Distribution: limited

IOC-IHO/GEBCO SCDB-XI/3
Bidston, 3 January 1995
English only

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION
(of Unesco)

INTERNATIONAL HYDROGRAPHIC ORGANIZATION

# Eleventh Meeting of the GEBCO Sub-Committee on Digital Bathymetry

**University of New Brunswick, Canada**

**25-27 May 1994**

## SUMMARY REPORT

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**ANNEXES**

# 1. OPENING OF THE MEETING

*1* The Chairman, Dr. Meirion T. Jones, opened the meeting at 09.30 on Wednesday 25 May 1994.

*2* In his opening address he commented that many of the goals, previously set for the Sub-Committee some eleven years ago, had now been achieved. Notable among these were the creation of the GEBCO Digital Atlas, the establishment of the IHO Data Centre for Digital Bathymetry and the revision of the 'Guidelines for the GEBCO'. With this in mind, revised 'Terms of Reference' for the Sub-Committee had been agreed with the GEBCO Guiding Committee at its Fourteenth Session in May 1993 (see Annex II). Dr. Jones said that a new era in bathymetric activities was beginning and it was time to set the foundation for a challenging future, which, *inter alia*, included advances in satellite altimetry and computer visualisation techniques. It was appropriate, therefore, that the meeting should be hosted by the Ocean Mapping Group of the University of New Brunswick, a group at the forefront of developing new techniques for the mapping and visualisation of the sea floor.

*3* Dr. Larry A. Mayer welcomed the participants to the Department of Geodesy and Geomatics Engineering of the University of New Brunswick.

*4* A list of participants is given in Annex VIII. Apologies for absence were received from John Hall, Don Pryor, Pauline Weatherall and Alexis Hadjiantoniou.

# 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**

- 'Feature and Contour Labelling in the GEBCO Digital Atlas', draft paper for discussion, Gary J. Robinson, NUTIS, May 1994
- 'Guidelines for the GEBCO, Part 4 - Digital Bathymetric Data (Multibeam Echo-sounders)' - preliminary draft prepared by George Sharman (NGDC) and Stuart Smith (SIO), May 1994
- 'Guidelines for digitizing bathymetric maps suitable as input for updating the GEBCO Digital Atlas', draft for discussion, Peter Hunter (IOSDL) and Pauline Weatherall (BODC), March 1994
- 'Report of the GEBCO Digital Atlas Manager (1993-94)', Pauline Weatherall, BODC
- 'The GEBCO Digital Atlas', coloured brochure, Meirion T. Jones, BODC, April 1994
- 'Report of IHO-DCDB and related activities of NGDC (1993-94)', Michael S. Loughridge, NGDC
- 'Report on IHB activities relating to digital bathymetry (1993-94)', Michel Huet, IHB
- 'Discussion paper on Bathymetric Data Exchange Formats', Ian W. Halls, RAN Hydrographic Service, January 1994
- 'Inventory of Multibeam Equipped Ships', Norman Z. Cherkis, May 1994
- 'Bathymetric Reduction from Dense Satellite Altimetry and Sparse Shipboard Bathymetry' - preprint of paper by Walter H.F. Smith (NOS) and David T. Sandwell (SIO), revised April 1994

- 'NRL Digital Bathymetry Activities (1993-94)', Norman Z. Cherkis
- 'Report of Bathymetric Mapping Work at HDNO (1993-94)', Andrey Popov
- 'Report of Digital Bathymetry Activities at UK Hydrographic Office (1993-94)', Roger Cavill
- 'Activities in Digital Bathymetry 1993-94', John K. Hall, Geological Survey of Israel
- 'Compilation of informal reports from agencies worldwide involved in bathymetric mapping', Peter Hunter, GEBCO Bathymetric Editor
- 'Ocean Mapping at the University of New Brunswick', Larry Mayer
- 'Progress Report on Compilation of Magnetic Data in the Arctic and North Atlantic Oceans', Ron Macnab et al, AGC, May 1993
- 'Geological Structure of the North-Eastern Mediterranean (Cruise 5 of the Research Vessel 'Akademik Nikolaj Strakhov'' edited by V.A. Krasheninnikov and J.K. Hall, 1994
- Information brochure on Atlantic Geoscience Centre, Geological Survey of Canada

**Charts**

- Printing proof of IBCEA Sheet 8 @ 1:1 million, SHOM
- Printing proof of revised GEBCO Sheet 5.12, CHS
- 'Regional Bathymetry of the Northern Norwegian - Greenland Sea' @ 1:3 million, NRL, 1994
- Track coverage of bathymetric data in the Persian Gulf, NRL
- Bathymetric maps of Franz Josef Land Region @ 1:500,000
- Bathymetric map of Franz Josef Strait @ 1:100,000, AWI
- 'Bathymetric Chart of the Weddell Sea' @ 1:3 million, working copy, AWI
- 'Topographic Map of Filchner-Ronne Shelf' - satellite image map prepared by AWI, BAS et al
- Track coverage of Arctic cruises by RV Polarstern and Icebreaker Oden, AWI
- Plotting sheets of RV Polarstern Multibeam Data @ 1:1 million and 1:200,000, AWI
- Index to the IHO INT Antarctica Chart Scheme
- A world map of Gravity Anomalies - Sandwell/Smith - 1994 edition
- Stereographic map of Antarctica and Southern Ocean Topography Predicted from Satellite Altimetry and Ships Depths Measurements including separate panels showing satellite gravity and ships' depths
- Two maps of radar altimetry data (one depicting improved accuracy) in the vicinity of the Sala y Gomez Ridge together with area coverage diagrams for SEASAT, GEOSAT, ERS-1 and TOPEX
- 2 experimental coloured maps @ 1:10 million, derived from ETOPO5 gridded data displayed with GEBCO counterpart maps 5.04 and 5.08, AGC
- Bathymetric and Topographic Shaded Relief (Stereographic) Map - North of 64°N. (Canadian Geological Survey), AGC

# 3. REVIEW OF RELATED ACTIVITIES OF OTHER INTERNATIONAL AND NATIONAL GROUPS

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

## 3.1 IHO ACTIVITIES

*7* Mr. Michel Huet reported that the final version of Part 2B of the 'Guidelines for the GEBCO', covering *'Bathymetric Data Management - Digital Data'*, had been distributed in July 1993 as part of publication B-7. The next and last section to be included in the Guidelines would be Part 4 *'Digital Bathymetric Data (Multibeam Echo-Sounders)'* - this was being worked on by the Sub-Committee (see agenda item 7).

*8* Mr. Huet stated that the IHB intended to publish, later this year, the 2nd Edition of IHO-IOC Gazetteer of Undersea Feature Names, publication B-8. It would be published only in digital form on disk together with a software interface.

*9* Mr. Huet informed the meeting that Version 2.0 of the IHO S-57 *Transfer Standard for Digital Hydrographic Data*, had been released in March 1994. He observed that S-57 did not yet allow for the exchange of bathymetric data (e.g. ships tracks were not handled). However, a 'Bathymetric Data' application profile, including multibeam data, might be added to the next version of S-57.

*10* Mr. Huet also reported IHO participation, under European Parliament auspices, in a Workshop on Mediterranean Pollution, Corfu, Greece, September 1993, where the creation in Monaco (Commission for the Scientific Exploration of the Mediterranean Sea - CIESM) of a GIS for coastal zone management, in the framework of the European Community Scientific and Technological Options Assessment (STOA) Mediterranean Sea Project, was envisaged.

*11* Mr. Huet related further IHO participation in a meeting in Brussels, Belgium, April 1994, under the auspices of the European Community, to discuss a proposal for the establishment of a European Seabed Information Service (ESIS), following an initiative of the UK Seafish Industry Authority. He said it was envisaged that the information provided on the existing paper fishery charts, including bathymetric data, would be made available as a digital geographic information system. The bathymetric data might come from the ECDIS database that was being established by the Norwegian Electronic Chart Centre.

*12* The Sub-Committee was informed of the activities of the IHO Permanent Working Group on Hydrographic Co-operation in the Antarctic. The group had 22 members including COMNAP, SCAR, IHO DCDB, SCALOP and several HOs and had met three times: Bonn 1991; Venice 1992; Valparaiso 1993. The next meeting was to be held in Buenos Aires in July 1994. Indexes of the proposed chart scheme for the region were displayed. At the request of the Sub-Committee, Dr. Schenke agreed to demonstrate the GDA at the Buenos Aires meeting.

*13* Concerns were raised by Dr. Schenke, Dr. Loughridge and also in a letter by Michel le Gouic about the need to optimise data exchange between HOs and other Institutions working in the Antarctic region. Hearsay evidence suggested that some data were not being released. The clear message from the meeting affirmed that IHO DCDB should be the primary exchange focus of echo sounding data for all bathymetric mapping/charting activities in the region.

## 3.2 IOC REGIONAL OCEAN MAPPING PROJECTS

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

*14* The sixth session of the Editorial Board for the IBCM was held in Jerusalem between 1-6 November 1993.

15 *The Editorial Board confirmed its past decisions that the Second Edition of the IBCM bathymetry would include:*

*(i) a traditional printed contour chart, or a chart in shaded hypsometric format;*

*ii) a set of digital contours (with shiptracks, etc.). These will, in addition, form an input into the GEBCO Digital Atlas;*

*iii) a gridded data-set (on a 0.25 min grid), as required for the production of digital terrain models (DTMs or DEMs).*

16 *The project was in a transitional stage, certain countries were still maintaining hand-drawn plotting sheets (1:250,000 and 1:1 million) and others archiving their data in digital form.*

17 *A letter from the Italian Hydrographer stated that his office wished to submit bathymetric contours for its area of responsibility on the base of the MEDINTCHART scheme instead of on the 1:250,000 plotting sheets. In response to a subsequent enquiry, the Italian Hydrographer confirmed that this material, which is in the form of contours, could be supplied in both hardcopy and in digital form.*

18 *All 1:250,000 plotting sheets with new data received by IHB had recently been sent to HDNO. These consisted of 72 sheets provided by France, Turkey, Greece and the United Kingdom. No sheets were available from Italy or Spain for the reasons given above.*

19 *A SeaBeam survey of the area 41°- 44° 30' N and 3°- 10° E, carried out by IFREMER, clearly superseded the French plotting sheets covering this area. Maurice Gennesseaux was invited to ask IFREMER if they would permit reproduction of their chart in the IBCM at half its published scale.* (Permission has since been granted by IFREMER.)

20 *Following the agreement reached at the last IBCM meeting in Trieste, to supply equipment to the HDNO for digitizing and processing data from under-represented areas so as to improve the quality of the IBCM Second Edition, John Hall arranged and saw through the delivery of a 486 DX-33 computer system with digitizer and assorted software to St. Petersburg.*

21 *Dr. Popov brought diskettes containing all HDNO's digitized soundings for the areas of the eastern Levant, and from Tunisia to Cyrenaica to the meeting.*

22 *Dr. Hall described the pitfalls encountered since the decision in 1989 by Dr. Makris and himself to produce a 0.25 min DTM of the Mediterranean. The initial hurdle had been the discovery that the digitized contours prepared by the HDNO did not include land topography, and that it was unlikely that those contours would be available in the immediate future. Dr. Hall then used the same graphical methods he had used to produce a 125 million point DTM on a 25 metre grid for Israel and vicinity to carry out the preliminary work of scanning and editing the area on IBCM Sheet 10, but was forced to stop because of time restrictions. The passage of several years now showed the wisdom of using all spot sounding data and not just digitized contours for making the mathematical interpolations, so this new effort was quickly curtailed. The present intention was to upgrade computers to a far more sophisticated Silicon Graphics system with UNIX and X-windows for using the great selection of share-ware workstation programs available for DTM construction, visualization, and presentation. This step was intended for his upcoming sabbatical at the Ocean Mapping Development Center at the University of Rhode Island in the USA.*

23 The Sub-Committee expressed interest in the DTM work being carried out by Dr. Hall and the news concerning the updating of the IBCM. However, concern was expressed about the suggestions that, for some areas, only the bathymetric contours would be made available. The Sub-Committee reaffirmed its view that the associated echo sounding data should also be made available, preferably in digital form, for submission to the IHO DCDB.

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

24 A report furnished by Dr. Troy Holcombe outlined progress on IBCCA. *There was a meeting of the IBCCA Officers during December 1993 and January 1994 and work was continuing as planned. Sheet 1-09 had been printed and was available through Lic. Alejandro del Conde Ugarte of the Dirección General de Difusión/INEGI, Mexico. Sheet 1-04 had been completed, reviewed, revised and was in press. Compilation work on sheets, 1-01, 1-02, 1-03, 1-05, 1-06, 1-07 and 1-08 was nearing completion and several of these sheets should be ready to go through their review stages during 1994. Progress on the project would be reviewed in more detail during the next Editorial Board meeting scheduled later in 1994.*

25 Peter Hunter said he had recently received a letter from the Cuban Hydrographic Institute about their plans to digitize the IBCCA contours. He reported that a draft set of guidelines to help in digitizing bathymetric contours to conform to the specifications of the GEBCO Digital Atlas had been prepared by himself and the GDA Manager, Pauline Weatherall, and that a copy had been sent to the Cuban Hydrographic Institute in February 1994.

### 3.2.3 International Bathymetric Chart of the Central Eastern Atlantic (IBCEA)

26 The GEBCO Bathymetric Editor furnished a report on the activities of the IBCEA. *During the 3rd Conference of the Eastern Atlantic Hydrographic Commission held in Lagos (Nigeria) in March 1991, the hydrographic offices of Spain, Portugal and France agreed to produce the IBCEA sheets as follows:*

*Portugal : Sheets 1.01, 1.02, 1.03, 1.07*
*Spain : Sheets 1.04, 1.05*
*France : Sheets 1.06, 1.08, 1.09, 1.10, 1.11, 1.12*

27 *Portugal had completed the compilation of the sheet 1.01 (with limits slightly moved northwards, without any consequence on the rest of the scheme because of the large overlap with sheet 1.04) and intended to print it during the first semester of 1994. They had also begun the compilation of sheet 1.02.*

28 *France had compiled available bathymetric data for sheets 1.06, 1.08 and 1.09 and had begun the compilation of sheet 1.10. Sheets 1.08 and 1.09 would be printed during the first semester of 1994. If funds were found in time, then sheet 1.06 could be printed during the second semester of 1994 and sheet 1.10 during the first semester of 1995.*

29 *In January 1994, copies of the first printing proof of the Sheet 1.08 of the IBCEA were circulated to the Editorial Board. Comments on this proof were required before 1st June 1994. This deadline would make it possible to take account of these comments before printing the proof of sheet 1.09.*

30 The printing proof of Sheet 1.08, the first in this series of 12 maps, was tabled by Peter Hunter. The map was compiled entirely at SHOM. Dr. Troy Holcombe (NGDC) and RAdm. Angrisano (IHB) had supplied Mr. Hunter with a copy of their comments on the map and had raised a number of important points e.g. concerning the presentation of bathymetric contours in certain key areas.

31 The map was also examined by the participants at the meeting. Notwithstanding much of its excellent quality, several expressed similar comments to those voiced by Troy Holcombe and RAdm. Angrisano. Items giving rise for concern were identified as: lack of canyons off the continental slope; omission of known cruise data; apparent disregard for evidence from satellite altimetry data; and lack of feature names. Particular concern was expressed over the method and style of contouring which reflected the use of automated techniques, particularly in areas such as the continental slope.

32 At the conclusion of considerable debate over this map, the Sub-Committee voiced its hopes that SHOM would endeavour to obtain more scientific input for its map. It was suggested that the function of Editorial Boards was indeed to provide such input. Further questions were raised about the possibility of liaison with the geo-scientists of IFREMER, over the compilation of Sheet 1.08.

### 3.2.4 International Bathymetric Chart of the Western Indian Ocean (IBCWIO)

*33* Dr. Werner Bettac (Chief Editor) had secured the co-operation of Valeriy Fomchenko (HDNO) over the digitizing of about three hundred 1:500,000 scale plotting sheets for the area. The next meeting, to be held in Zanzibar, was scheduled for October 1994.

### 3.2.5 International Bathymetric Chart of the Western Pacific (IBCWP)

*34* *The first joint meeting of the Editorial Board took place in Tianjin, China, October 1993, Mr. Adam Kerr represented the IHO. It was planned to produce 101 bathymetric sheets @ 1:1 million covering the entire Western Pacific Ocean from Kamchatka in the north to New Zealand in the south and stretching eastwards to French Polynesia. Regional responsibilities were allocated to Russia, Japan, China and Australia. SOPAC and New Zealand had also been invited to participate. It was suggested that bathymetric data held by the IHO DCDB would serve as a basis to this project. A meeting of the IBCWP Officers, to be held in Bali, was scheduled for November 1994.*

## 3.3 INTERNATIONAL ARCTIC SCIENCE COMMITTEE (IASC)

*35* Dr. Ron Macnab gave an informative account of the work of the IASC Working Group for Geophysical Compilation and Mapping. The Working Group promotes international co-operation in the acquisition and compilation of basic data sets that describe the geological and geophysical framework of the Arctic Ocean and surrounding land masses: bathymetry, gravity, magnetics, and seismic reflection/refraction.

*36* Over the past year, the Working Group's efforts had focused on the establishment of contacts and the development of communications pathways to facilitate the identification and exchange of information and Arctic data sets. A prototype list had been implemented and tested with listserver software on the Internet, while a trio of Canadian and US investigators travelled to Russia in summer 1993 to meet with fifty counterparts from twelve geoscientific laboratories in St. Petersburg and Moscow. The latter discussions were summarised in Geological Survey of Canada Open File 2717, issued in July 1993.

*37* Dr. Macnab emphasised that the updating of existing bathymetric charts of the Arctic was important to the Working Group: as backdrops for displaying many other forms of data, these charts should be as accurate and as up to date as possible. The Working Group *per se* would not create any new charts on its own, but it would do what it could to keep investigators aware of improvements in the bathymetric database, and to encourage the consolidation of high quality data sets from all quarters for ultimate use in producing the most accurate Arctic chart in a standard and widely-accepted form.

*38* The Working Group had been invited to spearhead a proposed NATO-funded initiative to salvage and convert to digital form a large body of Russian seismic data that had been collected in the central Arctic Ocean over the past several decades. The primary purpose of these experiments had been to measure sediment thickness in the deep basins, but water depth was an integral by-product of such observations; if this initiative was successful, it could result in a wealth of new bathymetric data in a region that had never been systematically surveyed.

*39* Dr. Macnab reported that the Working Group was also attempting to promote the publication of a major Russian geotraverse extending from the DeLong Islands on Russia's northern continental shelf out to the deep-ocean Makarov Basin. In executing this multiparameter geotraverse, Russian investigators had collected many new data sets; the extent of new bathymetric acquisition had not been fully documented, but it was believed there would be enough fresh information to improve our view of the sea floor in this region.

*40* The Working Group had adopted an advocacy role in promoting the Victor Project, which proposed to equip a de-militarised Russian submarine with a multibeam sounding system for bathymetric mapping beneath the permanent polar ice pack. Even though a US corporation was one of the project's chief proponents, it appeared that the US Navy had effectively killed prospects for US Government involvement. Current efforts were therefore aimed at improving the project's visibility on the international plane, with the objective of enlisting enough non-US participation to assure a successful mobilisation.

*41* The Sub-Committee looked forward to collaborating with IASC and recognised the urgent need to update the GEBCO Digital Atlas in the Arctic region. It was pleased to note that one of the leading GEBCO experts in the region, Mr. Norman Cherkis, was also the co-ordinator for bathymetry on the IASC Working Group for Geophysical Compilation and Mapping.

## 3.4 IUGS CIRCUM-ATLANTIC PROJECT (CAP)

*42* For the past year, the Circum-Atlantic Project had been in an almost standby mode. Mr. Cherkis reported that a decision by USGS to continue funding for the CAP was still awaited. Meanwhile, only work to complete the terrestrial data was in hand. Dr. Michael Max (SACLANT) was trying to stimulate enthusiasm for CAP in the Mediterranean area.

## 3.5 ANTOSTRAT PROJECT

*43* Dr. Schenke provided information on the ANTOSTRAT Project and its Ross Sea Regional Working Group (RWG), one of five groups established to compile, collate and analyze geological and geophysical data from the sedimentary sections of the entire Antarctic continental margin to better understand Antarctic glacial history. They were preparing an atlas which would include bathymetry and gravity amongst its themes. The Ross Sea RWG Atlas would be published after the 1994 ANTOSTRAT Symposium to be held in Siena, Italy, in August 1994. The bathymetric compilations for this atlas were being handled by Fred Davey in New Zealand. The general plans were to put all the maps together in an "atlas" format (i.e. probably a set of boxed separate sheets to accompany one of the ANTOSTRAT symposium volumes). There would be preliminary versions of most sheets ready by the Siena Symposium. Coverage would be 70°-78.5°S, 160°E to 155°W, but east of about 170°E, they may finish in the north at about 75°S because of lack of data. The maps would probably be at a 1:1 million scale on polar stereographic projection with a contour interval of 100m on the slope and 50m on the shelf. It was understood that GEBCO would be welcome to have copies of the maps when they were completed.

*44* It was also reported that Phil O'Brien in Australia was compiling a bathymetric map of Prydz Bay on behalf of the Ocean Drilling Project.

## 3.6 INTERRIDGE

*45* The GEBCO Bathymetric Editor reported that he was in contact with InterRidge through its Co-ordinator, Dr. Heather Sloan, at the University of Durham. InterRidge had been set up by the various international mid-ocean ridge projects. It was an administrative/organisational body and, as such, did not carry out any mapping activities *per se*. Their aim was to help co-ordinate any international efforts that might be going on and to help initiate new ones by facilitating communication and encouraging the community to identify appropriate scientific issues which they would then represent to other international organisations and funding agencies as priority items. One of the projects undertaken by their Global Working Group, was a global ridge crest atlas and Mr. Hunter reported that he was trying to obtain more details about it from Charlie Langmuir at the Lamont-Doherty Geological Observatory (LDGO).

## 3.7 SOUTH PACIFIC APPLIED GEOSCIENCE COMMISSION (SOPAC)

*46* The GEBCO Bathymetric Editor tabled written input provided by Dr. Jim Eade of the SOPAC Technical Secretariat in Fiji concerning SOPAC activities relating to bathymetry as follows:

*47* *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. Bathymetric studies are a major activity involving 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 (e.g. Tuvalu and Cook Islands), and nearshore maps from shore to about 1,000 metres (e.g. Cook Islands and Western Samoa). Data from many surveys are contoured and presented as figures in reports.*

48 *SOPAC is currently collecting a major new dataset of multibeam image and bathymetric information covering much of the Melanesian Borderland including areas in Fiji and Tuvalu, and island arc and adjacent areas in northern Vanuatu and Solomon Islands. The data are being collected by IFREMER under contract to SOPAC and funded by the EC under Lome III, using the RV Atalante in three 28-day cruises under the name SOPACMAPS. The equipment being used is hull-mounted, dual Simrad EM12 multibeam sounding systems operating at 13kHz, recording 162 beams of bathymetry, and up to 4,000 points being sampled for imagery. Bathymetric accuracy should be 0.25% of depth or better over the whole swath. The maximum swath width is about 20 km in water depths greater than 3 to 4 km. Very little data will be collected in water depths less than 500 metres, and much will be collected in depths between 1,000 and 3,000 metres. Both paper copy (much at scale 1.250,000) but some in more detail, and digital information will be provided, with the contours made available to GEBCO.*

49 *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. SOPAC is still receiving requests for the SOPAC Regional Bathymetry despite the fact that it is now well over 10 years out of date. To compile a new version manually would be a big task and beyond the Secretariat's present capability without additional assistance. The Secretariat believes that to maintain and update a digital bathymetric contour or gridded depth file would eventually prove to be the easiest and most efficient way to produce a second version of the regional bathymetry. Bathymetric maps of individual country EEZs have been produced and found to be very useful to SOPAC's country contacts in geoscience, fisheries, and planning. These are now being produced at the Secretariat from the GEBCO digital contour file - a routine procedure.*

50 *The GEBCO digital bathymetry, which the Secretariat now has and is using to produce regional bathymetric maps (maps at a scale less than 1:1 million), is proving to be a most useful tool. However, the GEBCO 5th Edition contours are more than 10 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, SOPAC will receive assistance to update the GEBCO digital file and lead to the production of new regional bathymetry. While some of this work will be carried out by present staff - the Computer Mapping Geologist and the Chief Cartographer - SOPAC will need additional assistance at its Secretariat. SOPAC cannot do this work alone and is relying on an exchange of information and collaborative assistance.*

## 3.8 AUSTRALIA

### 3.8.1 Australian Geological Survey Organisation (AGSO), Canberra

51 The GEBCO Bathymetric Editor tabled written input provided by Mr. Chris Johnston from AGSO as follows:

52 *The Australian Geological Survey Organization (AGSO) in conjunction with the Hydrographic Service, Royal Australian Navy, have, since March 1989, been compiling and publishing a series of 1:1,000.000 scale bathymetric charts for the entire Australian margin. This work is being undertaken under the project name of Offshore Resource Map Series (ORMS).*

53 *All available digital data are being assembled and large quantities of analogue data are being digitized to ensure coverage in areas where there are little digital data. These data are then machine contoured and subsequently the contours are modified, where necessary, to ensure that the bathymetric features are geologically correct. Of the 33 maps planned, six have been published, two more are ready for printing and four more will be compiled by the end of this year.*

54 *The ORMS project is the first systematic assemblage of digital bathymetric data for the entire Australian continental margin being presented in contoured form at 1:1,000,000 scale. The production of the map sheets in four colours, with a different shade of blue for each 1000 m interval, is achieved mainly by using commercially available software and hardware, supplemented by AGSO mapping and cartographic expertise together with printing assistance from the Hydrographic Service.*

55 *All data are stored in a digital database so that future revision of the series will be relatively simple. Wherever possible, the specifications produced for the IBCWP are being used for ORMS, including Mercator projection with true scale at latitude 33 degrees, thus ensuring that the sheets match at their boundaries.*

56 *The bathymetric database for ORMS comes from a wide variety of sources. On the continental shelf, to depths of 300 m, data from the Hydrographic Service are being used. The contours, available as published maps at a scale of 1:250,000 (National Bathymetric Map Series, 1976-90), have been digitized, some by automatic scanning. In deep waters, the AGSO Marine Database, containing survey lines spaced an average of 30-50 km apart, has been used. These data have been augmented by manually digitized data from the latest GEBCO compilation sheets (1986), provided by the Hydrographic Service, and GEODAS data obtained from the National Geophysical Data Center (Boulder, USA). In addition, other digital datasets collected by universities, other research organisations and private companies, particularly any available swath-mapping data, are being incorporated whenever possible. The locations of all depth points are shown on the published maps. All depths have been corrected for the variation of sound velocity in different water masses using the Third Edition Echo-Sounding (Carter's) Tables.*

57 *A number of seabed sampling sites have been included on the map sheets. These provide an indication of bottom conditions that may be of interest to deep-sea fishermen and others who need this information for cable or pipe-line laying, or other engineering purposes.*

58 *Exploration well locations are being plotted on the map sheets. Scientific drill sites undertaken as part of either the Deep Sea Drilling Project or the Ocean Drilling Programme are also shown. In some areas, such as the North West Shelf and Bass Strait, only the geologically most informative wells can be shown due to the high density of wells in these areas.*

59 *AGSO seismic survey lines have been identified on the map sheets, thus informing users of additional, readily available geoscientific information. The extent of the Australian Fishing Zone is also indicated.*

60 *Names of features on the maps comply with those shown on the GEBCO 1:10,000,000 scale compilations. Any new names are being registered with the International Hydrographic Bureau in Monaco.*

61 *As well as being available as printed maps, the data will also be available in digital form. A database of contour strings is the most likely form of digital data.*

62 *Although the ORMS maps represent a major step forward in the bathymetric mapping of Australia's margins, they are only an intermediate step towards obtaining a clear image of seabed features. The data density of about one depth value for every 60 sq km is sufficient to map major bathymetric trends, but in some places data tracks are more than 100 km apart and thus significant features can easily be missed.*

63 *In places, where depths are sparse, Seasat and Geosat data are being used to constrain bathymetric trends. Such an area lies along the southern boundary of the Naturaliste, Albany, Esperance and Eyre sheets (South-west Australia) - here a complex zone (Diamantina Zone) has very little bathymetric coverage relative to its complexity, and it has been necessary to both increase the contour interval to 500 m and manually smooth the contours.*

64 *The above information is given by way of background to the ORMS project. AGSO and the Hydrographic Service RAN, formally announced at the first meeting of the IBCWP Editorial Board, that the ORMS sheets within IBCWP Subregion 4 will be published under the auspices of IOC. Work on these sheets*

*will commence in 1994 and it is anticipated that the proposed 16 sheets should be completed by the end of 1996. It should then be possible to consider the compilation of additional sheets to ensure complete coverage of Subregion 4 by the end of 1998.*

## 3.9 CANADA

### 3.9.1 Atlantic Geoscience Centre (AGC), Geological Survey of Canada, Dartmouth, Nova Scotia

*65* Dr. Ron Macnab outlined the activities of AGC, highlighting his involvement in the work of IASC (see agenda item 3.3) and the AGC Magnetic Compilation Project. The latter began in late 1989 with the aim of assembling and rationalising all available magnetic observations from the Arctic and North Atlantic Oceans and adjacent land areas, in order to create a coherent database that could be applied to quantitative tectonic interpretations and to the automated production of accurate maps.

*66* So far, some fifty million magnetic data points had been obtained from 42 institutions in 14 countries; these consisted of original marine magnetic and aeromagnetic observations, as well as grid points created during previous compilations or by digitizing contour maps. Making some reasonable assumptions about rates of data collection, the database represented the fruits of about 6,600 ship-days (at 24 hours per day) and 3,900 aircraft-days (at 12 hours per day). The compilation was nearing completion and it was planned to distribute the data in the form of computer readable grids and printed maps. So as to facilitate the rapid visual correlation of magnetic and bathymetric features, the maps would be produced on bases compatible with GEBCO's 1:6 million Arctic Sheet 5.17 and its 1:10 million Atlantic Sheets 5.04 and 5.08, north of 30°N.

*67* Dr. Macnab commented that the magnetic compilation had several parallels with the development of GEBCO, in that both activities featured the processing and management of numerous disparate data sets that must be homogenized, correlated and merged for distribution in map and digital form. There existed many common problems in the handling of the two types of data, which suggested that regular contract between bathymetrists and magneticists should be encouraged. Present liaison was quite good and would no doubt yield greater dividends as the respective databases evolved and their related methodologies became more sophisticated.

*68* Finally, Dr. Macnab drew the meeting's attention to a shaded relief map, produced by AGC, of gridded bathymetry and topography north of 64°N. He explained that the bathymetric grid was not generated from contours extracted from the GEBCO Digital Atlas, but rather from a partial set of contours that had been digitized from GEBCO Sheet 5.17 in 1991, then merged in 1993 with the ETOPO5 grid for the surrounding land masses. The prime motivation for combining these two grids had been to eliminate the radial striations which were caused by artifacts in the latter, and which emanated from the north pole when the ETOPO5 data set was portrayed in a polar stereographic projection and in shaded relief.

*69* The new map was available as a paper plot or as a PostScript plot file and closely mimicked the original GEBCO Sheet 5.17, but without contours. Already several improvements were being contemplated for the next edition:

- More detail in the rendition of the seafloor, through use of the complete set of digital contours now available from the GEBCO Digital Atlas;
- A more accurate rendition of the land topography, if a suitable grid could be found;
- A more accurate coastline, if an improved variant could be obtained (perhaps the WVS);
- The inclusion of additional geographic and feature names.

*70* The meeting noted the AGC product with considerable interest in that it provided an excellent example of the technology available for presenting digital data.

### 3.9.2 Ocean Mapping Group (OMG), University of New Brunswick

*71* Dr. Larry Mayer explained that OMG was established at the University of New Brunswick in 1988 in response to a national need to develop advanced ocean mapping capabilities. The research of the OMG was focused on developing new and innovative techniques and tools for the management, processing, visualisation and interpretation of ocean mapping data. While ocean mapping was defined in its broadest sense (including the water column, sea surface and sea bottom), initial efforts had been directed to seafloor mapping and, in particular, towards problems associated with high-volume seafloor bathymetric and imaging systems.

*72* The Chair in Ocean Mapping worked within OMG which drew upon faculty and staff with expertise in the fields of hydrography, geographical information systems, digital image analysis, interactive computer graphics and 3-D data visualisation. Research support for the Chair in Ocean Mapping came through the sponsorship of industry and government agencies. In carrying out its research, the Group sought to define tasks that played an important fundamental role in furthering understanding of the ocean and ocean mapping systems but, at the same time, might lead to viable commercial products for its sponsors.

*73* Dr. Mayer summarised the current research activities of OMG as follows:

- The development of advanced software tools for real-time and post-processing of swathmap bathymetry and sidescan sonar imagery;
- The integration of airborne/spaceborne data sets with acoustic data in a GIS environment;
- Interactive 3-D visualisation of large multiparameter data sets;
- Quantitative high-resolution acoustic profiling for sea floor classification;
- Extraction of palaeoclimatic signals from geophysical databases;
- The Hydrographic Ground Truthing Experiment - an experiment that takes advantage of the 15m tidal range of the Bay of Fundy to evaluate the capabilities and limitations of modern acoustic mapping systems;
- Developing techniques for minimising sound errors - evaluating sources of error (like roll and refraction) and looking at new techniques (like multi-antenna DGPS systems) for minimising these errors.

*74* Dr. Mayer then gave a brief outline of the development of tools for interactive visualisation. He said that the recent developments in swath mapping and seafloor imagery had severely challenged one's ability to visualise the massive data sets produced by these systems. In response to this the OMG (Colin Ware) had developed a 6 degree of freedom mouse known as: 'bat'. This device permitted interactive exploration 'flights' through large multiparameter three-dimensional data sets. He added that with the use of LED glasses, it was possible to view these flights in true stereo. During a fascinating conducted tour of the OMG workshop, participants were given a very impressive demonstration of the three-dimensional flight capabilities of the 'bat'.

*75* Dr. Mayer provided information on a project at the University called Network Differential GPS. This project was concerned with the development of algorithms and software for the spatial interpretation of differential GPS correction messages. He said that this interpolation would reduce the accuracy deterioration of DGPS over larger distances. He added that because the project aimed at centimetre and millimetre accuracies, it was necessary to fit sensors to read the trim of the ship.

*76* Reporting on the Ground Truthing Experiment in the Bay of Fundy, Dr. Mayer said that he was encouraged by the latest results from a towed-vehicle which gave better results than photogrammetry. He added that he was less happy about the number of manufacturers who wanted the University to certify their equipment. The Bay of Fundy was proving a unique study area for examining the

relationship between actual seabed characteristics (topography, texture and composition) and acoustic measurements of these same characteristics. This was of interest for accurate hydrographic charting, dredging surveys, seabed classification for aquaculture sites, and mine countermeasures.

77 Finally, Dr. Mayer talked briefly about a remote sensing (aircraft) experiment to identify and measure migrating sandwaves. This technique was being actively used in the Netherlands.

## 3.10 CHILE

### 3.10.1 Servicio Hidrografico y Oceanografico de la Armada de Chile (SHOA), Valparaiso

78 The GEBCO Bathymetric Editor reported that SHOA had informed him that they had reviewed and digitized the sounding data on GEBCO Plotting Sheets 365, 395 and 424 and would be sending this data to him in due course.

## 3.11 CHINA

### 3.11.1 State Oceanic Administration (SOA), Tianjin

79 The GEBCO Bathymetric Editor tabled written input provided by Professor HOU Wenfeng on the activities of SOA as follows:

80 *The State Oceanic Administration attaches much importance to the International Bathymetric Chart for the Western Pacific (IBCWP) and has designated Mr Yang Wenhe, Deputy Administrator of SOA, to be responsible for national co-ordination and supervision of the Chinese participation in the project. SOA has allocated 400,000 RMB for initiating the project, including hosting the First Session of the Editorial Board of IBCWP, and will continue its financial support to this project.*

81 *A National Editorial Board has been established for IBCWP as a back-up to the Chief Editor, with the National Marine Data and Information Service (NMDIS) as the organisation for execution. This national board is composed of experts in the fields of oceanography, hydrography, cartography and marine geology and geophysics from the Chinese Navy, Academia Sinica, Ministry of Communications, Ministry of Geology and Mineral Resources, and the State Bureau of Survey and Mapping. Two meetings have been organised on data collection and technical support. Groups of experts on data collection, quality control and automatic plotting have been set up at NMDIS.*

82 *Preparation is being made on the catalogue of the bathymetric data to be used in IBCWP, with special reference to Subregions 2 and 3. This catalogue will include bathymetric data from 2,000,000 stations ranging from 100° E - 180° E, 90° N - 90° S from the current data holdings at both the Chinese National Oceanographic Data Center (CNODC) and World Data Center D (WDC-D Oceanography). The Chinese data experts are now conducting data processing and database designing for IBCWP and experimenting on bathymetry chart plotting for a selected area of the Western Pacific. CNODC and WDC-D Oceanography will continue the data collection, processing and exchange for the project. CNODC is willing to undertake data analysis, quality control and database establishment for the IBCWP.*

## 3.12 FRANCE

### 3.12.1 Institut Francais pour la Recherche de la Mer (IFREMER), Brest

83 The GEBCO Bathymetric Editor reported that Dr. Jean-Claude Sibuet had informed him that IFREMER had compiled a new bathymetric map of the Bay of Biscay based on all available conventional and multibeam data. The scale of the map was 1:2,400,000 at 41°N with the limits 43° - 49°N and 1° - 18°W. The contour interval used was 200 metres, with the 50 and 100 metre contours also shown on

the continental shelf. The main sources of multibeam bathymetry were the SeaBeam data collected by RV *Jean Charcot* and Simrad EM-12 data collected by RV *Atalante*.

## 3.13 GERMANY

### 3.13.1 Alfred-Wegener-Institut (AWI), Bremerhaven

*84* Dr. Hans Schenke outlined current bathymetric activities at AWI. For the first of these, he presented an index of the 13 maps that combine to form the series: *Bathymetric Chart of the Weddell Sea*, being produced at AWI. Except for the most northerly 5 maps, where complex topography and lack of data within AWI had prevented work, compilation of the remaining 8 sheets was in progress.

*85* Dr. Schenke reported that, in support of the next edition of the joint BAS/AWI Topographic Map of the Ronne Shelf at 1:2 million, AWI had completed the digitization of GEBCO Bathymetric Plotting Sheet 567 at 1:1 million. Coastlines, digitized from Landsat pictures, were now out of date and would be replaced by SAR imagery. He commented that, as this work was linked to SCAR, all data would be provided to the Antarctic database being maintained at BAS.

*86* Dr. Schenke gave notice that AWI was preparing large scale bathymetric maps of Fram Strait, and also reported that recent surveys had disproved the existence of the Mary Byrd seamounts (120°W, 70°S).

*87* Dr. Schenke recounted some of the data access problems connected with the new navigation and data acquisition systems installed in RV POLARSTERN. He also spoke of the new AWI processing system which includes: Hydrographic Cleaning System (HOCS); CARIS; DTM and 3D-Imaging. He concluded his review of bathymetric tools by adding that the Hydrosweep 120° (open angle) now provided post-processing for back-scatter analysis.

*88* Dr. Schenke then described the problems encountered by AWI in trying to resolve ERS-1 Satellite Altimetry data over sea ice. He said that they were unable to obtain a wavelength resolution of better than 30-40 metres and stated that, as orbits of ERS-1 differed by 3-4 metres, it was impossible to gather really accurate data. He remarked that the achievement of precise orbits was essential for study of the gravity model - this he hoped would be attained in 3-4 years.

*89* Dr. Schenke regretfully reported that Dr. Heinrich Hinze had left the AWI to further his career in administration. The Sub-Committee wished Dr. Hinze well in his new venture and acknowledged the excellent contributions he had made to its recent meetings.

*90* Dr. Schenke concluded by listing the AWI bathymetric surveys planned for 1993-95.

| | | |
|---|---|---|
| RV POLARSTERN | 1993 | South Atlantic<br>Amundsen and Bellingshausen Seas<br>SE Indian Ocean |
| | 1994 | Greenland Sea/Fram Strait<br>Scoresby Sund |
| | 1995 | Antarctica - 3 cruises |
| RV BORIS PETROV (Charter) | 1995 | Bransfield Strait |

### 3.13.2 Bundesamt fur Seeschiffahrt und Hydrographie (BSH), Rostock

*91* Dr. Schenke, reporting on behalf of the German Bathymetric Data Centre at the BSH, Rostock, said that the centre was now staffed with four officers who were initially engaged in compiling an inventory of bathymetric data collected by German organisations. They had visited a number of universities and agencies and were currently purchasing hardware and evaluating software needs.

*92* He suggested that Dr. Loughridge, on behalf of the IHO DCDB, should write to the Deutsche Forschungemeinschaft (German Science Foundation) requesting the bathymetric/geophysical data collected during the last 10 years.

## 3.14 GREECE

### 3.14.1 Hellenic Navy Hydrographic Service (HNHS), Athens

*93* The GEBCO Bathymetric Editor reported on information provided by Alexis E. Hadjiantoniou:

*94* *HNHS has responsibility for 12 plotting sheets at a scale of 1:250,000, which are required to support the IBCM project. All these sheets are currently in digital form under the Arc/Info environment. The data are organised by plotting sheet limits rather than by cruise. Future plans are:*

*a) to regularly update the sounding database;*

*b) to organise new data according to the GEBCO Guidelines;*

*c) to develop software to support the translation of Arc/Info files to MGD77 and vice versa.*

## 3.15 NEW ZEALAND

### 3.15.1 New Zealand Oceanographic Institute, Kilbirnie, and Other New Zealand Activities

*95* The GEBCO Bathymetric Editor tabled a brief review prepared by Dr. Ian Wright of the National Institute of Water and Atmospheric Research Ltd. (which includes the New Zealand Oceanographic Institute) concerning recent activities around New Zealand.

*96* *Within the last year a number of collaborative swath cruises have been undertaken within the NZ region. An NZ/French project used the EM20 system onboard the RV Atalante mapping parts east of North Island, southern Kermadec Trench, and Puysegur Trench south-western South Island. An NZ project used the ECHOS multibeam system onboard the chartered RV Lavrenytev to map a part of the southern Havre Trough. A swath imagery and bathymetry survey of the Macquaire Ridge (south of New Zealand) was completed by a collaborative US/Australian project.*

*97* *As part of its continuing charting programme the New Zealand Oceanographic Institute had completed the first chart of Oceanic Chart Lachlan (GEBCO Bathymetric Plotting Sheet 446 area) and updated the Coastal Chart (Poor Knights). Two other miscellaneous charts of the southern Kermadec submarine volcanoes, and sediment classifications of the Auckland Harbours have been completed.*

## 3.16 RUSSIA

### 3.16.1 Head Department of Navigation and Oceanography (HDNO), St. Petersburg

*98* Captain Andrey Popov reported that the HDNO was continuing its development of a digital bathymetric database for its area of GEBCO responsibility. Bathymetric Plotting Sheets 593 and 594 in the Arctic had been digitized and sent to the GEBCO Bathymetric Editor. It was planned to finish Plotting Sheets 591 to 595, 598 and 599 by the end of 1994.

*99* The HDNO had also digitized five IBCM plotting sheets at 1:250,000 scale for the eastern Mediterranean Sea and 13 others, in the central part of the Mediterranean Sea, would be completed by the end of 1994. HDNO had also undertaken responsibility for 40 plotting sheets at 1:250,000 scale and 20 plotting sheets at 1:500,000 scale for the IBCWP in the north Pacific Ocean.

*100* Captain Popov then introduced a proposal by Viktor Sedov for a new Edition of the *Atlas of the Ocean*. Details of the atlas had been sent to the IOC and a meeting had also been held in Moscow, May 1994. He added that it was planned to include GEBCO bathymetry in the atlas. The atlas was to be in 5 parts which included bathymetry, seismicity, seafloor sediments, gravity and magnetics. Michel Huet, speaking for the IHB, said they had examined the proposal but were somewhat confused. They had responded to the initiative by asking for a sample and proposals for the exact content of the atlas.

*101* Captain Popov concluded with the news that the atlas *Straits of the World Ocean* was now finished and was expected to be available for sale in late summer 1994, selling in the west for $450.

## 3.17 UNITED KINGDOM

### 3.17.1 British Antarctic Survey (BAS), Cambridge

*102* The GEBCO Bathymetric Editor reported that he had been in contact with Dr. Roy Livermore at BAS and had learnt that Dr. Livermore was hoping to prepare a revised bathymetric chart next year covering the East Scotia Sea. It was not yet known whether it would be available in digital form. It was understood that BAS would be prepared to release their underway marine geophysical data to the World Data Centre system, although there was some reluctance to do this in view of the attitude taken by some countries in not releasing their own Antarctic data. Dr. Schenke agreed to discuss this matter with BAS during a forthcoming meeting between BAS and AWI.

### 3.17.2 UK Hydrographic Office (HO), Taunton

*103* Mr. Brian Harper presented a written report from Mr. Roger Cavill of the UK HO describing the DIBON Project, the main component of which was the development of a digital bathymetry system with aims as follows:

1. To convert incoming digital bathymetry on a cruise by cruise basis, from a variety of formats and sources, including the IHO DCDB, to a standard internal format.
2. To validate and edit, both within and between, datasets.
3. To archive to a database all data that has been evaluated and considered valid, and to retrieve, edit and delete from the database as necessary.
4. To produce colour-banded, non-overwritten plots of depths from the database at any scale, to any geographical limits, on specific projections, up to A0 size.
5. To convert and output data from the internal format to the standard international format, MGD77.

*104* The system had been developed during 1993-94 and was now undergoing testing and trials, with the introduction of the live system expected in mid-1994. On-screen interrogation of any sounding held in the database provided a windowed information header for the entire cruise data.

*105* Mr. Hunter and Dr. Robinson expressed a keen interest in the new system and said they would seek an early opportunity for a demonstration.

*106* Mr. Cavill's note concluded by saying that the UK HO was continuing to digitize its holdings of original ocean cruise sounding data for inclusion in the IHO DCDB and was also providing data, as requested, for other mapping projects.

### 3.17.3 IOS Deacon Laboratory (IOSDL), Wormley

*107* Mr. Peter Hunter reported on his activities at IOSDL. Revision of the IOSDL 1:1 million scale bathymetry of the North-east Atlantic had continued, using data from sources including single-beam bathymetry from IOSDL and the NGDC GEODAS CD-ROM, multibeam bathymetry and sidescan sonar images. Unfortunately, lack of support staff during the first 9 months of the year had meant that no plotting sheets had been finished, except for two large areas: (1) the Abyssal Plains off Madeira and (2) Rockall Plateau and Porcupine Abyssal Plain. Lack of adequate plotting facilities at IOSDL had meant that it had not been possible, until recently, to plot out the finished contours as full sized maps.

*108* Mr. Hunter stated that he intended to raster scan the sixty or so 1:1 million scale manuscript bathymetric contour charts maintained at IOSDL for the North-east Atlantic and to store these images on CD-ROM. With the purchase of raster to vector conversion software, this would enable the maps to be both viewed and converted to digital contours and then updated through AutoCAD for insertion into the GDA. It should be possible to update the contours on 12 plotting sheet areas (6° Lat. x 12° Long.) per year on this basis.

*109* A procedure had been set up at IOSDL to process the UK research community's geophysical cruise data. Clean depth files, totalling 55 cruises, were deposited in the World Data Center at Boulder, USA. These data now form part of the NGDC's GEODAS CD-ROM. The next phase would be to obtain and archive bathymetric data collected during cruises by NERC ships since 1989 and to start processing RRS *Discovery* data collected since 1975.

*110* Mr. Hunter concluded by reporting that IOSDL's compilations of the "South-west Approaches to the British Isles" bathymetry had been digitized by BODC, principally for the OMEX project. These would now be inserted into the GDA. The HDNO bathymetry for the Kara and Laptev Seas had been edited. Future work would focus on including the IOSDL compilations of the Lau Basin, the abyssal plains in the vicinity of Madeira and the Canary Islands, the Porcupine Abyssal Plain and Rockall Plateau.

## 3.18 UNITED STATES

### 3.18.1 Hawaiian Institute of Geophysics (HIG), Honolulu

*111* The GEBCO Bathymetric Editor reported on his contacts with Dr. Barbara Keating (HIG) concerning their mapping work. HIG were compiling a new digital database for the Hawaiian Islands and seamount chain and hoped to have the compilation completed by the end of March 1994. They were working in the area between 145° W and 163° E and between 17° and 33° N, and had digitized Jacqueline Mammerickx's DNAG map for the regional bathymetry. This was being merged with:

USGS 1:125,000 topography for the main islands;

Nearshore NOS bathymetry around the islands;

Nearshore NOAA SeaBeam data around the main Island of Hawaii;

SeaMARC II data for individual seamounts.

*112* They would be producing a large format atlas with hard copies of the images and maps and hoped to have the atlas laid out ready for printing by the end of March. As soon as the atlas was ready for printing, Keating's two co-workers Fernando Martinez and Eric Halter would work on getting the digital data set out to NGDC, as required by their funding contracts. They had been asked to send the same data to the GEBCO Bathymetric Editor.

### 3.18.2 Naval Research Laboratory (NRL), Washington DC

*113* Mr. Norman Cherkis reviewed the various activities at NRL relevant to the updating of GEBCO.

*114* Since June 1993, NRL had been involved in creating a digital database for bathymetry in the Persian/ Arabian Gulf region. Old analogue surveys, most of which were of British Admiralty and US Navy Hydrographic Office origin, of 1950s and early 1960s vintage, had been identified, located and digitized. These data were on older or local datums, and the coastlines had been found to be inaccurate with respect to the World Vector Shoreline (WVS). Manual "rubber sheeting" had been necessary to make these surveys compatible with WVS; however, data shifts had been limited to within a quarter of a mile. Additional data sets were continually being sought. It was expected that these data would be passed to the NGDC, probably within two years, with the concurrence of DMAHTC. Approximately 160,000 data points had been digitized to date. The final map at 1:87,000 would be part of a published folio, containing bathymetry, surface sediments, tectonic structures and wreck/obstruction/anthropogenic features, e.g. platforms, pipelines, wrecks, reefs, shoals, etc. Methods of placing the data into a GIS format were being investigated.

*115* During the same period, NRL had produced a new map of the Norwegian and Greenland Seas, as the base map for the forthcoming *Seafloor Atlas of the Norwegian-Greenland Seas*. This atlas would be published later in 1994.

*116* Mr. Cherkis also reported that he had been compiling and revising a map of the Bathymetry of the Franz Josef Land Region. The primary author of this map was G.G. Matishov (Murmansk Marine Biological Institute). Land contours had been digitized from existing (and available) maps, and transferred to the land base, which was based on the World Vector Shoreline. The final contours were expected to be submitted to the Geological Society of America for publication in the GSA map and chart series in September 1994. Hopefully, the contours would be digitized and submitted for the GEBCO Digital Atlas. Unfortunately, Matishov was unable to release the soundings (due to classification restrictions by the Russian Navy), so verification of the details was impossible at this time. However, since Matishov had a good reputation with regard to contours, Mr. Cherkis recommended that they should be trusted. The GEBCO Bathymetric Editor raised the problem of edge-matching Matishov's contours into the GDA. It was agreed that Pauline Weatherall should have a first try at this task before sending her proposed solutions to Norman Cherkis. Later, David Monahan and Evgeniy Shchaulov, as reviewers for this region, should make the final decision.

*117* Mr. Cherkis further reported that, during Summer 1994, he would have a student assistant to digitize two cases of echogram records taken during USGS 1988, 1989, 1991 and 1992 operations in the Chukchi Sea (Northwind Ridge and vicinity). With USGS permission, these data would be given to NGDC for inclusion into the IHO database.

*118* Digital contours of the NRL chart, *Bathymetry of the Barents and Kara Seas* had been provided to the GEBCO Bathymetric Editor on Exabyte medium in April 1994. It appeared that the first copy, sent in June 1993, had been lost in the post.

*119* Finally, Mr. Cherkis tabled the latest update (20/05/94) of his inventory of Multibeam Equipped Ships (see Annex VII). Corrections and additions were called for. Dr. Michael Loughridge (NGDC) made the observation that there may have been some duplication of effort between NRL and NGDC concerning these listings. It was agreed that Mr. Cherkis and Dr. Loughridge would consult on this topic.

### 3.18.3 US Naval Oceanographic Office (USNOO), Bay St. Louis

*120* Mr. Frank Marchant reported that the Naval Oceanographic Office was building a new global digital bathymetric database, *Digital Bathymetric Data Base - Variable (DBDBV)*. A flexible database structure would allow the inclusion of bathymetric grids of varying grid spacings, and would support an almost unlimited range of grid spacings, with a maximum spacing of 5 minutes of latitude and longitude (DBDB5). Higher grid resolutions would be available where data existed to support them. More than one grid resolution could exist at a given location.

*121* Mr. Marchant added that, in addition to the database itself, DBDBV would include software to access the data. The database would be queryable for data at a point, along a great circle path, or within a

minimum bounding rectangle. The user would be queried when a choice of resolutions was available. In those instances where a great circle path or minimum bounding rectangle transected data of differing grid spacings, options for output spacing, feathering at the juncture of the varying grids, smoothing, and interpolation would be available.

*122* He concluded by saying that DBDBV would reside on and be accessible from CD-ROM. Both the database and the access software would be generic and portable to both UNIX workstations and PCs. It was anticipated that the first version, fitting on a single CD-ROM, would be ready for August 1994.

*123* In discussion, Mr. William Rankin, prime author of DBDBV, said he recognised users' needs for audit trails, fast access to information but avoiding the dangers of poor extraction. He added that the grids were held on geographic co-ordinates - registered to corners.

### 3.18.4 National Ocean Service (NOS), Washington DC

*124* Dr. Walter Smith gave an illuminating presentation on the work he had been carrying out in collaboration with Dr. David Sandwell of Scripps Institution of Oceanography in predicting the bathymetry of the Southern Oceans (south of 30°S) from the Geosat Geodetic Mission altimeter data. He explained the technique they had developed for incorporating existing bathymetric data into the algorithms for predicting bathymetry from the gravity field, so as to avoid most assumptions about isostatic compensation and to allow for regional variations in the correlations between bathymetry and gravity. For a full account of this work, the reader is referred to the forthcoming paper "*Bathymetric Prediction from Dense Satellite Altimetry and Sparse Shipboard Bathymetry*" by Smith and Sandwell, which has been accepted for publication in the Journal of Geophysical Research. An introduction to this topic may be found in Annex III, where Dr. Smith's notes to the Sub-Committee meeting of April 1993 are reproduced.

*125* At the conclusion of his presentation, Dr. Smith tabled his bathymetric predictions for the complete area of the Southern Oceans, south of 30°S. Whilst recognising some of the limitations of the altimetry predicted bathymetry (e.g. inability to resolve sharp features with their full amplitude and problems in areas of partial sediment cover where basement highs are exposed while the lows are filled in), the meeting was nevertheless very impressed by the potential offered by the technique in providing insight into the nature of bathymetry in poorly surveyed areas. The predictions would be of immense value in the compilation of bathymetric charts and Dr. Smith kindly agreed to make his gridded bathymetric prediction data set available to the GEBCO community through NGDC in Boulder. The meeting was particularly interested in the potential applications of the predicted bathymetry data set to the development of a standard GEBCO gridded data set (see agenda item 8.2) and looked forward to the release of the high resolution Geosat data north of 30°S in due course.

## 4. PUBLICATION OF THE GEBCO DIGITAL ATLAS (GDA)

*126* Dr. Meirion T. Jones said he was delighted to announce the publication of the first edition of the GEBCO Digital Atlas. It represented the culmination of almost a decade's work achieved through the co-operation and determined efforts of numerous individuals and institutions across the globe. The GDA included, in digital form, all the bathymetric contours, coastlines, tracklines and survey boxes shown on the 18 Fifth Edition sheets and would provide the base for the future updating of GEBCO.

*127* Dr. Jones then welcomed to the meeting Canada's former Dominion Hydrographer, Mr. Gerald Ewing. He recalled that in 1975 it was Mr. Ewing who was instrumental in initiating the preparation and publication of the entire set of GEBCO 5th Edition sheets which were completed in 1982. He said that at that time the Canadian Hydrographic Service was probably the only HO which could have undertaken this work; and as a result, he had laid the sure foundations for the GDA. Dr. Jones gratefully acknowledged Mr. Ewing's profound contribution to the GEBCO project. With the added thanks of the Sub-Committee, Mr. Ewing was presented with the first copy of the GEBCO Digital Atlas.

*128* Dr. Jones gave a brief slide presentation on the GEBCO Digital Atlas - details of the package, which included a CD-ROM, a software interface on floppy disk and a Supporting Volume, may be found in the black and white copy of the publicity brochure contained in Annex V. He explained how over 2 man years of concerted effort had been required at BODC over the past year to bring the Digital Atlas to publication. Careful work was needed to quality control, reformat and index the data sets on to optical disk, and detailed checks were carried out on the digitized Fifth Edition data so as to ensure a seamless join across sheet boundaries for the standard GEBCO contours. A highly sophisticated software interface, comprising 17,000 lines of Turbo-Pascal source code, was written for use with the CD-ROM, based on many of the concepts developed at BODC for the UK Digital Marine Atlas. In addition, a comprehensive 165 page Supporting Volume was written to accompany the CD-ROM and its software interface.

*129* Dr. Jones thanked Dr. Loughridge for the excellent co-operation shown by NGDC, in particular Dan Metzger, in providing BODC with a trackline inventory of the echo-sounding data holdings of the IHO DCDB for inclusion on the CD-ROM. Sincere thanks were also offered to Captain James Ayres of the U.S. Defense Mapping Agency for making the World Vector Shoreline available for use in the GEBCO Digital Atlas. Dr. Jones explained that, although WVS was included on the CD-ROM, the bathymetric contours had not been adjusted for compatibility with WVS except for the area of revised GEBCO Sheet 5.12. However, it would be used as the standard for the future updating of GEBCO.

*130* Dr. Jones then thanked M. Huet for making available, in digital form, the latest version of the IHO Gazetteer of Geographic Names of Undersea Features. He reported that the GDA Manager, Pauline Weatherall, and Michel Huet had collaborated closely in checking out the geographic positions of the names against the features on the GDA. He explained that, when viewed on the screen, the GDA displayed a queryable symbol at the location assigned to each name and that, when the symbol was queried, the name of the feature (and its associated entry in the Gazetteer) then appeared on the screen. At this stage, the GDA did not allow the Gazetteer to be listed out or copied but this facility would be considered for future releases. In addition to undersea features, the GDA also included the names of some 400 oceanic islands prepared by BODC with reference to the Comprehensive Edition of 'The Times' Atlas of the World.

*131* In the discussion that followed, Dr. Walter Smith offered software to link edgematching contours to provide area-fill capabilities. Dr. Jones said he recognised the absence of logical consistency in the topology of the GDA and added that it was his intention, during the next 5 years, to put topology back in the atlas. He thought that 90%-95% could be easily achieved by automatic means, the remainder would have to be done by hand.

*132* Dr. Jones reported that a two-tier price had been set for the Atlas; £99.00 for the academic community and for those organisations collaborating in GEBCO or supplying data to the IHO DCDB and £230.00 for other users. Numerous suggestions were offered about advertising the GDA and Dr. Jones said he would add these suggestions to the ever-expanding BODC list of 'targets'. He was particularly grateful to accept a generous offer from Dr. Mike Loughridge to include a GDA leaflet in the forthcoming mass mailing by NGDC to approximately 50,000 addresses worldwide.

*133* Dr. Jones concluded by stating that the distribution package for the GDA included a User Registration Form and a Problem Report Sheet. He made it clear that BODC considered it an important goal to keep in close contact with the community of users so as to ensure that they were made aware of future upgrades and bug corrections for the GDA Software Interface and of future updates to the GDA contours. It was important, therefore, for users to register with BODC.

## 5. UPDATING THE GEBCO DIGITAL ATLAS (GDA)

*134* The Chairman remarked that, with the completed digitization of the GEBCO (Fifth Edition) and the subsequent publication of the GDA, the stage was now set to consider the future updating of GEBCO. It was a salutary thought that, with the exception of the revised Sheet 5.12, most of the existing sheets were 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 the bathymetric contours in areas sparse in echo-sounding coverage (see e.g. Annex III).

*135* It had been agreed that the GDA would form the base from which future printed editions of GEBCO would be generated. However, rather than being geared towards the printing schedules of such future editions, the updating of the GDA would be a continual process. Without the scale constraints of the printed chart, it was envisaged that improved bathymetric compilations would be merged into GEBCO at scales ranging from 1:10 million up to 1:500,000 (or even 1:250,000 in isolated cases). This would be achieved by 'stitching in' (from outside the updated area) so as to maintain the seamless nature of the data set. It had been agreed that no attempt would be made to generalise the contours and that each updated area would be inserted at a resolution befitting the density of sounding data available for its compilation.

*136* In order to maintain the high quality and global nature of GEBCO, it would be necessary to set standards on the new material used for its updating. This issue had been discussed fully at the Tenth Meeting of the Sub-Committee at NGDC, Boulder, in May 1993 and the Chairman reported that the conclusions of these discussions had been documented as section 1.7.3 ("Updating the GEBCO Digital Atlas") of the GDA Supporting Volume (see Annex IV).

*137* The Chairman was pleased to report that the UK Natural Environment Research Council had agreed to continue its support of the work of GEBCO by funding the posts of GEBCO Bathymetric Editor and GEBCO Digital Atlas Manager for a further 5 years to the Spring of 1999. The posts would be held, as at present, by Peter Hunter at the IOS Deacon Laboratory, Wormley (transferring to the Southampton Oceanography Centre in 1995), and Pauline Weatherall at BODC, Bidston, respectively. The posts formed part of a successful project proposal submitted by the Director of BODC with the underlying assumption that the GEBCO could be brought completely up to date during the five year period. Part of the responsibility for Mr. Hunter's post would be the complete revision of the 60 or so 1:1 million bathymetric contour sheets maintained at IOSDL for the North-east Atlantic.

*138* The Chairman reported that work on updating the GDA was already well underway and that Pauline Weatherall had been working 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. The chart was being contoured on Mercator projection at a scale of 4 inches per degree longitude and involved 240 or so individual sheets. By April 1994, Dr. Fisher had completed work on all sheets between 10°W and 100°E.

*139* As each set of Dr. Fisher's sheets was completed, copies of both the contours and tracklines were sent to BODC for digitizing. The sheets were raster scanned at an external bureau for subsequent vectorization using a semi-automated digitizing system in-house. Once digitized, the contours were then checked for labelling, digitization accuracy and registration errors. Due to the nature of the source material (paper), it was usually necessary to re-register the geographic co-ordinates at 1° intervals in latitude and longitude. As of May 1994, Pauline Weatherall had completed the digitization of all 56 sheets between 20°E and 60°E, covering both the contours and the tracklines. Additional work was still required to merge in later update patches and to edgematch the individual sheets. Sheets between 10°W and 20°E were being digitized part-time by two undergraduates at Scripps Institution. During the summer 1994, BODC planned to employ a student to digitize the sheets between 60°E and 80°E and to start on the section between 80°E and 90°E.

*140* The Chairman was also pleased to report that Miss Weatherall had completed work on digitizing a series of charts contoured at intervals of 100m at scales between 1:250,000 and 1:500,000 supplied by Mr. Hunter for the area 47° to 52.2°N; 7.5° to 16°W. This work had been undertaken to support the European Community's Ocean Margin Exchange Experiment for which BODC acted as the project data centre.

*141* Mr. Hunter presented a draft set of guidelines for digitizing bathymetric maps suitable as input for updating the GDA. He explained that they had been developed jointly with Miss Weatherall and had been originally intended to provide simple technical advice to the Editorial Board of IBCCA. The Chairman welcomed this initiative and looked forward to seeing a fully developed version. An ensuing

discussion arose over the prospect of the GDA being formed by a mosaic of numerous digital maps, such that contours may have been derived from either generalised or detailed data without users being aware of the ranges in the resolution of the data used. Dr. Ron Macnab asked if there were any plans in hand for qualifying data in the GDA. Mr. Hunter, in reply, said that he had been giving some thoughts to this problem and would present some ideas later.

*142* The Chairman reminded the meeting that, in the updating of the GDA, the coastline would be standardised on the U.S. Defense Mapping Agency's World Vector Shoreline (WVS). This had already been used for revised Sheet 5.12 and was also being used for Dr. Fisher's compilation in the Indian Ocean. However, despite the excellent resolution of WVS across the globe, it was known to be of lower accuracy around Antarctica. Dr. Hans Schenke advised the meeting that the best circum-Antarctic coastline available at present was that published recently on CD-ROM by the British Antarctic Survey on behalf of SCAR. The Chairman agreed to approach the Secretary of SCAR to request permission for their coastline to be made available for use by GEBCO. (Note: This permission was forthcoming in an exchange of letters between the Sub-Committee Chairman and the Secretary SCAR in November 1994.)

## 6. IHO DATA CENTRE FOR DIGITAL BATHYMETRY (IHO DCDB), BOULDER

*143* Dr. Mike Loughridge reported on the inter-sessional activities of the National Geophysical Data Center (NGDC) and the co-located IHO-DCDB. He stated that, since April 1993, NGDC had responded to 193 requests for data or information from 13 countries, of which 10 were IHO Member States. Furthermore, over the same period, a total of 333 cruises/legs of data had been assimilated into the global marine geophysical database (GEODAS), including over 4 million soundings from 12 agencies located in 6 countries. There had been a 15 percent increase in bathymetric data holdings at NGDC in 1993 and the second update to the GEODAS CD-ROM data set was released in April 1994. The data set now contained over 11.5 million nautical miles of bathymetry from 3467 cruises with 27.6 million digital records. A statistical breakdown of total holdings, and of data assimilated since 28 April 1993 (and also for the period 1 April 1992 to 27 April 1993), are given in Annex VI which also includes a diagram showing data assimilation over the past decade.

*144* The Chairman commented that the growth of sounding data assimilated since the IHO DCDB was established in June 1990 had been spectacular, almost 50%, and he congratulated Dr. Loughridge on behalf of the Sub-Committee on such a splendid achievement.

*145* Dr. Loughridge added that NGDC was presently designing a new inventory system with search and retrieval mechanisms similar to the GEODAS system which would be used for area survey data as opposed to cruise ordered data. Data would be inventoried by using polygons around the perimeter of the survey area and would be searchable by area, vessel, date of survey, institution, and many other parameters. Work on this inventory system was expected to be complete by late 1994. Sounding survey sheets that had been digitizing under projects managed by NGDC for the US Defense Mapping Agency, the NOAA National Ocean Service, and the Portuguese Hydrographic Institute would be inventoried using this new system; 280 sheets from areas throughout the world had been digitized to date.

*146* Dr. Loughridge said that the DCDB, as part of the IHO family, was now in an information loop which had increased substantially. He regretted that there were still some countries which were not yet contributors. Michel Huet expressed the wishes of the committee in saying he hoped that all data collectors would actively support the IHO DCDB.

*147* NGDC had continued to work with IHB in improving the format of the B4 publication announcing recently collected bathymetric data and the next edition would be ready for publication in June 1994. M. Huet added that another innovation to be included in B4 was a new Part 3 giving information on the total holdings of data in DCDB for each GEBCO Plotting Sheet area. The meeting requested that the IHB letter accompanying the new B4 should ask the VHOs the status of the digitization of the soundings on the Plotting Sheets in their areas of responsibility and whether that digitization was proceeding on a cruise by cruise basis.

*148* The Chairman, noting that NGDC could now store data digitized on a Plotting Sheet basis rather than just in cruise order, suggested that VHOs that had digitized their data solely on that basis should be encouraged to send such data to Boulder. However, it was accepted that these data might duplicate other data already submitted in cruise order form, but it could be the only way of acquiring historical data that might not otherwise be digitized. Mr. Cherkis said that his experience had shown the position of some duplicated 'identical' data to be as much as 0.25 nautical mile apart. He added that software had been developed to flag such duplications.

*149* In discussing the question of data validation, Mr. Huet said that the IHB had sent a document to all HOs giving the algorithms to convert any local datum to WGS 84, this was accompanied by software on a disk. Dr. Loughridge added that there was now considerable debate about establishing a vertical datum - the protagonists were arguing between the choice of the Geoid and a reference Ellipsoid.

*150* Dr. Loughridge reported that, in December 1993, NGDC had been officially named as the Data Assembly Centre for bathymetric data collected on World Ocean Circulation Experiment (WOCE) cruises. Procedures had been established for data submission and for data exchange with WOCE participants. All data received would be entered into the GEODAS system.

*151* Dr. Loughridge informed the meeting that NGDC staff played an active part in the IOC Regional Ocean Mapping Projects. Thus, Dr. Troy Holcombe served on the Editorial Boards of IBCCA, IBCEA and IBCWIO, while Dr. George Sharman was a member of the IBCWP Editorial Board and LCdr. Maureen Kenny attended a recent meeting of the IBCM Editorial Board.

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

- The Global Relief CD-ROM was released by NGDC in July 1993. Represented on the disc are various images of global relief, colour representations of world topography, and a polar stereographic projection image of GEOSAT gravity anomalies from the oceans south of latitude 30°S. Databases include 5' gridded world relief (ETOPO5), SEASAT gravity anomalies, undersea features gazetteers, magnetic lineations, fracture zones and World Vector Shoreline data.

- A new colour-shaded gravity image (poster) derived from GEOSAT satellite altimetry between latitudes 30°S and 72°S in the circum-Antarctic region is now available from NGDC. The poster was produced by Dr. Karen Marks and Dr. David McAdoo of the Geosciences Laboratory, NOS. (The previous image only included data south of 60°S.)

- The new colour relief image of global topography, "Surface of the Earth" scheduled for release in summer 1994, portrays the continents and ocean floor in high-contrast shading with small, but important, features clearly visible. Elevation and depth data used in the image are taken from the ETOPO5 gridded database which is available on the newly released Global Relief CD-ROM.

- In the near future, NGDC will be distributing a colour image produced by Dr. Walter H. F. Smith of the Geosciences Laboratory, NOS, and Dr. David T. Sandwell of Scripps Institution of Oceanography that displays predicted seafloor topography in the sparsely sounded circum-Antarctic region south of 30°S. The gridded digital data set will also be available from NGDC (as mentioned under agenda item 3.18.4).

## 7. REVISION OF THE 'GUIDELINES FOR THE GEBCO'

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

*153* The meeting was pleased to receive a preliminary draft text for the remaining unpublished Part 4 of the 'Guidelines for the GEBCO', dealing with multibeam data, prepared by Dr. George Sharman of NGDC and Mr. Stuart Smith of the Scripps Institution of Oceanography, as requested at the last meeting of the Sub-Committee. The Chairman, recognising the difficulties of preparing such a document, expressed his thanks to the authors for providing such an invaluable first attempt.

*154* As participants had not had prior opportunity to examine the document, the meeting went through it page by page and raised several points. First amongst these was the comment that clear improvements could be achieved by simplifying some of the technical presentation. This observation was particularly aimed at the Introduction. The discussion then ranged over a number of specific technical points including: heading accuracy and omission of pitch and roll parameters; questions over the use of 'normal velocity; the term 'Metadata' was questioned on the grounds that it was thought to mean different things to different people; oversampling; cleaning processes; modes of operation; etc. etc.

*155* Following a lively and constructive discussion, it was agreed that Dr. Walter Smith, Dr. Larry Mayer and Dr. Hans Schenke should each send their considered views to Dr. Sharman by mid-June 1994 with a view to the authors then preparing a more formal first draft that could be circulated widely for the comment of other experts in the field, including manufacturers. Following a wide poll of opinion, Dr. Sharman and Mr. Smith would then be invited to prepare a second draft by March 1995, for subsequent review by the next meeting of the Sub-Committee.

### 7.2 EXCHANGE FORMATS FOR BATHYMETRIC DATA

*156* The Chairman introduced a 'Discussion Paper on Bathymetric Exchange Formats' written by Mr. I.W. Halls of the RAN Hydrographic Service at the request of the Fifth Joint COE/CEDD meeting held in November 1993. Mr. Halls had been asked 'to develop a discussion paper on matters relating to exchange formats used by the GEBCO Committee' and the Chairman expressed his surprise that he had not seen fit to contact the Sub-Committee.

*157* Mr. Halls' paper had reviewed the use of the MGD77 (NGDC), GF3 (IOC) and S-57 (IHO) formats for bathymetric data and had concluded: *"If only bathymetry data is to be exchanged, then either MGD77 or preferably a GSF-type (Generic Sensor Format of the DMA) of format should be used/developed. Where a hydrographic survey is to be exchanged which includes depth data, navaids, coastline, etc., it is recommended that S-57 be used. What is likely to occur is that depth data will be forwarded in one exchange file format while all other data will be included in another file format, particularly if the depth data have been collected using a multibeam system".*

*158* The paper was examined by the Sub-Committee and the following comments were made: Firstly, although S-57 was recognised as the official data format designed for exchange of hydrographic chart and survey data, it was probably unnecessarily complex for use with gathering and storing bathymetric data. Secondly, MGD77 was considered to be a perfectly acceptable delivery format - no problems had arisen with its use over a number of years. Thirdly, the committee recognised that multibeam data could not be handled in MGD77 or S-57 formats but were aware that NGDC had this matter under consideration and requested Dr. Loughridge to report on progress at the next meeting.

*159* The debate concluded with a short discussion on the GSF format which had been studied by Dr. George Sharman at NGDC. Dr. Loughridge explained that this particular format was probably excellent for collection but not good for exchange and storage.

*160* The Chairman agreed to make a response to Mr. Halls' paper.

## 8. FUTURE DEVELOPMENT OF GEBCO PRODUCTS

### 8.1 RESEARCH INVESTIGATIONS AT THE NERC UNIT FOR THEMATIC INFORMATION SYSTEMS (NUTIS)

*161* Dr. Gary Robinson reported that NUTIS activities in support of GEBCO had continued on two fronts: the mathematical modelling of bathymetry from sounding data and the development of a strategy for the handling of GEBCO feature names in the digital domain.

### 8.1.1 Bathymetric Data Analysis

*162* Dr. Robinson stated that the resignation from NUTIS of Paul Pan had meant that development of the Trident bathymetric data editing system had been put on hold for the time being. In the meantime, NUTIS GEBCO activities had been turned to an in-depth analysis of the sources of errors in the GEODAS echo-sounding data and an investigation of suitable interpolation techniques for creating bathymetric grids. A cross-over analysis of the entire GEODAS data set was underway, with the intention of establishing a reliable automated procedure for identifying and rectifying the systematic errors that arise from misinterpretation of the depth units and/or sound velocity in the data banking process and also phase errors. Whilst this work was being carried out, methods for 'fine-tuning' of the ship track positions were being developed to minimise the residual cross-over errors.

*163* An interpolation strategy based on the identification of structural trends from ship track data was also under development. This essentially mimicked the process used in manual compilation of bathymetric contours from depth profiles by comparing the similarity of neighbouring tracks and interpolating using a piece-wise continuous technique.

### 8.1.2 Digital Techniques for Labelling Features

*164* Dr. Gary Robinson introduced his draft paper entitled *Feature and Contour Labelling in the GEBCO Digital Atlas*. He explained that the development of a digital GEBCO had released it from the constraints of the 1:10 million scale of the previous five editions. However, before future high quality charting products could be derived from the GDA it was necessary to resolve the complex cartographic problem of naming features on multi-scale output maps. His paper set out the issues for consideration. These included the GDA and the IHO Gazetteer; the definition and representation of undersea features, the role and nature of labels and the electronic display medium.

*165* A particular problem to be faced by GEBCO was in the automatic placement of labels and Dr. Robinson presented a draft set of specifications based, in part, on current widespread cartographic practice:

- named features should always be labelled wherever possible;
- labels should be placed so that they can be readily related to the correct features;
- labels should be orientated so that they can be easily read;
- labels should not obscure important detail;
- the minimum and maximum character size of labels on computer displays should be 9 and 24 points respectively;
- the font used should be Helvetica, or a similar well-defined font;
- labels of areal features should span the feature as much as possible, subject to other constraints;
- linear features such as ridges should have their labels aligned along the feature, and repeated at appropriate intervals if necessary;
- small features should be treated as points and labelled accordingly;
- labels should have priority over all other graphical types on the display;
- contours should be labelled so that depths of both labelled and unlabelled contours can be easily determined;
- contour labels should be placed along the straighter sections of contours and mask out the underlying contour.

*166* Dr. Robinson stated that the strategy necessary to achieve these specifications was greatly complicated by the scale-free nature of digital products, enabling the user to zoom into higher levels of topographic detail (with the possible truncation of features) and to produce charts at different projections. Further work would be required to deal with this problem and this would entail, as a minimum, developing a hierarchical classification scheme for feature types, defining the geographical boundary for each named feature and defining appropriate scale limits and rules for each feature type. Dr. Robinson stressed that the geographic boundaries of features should not attempt to define the physical extent of features (this would be impractical) - it was intended solely for labelling purposes.

*167* The Chairman thanked Dr. Robinson for his excellent contribution, recognising the difficulty of transporting common sense paper map name placement conventions into computer mapping. Dr. Robinson agreed that, when his work was more advanced, it would be appropriate to present it to the GEBCO Sub-Committee on Undersea Feature Names (SCUFN) for further discussion.

## 8.2 THE DEVELOPMENT OF A GEBCO GRIDDED DATA SET

*168* The Chairman directed this agenda item from the blackboard and in brainstorming mode the meeting engaged in a full ranging discussion on the generation of digital derivatives from GEBCO. The Chairman began by observing that, at present, GEBCO had two major components - the GDA with its global set of digital bathymetric contours and the IHO DCDB with its global collection of digital echo-sounding data. Both had involved considerable effort and international collaboration in their creation, and procedures were now in place for their continual updating. The time was now ripe to consider the further development of the GEBCO system and, in particular, to address the widely expressed requirement for high quality gridded global bathymetry suitable for computer applications.

*169* Dr. Macnab observed from an Arctic perspective that, as things stood at present, the digital version of Sheet 5.17, whilst offering greater versatility than the original printed document, could also serve as a starting point for assembling and merging new bathymetric data from the Arctic. While this operation could result in a more accurate picture of selected portions of the seafloor, it could also create confusion by opening the way for any number of practitioners to create a plethora of custom and incompatible bathymetric grids and maps. When this possibility was multiplied by the unlimited options for grids and maps in other parts of the world, the need for some co-ordination and standardization was obviously apparent. The meeting agreed that part of the problem could be overcome by ensuring that the GDA was regularly updated (with the updates routinely published) in a timely manner such that it consistently contained the best available bathymetry, not only on a global basis but also on a regional basis.

*170* The meeting agreed that the release of the new GEBCO Digital Atlas was likely to unleash a flood of derivative products, particularly those involving the creation of bathymetric grids. Inevitably these grids would be created with different processing techniques resulting in products of uneven quality and varying characteristics. In many, but not all cases, the GEBCO patrimony would be acknowledged, and the marginal quality of some products could reflect poorly on the original database.

*171* In view of the potential for unwarranted criticism, the meeting agreed that the GEBCO organisation should consider a means of forestalling latent problems by establishing guidelines and principles for the creation of digital products, or better still by sponsoring and documenting the development of a standard set of derivative products. Mapmakers and investigators could then acquire or generate these approved products and use them secure in the knowledge of widespread acceptance by their community of peers.

*172* The meeting recognised that if further digital products were created there should be a clear focal point for their dissemination and that a detailed record should be kept of the update history of the products. A proper system of version numbers should also be adopted for labelling upgrades. Users should be made aware on a routine basis of product updating, irrespective of whether the updating was for the correction of errors or for enhancements to the product. Dr. Walter Smith said that, in his experience with the GMT software, only 15% of users registered and he was concerned that the remaining 85% might not be keeping in touch with software upgrades. The Chairman recognised a similar potential problem with the GDA and stated that he was actively trying to keep in contact with all users. For the

time being, he was discouraging users from passing on the GDA to third parties for this reason and had consequently set a low price for the GDA. It was obviously in GEBCO interests to ensure that its users always had access to, and were aware of, the best available versions of its products.

*173* The meeting unanimously agreed that the next GEBCO product should be a global gridded bathymetric data set although there was considerable debate on how it should be derived and on its specification.

*174* Dr. Gary Robinson pointed out the problems of attempting to derive grids from contour data. The drawing of supplementary contours was often necessary to control the gridding and with many gridding algorithms undue bias was often given to the digitized contour points. Furthermore, by using contours only, the gridding process was not making use of the wealth of underlying source data that was available when the contours were first compiled.

*175* Dr. Walter Smith had a number of ideas as to how the gridded data set might be created. He envisaged that a high quality product could be developed by using the GDA in conjunction with the GEODAS and altimetry data. The development of such a system could greatly reduce the need for human intervention in the gridding process. The meeting concurred that this approach had considerable potential.

*176* The meeting agreed that, as a starting off point, GEBCO should attempt to develop a uniform gridded data set commensurate with the resolution of the GEBCO (5th Edition) and identified a 5 minute grid as being appropriate. In view of the diversity of approaches available for creating such a grid, it was agreed that the area of Sheet 5.12 in the South Atlantic should be used as a test bed for comparing the various techniques. A small team comprising Peter Hunter, Ron Macnab, Larry Mayer, William Rankin, Gary Robinson and Walter Smith was set up to collaborate in this work over the coming year. The collaboration would be affected over Internet, with correspondence copied to all other members.

## 9. ANY OTHER BUSINESS

*177* The meeting agreed that, in order to maintain the momentum of the Sub-Committee's activities, a further meeting should be held in twelve months' time. Recognising that the Fifteenth Session of the GEBCO Guiding Committee would be held in Monaco, May 1995, it was agreed that the meeting should be held in the preceding week and that the Chairman should seek an appropriate venue in the Mediterranean region, preferably at an institute active in bathymetric mapping.

## 10. CLOSURE OF THE MEETING

*178* In closing the meeting, the Chairman thanked the participants for their active and constructive contributions, for the wealth of technical expertise they had brought to bear on the work of the Sub-Committee and for their enthusiasm and support for GEBCO. He remarked that the activities of the Sub-Committee were drawing interest from a wide range of scientists working in the field of bathymetry. In this context he looked forward to developments during the next 12 months which would seek to strengthen these bonds and encourage others to participate in the future developments of GEBCO.

*179* The meeting was informed that Mr. Frank Marchant, one of the original members of the Sub-Committee when it was formed in 1984, would be retiring before the end of the year. The Chairman recalled that Frank had hosted the first meeting of the Sub-Committee at Bay St. Louis and had participated in every subsequent meeting. He thanked Frank for his wise council and friendship over the past decade and, on behalf of the Sub-Committee, wished him and Kay health and happiness in their retirement.

*180* With the unanimous support of the meeting, the Chairman thanked Dr. Mayer and his colleagues for the excellent arrangements and support given for the meeting and for being such perfect hosts in ensuring a successful social agenda.

*181* The meeting closed at 16.30 on Friday 27 May 1994.

Meirion T. Jones (Chairman)

# ANNEX I

## AGENDA

1. Opening of the Meeting
2. Conduct of the Meeting and tabling of documents
3. Review of related activities of other international and national groups
4. Publication of the GEBCO Digital Atlas
5. Updating the GEBCO Digital Atlas
6. IHO Data Centre for Digital Bathymetry
7. Revision of the 'Guidelines for the GEBCO'
8. Future development of GEBCO products
9. Any other business
10. 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 Digital 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

## INTRODUCTORY NOTES ON THE USE OF SATELLITE ALTIMETER DATA IN BATHYMETRIC CHARTING

(Prepared for the GEBCO Sub-Committee on Digital Bathmetry)
Walter H.F. Smith
1 June, 1993

### I. Description of the altimeter missions and the accuracy of marine gravity fields derived from them

Recent satellite altimeter missions measuring the height of the sea surface above the Earth ellipsoid have made possible very accurate resolution of the marine gravity field. These are the U.S. Navy's Geosat (March, 1985 to January, 1990), the European Space Agency's ERS-1 (July, 1991 to present), and the NASA/CNES Topex/Poseidon (August 1992 to present). The altimeter instruments of these satellites are all similar in design, and capable of measuring the sea surface height to ±2-3 cm. Comparison of these measurements along co-registered ground tracks indicates that the measurements are repeatable at wavelengths as short as 20-30 km [*Sandwell and McAdoo*, 1990]. The missions are different in their manner of orbital tracking and in their corrections for refraction effects in the ionosphere and troposphere. These have improved the accuracy of very long wavelength (greater than several thousand km) anomalies in sea surface height, but are of no consequence for estimation of gravity and bathymetry. The very long wavelengths of the gravity field are already well known, and the process by which gravity anomalies are estimated from the altimeter data emphasizes the better determined shorter wavelengths. Furthermore, the correlation between the gravity and bathymetry fields is strongest in the 15 - 230 km wavelength band, at wavelengths much shorter than the uncertainties in the altimeter data.

Geosat's original geodetic mission (GM) was designed to map the marine gravity field, and so it was initially placed in an orbit which allowed the satellite's ground tracks to drift over the globe during an 18 month period. This resulted in ground tracks spaced approximately 5 km apart at the equator. While these data were originally classified by the U.S. Navy, the portion of the data lying south of 30°S has recently been declassified. Gravity anomalies derived from these data agree with ship measurements at wavelengths as short as 20 km [*Smith et al.*, 1993]. There are indications that the U.S. Navy may release more of these data in the future.

Following the GM, Geosat was placed in a "frozen" orbit designed for an "exact repeat mission" (ERM). During this phase, the satellite re-visited the same 244 orbit tracks every 17 days, allowing oceanographers to obtain time series of variations in sea height, but only on tracks separated by 160 km at the Equator. The ERS-1 and Topex orbits have also been designed for oceanographic purposes. ERS-1 is currently in an orbit with 501 tracks repeating every 35 days (80 km apart at the Equator); there are plans for a 176 day repeat orbit which would have ground tracks spaced only 16 km apart at the Equator, to begin in 1994. This orbit would be nearly as good as Geosat GM for gravimetric purposes. Topex/Poseidon is in an orbit with 127 tracks repeating every 10 days, spaced 315 km apart at the Equator. The exact repeat orbits which have wide ground track spacing afford high accuracy data along-track, but poor across-track resolution.

The inclination of the orbit plane with respect to the equator affects the North-South range of the satellite's data coverage. Geosat's inclination of 108° mapped areas between ±72° latitude; ERS-1's 98.5° covers areas between ±81.5° latitude; Topex's 66° covers areas between ±66° latitude.

By combining data from several missions, *Sandwell and Smith* [1992] produced a map of gravity anomalies over the ocean areas between ±72° latitude. Their map has the high resolution of the Geosat GM data south of 30°S; north of this parallel it has an average resolution of approximately 100 km. This map was shown at the subcommittee meeting; copies are available from Virginia Wells at the Geological Data Center, Scripps Institution of Oceanography, 9500 Gilman Drive, La Jolla, CA 92093-0223.

In summary, all satellites make very precise measurements along their tracks. The orbit governs the track spacing over the ground and the maximum latitude reached. The Geosat GM mission, covering the area between ±72° latitude, has the most dense track spacing and thus produces the most accurate gravity field. However, to date these data have been declassified only in the area south of 30°S. The 176-day repeat orbit planned for the ERS-1 satellite will provide nearly the same resolution as the Geosat GM between ±81° latitude. This phase of the ERS-1 project will not be complete until end 1994.

## II. Use of altimeter-derived gravity fields in bathymetric charting

The marine gravity field is highly correlated with sea floor topography over a range of spatial scales, generally in the band 15 - 230 km wavelengths [*Smith and Sandwell*, 1992]. The exact nature of the correlation and the long-wavelength extent to which it holds depend on the nature of isostatic compensation of topographic features and the degree of sediment burial of basement topography. Satellite altimeter missions provide uniform coverage of the ocean basins, in contrast to the variable coverage afforded by ship soundings. Much of the ship data in the remote southern oceans is old, and the navigation is of poor quality [*Smith*, 1993]. While current technologies can provide very accurate navigation and multi-beam acoustic swath mapping, these are rarely deployed in the remote southern oceans. If present trends in ship deployment continue, vast areas of the southern oceans may never be surveyed. Man-made satellites have now provided better topographic maps of Mars and Venus than are available for some areas of Earth's ocean basins. The uniform coverage of satellite gravity data and its correlation with bathymetry can be used in bathymetric charting in several ways:

a) Suspicious soundings on charts can be compared with gravity maps to test their validity. Occasionally, bathymetric charts report isolated, very shallow values in regions of otherwise very deep water. Such features, if real, would be expected to have large gravity anomalies. Thus, the presence or absence of gravity anomalies at these sites could be used to confirm, or cast suspicion upon, such features.

b) Mis-navigated segments of surveys might be detected and relocated by comparison with gravity maps. Many of the plotting sheets upon which the charts are based contain segments of cruises which show large discrepancies at intersecting tracks. Often, it is not clear which segment is in error, or in which direction the track should be displaced in order to bring it into agreement with other data. Comparison of the soundings with a gravity map might suggest a solution.

c) The gravity field can be used to suggest trends or directions in the sea floor fabric, to guide the contouring of soundings on plotting sheets. At the Scripps Institution of Oceanography, Sandwell has produced computer-contoured maps of the gravity field at the same scale as plotting sheets used by Jacquie Mammerickx. Jacquie lays these contours on a light table with her sounding sheets on top, and then contours her data with the gravity contours as a guide. I believe Norm Cherkis (U.S. Naval Research Lab) has done a similar thing in preparing his latest South Atlantic chart.

d) Bathymetry can be predicted directly from satellite gravity data. *Smith and Sandwell* [1992] have demonstrated a technique by which depths are estimated directly from the satellite gravity by computer. The method is designed for areas where there are dense altimeter measurements and sparse ship data. The process uses the existing ship data to discover an empirical transfer function by which the gravity data may be transformed into predicted bathymetry. This transfer function is of geophysical interest because it encodes information about the mechanism of isostatic compensation and the thickness of sediment cover. The transfer function is applied to the gravity data to fill the holes in ship coverage. *Smith and Sandwell* [1992] report accuracies of ±250 m in a band of wavelengths 15 - 230 km. Earlier workers had tested the approach along one-dimensional profiles under satellite tracks [*Dixon et al.*, 1983; *Jung and Vogt*, 1992], and had success in finding uncharted seamounts near altimeter tracks [*Baudry et al.*, 1987].

Sandwell and I continue our research on bathymetric prediction from altimeter data. W.-Y. Jung and P.R. Vogt at the U.S. Naval Research Lab are also working on this technique, and recently presented a bathymetric map [*Jung and Vogt*, 1993]. In producing their map, Jung and Vogt assumed the transfer function between gravity and topography was a constant throughout the ocean basins, whereas *Smith and Sandwell* [1992] demonstrated that this is not the case, and the effect of sediment thickness variations and isostasy must be considered. N. Baudry may also be working on this subject at the ORSTOM lab in New Caledonia.

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# ANNEX IV

## PROCEDURES FOR UPDATING THE GEBCO DIGITAL ATLAS

(As published in Section 1.7.3 of the GDA Supporting Volume
and modified subsequently by the GEBCO Officers, May 1994)

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.

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.

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.

Adherence to the above principles should ensure that, at any given time, a high quality, seamless global bathymetric chart of GEBCO basic contours can be output from the GDA. In general, it is envisaged that the geographic coverage of newly inserted compilations will normally (but not exclusively) be in excess of a minimum size of 5° by 5°, or its equivalent area. It is anticipated that compilations at the larger scales will include progressively increased numbers of intermediate contours, possibly with intervals as small as 20m at the largest scale. The contour interval will, in general, be governed by the sounding density and the smoothness of the topography. The use of digital techniques will enable seafloor relief to be stored at high resolution where appropriate, without compromising the facility to produce smaller scale seamless charts of the GEBCO basic contours. It is planned that the generalisation of larger scale compilations being input into the GDA will be kept to minimum so as to avoid loss of information.

It is envisaged that updating material for GEBCO will come from one of three sources:

a) IOC Regional Ocean Mapping Projects

As the specifications used by these projects for bathymetric mapping are closely compatible to GEBCO, it is anticipated that they will produce 1:1 million scale updates that can be readily incorporated into the GDA.

b) Other International, National or Laboratory-based Mapping Projects

The compilers of revised bathymetry within these projects are encouraged, where practicable, to follow the GEBCO principles listed above. However, it is expected that some (if not most) of these projects will not adhere to these principles e.g. on the use of corrected metres or basic contour values and intervals. In such cases it will be the responsibility of the GEBCO Guiding Committee to decide whether these compilations should be incorporated and, if so, to find the necessary resources to undertake the conversion of these compilations into a form compatible with the GDA, i.e. there is no commitment by GEBCO and such action will only be taken if resources permit.

c) GEBCO-initiated Compilations of Revised Bathymetry

The GEBCO Guiding Committee has recently established a global Network of Regional Reviewers covering all oceanic areas. Each Reviewer will be required to maintain a continuing review of all new bathymetric data that has become available within his geographic area of responsibility since compilation of the relevant GEBCO Fifth Edition sheets, and to advise the GEBCO Guiding Committee when sufficient new data have been collected to justify a block revision of the contours within a significant part of his area. It will then be the responsibility of the Guiding Committee to find and work with a suitably qualified geoscientist on a new compilation satisfying GEBCO principles which, when complete, can be incorporated into the GDA as a block update.

As in the past, the future resourcing of GEBCO will be dependant on the voluntary contributions of individuals and national agencies. At the present time, the UK Natural Environment Research Council is supporting GEBCO by funding the posts of GEBCO Bathymetric Editor and GEBCO Digital Atlas Manager at the IOS Deacon Laboratory, Wormley, and the British Oceanographic Data Centre, Bidston, respectively.

The GEBCO Bathymetric Editor is responsible for maintaining a supervisory role over the flow of data relevant to GEBCO by searching out new data sources; by liaising with national and international organisations involved in ocean mapping and with academic and agency geoscientists and hydrographic services researching the geomorphology of the world's oceans; by receiving and assessing recommendations from the Regional Reviewers for upgrading the GDA; and by identifying, and subsequently liaising with, compilers for revised blocks of contours. The GEBCO Bathymetric Editor should report annually to the GEBCO Guiding Committee or GEBCO Officers on proposed updates, with supporting evidence.

The GEBCO Digital Atlas Manager is responsible for maintaining and periodically updating the GDA by the integration (and 'stitching in' as necessary) of new blocks of data when supplied through the GEBCO Bathymetric Editor and digitizing incoming material where necessary. It is planned that updated versions of the GDA will be published from time to time as and when significant upgrades have taken place.

When a new block of data has been identified by the Reviewers, the GEBCO Bathymetric Editor will negotiate with the holders (suppliers) regarding provision of data for incorporation into the GDA, and who will 'stitch' it in, i.e. the Supplier, the Reviewer, the GEBCO Bathymetric Editor or the GDA Manager. The GEBCO Bathymetric Editor must ensure that the GEBCO standards are maintained.

For the time being, it is planned that the bathymetry of the world's oceans will be maintained in the GEBCO Digital Atlas in the form of contour vectors, and will be made available to users on CD-ROM. However, it is recognised that there is an increasing requirement, particularly amongst ocean modellers, for it to be made available in the form of a gridded data set and it is intended that such a product will be developed as soon as resources allow.

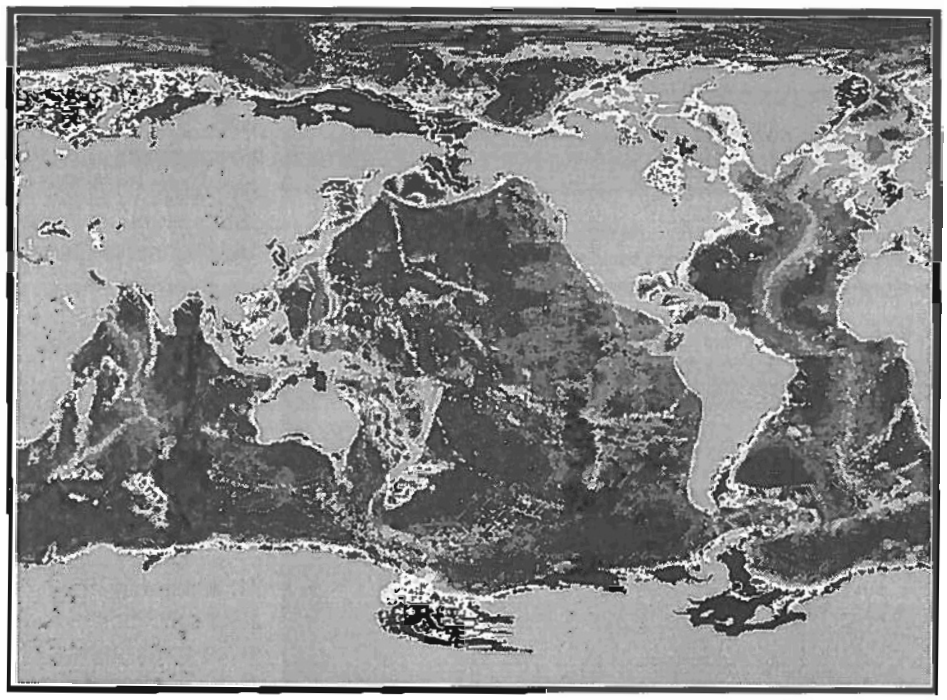
General Bathymetric Chart of the Oceans

# The GEBCO Digital Atlas

**Dr. Meirion T. Jones of the British Oceanographic Data Centre at the NERC Proudman Oceanographic Laboratory, Bidston Observatory, describes the release of the first seamless, high quality, digital bathymetric contour chart of the world's oceans.**

A CD-ROM of the GEBCO Digital Atlas (GDA) has recently been published by BODC on behalf of the Intergovernmental Oceanographic Commission (IOC) of Unesco and the International Hydrographic Organization (IHO). Funding for the work was provided by NERC's Marine and Atmospheric Sciences Directorate.

The General Bathymetric Chart of the Oceans, better known as GEBCO, was initiated at the turn of the century by Prince Albert I of Monaco and the First Edition was published in 1903 as a compilation of the 18,000 depth measurements then available for the world's oceans. Sheets of the succeeding three editions began to reveal the presence of large scale positive relief features, such as parts of the mid-ocean ridge system, but they lacked detail.



*Bathymetry of the world's oceans displayed from the GEBCO Digital Atlas*

Almost up to World War II, all soundings in the deep ocean were discrete wire soundings, and only with the advent of the echo-sounder in the 1940s did sufficient data start becoming available for the compilation of meaningful bathymetric charts. However, even to the present day, the sounding coverage of the world's oceans is very patchy and often concentrated on isolated tracklines with large gaps in between. Very few areas of the deep ocean have been systematically surveyed and a proper scientific understanding of the processes involved in shaping the seafloor is required in order to interpolate the bathymetry between sounding lines.

The Fifth Edition of GEBCO was published by the Canadian Hydrographic Service between 1975 and 1982 with 16 Mercator sheets covering the world from 72°N to 72°S, on a scale of 1:10 million at the equator, and two polar stereographic sheets covering the polar regions to 64°N and 64°S respectively, on a scale of 1:6 million at 75° latitude. Each sheet depicted bathymetric contours at 200m, 500m and at 500m intervals thereafter, with some sheets also including contours at other intermediate depths. Tracklines and outlines of survey boxes were included on the printed sheets to show the coverage of sounding data available when the contours were drawn.

The preparation of the Fifth Edition was a collaborative effort between the IHO and the IOC, with the IHO responsible for coordinating the efforts of the Hydrographic Offices in its Member States and the IOC responsible for attracting eminent

### CONTENTS OF THE CD-ROM

Bathymetric contours, coastlines and trackline control from the GEBCO Fifth Edition published at a scale of 1:10 million.

Bathymetric contours and coastlines from the First Edition of the International Bathymetric Chart of the Mediterranean published at a scale of 1:1 million.

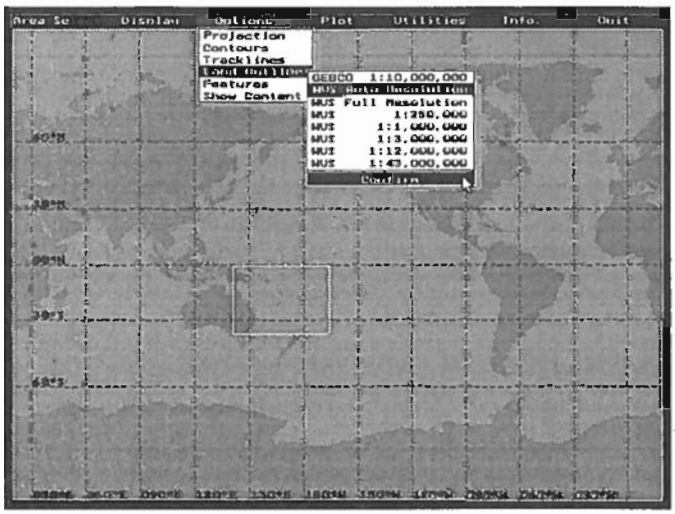
A set of digital global coastlines, based on the US Defense Mapping Agency's World Vector Shoreline, at a range of scales from 1:43 million to 1:250,000.

A trackline inventory of the digital echo-sounding data held at the IHO Data Centre for Digital Bathymetry as of December 1993.

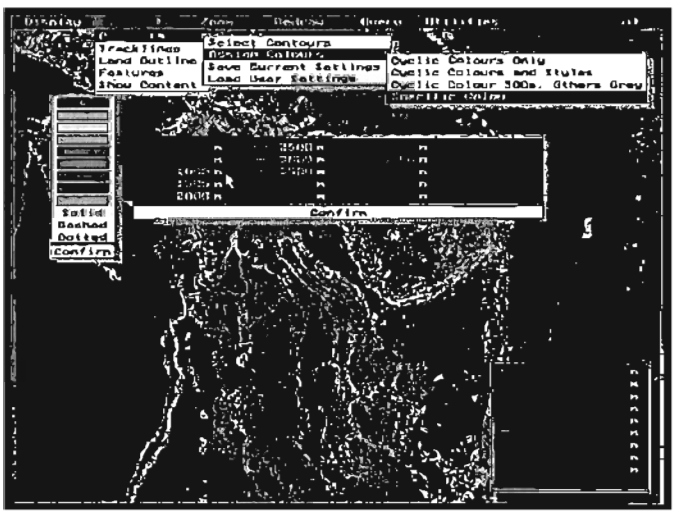
A digital set of geographically referenced feature names including the IHO/IOC Gazetteer of Geographical Names of Undersea Features and a specially prepared list of oceanic islands.

A digital version of the Third Edition of the Echo-Sounding Correction Tables.

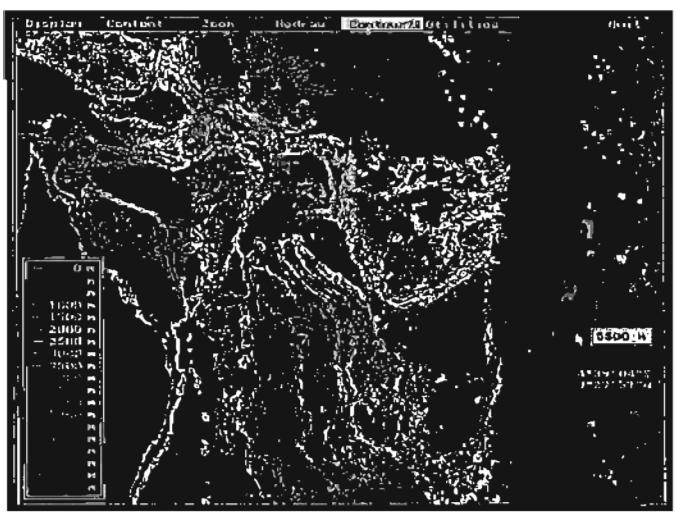
# General Bathymetric Chart of the Oceans




*The Atlas system is user-friendly, with a low learning overhead. It is controlled by pull-down menus and context sensitive help is available at all times. The user's geographic area of interest may be selected using an on-screen zoom box.*




*The user has control over the contours to be displayed and on their colour and line style*




*The geographic coordinates of the cursor are constantly displayed and the depth of any contour may be queried*

marine geologists and geophysicists to collaborate in the work of GEBCO. Supervision of the project was provided by a Joint IOC-IHO Guiding Committee for GEBCO composed of ten members, five nominated by the IHO and five by the IOC. This arrangement continues through to the present day, with the IHO maintaining the international collection of echo-sounding data and the IOC community providing the scientific expertise for contouring these data.

Until recently, the IHO collection of echo-sounding data was maintained on a worldwide series of 655 hard copy 1:1 million scale Collected Soundings sheets. From the mid-1950s onwards, these sheets were maintained by a network of Volunteering Hydrographic Offices, each with their own geographic area of responsibility. However, as data volumes increased, it became increasingly more difficult to keep the sheets regularly updated. To overcome this problem, an IHO Data Centre for Digital Bathymetry (DCDB) was set up in June 1990, co-located with the US National Geophysical Data Center in Boulder and taking advantage of their well developed computerised system for banking underway geophysics data on a global basis. The Collected Soundings sheets are now being phased out and the IHO DCDB database currently holds over 28 million echo-soundings covering 12 million nautical miles of track from over 3600 cruise legs.

In order to establish a digital base for the future updating of GEBCO, and to provide a more flexible product for users, the GEBCO Guiding Committee decided in 1983 that the printed sheets of the Fifth Edition should be digitised. As with other GEBCO activities, funding was a major problem and the provision of resources for the work was dependent on the foresight and goodwill of national agencies, particularly NERC and the French Institut Géographique National. The bulk of the work was carried out by the Bureau Gravimétrique International in Toulouse and by BODC, although invaluable contributions were also made by the NERC Unit for Thematic Information Systems, Reading; the Head Department of Navigation and Oceanography, St. Petersburg; the Alfred-Wegener-Institut, Bremerhaven; and the Japan Oceanographic Data Center, Tokyo.

At each laboratory the digitisation was undertaken by raster scanning stable base transparencies of the master plates of the printed charts. The raster output was converted into vector streams which were then checked, edited and labelled using an interactive graphics terminal. The resulting vectors were converted into geographic coordinates and submitted to BODC for quality control, final editing and reformatting into a uniform data set. All bathymetric contours, coastlines, tracklines and survey boxes shown on the 18 Fifth Edition sheets were converted into digital form. Editing was carried out at BODC to ensure a seamless join across sheet boundaries.

The digitised data from the Fifth Edition have been used to initialise the GEBCO Digital Atlas (GDA), which will

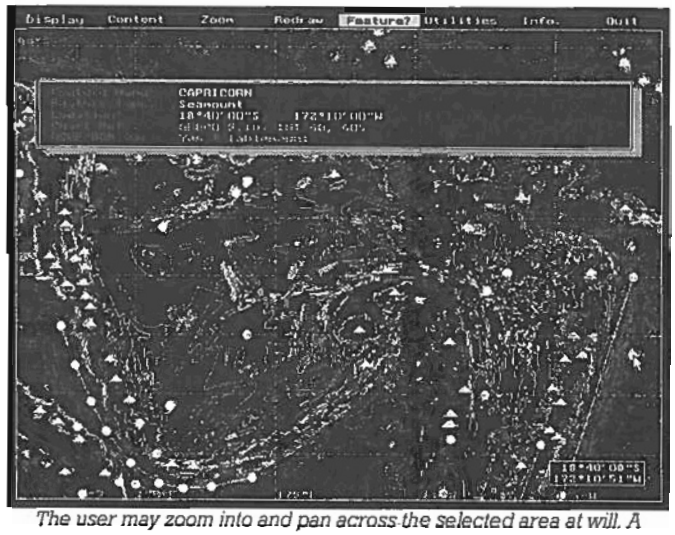
# General Bathymetric Chart of the Oceans

## CD-ROM DISPLAY FEATURES

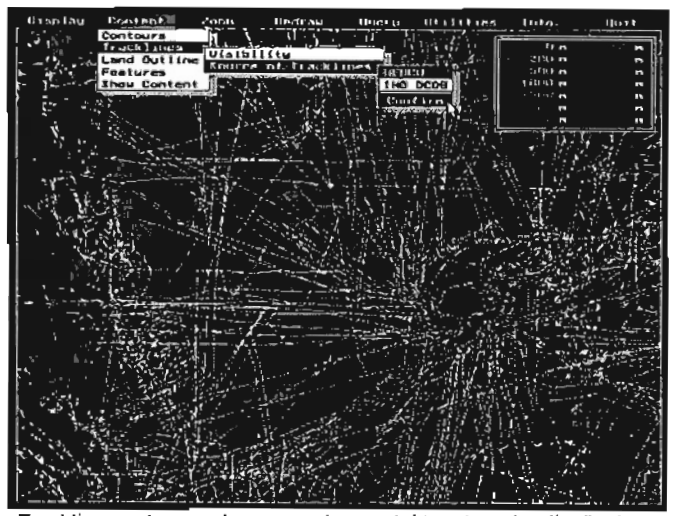
- Choice of GEBCO and IBCM charts
- Choice of GEBCO, IBCM and WVS coastlines
- Choice of resolution for WVS coastline, including an automatic option
- Choice of 5 projections; Equidistant Cylindrical, Mercator, Miller Cylindrical, Lambert Cylindrical Equal-Area and Peters Equal-Area
- Select your geographic area of interest either by chart number, by latitude and longitude limits, or by an on-screen zoom box
- Zoom into and pan across your selected area
- Backtrack and 'where am I?' facilities
- Overlay a geographic grid for reference
- Select/de-select contours and assign depth colours
- Cursor query on contour depths
- Current cursor position constantly displayed in geographic coordinates
- Overlay tracklines and survey boxes from the GEBCO Fifth Edition
- Query survey boxes for source information
- Overlay tracklines showing data held at the IHO Data Centre for Digital Bathymetry
- Display symbols for named undersea features, ports and oceanic islands. Cursor query on symbol will reveal name and supporting documentation
- Copy the current screen display to your printer (IBM or Epson 8-pin, HP Laserjet or HP Paintjet)
- Store the current screen display as a PCX or GEM image for use in desktop publishing or wordprocessing software
- Export selected contours, coastlines and tracklines in vector form into your own files, either in DXF format or as a simple flat ASCII file

form the base from which future printed editions of GEBCO will be generated. The updating of GEBCO through the GDA will be a continual process and the GDA will be published regularly as a product in its own right. Without the scale and projection 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 better, depending on the density of the sounding coverage. New data will be "stitched in" so as to maintain a seamless global data set.

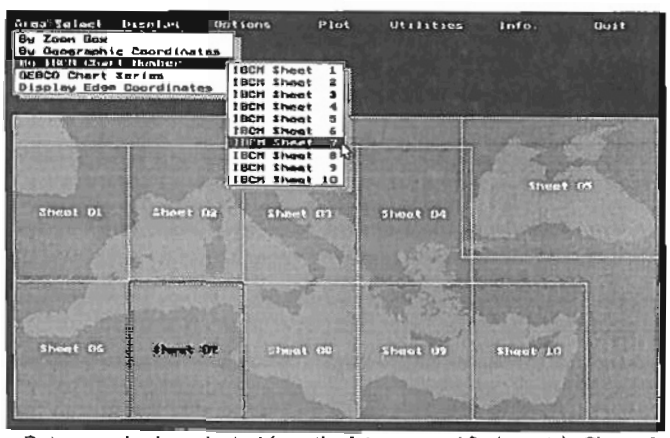
For the future updating of GEBCO, the coastline will be standardised on the US Defense Mapping Agency's World Vector Shoreline (WVS). It was developed as a digital data file, at a nominal scale of 1:250,000, providing global coverage such that 90% of all identifiable shoreline features are located within 500m of their true geographic position with respect to the World Geodetic System (WGS-84)




*The user may zoom into and pan across the selected area at will. A geographic grid provides reference, and symbols indicate the location of named features. A symbol query reveals the feature's name.*




*Tracklines and survey boxes may be overlaid to show the distribution of data used in the compilation of the contours.*




*Data may also be selected from the International Bathymetric Chart of the Mediterranean*

## TO RUN THE DIGITAL ATLAS YOU WILL NEED:

An IBM PC (or compatible) with a VGA colour display, a CD-ROM drive, a 3.5" floppy disk drive and a hard disk with at least one Megabyte of free space in which to install and run the software. The software is designed to run under DOS 3.0 or later, and requires about 500k of free RAM. A mouse (Microsoft compatible) is highly desirable, but not essential.

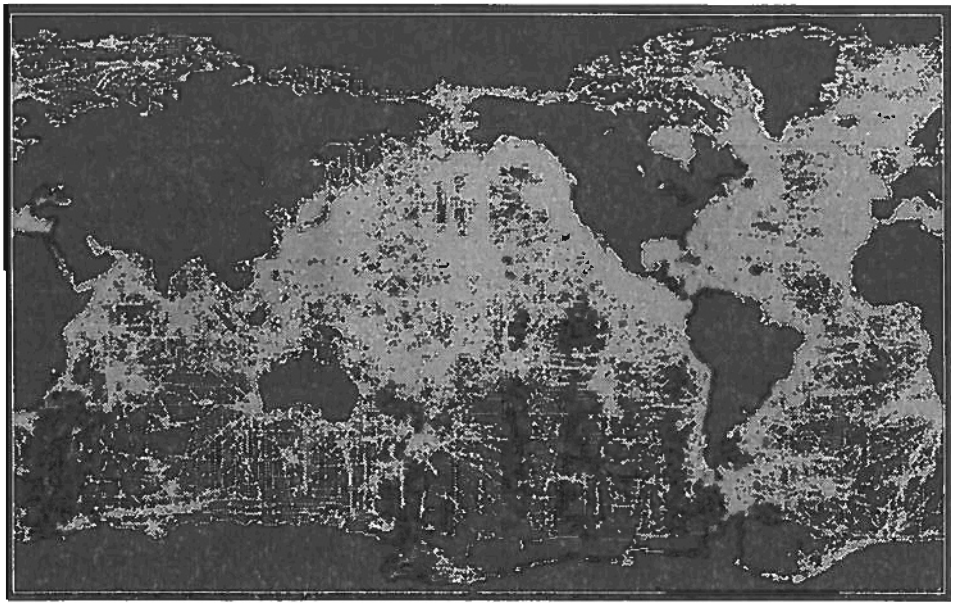
# General Bathymetric Chart of the Oceans

Datum. For the Antarctic region, it is hoped to use the digital coastline recently published by the NERC British Antarctic Survey on behalf of the Scientific Committee on Antarctic Research.

GEBCO has international responsibility in the naming of undersea features falling outside territorial waters, and a digital Gazetteer of Undersea Names is maintained on behalf of GEBCO by the International Hydrographic Bureau in Monaco. As and when the Gazetteer is updated, a copy is sent to the BODC for use within the GDA.

The updating of GEBCO through the GDA has already started. While the Fifth Edition was being digitised, the Guiding Committee decided to completely revise the bathymetry of the South Atlantic down to 50°S. The revised contouring was carried out by scientists in the USA, Russia, New Zealand and the UK. Their hand drawn contours and tracklines were then submitted to BODC for digitising and for compiling into a single seamless sheet edge matched to the existing Fifth Edition bathymetry but at a scale of 1:5 million.

A global network of GEBCO Regional Reviewers has been set up to advise on the need for updating GEBCO in the various regions and the post of GEBCO Bathymetric Editor has been created at the NERC IOS Deacon Laboratory to coordinate this work and to feed updated bathymetric compilations to BODC for incorporating into the GDA. The IOC Regional Ocean Mapping Projects will be an important source of new material and the digitised contours and coast-lines from the International Bathymetric Chart of the Mediterranean (IBCM) have already been included in the GDA . A major revision of the bathymetry of the Indian Ocean is currently being compiled at the Scripps Institution of Oceanography, La Jolla, and work is underway at BODC in digitising this material.



*Distribution of sounding data held at the IHO Data Centre for Digital Bathymetry. Note the sparse coverage of the Southern Hemisphere. Even in the North Atlantic, trackline separation is typically of the order of 30km and up to 300km in places.*

It is salutary to note that, whereas high resolution topographic maps have already been produced for the moon, Mars and Venus, the mapping of the world's oceans will continue well into the foreseeable future. There is a growing need for improved global bathymetry, particularly amongst modellers studying the role of the oceans in the climate system and sea floor bathymetry has been recognized as an essential component for the Global Ocean Observing System (GOOS). Recent satellite altimetry missions have, of course, provided invaluable insights into the nature of the topography in waters uncharted by modern echo-sounders. However, the detailed mapping of the sea floor will continue to depend on a small band of scientists across the world who are prepared to apply their skills to the interpretation of random tracklines of data from a multitude of sources and with highly variable data quality and coverage. It is of paramount importance that future research cruises should aim wherever possible to traverse the gaps in the coverage and to make their soundings available to the IHO Data Centre. In the meantime, it is hoped that this first release of the GDA will be the forerunner of a series of products each delivering progressively improved bathymetric maps of the world's oceans.

# ANNEX VI

## 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

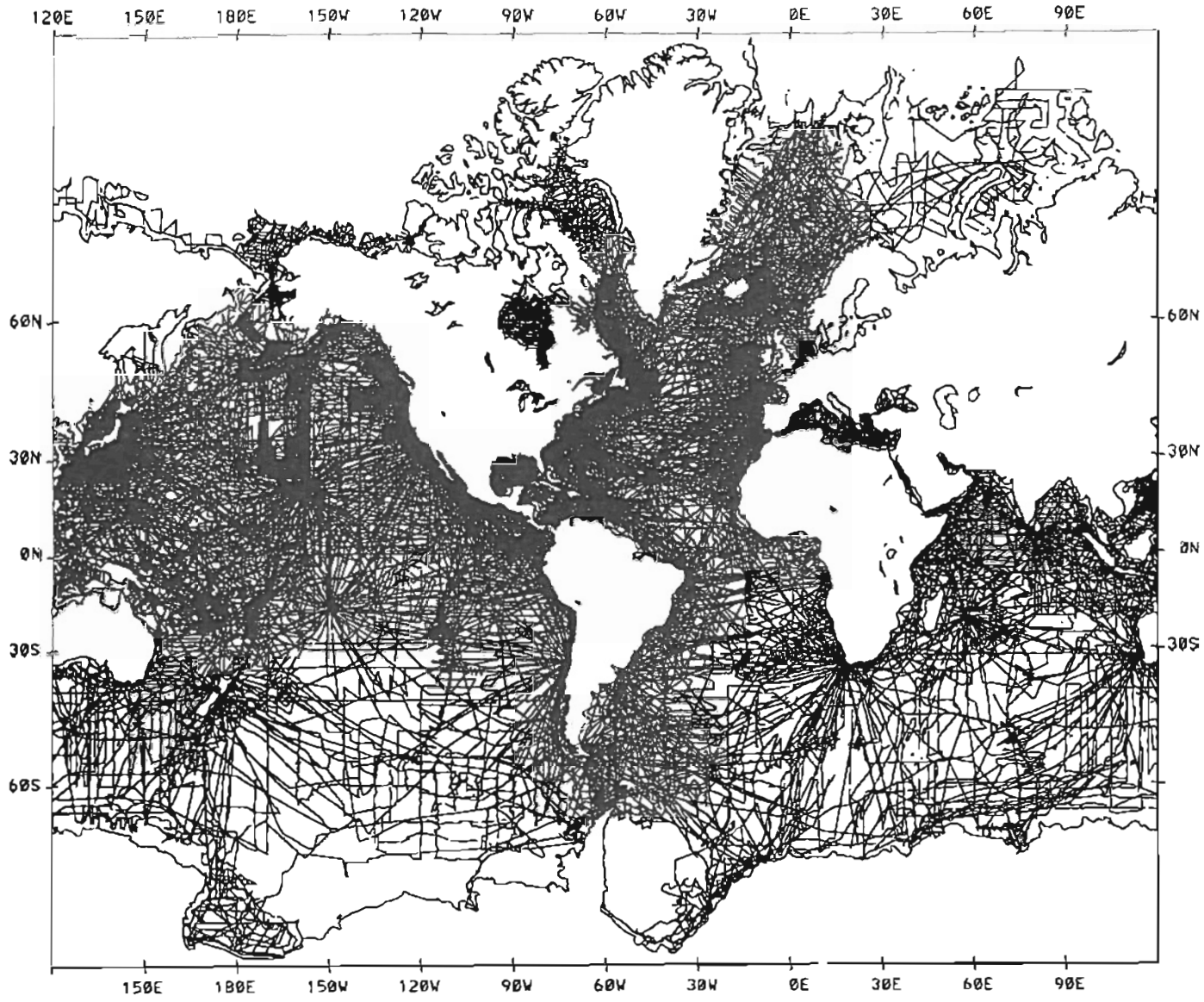
| SOURCE | NO. OF CRUISES /LEGS | TRACKLINE IN NAUTICAL MILES | | | | NO OF BATHYMETRIC SOUNDINGS |
|---|---|---|---|---|---|---|
| | | TOTAL | BATHYMETRY | MAGNETICS | GRAVITY | |
| Lamont (LDGO) | 588 | 2469994 | 2363288 | 2033796 | 1809589 | 4388486 |
| Woods Hole O.I. | 149 | 549001 | 532787 | 341932 | 302413 | 991977 |
| NOAA | 349 | 884567 | 876399 | 550600 | 341990 | 2005308 |
| US Geol. Survey | 188 | 365930 | 275052 | 172849 | 164623 | 1889009 |
| Oregon St. Univ. | 70 | 175745 | 166195 | 125886 | 115550 | 251092 |
| Hawaii Inst. Geo. | 208 | 746137 | 712643 | 408973 | 445516 | 1888021 |
| US Navy | 201 | 908522 | 877389 | 364500 | 35390 | 2898849 |
| Univ. of Texas | 78 | 138647 | 116796 | 90384 | 0 | 218700 |
| Rice Univ. | 2 | 7681 | 7681 | 0 | 0 | 3558 |
| Univ. of Conn. | 4 | 4533 | 3893 | 0 | 4533 | 2183 |
| Scripps Inst. Oc. | 545 | 2143744 | 1967383 | 1483633 | 166631 | 4328602 |
| U Rhode Island | 25 | 62376 | 61272 | 7164 | 0 | 385677 |
| U Washington | 16 | 36813 | 36660 | 0 | 0 | 160769 |
| Texas A & M Univ. | 48 | 129802 | 98032 | 87959 | 0 | 154786 |
| Defense Map. Ag. | 84 | 358757 | 357634 | 0 | 0 | 677751 |
| Min. Manag. Serv. | 7 | 43168 | 43168 | 0 | 0 | 402174 |
| NEW ZEALAND | 15 | 27388 | 26344 | 21258 | 17306 | 20219 |
| CANADA | 150 | 636570 | 619572 | 18488 | 1173 | 609842 |
| CHINA | 4 | 23987 | 23852 | 0 | 23983 | 10108 |
| UNITED KINGDOM | 192 | 356042 | 339607 | 138089 | 141387 | 548865 |
| AUSTRALIA | 4 | 31564 | 22927 | 26748 | 9242 | 157134 |
| USSR | 31 | 254687 | 219543 | 0 | 248130 | 97941 |
| NETHERLANDS | 7 | 29705 | 26755 | 7366 | 9755 | 149230 |
| FRANCE | 215 | 581251 | 517157 | 377573 | 272639 | 2932918 |
| SOUTH AFRICA | 19 | 61100 | 54014 | 49964 | 0 | 75930 |
| BRAZIL | 7 | 32195 | 32195 | 0 | 0 | 131418 |
| INT. GRAV. BUR. | 9 | 59843 | 59072 | 0 | 0 | 29727 |
| GERMANY | 33 | 143435 | 142921 | 0 | 0 | 1376548 |
| ORSTOM NEW CAL. | 22 | 65027 | 63009 | 51005 | 28449 | 89765 |
| CUBA | 5 | 33092 | 33092 | 0 | 0 | 14951 |
| ARGENTINA | 2 | 769 | 769 | 0 | 0 | 206 |
| HYDR. DEPT. JAPAN | 81 | 270671 | 268795 | 200321 | 258426 | 273402 |
| GEOL. SRVY. JAPAN | 26 | 167374 | 145059 | 139062 | 165795 | 161174 |
| UNIV. TOYKO | 45 | 308029 | 301928 | 156207 | 199850 | 234565 |
| KOBE UNIV. | 11 | 13442 | 9583 | 13412 | 0 | 10390 |
| UNIV. OF RYUKYUS | 3 | 2931 | 1809 | 588 | 0 | 897 |
| J.O.D.C. JAPAN | 20 | 117487 | 116300 | 0 | 0 | 78743 |
| CHIBA UNIV. | 4 | 9324 | 7894 | 5505 | 0 | 33631 |
| GRAND TOTAL | 3467 | 12251330 | 11528469 | 6873262 | 4822202 | 27684546 |

**DATA BANKED BETWEEN 1 APRIL 1992 AND 27 APRIL 1993**

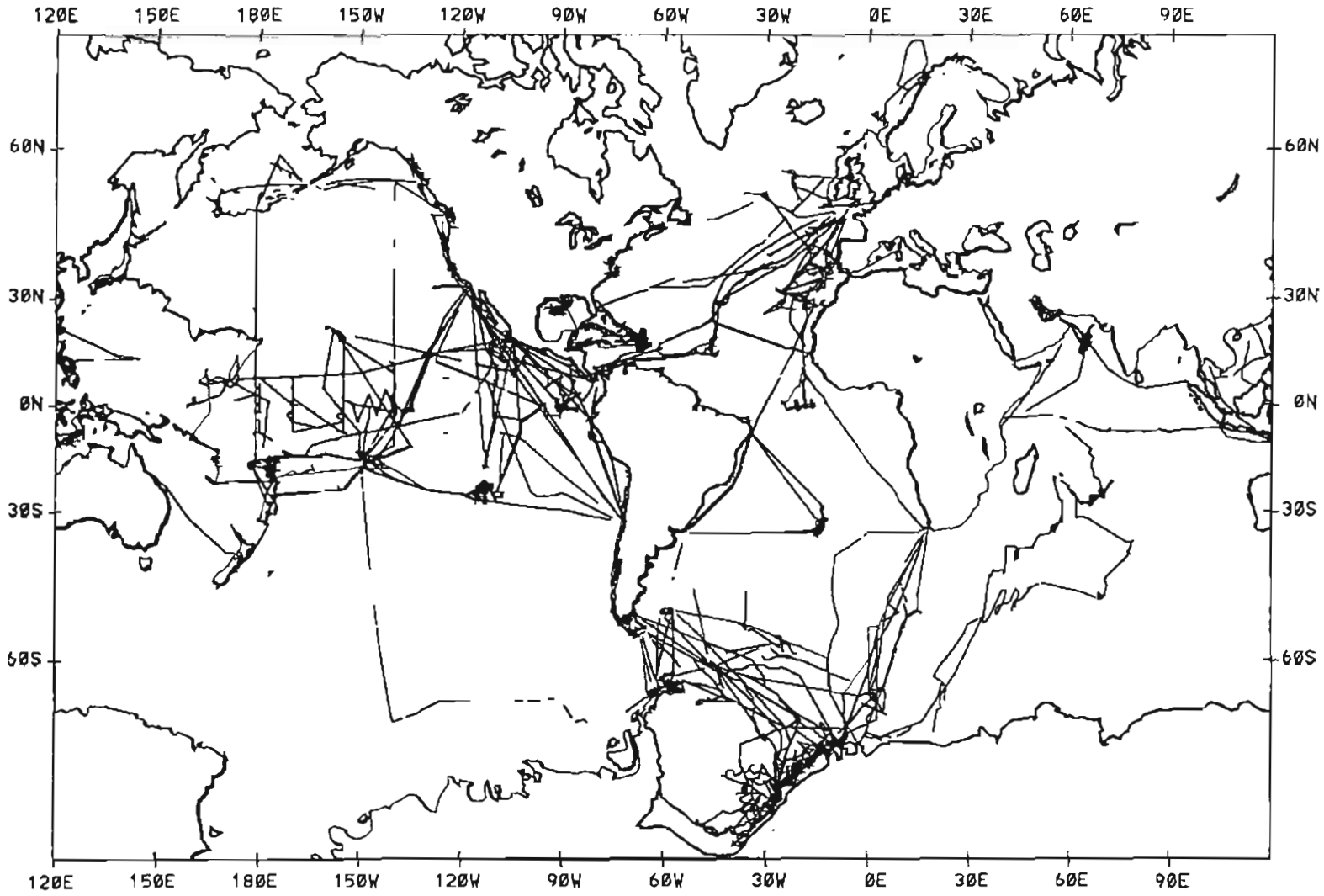
| SOURCE | NO. OF CRUISES /LEGS | TRACKLINE IN NAUTICAL MILES | | | | NO. OF BATHYMETRIC SOUNDINGS |
|---|---|---|---|---|---|---|
| | | TOTAL | BATHYMETRY | MAGNETICS | GRAVITY | |
| Lamont (LDGO) | 1 | 2491 | 2476 | 0 | 0 | 21616 |
| Woods Hole O.I. | 2 | 8753 | 8753 | 0 | 0 | 52478 |
| NOAA | 98 | 79081 | 79081 | 0 | 0 | 376664 |
| Hawaii Inst. Geo. | 10 | 30822 | 29488 | 0 | 2888 | 146563 |
| U.S. Navy | 2 | 6332 | 6332 | 0 | 0 | 9375 |
| Univ. of Texas | 29 | 54063 | 43299 | 36772 | 0 | 78713 |
| Scripps Inst. Oc. | 12 | 53422 | 50434 | 1611 | 0 | 263572 |
| Texas A & M Univ. | 4 | 14015 | 13547 | 13276 | 0 | 16581 |
| UNITED KINGDOM | 67 | 70566 | 70566 | 0 | 0 | 46714 |
| AUSTRALIA | 1 | 1665 | 1665 | 0 | 0 | 6313 |
| RUSSIA | 11 | 57242 | 51430 | 0 | 57242 | 30806 |
| NETHERLANDS | 2 | 6460 | 5786 | 1589 | 0 | 36151 |
| FRANCE | 55 | 182762 | 149290 | 125586 | 122188 | 933489 |
| CUBA | 5 | 33092 | 33092 | 0 | 0 | 14949 |
| HYDR. DEPT. JAPAN | 20 | 53408 | 53018 | 15796 | 48683 | 109482 |
| GEOL. SRVY. JAPAN | 7 | 38268 | 37569 | 33350 | 37373 | 38945 |
| UNIV. OF RYUKYUS | 3 | 2931 | 1808 | 588 | 0 | 896 |
| J.O.D.C. JAPAN | 1 | 8012 | 6996 | 0 | 0 | 36019 |
| CHIBA UNIV. | 4 | 9325 | 7894 | 5505 | 0 | 33626 |
| GRAND TOTAL | 334 | 712710 | 652524 | 234073 | 268374 | 2252952 |

**DATA BANKED BETWEEN 28 APRIL 1993 AND 4 MAY 1994**

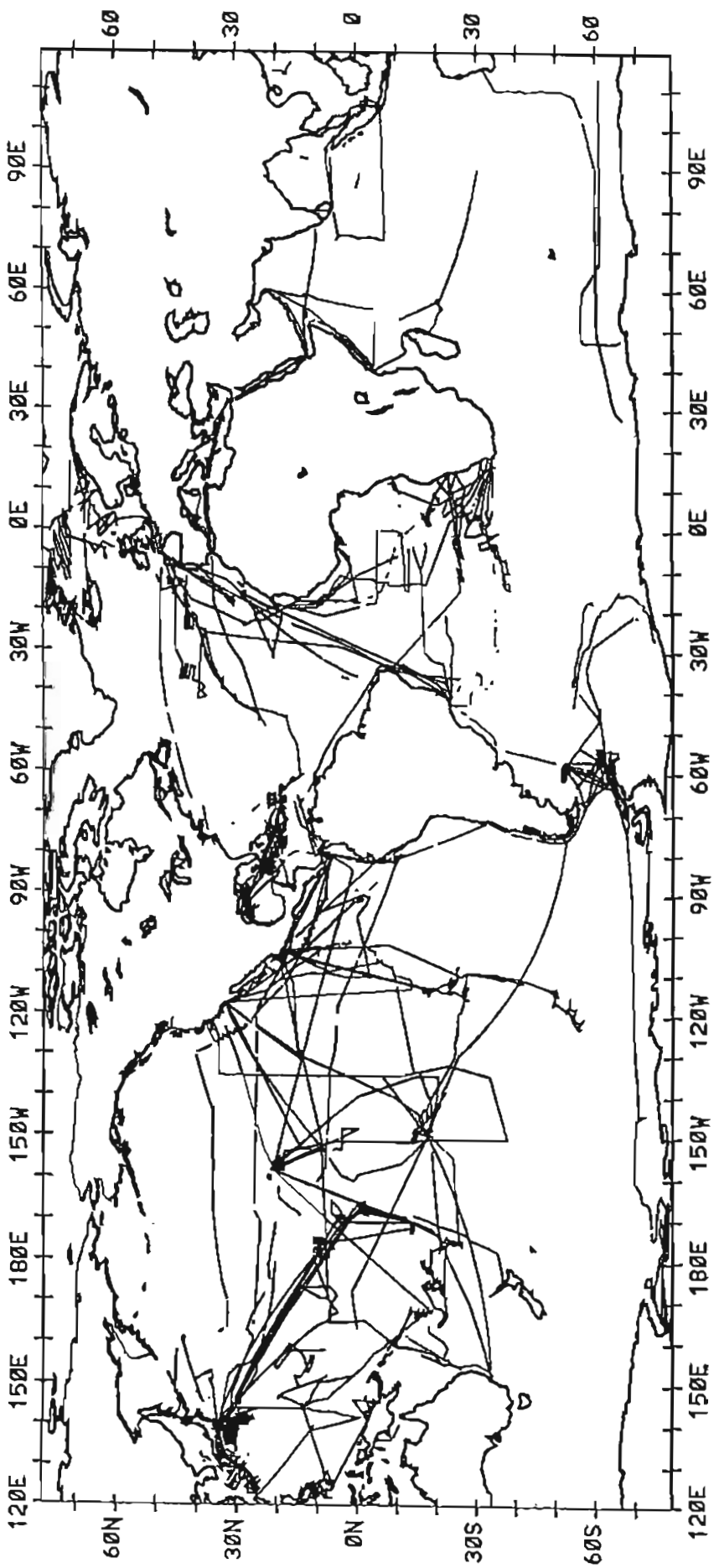
| SOURCE | NO. OF CRUISES /LEGS | TRACKLINE IN NAUTICAL MILES | | | | NO. OF BATHYMETRIC SOUNDINGS |
|---|---|---|---|---|---|---|
| | | TOTAL | BATHYMETRY | MAGNETICS | GRAVITY | |
| Lamont (LDGO) | 3 | 21958 | 7507 | 0 | 0 | 40695 |
| NOAA | 168 | 212572 | 212500 | 0 | 0 | 979456 |
| US Geol. Survey | 1 | 5316 | 5233 | 5080 | 0 | 19557 |
| Hawaii Inst. Geo. | 4 | 20609 | 19916 | 10452 | 20354 | 95174 |
| Scripps Inst. Oc. | 23 | 108158 | 99801 | 82921 | 51472 | 652851 |
| U. Washington | 7 | 23950 | 23796 | 0 | 0 | 126465 |
| Texas A & M Univ. | 4 | 16843 | 14490 | 13548 | 0 | 15393 |
| UNITED KINGDOM | 85 | 149435 | 142421 | 46724 | 50039 | 223557 |
| FRANCE | 29 | 116310 | 105107 | 87900 | 80846 | 630446 |
| SOUTH AFRICA | 1 | 8095 | 8094 | 0 | 0 | 19473 |
| GERMANY | 6 | 58930 | 58416 | 0 | 0 | 1327498 |
| ARGENTINA | 2 | 770 | 770 | 0 | 0 | 206 |
| GRAND TOTAL | 333 | 742946 | 698052 | 246626 | 202712 | 4130771 |



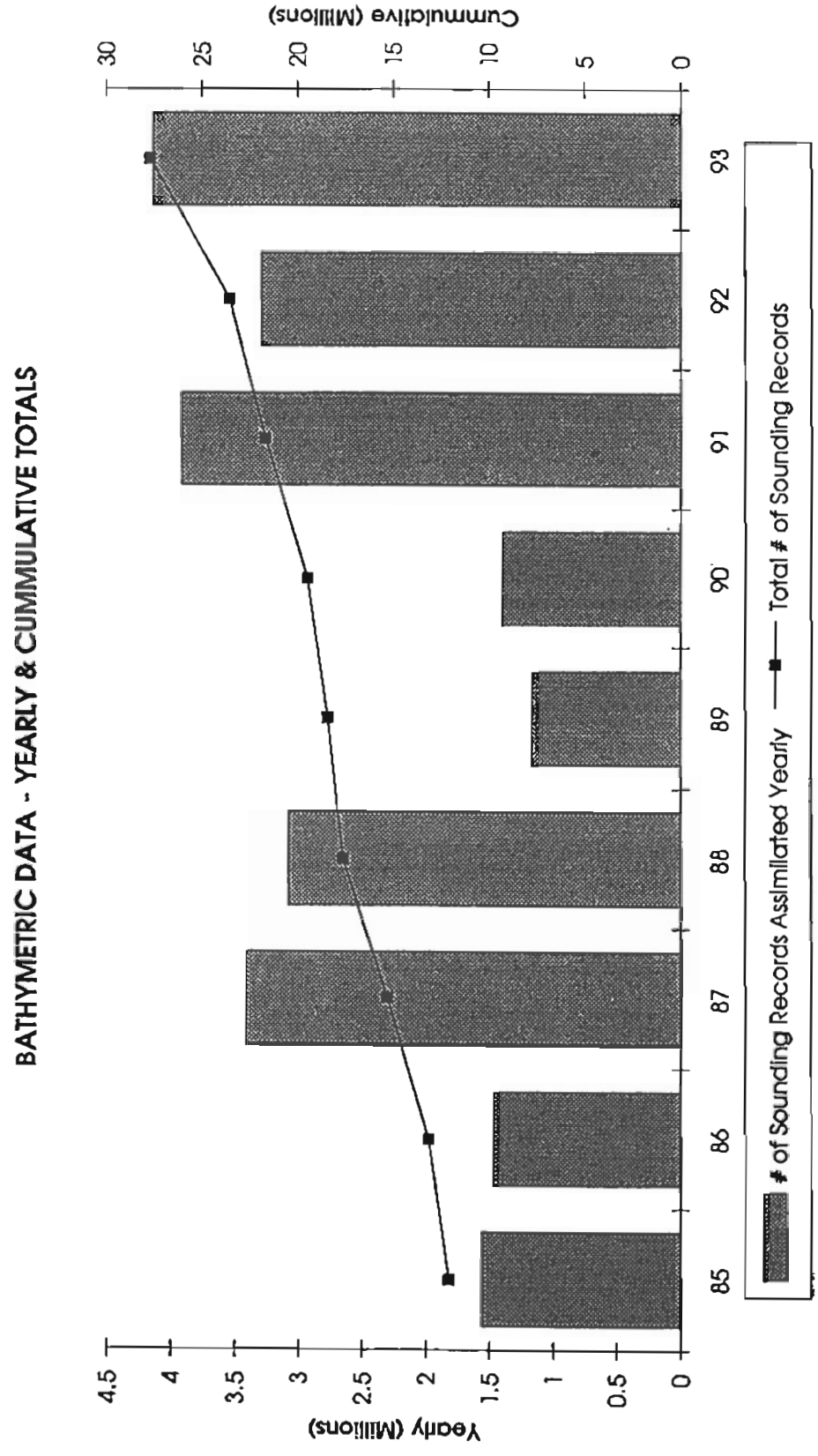

Trackline plot of total holdings of digital bathymetric data in the
NGDC Global Marine Geophysical Data Base (GEODAS) - 20 May 1994




Trackline plot of bathymetric data assimilated into the NGDC Global Marine Geophysical Data Base (GEODAS) from 29 April 1993 to 20 May 1994




Trackline plot of bathymetric data assimilated into the NGDC Global
Marine Geophysical Data Base (GEODAS) from 1 April 1992 to 27 April 1993


BATHYMETRIC DATA - YEARLY & CUMMULATIVE TOTALS
Yearly (Millions)
Cummulative (Millions)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
0
5
10
15
20
25
30
85
86
87
88
89
90
91
92
93
# of Sounding Records Assimilated Yearly
Total # of Sounding Records

# ANNEX VII

## LIST OF SHIPS EQUIPPED WITH MULTIBEAM SYSTEMS

(NRL list of 20 May 1994)

| SHIP NAME | OPERATOR | | SYSTEM |
|---|---|---|---|
| **USA-OPERATED** | | | |
| US-NAVY (USN/MSC) | | | |
| USNS Bowditch (TAGS-62) | NAVOCEANO | (insvc '96) | SIMRAD EM121A |
| USNS Silas Bent | NAVOCEANO | (ret '99) | SEABEAM |
| 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 Pathfinder (TAGS-60) | NAVOCEANO | (insvc '94) | SIMRAD EM121A(awd) |
| USNS Sumner (TAGS-61) | NAVOCEANO | (insvc '95) | 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) | BOTASS |
| USNS Zeus (T-ARC-7) | NAVOCEANO | (ret '97) | SIMRAD EM121-(fall 93) |
| R/V Laney Chouest | COMSUBDEVGRU 1 | | SEABEAM |
| RESEARCH INSTITUTIONS | | | |
| Atlantis II | Woods Hole | | SEABEAM |
| Robert Conrad | Lamont-Doherty | (ret '89) | SEABEAM |
| Maurice Ewing | Lamont-Doherty | | HYDROSWEEP |
| Ka'imikai o Kaniloa | Univ. Hawaii | | SEABEAM |
| Melville | Scripps | | SEABEAM 2000 |
| Nathaniel Palmer (ICEBRKR) | NSF/Edison Chouest | | SEABEAM 2100 |
| Moana Wave | Univ. Hawaii | | SEAMARC II |
| Thomas Thompson (AGOR-23) | Univ. Wash. | | HYDROSWEEP |
| Thomas Washington | Scripps | (ret '92) | SEABEAM (transferred to Chile) |
| NOAA/NOS (USC&GS) | | | |
| NOAAS Davidson | NOAA/NOS | | $BS^3$ Installed, HYDROCHART II (upgrade plan) |
| NOAAS Discoverer | NOAA/NOS | | SEABEAM |
| NOAAS Mt Mitchell | NOAA/NOS | | SEABEAM |
| NOAAS Surveyor | NOAA/NOS | | SEABEAM |
| NOAAS Whiting | NOAA/NOS | | HYDROCHART II |
| COMMERCIAL VENTURES | | | |
| Inland Surveyor (Portable) | C&C Technologies | | SIMRAD EM-950 |
| NATO: | | | |
| Alliance | SACLANTCEN La Spezia | | HYDROSWEEP |

## NON-UNITED STATES-CONTROLLED MULTIBEAM VESSELS

| | | |
|---|---|---|
| AUSTRALIA: | | |
| HMAS Cook (Decomm?) | Australian Navy | SEABEAM |
| CANADA: | | |
| Frederick G. Creed | Canadian Hydro | SIMRAD EM-1000 |
| Dolphin (ROBV) | Canadian Hydro | SIMRAD EM-1000 |
| Jean Charcot (Ex-France) | LD CANOCEAN | SIMRAD EM-100 |
| Matthew | Canadian Hydro | SIMRAD EM-100 |
| Smith (Swath/Sweep System) | Canadian Hydro | NAVITRONICS(210 kHz) |
| FRANCE: | | |
| L'Atalante | IFREMER | SIMRAD EM-12 (Dual) |
| Borda | EPSHOM | THOMPSON CSF |
| L'Esperance | EPSHOM | SIMRAD EM-12 (Dual) |
| | IFREMER | SIMRAD EM-1000 (Portable) |
| GERMANY: | | |
| Meteor | DFG/BMFT | HYDROSWEEP DS |
| Polarstern | AWI | HYDROSWEEP DS |
| Sonne | BMFT/RF | HYDROSWEEP DS |
| Vega | BSH/Univ. Hamburg | HYDROSWEEP MD |
| INDIA: | | |
| Sagar Kanya | NIO | HYDROSWEEP DS |
| ITALY: | | |
| Magnagni | Italian Hydrogr. Off. | Bottom Chart |
| Ravello | DIAMAR | SIMRAD EM-1000 |
| JAPAN: | | |
| Fukae-Maru | Kobe Univ.-MMA | FURUNO HS-10 |
| Hakuho Maru | Univ. Tokyo | SEABEAM |
| Hakurei Maru II | MMA/DORD | HYDROSWEEP |
| Iwate-Maru | Iwate Pref. | FURUNO HS-200/II |
| Kaiyo (Swath Hull) | JAMSTEC | SEABEAM |
| Kaiyo | JMSA HD | SEABEAM 2000 (10/93) |
| Meiyo | JMSA HD | SEABEAM 2000 |
| Miyako | Tokyo Met/Fish Exp. | FURUNO HS-100 |
| Myojin-Maru No. 8 | Fisheries Agcy. | FURUNO HS-100 |
| Nojima | JMSA | FURUNO HS-100 |
| Ojika | JMSA | FURUNO HS-200/II |
| Oyashio | Hokkaido Pref. | FURUNO HS-200/II |
| Rishiri | JMSA | FURUNO HS-100 |
| Tajima | Hyogo Pref. Fish Exp. | FURUNO HS-100 |
| Takuyo | JMSA HD | SEABEAM |
| Taneichi-Maru | Taneichi Hi. Sch. | FURUNO HS-500 |
| Tenyo | JMSA HD | HYDROCHART II |
| Yokosuka | JAMSTEC | FURUNO HS-10 |
| Yosyu | Ehime Pref. | FURUNO HS-100 |
| KOREA: | | |
| Onnuri | KORDI | SEABEAM 2000 |

| | | |
|---|---|---|
| NETHERLANDS: | | |
| Blommendal | Navy Hydro Dept | BATHYSCAN 300 |
| Chr. Brunings | Rijkswaterstaat | SIMRAD EM-100 |
| Burskyes | Navy Hydro Dept | BATHYSCAN 300 |
| Rocky Giant | Van Oord (fallpipe) | SEABAT 9001 |
| Trollnes | Van Oord (fallpipe) | SEABAT 9001 |
| Wijtvleit | Rijkswaterstaat | SIMRAD 950 (Awarded) |
| NORWAY: | | |
| Bergen Surveyor | Stolt-Bielsen Norway | SIMRAD EM-100 |
| Div. "U" | Forsvarets Forsk. Inst. | SIMRAD EM-100 |
| Geograph | A/S Geoconsult | SIMRAD EM-1000 |
| Geofjord | Norw. Hydro | SIMRAD EM-100 |
| Geomaster | A/S Geoconsult | SIMRAD EM-1000 |
| Ice King | K/S A/S Ice King | SIMRAD EM-100 |
| Lance | Norwegian Hydrogr. Off. | SIMRAD EM-100 |
| North Sea Surveyor | Stolt-Nielsen | SIMRAD EM-100 |
| Odin-Finder | Forsvarets Forsk. Inst. | SIMRAD EM-100 |
| Simrad | Simrad Subsea | SIMRAD EM-1000 |
| Simson Echo | Simrad Subsea | SIMRAD EM-100 |
| RUSSIA: | | |
| Akad. Boris Petrov. | Akad.Sci.Russia | HOLLMING EKHOS II |
| Akad. Ioffe | Akad.Sci.Russia | HOLLMING EKHOS XD |
| Peter Kottsov | Russian Hydrogr. Off. | SIMRAD EM-100 |
| Akad. M.A. Lavrentyev | Akad.Sci.Russia | HOLLMING EKHOS II |
| R/V Dmitry Mendeleev | Acad.Sci.Russia | HOLLMING EKHOS MD |
| Akad. Nikolay Strakhov | Akad.Sci.Russia | HOLLMING EKHOS II |
| Akad. Sergei Vavilov | Akad.Sci.Russia | HOLLMING EKHOS XD |
| R/V Gelendzhik | ???????????????? | Russian Built Sys. Navy Design-Due '94 |
| SAUDI ARABIA: | | |
| Karan 8 | ARAMCO | SIMRAD EM-1000 |
| SPAIN: | | |
| Hesperides | Consejo Superior de Investigaciones Ceintif. | SIMRAD EM-1000/12 |
| 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 Surveying Ltd. | SIMRAD EM-100/12 |

# ANNEX VIII

## LIST OF PARTICIPANTS

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# ANNEX IX

## 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 |
| ANTOSTRAT | Antarctic Offshore Acoustic Stratigraphy Project |
| AWI | Alfred-Wegener-Institut fur Polar- und Meeresforschung |
| BAS | British Antarctic Survey |
| BODC | British Oceanographic Data Centre |
| CAP | Circum-Atlantic Project (of IUGS) |
| CD-ROM | Compact Disc - Read Only Memory |
| CEDD | Committee on Exchange of Digital Data (of IHO) |
| CHS | Canadian Hydrographic Service |
| COE | Committee on ECDIS (IHO) |
| COMNAP | Council of Managers of National Antarctic Programmes |
| DBDB5 | Digital Bathymetric Data Base (5 minute grid) of USNOO |
| DBDBV | Digital Bathymetric Data Base (variable grid) of USNOO |
| DCDB | Data Centre for Digital Bathymetry (IHO - at NGDC, Boulder) |
| DEM | Digital Elevation Model |
| DGPS | Differential GPS |
| DMA | US Defense Mapping Agency |
| DMAHTC | DMA Hydrographic/Topographic Center |
| DNAG | Decade of North Atlantic Geology |
| DTM | Digital Terrain Model |
| EC | European Community |
| ECDIS | Electronic Chart Display and Information System (of IHO) |
| EEZ | Exclusive Economic Zone |
| ETOPO5 | Earth Topography on a 5 minute grid (NGDC) |
| GDA | GEBCO Digital Atlas |
| GEBCO | General Bathymetric Chart of the Oceans (IOC/IHO) |
| GEODAS | Global marine geophysical database (NGDC) |
| GF3 | General Format-3 (of IOC) |
| GIS | Geographic Information System |
| GMT | Gravity, Magnetics and Topography software system (P. Wessel and W.H.F. Smith) |
| GPS | Global Positioning System |
| GSA | Geological Society of America |
| GSF | Generic Sensor Format (of US DMA) |
| HDNO | Head Department of Navigation and Oceanography, St. Petersburg |
| 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 |
| IBCWIO | International Bathymetric Chart of the Western Indian Ocean (IOC) |
| IBCWP | International Bathymetric Chart of the Western Pacific (IBCWP) |
| 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 |
| JODC | Japan Oceanographic Data Center |
| MEDINTCHART | MEDiterranean INTernational Chart |
| MGD77 | Magnetics, Gravity and Depth Format 1977 (NGDC) |
| 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) |
| NUTIS | NERC Unit for Thematic Information Systems |
| OMEX | Ocean Margin Exchange Project (of the EC) |
| OMG | Ocean Mapping Group (University of New Brunswick, Canada) |
| RAN | Royal Australian Navy |
| S-57 | IHO Transfer Standard for Digital Hydrographic Data |
| SAR | Synthetic Aperture Radar |
| SCALOP | Standing Committee on Antarctica Logistics and Operations |
| 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) |
| SOPAC | South Pacific Applied Geoscience Commission |
| USGS | US Geological Survey |
| USNOO | US Naval Oceanographic Office |
| VHOs | Volunteering Hydrographic Offices (IHO) |
| WESTPAC | Western Pacific regional programme of the IOC |
| WGS-84 | World Geodetic System 1984 |
| WVS | World Vector Shoreline (DMA) |