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Chairman of WG 34

The group has recently become aware of proposals being developed in the United States of America for an International Southern Ocean Dynamics Experiment. Whilst the details of such a proposal are not yet available, it is apparent that such a project would provide a much needed stimulus for furthering the understanding of circum-Antarctic oceanic processes and will deserve the fullest possible international support and collaboration.

If these proposals become available before the proposed meeting of WG 38 in late 1973, the group will examine them carefully, together with the earlier USSR collaborative proposal, to see what useful contribution the supply ships could make to achieve the stated goals.

ANNEX VI

REPORT OF SCOR WG 41

Morphological Mapping of the Ocean Floor

The second meeting of SCOR WG 41 was held at the National Institute of Oceanography, UK on 2 and 3 April 1973.

The following members of SCOR WG 41 were present: J. Ulrich (Chairman, FRG), A. S. Laughton (Acting Chairman, UK), R. L. Fisher (USA), J. W. Brodie (NZ), Commodore D. C. Kapoor (IHO), D. Newson (UK) and T. Sato (Japan). Apologies for absence were received from E. Uchupi (USA), A. V. Ilyin (USSR) and V. Kanaev (USSR).

The following observers were present: Lt Cdr D. P. D. Scott (IOC), F. W. G. Baker (GEBCO and ICSU), A. J. Kerr (ICA Working Group on Oceanic Cartography), A. Ferrero (IHO), D. P. Bickmore (Experimental Cartography Unit, UK), D. G. Roberts (Acting Secretary, NIO), Mrs G. Kredel (IFM, FRG).

The Chairman, Dr Ulrich, after a few introductory remarks, requested that Dr Laughton take the chair for this meeting.

1. The minutes of the first meeting of WG 41 in Montreal in August 1972 were accepted, and subsequent activity in the field was reported by the Acting Chairman.

Written and verbal reports on the ICA Symposium on Marine Cartography held in Ottawa in August 1972 were given by Mr Newson and Dr Fisher who attended on behalf of SCOR WG 41, and by Mr Kerr, the newly appointed Chairman of the ICA WG on Oceanic Cartography (formerly Marine Cartography). The status and activities of the ICA WG are reported later, but at Ottawa close links were established between SCOR and ICA WGs with some dual membership. The ICA WG meeting was planned to take place in London on 5 and 6 April so that observers could attend both meetings.

The Acting Chairman reported on the activities of SCOR WG 41 at the 11th

General Meeting of SCOR in Oban in September 1972, when the revised terms of reference were accepted and when WG 41 were asked to give particular attention to the value of continuing the GEBCO 1:10 million series.

2. Critical review of existing bathymetric charts of the oceans

At the WG meeting a selection of bathymetric charts were displayed, parts of which had been copied and circulated in advance to members together with a list of chart details. The charts were divided into three groups by scale:-

- (a) 1:12 to 1:6 million
- (b) 1:5 to 1:2 million
- (c) 1:1 million to 400 thousand.

A series of questions about these charts were circulated to members and written analyses were received from Dr Kanaev (USSR), Dr Ilyin (USSR), Mr Sato (Japan) and Mr Newson (UK). Copies of these replies were tabled at the meeting. Additional charts were also received and displayed, from Mr Sato (Japan) and Dr Fisher (USA). Details of the Japanese charts were also tabled.

These chart groups were reviewed in order of increasing scale.

(a) Scales from 1:12 to 6 million

There was general agreement that there was a need for a world bathymetric chart at the scale of about 1:10 million, but that none of the charts displayed fulfilled this need. Users can be divided into (a) scientists who need a world chart to look for global patterns, comparisons between oceans, a basis for distribution of other parameters and as a stimulus to thinking about global problems, (b) librarians and users of libraries covering a wide range of interests, (c) teachers and students, (d) compilers of smaller scale charts and Atlases.

Existing charts show great variations in the concepts of contouring, in visual treatment, in resolution and generally lack a good reliability index. The WG did not address the list of questions to all the charts in turn, but all the points raised were discussed, and particularly with regard to the GEBCO 10 million chart series which is the only internationally produced world series. The following deficiencies of the GEBCO chart were noted, some of which also applied to other world or ocean wide series:-

- (i) the series hardly constitutes a current world series since the publication dates of sheets range from 1923-1970 and only 8 out of 24 were published after 1960,
- (ii) the contouring of sounding data has not been done with due regard to the existing state of knowledge of sea floor morphology or of the geological and geophysical processes active on the sea floor. Because of this, erroneous data has not been identified and rejected. (N. B. contouring by geoscientists of the same data is in no way a generalization. Where contours cross sounding lines they must be consistent with the data. The difference between the geoscientists' approach and the cartographers' is in how to interpolate between sounding lines),
- (iii) no use has been made of the large variety of special surveys contoured at larger scales or of previous work of geoscientists in contouring the collected

- sounding sheets (the WG regretted the decision of the GEBCO Committee to reject, during the preparation of the 4th edition, the contoured Indian Ocean charts prepared at 1:2 million for the IIOE Atlas),
- (iv) there is no indication of the reliability of the contours or of the data on which they are based,
 - (v) the scattered sounding values do not add to the usefulness of the chart unless they represent isolated high or low points,
 - (vi) the contour interval is too wide and the contours too generalized,
 - (vii) the charts do not indicate whether soundings are in corrected or uncorrected metres.

The WG recognized that the quality of a 1:10 million world bathymetric chart depends on the quality of the contoured charts drawn at larger scales and on the quality of the data input. Following a long discussion the ideal specifications for a new World Bathymetric Chart Series were prepared, based on the best points of existing charts and on the needs of oceanographers:-

- (1) the scale should be about 1:10 million,
- (2) the projection should be Mercator except for the polar regions and high latitudes (Mr Sato would prefer a modified polyconic or equal area projection),
- (3) the depths should be in corrected metres,
- (4) the contour interval should be 500 m although occasionally additional intermediate contours could be used in flat areas provided the line weight did not confuse the visual impressions of relief,
- (5) the land should also be contoured in 500 m intervals in order to make direct comparisons of relief,
- (6) the sounding control should be shown as dots where there are random tracks and by labelled boxes where detailed surveys have been used. Carefully selected spot depths of important high and low features should be shown. It is recognized that the very large number of dots in a world series (possibly 10 million) may pose problems,
- (7) the contours must be derived from the best available larger scale charts prepared or approved by marine scientists employing current geological and geophysical knowledge, or from saturation surveys where there is no room for interpretation. Where such charts do not exist, the contouring of soundings at the 1:1 million scale must be done by experienced geoscientists. The resultant patchiness of the final chart will reflect the quality of the input data and indicate the need for more surveys. No attempt should be made to generalize down to the lowest quality data,
- (8) the charts should be relatively up to date, being revised, perhaps, on a rolling 5 year basis as new data becomes available,
- (9) the topography represented in the charts must be easily visualized, requiring the use of multicoloured layer tints or some equivalent cartographic technique. A two-colour or monochrome chart would not be suitable even though it might be cheaper,
- (10) modern cartographic techniques, such as variable line weight to indicate reliability, automatic hill shading, data-banking of contours and updating, need consideration.

(b) Scales from 1:5 to 2 million

It was noted that examples of these mostly comprised the fair copies of charts prepared at 1:1 million and reduced in scale for convenience of the scientific study of relatively large areas of an ocean. They are used extensively for cruise planning and for studying features such as part of a mid-ocean ridge, fracture zones, abyssal plains etc. The existing charts reflect areas of especial scientific interest and do not form part of a designed world series, although a scale of 1:2 million was used for the compilation input for the IIOE Atlas of Geology and Geophysics of the Indian Ocean. The WG noted the desirability of a world coverage at 1:2 million but recognized that this was unlikely to be achieved in the near future, and that charts of this scale should be considered, in international terms, as an intermediate step in the preparation of a 1:10 million chart series. However, it hopes that all such charts will be in corrected metres and will contain contours at 500 m intervals whatever smaller intervals they might have.

There was no support for the suggestion proposed by Pascoe (IHR, January 1972) for a world BM series based on the 1:3.5 million International Series of Navigational Charts, which has different objectives, does not cover many parts of the oceans, and for which the contour preparation so far done, has not been done in accordance with the principles outlined above.

(c) Scales from 1:1 million to 400 thousand

On account of the limited accuracy of navigation in the open ocean, most oceanic data outside the limits of anchored buoys and near shore navigation systems, are collected on scales between 1:1 and $\frac{1}{4}$ million. The collected sounding sheets for GEBCO are prepared at 1:1 million and the initial contouring of oceanic data is therefore also concurrently done at this scale. The charts examined comprised both compilation charts (and cheap expendable copies of working sheets) where constant updating is possible, and fair drawn charts of regions adjacent to some continental margins. In some cases, the GEBCO collected sounding sheets had been contoured by the Hydrographic Office responsible with widely varying success. For the purposes of compiling the 1:10 million world chart, such contours must be examined and approved by experienced marine geoscientists before inclusion. In themselves, contoured 1:1 million charts are extremely useful for detailed studies of the ocean bed, provided the exact data control is shown. The WG recommended wider publicity and distribution of these charts, which are often only found in oceanographic institutions or similar organizations.

3. Organization of bathymetric data exchange and compilation

The present valuable role of the IHO as the specialised world data centre for soundings was noted and the large contribution made through the volunteering hydrographic offices was welcomed by SCOR WG 41. The system provides the foundation for many scientific studies of the ocean floor as well as the starting point for a world bathymetric chart. The WG considered ways in which the collection and exchange of data could be improved,

- (1) The value in showing data sources as overlays was noted and the SCOR WG 41 recommended that both these and the 1:1 million plotting sheets should also show sources and precise limits of high quality bathymetric surveys made at larger scales. It was noted that such references would permit access to the original sounding data for contouring purposes. It was recognized that in certain cases

- only a selected set of soundings might be available or perhaps only contours. In such cases, the selected soundings or reduced contours should be shown on the collection sheets.
- (2) It was noted that many scientists have made use of additional sounding data not put into the GEBSCO system. It was regretted that many sources do not routinely transmit soundings to the IHO and the offer of the IOC to find ways and means of including such soundings was welcomed by SCOR WG 41. The WG would particularly welcome the contribution of Russian soundings to the world data centre.
 - (3) The increasing number of vessels and institutions processing and storing bathymetric data in digital formats was noted and it was recognized that a study of future methods of automatic data storage, retrieval and transmittal based on standard data formats would be desirable for an extension of the 1 in 1 million sounding collection system. Initially the hand copy exchange system should be maintained using machine plotted output from these sources, but ultimately a mixed system could be used and the IHO should be equipped to read cards or tapes.
 - (4) The use of uncorrected and corrected soundings was reviewed by SCOR WG 41. Although uncorrected soundings allow direct comparison with the echo-sounder, there are now different standard speeds of echo-sounder (800, 820 fms/sec, 1500 m/sec), so it was agreed to continue with corrected soundings. The present system of correction is based on Matthew's tables (1939). It was noted there are two disadvantages in the present system:-
 - (a) Changes in correction factor from one area to the next produces a step in the soundings. However these steps are small and relatively rare.
 - (b) Matthew's tables are seriously wrong in areas such as the Kuroshio and Gulf Stream. It was noted Japan has produced a new set of tables for the Kuroshio but still uses the Matthew's (1939) tables to correct the 1:1 million collector sheets that it provides for GEBSCO. A revised version of Matthew's tables is being prepared by Canada, UK and IHO, and this will create a problem by mixing soundings corrected by old and new versions. It was suggested that a new series of collected sounding sheets be initiated containing only soundings taken by precision echo-sounding corrected by the new Matthew's tables and whose positions are controlled by a precise navigation system. A new series would ensure that the newer soundings are not lost because of inadequate space to compile them on the existing collected sounding sheets. It is necessary to establish whether the new corrections differ from the old by more than the time fluctuations in apparent depth due to meandering ocean currents.
 - (5) The desirability of precisely defining agreed limits to Matthew's areas on a 1:1 million scale was noted and the difficulty of producing 600 plotting sheets containing this data alone was recognized by SCOR WG 41. The possibility of producing all Matthew's area boundaries within a single latitude band on one plotting sheet was noted as a method of minimizing the number of sheets.
 - (6) The desirability of continuing the use of Mercator projection for the 1 in 1 million sounding collection series was noted. Arguments in favour of a single longitude scale or of a conformal conic projection were noted but it was felt to be impractical to change the present system.
 - (7) It was suggested that ships' names on the border against a line of soundings would be a desirable addition to the chart, that would aid the scientist responsible for contouring the data. Further, it was recommended that the information supplied by oceanographic vessels relating to positional reliability, type of echo-sounder

etc. should be included on the source of overlay. The desirability of including as many soundings as possible on the sheets was expressed and it was suggested all soundings should be written perpendicular or oblique to the ship's track using a dot or the centre of the sounding to indicate position.

The representative of the IHO explained that modifications to the method of preparation of the 1:1 M plotting sheets require the approval of the volunteering Hydrographic Offices participating in the GEBCO programme. Accordingly, the IHO will take steps to inform the concerned Hydrographic Offices of the views expressed by the Working Group.

4. Future of GEBCO

The SCOR WG 41 welcomed the paper "Future of GEBCO" reporting discussions of the future of GEBCO between Rear-Admiral Ritchie (IHO), F.W.G. Baker (ICSU and GEBCO) and D.P.D. Scott (IOC) held at UNESCO on 12 March 1973. It was noted that a priority of LEPOR, approved by the IOC Assembly, is morphological charting of the sea floor.

The IHO representative reported their awareness of the inadequacies of the GEBCO project and that they have been examining methods of evolving a programme with stronger scientific participation. The following points arose from the discussion of "Future of GEBCO".

- (1) IGN have reported low sales of the GEBCO sheets and have stated that they will not be able to continue to bear the present losses incurred through the production of this series. Their proposal for a cheaper production using 2 colours only was felt to be unlikely to meet the needs of the scientific community.
- (2) The low sales are considered to be due to the failure of the sheets to meet the needs of the scientific community and to a lack of publicity.
- (3) The offer of IOC to extend publicity through the International Marine Science Newsletter and through UNESCO publications was welcomed. Although this was unlikely to effect any real improvement in GEBCO sales, it was welcomed as a means of publicizing a future world bathymetric chart series.
- (4) The failure of the GEBCO sheets is discussed above in para. 2(a) and the reasons agreed. However, it was noted that oceanographic institutes will continue to produce their own charts of limited areas and that advantage should be taken of this trend as an input for a future world bathymetric series.
- (5) The obsolescence of much of the GEBCO series reflects partly the lack of effort and funds, but more frequent revision would not overcome the basic objection of the scientific community to the GEBCO 1 in 10 million series as scientific base charts.
- (6) The following proposals were put forward in the paper by Ritchie, Baker and Scott for consideration by SCOR WG 41:-

6.1 'The IHO should continue in its role as the Specialized World Data Centre for bathymetry and as part of this role it should continue to sponsor and generally co-ordinate the existing collection of sounding data on the 1 in 1 million series oceanic plotting sheets'.

SCOR WG 41 accepted this proposal (see Summary of Recommendations 1 and 2) but with the improvements suggested in para. 3.

- 6.2 'The IHO (in conjunction with IOC and SCOR) should investigate methods of automatic data archiving and retrieval as it applies to sounding data'.

It was noted that many oceanographic institutes now acquire bathymetric data in computer compatible form. The present system involves submission of soundings through national hydrographic offices to the regional collecting hydrographic office and thence to the IHO. It was noted that not all hydrographic offices have appropriate data processing facilities and the present system is not set up to handle digital bathymetric data. It was agreed that a study by the IHO (in conjunction with IOC, CMG and SCOR) of data processing methods would be desirable as a future extension of the 1 in 1 million sounding collection system (see recommendation 4).

- 6.3 'The IOC should investigate ways and means of ensuring that all high quality bathymetric data, in particular those from oceanographic research ships, is made available to the IHO for incorporation in the 1 in 1 million sheets'.

It was noted that an improvement in the situation can be effected by IOC, but the most significant improvement will be made if potential contributors can see that a worthwhile final bathymetric chart results. It was noted that individual hydrographic offices could be more effective in compiling data.

- 6.4 'The 1 in 10 million GEBCO sheets be abandoned as a scientific global base chart of the oceans'.

This subject was extensively discussed earlier in the meeting and the proposal is accepted in the form of recommendation 6.

- 6.5 'The list of bathymetric charts prepared by Laughton et al should be studied and a selection made of those which best meet the needs of the oceanographic community in different ocean areas as regards quality, projection and scale. The authors of these sheets should then be approached and asked whether they (or their institutes) would be prepared to continue publication of these specialized bathymetric sheets of the ocean areas already covered and (most important) whether they would be prepared to keep these sheets updated at relatively frequent intervals'.

Much of this proposal was considered in the earlier discussion when it was recognized that a new world bathymetric chart was needed and that the existing intermediate scale charts should not be considered as a suitable substitute. It was felt that a small unit of full time geoscientists associated with an active oceanographic laboratory, but paid for by international funds, could search out suitable charts for the compilation of a new world bathymetric chart at 1:10 million, and prepare the contours from 1:1 million collected sounding sheets in areas where good charts do not exist. The unit should be under the guidance of an advisory group set up by IOC/SCOR/CMG/IHO and should be able to call together ad hoc regional groups of involved regional specialists when necessary, to prepare charts in particular areas (e. g. as took place for the Indian Ocean bathymetry for the IIOE Atlas).

- 6.6 'The IHO to provide the responsible authors (institutes) referred to in 6.5 above with copies of the 1 in 1 million sheets as and when required'.

This is no longer applicable in view of the comments in 6.5.

6.7 'The IOC to publicize the above adopted bathymetric sheets and to negotiate sales arrangements with the authors' institutes'.

It was noted that periodical publication of lists of bathymetric charts and their sources by IOC would be welcome (recommendation 15).

The WG envisaged that the international scheme for the reduction and presentation of sounding data should therefore have three parts:-

- (a) The collection, exchange and compilation of soundings at the 1:1 million scale should continue as presently organized under the control of IHO,
- (b) The preparation of contours, the search for and compilation of contributing contour charts and special surveys, and the preparation of draft compilations of the world bathymetric chart for cartographic drawing etc. should be organized jointly by IOC/SCOR/CMG/IHO as proposed in para. 6.5,
- (c) The final cartography, printing, distribution and sales should continue to be associated with IHO.

A meeting of the GEBCO Committee will take place on 5-6 June 1973 and will be attended by Dr Ulrich (SCOR), Dr Laughton (CMG & GEBCO), Commodore Kapoor (IHO) of SCOR WG 41.

(7) Relationship with the ICA Working Group on Oceanic Cartography

The following members of SCOR WG 41 are also members of the ICA WG on Oceanic Cartography:- Mr D.W. Newson, Mr T. Sato, Commodore D.C. Kapoor. The WG met on 5 and 6 April in London and in addition to the above members, Dr Ulrich, Dr Laughton and Mr Brodie attended the meeting. A close collaboration was thereby established.

The terms of reference of the ICA WG were agreed as follows:-

- "(1) To advance the study of cartographic problems of oceanography,
- (2) To facilitate communication with oceanographers, in order to explore methods of cartographic representation of oceanographic data,
- (3) To maintain a close liaison with the Scientific Committee on Oceanic Research and the International Hydrographic Organization with the object of promoting co-operation and avoiding duplication,
- (4) To confine its attention to Thematic Oceanic Cartography excluding navigational charts".

It was decided that during the 7th ICA Conference in Madrid (28 April - 4 May, 1974) a short symposium should include papers by the editors of the IIOE Atlases on the cartographic and representational problems involved. It was also suggested that a symposium on problems of oceanic cartography might be held at the Joint Oceanographic Assembly in Edinburgh in 1976.

- (8) Dr Ulrich tendered his resignation as Chairman and suggested that he should be replaced by the Acting Chairman, Dr Laughton. This met with the Committee's approval subject to approval from the SCOR Executive.
- (9) Summary of recommendations of SCOR WG 41

Following a thorough review of existing bathymetric charts of the oceans, at scales between 1:12 million and 1:400 thousand, by members of the WG in their own countries, by correspondence and by examination and discussion during the present meeting, the WG has recognized the need for a new world bathymetric chart series based on a world wide compilation of soundings. The WG has noted the excellence of the original concept of the General Bathymetric Chart of the Oceans, inspired and generously supported by successive Princes of Monaco, but has concluded that, in order to meet the full scientific objectives defined by Prince Albert I, the present system for the production of the international bathymetric chart of the oceans requires certain modifications, which will be described.

SCOR WG 41:-

- (1) advises that the IHO continue its role as the specialised world data centre for oceanic soundings, recommends the continuing collection of soundings on a 1 in 1 million scale and welcomes the large contribution made through the volunteering hydrographic offices,
- (2) recommends the 1 in 1 million plotting sheets should show sources and precise limits of available high quality bathymetric surveys made at larger scales,
- (3) recommends IOC should attempt to locate data sources not at present routinely transmitting soundings to the IHO and to find ways and means of including such soundings in the world 1 in 1 million collector series,
- (4) recommends that the IHO (in conjunction with IOC, CMG and SCOR) should implement a study of future methods of automatic data storage, retrieval and transmittal based on standard data formats in parallel with and as a future extension of the 1 in 1 million sounding collection system,
- (5) recognizes the need in the scientific community for a Mercator world bathymetric chart in colour on an approximate scale of 1 in 10 million. Such a chart must be derived from larger scale charts prepared or approved by marine scientists employing current geological and geophysical knowledge,
- (6) notes that wide discussions with colleagues have shown that the 1 in 10 million GEBCO series of bathymetric charts as prepared under the present system does not fulfil the needs of marine scientists because the contouring of the collected soundings has not responded to advances in earth science. Therefore the chart does not portray the closest approximation to the true shape of the sea floor that might be obtained from bathymetric data so interpreted. Additionally, the present series has deficiencies in presentation and is mostly out of date,
- (7) recommends that it be recognized that the world bathymetric chart must be compiled from the best available bathymetric charts, published or unpublished, supplemented by contoured soundings collected on a 1 in 1 million scale,
- (8) believes that a new system of production is imperative and recommends that a guiding committee for the preparation of the world chart be set up with nominations from IOC/SCOR/CMG/IHO. This advisory group should be

composed of active marine scientists and hydrographers and its activities would replace those of the present GEBCO committee,

- (9) recommends a small, full-time geoscience unit consisting of two experienced marine geologists or geophysicists with a draughtsman and secretarial support be set up to handle the task of preparing an acceptable final compilation of bathymetry for subsequent cartographic drawing, printing and distribution,
- (10) recommends this core unit should be internationally funded and based at a centrally located oceanographic institution with an active group in oceanic geology where good map collections and library facilities would also be available,
- (11) recommends that where appropriate, ad hoc consultant groups of marine scientists knowledgeable in particular areas, should be set up to assist the core unit and guiding committee,
- (12) recognizes that the task of draughting for reproduction and printing will need to be considered as a separate stage in the publication of the world chart. We appreciate that funds have been previously made available by the Monegasque government at the comparable stage of the GEBCO 1 in 10 million series but understand that considerable additional funding will be required to implement this new project,
- (13) notes the long association of the world bathymetric chart with the IHO and wishes to continue the association of the final product with the IHO,
- (14) recommends that rapid publication is essential and that revision should be undertaken at frequent intervals on a continuing basis; intervals of revision of any particular chart would be determined by the acquisition or generation of significant quantities of new soundings,
- (15) recommend that wide publicity be given to the new charts produced under the proposed system.

ANNEX VII

SCOR WORKING GROUP 42 (WITH ICES) ON THE STUDY OF THE POLLUTION OF THE BALTIC Report from the Chairman - I. Hela

The Working Group has continued its work in the frame of the following meetings and other undertakings:-

- (1) The Working Group had its first meeting in Lund 3-5 May 1972, an ad hoc meeting in Copenhagen 30 September 1972 and will have its second actual meeting in Kiel 28-29 June 1973.