETRY

Prepared for GEBCO by Dr. Philip Woodworth, Director of
Permanent Service for Mean Sea Level
January 1995

1. Ocean Tide Modelling

At a recent meeting of the TOPEX/POSEIDON team at the AGU in December 1994, over half a dozen new global ocean tide models based on altimetry data were presented. These empirical models ('models' here meaning empirical tidal parameterisations of observed sea surface height variability) are consistent at the few centimetre level, although there are discrepancies in continental shelf areas.

This radical improvement in empirical knowledge of the ocean tides contrasts with current ability to model them from first principles in numerical computer models (i.e. starting with the gravitational tidal potential through depth averaged equations of motion allowing for frictional effects etc). Even the most sophisticated such model, that developed at the University of Grenoble (Le Provost et al), shows systematic differences compared to the TOPEX/POSEIDON derived fields, and almost certainly these discrepancies are in turn primarily related to large scale errors in bathymetric knowledge.

Although tidal experts have a number of approaches by which they can obtain optimal solutions between 'pure' models and the empirical findings (e.g. assimilation schemes), scientists will not be satisfied that maximum understanding exists until the 'pure' models are sufficiently accurate alone, i.e. until the global bathymetry itself is sufficiently precise.

Improved versions of the DBDB5 (ETOPO5) dataset, free of bias due to variations in sound velocity and providing accurate and reliable data particularly in depths below 200m, are urgently required. Interpolation of bathymetry by means of algorithms which employ altimetric mean sea surfaces (geoids) is one obvious way to proceed for tidal purposes, although at the expense of compromising the use of the derived bathymetric model for geophysical studies.

At a regional level (e.g. the NW European shelf or the Patagonian shelf), a common approach is to construct a local model with deep ocean 'boundary conditions' which one believes sufficiently precise. The modelling of the tidal propagation on to the shelf, however, is critically dependent on the local bathymetric knowledge (e.g. problems of shallow water frictional effects, drying areas etc). Relative depth errors increase in shallow water while tidal wavelengths decrease, implying more local variability. Many modellers resort to reading depths from navigational charts but this is extremely time consuming and the depths are biased low by uncertain amounts in order to ensure safe navigation.

High resolution bathymetric datasets are known to exist for many coastal areas, obtained by the world's navies, but classified for military reasons. This classification even precludes the use of the bathymetry, and therefore limits the accuracy of the models, in tidal and storm surge work, for other government ministries (e.g. in studies of coastal flooding). This situation should be reviewed again. It is possible that bathymetric data could be degraded to a lower resolution, say 1 - 10 km in depths below 200m, which would still be an improvement on what is currently available to non-military research.

2. Ocean Circulation Modelling

The issue here is not nearly as clear-cut as with tides. A merged GEBCO/geoid data set could solve a lot of problems, but quality control and sparsity of observations will still be a problem in some regions.

The effect of bottom topography on ocean circulation is a subtle problem which is far from being properly understood. It is known that eddies are influenced by the ocean bottom even in depths as great as 4000 m, and there are many circumstances in which dynamical information can be thought of as propagating along contours of constant depth, or of depth divided by sine (latitude). These effects have been seen in observations as well as in many numerical models of the ocean, but there are always differences between models and observations. Currently, it is impossible to say that these errors reflect inadequacies in the formulation of the models. Poor representation of bottom topography is often invoked instead.

Two types of improvement are necessary to resolve this problem. In many areas of the deep ocean, the detailed topography is not needed to a high resolution, but it is important that the mean depths and large scale slopes are given accurately. It is also important that the character of the smaller scale features (down to about 20 km) is properly represented so that the model topography is not artificially smooth. This small scale structure could be adequately constructed using altimeter-derived geoids.

In some regions, however, the interaction between ocean currents and topography occurs at small scales (down to 20 km or less), with an influence on the large scale circulation. It is important that the details of the topography be right in these regions, i.e. not inferred from altimetry. They are easily identified: narrow straits, continental slopes (particularly those occurring on the eastern sides of land masses or sub-surface plateaux), and other features which are known to have an influence on currents.

Now that computer power has reached the point where global, eddy-resolving models are feasible, it is becoming more important to test those models against reality. The availability of a high quality data set, representing the dynamically-relevant aspects of ocean bathymetry at a resolution of at least 15 minutes, would make those tests much more valuable. At the moment we still cannot say we are comparing like with like, and that can excuse almost any discrepancy. With good bathymetry, any discrepancy would have to be explained in terms of the formulation of the model.

ANNEX V

SATELLITE STUDIES OF THE SEA FLOOR
REPORT ON INTERSESSIONAL ACTIVITIES AT NATIONAL OCEAN SERVICE (NOS), WASHINGTON DC, 1994-95

Dr. Walter H.F. Smith

1. On 29 July 1994, S. Laxon (Mullard Space Science Laboratory, University College London) and D. McAdoo (NOAA Geosciences Laboratory, Silver Spring) published a paper in 'Science' on an "Arctic Ocean gravity field derived from ERS-1 satellite altimetry". They used a new technique for ice-covered areas and produced a map of gravity anomalies over ocean areas between 64°N and 81.5°N. It shows some new tectonic structures of possible interest to GEBCO. They are continuing to work on this technique and are now focusing on the Weddell and Ross Seas. (The ERS-1 orbit extends to 81.5 degrees north and south latitude.)

2. In late summer 1994, the U.S. Government Printing Office printed a poster "Sea floor topography predicted from satellite altimetry and ship depth measurements" by W.H F. Smith and D.T. Sandwell. The poster carries report number MGG-09 of the U.S. National Geophysical Data Center/World Data Center in Boulder, Colorado. Copies were mailed to addressees on the GEBCO Personality List. This poster is a polar stereographic projection of the area between 30°S and 70°S. The digital data are available through anonymous ftp over Internet or on the CD-ROM published by NGDC.

3. In September 1994, the European Space Agency's ERS-1 satellite completed the first 168-day cycle of its geodetic phase orbit. This orbit yields ground tracks spaced 16 km apart at the equator. The spacecraft was manoeuvred so as to begin collection of another cycle shifted 8 km with respect to the first cycle. The plan at this time was to complete only part of the second cycle, terminating it in December 1994, but see paragraph 6 below.

4. On 10 November 1994, an article on "Bathymetric prediction from dense satellite altimetry and sparse shipboard bathymetry" by Smith and Sandwell appeared in the Journal of Geophysical Research. This paper gives the technical details of the work presented at the last GEBCO meetings (and in paragraph 2 above). The paper is careful to point out the limitations of the technique and stresses that prediction from altimetry is no substitute for actual bathymetry obtained by conventional means.

5. On 5 December 1994, the Fall Meeting of the American Geophysical Union began in San Francisco with two sessions devoted to display of new results from the European Space Agency's ERS-1 Geodetic Phase data. Many investigators from several countries presented papers. Abstracts are printed in EOS Transactions of the AGU, vol. 75, no. 44, 1994 Fall Meeting Supplement, Nov. 1 1994. Of particular interest was the marine gravity field by D.T. Sandwell, M.M. Yale, and W.H.F. Smith which used the newest ERS-1 data as well as other data from ERS-1, Topex/Poseidon, Geosat, and Seasat (ESA, NASA/CNES, US Navy, and NASA, respectively). The digital data are available by anonymous ftp from baltica.ucsd.edu in file "world grav-img.4". See paragraph 11.

6. In early December 1994, there was a launch failure at Arianespace, raising the possibility of a delay in the launch of the ERS-2 satellite. At the Fall AGU Meeting, I wrote a letter to Dr. Guy Duchossois of ESA and I got close to 30 scientists from several countries to sign the letter which I faxed to him in Paris. The letter expressed thanks and praise for the ERS-1 geodetic phase data and urged ESA to extend the mission to complete the collection of global coverage with an 8 km ground track spacing. ESA decided to do this. It was not an easy decision. ESA had orders for data in the planned 35-day orbit and the geodetic mission extension disappointed other customers. However, the extension has resulted in globally uniform and high-resolution gravity data for mapping purposes.

7. On 21 March 1995, ERS-1 completed the second cycle of the geodetic phase orbit. The data were made available in the form of NOM IGDRs (Interim Geophysical Data Records) on 30 March 1995. The final archival form of the data will be the Ocean Product Record (OPR) which is produced several months after real time by ESA's French Processing and Archiving Facility (F-PAF). The F-PAF expects to have these data out in September 1995.

8. In April 1995, Dave Sandwell and I began to process the ERS-1 IGDRs to produce gravity maps for areas similar to the GEBCO sheets at the 1:10 million scale. This preliminary solution looks very interesting. There are a few problems caused by bad orbits and some patches in the North Atlantic where there are data gaps. We also have not yet decided how best to process the data in the near shore areas and shallow marginal seas.

9. On 21 April 1995, ESA launched ERS-2 and is working to establish it in a 35-day repeat orbit (ground track spacing approximately 80 km) in tandem with ERS-1, so that the two satellites will pass over the same areas 1 day apart. This will permit new work using Synthetic Aperture Radar (SAR) which will allow topographic mapping of the world's land areas to a possible resolution of 30 m horizontally and 3 m vertically. ESA splits the satellite data streams among different investigators and I have no direct access to this data. I suggest that the GEBCO may wish to locate an ESA SAR investigator and ask him/her to contribute high quality land elevations to any gridded bathymetric products which the GEBCO may develop.

11. On approximately 26 April, a paper by M.M. Yale, D.T. Sandwell and W.H.F. Smith entitled "Comparison of along-track resolution of stacked Geosat, ERS-1, and Topex Satellite Altimeters" was accepted for publication in the Journal of Geophysical Research. This paper demonstrates that the resolving power and noise characteristics of the ERS-1 altimeter are essentially the same as the Geosat altimeter.

12. On 1 June 1995, at the 1995 Spring Meeting of the American Geophysical Union in Baltimore, there will be a session on "Marine Geology and Geophysics from Satellite Altimetry". The abstracts are published in EOS Transactions of the AGU, vol. 76, no. 17, 1995 Spring Meeting Supplement, Apr. 25 1995. Of particular interest is the global gravity field presented by D.T. Sandwell, M.M. Yale, and W.H.F. Smith. The digital form of these data is "world grav.img.5" which can be obtained by anonymous ftp from baltica.ucsd.edu. The spacing of the pixels is based on a Mercator projection, with samples every three minutes of longitude. Track location information may also be encoded. The directory also contains software for handling the data. Another paper in this session is by Smith and Sandwell and concerns combining the altimeter data with ship data. This is, I hope, the first in a series of papers detailing how altimeter data can be used for quality control of archival ship data. A third paper in this session is by Laxon and McAdoo (of paragraph 1) and concerns mapping of ice-covered seas.

ANNEX VI

INTRODUCTORY NOTES ON THE PROBLEMS INVOLVED IN PRODUCING A GRIDDED DATA SET FROM THE GEBCO (FIFTH EDITION) DIGITAL CONTOURS

Dr. Walter H.F. Smith

1. THE INTERPRETATION OF CONTOURS

1.1 Mathematics

Suppose we have a function z=f(x,y). In order for z to be a function of x,y it must be single-valued; that is, there is only one z for any x,y. This means that if a topographic surface is to be represented by a function, that surface cannot have any vertical or overhanging walls.

Consider the set of all points x,y satisfying z=c for some given value c. If z is a continuous function then this set of points can be organized into one or more continuous paths through the x,y plane; we call each such path a contour of z. Implicit in the mathematical idea of a contour map is that the contouring is complete; that is, if a contour z=c is shown then it is implied that all places in the map domain where z=c have been found and are shown. If z is not continuous then the set of all points x,y satisfying z=c will have isolated points or contours which end without closing or reaching the boundary of the region.

If z is continuous and the contouring is complete, then we may be sure that at a point x,y between two contours c1 and c2 the value of z is between c1 and c2. Let us call this property of contours the bounding property.

If z is differentiable then we may form the gradient of z, and the projection of this gradient onto the x,y plane at any point will be perpendicular to the path of a contour through that point. In this case the contour will also be a smooth curve; it will not have sharp corners. Conversely, if the contour path has sharp corners then z is not differentiable. Let us call this property of contours to define trends the trend property.

If z= f(x,y) is exactly known everywhere and it is continuous then given a set of contour values c1, c2, c3, ... we can produce a contour map of z. This map is unique. Given a complete and exact contour map we cannot uniquely reconstruct z. There are an infinite number of functions satisfying any contour map, because the values of z between the contours are not specified.

1.2 Bathymetry

We may not want to interpret bathymetric contours in the strict sense as identifying places where the depth is known to be z=c. We could interpret them this way where the contours cross control track lines, but away from control surveys they probably do not have this property exactly. Even at control points this property is not exact if we allow for navigational errors. And when we get down to splitting hairs we also have to allow for the precision of our depth measurements and the fact that they reflect the average properties over the region which scattered the acoustic energy.

We may want to interpret bathymetric contours as defining trends. The scientist who drew the contours may have been guided by other information in addition to bathymetric surveys when s/he drew the contours in a particular direction. In some cases the contours may be more valuable as trend indicators than as indicators of absolute depths.

Not all of the GEBCO Fifth Edition contours can be interpreted as having the bounding property in the strict sense, even assuming that the depth values and contour locations are exact, because the contours are not all complete. There are auxiliary contours which are drawn in some areas but are not completed throughout the map area.

The Fifth Edition digital contours look quite rectilinear, perhaps due to the digitizing algorithm used to collect them. This makes their use as trend indicators, at least at the fine scale, difficult.

2. GRIDDED DATA

2.1 Interpolation

Given a gridded data set, we may wish to contour it, or re-grid it in a new coordinate system such as a map projection. This requires us to evaluate z (interpolate) at points which are not on the given grid. The simplest interpolation would fit a bilinear surface to the four given points surrounding the point to be interpolated, but other methods are possible. We might require a higher-order interpolant to provide smooth derivatives, or a scheme based on weighted averages. Each of these will give a different result.

In particular, different contouring algorithms will give different results. Therefore it may not be a fair test of a gridded solution to see if it reproduces the GEBCO Fifth Edition contours.

The interpolation scheme may fail to honour the boundedness property. For example, in the gridded solution I derived for GEBCO Sheet 5.12, I prepared a 5-minute latitude-longitude grid and then interpolated this on to a Mercator projected grid for computer imaging purposes. The interpolated solution shows a few grid points which exceeded the latitude-longitude contour bounds.

2.2 Nyquist wavelength

It should be intuitively clear from the idea of interpolation that there are features which a given grid cannot reproduce, and these are features whose size is small with respect to the grid spacing. Equidistant sampling of functions of one variable is a well-known topic in time-series analysis. The concepts generalize readily to a function of two variables in the Cartesian x,y plane. Using Fourier analysis one breaks down f(x,y) into component wavelengths. A grid with values spaced every dx and dy can reproduce features in the x and y directions of wavelengths 2dx and 2dy and longer. Shorter features cannot be resolved. These wavelengths are called the Nyquist wavelengths.

2.3 Aliasing

If a function z=f(x,y) contains features shorter than 2dx and it is sampled on a grid of spacing dx, then these shorter features will masquerade as longer features in a phenomenon known as aliasing. Therefore to be safe, one should take z through some sort of averaging or smoothing process to remove features shorter than 2dx before reducing z to a grid.

2.4 Spherical co-ordinates

When we work in latitude and longitude most of the concepts carry over. The distance between two meridians of longitude is a function of latitude, and so the Nyquist wavelength definition must be changed. If we replace the Fourier analysis with spherical harmonics and we sample latitude and longitude in equal angular increments then we can express the Nyquist wavelength approximately as an angular distance which can be resolved. We would avoid aliasing by averaging or smoothing in the area of a spherical cap, rather than a rectangular Cartesian neighbourhood.

3. GRIDDING ALGORITHMS AND GRIDDING OF CONTOURS

3.1 Traditional gridding algorithms

Gridding is an interpolation-extrapolation process, and it assumes that given values of z(x,y) at certain arbitrary points are useful in determining z at other points (the grid points). This means that z is smooth, or if z is a stochastic surface, at least that z's autocovariance is smooth, to some degree. All standard gridding algorithms therefore estimate z at grid points by a weighted average of the given nearby values. In the simplest methods the weighting scheme is ad hoc, while more sophisticated methods choose the weights to be optimal in some sense. One kind of optimality uses statistical models, estimates the autocovariance of the data, and uses this to choose weights which minimize the variance (expected

uncertainty) of the grid estimates. "Kriging" is a method of this kind. Another kind of optimality is smoothness of the solution. Methods such as "minimum curvature" choose the weights so as to find the smoothest solution consistent with the given data.

None of these traditional methods, if given contour data as input, will honour the boundedness property of contour maps. In some cases they fail rather spectacularly, as I showed in a paper on "Gridding with continuous curvature splines in tension" (Geophysics, vol. 55, pp. 293-305, 1990). That article introduced a method which can alleviate this problem, and the computer program "surface" which does this is part of the GMT software package. Since writing that article I have added the boundedness feature to "surface" - the program can now be given bounds as constraints.

3.2 Programs specifically for gridding contour data

There exist algorithms intended to grid contour data. One common approach is to create a surface of triangular facets, with each triangle having one edge along a contour and the opposite vertex on another contour. The surface is then sampled at the grid points. Note that with such a triangulation the trend directions are preserved, but if two adjacent contours have the same value then the resulting surface is flat between them, whereas the bathymetrist intended to portray a ridge or trough with those contours. Also, if the two contours are separated by a large distance but each contour is densely digitized then the triangles will have a very needle-like shape and the resulting surface can look peculiar.

4. SOME THOUGHTS

Last year I said it should be simple to produce a grid from the GEBCO Fifth Edition contours. Knowing of the drawbacks of triangulation and the feature of "surface" (GMT software) which can make a smooth surface honouring bounds constraints, I thought I would use "surface" to produce a solution. I set to work to create grids of upper and lower bounds implied by the Fifth Edition digital contours. I ran into difficulties because the contour lines often ran along the grid mesh for some distance and so the scheme I had programmed was not the best way of determining the bounds. Also, as I examined the digital contours closely I realized that we should discuss how the contours are to be interpreted, in light of section 3 of this report.

What I have produced in the meantime uses "surface" but without the strict sense of bounded regions which contours could provide. I treated the contour points simply as point data. I used GMT program "blockmean" to average the data in 5-minute squares. There are many places on GEBCO Sheet 5.12 where several contours pass through one 5-minute square, and so it is likely that the contours contain features which would be "aliased" and not resolved by a 5-minute grid.

I think we need to decide what is the meaning of the GEBCO contours and how we will interpret them or use them as constraints for the gridding algorithm. We also need to decide the registration of the grid (what GMT calls "grid" or "pixel"), what smoothing will be done to avoid aliasing, etc.

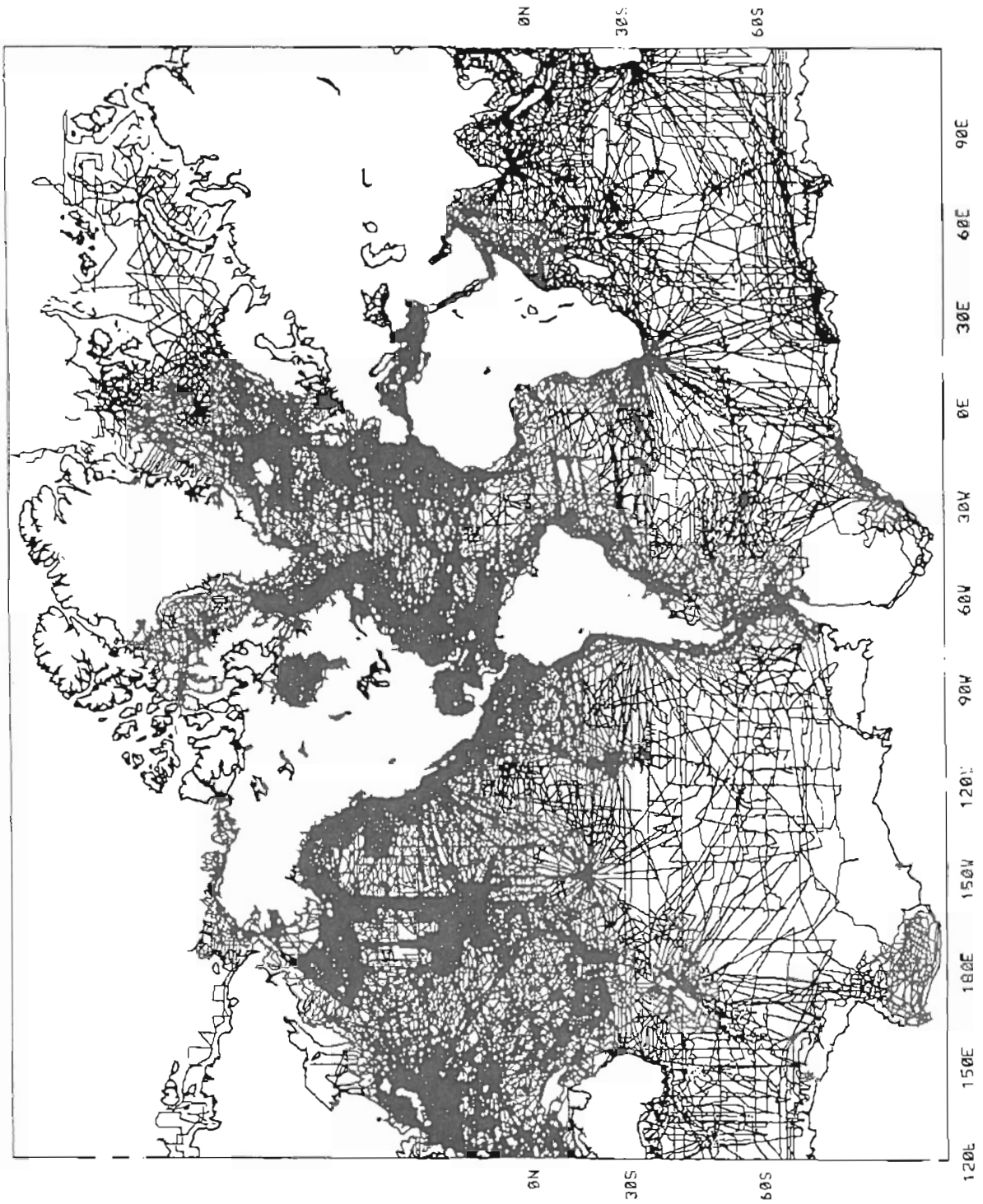
ANNEX VII

SUMMARY OF DIGITAL BATHYMETRIC DATA HELD IN THE GLOBAL MARINE GEOPHYSICAL DATA BASE (GEODAS) AT THE US NATIONAL GEOPHYSICAL DATA CENTER AND THE IHO DATA CENTRE FOR DIGITAL BATHYMETRY

TOTAL HOLDINGS

SOURCE	NO. OF CRUISES /LEGS	TRACKLINE IN NAUTICAL MILES				NO. OF BATHYMETRIC SOUNDINGS
		TOTAL	BATHYMETRY	MAGNETICS	GRAVITY	
Lamont (LDGO)	602	2515158	2404862	2033274	1810289	4544010
Woods Hole O.I.	149	548797	532603	341774	302323	991734
NOAA	348	882590	876105	548205	341546	2003514
US Geol. Survey	215	483084	388131	279370	248234	2205343
Oregon St. Univ.	70	175633	166122	125892	1.5555	250973
Hawaii Inst. Geo.	216	772545	736210	408962	445502	1994154
US Navy	201	905784	875426	363513	35023	2891393
Univ. of Texas	78	138647	116796	90383	0	218668
Rice Univ.	2	7681	7681	0	0	3557
Univ. of Conn.	4	4522	3884	0	4522	2175
Scripps Inst. Oc.	560	2186891	2009451	1530717	199847	4639227
U Rhode Island	25	62402	61298	7165	0	385876
U Washington	16	36818	36664	0	0	160771
Texas A & M Univ.	57	160132	126365	114322	0	187341
Defense Map. Ag.	84	358808	357687	0	0	678526
Min. Manag. Serv.	7	42957	42784	0	0	399693
US NSF	3	17341	15238	4994	15667	77433
NEW ZEALAND	15	27390	26345	21257	17307	20218
CANADA	150	636575	619574	18490	1173	609799
CHINA	5	33343	32977	9357	33136	13437
UNITED KINGDOM	210	419042	394675	154047	164635	935362
AUSTRALIA	4	31567	22928	26749	9243	.57139
RUSSIA	31	254692	219544	0	248135	97930
NETHERLANDS	7	29706	26755	7366	9754	.49231
FRANCE	215	581062	516968	377490	272663	2932698
SOUTH AFRICA	19	61086	54001	4995.	0	75905
BRAZIL	7	32195	32195	0	0	131415
INT. GRAV. BUR.	9	59789	59020	0	59779	29699
GERMANY	33	143453	142939	0	0	1376985
ORSTOM NEW CAL.	22	65025	63007	51001	28449	89752
CUBA	5	33092	33092	0	0	14949
ARGENTINA	2	770	770	0	0	206
INDIA	13	8867	8867	0	0	4735
PORTUGAL	8	9155	9155	0	0	8650
HYDR. DEPT. JAPAN	81	271279	268544	200069	258171	272330
GEOL. SRVY. JAPAN	26	167169	.44848	138872	165537	160935
UNIV. TOKYO	45	308029	301924	156205	199849	234543
KOBE UNIV.	11	13446	9582	13411	0	10385
UNIV. OF RYUKYUS	3	2931	1808	588	0	896
J.O.D.C. JAPAN	18	100780	99157	0	0	74825
CHIBA UNIV.	4	9325	7894	5505	0	33626
INST. POLAR RES.	29	119041	107973	0	119041	376979
GRAND TOTAL	3609	12717594	11961897	7078929	5105380	29447017

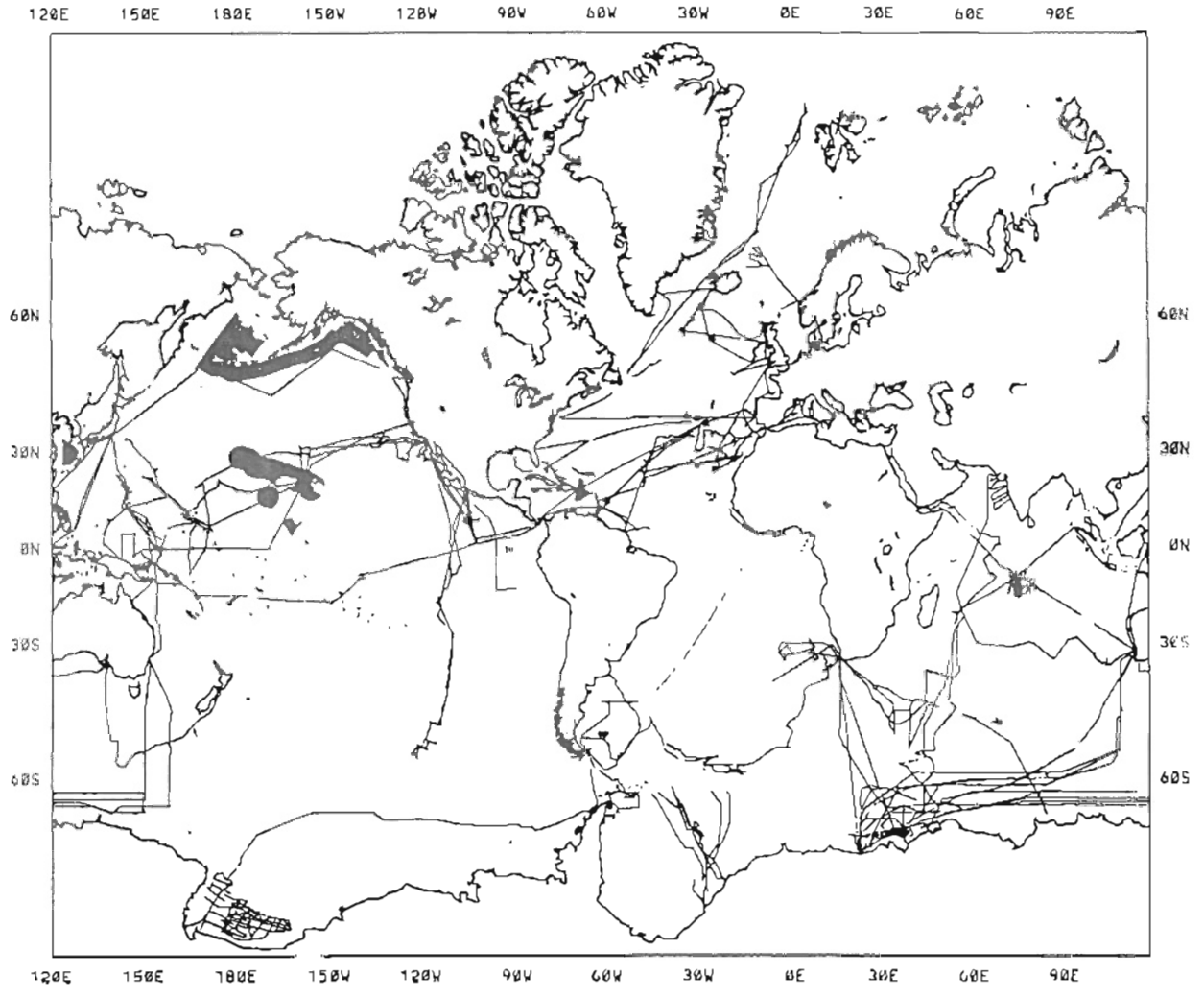
TRACKLINE PLOT OF TOTAL HOLDINGS OF DIGITAL BATHYMETRIC DATA
IN THE NGDC GLOBAL MARINE GEOPHYSICAL DATABASE (GEODAS/TRKDAS)
AS OF 8 MAY 1995



BATHYMETRIC DATA ASSIMILATED INTO GEODAS/TRKDAS FROM 21 MAY 1994 TO 08 MAY 1995

SOURCE	NO. OF CRUISES /LEGS	TRACKLINE IN NAUTICAL MILES				NO OF BATHYMETRIC SOUNDINGS
		TOTAL	BATHYMETRY	MAGNETICS	GRAVITY	
Lamont (LDGO)	15	52249	47662	5044	5265	164782
NOAA	2	4414	4414	0	0	17866
US Geol. Survey	27	117110	113053	106530	83605	316026
Hawaii Inst. Geo.	8	26425	23582	0	0	106087
Scripps Inst. Oc.	20	70245	65717	48621	33236	441517
Texas A & M Univ.	9	30326	28328	26366	0	32560
US NSF	3	17341	15288	4994	15667	77433
CHINA	1	9357	9126	9357	9154	3330
UNITED KINGDOM	43	109509	101529	16031	23242	417950
FRANCE	1	4092	4010	0	0	20328
INDIA	13	8867	8867	0	0	4735
PORTUGAL	8	9155	9155	0	0	8650
INST. POLAR RES.	29	119041	107973	0	11904.	376979
GRAND TOTAL	179	578131	538704	216944	289211	1988243

TRACKLINE PLOT OF BATHYMETRIC DATA ASSIMILATED INTO THE NGDC GLOBAL MARINE GEOPHYSICAL DATABASE (GEODAS/TRKDAS) FROM 21 MAY 1994 TO 08 MAY 1995



ANNEX VIII

LIST OF SHIPS EQUIPPED WITH MULTIBEAM SYSTEMS

(NRL list of 9 November 1995)

SHIP NAME	OPERATOR		SYSTEM
USA-OPERATED			
US-NAVY/MSC Operated			
USNS Bowditch (TAGS-62)	NAVOCEANO	(insvc '96)	SIMRAD EM121A
USNS Silas Bent	NAVOCEANO	(ret '99)	SEABEAM
USNS Matthew Hensen (TAGS-63)	NAVOCEANO		SIMRAD EM-121A
USNS Harry Hess	NAVOCEANO	(ret '90)	SASS
USNS Elisha Kane	NAVOCEANO	(ret '96)	SEABEAM
USNS Littlehales (TAGS-52)	NAVOCEANO		SIMRAD EM-100
USNS John McDonnell (TAGS-51)	NAVOCEANO		SIMRAD EM-100
USNS Matthew F. Maury (TAGS-39)	NAVOCEANO	(ret '94)	SASS IV
USNS Mizar	NAVOCEANO	(ret '90)	SEABEAM
USNS Neptune	NAVOCEANO	(ret '91)	SEABEAM
USNS Observation Island	NAVOCEANO	(retired)	SASS
USNS Pathfinder (TAGS-60)	NAVOCEANO		SIMRAD EM121A
USNS Sumner (TAGS-61)	NAVOCEANO		SIMRAD EM121A
USNS Tanner (TAGS-40)	NAVOCEANO	(ret '93)	SASS IV
USNS Waters (TAGS-45)	NAVOCEANO/SPAWAR		SEABEAM
USNS Wilkes	NAVOCEANO	(ret '95)	SEABEAM
USNS Wyman	NAVOCEANO	(ret '99)	SASS IV/BOTASS
USNS Zeus (T-ARC-7)	NAVOCEANO	(ret '97)	SIMRAD EM121
R/V Laney Chouest	COMSUBDEVGRU 1		SEABEAM
Sea Lion	NAVOCEANO/NRL	(1994)	SIMRAD EM-950
RESEARCH INSTITUTIONS			
Atlantis (AGOR-25)	Woods Hole	(under const.)	SEABEAM 2112
Atlantis II	Woods Hole		SEABEAM
Robert Conrad	Lamont-Doherty	(ret '89)	SEABEAM
Maurice Ewing	Lamont-Doherty		HYDROSWEEP
Ka'imikai o Kanaloa	Univ. Hawaii		SEABEAM
Knorr	Woods Hole		SEABEAM 2112
Melville	Scripps		SEABEAM 2000
Moana Wave	Univ. Hawaii		SEAMARC II
Nathaniel Palmer (Icebreaker)	NSF/Edison Chouest	(ice)	SEABEAM 2112
Roger Revelle (AGOR-24)	Scripps	(launch '95)	SEABEAM 2112
Thomas Thompson (AGOR-23)	Univ. Wash.		HYDROSWEEP
Thomas Washington	Scripps	(ret '92)	SEABEAM (to Chile)
NOAA/NOS (US Coast Survey)			
NOAAS Davidson	NOAA/NOS	(ret '94)	BS3
NOAAS Discoverer	NOAA/NOS		SEABEAM
NOAAS Mt Mitchell	NOAA/NOS	(ret '96)	SEABEAM
NOAAS Rainier	NOAA/NOS		HYDROCHART II
NOAAS Surveyor	NOAA/NOS		SEABEAM
NOAAS Whiting	NOAA/NOS		HYDROCHART II
S/V Rude	NOAA/NOS		SEABAT 9001
AGOR-NOAA (AGOR-26)	NOAA	(under const.)	SEABEAM 2112A

US COMMERCIAL VENTURES

Inland Surveyor (Portable)	C&C Technologies		SIMRAD EM-950
S/V Seabat 1	EMC, INC		SEABAT 9001
Seis Surveyor	John Chance & Assoc.		SEABEAM 2136 (36° sys)

NON-UNITED STATES-CONTROLLED MULTIBEAM VESSELS

NATO:

Alliance	SACLANTCEN La Spezia		HYDROSWEEP MD

AUSTRALIA:

HMAS Cook	Australian Navy		SEABEAM

BELGIUM:

Ter Streep	Dienst der Kusthavens		SIMRAD EM-950

CANADA:

Frederick G. Creed	Canadian Hydro. Svc.		SIMRAD EM-1000
Dolphin (ROBV)	Canadian Hydro. Svc.		SIMRAD EM-1000
Jean Charcot (ex-France)	LD CANOCEAN		SIMRAD EM-12, EM-100
Matthew	Canadian Hydro. Svc.		SIMRAD EM-100
Revisor	Canadian Hydro. Svc.	(1995)	SIMRAD EM-3000
Smith (Swath/Sweep System)	Canadian Hydro. Svc.	(210 kHz)	NAVITRONICS

CHINA (PRC):

Dayang Yi Hao	COMRA	(instal '97)	SEABEAM 2112.360
Hai-Yang 4	Ministry of Geology		SEABEAM 2112

FRANCE:

L'Atalante	IFREMER		SIMRAD EM-12 (Dual)
Borda	EPSHOM		THOMPSON CSF
L'Esperance	EPSHOM		SIMRAD EM-12 (Dual)
Le Suroit	IFREMER		SIMRAD EM-1000
-	IFREMER		SIMRAD EM-950

GERMANY:

Meteor	DFG/BMFT/RF		HYDROSWEEP DS
Polarstern (Icebreaker)	Alfred-Wegener Inst.		HYDROSWEEP DS
Sonne	BMFT/RF		HYDROSWEEP DS
Wega	BSH		HYDROSWEEP MD

INDIA:

Sagar Kanya	NIO		HYDROSWEEP DS

INDONESIA:

-	R&D Centre of Oceanol.	(instal '96)	SIMRAD EM-950

ITALY:

Magnagni	Italian Hydrogr. Off.		Bottom Chart
Ravello	DIAMAR		??
-	ELLETRA		SIMRAD EM-1000

JAPAN:

Fukae-Maru	Kobe Univ.-MMA		FURUNO HS-10
Hakuho Maru	Univ. Tokyo		SEABEAM
Hakurei Maru II	MMA/DORDO		HYDROSWEEP DS
Iwate-Maru	Iwate Prefecture		FURUNO HS-200/II
Kaiko	JAMSTEC	(instal '96)	SEABEAM 2100
Kaiyo (Swath Hull)	JAMSTEC		SEABEAM
Meiyo	JMSA/Hydrog. Dept.		SEABEAM 2000
Miyako	Tokyo Met/Fish Exp.		FURUNO HS-100
Myojin-Maru No. 8	Fisheries Agency		FURUNO HS-100
Nojima	JMSA		FURUNO HS-100
Ojika	JMSA		FURUNO HS-200/II
Oyashio	Hokkaido Prefecture		FURUNO HS-200/II
Rishiri	JMSA		FURUNO HS-100
Tajima	Hyogo Pref. Fish Exp.		FURUNO HS-100
Takuyo	JMSA/Hydrog. Dept.	(upgrade '95)	SEABEAM 2100
Taneichi-Maru	Taneichi High Sch.		FURUNO HS-500
Tenyo	JMSA/Hydrog. Dept.		HYDROCHART II
Yokosuka	JAMSTEC		FURUNO HS-10
Yosyu	Ehime Prefecture		FURUNO HS-100
(to be decided)	JAMSTEC	(instal '96)	SEABEAM 2100

KOREA:

Hae Yang 2000	Korean Hydro. Svc.	(instal '97)	SEABEAM 2112.360
Onnuri	KORDI		SEABEAM 2000
	KIGAM	(instal '96)	SIMRAD EM-12
	KIGAM	(instal '96)	SIMRAD EM-950

NETHERLANDS:

Blommendal	Rijkswaterstaat	BATHYSCAN 300
Chr. Brunings	Rijkswaterstaat	SIMRAD EM-100
Burskyes	Van Oord (fallpipe)	BATHYSCAN 300
Octans	Rijkswaterstaat	SIMRAD EM-950
Rocky Giant	Van Oord (fallpipe)	SEABAT 9001
Trollnes	Rijkswaterstaat	SEABAT 9001
Wijtvleit	Rijkswaterstaat/Zeeland	SIMRAD 950

NORWAY:

Bergen Surveyor	Stolt-Nielsen Norway	SIMRAD EM-100
Div. "U"	Forsvarets Forsk. Inst.	SIMRAD EM-100
Geograph	A/S Geoconsult	SIMRAD EM-1000
Geofjord	Norwegian Hydro. Svc.	SIMRAD EM-100
Geomaster	A/S Geoconsult	SIMRAD EM-1000
Geo Scanner	Geoteam	SIMRAD EM-1000
Hylsfjord	Blom A/S	SIMRAD EM-950
Ice King	K/S A/S Ice King	SIMRAD EM-100
Lance	Norwegian Hydro. Svc.	SIMRAD EM-100
North Sea Surveyor	Stolt-Nielsen Norway	SIMRAD EM-100
Odin-Finder	Forsvarets Forsk. Inst.	SIMRAD EM-100
Simrad	Simrad Subsea	SIMRAD EM-1000

POLAND:

-	Port of Gdansk	SIMRAD EM-950

PORTUGAL:

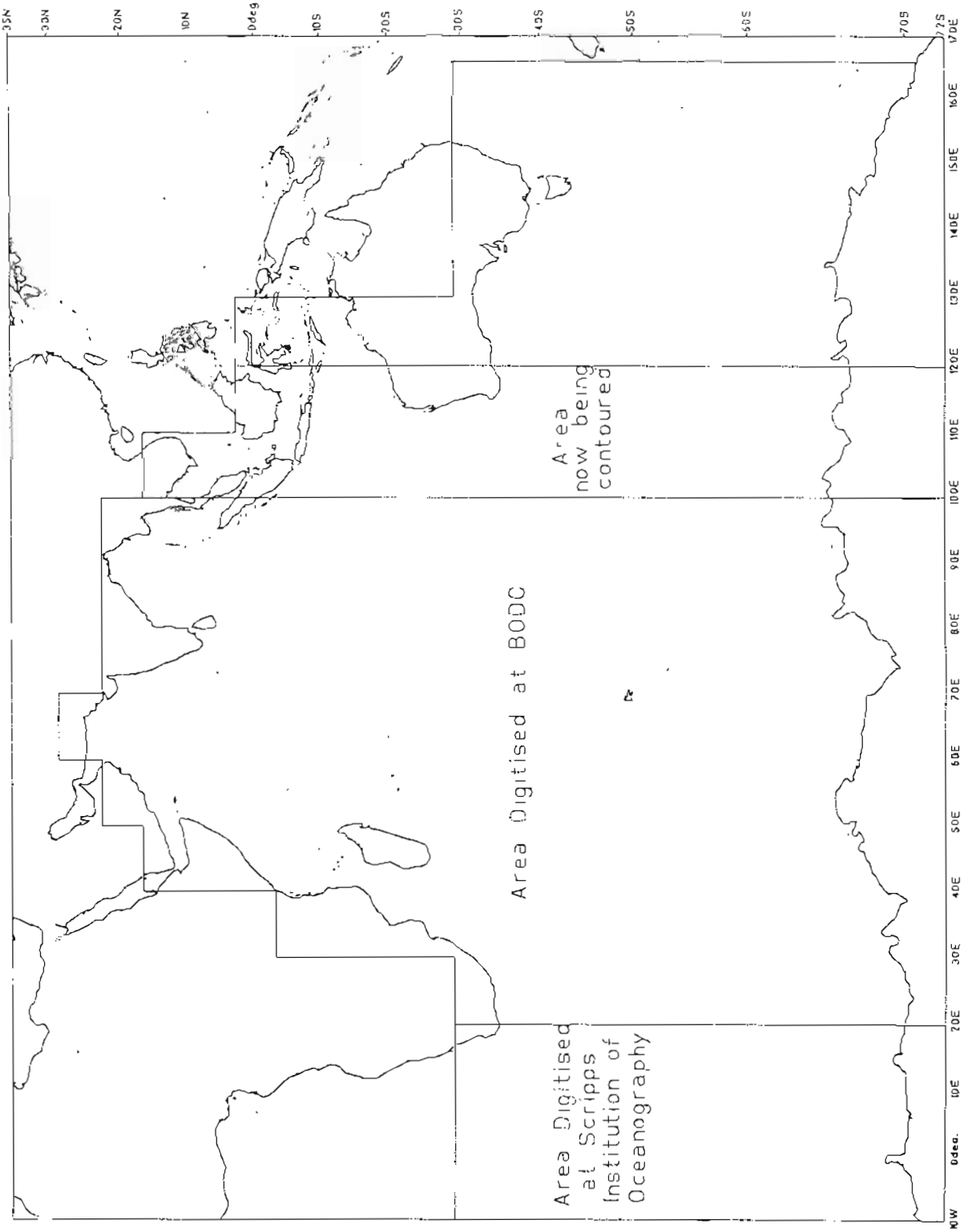
-	Instituto Hydrografico	SIMRAD EM-950

RUSSIA:		
Akad. Boris Petrov	Akad. Sci. Russia	HOLLMING ECHOS II
Akad. Ioffe	Akad. Sci. Russia	HOLLMING ECHOS XD
Peter Kottsov	Russian Hydrogr. Off.	SIMRAD EM-100
Akad. M.A. Lavrentyev	Akad. Sci. Russia	HOLLMING ECHOS II
R/V Dmitri Mendeleev	Acad. Sci. Russia	HOLLMING ECHOS XD
Akad. Nikolai Strakhov	Akad. Sci. Russia	HOLLMING ECHOS II
Akad. Sergei Vavilov	Akad. Sci. Russia	HOLLMING ECHOS XD
R/V Gelendzhik	Russian Central Marine Geol. & Geophys. Exped.	SIMRAD EM-12
SAUDI ARABIA:		
Karan 8	ARAMCO	SIMRAD EM-1000
SINGAPORE:		
Sea Wind	Fugro Geodetic	SIMRAD EM-950
Simson Echo	Simrad Asia Pte. Ltd.	SIMRAD EM-950
SPAIN:		
Hesperides	Consejo Superior de Investigaciones Ceintific.	SIMRAD EM-1000/12
SWEDEN:		
-	Marin Matteknik	SIMRAD EM-950
TAIWAN ROC:		
Takuan	Min. of Transport & Comm.	SIMRAD EM-12 (Dual)
-	Min. of Transport & Comm.	SIMRAD EM-1000
UNITED KINGDOM:		
RRS Charles Darwin	NERC	SIMRAD EM-12 S/120
RRS Discovery	NERC	GLORIA
Farnella	John Marr Shipping	GLORIA
Geo Surveyor	Geoteam Ltd.	SIMRAD EM-1000
Ocean Surveyor	Worldwide Ocean Surv. Ltd.	SIMRAD EM-100, EM-12
Sea Explorer	Gardline Surveys Ltd.	SIMRAD EM-1000
HMS (to be decided)	Royal Navy	SASS IV

ANNEX IX

STATUS OF THE BATHYMETRIC CHART OF THE INDIAN OCEAN BEING COMPILED BY DR. R.L. FISHER AT SCRIPPS INSTITUTION OF OCEANOGRAPHY

15 May 1995

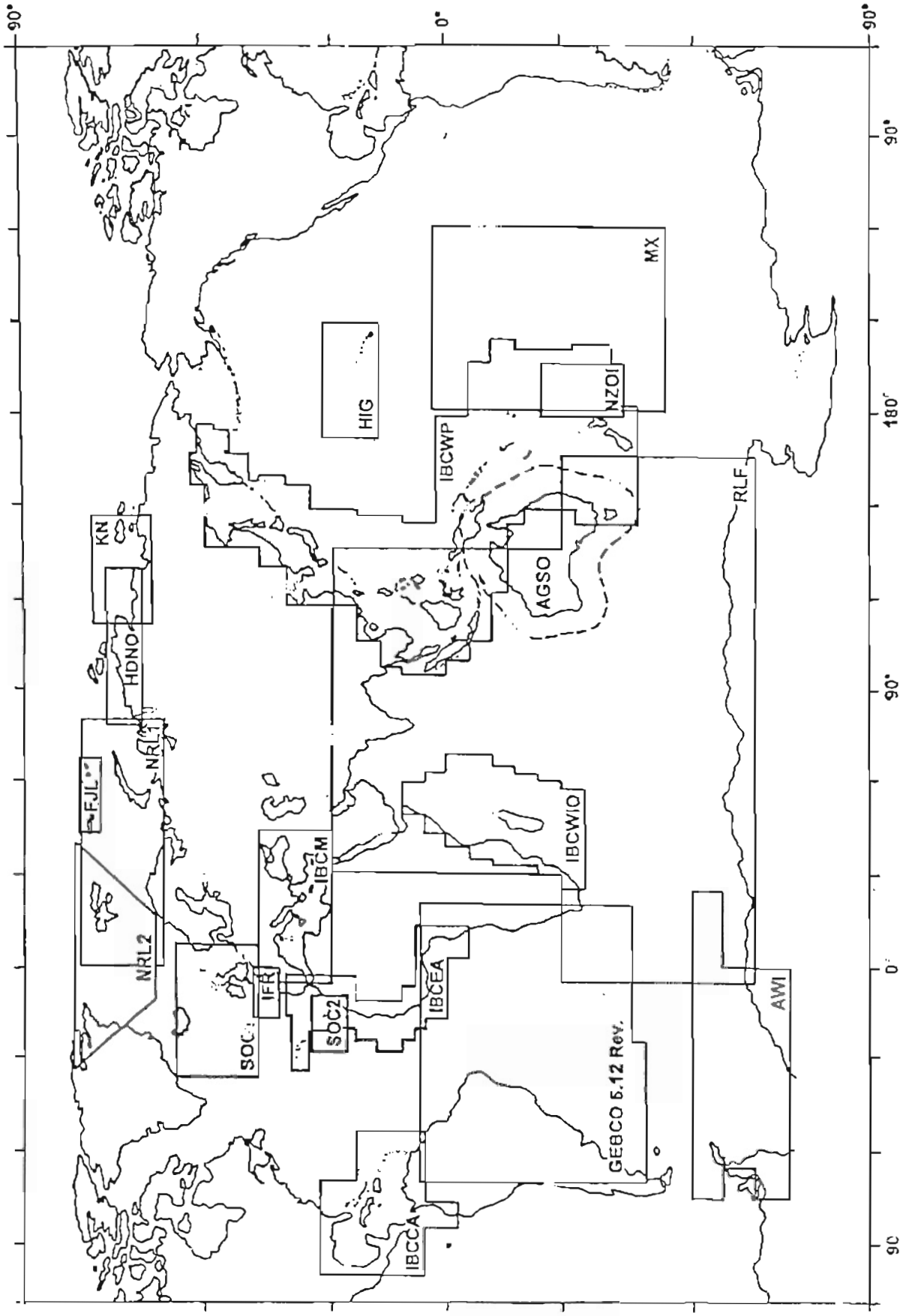


ANNEX X

CHART INDEX OF RECENT/PLANNED BATHYMETRIC CHARTS OF POTENTIAL USE FOR UPDATING THE GEBCO DIGITAL ATLAS

Key to Bathymetric Maps

AGSO	Offshore Resource Map Series - Australian Geological Survey Organisation, scale 1:1 million.
AWI	Bathymetric Charts of the Weddell Sea - Alfred-Wegener-Institut, scale 1:1 million.
FJL	Bathymetric Map of the Franz Josef Land Area - Matishov et al., Murmansk (1995), scale 1:500,000 @ 80°N.
GEBCO 5.12 (rev)	GEBCO Sheet 5.12 Revised (already included in GDA)
GL	Bathymetry of the Great Lakes - NGDC, USA and Canada.
HDNO	Bathymetric Maps of the Kara and Laptev Seas - Head Department of Navigation and Oceanography (1993), (digital files).
HIG	Hawaii Seafloor Atlas - Keating, Hawaii Institute of Geophysics (1995), scale 1:4 million.
IBCCA	IBC Caribbean Sea and Gulf of Mexico, scale 1:1 million @ 15°N.
IBCEA	IBC Central Eastern Atlantic, scale 1:1 million @ 20°N.
IBCM	IBC Mediterranean, scale 1:1 million @ 38°N.
IBCWIO	IBC Western Indian Ocean, scale 1:1 million @ the Equator.
IBCWP	IBC Western Pacific, scale 1:1 million @ 33° latitude.
IFR	New Bathymetric map of the Bay of Biscay - Sibuet et al., IFREMER (1994), scale 1:2.4 million @ 41°N.
KN	Bathymetry of the Laptev Seas - Kassens, GEOMAR.
MX	Bathymetry of Southcentral Pacific - Mammerickx, Scripps Institution of Oceanography (1992), scale 1:6.4 million @ Equator.
NRL1	Bathymetry of the Barents and Kara Seas - Cherkis, Naval Research Lab. (1991), scale 1:2.3 million @ 72°N.
NRL2	Regional Bathymetry of the Northern Norwegian & Greenland Seas - Cherkis, Naval Research Lab. (1994), scale 1:3 million.
NZOI	NZOI Oceanic Chart Series - New Zealand Institute of Water and Atmospheric Research Ltd. (NIWAR), scale 1:1 million @ 46°S.
RLF	Bathymetry of the Indian Ocean (Alliance Exotique) - Fisher, Scripps Institution of Oceanography, scale of compilation 4 ins = 1° Long.
SOC1	Bathymetry of the Northeast Atlantic, sheets 1 & 2 - Southampton Oceanography Centre, scale 1:2.4 million @ 41°N.
SOC2	Bathymetry of the Madeira and Canary Abyssal Plains - Southampton Oceanography Centre, scale 1:1 million.


90°
0°
90°
90°
180°
90°
0°
90°
MX
HIG
NZOI
IBCWP
RLF
AGSO
KN
HDNO
NRL1
FJL
NRL2
IBCM
IBCWIO
IBCEA
IFR
SOC2
AWI
GEBCO 5.12 Rev.
IBCCA

ANNEX XI

UPDATING THE GEBCO DIGITAL ATLAS (DATA STANDARDS)

(Extracted from Section 1.7.3 of the GDA Supporting Volume)

The GEBCO Digital Atlas (GDA) will form the base from which future printed editions of GEBCO will be generated. However, rather than being geared towards the printing schedules of such future editions, the updating of the GEBCO through the GDA will be a continual process. Without the scale constraints of the printed chart, it is envisaged that improved bathymetric compilations will be merged into GEBCO at scales ranging from 1:10 million up to 1:500,000 (or larger scales in isolated cases). This will be achieved by 'stitching in' so as to maintain the seamless nature of the data set. Use of larger scale material for any given area will be dependent on there being an adequate density of sounding data therein to justify its inclusion. It is planned that the generalisation of larger scale compilations being input into the GDA will be kept to a minimum so as to avoid loss of information.

In order to maintain the high quality and global nature of GEBCO, it will be necessary to set standards on the new material used for its updating. Prior to their inclusion in the GDA, new updated bathymetric compilations in any given area will need to conform to the following principles:

a) contours should be expressed in corrected metres.

b) as a minimum, the GEBCO basic contours of 200m, 500m, 1000m and at 500m intervals thereafter should be included. Where appropriate, the inclusion of contours at 20m, 50m and 100m is to be encouraged. Where additional intermediate contours are included an interval of 100m is recommended. (It is anticipated that larger scale compilations will include progressively increased numbers of intermediate contours, possibly with intervals as small as 20m at the largest scale).

c) the GEBCO basic contours should be continuous within the compilation area.

d) contours cutting the edges of the compilation area should be 'stitched in' to those in the surrounding area of the GDA - in general the 'stitching in' should be from outside the compilation area rather than from inside.

e) in coastal zones and around islands, the contours should be compatible with the World Vector Shoreline.

f) compilations submitted should be accompanied by the ship tracks and survey boxes (annotated with their source) used in compiling the contours.

g) the updating material should normally consist of digitized contours - if submitted in hard copy form, sufficient graticule points should be included within and at the edges of the map to enable potential distortions to be checked through subsequent digitizing, and if necessary corrected.

h) compilation methods should be fully described in supporting documentation, including details of the projection, ellipsoid and scale used, as well as information on any additional support material that might have been used e.g. magnetic surveys, sonar images, satellite altimetry, proprietary compilations; the names and affiliation of the authors of the map; the data sources used; and the date the map was compiled.

i) in international waters, the names of newly named undersea features should be submitted for approval to the GEBCO Sub-Committee on Undersea Feature Names, or to the appropriate national authority where they fall within territorial waters.

j) before release into the public domain, updated compilations and supporting material will be submitted for review by an approval panel of referees which will consist of the compiler and two independent experts. The review team will report back to the GEBCO Officers.

ANNEX XII

PROMOTION AND SALES OF THE GEBCO DIGITAL ATLAS

1. PROMOTION OF THE GEBCO DIGITAL ATLAS (MAY 1995)

Publications:

- NERC News, April 1994, 4 page article
- InterRidge News (InterRidge Office), vol 3, no 1, Spring/Summer 1994, 1 page announcement
- Ocean News (Elsevier Pergamon Marine Sciences Newsletter), No. 2, 1994 Summer 1994, 1 page article
- WOCE Newsletter (International WOCE Office), Summer 1994, 1 column announcement
- Offshore International (Response Publishing Group), Summer 1994, 29,000 worldwide readership, 1 page advertorial
- January/February 1995, Two-sided page flier distributed to 40,000 addresses worldwide by National Geophysical Data Center, Boulder

Spring 1995, Entry in 14th Edition of 'The CD-ROM Directory' published on CD-ROM by TFPL Ltd - contains 10,000 entries - worldwide distribution

Spring 1995, Abstract in Oceanographic Literature Review and GEOBASE, products of Elsevier Sciences Geo Abstracts

- Summer 1995, Announcement to appear in IMS Newsletter and Geotimes

(Review copy sent to the Geographical Magazine in April 1995)

- Catalogue of the IHO Publications, 1995, 1 page announcement

International Hydrographic Review, March 1995, pp.43-58 "Progress in producing bathymetric charts at a global and regional level" by Rear Admiral Andreasen

Workshop/Conference Demonstrations:

- British Association for the Advancement of Science, Loughborough, Summer 1994
- Second International Conference on Oceanography Lisbon 94 'Towards Sustainable Use of Oceans and Coastal Zones. Lisbon', 14-19 November 1994
- International Commission for the Scientific Exploration of the Mediterranean Sea, XXXIVth Congress, Malta, 27-31 March 1995
- Third Meeting of the IHO Permanent Working Group on Cooperation in Antarctica, IHO PWGCA, on 7 July 1994 in Buenos Aires. Meeting was attended by approximately 15 representatives of the IHO and SCAR Organisations.
- Demonstration at the Servicio Hydrografico y Oceanografico de la Armada de Chile in Valparaiso on 11 July 1994. Approximately 20 co-workers, scientists, cartographers attended the presentation.

2. DISTRIBUTION/SALES OF GEBCO DIGITAL ATLAS BY COUNTRY (MAY 1995)

Country	Sector				Total (sold)	
	GOV	UNIV	COMM	Other		
Australia	12	5	-	-	17	(14)
Belgium	1	2	-	1	4	(3)
Canada	10	3	-	2	15	(10)
Chile	1	-	-	-	1	(1)
Colombia	1	-	-	-	1	(0)
Croatia	1	-	-	-	1	(1)
Cuba	1	-	-	-	1	(0)
Denmark	3	3	-	-	6	(6)
Falkland Is.	1	-	1	-	2	(2)
Faeroes	1	-	-	-	1	(1)
Fiji	-	-	-	1	1	(0)
France	7	3	2	6	18	(10)
Germany	16	12	-	-	28	(26)
Greece	-	1	-	1	2	(2)
Iceland	1	2	-	-	3	(3)
India	1	-	-	-	1	(0)
Ireland	1	-	-	-	1	(0)
Israel	1	-	-	-	1	(0)
Italy	4	3	-	4	11	(9)
Japan	4	4	6	-	14	(13)
Korea	2	-	-	-	2	(1)
Mexico	1	-	-	-	1	(0)
Monaco	-	-	-	8	8	(6)
Netherlands	1	1	5	1	8	(7)
New Caledonia	-	-	-	1	1	(1)
New Zealand	3	1	-	-	4	(2)
Norway	4	2	2	2	10	(7)
Peru	1	-	-	-	1	(1)
Philippines	-	-	-	1	1	(1)
Poland	1	-	-	-	1	(1)
Polynesia (French)	-	1	-	-	1	(1)
Portugal	-	-	-	1	1	(1)
Russia	9	1	-	-	10	(1)
Singapore	1	-	-	-	1	(1)
South Africa	1	1	1	-	3	(2)
Spain	1	3	2	2	8	(6)
Sri Lanka	-	-	-	1	1	(1)
Switzerland	-	1	-	-	1	(1)
Taiwan	-	1	-	-	1	(1)
Tanzania	1	-	-	-	1	(0)
Turkey	1	-	-	-	1	(1)
Ukraine	2	-	-	-	2	(0)
UK	45	31	19	9	104	(53)
USA	19	35	18	-	72	(58)
Vietnam	1	-	-	-	1	(1)
TOTAL	161	116	57	40	374	(256)

Figures above refer to total number of copies sold or distributed up to 1 May 1995. GOV = Government/ Public funded organization; UNIV = University; COMM = Commercial organization. Number in parenthesis refers to total number of copies sold as opposed to complementary copies.

3. DISTRIBUTION/SALES OF GEBCO DIGITAL ATLAS - SUMMARY STATISTICS (1 MAY 1995)

a) Total number sold/distributed = 374 copies
Total number sold = 256 copies
Number of complementary copies = 118 copies

b) Copies sold/distributed to 45 countries

c) Breakdown of copies sold/distributed by sector:

Government bodies	161 copies
University groups	116 copies
Commercial bodies	57 copies
Other organisations	40 copies

d) Distribution of 118 complementary copies:

GEBCO community	57 copies
International exchange	25 copies
UK national exchange	36 copies

e) Sales/distribution by month

Month		Copies sold	Gratis copies	Total copies
May	1994	17	18	35
June	1994	33	52	85
July	1994	20	3	23
August	1994	8	9	17
September	1994	21	7	28
October	1994	16	2	18
November	1994	18	2	20
December	1994	13	6	19
January	1995	13	1	14
February	1995	48	5	53
March	1995	31	8	39
April	1995	18	5	23

f) Number of recipients registering their copies with BODC = 233 i.e. 62%

ANNEX XIII

LIST OF PARTICIPANTS

Dr. Meirion T. Jones (Chairman),
Director, British Oceanographic Data Centre,
Proudman Oceanographic Laboratory,
Bidston Observatory, Birkenhead,
Merseyside L43 7RA
UNITED KINGDOM.

Fax: +44 (151) 652 3950
Telex: 628591 OCEANB G
Tel: +44 (151) 653 8633
Email: bodcmail@pol.ac.uk
Zone: UT (Summer +l)

Mr. Brian Harper (Rapporteur),
Park House,
Donyatt,
Somerset TA19 0RN
UNITED KINGDOM

Fax: +44 (1823) 284077
Tel: +44 (1460) 52994
Zone: UT (Summer +1)

Rear Admiral Christian Andreasen,
President of the Directing Committee,
International Hydrographic Organization,
7, avenue President J. F. Kennedy,
B.P. 445 - MC 98011 Monaco Cedex,
PRINCIPALITY OF MONACO.

Fax: +33 93 25 20 03
Telex: 479164 MC - INHORG
Tel: +33 93 50 65 87
Email: ihb@unice.fr
Zone: +1 (Summer +2)

Dr. Michael Carron,
US Naval Oceanographic Office, Code N3T,
1002 Balch Blvd.,
Stennis Space Center,
Mississippi 39522-5001,
UNITED STATES OF AMERICA.

Fax: +1 (601) 688 5701
Tel: +1 (601) 688 5709
Email: carron@msrcnavo.navy.mil
Zone: -6 (Summer -5)

Mr. Norman Z. Cherkis, Code 7420-CH,
Marine Physics Branch,
Naval Research Laboratory,
Washington, D.C. 20375-5350,
UNITED STATES OF AMERICA.

Fax: +1 (202) 767 0167
Tel: +1 (202) 767 6956 or 2024
Email: cherkis@hp8c.nrl.navy.mil
Zone: -5 (Summer -4)

Commander Lucas de Campos Costa,
Diretoria de Hidrografia e Navegacao,
Ministerio da Marinha,
Rua Barao de Jaceguay, S/No,
Ponta da Armacao, CEP-24048-900,
Niteroi - Rio de Janeiro,
BRAZIL.

Fax: +55 (21) 719 7921, 4989, 3711
Telex: 21-53259 MMAR BR
Tel: +55 (21) 719 2626 or 4824
Zone: -3 (Summer -2)

Dr. James V. Eade,
(for Alf Simpson, Deputy Director),
South Pacific Applied Geoscience Commission (SOPAC),
SOPAC Technical Secretariat,
Private Mail Bag, Suva,
FIJI.

Fax: +679 370040
Telex: 2330 SOPACPRO FJ
Tel: +679 381139 or 381377
Email: alf@sopac.orstom.fr
Zone: +12

Mr. Jeremy Evans,
Challenger Division for Seafloor Processes,
Southampton Oceanographic Centre,
Empress Dock,
Southampton, SO14 3ZH,
UNITED KINGDOM.

Fax: +44 (1703) 596554
Tel: +44 (1703) 596559
Email: j.evans@soc.soton.ac.uk
Zone: UT (Summer +1)

Dr. John K. Hall,
Marine Geology, Mapping & Tectonics Division,
Geological Survey of Israel,
30 Malchei Israel Street,
Jerusalem 95501,
ISRAEL.

Fax: +972 (2) 346590 or 380688
Telex: 26144 BXJM IL
Tel: +972 (2) 346455
Zone: +2 (Summer +3)

Ing.en Chef Michel Huet,
International Hydrographic Bureau,
7, avenue President J. F. Kennedy,
B.P. 445 - MC 98011 Monaco Cedex,
PRINCIPALITY OF MONACO.

Fax: +33 93 25 20 03
Telex: 479164 MC - INHORG
Tel: +33 93 50 65 87
Email: ihb@unice.fr
Zone: +1 (Summer +2)

Mr. Peter Hunter,
GEBCO Bathymetric Editor,
Challenger Division for Seafloor Processes, Room 786/14,
Southampton Oceanography Centre,
Empress Dock,
Southampton, SO14 3ZH,
UNITED KINGDOM.

Fax: +44 (1703) 596554
Tel: +44 (1703) 596559
Email: p.hunter@soc.soton.ac.uk
Zone: UT (Summer +1)

Dr. Michael S. Loughridge,
Director, World Data Center 'A' for Marine Geology & Geophysics,
NOAA Mail Code: E/GC3,
325 Broadway,
Boulder, Colorado 80303,
UNITED STATES OF AMERICA.

Fax: +1 (303) 497 6513
Telex: 6735123 WDCA
Tel: +1 (303) 497 6487
Email: msl@ngdc.noaa.gov
Zone: -7 (Summer -6)

Dr. Michael D. Max,
SACLANT Undersea Research Centre,
Viale San Bartolomeo, 400,
19138 San Bartolomeo,
La Spezia,
ITALY.

Fax: +39 (187) 524 600
Telex: 271148 SACENT I
Tel: +39 (187) 540 111
Email: max@saclantc.nato.int
Zone: +1 (Summer +2)

Professor Carlo Morelli,
Facolta d'Ingegneria dell' Universita,
Piazzale Europa 1,
I-34127 Trieste,
ITALY.

Fax: +39 (40) 676 3497
Tel: +39 (40) 676 7158
Zone: +1 (Summer +2)

Mr. Donald E. Pryor,
NOAA National Ocean Service,
Nx2, SSMC4,
1305 East-West Highway,
Silver Spring, Maryland 20910,
UNITED STATES OF AMERICA.

Fax: +1 (301) 713-4307
Telex: RCA 248376
Tel: +1 (301) 713-3070
Email: dpryor@ocean.nos.noaa.gov
Zone: -5 (Summer -4)

Mr. William Rankin,
US Naval Oceanographic Office, Code N3T,
1002 Balch Blvd,
Stennis Space Center,
Mississippi 39522-5001,
UNITED STATES OF AMERICA.

Fax: +1 (601) 688 5701
Tel: +1 (601) 688 5709
Email: rankin@navo.navy.mil
Zone: -6 (Summer -5)

Dr. Gary J. Robinson,
Environmental Systems Science Centre,
University of Reading,
Whiteknights,
Reading, Berkshire RG6 2AB
UNITED KINGDOM.

Fax: +44 (1734) 755865
Telex: 847813
Tel: +44 (1734) 318742
Email: gazza@mail.nerc-nutis.ac.uk
Zone: UT (Summer +1)

Lic. José Luis Frias Salazar,
Instituto Nacional de Estadistica, Geografia e Informatica,
Av. Patriotismo #711-PH,
Col. San Juan Mixcoac - C.P. 03910,
Mexico D. F.,
MEXICO.

Fax: +52 (5) 563 9932
Tel: +52 (5) 598 9946 or 615 0966
Zone: -7 (Summer -6)

Dr. Hans-Werner Schenke,
Alfred-Wegener-Institut fur Polar- und Meeresforschung,
Postfach 12 01 61,
Columbusstrasse,
D-27515 Bremerhaven,
GERMANY.

Fax: +49 (471) 4831 149
Telex: 238695 POLAR D
Tel: +49 (471) 4831 222
Email: schenke@awi-bremerhaven.de
Zone: +1 (Summer +2)

Dr. Walter H.F. Smith,
Geosciences Laboratory, NOAA/NOS: N/OES 12,
SSMC-IV, Sta. 8423,
1305 East-West Highway,
Silver Spring, Maryland 20910,
UNITED STATES OF AMERICA.

Fax: +1 (301) 713 4475
Tel: +1 (301) 713 2860
Email: walter@amos.grdl.noaa.gov
Zone: -5 (Summer -4)

Miss Pauline Weatherall,
British Oceanographic Data Centre,
Proudman Oceanographic Laboratory,
Bidston Observatory, Birkenhead,
Merseyside, L43 7RA,
UNITED KINGDOM.

Fax: +44 (151) 652 3950
Telex: 628591 OCEANB G
Tel: +44 (151) 653 8633
Email: bodcmail@pol.ac.uk
Zone: UT (Summer +1)

ANNEX XIV

LIST OF ACRONYMS

(Acronyms used only in the paragraph in which they are already defined are not included)

AGC	Atlantic Geoscience Centre, Geological Survey of Canada
AGSO	Australian Geological Survey Organisation
AWI	Alfred-Wegener-Institut fur Polar- und Meeresforschung
BAS	British Antarctic Survey
BODC	British Oceanographic Data Centre
BRIDGE	Mid ocean ridge project of NERC
CD-ROM	Compact Disc - Read Only Memory
CEDD	Committee on Exchange of Digital Data (of IHO)
CGOM	IOC Consultative Group on Ocean Mapping
DBDB5	Digital Bathymetric Data Base (5-minute grid) of USNOO
DCDB	Data Centre for Digital Bathymetry (IHO - at NGDC, Boulder)
DEM	Digital Elevation Model
DMA	US Defense Mapping Agency
DNAG	Decade of North Atlantic Geology
DTM	Digital Terrain Model
DX-90	IHO format for information transfer
ECDIS	Electronic Chart Display and Information System (of IHO)
EEZ	Exclusive Economic Zone
EPSHOM	Etablissement Principal du SHOM
ERS-1	European Research Satellite-1
ESA	European Space Agency
ESCAP	Economic and Social Commission for Asia and the Pacific
ETOPO5	Earth Topography on a 5-minute grid (NGDC)
EU	European Union
GDA	GEBCO Digital Atlas
GEBCO	General Bathymetric Chart of the Oceans (IOC/IHO)
GEODAS	GEOphysical DAta System for marine geophysical data (NGDC)
GIS	Geographic Information System
GMT	Generic Mapping Tools (P. Wessel and W.H.F. Smith)
GPS	Global Positioning System
GSA	Geological Society of America
HDNO	Head Department of Navigation and Oceanography, St. Petersburg
HIG	Hawaiian Institute of Geophysics
HO	Hydrographic Office
IASC	International Arctic Science Committee
IBCCA	International Bathymetric Chart of the Caribbean Sea and Gulf of Mexico (IOC)
IBCEA	International Bathymetric Chart of the Central Eastern Atlantic (IOC)
IBCM	International Bathymetric Chart of the Mediterranean and its Geological-Geophysical Series (IOC)
IBCWIO	International Bathymetric Chart of the Western Indian Ocean (IOC)
IBCWP	International Bathymetric Chart of the Western Pacific (IOC)
ICA	International Cartographic Association
IFREMER	Institut Francais pour la Recherche de la Mer
IHB	International Hydrographic Bureau, Monaco
IHO	International Hydrographic Organization
INEGI	Instituto Nacional de Estadistica, Geografia e Informatica (Mexico)
INT	INTernational Chart
IOC	Intergovernmental Oceanographic Commission
IOSDL	Institute of Oceanographic Sciences, Deacon Laboratory (UK)
IUGS	International Union of Geological Sciences
JICA/MMAJ	Japan International Co-operation Agency/Metal Mining Agency of Japan
MGD77	Magnetics, Gravity and Depth Format 1977 (NGDC)
NATO	North Atlantic Treaty Organisation
NavOceano	US Naval Oceanographic Office
NERC	Natural Environment Research Council (UK)
NGDC	National Geophysical Data Center (USA)
NOAA	National Oceanic and Atmospheric Administration (USA)
NOS	National Ocean Service (USA)
NRL	Naval Research Laboratory (USA)
NSF	National Science Foundation (of USA)
NZOI	New Zealand Oceanographic Institute (NIWAR)
PSMSL	Permanent Service for Mean Sea Level
RAN	Royal Australian Navy
S-57	IHO Transfer Standard for Digital Hydrographic Data
SACLANT	Supreme Commander Allied Command Atlantic (NATO)
SAR	Synthetic Aperture Radar
SCAR	Scientific Committee on Antarctic Research
SCDB	GEBCO Sub-Committee on Digital Bathymetry
SCUFN	GEBCO Sub-Committee on Undersea Feature Names
SHOM	Service Hydrographique et Oceanographique de la Marine
SIO	Scripps Institution of Oceanography (USA)
SOC	Southampton Oceanography Centre (UK)
SOPAC	South Pacific Applied Geoscience Commission
UNCLOS	United Nations Convention on the Law of the Sea
USGS	US Geological Survey
USNOO	US Naval Oceanographic Office
WESTPAC	Western Pacific regional programme of the IOC
WGS-84	World Geodetic System 1984
WVS	World Vector Shoreline (DMA)
WWW	World Wide Web