SCIENTIFIC COMMITTEE ON OCEANIC RESEARCH

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INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS

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PROCEEDINGS

of the

SCIENTIFIC COMMITTEE ON OCEANIC RESEARCH

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SCIENTIFIC COMMITTEE ON OCEANIC RESEARCH

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This volume of the Proceedings is dedicated to Dr. Gunther Böhnecke on the occasion of his seventieth birthday (on 5 September 1966). Dr. Böhnecke served as the Secretary of SCOR during its first seven years. The Members of SCOR wish to express their appreciation of his substantial contributions to the work of SCOR and their hope for his continuing happiness and success.

Dr. Gunther Böhnecke

Dr. Böhnecke studied geography and oceanography in Berlin and began his distinguished career with a dissertation on the hydrography of the North Sea. It led to his first published paper which was a very sound and timely contribution. Beginning with a careful summary of previous work he analysed the international observations made before 1914 and presented a clear picture of the nature and significance of the surface salinity and current distributions and their seasonal changes. Though he soon had to extend his activities to ocean-wide scientific exploration he always retained his interest in European waters and fisheries. He took an active part in the work of the International Council for the Exploration of the Sea, serving for three years as Chairman of the Hydrographic Committee and contributing much to the success of the IGY Polar Front Survey.

From the Institut für Meereskunde he joined the Meteor in 1925 and was largely responsible for methods of observation, winches, wires and instruments. The care he devoted to this work is clearly demonstrated in his sections of Vol. IV of the expedition reports. He gives much information on the performance of wires, on the tests applied to them, the strains experienced while working from the moving ship, as well as interesting comparisons with the properties of the wires and hemp lines used by contemporary and earlier expeditions. He wrote a detailed report on the variations in zero point and overall calibrations of the reversing deep-sea thermometers during the expediton, with a careful assessment of the

accuracy of the observations, and made a useful comparison of the recordings of an electrical resistance thermometer in the condenser intake with readings of a surface themometer. He reported on the Ekman-Merz current meter and the repeating Ekman meter as used by the Meteor expedition, and analysed the results of one of the anchor stations.

He made an important contribution to the study of the surface temperature and salinity distribution of the Atlantic Ocean as a whole using all available material. He worked out mean monthly values for one and ten-degree squares, and investigated their seasonal variations in different latitudes. He also studied the significance of regional boundaries such as the antarctic and subtropical convergences, comparing them with what could be discovered about the surface current distribution. This work was published in 1936 and later on he used it for further study of upwelling areas in the Atlantic Ocean. In one of the preliminary Meteor papers he described a careful study of the distribution of bottom temperature in the Romanche Deep using the earlier observations as well as those of the Meteor. He concluded that there must be a narrow channel between the western and eastern basins with a sill depth of 4100 to 4400 m. This is close to the results obtained by Metcalf, Heezen and Stalcup with the very best of today's methods and experience. He wrote an interesting popular account of the Meteor expedition in the Meereskunde series published by the Institut für Meereskunde. He appears in several group portraits of the scientific staff in the popular narrative Die Meteor Fahrt by Captain Spiess, and does not look very much older today.

He complied several oceanographic atlases, notably of the surface temperature and salinity of the Atlantic Ocean in Vol. V of the Meteor reports, and of the North Sea and Baltic Sea in 1927, and again, with Dietrich, in 1951. He has been very active in efforts to improve and get the best value from current meters. His Principles of Measuring Currents published by AIOP in 1955 is an essential guide to the subject urging closer co-operation between theoretical workers, engineers, and other practical men.

In his own papers and jointly with Wattenberg, Hentschel and Føyn he made substantial contributions to our knowledge of the Denmark Straits and Irminger Sea, and he was largely responsible for the recent work of the Anton Dohrn and Gauss. He had much to do with the re-entry of Germany into the ICES and IHB, and, attending the first meetings at which this was possible, he soon took an active part. He was Chairman of the ICES Hydrographic Committee from 1955 to 1958, and was unanimously elected President of the 1957 IHB meeting. He also took an active part in the work of UNESCO's International Advisory Committee on Marine Sciences, and when SCOR was started in 1957 he became its first Secretary, holding

this position till 1964. He has been active in the work of the International Association of Physical Oceanography, International Union of Geodesy and Geophysics, International Council of Scientific Unions, and Intergovernmental Oceanographic Commission. He worked hard for the continuation of the international bathymetric chart and for the IGY.

He was Director of the Marine Observatorium at Wilhelmshaven from 1935, and when this laboratory and the Deutsche Seewarte were incorporated in the new German Hydrographic Institute after the war became its first President. Much of the new Institute's success must be attributed to him, and he was very highly commended by Government and scientists alike when he retired at the end of 1960. Since then he has been joint author, with Dr. Meyl, of the memorandum on the state of marine investigation in Germany prepared by the Deutsche Forschungsgemeinschaft.

After 5 1/2 years of retirement from the German Hydrographic Institute, Dr. Böhnecke is still doing pioneering work as Director of the Office of the German Society for the Application of Nuclear Power to Shipping, now supervising the construction of the first German nuclear-powered merchant ship.

During his seven years as Secretary of SCOR, Dr. Böhnecke earned the gratitude and good wishes of marine scientists all over the world, and it is difficult in short space to do justice to his very wide range of achievements in science and administration, at sea and on shore. He always acted with kindness and goodwill so that difficulties were lessened and friendship and understanding were increased. All who know him will wish him continued health, happiness and success and we hope we shall still see him and be able to welcome his continued help and advice at oceanographic meetings.

G.E.R. Deacon

NOTE: In preparing this brief message of good wishes, I have had the enthusiastic help of Dr. J. N. Carruthers.

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SCIENTIFIC COMMITTEE ON OCEANIC RESEARCH

Report of the Eighth General Meeting

Rome, 23 - 27 May 1966

The Eighth General Meeting of SCOR was held at the Consiglio Nazionale delle Ricerche, Rome, 23 - 27 May 1966, with the President, Captain Luis Capurro, in the chair. Participants were welcomed by Professor Giussepina Aliverti on behalf of Professor Cagliotti, President of the Consiglio.

A business meeting on 23 May was followed by the Symposium on Variability in the Ocean during the next three days. On 27 May a visit was made to the Zoological Station in Naples, where the group was greeted by the Director, Dr. Peter Dohrn. This visit was made possible through the generosity of the Italian Research Council with the help of the Camera Industria e Commercio, Napoli. A reception for the ladies at the Palazzo Reale in Naples, and a visit to Pompei were sponsored by the Azienda de Soggiorno, Cura e Turismo di Napoli.

Subsequently, on 2 June 1966, the Executive Committee met in Moscow to complete action on items referred to it during the General Meeting. Deliberations of the Executive Committee are included in the present report.

A list of those who attended the business session of the General Meeting, and those who participated in the Executive Meeting, is given in Annex I. The agenda used in the former meeting serves as an outline for the report which follows.

1. Organization and Finance

1.1 Revision of Constitution

On the initiative of the IUGG Executive Committee, the question of the most effective working relationship between IAPO and

SCOR was considered at the Eleventh General Assembly of ICSU (Bombay, 6 - 10 January 1966). The following recommendation was adopted:

> "The General Assembly recognized the importance of close cooperation between SCOR and the appropriate constituent bodies of IUGG, IUBS and IUGS. Accordingly it invited SCOR at its next General Meeting to consider revision of its Constitution to provide that the Presidents of IAPO (IUGG), the Commission on Marine Biology (IUBS), and the Commission on Marine Geology (IUGS) should, ex officio, be members of the SCOR Executive Committee. In order that this expansion of the Executive Committee should not place an undue financial burden on SCOR, it was recommended that the expenses of these ex officio officers should be paid by their parent bodies. It was recognized that this ex officio representation would be in addition to the Union representation on SCOR already stipulated in the Constitution."

After some discussion, this recommendation was accepted by the SCOR General Meeting as a means of establishing a close working relationship with these organizations.

At the Seventh Meeting of SCOR (Hamburg, 30 November - 4 December 1964), it was decided that general meetings should normally be held at eighteen-month intervals. However, for a variety of reasons including the IOC decision to hold its meetings every two years, it now appears more appropriate for SCOR to meet at two year intervals in alternate years from the IOC Sessions. This schedule was approved by the Meeting.

This change in the interval between meetings necessitates a corresponding change in the terms of office of members of the Executive Committee. Accordingly it was agreed that the normal term would be four years, which would be the maximum period of office of the President. Vice-Presidents and the Secretary would be eligible for a further term of two years, the limit for continuous service on the Executive being six years.

The Executive Committee was instructed to work out the rewording of the Constitution to reflect these decisions, and to forward the revisions to the ICSU Executive Committee for consideration at its October meeting in Monaco. The revised sections are given in Annex II.

1.2 Report of the Secretariat

No formal report was presented since activities of the secretariat are reflected in the first two numbers of the Proceedings. Only the present meeting will be held in 1966, so that it will be necessary to publish only one number of the Proceedings this year.

It was noted that secretarial assistance and office space and equipment were furnished to the Secretariat by the University of California, and that no wages are paid by SCOR at the present time.

1.3 Budget

An estimate of SCOR expenses in 1965 and 1966 (to 1 May) is given in Annex III, together with an estimate of the 1966 income. It has been difficult to keep track in detail of SCOR finances because of the existence of accounts in both Rome and La Jolla; the Acting Secretary of ICSU has promised a four-monthly accounting from Rome which should eliminate this problem.

Final payment on the 1965 UNESCO contract was made in April 1966, and the 1966 contract for a somewhat reduced amount was signed in May. A UNESCO contract to facilitate preparation of oceanographic station curves from ICITA data has been completed; all funds were transferred to the U. S. National Oceanographic Data Center where the work was performed.

A sum of $19,640.74 was transferred to SCOR in July 1965 by the American Association for the Advancement of Science. This amount remained from the First International Oceanographic Congress, and by decision of the Executive Committee was used to pay travel expenses of scientists nominated by UNESCO or by conveners of symposia of the Second Congress. Before use, interest accrued to the amount of $639.93, making available a total of $20,280.67. These funds were used to support the attendance of twenty-five scientists at the Congress. A report on the use of these funds will be made to the AAAS.

2. Working Groups

2.1 Report of existing groups

A summary of working group activities and reports is given in Annex IV. Additional reports are mentioned in the following section where action on the continuation of WG activities is reported.

2.2 Establishment of groups for 1966-67

During the Executive meeting of June 1965 (SCOR Proceedings, 1 (1)), it was decided that the tenure of SCOR Working Groups would expire at each General Meeting at which time decisions would be made about reestablishing each group, changing its membership or revising its terms of reference. Accordingly the work of each group was discussed and the decisions reported below were taken. Representatives of other sponsoring bodies were present in Rome and Moscow, and agreed to support these decisions in presenting them to their orgainzations.

In order to ensure close liason with national committees in the activities of SCOR working groups, it was agreed to make available to national committees lists of WGs and members, to ask for new nominations of national participants, and to instruct WG chairmen to keep national participants fully informed on all activities of the group.

WG 10 Oceanographic Tables and Standards (with ICES, IAPO, and UNESCO). The full report of the October (1965) meeting of this group has been published by UNESCO (Second Report of the Joint Panel on Oceanographic Tables and Standards, UNESCO Technical Papers in Marine Science No. 4, 1966). Tables relating conductivity ratio and salinity have been prepared and will be published by UNESCO. A new definition of salinity, based on conductivity ratio, has been established. Further tables are under consideration, including the following:

A) effect of pressure on conductivity
B) specific gravity as a function of temperature and salinity
C) chlorosity as a function of salinity or chlorinity
D) velocity of sound, as a function of temperature, salinity, and pressure
E) salinity as a function of refractive index

It was agreed thet the work of this important group should contimue. Until now, major emphasis has been on the effect of the concentration of dissolved constituents. In the future, it will be important also to emphasize the accurate determination of the coefficients of thermal expansion and isothermal compressibility so that the equation of state of sea water can be more completely established. In view of this change of emphasis it was agreed that two physicists concerned with such measurements should be added to the group (or should replace two of the chemists). This change in membership will be worked out in consultation with the chairman, Professor Dietrich, and with other sponsoring bodies.

WG 12 Abstracts and Bibliography. It was agreed that the report of this group (SCOR Proceedings, 1 (2). Annex IV) had served a very useful purpose in identifying further studies which should be carried out, and in describing the present status of the information problem in marine science. It was decided to discontinue the group at this time, and to keep under review the possibility of further activity when it was clear how SCOR could most effectively contribute to a solution. The Secretary was instructed to report this decision to the members, thanking them for their contribution.

A recommendation of WG 12 has recently been implemented by FAO with the publication in May of the first number of "Current Contents in Marine Sciences." This will contain the tables of contents of about fifty primary journals covering fisheries biology, oceanography, maritime meteorology and other disciplines in marine science. Further information can be obtained from the FAO Department of Fisheries.

WG 13 Zooplankton Sampling Methods (with ICES and UNESCO). A status report from the chairman of this group is given in Annex V, together with reports from the various working parties. Comments on these reports should be sent to the chairman, Dr. Fraser. The task set for this group is nearly completed, and it was decided to reduce membership to the chairman, conveners of the four working parties and Dr. G. Hempel, the final integrated report being completed by this small group. This report would be published by UNESCO together with the reviews prepared upon recommendation of the Sydney meeting of w.p. 3. In order to give this information the widest possible distribution, the chairman, Dr. Fraser, was requested to prepare an appropriate article for publication in Nature. It was noted that field trials of recommended equipment will eventually be necessary, and the WG and Executive Committee were requested to consider when and how these trials should be organized.

WG 14 General Scientific Framework. Revision of this document is expected to be completed this summer, and it will be published by UNESCO. A new title is to be chosen by the editors. It was decided to abolish the working group, but to ask Professor Revelle, Dr. Deacon, Professor Kort and Dr. Cushing to continue as an editorial board until the work is completed.

WG 15 Photosynthetic Radiant Energy (with IAPO and UNESCO). A meeting of this group is scheduled to be held at the time of the Pacific Science Congress in Tokyo, and it was agreed that the group should be continued at least until that time.

WG 16 General Problems of Standardization and Intercalibration. In addition to the several SCOR working groups on specific methodological problems, WG 16 has attempted to look at the more general aspects of

methodology. This group, made up of some ten specialists, has made some valuable suggestions, but it now appears that a smaller unit with more specific terms of reference might be able to keep this matter under review more effectively. Professor Kort agreed to study the terms of reference of such a group. In the meantime the Executive Committee, in consultation with the secretariats of cooperating organizations, such as UNESCO, FAO and ICES, will arrange for scientific evaluation of such proposals for action in this field as may arise. The present work-group will be disbanded, and its members commended for their help in this difficult problem.

WG 17 Photosynthetic Pigments (with UNESCO). The original task of this group has been completed, and the resulting reports are being published by UNESCO. It was noted that certain aspects of this matter had been left unresolved - the utility of the fluorescence method for chlorophyll, the desirability of measuring carotenoids, the establishment of satisfactory equations for chlorophyll a, b and c, etc. Therefore, while abolishing the working group for the present, it was decided to ask Dr. Humphrey to serve as rapporteur, to keep the matter under review and at the appropriate time, to present recommendations for future action.

WG 18 Biological Data (with ACMRR). The report of this group (SCOR Proceedings, 1 (2), Annex V), played an important part in discussions of the IOC Working Group on Data Exchange (Copenhagen, 31 March-2 April 1966), and in the revision of biological sections of the Provisional Guide for the Exchange of Oceanographic Data. It is still necessary for various groups of specialists to consider the format for the exchange of biological data. It was agreed to retain this group until the next Executive Meeting, with its work being carried on by correspondence with the initiative of its chairman, Dr. Hempel. Future activities, terms of reference, and membership would be discussed by ACMRR and a recommendation would be passed to the Executive. The Secretary of SCOR was instructed to obtain from NODC and CODC copies of their proposed formats for the exchange of biological data, for consideration by the group.

WG 19 Micropaleontology of Bottom Sediments. It was agreed that this group should continue, at least until the proposed symposium on marine micropaleontology had been held. The representative of UNESCO stated that some financial support for this symposium might be available in 1967. It was agreed that close cooperation with IUGS in development of the symposium was desirable. Informal meetings of the group were held in Moscow during the Second International Oceanographic Congress, and a report of these discussions together with appropriate portions of the report (unpublished) of the January meeting is attached as Annex VI.

WG 20 Primary Production (with ICES and UNESCO). This group has not yet met and must be continued at least until it has reported on its terms of reference. An early meeting should be encouraged.

WG 21 Continuous Current Velocity Measurements (with IAPO). Resolution IV-7 of IOC "invites SCOR to consider the establishment of a working group of scientists to evaluate suitable instrumentation for time series measurements." This proposal was discussed several times during the SCOR meeting, the Symposium on Variability, and the Executive Meeting in Moscow. At the last session it was decided to establish such a group to design, and propose means for carrying out, an intercomparison at sea of the principal current measuring systems now employed for the continuous recording of current velocity on moored stations. These systems include recording meters designed by Richardson, Alekseev, and the Bergen group. The representative of IAPO agreed that co-sponsorship by his organization would be appropriate and indicated which of the proposed members would be appropriate IAPO nominees. The Secretary was instructed to invite participation from a list of appropriate scientists suggested during the meeting. Subsequently, UNESCO agreed to join in sponsorship of the group.

Several additional working groups were proposed, but their establishment was deferred until additional information is available. These include the following:

Proposed WG on Nutrient Chemistry (with ICES and IBP). During the Fifty-third Meeting of the International Council for the Exploration of the Sea (Rome, October 1965), it was decided to establish a group within the frame of the Hydrographical Committee, for intercalibration and standardization of chemical methods in oceanography. The PM section of IBP has recently established a small group to consider nutrient chemical methods in brackish waters. Establishment of a SCOR working group on chemical methods has also been considered by WG 16.

The Chairman of the IBP PM Section, Dr. Ketchum, compared the situation in sea water analysis with that in agricultural chemistry and referred to the practice of the American Association of Agricultural Chemists. This organization has a panel of experts who try out all new analytical methods on exchanged samples. As a result of their work, it is possible to publish periodically a handbook of tentative and approved methods. This practice might eventually be useful in marine chemistry.

The need for common action on this problem was recognized, and the Secretary was instructed to correspond with officials of ICES, IBP UNESCO and IAPO to obtain more specific information on existing activities, which could form the basis for formulation of the most effective role of SCOR. The matter will be discussed again at the next SCOR Executive Meeting.

Proposed WG on Marine Pollution (with ACMRR). Resolution IV-10 of IOC concerns the establishment of an IOC Working Group on Marine Pollution. During the Sixth Meeting of the IOC Bureau and Consultative Council, it was noted that several other international bodies were active in this field, and that the proper role for IOC required careful consideration. A proposal was made that a small panel of experts organized by SCOR and ACMRR might usefully consider such problems prior to meeting of the IOC working group.

During the SCOR meeting it was agreed that such a panel, if given specific terms of reference, would serve a useful purpose. Compilation of the activities of existing international bodies could be most effectively done by the UNESCO and FAO Secretariats. The SCOR - ACMRR working group would, in effect, prepare the terms of reference for the IOC working group by considering the scientific problems involved in marine pollution and by identifying the areas in which IOC might make an important contribution. The Secretary was instructed to correspond with other members of the Executive and with the secretariats of UNESCO/IOC and FAO/ACMRR in order to arrange for establishment of this group.

Proposed WG on Zooplankton Laboratory Methods. The Consultative Committee of IOBC, during a recent meeting, recommended international consideration of zooplankton laboratory methods. During the SCOR meeting, an ad hoc group of biologists prepared a proposal for a working group to examine problems of preservation of zooplankton samples, preservation of microplankton and estimation of biomass. This proposal is attached as Annex VII. It was agreed to refer the matter to WG 13 and to other zooplankton experts, and with their advice to discuss possible SCOR action at the next Executive Meeting.

3. Relations with UNESCO and other UN Agencies

3.1 Advisory matters concerning UNESCO/IOC

Several resolutions of the Fourth Session of IOC referred to SCOR, and the following called for specific action:

IV-1 Ocean-Atmosphere Interchange - Urges IAMAP, IAPO and SCOR to act vigorously in stimulating the scientific study of the physical and chemical processes governing the exchange of energy and matter between ocean and atmosphere and the development of satisfactory methods for estimating the flux of energy and matter between ocean and atmosphere.

Professor Stewart has been designated representative of SCOR on the IUGG Committee on Atmospheric Sciences and attended their recent meeting in Geneva (22-25 April 1966). In reporting on the plans for the World Weather Watch, he noted the plans to use ships-of-opportunity with trained observers aboard to obtain coverage in a significant portion of ocean areas. Although the principal responsibility of these observers will be to obtain meteorological observations (which in themselves will be useful for oceanographic investigations), there are additional measurements of oceanographic importance which might be made. It was agreed to urge UNESCO to discuss with WMO the possibility of enriching the oceanographic component of the World Weather Watch by incorporating measurements of subsurface thermal structure (by expendable BT) and estimates of surface currents (from navigational data). (See also Section 4.1).

IV-2 General Scientific Framework - Invites SCOR and ACMRR to keep under review the desirability of developing another revision at a future date. Status of the present revision is reported above (Section 2.2, WG 14). It seems premature to respond to the IOC resolution at the present time, and action was deferred until the next General Meeting.

IV-7 Variability in the Ocean - Invites SCOR to consider the establishment of a working group of scientists to evaluate suitable instrumentation for time series measurements. Action is reported above (Section 2.2, WG 21). The discussion following the Symposium on Variability, recorded at the end of this report, is also relevant.

IV-10 Marine Pollution - Requests SCOR and ACMRR to assist the IOC Working Group. Action is reported above (Section 2.2).

IV-12 Storage and Retrieval of Scientific Information - Recommends that Member States, together with SCOR and ACMRR, urgently consider what steps might be taken, in collaboration with other interested bodies, to ensure, for the promotion of oceanography in general, that sufficient funds, facilities and staff are made available for the provision of a retrieval service adequate to the needs of the international marine research community. Although WG 12 is being discontinued (Section 2.2), SCOR agreed to keep under review the possibility of further activity when it was clear how SCOR could most effectively contribute to a solution.

IV-14 North Atlantic Ocean - Requests SCOR and ACMRR in cooperation with ICES and ICNAF and taking into account all the work in progress to study the possibility of developing cooperative investigations of this region, reporting their recommendation to the next Session

of the Commission including, if feasible, suggested plans for its conduct. Professor Kort, on behalf of SCOR, is preparing a proposal for such investigations, which should be available for discussion at the next Executive Meeting.

In connection with Resolution IV-8 (Development of National Programs), SCOR requested Dr. Humphrey to serve as its representative at the meeting of the Working Group on Mutual Assistance, Paris, 14-17 June 1966. Attention was drawn to the proposals discussed at the last Executive Meeting and reported in SCOR Proceedings, 1 (2):51.

The UNESCO Office of Oceanography, recognizing the need for more extensive exchange of views between scientists engaged in theoretical studies of the general ocean circulation and its variability, deep sea currents, storm surges, upwelling, internal waves, etc., has proposed the organization, at two year intervals, of an international seminar on dynamics. A three-day meeting, with fifteen to twenty invited participants, organized around a single topic, has been considered. UNESCO might be able to organize and finance the seminars if scientists feel they are desirable. SCOR has been asked to consider this proposal. The Secretary was instructed to inform UNESCO of SCOR's feeling that such a seminar might best be worked out with IAPO and IUTAM.

During the Sixth Meeting of the IOC Bureau and Consultative Council (Paris, 16-18 May 1966), the IOC Secretary presented a proposal for a Cooperative Study of the South Mediterranean and the Levant Basin, emanating from a UNESCO Meeting of Experts held in Split, Yugoslavia in December, 1965. SCOR, together with ACMRR, was asked to consider the scientific aspects of the program.

This program consists principally of a study of the Atlantic Current and its spread and influence in the South Mediterranean and Levant Basin. In addition, considerable interest has been shown in biological changes in the Levant Basin resulting on the one hand from migration of animals from the Red Sea through the Suez Canal and on the other hand from reduction of the Nile floods. Professor Braarud emphasized that in the case of these biological changes an immense experiment was being conducted, and that we should not miss the opportunity this provided to gain new understanding of the processes involved.

It was also noted that a Mediterranean atlas is being prepared by a group at Woods Hole, in cooperation with British and French scientists, and that FAO is sponsoring preparation of a synopsis on the biology of the region. Future work in the Mediterranean should benefit considerable from availability of this material.

It was agreed that the cooperation of neighboring countries in a regional investigation was to be encouraged, but that endorsement by IOC implied more widespread participation. The interest of IOC members in the investigation was to be ascertained by the IOC Secretariat. At the next Executive Meeting, when the nature and extent of national interest in the program is more clear, possible SCOR action will be considered.

The terms of office of several members of the Consultative Committee of the Indian Ocean Biological Center will finish in 1966; UNESCO has invited the suggestions of SCOR for new members. This matter was considered by the Executive Committee, which recommended that Dr. Anraku (Japan) and Dr. Fleminger (USA) be appointed. Some members of the Executive also felt that it would be useful to have the retiring Curator as an ex officio member of the Consultative Committee.

3.2 Other Matters

SCOR has been invited to nominate experts to participate in a WMO Technical Conference on Automatic Weather Stations, to be held in Geneva, 20 September to 1 October 1966. It was decided not to send a representative, but to keep the matter under review.

4 Relations with ICSU and Constituent Bodies

4.1 IUGG Committee on Atmospheric Sciences

Action is reported above (Section 3.1, Resolution IV-1). In addition it was decided to contribute financially if required in order to facilitate a meeting of the IAMAP-IAPO Joint Committee on Air-Sea Interaction in Kyoto in September 1966.

4.2 International Association of Physical Oceanography

Information on the IAPO Deep-Sea Tide Program was presented in the Proceedings, 1 (2), Annex VII. The program was endorsed

by the Fourth Session of IOC (Resolution IV-15). Professor Munk reported that a meeting of the IAPO Working Group, including sea trials, was now scheduled for 4 - 11 February 1965. It is hoped that the French instrument would be available for comparison with that being developed by Professor Munk. The meeting will be supported by IAPO and UNESCO and it was agreed that SCOR support up to $2000 could also be made available. A meeting of the working group was subsequently held in Moscow, the report is given in Annex VIII.

Announcement has been received that IAPO will hold its General Assembly in Bern, from 25 September through 6 October 1967. Some SCOR working groups may find it convenient to meet at that time. Several symposia and sessions on topics such as the following will be held:

general circulation, currents of the Indian Ocean, continental margins and island arcs, air-sea interaction, computers, problems of geochemistry, diffusion, internal waves, geothermal problems, surface waves, tsunami, tidal problems, physical properties of sea water.

4.3 International Biological Program

Dr. Oren, SCOR Representative on SCIBP, reported on the April meeting of that Committee. He indicated that major emphasis on the PM section would be given to estuarine and coastal waters and to the work of small coastal laboratories. A group has been established to consider nutrient chemical methods in brackish waters (see Section 2.2 above). A proposal for establishment of a Center for the Development of Statistical Methods for Zoo- and Phyto-plankton Research has been discussed, and referred to SCOR for possible support. The Secretary was instructed to request an evaluation of this proposal by Working Group 13 and by other appropriate experts, in preparation for consideration at the next Executive Meeting.

4.4 Scientific Committee on Antarctic Research

A Symposium on Antarctic Oceanography will be held in Santiago, Chile, 13-16 September 1966, under the sponsorship of SCAR, SCOR, IAPO and IUBS. In view of the cosponsorship of this meeting by SCOR, it was decided to make available the sum of $2000 to assist in bringing participants to the meeting.

5. Relations with Other International Organizations

Mr. Arthur Lee has served as SCOR representative to ICNAF, and will attend the Sixteenth Annual Meeting in Madrid, 6 - 11 June 1966.

The Eleventh Pacific Science Congress will be held in Tokyo, 22 August - 10 September 1966. It is understood that the SCOR President, Captain Capurro and SCOR Members Drs. Gaskell, Hidaka and Steemann-Nielsen are planning to attend, and the Secretary was instructed to inform officials of the Congress that these Members would be the SCOR representatives.

6. Consideration of Future SCOR Activities

The UK National Committee had proposed a discussion reviewing SCOR's achievements to date and its objectives for the future, and in particular the ways in which SCOR might generate new ideas in international oceanography.

Future programs of international investigations were discussed at the last Executive Meeting in October 1965. In accordance with the proposal of that meeting, the Secretary has initiated a study of the desirability of organizing an international exploration of the South Pacific. On 15 March 1966 a letter was sent to seventeen experts in various aspects of oceanography, requesting comments on the important scientific questions concerning the South Pacific which merit large scale and intensive investigation. Prior to the next Executive Meeting, available replies will be circulated, so that the merits of further action in this matter can be considered.

With regard to a review of SCOR's achievements to date, it was agreed that these should be made better known to scientists. It has always been difficult to find people willing to involve themselves in international activities such as SCOR's working groups, due in part perhaps to a lack of general understanding on the usefulness of such activities.

The review of scientific aspects of proposed international programs, such as that requested by UNESCO in the case of the South Mediterranean study, may prove to be a constructive type of activity for SCOR to carry out in the future.

7. Other Business

The Executive Committee, during its Paris meeting in September 1962, strongly supported the Israeli plan to establish a marine research station at Eilat, on the Gulf of Aqaba, Red Sea. Dr. Oren reported that since then important progress had been made, both in the development of oceanography in Israel, and in the implementation of plans in Eilat, where the Marine Biological Research Station is under construction.

This station, a facility of the Hebrew University, will be used for teaching and research. SCOR has recognized the international value of such a station, and reaffirms its hope that other countries will support the development of this project and its use as a scientific center for research in the Red Sea.

In this connection an invitation was received from the Israel Academy of Sciences and Humanities for SCOR to hold its next Executive Committee meeting in Israel. It was agreed to accept this invitation and to arrange the meeting for late 1966 or early 1967.

In view of the decision to hold future General Meetings at two-year intervals (see Section 1.1 above), it was agreed that the next such meeting would be in May 1968. At that time it may be appropriate to hold a symposium on the South Pacific. The location and dates of the meeting should be discussed at the next Executive meeting.

Subsequent to the business session in Rome, the Symposium on Variability in the Ocean was held (see Annex IX for program). An offer of the Italian National Research Council to publish the papers and discussion was accepted with gratitude, and Professors Stewart and Braarud agreed to serve as editors of the volume.

The general discussion on the final afternoon of the symposium centered on the question of a pilot-scale experiment proposed by the IOC Working Group on Cooperative Investigations of Variability in the Ocean. This experiment was envisaged on a section several hundred miles in length located in an appropriate part of the eastern north Atlantic. In addition to frequent sampling of the distribution of properties from ships, perhaps at weekly intervals, several instruments allowing the continuous measurement of total fluxes would be installed along the section. The IOC Working Group felt that design of the experiment should await a clearer picture of the suitability of existing equipment, and the detailed analysis of existing time series data from analagous sections. In this connection it was considered that the SCOR symposium would permit an evaluation of these problems.

During the discussions in Rome it was noted that several laboratories are actively engaged in the development of suitable instruments. the design of adequate mooring systems for their installation in the ocean, and the formulation of procedures for the analysis of time-series data. It was considered premature to proceed with planning of an international experiment before the characteristics and capabilities of these

instruments were better known.

In this connection it was agreed that the organization of small groups of scientists to arrange for intercomparison of instrument systems, such as the new SCOR WG 21 on Continuous Current Velocity Measurements, and the IAPO WG on Deep Sea Tides, is an essential step in the development of an eventual international investigation of variability. Additional work by individual laboratories in the analysis and interpretation of time-series data resulting from such measurements is also necessary.

The consensus of symposium participants was to recommend postponement of the proposed September meeting of the IOC WG on Variability in order to permit further progress in the research referred to above, and to await recommendations of the pertinent SCOR and IAPO working groups before proceeding with decisions on an international experiment. In the meantime, Drs. Kort, Dietrich and Mann, conveners of the informal regional committees referred to in IOC Resolution IV-7, should be encouraged to proceed with development of their proposals for possible international experiments. In this connection, Professor Dietrich's suggestion for the intensive study of key areas rather than single sections was received with great interest, and it was hoped that he would provide additional details on the project.

EIGHTH GENERAL MEETING

Rome, 23 - 27 May 1966

List of Participants

MEMBERS

Prof. G. Aliverti	Italy
Prof. T. Braarud	Norway
Mr. J. W. Brodie	New Zealand
Capt. L. Capurro	Argentina
Prof. T. Y. Chu	China (Republic of)
Dr. G. E. R. Deacon	United Kingdom
Prof. G. Dietrich	Germany (Federal Republic)
Dr. T. F. Gaskell	IUGS
Prof. R. Groen	Netherlands
Capt. R. Herrera	Chile
Prof. K. Hidaka	Japan
Dr. G. F. Humphrey	Australia
Prof. J. Krog	IUPS
Prof. J. K. Mallory	South Africa
Prof. H. Postma	ICSU
Prof. R. W. Stewart	Canada
Prof. S. Szymborski	Poland
Prof. P. Tchernia	France
Prof. W. Wooster	U. S. A.

OBSERVERS

Mr. F. W. G. Baker	ICSU
Dr. L. H. N. Cooper	United Kingdom
Dr. J. S. Creager	U. S. A.
Mr. R. I. Currie	IUBS
Dr. J. H. Fraser	WG 13
Mr. G. E. Hemmen	SCAR
Dr. G. Hempel	UNESCO/IOC
Mr. A. Lee	United Kingdom
Mr. J. W. McGary	U. S. A.
Dr. C. Morales	WMO
Dr. O. H. Oren	Israel
Dr. M. Ruivo	FAO/ACMRR
Dr. R. Schemainda	Germany (Democratic Republic)
Mr. R. C. Vetter	U. S. A.

EXECUTIVE MEETING

Moscow, 2 June 1966

List of Participants

MEMBERS

President:	Captain L. R. A. Capurro
Retiring President:	Dr. G. F. Humphrey
Vice-Presidents:	Professor T. Braarud
	Professor V. G. Kort
Secretary:	Professor W. S. Wooster

OBSERVERS

Professor G. Dietrich	FRG/WG 10
Dr. K. N. Fedorov	UNESCO/IOC
Professor I. Hela	IAPO
Dr. G. Hempel	UNESCO/IOC
Dr. R. Jackson	FAO
Dr. B. Ketchum	IBP
Dr. M. Ruivo	FAO/ACMRR
Professor R. W. Stewart	Canada
Mr. H. Tambs-Lyche	ICES

Proposed Revision of Sections 4, 9 and 12 of the SCOR Constitution

4. The Executive Committee of SCOR shall consist of elected and ex officio members, determined in the following manner:

(a) SCOR shall elect from amongst its own members a President, two Vice-Presidents and a Secretary. The retiring President shall also be considered an elected member of the Executive Committee. The maximum period of office of the President is 4 years, but the Vice-Presidents and the Secretary shall each be eligible for one further term of 2 years' service. Normally no elected member should remain on the Executive for more than 6 continuous years.

(b) The President (or Chairman) of the International Association of Physical Oceanography (IUGG), the Section on Biological Oceanography (IUBS), and the Commission on Marine Geology (IUGS) shall, ex officio, be members of the SCOR Executive Committee.

9. The national institutions and international scientific unions shall pay the expenses of their nominees to attend SCOR General Meetings. The payment of travel and per diem expenses for the Executive Meetings shall be decided by the SCOR Executive in accordance with the approved budget, except that the expenses of ex officio members shall be paid by their parent bodies.

12. General Meetings of SCOR shall normally be held at two year intervals.

ESTIMATE OF SCOR FINANCES, CALENDAR 1965

INCOME

Balance as of 1 January 1965	$ 19,644.00
National Contributions	15,483.94
Sale furniture, Hamburg balance	249.46
UNESCO Contract, 1963	1,500.00
UNESCO Contract, 1964	1,500.00
UNESCO Contract, 1965	8,500.00
Total	$ 46,877.40

EXPENDITURES

Paid by ICSU on SCOR behalf	$ 4,450.15
Disbursed in La Jolla	25,890.08
Total	$ 30,340.23

BALANCE on 31 December 1965

In Rome	$ 4,927.25
In La Jolla	11,609.92
Total	$ 16,537.17

ESTIMATE OF SCOR FINANCES, CALENDAR 1966 (to 1 May)

INCOME

Balance as of 1 Janaury 1966		$ 16,537.17
National Contributions		4,606.12
UNESCO Contract, 1965		4,000.00
Total		$ 25,143.29
Additional income anticipated		
ICSU allocation	$ 4,000.00	
National Contributions (Estimate)	10,000.00	
UNESCO Contract	10,000.00	
	$ 24,000.00	
EXPENDITURES		$ 11,202.15
BALANCE		$ 13,941.14

Annex IV

SUMMARY OF SCOR WORKING GROUP ACTIVITIES
1 January 1965 - 1 May 1966

Activity	Meetings	Reports
WG 10	Rome, 8 and 11 October 1965	SCOR Proceedings, 1 (2), Annex III
WG 12	Marseille, 27 - 29 October 1965	SCOR Proceedings, 1 (2), Annex IV
WG 13	(wp 2) Villefranche, 28 September - 10 October 1965	SCOR Proceedings, 1 (1), Annex VI (wp 1) Interim report, UNESCO AVS/9/12H of 21 September 1965 (wp 2) Interim report, unpublished, October 1965
	(wp 3) Sydney, 10 - 18 February 1966	(wp 3) Interim report, unpublished, 1965 (wp 4) Interim report, UNESCO AVS/9/12H of September 1965 Report of Chairman, 25 March 1966
WG 14	Moscow, 10 - 12 May 1965	SCOR Proceedings, 1 (1), Annex VII
WG 16	Rome, 9 - 11 June 1965	SCOR Proceedings, 1 (1), Annex VIII
WG 18	Paris, 25 - 27 October 1965	SCOR Proceedings, 1 (2), Annex V
WG 19	Paris, 3 - 4 January 1966	Unpublished, distribution on 4 February 1966
Program Committee, Second International Oceanographic Congress		
	Moscow, 13 - 15 May 1965	SCOR Proceedings, 1 (1), Annex IX
	Moscow, 1 - 3 February 1966	UNESCO AVS/9/149 of 9 February 1966

REPORTS OF WORKING GROUP 13 ON ZOOPLANKTON SAMPLING METHODS

Report of the Chairman

Introduction

WG 13 can be said to have originated in January 1964 following discussions by various international and national bodies which had expressed keen desire to consider the possibilities of standardization of zooplankton methods where it was reasonably practical to do so.

A joint working group of SCOR, UNESCO and ICES was therefore set up to deal with this problem and at their first meeting in Paris 1964 a general plan was prepared.

Present were the convener, J. H. Fraser (ICES), Dr. G. Humphrey (SCOR), Dr. T. Parsons (UNESCO) and Prof. J. Krey (chairman of the Plankton Committee ICES). As plankton covers such a great range of organisms, in size, shape, consistency, behaviour and taxonomic grouping no single standardized method is possible and arbitrary divisions become necessary, each with its disadvantages as well as advantages. Of these size was chosen as the most practicable and innocuous, and the following terms of reference were agreed:

Terms of reference

To set up small working parties from experts in their particular fields of work, who will examine and consider the methods used at sea and in the laboratory in sampling zooplankton of various categories, and make recommendations concerning the methods they consider the most satisfactory for general adoption. Where they consider present methods inadequate, new methods should be recommended, based if necessary on new hydrodynamic or other research. Where it is possible to do so the working parties should compile a series of intercalibration factors between the methods especially where much data have been published.

There should be four such working parties in zooplankton (including fish eggs and larvae) to deal with:

1) The microzooplankton, at present samples by water bottle, very fine meshed nets and pump filters.

2) The zooplankton now sampled by a great range of techniques, but largely dependent on filtration through a No. 3 mesh (about 60 meshes per inch).

3) The larger zooplankton, often sampled by stramin or other coarse meshed nets.

4) The faster moving macroplankton, such as the larger euphausids and small fish.

We agree that the working parties should be of a practical size and there should be five members to parties 1, 3 and 4 but seven for w.p. 2 which has more complex problems, chosen from suitable experienced experts and representing as far as reasonably practical a world wide coverage of interests.

It is important to emphasize that while standardization of plankton methods would assist greatly in the comparisons of one area with another, and would help in the selection of gear by those needing such help, standardization should in no way be interpreted as a bar to progress towards further improvements of methods, nor as a discouragement in the use of other more specialised gear for purposes where this is considered desirable

It was agreed that an effort should be made to complete the work of WG 13 in two years time.

Personnel of the working parties

It was regarded as essential that the members of each working party should not only be experienced in the appropriate field but should be selected on as wide a geographic basis as possible. With a view to this all the countries represented in SCOR were asked to nominate suitable personnel for consideration by the convening committee and these lists were very helpful in selecting the w.p. members. Not all those first selected were able to give their services and those finally selected were:

Working Party 1

R. Currie	(U.K.) Convener
J. Krey	(Germany)
K. Banse	(U.S.A.)
V. Hansen	(Denmark)
I. McLaren	(Canada)

Working Party 2

A. W. H. Bé	(U.S.A.) Convener
N. Della Croce	(Italy)
A. Boudillon	(France)
A. de Decker	(South Africa)
B. Kimor	(Israel)
E. Hagmeier	(Germany)
B. Bogorov	(U.S.S.R.)

Working Party 3

D. Tranter	(Australia) Convener
M. Vannucci	(Brazil)
J. Gehringer	(U.S.A.)
M. Vinogradov	(U.S.S.R.)
M. Anraku	(Japan)

Working Party 4

P. Foxton	(U. K.) Convener
W. Aron	(U.S.A.)
M. Legand	(New Caledonia)
T. Nemoto	(Japan)

Although these members are given with their nationality, their representation on the working parties is entirely international. The chairman of WG 13 would endeavour to attend any working party meeting if this was desired by the convener and would also act in an advisory capacity by correspondence with all four working parties.

Financial

To help keep expenses within reasonable bounds we expected the working parties to do much of their work by correspondence, but some meetings would certainly be necessary. The costs of the working parties would be borne on an equal basis between SCOR, UNESCO and ICES. Although an assessment of costs before hand could not be expected to be accurate, a figure of 12,000 U. S. dollars was estimated, i.e. 4,000 dollars for each of these three organizations over a two year period. Each organization agreed to meet costs up to this estimated figure.

When arranging from which source the various expenditures would come, it has not been possible, in practice, to divide these very evenly.

In part this is due to the way different people naturally fall heir to patronage by one organization rather than another. Certain expected expenditures failed to materialize; for example, Soviet members were unable to attend meetings at Villefranche and Sydney, and international expenditure for the Sydney meeting earmarked for ICES was generously born by CSIRO. Also, working parties 1 and 4 have done their work by correspondence, thus saving the expense of meeting.

As things stand, UNESCO payments have slightly exceeded the quota ($4,302). In addition, UNESCO helped very considerably in meeting expenses of the Sydney symposium. SCOR also supported the symposium generously, and has spent most of its quota. ICES still has about $2000 in hand which will be held for future expenses of WG 13 in producing their reports.

Symposium on the Hydrodynamics of Plankton Samplers

The suggestion to hold this symposium was first proposed by David Tranter as a valuable way to provide the background knowledge necessary to the proper functioning of w.p. 3. It was logical to recommend that it be held at Sydney, where the right facilities were readily and freely available at the University of Sydney through the courtesy and co-operation of the Department of Aeronautical and Mechanical Engineering, and where all the prior organization could be done on the spot without additional expenditure.

The idea was strongly supported by w.p. 2 and by ICES, and thanks to help from SCOR and UNESCO it was possible to hold the symposium at Sydney in February 1966. There were 27 participants plus 7 observers from Australia, and 38 contributions were presented.

The Symposium started with two days practical testing at the University of Sydney. Here experimental work was carried out:

1) Using model nets in wind tunnels with visible smoke trails. Models of various meshes and length of cone were tested without and with clear perspex cases to represent encased nets such as the Gulf III; nets were held at different angles, and various degrees of artificial clogging were used.

2) Testing the w.p. 2 net in a larger wind tunnel. A hot wire anemometer was used to give a full picture of the flow and turbulence over the whole diameter of the net at various distances in front of it, and including the effects of the bridles and to ascertain the best position for the flowmeter.

3) Testing the Clarke-Bumpus net for flow and filtration coefficient using various meshes and lengths of cone and at various speeds in the water test tank.

The w.p. 2 net was also tested from a boat in Sydney Harbour to ascertain wire-angles and behaviour at sea.

Much of great value was learned at the Symposium and it is a pleasure to record appreciation of the very helpful co-operation of the staff of the University of Sydney, of the excellent organization by the convener David Tranter of CSIRO through the courtesy of Dr. Humphrey.

It was suggested that UNESCO publish in their monograph series a review based on the papers contributed to the Symposium and prepared in seven chapters (see w.p. 3 report). Some of the papers presented at the Symposium were being prepared for publication elsewhere, others were concerned with work not yet completed, and it was considered best to publish in this review form rather than publish the individual papers (as suggested in SCOR Proceedings, 1 (2): 50).

Implementation of Recommendations

Working Group 13 has essentially completed its studies on the standardization of zooplankton sampling. Reports of the individual working parties are attached to the present document. The final integrated report is now to be written.

No progress has been made towards the production of intercalibration factors between various methods as this is considered impracticable or would involve an undue amount of effort that could be better spent on more fruitful pursuits.

We have made recommendations for the adoption of a standardized net for biomass sampling, which we hope will be internationally adopted, and for the design of a net for sampling the larger zooplankton until a more satisfactory encased high speed sampler has been designed. This, too, we hope will be internationally adopted. ICES Plankton Committee at their 1965 meeting in Rome recommended "that as soon as the recommendations from the working parties on the Standardization of Zooplankton Methods organized by ICES/UNESCO/SCOR are available, the member countries of ICES should co-operate in comparative tests with the recommended gear." It is hoped that other countries and institutions throughout the world will also adopt these recommended gear, where necessary as an addition to their own specialized equipment.

We have also made recommendations for future work, some of which we consider can be left in their present form to stimulate relevant research by interested laboratories, but SCOR should help by publicising them. Other recommendations should be given special impetus. The most important of these is the recommendation to ask appropriate institutions which have the necessary facilities, to design the best possible encased high speed sampler to meet as far as practicable the points laid down by w.p. 3. Such an impetus could come either from the SCOR executive or from the convener of WG 13 with the backing of SCOR, UNESCO, and ICES.

SCOR could also, we believe, help by organizing the preparation of the list of facilities available for testing plankton nets (w.p. 3 recommendation 3). The recommendation of w.p. 3 (Rec. 4) concerning telemetry is closely linked with w.p. 2 (Rec. 2) and in this connection it is useful to state that at the October 1966 meeting of ICES a joint session of the Plankton and Hydrographic Committees will have as its main theme "The present use of recording and telemetering apparatus in plankton research and hydrography."

Working party 2 has recommended that "a small permanent international committee be set up to keep standardization of plankton sampling under review and to make such recommendations as may be advisable." I envisage this not as an unlimited prolongation of WG 13 but that SCOR should periodically set up a working group to look into this question. The choice of period for review would be decided by SCOR Executive, but I would expect something in the order of five years or more would be adequate, and the personnel would be chosen afresh each time. I believe this to be a sound recommendation as further research will undoubtedly lead to improvements in methods that will gradually make the present recommendations of WG 13 out of date.

WG 18 has suggested (SCOR Proceedings 1 (2): 88) that the terms of reference of WG 13 "be extended to include a guide for the presentation of biomass data and qualifying information to World Data Centres (and specialised centres, where such exist, for international expeditions)." They also recommend (page 89) that WG 13 (with other WGs) consider whether data on presence and abundance of the various taxa "can be submitted to W.D.Cs. in a breakdown and with the supplementary information as far as possible compatible with the data forms given in the 'Manual' of NODC, Washington."

These suggestions of WG 18 need special consideration in the question of the future of WG 13 as they came too late to be included in the topics discussed by the WG 13 working parties. The members of the four w.ps. were selected for their abilities to discuss the original terms of

reference and it may well be that they should complete only their original duties. Rather than prolong the existence of WG 13, SCOR should consider the advisability of selecting new personnel for the new topic and to set up a new WG.

As Chairman of WG 13, I wish to express appreciation of the help given by SCOR and by UNESCO in the duplication and dispatch of letters and reports, and of the work and time given by the working party conveners and members with such generous enthusiasm.

James H. Fraser
Chairman WG 13

Report of Working Party 1 (Microzooplankton)

The activities of working party 1 have been conducted by correspondence. The progress made has thus been subject to the customary limitation of this approach, but the convener has had personal meetings with all but two of the members and believes this report is a fair statement of opinion.

1. Size range of organisms considered

Members of the w.p. have assumed that they are concerned with the animals ranging in size downwards from those with which w.p. 2 are concerned. Since no joint discussion has as yet taken place with w.p. 2 we have assumed arbitrarily for the present an upper size limit of about 200 μ. The size group dealt with thus includes all the smaller animal constituents of the plankton community variously described as nannoplankton, microplankton, etc., and includes everything from the smallest protozoa to the eggs and larvae of a wide range of organisms and the adults of many smaller forms such as the copepods.

2. Objective of investigations

These can be classified as follows:

2.1 Qualitative

- 2.1.1. Systematic
- 2.1.2. Distributional
- 2.1.3. Life histories
- 2.1.4. Community structure

2.2 Quantitative

2.2.1 Production
2.2.2 Biomass
2.2.3 Population dynamics
2.2.4 Physiological studies

3. Requirements for a standard method

There is a very pressing need to find out more about the composition of the microzooplankton and to find out how important they are in the general ecology of the sea. They are undoubtedly a very important link between the bacteria and phytoplankton and the zooplankton organisms and it is possible that a substantial part of the energy transfer is conducted by the microzooplankton. Qualitatively we need to acquire information about their systematics, their distribution in time and space and their community structure and trophic relationships. Quantitatively we need measurements of their biomass, information on their physiology, particularly of feeding, respiration and excretion, and information about their behaviour.

The main fields in which some unification of methods might help would seem to be in distributional and quantitative studies.

4. Existing methods

Field methods

Water bottle samples varying in size from 100 cc to 100 litres
Pump samples
In situ filtration with
Membranes
Micro-mesh nets
Fine nets (> 40 x 40 μ aperture)

Laboratory methods

Fixation and preservation
Formalin
Lugol
Osmic acid, etc.

Concentration
None
Sedimentation
Centrifugation
Filtration (membrane, paper or mesh)

Subsampling

Counting
- Staining
- Haemacytometers
- Larger squared slides
- Inverted microscope

Biomass determination
- Dry weight
- Protein, Carbohydrate, etc.,
- Total carbon, phosphorus, nitrogen, etc.
- Electronic volume measurement
- Computation from microscopic size measurements

5. Recommended methods

Clearly there has been no time to conduct any experimental work and make comparisons of different methods and the following comments are thus merely the majority opinions of the working party.

Field sampling - The majority perference is for the use of water samples and it is generally felt that a 10 liter water bottle should give a significant sample of forms up to about 150 μ in size. The main disadvantage of water bottles, however, is that many samples must be taken to cover different depth ranges and for certain purposes water samples integrated over a depth range may be perferable (as used by Lohmann, Strickland and Parsons and others).

Some members of the w.p. expressed a preference for nets for organisms at the larger end of the size range (75-200 μ) and for the more sparsely distributed organisms but it is doubtful whether we should be concerned with the latter at the present state of work in this field. In particular nets have the advantage of eliminating the effects of marked vertical stratification but at the same time existing fine mesh nets are difficult to operate in bad weather, they clog easily and inevitably lose the smaller organisms. Probably the question of the use of nets would best be discussed further when the recommendations of w.p. 2 are available.

Laboratory methods - Little comment has been made on methods of fixation and preservation. Formalin perferably buffered with Hexamine is the most satisfactory general fixative but is of questionable value for use with calcareous forms. Rhode's iodine fixative is preferable for use with the naked forms but is still a poor substitute of the examination of living material. Clearly there is a great need for further research in this field and

some liaison with phytoplankton workers dealing with the same problem would seem desirable.

The occasions on which no concentration of material for counting is required are the exception rather than the rule, and generally some technique is required to present the material in a suitable form for counting. Sedimentation appears to be the method most widely favoured. The reason for this is largely the uncertainty of other methods. Both evidence for and against the reliability of centrifugation has been produced and filtration, while adequate for larger forms, can not really be considered satisfactory as a quantitative technique for many of the smaller organisms as they are either disrupted or disappear optically.

Subsampling and counting can, for convenience, be considered together. Generally it is felt that to obtain an acceptable numerical estimate, one should count a sample of such size that some 30-40 organisms of the particular species of interest can be counted. It is thus inevitable that the sample size chosen must be varied inaccordance with the object of the count. The working group is in favour of using a mechanical form of subsampling (as, for example, by means of a Stempel pipette) to make this possible. There seems to be sufficient evidence to cast doubt on the reliability of making counts on only part of the area of a squared slide and counting only part of the area of a filter can be extremely misleading owing to the non-random distribution of material.

The actual technique of counting must inevitably depend on the size of organism being dealt with. The Sedgwick-Rafter cell is satisfactory for the larger organisms and Haemocytometers are adequate for the smallest but care must be taken to avoid counting say nannoplankton on a Sedgwick-Rafter cell about 1 mm. deep as many specimens can be overlooked. A useful halfway measure is a squared slide with a cell of coverslip thickness and having a capacity of about 0.5 ml. This has the advantage that moderately high power objectives can be used for examination. Inverted microscopes overcome some of these difficulties but have the disadvantages of making difficult detailed examination of an object from different aspects. Beyond aiming to make counts as quantitative as possible and avoiding these more obvious difficulties little else can be said with regard to counting.

The estimation of biomass is perhaps the field most calling for standardisation but at the present time no one method seems to offer the potential for widespread adoption. The basic difficulties of separating dead from living material, phytoplankton from zooplankton as yet seem to forestall any completely satisfactory approach and any method adopted

would at best be a compromise. Similarly some uniformity of approach to the problem of production must be sought but again little progress has been made towards agreement and at best we can only recommend active investigation in this field.

Report of Working Party 2 (Small Zooplankton)

(NOTE: Not all members of w.p. 2 have had a chance to comment on this draft, which thus must be regarded as an interim report).

INTRODUCTION

A standard sampler of simple, practicable design is proposed as one of a set of four instruments for quantitative, comparative biomass studies of marine plankton in the upper 200 m. of water. The design of the net and other pertinent recommendations were agreed upon during a conference held between September 28-30, 1965 at the Station Zoologique at Villefranche, France, and it will be referred to as the "original version" of the WP 2 Net (for working party two) in this report. An improved version of this net will be described below and recommended for standardization. Because the net material has a mesh aperture width of 202 μ, the WP2 Net can be considered to sample the "microplankton" or the planktonic organisms in the size spectrum from 10 mm downward to a width of at least 200 μ. We realize that the retention of motile organisms by a mesh screen depends largely on their largest cross-section or width dimension. Thus, a copepod 600 or 700 μ in length, having a cross-section of 150μ, has a better chance of escaping than a spherical radiolarian of 210 μ diameter.

The WP2 Net (original version) has been tested in a wind tunnel using a hot wire anemometer and in a towing channel at the aeronautical and hydrodynamic laboratories of the University of Sydney in February, 1966 under the direction of Mr. David Tranter of CSIRO, Cronulla. Profiles of velocity and turbulence in front of the mouth opening were obtained with and without bridles. These measurements yielded data on flow patterns, filtration efficiencies at various towing velocities, and the optimum site for flowmeter placement.

In addition, the WP2 Net was field tested on several cruises in waters of widely variable plankton standing crops. The tests were conducted by Dr. Paul Smith of the U. S. Bureau of Commercial Fisheries in the eastern North Pacific during the spring of 1966. Using two telemetering flowmeters, one mounted outside and the other inside the mouth opening of the net, he was able to monitor the water flow through the net at

various velocities. Ten-second readings were taken simultaneously for both meters every 30 seconds on an electronic event counter.

The field tests clearly demonstrate that the filtration efficiency of the WP 2 Net changes during towing due to clogging. From a limited munber of observations in oceanic waters of California, it was noted that the filtration efficiency of the WP 2 Net decreased from 94% efficiency at the start to 85% (level at which clogging is considered to begin) after a period of 4 minutes towing at 2 knots in very rich, neritic California Current waters. In relatively clear waters outside the California Current enrichment, 200 miles off Point Conception, the WP 2 Net began to clog (filtration efficiency dropping to 85%) after 16 minutes of towing at 1 1/2 knots.

In light of the field results, we can now suggest three changes in our preliminary recommendations. First, an increase of filtration ratio from 5:1 to 6:1 should add a margin of safety against clogging. Second, the shape of the net should have a cylindrical front section and a conical end section, each having a filtration ratio of 3:1, giving a filtration ratio for the total net of 6:1. The cylindrical portion will act as a self-cleaning section and has a superior sustained filtration efficiency (Smith, Counts and Clutter, 1965), while it simultaneously helps to shorten the length of the net without altering the filtration area. Third, the net should be towed in a vertical (rather than oblique) manner in the upper 200 m. of water, so as to reduce the towing period, and, hence, avoid the possibility of clogging. Since plankton-rich waters often occur over continental shelves where water depths are less than 200 m., the vertical tows are consequently limited to correspondingly shorter water columns in these regions.

SPECIFICATIONS OF WP 2 NET

Shape = cylindrical - conical. Length of cylindrical section is 95 cm; side length of conical section is 166 cm.

Mouth opening = 57 cm internal diameter, circular, maintained by a brass or galvanized iron ring made of metal rod 1.5 cm in diameter thickness. To give an area of 0.25 m^2, the diameter should be 56.4 cm. However, the 57 cm internal diameter is intended to make up for the thickness of canvass.

Mouth area = 0.25 m^2

Net material = Nylon Nytal 7P or similar net material*, basket weave, with mesh aperture width of 200 microns. Porosity (= ratio of mesh aperture area to total mesh area = mesh transparency) = 55%.

*A list of alternative materials and their manufacturers is being compiled by w.p.2.

Canvas attachment to ring = 10 cm width.

Canvas band for throttling line = 10 cm width (57 cm below upper canvas band).

Bridle (3) = 57 cm long each, attached to swivel.

Filtration ratio (ratio of mesh aperture area to mouth area) = 6:1

Filtration efficiency = 0.94 (94%)

Lead weight = 25 kg (40 kg or heavier when wire angle tends to exceed 25°).

Flowmeter = TSK or equivalent, to be attached from three points on mouth ring and centered at 14.25 cm from rim.

Cod-end = a) bucket with window of same mesh as net (7.5 cm diameter; volume of 150-200 cc) for biomass or taxonomic purposes. PVC (polyvinylchloride) or light brass.

b) bucket with window of same mesh as net (7.5 cm diameter; volume of 500 cc) for living plankton catches.

c) bag of same mesh as net (for tows in very rich waters).

Iron ring = 57 cm internal diameter of ring; 1.5 cm diameter thickness; with three eyelets, 120° apart, for bridles and rope lead attachments.

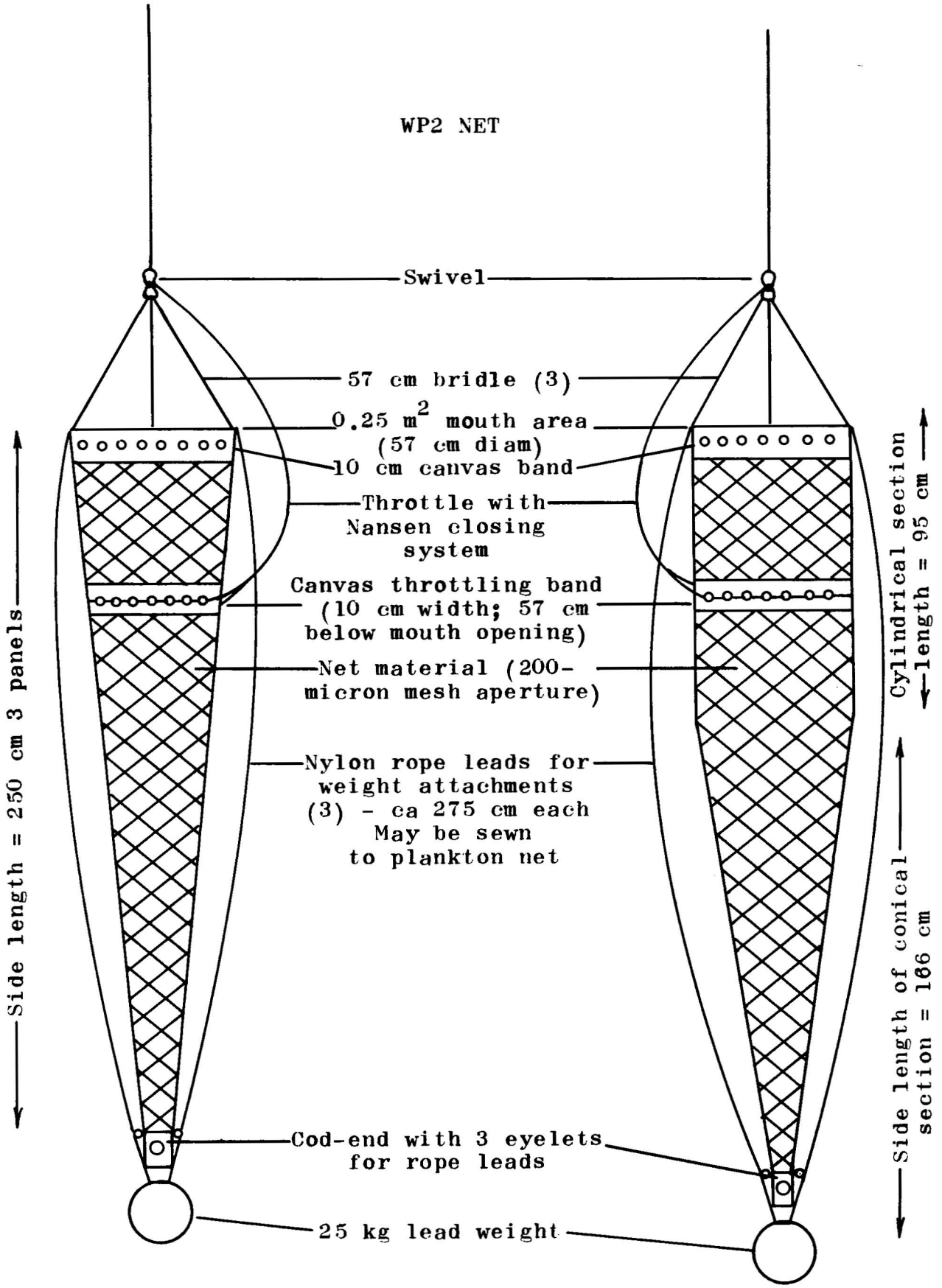
Cod-end arrangements

The hydrodynamics of a conical net are such that precise details of the cod-end arrangement are not of great importance and laboratories can use the method they find most suitable for the conditions in which they operate. If there are no special perferences we recommend:

a) A bucket, with one or more windows of a metal gauze of the same mesh as the net. Where the catch is to be used for research with living material, a reasonably large volume of water - 500 cc or more - below the windows is desirable; where it is to be preserved for biomass or taxonomic purposes, a smaller bucket is preferable, and we recommend a diameter of 7.5 cm and a volume of 150-200 cc. Buckets should be made of PVC (polyvinylchloride) or brass of light construction.

Original Version

Modified and
Recommended Version



Filtration ratio 5:1

Filtration ratio 6:1

b) Where plankton is rich, and is not required living, a detachable cod-end bag of the same mesh as the net is more convenient to handle than a bucket.

The end of the net should fit flush into the cod-end so that there is no pocket in which plankton can collect. The bucket, or bag, can be attached by a simple band, screw, or bayonet fitting. The ring supporting the cod-end should be fitted with eyelets to which cords can be attached so that the weight of the cod-end is not taken directly by the filtering material of the net.

Flowmeter

The flowmeter should be of the Tsurumi-Keiki Kosakusho Co. (Japan) type or of any other equally effective or robust manufacture. It should have a stop to prevent reversing and another stop to prevent turning in air, although they are not so necessary with a depth-flowmeter. Recent hydrodynamic tests in the U.S.A. have indicated that the optimum placement of the flowmeter for the most representative measurement of the flow of water into a net should be half-way between the center and the rim of the sampler's mouth. Accordingly, we recommend that the flowmeter be centered at 14.25 cm from the rim. Whenever possible a second flowmeter should be placed an equivalent distance outside the rim. The ratio of the inner to outer flowmeter readings will yield the integrated filtration efficiency for each tow. A filtration efficiency less than 85% would indicate that clogging has occurred and the tow should not be regarded as quantitatively accurate.

Flowmeters should be calibrated at least every three months in a swimming pool; these calibrations may be checked at sea under very calm conditions by hoisting the meter in a vertical manner at velocities of about 90 m/min.

Net material and mesh size

Nylon has several advantages over silk as netting material. The former is more durable and does not shrink when wet as silk, although it is subject to considerable deformation in shape under stresses. We recommend nylon monofilament, basket-weave netting material (e.g. nylon Nytal 7 P and the polyester Estal Mono P.E.) because of their good resistance against friction and moderate deformation. The mesh should be entirely basket-weave rather than alternate basket and twist weave, which are deformed more easily. The mesh opening should have an aperture of 200 microns by 200 microns when the net is wet and used.

SAMPLING METHODS

Depth of towing, towing speed, duration and time of towing

In view of the field tests results which have shown that clogging of the Villefranche net can occur rapidly in rich, neritic waters, we recommend that this net be towed in a vertical manner in the upper 200 m. of water. In shallower waters, the vertical tows should be taken from just above the sea bottom to the surface.

In order that the tows be taken in as vertical a manner as possible, a lead weight of 25 kg is recommended when sea conditions are relatively calm. When the ship drifts rapidly, a lead weight of 40 kg or more may be required to keep the wire angle below our suggested maximum of 25°.

The net may be lowered at 60 m/min. and raised at 45 m/min. Since the Villefranche net will be lowered with weight and cod-end first and the mouth opening is not presented to the direction of water flow, it is assumed that no plankton is collected in the net during lowering. The plankton is collected during hoisting, which should give a towing duration of about 4 1/2 minutes for the 200 m. water column at a raising speed of 45 m/min.

In order to minimize the influence of diurnal migration on biomass studies, it is recommended that sampling be done as far as possible during the 3-hour period after sunrise and after sunset. This does not preclude sampling at other times, but these may not be so strictly comparable in biomass studies.

OPENING-AND-CLOSING SAMPLES

For vertical distributional studies, sampling should preferably be carried out in accordance to the water structure.

When hydrographic information is not available, the following water columns should be sampled by vertical tows while the boat is drifting:

0 - 200 m
200 - 500 m
500 - 1000 m
1000 - 1500 m
1500 - 2000 m
2000 - 3000 m

Two alternative ways of obtaining such samples are by:

a) Modified Nansen method. A throttling line can be attached to the lower canvas band of our standard sampler and linked to the release mechanism (Discovery Rept., vol. 1, pp. 151-222, 1929), and a weight shou . be used below the cod-end for vertical series.

b) Multiple opening-and-closing plankton sampler (Bé, Deep-Sea Research, vol. 9, 1962) for obtaining larger quantities of plankton by oblique towing. Three quantitative samples from three predetermined depth ranges can be collected during a single lowering.

PRESERVATION OF PLANKTON SAMPLES

We recommend the use of formaldehyde as a fixative and preservative. The saturated solution known as "Concentrated formalin" contains 38-40% formaldehyde. One part of concentrated formalin should be added to nine parts of sea water including the plankton sample, and this should be done as soon as possible after collection. As a precaution against the dissolution of calcareous plankton in highly concentrated samples, the strength of buffered formalin should be doubled in such samples.

It is essential that the formalin be neutralized before use by addition of either borax (sodium tetraborate), marble chips or another suitable buffering agent. Marble chips have the advantage of dissolving gradually in the same measure as acid is prod ced in the formaldehyde solution. Checking on the presence of undissolved marble chips or checking with pH indicator paper are two simple ways of ascertaining whether the solution is still neutral. Hexamine, apart from being expensive, has the disadvantage of easily crystallizing around organisms when the sample is subject to even a slight amount of evaporation, e.g. while being examined under the microscope in an open dish.

Commercial formalin is often contaminated with iron componds which, on neutralization, produce a brown precipitate of iron hydroxide. This precipitate spoils the sample by sticking to the surface of the organisms and obliterating their finer structures. It is, therefore, recommended that analytical grade formalin be used and stored in glass or plastic containers.

GENERAL CARE AND MAINTENANCE

Nets should be hosed before being brought aboard to wash plankton into the cod-end.

Nets that show signs of clogging can be washed by towing the net without a cod-end or when clogging is more severe the nets should be washed in detergent. Nets should be washed in fresh water after each cruise before storage.

Nets should not be left in the sun for prolonged periods nor left where there is risk of unnecessary damage by friction wear and tear.

Flowmeters should be washed with fresh water after use.

DETERMINATION OF BIOMASS

If possible, two identical plankton samples should be taken simultaneously -- one for biomass study, the other for taxonomic use. If not, a single sample is taken and split in half by a method still to be recommended.

The first sample (or sub-sample, in case of splitting) is preserved in formalin for taxonomic and counting purposes.

The second sample (or sub-sample) is deep-frozen, then dried according to the technique recommended by Lovegrove (In: H. Barnes, edit., "Some Contemporary Studies in Marine Science", pp. 429-267, 1966) and finally weighed for dry-weight measurement. The organic matter will be determined on this sample by loss upon ingition. The results (dry weight and organic matter) are expressed in mg/m^3.

Tests should be made to determine the effect of formalin fixation upon dry weight and organic matter content. If formalin preservation should be found to have no undesirable effect, it could be used as a routine technique and samples preserved in formalin could be split in the laboratory ashore, one-half to be used for dry-weight and organic matter measurements.

RECOMMENDATIONS FOR FUTURE WORK

1. Hydrodynamic and field testing of our standard samplers and to acquire basic knowledge of net design and high-speed samplers in relation to water flow, plankton behavior, concentration, and patchiness. Research on materials (e.g. net material).

2. Development of a telemetering depth-flowmeter, electrically opening-closing samplers, a shipboard flowmeter calibration tank, and a flowmeter with digital dial operated magnetically.

3. Research toward elimination of bridle and other obstructions in front of net -- as related to plankton avoidance of nets.

4. To study effect of ship's shock wave and noise on plankton sampling.

5. Compile and keep up-to-date a bibliography on sampling gear, sampling methods and processing plankton samples.

MEASURING TOTAL PLANKTON BIOMASS

Assuming that agreement can be reached on standardization of a set of plankton samplers of different dimensions and mesh apertures, we are then faced with the problem of integrating our various catches to obtain "total biomass".

The plankton catches from these various samplers will overlap with one another with respect to kind and size. A net can theoretically select the lower size limit of organisms, but can not discriminate for the upper size limit which depends largely on the kind of plankton present, the towing speed, and the area of the mouth of the net.

A scheme is proposed for eliminating the overlapping upper size fractions from each haul that are duplicated in the samples from the coarser-meshed nets by means of a series of graded sieves whose meshes are equivalent to those of the standard samplers used. Each plankton catch is filtered through a separatory column and is divided into as many classes as there are standard samplers. For a series of four standard samplers the theoretical total would be 16 fractions as shown in the following arbitrary model:

Separatory column with graded sieves	water bottle (o μ)	202 μ Net	1000 μ Net	5000 μ Net
5000 μ	A^3	B^2	C^1	D
1000 μ	A^2	B^1	C	D^{-1}
200 μ	A^1	B	C^{-2}	D^{-2}
0 μ	A	B^{-1}	C^{-3}	D^{-3}

The fractions A, B, C and D theoretically contain the plankton organisms that are most ideally collected by each of the standard samplers and their sum (after correcting for the volumes of water filtered by each sampler) should give us the best estimate of "total plankton biomass".

This scheme was proposed by A. Bé at the "Symposium on Hydrodynamics of Plankton Samplers" CSIRO, Cronulla, Australia -- February 14 - 16, 1966 and its validity as well as "sampling suitability" of each of the recommended plankton samplers need to be investigated more thoroughly.

Report of Meeting of Working Party 3 (Large Zooplankton)

February 1966, Cronulla, Australia

A. SYMPOSIUM

A symposium on plankton samplers preceded the meeting of the working party. The theme was 'Hydrodynamics of Plankton Samplers' but the papers and discussion covered a wider range of relevant topics. There were 38 contributions presented or read. The Symposium included demonstrations and tests in the aeronautical and hydrodynamic laboratories of the University of Sydney. The tests were made on a net of mesh aperture 200 μ, recommended by working party 2. There were 27 participants and 8 (Australian) observers. Eight papers were read in absentia.

B. REVIEW OF PLANKTON SAMPLING METHODOLOGY

It was agreed that a review of plankton sampling methodology should be prepared to be published by UNESCO, the work to include the bibliography already prepared and an appendix on terminology. The publication of approximately 100 pages will be prepared by the following contributors:

1. History of sampling - Fraser
2. Gauzes - Heron
3. Flow patterns - Tranter and Smith
4. Loss through the meshes - Hempel and Vannucci
5. Avoidance - Anraku and Clutter
6. Field techniques - Aron and Gehringer
7. Design of sampling - Cassie

The contributions are to be in the hands of the Editor (CSIRO Cronulla) by September 30.

C. RECOMMENDATIONS

Upon the assumption that the goal in quantitative plankton sampling is to take a representative sample of a particular size group in the plankton spectrum, the following recommendations were made:

1. That an encased sampler with a net of mesh aperture 1 mm be designed to sample the larger zooplankton, its specifications to be dictated by the following considerations:

(i) That the sampler should filter at a rate of not less than 20 m^3/ minute.

In addition it would be useful to measure also the speed of the sampler in situ.

(ii) That the flow through the sampler should be metered.

(iii) That the mesh velocity (exit velocity from the meshes) should not exceed 10 cm/sec.

(iv) That there should be no obstructions ahead of the sampler mouth.

(v) That the sampler should tow in a stable manner and the drag be as low as possible.

(vi) That the sampler be fitted with a depressor capable of taking it to a depth of at least 200 m at a speed of at least 6 kt.

(vii) That the sampler should be fitted with an acoustically operated opening closing action and a depth sensor telemetering to the surface, and that space should be left available for further modules if required.

(viii) That the sampler be robust and non-corrodable.

(ix) That the net and the catch be easy to remove and the flowmeter easy to read.

(x) That the sampler be as small as possible consistent with the above requirements.

2. That a simple unencased net with the following specifications would serve as the best interim sampler for the larger zooplankton.

(i) Mouth of 1 m^2 consisting of a 3/4" (approx. 2 cm), outside diameter, ring of galvanized tubing.

(ii) Net with a cylindrical forward part, 57 cm long, and a conical after part, 200 cm long, strengthened with 6 longitudinal tapes not more than 2 cm wide.

(iii) Gauze of monofilament nylon of mesh aperture 1 mm.

(iv) Throat of dacron sailcloth not more than 12 cm wide to be wrapped around the ring. Notches at 3 equidistant points to take the bridle lugs.

(v) Bridle of 3 legs equal in length to the mouth diameter.

(vi) Flowmeter to be placed 25 cm inside the ring. It would be useful also to have a second flowmeter outside the net to measure the speed of the net through the water.

(vii) Bucket to be light in weight.

(viii) Towing speed to be 2 - 3 kt.

(ix) Sinker to be either a dead weight of approximately 40 kg or an equally efficient depressor.

(x) It is considered that there is no satisfactory way of closing this net.

3. That a list be made of the facilities available throughout the world, suitable for testing plankton nets, e.g. test tanks, circulating water channels, wind tunnels etc.

4. That further research be undertaken to find the best practical means of telemetering information from the sampler to the surface and telemetering control signals from the surface to the sampler.

D. J. Tranter
Convener

NOTE: The points made by w.p. 3 for consideration in the design of a sampler are suggested as ideals. In practice these ideals cannot be

achieved without making a sampler larger than can be conveniently handled so that a sacrifice of ideals will be necessary. WG 13 will discuss this by correspondence so that some indication of where and how far the sacrifices may be made can be given to the designers.

J.H.F.

Report of Working Party 4 (Micronekton)

INTRODUCTION

The development of sampling methods for capturing the larger plankton and smaller nekton in a quantitative manner is in its infancy and although some progress has been made little gear has been designed specifically for this purpose. A plea for standardisation might thus appear inopportune at this stage. However, it is apparent that one promising design is in widespread use and already a large body of catch data is available. Our recommendations are therefore directed towards introducing some degree of acceptable uniformity in the construction, dimensions, and operation of this sampling device, so that valid comparisons can be made with data from different sources. It is also hoped that these recommendations will serve as a guide to those initiating new sampling programmes.

1. CATEGORY OF ANIMALS TO BE CONSIDERED

We have considered methods by which a representative sample can be taken of pelagic organisms lying within the arbitrary size range 2.0 to 10.0 cms. No single term as yet defined (macrozooplankton, micronekton, forage organisms) is strictly applicable under this definition but if a term is to be used the "micronekton" is recommended since it implies less of an overlap with the planktonic animals considered by w.p. 3.

Within the size range 2.0 to 10.0 cms large decapods (Sergestiids, Penaeids, Oplophorids), fish larvae, small adult fish, small cephalopods and large euphausiids will predominate. Gelatinous organisms and animals lying outside the size range will occur in the catches and these must be considered separately from the main sample.

2. TYPE OF SAMPLER

Of the methods available it is apparent that one type of sampler - the Isaacs-Kidd midwater trawl (IKMT) - is in widespread use. Its advantages include a large mouth opening relatively free of bridles and other

obstructions, it is self-depressing, it is versatile and easier to fish than conventional conical nets of comparable mouth area, and it can be towed at great depth and at high speed. Of its disadvantages perhaps the most important is that we have no measure of the volume of water filtered so that it is only semi-quantitative. Nevertheless with the realisation that it falls short of the requirements of an ideal sampler we have no hesitation, at this state in the development of sampling devices, in recommending the IKMT as a basis for standardisation.

2.1 Size of Sampler

There are advantages in having as large a net as possible but shipboard facilities vary to such an extent that absolute size could be a limiting factor. For this reason we recommend two sizes: 6 foot and 10 foot, -- this dimension referring to the spread of the depressor.

2.2 Overall physical dimensions and method of rigging

Specifications of net, depressor, spreader bar, etc. and method of rigging can be found in the following reports:

6': Aron, W., 1962. Some aspects of sampling the macroplankton. Rapp. Cons. Expl. Mer, 153: 29-38.

10': Isaacs, J. D. and L. W. Kidd, 1953. Isaacs-Kidd midwater trawl. Scripps Institution of Oceanography S.I.O. Ref. 53-3: 1-18.

2.3 Mesh-size

0.5" stretched mesh nylon, preferably knotless. It is usual to support this finer mesh within a 2 1/2" knot to knot outer net. We strongly deprecate the use of nets having mixed or graded meshes.

2.4 Cod-end

There is evidence that the catch is maintained in better condition if the trawl terminates in a metal or plastic container preceded by a short fine mesh section, of 3 mm mesh aperture. It must be emphasized that thes finer mesh will superimpose on the main catch a fraction of animals smaller than 2.0 cm. which must be excluded in the final treatment of the sample.

3. TYPE OF HAUL

Whether an oblique or horizontal tow is used depends largely upon the nature of the problem under investigation since they meet different requirements. Oblique tows are best suited to small or large scale regional surveys aimed at delimiting distributional patterns, of species or biomass, within the top 200 m. Horizontal tows are applicable to studies of variation in vertical distribution, sampling with respect to thermoclines and scattering layers, and sampling more sparsely distributed organisms.

In the circumstances we can only recommend procedures that should be followed in making these two quite different types of haul. The importance of adopting and maintaining rigorously a standard sampling procedure cannot be overemphasized since only in this way can valid comparisons be made between a series of hauls.

3.1 Oblique haul

3.1.1 Pay out at 40 meters/min.

3.1.2 Haul in at 40 meters/min.

3.1.3 Ship's speed throughout tow: 3 knots (except for shooting and recovering the trawl).

3.1.4 Depth of haul: 200 - 0 m.

3.2 Horizontal tow

3.2.1 Pay out at 40 meters/min.

3.2.2 Haul in at 60 meters/min.

3.2.3 Ship's speed 3 knots (see 3.1.3)

3.2.4 Duration of tow 2 hours at fishing depth

3.2.5 Depth of tow at 50 m intervals down to 1000 m.
at 250 m intervals below 1000 m.

4. SHIP'S SPEED

Recent work has shown that the IKMT is extremely sensitive to variations in ship's speed. It is therefore important to maintain a constant speed throughout the tow if the depth of fishing is to remain uniform.

5. DEPTH OF FISHING

The use of a depth-time recorder or a depth telemeter is a prerequisite of midwater sampling since an accurate knowledge of the depth of fishing is essential to a proper interpretation of the data.

6. DISTANCE OF TOW

Methods of metering the flow of water through the IKMT have yet to be evolved. However as a first approximation of volume filtered, estimates can be made based on mouth area X distance towed through the water (which equals the length of the sampled column). A flowmeter mounted in the cod-end can be used to give a relative measure of the length of water column sampled.

7. TREATMENT OF CATCH

Animals falling outside the size range 2 - 10 cm should be treated separately from the main catch. Consider catch by taxa: measure displacement volume or net weight and enumerate. If possible pool taxa and consider by tropic level.

CONCLUDING REMARKS

In concluding this report it must be emphasized that while our recommendations refer to existing gear we do not wish to imply that the methods available are adequate. On the contrary, it is clear that they leave much to be desired and progress in the quantitative study of these more active pelagic organisms will largely depend upon technical improvements in the IKMT and in the evolution of new devices and approaches. This work must be encouraged, it is long overdue, and we strongly urge that support be given to the following:

(a) Field and laboratory studies of the hydrodynamics and catching efficiency of the IKMT. An objective appraisal of this sampling device can only be made as a result of such work.

(b) Studies to evaluate the effectiveness of existing opening-closing systems and if necessary to design and produce new ones.

(c) The design and production of reliable, accurate depth-telemeters, operative to 5000 m.

(d) The design of devices that can be incorporated in the sampler to telemeter or record environmental parameters (light, temperature, etc.).

SUMMARY OF FIRST AND SECOND REPORTS OF SCOR WORKING GROUP 19 ON MICROPALEONTOLOGY OF BOTTOM SEDIMENTS

Meetings of WG 19 were held in Paris, on January 3 - 4, 1966, at the Laboratoire de Micropaléontologie, École Pratique des Hautes Etudes, and in Moscow, between June 2 and June 7, 1966, at the Moscow State University. All members of the working group were present at the meeting in Paris, but G. Deflandre and T. Kanaya were unable to attend the meeting in Moscow.

During the Second International Oceanographic Congress in Moscow, an open meeting of WG 19 was held in order to acquaint attending micropaleontologists with the aims of the working group, and to solicit suggestions. About 50 micropaleontologists (three quarters of them from the USSR) attended, and the resulting discussion influenced the content of the provisional version of the program appended hereto. In addition, a number of microscopes were available, and Russian workers demonstrated some of their microfossil preparations for discussion.

The principal results arising from all meetings are summarized below:

1. Definition of Field of Interest

The study of floras and faunas which contribute preservable micro-remains to bottom sediments of present seas and oceans, and their occurrence as fossils in these regions.

2. Terms of Reference

Taking into account the draft terms of reference presented by Professor Kort and comments received from national committees and individuals, it is proposed to amplify the original terms of reference (SCOR Proceedings, Vol. 1, No. 1, p. 25) by the addition of the following:

(a) Discussion of the technical and scientific procedures used in micropaleontological investigations of marine bottom sediments.

(b) Discussion of the principles of systematics, stratigraphy and environmental interpretation as applied in the above field.

(c) Facilitation of comparison of submarine stratigraphy with that of land areas.

3. Exchange of Samples

During the Moscow meetings, Cenozoic micropaleontological samples of various ages were distributed among working group members by W. R. Riedel and A. P. Jousé, in order that workers in the institutions and countries represented might be able more effectively to coordinate species identifications and age assignments. It is expected that some results from examination of these samples will be available by the time of the proposed Symposium, and that further exchanges will take place.

4. List of Marine Micropaleontologists

A list of active workers in this field will be compiled. Lists have been received for the USSR, Japan, Poland and New Zealand, and others are expected shortly.

5. Lists of Marine Bottom Samples

It was agreed to initiate the exchange of lists of available core and dredge samples.

6. Proposed Symposium "Micropaleontology of Marine Bottom Sediments"

Most of the discussions of WG 19 have been concerned with the organization of a Symposium. Its purpose is to bring together the widely-dispersed active workers in this field for the exchange of ideas, experience and materials.

The provisional program below includes twelve principal lectures to be given on specific topics by invited experts, shorter contributions on individual microfossil groups, and ample periods for discussion. Only one day is provided for uninvited papers on new advances in the field, and it was suggested that papers in this category be brought to the Symposium in a sufficient number of copies for general distribution so that they can be read and discussed informally by interested colleagues. It is expected that a number of microscopes will be available, and participants will be encouraged to bring illustrative samples and preparations with them, for mutual examination.

It is proposed to hold the Symposium in Scandinavia (possibly in Oslo, with Professor Braarud and associates acting as local organizers). Taking into consideration other European meetings of micropaleontologists, it seems that the nine-day Symposium should be scheduled between the middle of August and the end of September, 1967. It is estimated that about eighty researchers should be invited to attend. A way

will be sought to publish the papers and discussions in a form that will achieve world-wide circulation. (Both English and Russian editions are envisaged, and competent specialist translators will be required at the Symposium).

Provisional Program for the Symposium

Day 1

09.00-10.00	(1)	Distribution of plankton in the oceans in relation to physical and chemical conditions - main lecture
10.00-10.30		Discussion
11.00-12.00	(2)	Distribution of benthos in the oceans in relation to physical and chemical conditions - main lecture
12.00-12.30		Discussion
14.00-16.00		Short contributions (15 min.) on: Diatoms, Coccoliths, Radiolaria, Planktonic Foraminifera, Benthonic Foraminifera, Pteropods, Ostracods. Remarks (2 min.) backed up by written notes and bibliography on: Silicoflagellates, Dinoflagellates and Hystrichospheres, Pollen and Spores.
16.00-17.00		Preliminary examination and discussion of exchanged samples.

Day 2

09.00-10.00	(3)	Occurrence of siliceous microfossils in bottom sediments - main lecture
10.00-10.30		Discussion
11.00-12.00	(4)	Occurrence of calcareous microfossils in bottom sediments - main lecture
12.00-12.30		Discussion
14.00-17.00		Short contributions (15 min.) on: Diatoms, Coccoliths, Dinoflagellates and Hystrichospheres, Pollen and

Spores, Radiolaria, Planktonic Foraminifera, Benthonic Foraminifera, Ostracods, Pteropods.

Remarks (2 min.) backed up by written notes and bibliography on: Silicoflagellates et al.

Day 3

09.00-09.45		Problems in the systematics of important organisms: Diatoms
09.45-10.00		Discussion
10.00-10.45		Coccoliths
10.45-11.00		Discussion
11.30-12.15		Foraminifera
12.14-12.30		Discussion
14.00-14.45		Radiolaria
14.45-15.00		Discussion
15.30-18.30		Group discussions

Day 4

09.00-10.00	(5)	Statistical methods applicable to micropaleontology of bottom sediments - main lecture
10.00-10.30		Discussion
11.00-12.00	(6)	Geochemical and isotopic methods applicable to micropaleontology of bottom sediments - main lecture
12.00-12.30		Discussion
14.00-15.00	(7)	Stratigraphical methods applicable to micropaleontology of bottom sediments - main lecture
15.00-15.30		Discussion
15.30-17.30		Methodology by groups (collection, preparation, etc.)

Day 5 FREE

Day 6

Lectures on the vertical and horizontal distribution of microfossils in Quaternary sequences.

09.00-10.00	Diatoms
10.00-10.30	Discussion
11.00-12.00	Planktonic Foraminifera
12.00-12.30	Discussion
14.00-14.30	Coccoliths
14.30-15.00	Pollen and Spores
15.00-15.30	Discussion
16.00-16.30	Radiolaria
16.30-17.00	Pteropods
17.00-17.30	Discussion

Remarks (2 min.) backed up by written notes and bibliography on: Silicoflagellates, Dinoflagellates and Hystrichospheres, Benthonic Foraminifera, Ostracods

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Day 7

09.00-10.00	(8)	Occurrence of pre-Quaternary microfossils in the oceans - main lecture
10.00-10.30		Discussion

Short lectures

11.00-11.30	Diatoms
11.30-11.45	Discussion
11.45-12.15	Coccoliths
12.15-12.30	Discussion

14.00-14.45		Radiolaria
14.45-15.00		Discussion
15.00-15.45		Planktonic Foraminifera
15.45-16.00		Discussion
16.00-17.00		Remarks (2 min.) backed up by written notes and bibliography on: Silicoflagellates, Dinoflagellates and Hystrichospheres, Pollen and Spores, Benthonic Foraminifera, Ostracods, Pteropods

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Day 8

09.00-10.00	(9)	Quaternary correlations between groups and with land-based sequences
10.00-10.30		Discussion
11.00-12.00	(10)	Tertiary correlations between groups and with land-based sequences
12.00-12.30		Discussion
14.00-14.30	(11)	Quaternary boundaries
14.30-15.30		Discussion
15.30-16.00	(12)	Tertiary boundaries
16.00-17.00		Discussion

Day 9

New advances - offered papers

Recommendations.

Note

Each invited participant should be given instructions on what special topic to prepare; should have it as a manuscript at the meeting. Other persons should be asked to prepare specifically for the discussions to be held at the symposium.

WORKING GROUP TO CONSIDER ZOOPLANKTON METHODS IN THE LABORATORY

The members of WG 13 at present in Rome (Currie, Hempel and Fraser) discussed together the proposal to set up a Working Group to consider Zooplankton methods in the laboratory: whether this should be done by WG 13 or by a new group, and to state the main problems that they should consider.

We decided that we should not add to the remit of WG 13. This is a joint group sponsored by SCOR, ICES and UNESCO and any alteration of its terms of reference would need the approval of all three organisations. A new working group should be set up, although this could - but need not be - the same personnel. The interests of the present WG 13 members do not necessarily suggest that they would be the best people for the work although this is probably not of importance. We consider that it would be the duty of the new working group to set up suitable working parties for the topics to be considered, and that the working party members would be the acknowledged experts in their fields.

These fields would be:

1) The preservation of plankton samples. Formalin has been the traditional preservative, but we do not know enough about its chemistry and the reactions on the organisms preserved. Nor do we know whether there is a new modern preservative that would be better than formalin, or equally as good without unpleasant effects on the user.

One working party should be set up to study and report on methods of preserving zooplankton. It should include at least one interested planktologist but also one or more chemists with experience with preservatives.

2) The second working party should study and report on the preservation of microplankton, both phytoplankton and microzooplankton as the methods are not likely to be the same as for the larger zooplankton.

3) A third working party should be set up to advise on laboratory methods of estimating biomass, and methods of sub-sampling and counting.

4) We also discussed statistical methods for plankton work and decided that we would not recommend the new working group to set up a working party for this purpose. We suggest that SCOR should strongly advise UNESCO to support the plan proposed by IBP to set up a unit under the leadership of Dr. Cassie and that this unit should be responsible for issuing advice on statistical methods.

REPORT OF IAPO WORKING GROUP ON DEEP SEA TIDES

1. The following people met on June 4, 1966 at Moscow University for a review of the problem of deep sea tides.

Canada:	Stewart
Finland:	Hela
France:	Peluchon
Germany (FRG):	Brettschneider, Dietrich, Düing, Friedrich, Huber, Krauss, Siedler, Sündermann, Tomczak, Trepka, Weidemann
Germany (DDR):	Voigt
Italy:	Frassetto
Japan:	Uda
Monaco:	Grinda
Netherlands:	Dorrestein
United Kingdom:	Lilly, Swallow
USSR:	Bogdanov, Duvanin, Menzin, Nekrasov, Tamsala, Voit, Yampolsky
UNESCO:	Fedorov
USA:	Baker, Wooster, Cox, Hendershott, Isaacs, Knauss, Munk, Revelle

2. The purposes of the working group were reviewed. It was decided that an associated committee should be formed, dealing with theoretical problems related to the deep sea measurements of tides. The membership is as follows:

H. Hansen and S. S. Voit, Joint Chairmen
Hendershott
Pekeris
Redfield
Yoshida

The membership may be altered or augmented at the desire of the chairmen. The Hansen-Voit committee has the following tasks:

i. To report to the working group on theoretical efforts now being made concerning the calculations of deep sea tides. This should include a statement concerning the procedures adopted by different investigators.

ii. To advise on the transition problem: that is the calculations of deep sea tides from coastal observations, and vice versa. Ultimately one may wish to compute the tidal coefficients along (say) the 1000 fathom boundaries of the global oceans, as boundary condition to problem (i).

iii. To advise on the measurements most urgently required for problems (i) and (ii).

iv. To contact Dr. Eyries, who is organizing a IUGG symposium at Bern, Switzerland on 29 September 1967. Hopefully, the work of this sub-group can be discussed at that occasion. In the meantime, the chairman of the working group would appreciate early reports from the Hansen-Voit committee, so that these can be used in planning the observations, and distributed to all members of the working group.

3. Plans were discussed for the seagoing tests off La Jolla during 15-22 January 1967. These tests have two main purposes:

i. To make simultaneous drops of the AFEGPO gauge now being developed in France, and of the Snodgrass gauge being developed in California.

ii. To acquaint the technical representatives from various countries with the present state of the French and American efforts. It is my understanding that Dr. Roll will recommend someone from his Institute in Germany and Dr. Monin will recommend someone from his Institute in the USSR (possibly Shekhvatov). We urgently need to know who will come so that plans can be made.

4. It was recommended that a discussion of deep sea measurements be included in the Eyries symposium in Bern on 29 September 1967.

5. I attach a summary of a talk given at the SCOR meeting in Rome in May 1966. SCOR has been instrumental in obtaining the funds to support expenses of the sea-going trials in February 1967.

W. H. Munk

Deep Sea Tides

Hourly values of tide level have been recorded over a century at something like 20 stations. These series are the most continuous time series available to oceanographers, and they contain a wealth of information. Cartwright and I have studied some of these series. After subtracting the astronomic tides from the recorded tides in some optimum manner, the residuals oscillations have typical rms amplitudes of 1 cm to 10 cm. Curiously, these oscillations are prominent at tidal frequencies, yet they are "incoherent" with the tide-producing forces. I suspect that these are "steric" tides, that is, small surface oscillations associated with internal oscillations of the density layers. Persumably they are generated by bottom scattering of surface tides into internal tides, but the phase relative to the tide producing forces varies at a fixed point from month to month because of the variability in the thermal structure of the ocean. So much for the variability of coastal tide records.

We have become interested in measuring tides in the deep sea. Frank Snodgrass has built a selfcontained capsule which is dropped to the sea floor, records in situ, and is subsequently recalled by acoustic signals from a surface vessel. The instrument is necessarily somewhat complex (though it fulfills the Spillhaus criterion of a good oceanographic instrument by having less than one vacuum tube - all components are solid state).

We have had rather more than the usual number of failures and believe that it is essential to pay more attention to a subject that has been christened "reliability engineering" by space engineers. This involves (1) a planned redundancy of critical circuits, (ii) quality control of individual components, (iii) long periods of pretesting plus (v) pretesting under severe environmental conditions. Ultimately I believe that the precision of the deep sea tide capsule will be limited by plastic flow in the transducer, giving rise to what is ordinarily called "instrumental drift". I am confident that we can obtain a precision of 1 cm at 4 km depth in the measurement of tides.

Professor Eyries has led a group in France developing a similar instrument, and in this effort he is ahead of what we are doing. Dr. Eyries and I are members of an IAPO working group whose goal it is to organize for systematic measurements of deep sea tides. Ultimately we need something like 300 stations each to be occupied for one month, but it is important to note that these need not be occupied simultaneously. This is becuase the input functions (the tide producing forces) are known.

What can be learned from deep sea measurements of tides? First this work may lead to a new method of tide prediciton. By making a coordinated theoretical-observational attack, consisting of the Pekeris-Hendershott theoretical calculations on the one hand, and the deep-sea

observations on the other hand, it should be possible to develop a computer program which yields the tides for any specified time and place in deep sea. By solving the transition problem of how the tides are modified in shallow water, the coastal prediction can be developed as an appendix to the deep sea prediction.

For geophysical measurements on land, the tidal frequencies cannot be interpreted without making allowance for the effect of oceanic tides on a global basis. This applies to measurements of gravity, magnetic field, etc. Measurements of electric potential at the sea bottom can be used to estimate the conductivity of the sea bed and from this one can make estimates of the distribution of temperature in the upper mantle. The work on deep sea tides should also give an unequivocal estimate of tidal dissipation. The total dissipation is known from astronomy to be 3×10^{19} ergs sec^{-1}, and the difference between this amount and the oceanic tidal dissipation gives the dissipation in the solid earth. From that we should be able to learn something about the plastic properties of the earth's mantle.

Another class of problems that one might be able to study with the deep sea capsules has to do with the variations in barotropic currents. This would be obtained from measurements of the time variations in the pressure difference between adjoining stations. It is curious that planetary waves which are so prominent in the atmosphere have not been convincingly demonstrated in the oceans. This could be because they are poorly generated, or poorly transmitted, or because the observations so far have not measured the proper variables. What one really needs is long measurements of horizontal motion at great depth (away from surface noise). Such measurements are simply not available at this time.

Perhaps it is futile to speculate what one will learn with new types of instruments operating in an unorthodox geometry. Already the most interesting results obtained have nothing to do with tides: they refer to a sharp increase in temperature in the bottom few meters of the oceans (the existence of a warm bottom layer had previously been reported by Von Herzen and co-workers from measurements with a geothermal probe). How is this warm layer maintained? Is it weighted by an increased content of salt or of sedimentary particles? In fact, in the measurements of temperature gradients in sediments, what is the role of tidal "pumping" of interstitial water? The bottom of the sea is perhaps the least explored of the "accessible boundary layers" on this planet, and we may be in for some surprises.

W. H. Munk

INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS
Scientific Committee on Oceanic Research

Eighth General Meeting, Rome, 23 - 27 May 1966

SYMPOSIUM ON VARIABILITY IN THE OCEAN

Program

24 May 1966

Biological Section

1.	Opening Remarks	T. Braarud (Norway)
2.	Oceanographic and Biological Influence of the Suez Canal, the Nile and the Aswan Dam on the Levant Basin.	O. H. Oren (Israel)
3.	Biological Fluctuations in the Baltic Sea	S. G. Segerstrale (Finland)
4.	Variability in the Oceanic Content of Plankton in the Scottish Area.	J. H. Fraser (UK)
5.	Variability in the Plankton.	J. M. Colebrook (UK)
6.	Time Series Observations and Zooplankton	J. A. McGowan (USA)
7.	Extraction of Oceanographical Time Series from the Four-dimensional 'Liquidum' (or Continuum).	L. H. N. Cooper (UK)

25 May 1966

Morning - Physical Section

1.	Opening Remarks	R. W. Stewart (Canada)
2.	On a statistical index of the ocean variability	A. De Maio (Italy)
3.	Deep Sea Tides	W. H. Munk (USA)

4.	Moored Oceanographic Buoys (reliability, representativity and application).	T. Kvinge (Norway)
5.	The capability of the Aanderaa recording and telemetering instrument.	O. Dahl (Norway)

Afternoon - Physical Section

6.	A summary of variability observed with monitoring sections of the East and West Coast of Canada.	C. R. Mann (Canada)
7.	Variation in monthly mean dynamic topography at Bermuda.	H. Stommel (USA)
8.	Fluctuations in the atmospheric and marine climates in the region of the European shelf seas since 1900.	A. J. Lee (UK) (co-author, R.R. Dickson)

26 May 1966

Morning - Physical Section

9.	Typical features of internal wave spectra.	W. Krauss, (F.D.R.)
10.	On the fine structure of density and current distribution and its short-time variations in different areas.	G. Siedler, (F.D.R.)
11.	Plans for variability studies in the Norwegian Sea.	H. Mosby (Norway) (read by T. Kvinge)
12.	On the representativeness of direct deep-sea current measures.	F. Webster (USA)

Afternoon - General Section

Discussion of implications of presented papers for proposed IOC investigations of variability in the ocean.

MEETINGS OF SCOR AND ASSOCIATED ORGANIZATIONS IN 1966-67

1966

15-19 August	Karuizawa, Japan	SCOR Working Group 15 (with IAPO, UNESCO), on Photosynthetic Radiant Energy
17-20 August	Tokyo	IOC CSK Coordination Group
22 August 10 September	Tokyo	Eleventh Pacific Science Congress
13-16 September	Santiago, Chile	SCAR/SCOR/IAPO/IUBS Symposium on Antarctic Oceanography
19-24 September	Kyoto	IUGG/IUTAM Symposium on Boundary Layers and Turbulence, and IAMAP/IAPO Joint Committee on Air-Sea Interaction
2-12 October	Copenhagen	ICES 54th Statutory Meeting
20-28 October	Abidjan	UNESCO/FAO/OAU Symposium on Oceanography and Fisheries Resources of the Tropical Atlantic (Results of ICITA and GTS).
25 October - November	Paris	UNESCO General Conference

1967

15-22 January	La Jolla, U.S.A.	IAPO WG on Deep Sea Tides
16-28 January	Rome	ACMRR
30 January - 2 February	Monaco	Seventh IOC Bureau and Consultative Council.

early February	Jerusalem	SCOR Executive Meeting
August or September	Oslo (?)	SCOR Symposium on Micropaleontology of Marine Bottom Sediments
25 September - 7 October	Switzerland	Fourteenth IUGG General Assembly. IAPO Meeting (in Berne).
mid-October	Paris	Fifth Session of IOC

ABBREVIATIONS

AAAS	American Association for the Advancement of Science
AFEGPO	Association Francaise Pour L'Etude des Grandes Profondeurs Océaniques
BT	Bathythermograph
CODC	Canadian Oceanographic Data Center
CSIRO	Commonwealth Scientific and Industrial Research Organization (Australia)
FAO	Food and Agriculture Organization of the United Nations
IAMAP	International Association of Meteorology and Atmospheric Physics
IAPO	International Association of Physical Oceanography
IBP	International Biological Programme
ICES	International Council for the Exploration of the Sea
ICITA	International Cooperative Investigations of the Tropical Atlantic
ICNAF	International Commission for Northwest Atlantic Fisheries
ICSU	International Council of Scientific Unions
IGU	International Geographical Union
IGY	International Geophysical Year
IHB	International Hydrographic Bureau
IKMT	Isaacs-Kidd midwater trawl
IOBC	Indian Ocean Biological Center
IOC	Intergovernmental Oceanographic Commission
IUBS	International Union of Biological Sciences
IUGG	International Union of Geodesy and Geophysics
IUGS	International Union of Geological Sciences
IUPAP	International Union of Pure and Applied Physics
IUPS	International Union of Physiological Sciences
IUTAM	International Union of Theoretical and Applied Mechanics
NODC	National Oceanographic Data Center (U.S.A.)
PM	Productivity-Marine
SCAR	Scientific Committee on Antarctic Research
SCIBP	Special Committee for the International Biological Programme
SCOR	Scientific Committee on Oceanic Research
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
WG	Working Group
WMO	World Meteorological Organization
w.p.	Working Party