SCIENTIFIC COMMITTEE ON OCEANIC RESEARCH

SCOR Proceedings
Vol. 6, No. 2

INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS

SCIENTIFIC COMMITTEE ON OCEANIC RESEARCH

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INTERNATIONAL COUNCIL OF SCIENTIFIC UNIONS

PROCEEDINGS
OF THE
SCIENTIFIC COMMITTEE ON OCEANIC RESEARCH

Volume 6, Number 2

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La Jolla, California

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PROCEEDINGS

of the

SCIENTIFIC COMMITTEE ON OCEANIC RESEARCH

Report of the Tenth General Meeting
Tokyo, 13-25 September 1970

The Tenth General Meeting was held at Keidanren-kaikan, Tokyo, 13-25 September 1970, with the President, Professor Wooster, in the chair. The Meeting was part of the Joint Oceanographic Assembly, in which the following organizations also participated: International Association for the Physical Sciences of the Ocean (IAPSO), International Association of Biological Oceanography (IABO), and the Commission for Marine Geology (CMG). Local arrangements were made by a Japanese organizing committee, under the Science Council of Japan, with the assistance of the Oceanographic Society of Japan.

SCOR business meetings were held on the afternoons of 16 and 23 September; the Executive Committee also met on 25 September. A list of participants in these meetings is given in Annex I. The agenda serves as an outline for the report which follows.

1.0 ORGANIZATION AND FINANCE

1.1 MEMBERSHIP

A brochure describing the purposes and activities of SCOR was prepared for distribution at the Joint Oceanographic Assembly, as a contribution to the discussions on improved arrangements for marine science within ICSU (see 4.1). The document is a useful source of general information on SCOR and may be of particular value to new members and committees and other organizations. It was agreed that the brochure should be revised to reflect changes resulting from decisions of the present meeting, provided to National Committees, and given other appropriate distribution.

The new Constitution (see 4.1) contains provisions for broadening SCOR membership. The Executive Committee was requested to implement these provisions when the Constitution had been approved by ICSU.

1.2 PUBLICATIONS

The report of the 14th Executive Meeting (London, 17-20 March 1970) was published in Proceedings, vol. 6, no. 1, which was distributed in July. Papers presented during the 9th SCOR General Meeting were published in the following:

"Scientific Exploration of the South Pacific" (W.S. Wooster, Ed.), National Academy of Sciences, Washington, 1970, pages vii + 257.

Publication of symposia volumes on micropaleontology of marine bottom sediments and on east Atlantic continental margins is expected by the end of the year. It is not planned to publish papers from the three SCOR symposia of the Tokyo meeting. The decision on publication of other symposia from that meeting has been left to appropriate participating organizations.

The distribution of Proceedings will be increased as membership is broadened in accordance with the new Constitution. Distribution through depository libraries must await completion of a joint UNESCO/FAO list. That list will include about 200 libraries, and the necessary copies would be purchased by UNESCO. Additional copies can be made available to National Committees for distribution, but it is desirable first to ascertain the extent of present national distribution.

1.3 BUDGET AND FINANCE

An ad hoc budget committee was appointed to review available information on budget and finance; the committee consisted of Professor Postma (chairman), Professor Stewart and Dr. Voigt. In its report, the committee noted that the increase in SCOR activities, and hence in expenses, during the last few years had not been matched by an increase in income, either from National Committees or from UNESCO, the additional expenses having been met from reserves. In the future it would be necessary either to increase income or decrease activities. An estimate of the present financial situation (through 30 September) is given in Annex II.

Additional financial support is being sought from UNESCO and ICSU. A proposal for increased national contributions starting in 1971 was sent to National Committees early in 1970 and had met general support. Accordingly, it was decided to accept the following new categories of contributions: I - $300; II - $800; III - $1500; IV - $3000; and V - $5000. Approval for this change is to be sought from ICSU, and National Committees are to be asked to indicate the category they select.

1.4 ELECTION OF VICE PRESIDENT

The election was necessitated by Professor Braarud's decision to retire from the Executive Committee. A nominating committee was appointed, consisting of Mr. Currie (chairman), and Professors Braarud and Seibold. Subsequently, Professor Postma was elected.

As a consequence of elections held by other organizations, Professor Dietrich and Mr. Currie left the Executive Committee, being replaced as ex officio members by Professor Lacombe, new President of IAPSO, and Professor Hempel, new President of IABO.

2.0 WORKING GROUPS

2.1 ACTIVITIES RELATED TO PREVIOUS WORKING GROUPS

The nutrient intercalibration experiment proposed by SCOR WG 25 is being conducted by the ICES Working Group on Chemical Analysis of Sea Water. Samples for analysis were distributed to 55 laboratories in early 1970; by September, results from 36 laboratories had been reported to Dr. Koroleff, coordinator of the experiment. A progress report was presented to the 58th Statutory Meeting of ICES (Copenhagen, 28 September - 7 October 1970).

2.2 REPORT ON EXISTING GROUPS

WG 10 Oceanographic Tables and Standards (with ICES, IAPSO and UNESCO): The report of the Kiel meeting was published as No. 14 in the series UNESCO Technical Papers in Marine Science (it had previously been published as Annex IV in SCOR Proceedings, vol. 6, no.1). Since then, detailed oxygen saturation tables have been computed at Kiel University, and submitted to UNESCO for publication in International Oceanographic Tables.

It was agreed that this working group should be continued. It was further recommended that the group examine the possibility of determining the entropy of sea water as a function of temperature, pressure and salinity (or conductivity). If existing information is inadequate for this purpose, the group should propose the necessary laboratory measurements.

WG 15 Photosynthetic Radiant Energy (with IAPSO and UNESCO): Sea trials aboard R/V DISCOVERER were held during the period 2 May - 4 June 1970. The SCOR scientific party consisted of 17 scientists from eight countries. Observations were made on 23 stations in the Caribbean Sea and the eastern tropical Pacific. A preliminary report has been published by the Scripps Institution of Oceanography (SIO Ref.No.70-25); extracts from this report are given in Annex III.

In reviewing this project, it was agreed that all concerned were to be congratulated on its success. Particular thanks were due to the U.S. Environmental Science Services Administration and to Dr. H.B. Stewart of the ESSA Miami Laboratory for their help in making the cruise possible. The working group must be continued to report on results of the experiment. A final meeting should be arranged, possibly in 1971, when data analysis has been completed and completion of the report should be discussed.

WG 21 Continuous Current Velocity Measurements (with IAPSO and UNESCO): The intercalibration experiment aboard AKADEMIK KURCHATOV was discussed in the previous issue of Proceedings (especially Annex V). Subsequently, SCOR has assisted in arrangements to bring Dr. Chekotillo to Woods Hole to participate in analysis of the data.

The President was instructed to transmit SCOR's appreciation to the USSR Academy of Sciences for their help in making the cruise possible. It was agreed that the group should be continued in order to report on the results of the experiment, with a final meeting to be held at an appropriate time in 1971.

WG 23 Zooplankton Laboratory Methods (with UNESCO): Reports were received on the continuing investigations being conducted under the guidance of Dr. H.F. Steedman, excerpts from which are given in Annex IV. It was agreed that the group should be continued, with the chairman being invited to submit proposals for any changes in membership. Arrangements should be made for a workshop meeting to be held in 1972.

WG 24 Estimation of Primary Production Under Special Conditions (with IBP/PM): Plans were noted for the next meeting to be held in Nanaimo on 9-12 November 1970. It was agreed that the group should be continued until completion of a final report after the November meeting.

WG 27 Deep-Sea Tides (with IAPSO and UNESCO): An interim report was presented by the chairman, Professor Munk, to the IAPSO General Assembly and is given in Annex V. It was agreed that a meeting should be arranged in 1971, possibly in UK.

WG 28 Air-Sea Interaction (with IAMAP and IAPSO): A progress report was made available by the chairman, Professor Charnock, and is given in Annex VI. The group plans to meet in Moscow on the occasion of the IUGG General Assembly (August 1971).

It was recommended that the working group give special attention to the question of direct eddy flux measurements of the water vapor transport. The adequacy and intercomparability of existing instrumentation should be evaluated, as should the distribution of measurements needed to establish reliable estimates of evaporation for any place on the surface of the world ocean.

WG 29 Continuous Monitoring in Biological Oceanography (with ACMRR, UNESCO and IBP/PM): The group met in La Jolla, 25-29 May 1970. The report of this meeting is given in Annex VII. A number of general recommendations were made, in addition to assignments being given to various members of the group for further review.

It was agreed that the group should be continued until a further meeting and preparation of a final report. The chairman would be asked if any changes or additions in membership would facilitate completion of the group's work.

WG 30 Scientific Aspects of International Ocean Research (with ACMRR and WMO): Since this group has completed its task, with the concurrence of the other sponsoring bodies it was agreed to thank the members and discharge the group.

WG 31 East Atlantic Continental Margins (with UNESCO and IUGS): Papers presented at the Cambridge Symposium of this group (23-27 March 1970) are being prepared for publication by the Institute for Geological Sciences (UK). Recommendations have been published (Proceedings, vol. 6, no. 1, Annex VI) and made known to those concerned with planning of cooperative investigations in the eastern Atlantic. It was agreed that the group had completed its task and should be discharged with thanks. The CMG should be invited to keep the implementation of WG 31 recommendations under review, and to advise SCOR when further action is required.

WG 32 Biological Data Inventories (with ACMRR): The report of this group (see Proceedings, vol. 6, no. 1, Annex VII) was made available for discussion by the IOC Working Group on Oceanographic Data Exchange in September. It was agreed that after this discussion, the group should soon hold a final meeting. Professor Hempel's proposal, that Dr. Colebrook be invited to chair this meeting, was accepted. It was agreed to drop the term of reference pertaining to museum cataloging, as a matter too important and too general to be handled adequately by the present group. It was noted that certain reports were called for in the WG recommendations and would presumably be available for the coming meeting.

WG 33 Phytoplankton Methods (with IBP/PM): It was noted that the first meeting of the group would be held on 1-3 December 1970 at Kingston, Rhode Island.

WG 34 Oceanographic Basis of Ocean Monitoring and Prediction Systems: As agreed at the 14th Executive Meeting, a theoretical panel has been established with the following membership: Allan Robinson, USA (Chairman); L.M. Fomin, USSR; A.E. Gill, UK; K. Hasselmann, FRG; N. Phillips, USA; P. Welander, Sweden. This panel is concerned with development of a scientific field study known as MODE (Mid-Ocean Dynamics Experiment) which might be carried out internationally some time in the future, possibly in 1975-78.

Professor Stommel, Chairman of WG 34, has reported "The oceanographers of the USSR have already conducted, during the first half of this year, a very impressive experiment in the eastern North Atlantic Ocean, using 20 moorings, each with several current meters. It is likely that the analysis of these unique data will provide a scientific basis for MODE. Oceanographers of the USA and UK are planning another experiment of approximately the same scale. Its duration will not be as long as the USSR effort, but it will include some extra types of sensors, such as clusters of neutrally buoyant floats, bottom pressure gauges, etc. This effort has been called PREMODE. It will possibly take place in October 15, 1972 through February 15, 1973."

The PREMODE experiment is being planned for a location southwest of Bermuda. It is hoped that the results of the USSR experiment and of PREMODE will be fully worked up and made available to WG 34 by mid-1973, to be used in planning of the MODE operation. The theoretical panel plans to hold an informal meeting during the Royal Society Symposium on Ocean Currents and their Dynamics in November, and may consider a further meeting desirable in early 1971.

2.3 CONSIDERATION OF NEW WORKING GROUPS

The U.S. National Committee proposed that a new group be organized jointly with other appropriate bodies such as ACMRR and with the following terms of reference:

".... to evaluate the need for freedom of scientific research in the ocean and the obligations implied by that freedom; to examine the consequences for scientific research of the various alternative ocean regimes; to prepare a report on the freedom of scientific research to be used in relevant discussions in international bodies."

In a discussion of this proposal, SCOR Members accepted the importance of the problem but differed on methods by which it could be most effectively handled. On the one hand, SCOR had a responsibility to marine scientists to represent their interests in intergovernmental discussions of such matters, and thus needed to be fully informed of their views. On the other hand, by becoming involved in such a controversial problem, SCOR could weaken its credibility as a scientific body. It was ultimately agreed that the Executive Committee should solicit the views of its Members and National Committees, as well as of a number of other scientists, on the necessary conditions for effective scientific research in the oceans. These views should be compiled by the Executive Committee in a document which would be made widely available for use by National Committees and other scientists.

3.0 RELATION WITH UNITED NATIONS ORGANIZATIONS

3.1 ADVISORY MATTERS CONCERNING UNESCO

Previously SCOR had advised UNESCO on the development of the IOBC Consultative Committee into a more general advisory panel on international sorting centers. The President was asked to obtain and make available information on UNESCO plans for carrying out this transformation.

In a general discussion of areas in which SCOR might assist UNESCO, it was noted that a useful advisory role might be played in the program of technical assistance to developing countries as it related to the initiation or strengthening of marine science research.

3.2 ADVISORY MATTERS CONCERNING IOC

As previously reported, the IOC Bureau at its 11th Meeting established a procedure for nomination and selection of members of the Group of Experts on Long Term Scientific Policy and Planning. In accordance with this procedure, a list of SCOR nominees was submitted, and the SCOR President participated in discussions of the Selection Committee (Malta, 28-30 June 1970). The 1st Meeting of the Group of Experts is scheduled to be held in Monaco, 16-25 November 1970, and will be attended by a representative of SCOR.

SCOR representatives have attended other meetings of concern to IOC, including the Group of Experts on Scientific Aspects of Marine Pollution (Paris, March 1970), the coordination group for the Cooperative Investigations of the Northern Part of the Eastern Central Atlantic (Paris, April 1970), the Group of Experts on Ocean Variability (Paris, July 1970) and IGOSS discussions (Geneva, April 1970 and Paris, July 1970). It is also planned that a SCOR representative will participate in the 1st Meeting of the International Coordination Group on the Southern Ocean (Brussels, November 1970).

3.3 RELATION WITH FAO/ACMRR

SCOR has joined ACMRR and other organizations in the sponsorship of a Seminar on Methods of Detection, Measurement and Monitoring of Pollutants in the Marine Environment, to be held in Rome, 4-10 December 1970 in conjunction with the FAO Technical Conference on Marine Pollution and its Effects on Living Resources and Fishing. Panels have been organized on halogenated hydrocarbons, petroleum, inorganic chemicals, organic chemicals, nutrient chemicals, suspended solids and turbidity, radioactivity, test organisms, and design of a world monitoring system. It is hoped that a handbook of methodology will result from this seminar.

3.4 RELATION WITH WMO/ACOMR

The 1st Meeting of the WMO Advisory Committee on Oceanic Meteorological Research is planned for early 1971; SCOR will be invited to send a representative.

4.0 RELATION WITH ICSU AND CONSTITUENT BODIES

4.1 IMPROVED ICSU ARRANGEMENTS FOR MARINE SCIENCE

After the discussions at the 14th Executive Meeting (see <u>Proceedings</u>, vol. 6, no. 1, p.10), a new draft constitution was prepared and circulated to Members and National Committees. Copies of this were also made available in Tokyo during the Joint Oceanographic Assembly, when there was a general session on the desirability of an International Union of Marine Sciences. During that session, there appeared to be a general preference for broadening and strengthening SCOR, as envisioned in the new constitution. Subsequently, during the SCOR Meeting, the draft was considered, paragraph by paragraph. The final revision, as given in Annex VIII, was approved at the meeting on 23 September 1970. A copy was immediately transmitted to Madrid for approval by the ICSU 13th General Assembly. When this approval is granted, the constitution should be distributed to Members, National Committees and Unions. National Committees should be asked to nominate additional members as provided in Article 3. New Representative Members (Article 4) should be notified. With regard to Invited Members (Article 5), a consensus of the Executive Committee should be obtained before invitations are issued; normally only one member will be invited per country. National Committees should be informed of other consequences of the new constitution, including its possible effect on their relations with other national bodies corresponding to the Affiliated Organizations.

4.2 RELATION WITH COMMITTEES AND COMMISSIONS

Dr. Oren, as SCOR nominee, will meet with SCIBP and its Productivity Marine Section in Rome, September-October 1970. SCOR was not able to send a representative to the 1st Meeting of the Special Committee on Problems of the Environment (Madrid, 19-20 September 1970), but Dr. Grasshoff has agreed to serve as an interim means of communication with the group. Professor Monin represented SCOR at the 13th Meeting of COSPAR (Leningrad, May 1970).

The representative of SCAR, Mr. Hemmen, noted the continuing interest of SCAR in scientific problems of the pack-ice zone. A major international symposium might be required to elucidate and stimulate interest in these problems. In a discussion of this matter, it was agreed that the 11th General Meeting of SCOR in 1972 might be an appropriate occasion for such a symposium. A proposal for a related meeting, on Arctic problems, was being discussed between Iceland and UNESCO, although it seemed likely that that meeting would be in 1971. The President and Executive Committee were asked to explore the possibility of organizing a pack-ice symposium in 1972, together with SCAR and other appropriate organizations, as the scientific component of the 11th General Meeting.

Dr. S.Z. El Sayed reported on U.S. plans for the Ross Ice Shelf Drilling Projects, the objectives of which are to investigate the physical, chemical, biological, and geological conditions beneath the shelf including the basal ice, the water mass, the ocean floor, and the sub-sea sediments. SCAR has established a specialist group on Ice Shelf Drilling Projects. It was agreed that SCOR should keep informed on this project, and that Professor Seibold, with the help of CMG, should be asked to serve as the liaison. SCAR would furnish additional information to SCOR National Committees.

5.0 FUTURE MEETINGS

5.1 SYMPOSIA

The Second Announcement has been issued of the Symposium on the Biology of the Indian Ocean with particular reference to the International Indian Ocean Expedition, to be held in Kiel 31 March - 6 April 1971. The expenses of this symposium are to be shared among SCOR, UNESCO, FAO, IBP/PM and IABO. It is generally agreed that publication of the symposium papers would be useful, and Professor Hempel, on behalf of the German National Committee, offered to explore the various possibilities. Dr. Humphrey has continued with the major responsibility, on behalf of SCOR, for organizing the symposium, and Dr. Zeitschel of the Institut für Meereskunde in Kiel has been designated the contact for local arrangements.

5.2 BUSINESS MEETINGS

The President was asked to continue his exploration for an appropriate site for the 15th Executive Meeting in May 1971. The 11th General Meeting will be held in Oban, Scotland, in September 1972, following the Second International Congress on the History of Oceanography and the Challenger Expedition Centenary Celebrations, to be held in Edinburgh 12-20 September 1972. A possible subject for the scientific portion of the SCOR Meeting is discussed above (item 4.2).

6.0 OTHER MATTERS

The Secretary presented a proposal for SCOR assistance in publication of results of the International Baltic Year. Material is being compiled by participants, and publication is not anticipated before early 1972. It was agreed that a progress report should be made to the 15th Executive Meeting when a decision could be reached on the amount of financial assistance to be provided.

Information was received that the New Zealand National Commission for UNESCO, in cooperation with the Royal Society of New Zealand, is organizing an international symposium on the oceanography of the South Pacific, to be held in Wellington 9-15 February 1972. The support of SCOR has been requested. It was agreed that information on the analogous 1968 SCOR symposium should be sent to the organizers, and that the possibility of appropriate SCOR support should be explored.

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A report on the Joint Oceanographic Assembly is given in Annex IX. A list of future meetings of SCOR and associated organizations is given in Annex X.

10th SCOR GENERAL MEETING
BUSINESS MEETING
Tokyo, 16, 23, 25 September 1970

List of Participants

MEMBERS OF THE EXECUTIVE COMMITTEE

Professor Warren S. Wooster	(U.S.A.)	President
Captain Luis R.A. Capurro	(Argentina)	Retiring President
Professor Trygve Braarud	(Norway)	Vice President (3)
Professor A.S. Monin	(U.S.S.R.)	Vice President (3)
Dr. Klaus Voigt	(GDR)	Secretary
Mr. Ronald I. Currie	(IUBS/IABO)	Ex Officio
Professor Dr. G. Dietrich	(IUGG/IAPSO)	Ex Officio (3)
Dr. Thomas F. Gaskell	(IUGS/CMG)	Ex Officio

OTHER PARTICIPANTS

Professor Karl Banse (U.S.A.) (1)
Professor K.F. Bowden (U.K.) (4)
Professor L.M. Brekhovskikh (SCOR member from ICSU) (3)
Sir Edward Bullard (SCOR member from IUPAP) (2)
Professor T.Y. Chu (China, Rep.of) (1)
Professor J.H. Day (South Africa) (1)
Dr. G.R. Deacon(SCOR member from UK)(3)
Professor N. Della Croce (Italy) (2)
Dr. H.R. Gould (U.S.A.) (3)
Dr. Bruce C. Heezen (U.S.A.) (1)
Mr. G.E. Hemmen (SCAR/U.K.)
Professor Dr. G. Hempel (FRG/IABO Secretary) (3)
Dr. A.E.F. Heydorn (South Africa) (3)
Dr. S.J. Holt (UNESCO/IOC) (3)
Professor B. Kimor (Israel) (3)
Dr. A.H. Meyl (FRG) (3)
Professor Y. Miyake (SCOR member from Japan) (3)
Professor B.R. Morton (SCOR member from Australia) (3)
Dr. S.M. Naude (South Africa) (3)
Dr. N.K. Panikkar (SCOR member from India)(2)
Dr. P. Kilho Park (U.S.A.) (3)
Professor Dr. H. Postma (SCOR member from the Netherlands)
Dr. J.R. Rossiter (U.K.) (3)
Dr. Mario Ruivo (FAO/ACMRR) (2)
Dr. I.I. Schell (U.S.A.) (1)
Professor Dr. E. Seibold (SCOR member from FRG)
Professor E.S.W. Simpson(South Africa/CMG Secretary)
Professor H. Steinitz (Israel) (3)
Dr. R.W. Stewart (SCOR member from Canada) (3)
Dr. J.C. Swallow, (U.K.) (1)
Professor S. Szymborski (SCOR member from Poland) (2)
Dr. S. Tanaka (ACMRR/Japan) (3)
Professor P. Tchernia (SCOR member from France)
Dr. T. Torii (Japan) (2)
Professor Dr. L. van Straaten(Netherlands) (1)
Mr. N.L. Veranneman (WMO) (1)
Dr. Torben Wolff (Denmark) (3)

(1) 16 September only
(2) 23 September only
(3) 16 and 23 September only
(4) 23 and 25 September only

ESTIMATE OF SCOR FINANCES

(1 January thru 30 September 1970)

BALANCE AS OF 1 January 1970

In Rome				$ 5,633.63 *
In La Jolla				12,840.08
				$ 18, 473.71

* 2,133.63 in Indian Rupees

INCOME

National Contributions		15,729.95		
ICSU support for "Ocean World"		2,500.00		
UNESCO Contract		12,500.00		
Interest, Savings Account		340.97		31,070.92
				$ 49,544.63

EXPENSES

Office		3,110.57	
Publication		2,087.03	
Working Groups			
WG 15	11,218.57		
WG 21	706.10		
WG 23	545.00		
WG 25	632.00		
WG 29	1,329.65		
WG 31	1,512.00		
WG 32	1,333.00	17,276.32	
Executive		1,921.06	
Rep. Other Meetings		1,400.66	
"Ocean World"		3,844.95	
TOTAL EXPENSES		$ 29,640.59	

BALANCE AS OF 30 September 1970

In Rome	$ 3,333.63 *
In La Jolla	16,570.41
	$ 19,904.04

* 2,333.63 in Indian Rupees

REPORT OF SCOR WORKING GROUP 15

PHOTOSYNTHETIC RADIANT ENERGY

Sea Trials on R/V DISCOVERER, 2 May - 4 June 1970

Introduction

At the meeting of SCOR Working Group 15 in August, 1966, tentative plans were outlined for the collection of experimental data at sea. Primary objectives of the work at sea were to be the further testing and development of simple instrumentation for measuring the radiant energy available for photosynthesis and the collection of data to reveal any relationship between primary productivity and the radiant energy available for photosynthesis. A broad program including measurements of primary productivity, chlorophyll concentration, nutrient analysis, and other variables as well as optical measurements was outlined in order to have at each station a large body of interrelated data under specified lighting conditions.

It was originally suggested that this research should be conducted during the period of May to August, 1969, in the vicinity of the Canaries, and it was anticipated that a scientific party of 15 would participate.

Dr. W. Wooster initiated ship requests to various oceanographic organizations, but it was not until early in January, 1969, that a firm commitment was made. At that time, through Dr. Harris Stewart, Director of the Atlantic Oceanographic and Meteorological Laboratory, ESSA, and Rear Admiral D.A. Jones, Director of the Coast and Geodetic Survey, ESSA, the vessel, DISCOVERER, was scheduled for our use for a period of three to five weeks during the spring months of 1970.

In November, 1969, the Working Group met in Miami to discuss the program to be conducted during the expedition and to visit the ship. It was decided to equip the stern of the ship with a 25- to 30-foot boom so that the launching of the optical equipment could take place well away from the ship and the presence of the ship as a perturbation to the light field would be minimized. Also at the meeting, each Working Group member was assigned specific tasks related to the objectives of the expedition and arrangements were made to assure that all required instrumentation would be available for the work.

The Working Group was scheduled to sail from Miami on April 30, 1970, but late arrival of essential scientific instrumentation from Europe delayed the departure until Saturday morning, May 2. The effect of late sailing increased the cost of the expedition by approximately $1000. The cost to the Atlantic Oceanographic and Meteorological Laboratory was undoubtedly also increased as a result of late sailing but the dollar amount is not known. Late sailing did not affect the duration of the expedition's sea time.

The ship returned to Miami on Thursday, June 4, and all members of the SCOR group were on their way to their homes by Saturday, June 6. During the period at sea the Working Group obtained data at 23 stations.

Participants

The SCOR scientific party aboard the DISCOVERER during the expedition consisted of 17 scientists from eight nations, as follows:

- James J. Alberts; Chemist; now at State Geological Survey of Kansas, the University of Kansas, U.S.; sponsored by Dr. C. Oppenheimer.
- Roswell W. Austin; Research Engineer; Scripps Institution of Oceanography, University of California, San Diego, U.S.; accompanied Mr. J.E. Tyler.

Ian E. Baird; Biologist; Department of Agriculture and Fisheries, Marine Laboratory, Scotland; member of Working Group 15.

Jeane-Pierre Bethoux; Attaché de Recherche, C.N.R.S.; Laboratoire d'Oceanographie Physique, France; accompanied Dr. A. Morel.

David Carpenter; Experimental Officer, C.S.I.R.O.; Division of Fisheries and Oceanography, Australia; accompanied Mr. H.R. Jitts.

Niels Højerslev; Research Associate; Institute of Physical Oceanography, University of Copenhagen, Denmark; accompanied Dr. K. Nygaard.

Harry R. Jitts; Senior Research Scientist, C.S.I.R.O.; Division of Fisheries and Oceanography, Australia; member of Working Group 15.

Thomas C. Malone; Graduate Student; Hopkins Marine Station, U.S.; sponsored by Dr. M. Gilmartin.

Andre Morel; Maitre Assistant; Laboratoire d'Oceanographie Physique, University of Paris, France; delegated by Working Group member Professor A. Ivanoff.

Nobutada Nakamoto; Graduate Student; Department of Biology, Tokyo Metropolitan University, Japan; accompanied Dr. Y. Saijo.

Kjell Nygaard; Chief Engineer; Institute of Physical Oceanography, University of Copenhagen, Denmark; delegated by Working Group member Dr. N. Jerlov.

Yulen Ochakovsky; Physicist; Institute of Oceanology, USSR Academy of Sciences, USSR; member of Working Group 15.

Yatsuka Saijo; Biologist; Water Research Laboratory, Nagoya University, Japan; member of Working Group 15.

Raymond C. Smith; Physicist; Scripps Institution of Oceanography, University of California, San Diego, U.S.; accompanied Mr. J.E. Tyler.

Anatol Susliaev; Engineer; Institute of Oceanology, USSR; accompanied Dr. Y. Ochakovsky.

Jahn Throndsen; Magister Scientia; Institute of Marine Biology, University of Oslo, Norway; delegated by Professor Steemann-Nielsen.

John E. Tyler; Research Physicist; Scripps Institution of Oceanography, University of California, San Diego, U.S.; Chairman of Working Group 15.

The officers and other personnel on the ship provided valuable scientific and logistic support and in a very real sense became a part of the Working Group effort during the voyage. Comdr. R.E. Alderman, the Executive Officer, easily solved the many problems associated with the presence of two international Working Groups on the ship[(1)].

Comdr. R.C. Johnson, Jr., Chief Engineer, and his staff solved numerous electrical and mechanical problems associated with the use of our specialized equipment on the ship. Comdr. Johnson personally assisted in re-engineering and repairing scientific equipment that was damaged or failed to function properly.

Comdr. Archibald Patrick, Jr., Operations Officer, provided valuable assistance during several weeks of pre-expedition arrangements, and during the voyage, assisted in scheduling the experiments and acted as liaison between the Working Group and the ship's personnel.

Because of the importance of local sun time to the determination of primary productivity and to the scheduling of radiant energy measurements, the ship's Navigation Officer, Lt.(jg.) Floyd Childress, made arrangements to provide the laboratory with a "sun-time" clock which was set correctly each morning to indicate noon when the sun reached maximum altitude. He also had posted under the clock zulu time for sunrise and sunset and provided latitude and longitude determinations for the beginning and end of each daily drift station as well as the ship's position for local apparent noon.

The computer officers, Ens. Lawrence Lake and Ens. Stephen Mangis, together with the group of survey technicians under Mr. Hopkins, took full responsibility for providing the SCOR

(1) The other Working Group was engaged in intercalibration of radiometersondes. The instruments were launched with helium-filled balloons in the evenings. The group was chaired by Mr. P. Kuhn.

group each day with a record of temperature, salinity, and density as a function of depth to 500 meters. They also made two daily casts with a mechanical BT to 275 meters, generally at times 1000 and 1400, and obtained surface temperature with a bucket thermometer. On several days expendable BT's were used every four hours to locate upwelling and the associated high chlorophyll concentration.

Chemical analysis of the sea water at each station was conducted by James Alberts. Alberts used sea water from the "Jitts bottles" (explained below under simulated-in-situ procedure) and, at greater depths from the Nansen bottles. He determined phosphates, silicates, nitrates, and nitrites and reported phosphorous, silica, and nitrogen in micrcgramatoms per liter. On the water from the Nansen bottles he also obtained water temperature and salinity. During the first week of the expedition he obtained samples to depths of 200 meters and after that he extended his sampling to 500 meters in order to more precisely describe the water type.

Continuous recording of total energy and energy available for photosynthesis (both at the ocean surface) was the responsibility of Dr. Yulen Ochakovsky. Total energy, including the infrared, was measured by means of a thermopile and electrolytic integrating recorder. Integration was carried out from noon to sunset every day to coincide with the period of incubation of the primary productivity samples. Measurements of total energy by means of a second thermopile were also continuously recorded on a strip-chart recorder for the same period of time. Measurements of the total energy available for photosynthesis were continuously recorded by the Russian Amici-prism instrument on a second strip-chart recorder and for the same period of time. The Amici-prism instrument isolates and records the energy within the spectral regions from 350 nanometers to 700 nanometers by means of a fitted template in the image plane of an Amici-prism dispersing system.

The time recorded energy, on occasion, showed massive changes in surface energy due to the passage of clouds over the sun. This, of course, is a real event to the phytoplankton and should be recognized for purposes of correlation. These events do, however, create problems with subsequent integration of the time recordings. These problems were discussed and tentative methods were adopted for reporting the time based data.

The Amici-prism instrument was also used to collect data on total energy as a function of depth in the ocean. These measurements will provide additional means for studying the relationship between primary productivity and the energy available for photosynthesis.

Identification of plankton species and estimation of relative populations was the responsibility of Jahn Throndsen. Throndsen generally analyzed six samples at as many depths at each station. He separated the phytoplankton into five size groups and counted the dinoflagellates, coccolithophores, diatoms, and flagellates in each size group. He also reported the total number of cells per liter in each size group, the total cells for each form and the percents of total in each case.

Spectral irradiance as a function of depth was measured by Dr. R.C. Smith, who employed the Scripps spectroradiometer. This measurement was made at or near noon, sun time, to avoid possible changes in irradiance due to changes in the altitude of the sun. A scalar irradiance collector was used as a deck reference cell. In order to avoid taking data during the intervention of a cloud over the sun, Smith observed the performance of the Russian instruments that were monitoring and recording surface energy on strip-chart recorders. The Russian instruments were located where they could be easily observed for this purpose. Smith also used the spectroradiometer to obtain monochromatic values of irradiance as a function of depth. These latter measurements were for intercomparison with similar measurements being made from the ship with other instruments. Measurements with the Scripps spectroradiometer were made to a depth of 30 meters. During the time assigned for this work on the stern boom an average of about five or six spectroradiometric curves were obtained at each station.

Spectral irradiance measurements were also made by Dr. A. Morel with a French designed instrument capable of rapid spectral scanning. Spectral irradiance measurements were made to a depth of 150 meters with this instrument. The French group employed other instrumentation for measuring radiant energy. Attached to the same frame, and lowered at the same time, were an underwater thermopile and a quanta meter of French design. Results from these three instruments will be exactly comparable in space and time. To record the deck irradiance the French group employed an Eppley thermopile and an irradiance meter filtered to have sensitivity at 480 nanometers.

During the time assigned to the French group on the stern boom they were able to obtain an average of about 20 measurements of spectral irradiance per station as well as measurements with the thermopile and the quanta meter lowered on the same frame.

The measurement of the total quanta available for photosynthesis was undertaken primarily by the Danish group, who constructed quanta meters for their own use during the expedition and supplied, as well, several of these instruments to other members of the Working Group. The quanta meters were used, for example, in conjunction with other radiant energy measurements, in the incubators used for simulated-in-situ primary productivity work and in connection with the in-situ samples for primary productivity.

The measurement of total quanta as a function of depth was obtained regularly (generally every hour) by Dr. K. Nygaard, who also frequently lowered his quanta meter by attaching it to the frame of the French or American spectral irradiance meter.

The Danish group also obtained samples of water and made laboratory scattering measurements at 45° and 90° from the forward direction. They also employed instruments for measuring the scattering function and the total scattering function which were used after dark when the ambient light in the water would not interfere with the measured results.

The transmittance of the water, for a beam of light, and the scattering function between 10° and 170° were measured by Mr. Austin. The beam transmittance was measured before and after the midday period in order to locate and describe any existing stratification and record any changes in stratification during that period.

The scattering function was measured after dark, again to avoid interference by ambient daylight underwater.

The measurement of primary productivity by the in-situ method was made each day by Dr. Y. Saijo. Dr. Saijo used water from the Jitts bottles which he inoculated with C^{14} in the usual manner. The string of about seven bottles had included with it a quanta meter located at the level where 25% (sometimes 18%) of surface light was obtained. When launched, the string of bottles was attached to a Roberts buoy inside of which was a small battery-operated strip-chart recorder. Dr. Saijo was able, therefore, to obtain exactly correlating measurements of the quanta available for photosynthesis and the in-situ primary productivity. Since the attenuation coefficient for quanta will be available for each station from Dr. Nygaard's measurements, Dr. Saijo will be able to have the quanta available for photosynthesis at every bottle depth as well as the measured productivity at each depth.

Dr. Saijo also performed enrichment experiments in the laboratory and determined particulate carbon and nitrogen.

The measurement of primary productivity by the simulated-in-situ method was carried out by Mr. Jitts. Mr. Jitts used a daylight incubator with blue filters to simulate the light level and its spectral distribution at six depths. He also used an artificial light incubator. Both incubators were equipped with quanta meters and the quanta actually available for photosynthesis during incubation in each incubator was carefully monitored and recorded.

The technique used for the simulated-in-situ procedure was the determinant for the Jitts depths and for the water samples used for other analyses. This comes about as follows. At about time 1000 a measurement was made of quanta as a function of depth at the station site. The blue filters in the Jitts incubators transmitted a fixed percentage of incident quanta. The depths at which these percentage transmissions occur in the ocean were read from the curve of quanta versus depth for the station and these depths became the Jitts depths. This technique resulted in all incubations being conducted under very nearly the same selected levels of quanta.

The determination of chlorophyll concentration was the responsibility of Dr. Ian Baird. Dr. Baird also used water from the Jitts bottles and, at greater depths, from the Nansen bottles. A typical station analysis consisted of 10 to 14 samples from as many depths. Both chlorophyll-a and phaeo-pigments were determined. The determination of chlorophyll-a was done by means of a Turner fluorometer and also by a standard spectrophotometer method.

Mr. Malone, who worked with Dr. Baird, was collecting data for a doctoral thesis which involved the determination of chlorophyll-a in nannoplankton versus net plankton. His study fitted in beautifully with the interests of the Working Group and provided a more detailed study of chlorophyll concentration than had originally been anticipated.

A daily record of all measurements made is included in the Appendix.

Planned Track

The track of the expedition was primarily planned with the objective of reaching ocean waters with widely different productivities. From Miami the track was planned to round the west end of Cuba, travel through the Caribbean Sea to the Panama Canal, through the canal into the Gulf of Panama and then southerly into the plankton rich water along the coast of South America, then southwesterly into south Pacific water as far as time would permit.

On the return voyage it was planned to repeat some of the stations south of the canal and one or two in the Caribbean. The return track would then take us through Windward Passage and into the Sargasso Sea to about 25°N65°W and then westward to Miami.

Although an early request was made to the government of Ecuador to enter the coastal waters off Ecuador for research purposes, their answer was overtly delayed and the conditions imposed by them were unacceptable, nor could their conditions be reconciled with the time requirements of the expedition.

The studies in the ocean and the collection of water samples were carried out from two deck areas, the stern area and an outboard station on the starboard side. These areas were separated by about 25 feet. The stern area had been specially equipped with a 25-foot aluminum I-beam with a trolly and appropriate rigging. The heavy optical instrumentation could be conveniently launched and hauled out to the end of the boom where the optical perturbation caused by the ship would be minimized. Also available in this area and accessible from the deck above, were the ship's smaller A-frame and two heavy duty winches. These launching facilities were prepared and used alternately. At times, wire was being payed out from the A-frame on the upper deck while instrumentation was being retrieved from the stern boom. Although the wires often crossed, careful observation and planning prevented their fouling.

On the starboard side the ship's equipment provided an overhanging platform, a suitable davit with metering pulleys and heavy duty winches. The United States group had also located an electric cable winch in this area. The STD was launched at this location followed by the Nansen cast and later by instrumentation requiring the electric cable winch. It was thus necessary to employ three wires at this location and to rerig the davit with the block appropriate for each wire.

The launching of the in-situ primary productivity experiments and the Roberts buoy also took place on the starboard side.

The scheduling of events to meet the requirements of this program was complex. The optical measurements required that the stern of the ship be exposed to the sun. The work from the starboard platform required that the wind should be on the starboard side. The in-situ primary productivity samples had to be launched at noon on the windward side and recovered at sunset. The most valuable time for optical measurements was the four hours around sun noon. All instruments, of course, had to be out of the water in order to maneuver the ship. The ship's engines required time to warm up, etc., etc.

The reconciliation of these conflicting requirements required close cooperation between the ship's officers and the scientific party. Fortunately the ship could usually be hove-to with the wind on the starboard and the stern exposed to the morning sun. At noon, as soon as the Roberts buoy was adrift, the ship was often rotated 180° to expose the stern to the sun during the afternoon. On days when conditions did not favor this simple solution, the ship was turned more often.

A chronological routine for the measurements in the ocean was soon established and is illustrated in Table I.

TABLE I

Sun Time	Starboard Platform Wire 1	 Wire 2	 Wire 3	Ship Orientation	Stern A-Frame	 Boom	Over The Side
0800				Wind on Starboard			
0900	Hopkins	Austin C-Meter		↓			Throndsen Net Sam. Malone 3-m. Sam.
1000		Saijo Water Sam		Sun on Stern Wind on Starboard		Morel Optics Kjell N.	Hopkins Mechn.BT Jitts H-Meter
1100		Albert's NansenCst Saijo		↓	Jitts Water Sam		
1200		In-Situ Samples	Austin C-Meter	Sun on Stern and on Deck Incubator		Smith Optics	Marker Buoy over
1300			↓	↓		Optics Nygaard-Smith	Amici Prism
1400						Morel Optics	Hopkins Mech.BT
1500						Nygaard Morel Optics	Malone 3-M Sam.
1600						Nygaard Morel Optics	
1700		Saijo		Steaming to Marker Buoy		Nygaard Morel Optics	Marker Buoy
1800		Samples Aboard	Austin Scattering			Nygaard Scattering	Recovery

Intercalibration and Standardization

A tungsten-iodine lamp mounted on a 2-meter optical bench was provided on the ship for purposes of standardization and intercomparison of the various radiant energy detectors. This facility was used for checking the linearity of response of photodetectors, comparing the outputs of various instruments, rechecking output over elapsed time, determining absolute calibration within the range of energy levels provided by the lamp and performing other tests on the phototubes and photocells being used in the work.

In addition to this, the last two experimental stations, both in Sargasso Sea water, were devoted to direct underwater intercomparisons. All available radiometric instruments were first fastened to the frame of the Scripps spectroradiometer and readings were taken simultaneously with all instruments at specified depths to 90 meters. Then the same procedure was carried out with the same complement of instruments attached to the frame of the French spectroradiometer. The French and Scripps spectroradiometers could not be launched simultaneously because together they exceeded the load limit of the stern boom.

Sponsorship

The DISCOVERER Expedition was a planned activity of the Scientific Committee on Oceanic Research Working Group 15 and enjoyed the financial and moral support of SCOR, UNESCO and IAPSO.

As stated earlier in this report, the ship DISCOVERER was provided by the U.S. Coast and Geodetic Survey through the courtesy of Rear Admiral D.A. Jones, Director, Coast and Geodetic Survey, Environmental Science Services Administration and Dr. Harris Stewart, Director of the Atlantic Oceanographic and Meteorological Laboratories of ESSA.

The parent laboratories of the various Working Group members, of course, provided direct support of the participant's time during the expedition, as well as the use of specialized scientific equipment. In many cases the parent laboratories supported the modification of construction of special equipment to be used during the expedition and plan to support the time necessary for data reduction.

For the DISCOVERER Expedition, scientific skills in addition to those available among Working Group members were required to carry out the integrated program of research that had been planned. The additional expenses involved in securing skilled personnel, providing for suitable equipment, transporting both to and from the ship, and solving the many local problems attendant to a large expedition received financial and/or direct-action support from the NSF, the Royal Society, the ONR and the U.S. Air National Guard. Travel for two graduate students was provided in one case by the Hopkins Marine Station and in the other case by Florida State University.

REPORT ON SCOR WORKING GROUP 23
ZOOPLANKTON LABORATORY METHODS

Introduction

Of the activities recommended by the working group at its Washington meeting in March 1968, the following have received major attention:

1. The experimental program on plankton fixation and preservation, mainly in liquids, the results of which will ultimately be incorporated in;

2. A manual on zooplankton fixation, preservation and storage.

Dr. Steedman has supervised the experimental program, with the assistance of Drs. Beers and Tokioka, and the coordination of the WG chairman. Working group members have participated in the execution of various projects. However, the success of this work has been possible only because Dr. Steedman has devoted so much of his time, both to the program at the Smithsonian Oceanographic Sorting Center (where his holidays have been spent) and in his own department at Bath. Now technical staff have been trained and can assume part of the burden.

Description of Activities

The following summary and outline are extracted from Dr. Steedman's report of 10 August 1970:

Summary of the year's work - August 1969 to July 1970

"Comparison of a large variety of different fixatives on various plankters has been made, and the effects of an even larger number of preservatives have been followed and closely examined.

In any project of this size and complexity it is natural that some aspects may fall behind in the rate of development. This is partly true of calcareous plankters, and to some extent of oily plankters, but the coming year should produce clear answers to these problems. Ctenophore fixation and preservation still leaves something to be desired.

The effects of formaldehyde in almost all of its variations, as well as a variety of formaldehyde donors, and with many buffers, have been observed with great care , and a considerable reduction in the strength of its solutions should be possible. The most satisfactory buffer has yet to be decided.

At the Smithsonian Institution Oceanographic Sorting Center some 500 solutions have been devised and used; more than 5,000 pH readings have been made at regular intervals; approximately 5,000 visual and low power binocular observations have been made, and some hundreds of whole mounts and tissue sections have been produced."

Outline of work for the year - August 1970 to July 1971

"When the new series of fixatives and preservatives are produced, on the basis of data obtained over the past year, specimens will be treated for a minimum of 6 months and will then be referred to specialists in the appropriate groups for their appraisal. Several samples will be submitted.

At the same time chapters of the UNESCO handbook will be compiled leaving appropriate space for specialist comment. By July 1971 it is hoped to have most of the chapters completed in rough draft.

It is also intended to pass on to all members of WG 23 either the fluids themselves or the formulae in the hope that they will have time to test them without undue delay. This corroboration is an essential feature of the work. It will involve considerable postage, packaging, and expense."

Description of the Activities

The experiments have been made almost exclusively at the Smithsonian Oceanographic Sorting Center (SOSC), Washington, D.C., and at the University of Bath, at both institutes under the personal leadership of Dr. Steedman. The experiments conducted at the SOSC were initiated during the summer of 1968, and at the University of Bath in April 1969. Dr. Steedman has made several journeys to the SOSC Washington, D.C., to initiate and later to supervise the work there.

The duration of the two projects is anticipated to be approximately three years each, the effects of the various methods being impossible to see or evaluate in a short period of time. The series of experiments comprise 20-25, each of about 40 single experiments each.

In addition to the two main centers, attempts are made to follow up parts of the main program at the following places: at IOBC, Cochin, India; at the Sorting Center in Singapore, headed by Dr. Tham Ah Kow; in Bangkok, Thailand; and in Japan. Dr. Steedman visited the above institutions (also Scripps, California) in May-June 1969, and Vagn Hansen in December 1968 and November 1969. So far no effort has been made in Thailand, whereas the efforts made at the other regional laboratories are highly appreciated, in Japan and at Scripps especially in the field of biomass determination. The main series of experiments at both SOSC and Bath University have been somewhat hampered by problems concerning personnel, facilities and surprisingly enough, also by lack of bulk quantities of fresh zooplankton. Many institutes have given valuable help in supply of zooplankton material.

The expenses for travel have been paid by SCOR, UNESCO, SOSC, and Danish Government sources. Per diem for Dr. Steedman during his stays at SOSC has been paid by the Smithsonian. Salaries for technical staff have come from SOSC, and NERC (U.K.); UNESCO has contributed to secretarial assistance for Dr. Steedman, and a photomicroscope has been supplied by the Royal Society, London. In general, financial support from U.S.A. and U.K. sources has been granted in accordance with the period needed for proper evaluation of the experiments.

Evaluation of the Program

In spite of the above mentioned difficulties which also could be anticipated in such a multilateral supported program, the project must be considered to have given adequate results. The present two main operational centers should be able to come out during 1971 with results such as proposed by WG 23 in 1968. This is especially the case for the below aspects:

1. Test on buffers in liquids.
2. Effects of classical fixatives as well as recently developed organic compounds tested in several combinations.
3. Criteria for quality of fixation and preservation of specific groups of plankters and tissues (the latter by histological and cytological effects on tissues) also through electron microscopy studies.

The main outline of the results of the program should be so advanced that a report can be made available in 1971. The report should at an early date be distributed for comments to selected experts. The report will form the basis of a handbook, possibly to be published by UNESCO in the series of Monographs on Oceanographic Methodology. However, before publication, other of the recommendations of WG 23 should materialize: The workshop on zooplankton fixation and preservation recommended by WG 23 should be held.

Recommendations

1. The Working Group should continue its present work till the experiments can be evaluated and the results be reported, by the end of 1971 or the beginning of 1972. Travel grants for Dr. Steedman's visits to SOSC should be envisaged, and the chairman should be enabled to visit Dr. Steedman in 1971 for discussion of the final report.

2. A workshop should be organized for exchange of information and for application of methods of fixation and preservation. The draft report on the present experiments carried out under the supervision of Dr. Steedman should be critically analyzed before publication. Recent methods, such as deep dry freezing done in mass scale in medicine and food technolgoy, should be discussed and applied to fresh zooplankton during the workshop. Participants should include a few planktonologists, and experts from such fields as medicine, pathology, histology, and food technology, perhaps 10-12 in number. The meeting might be in U.K. West Germany or U.S.A.; adequate facilities and space must be available for the activities of the workshop. Sponsorship by SCOR and UNESCO would be appropriate.

3. Results of the present experiments conducted by WG 23 should be published by UNESCO in the series Monographs on Oceanographic Methodology. The proceedings of the workshop should be included as an annex to enable planktologists to evaluate the results which may serve as a guideline for future research at institutional and individual levels.

4. Although experiments have been initiated on the determination of zooplankton biomass, it is not clear that conclusive results can be obtained at the present level of activity. A report on this problem should be prepared by Drs. Beers and Hansen, for consideration by the SCOR Executive Committee in 1971.

5. In view of the important role of microzooplankton in the secondary production of the ocean, the SCOR Executive Committee should consider whether problems of microzooplankton fixation and preservation should be considered by a separate working group.

Vagn Hansen, Chairman
Phuket, 11 August 1970

ANNEX V

REPORT ON SCOR WORKING GROUP 27
DEEP-SEA TIDES

There have been no formal meetings for the last two years, but the time may be ripe for a new review.

Theoretical efforts to compute the global tides by Pekeris in Israel, Hendershott in the United States, and Zahel in Germany have made considerable progress. I have not learned of the recent results in the Soviet Union where similar work is underway. It is my impression that a meaningful comparison between deep-sea calculations and deep-sea measurements is only a short time away. The boundary dissipation problem has not been solved, but it now looks as if the total energy in the oceans is rather larger than had been estimated; so the relative dissipation is not quite so dramatic. Some connection between the age-old problem of the age of the tides and tidal dissipation has been established by Christopher Garrett.

The ESSA (Miami) group is getting set for employing Filloux tide gauges during September to study the M_2 node in the Gulf of Mexico and the tide in Yucatan Channel. Current meters will be deployed in the latter location. One principal goal is to study the M_2-S_2 difference in this location.

The ESSA (Seattle) group under the leadership of Capt. Barbee has been making measurements of internal tides off the continental shelf. Apparently, such internal tides are generated at the break of the shelf by mode coupling and propagating seaward along predictable "rays".

At the Scripps Institution we have occupied stations offshore from California, and these form the basis of the paper by Munk, Snodgrass, and Wimbush: Tides Off-Shore: Transition from California Coastal to Deep-Sea Waters, Geophysical Fluid Dynamics, Vol. 1, pp. 161-235, 1970. I think the work has served to clarify the cotidal structure in this part of the world. We now plan for a special cruise this October to occupy stations surrounding the alleged M_2 amphidrome.

Frank Snodgrass made a successful drop and recovery of three capsules at 40°, 50° and 60°S between Australia and Antarctica. The duration was approximately a month. Most of the equipment worked, and the tides show a sensible continuity between the Antarctic and Australian continents.

Our main emphasis for the next year will be the design and construction of a capsule which is to remain on the sea floor unattended for one year.

Walter H. Munk, Chairman

ANNEX VI

REPORT ON SCOR WORKING GROUP 28
AIR-SEA INTERACTION

Interim Report of Proceedings, 1967-1970

Meetings

The Joint Committee met in Lucerne (September 1967) and in Princeton (January 1969). Minutes of these meetings have been widely circulated. A third meeting planned for Tokyo (September 1970) was postponed until the XV General Assembly (Moscow July/August 1971).

Members of the Committee have met informally on several occasions to discuss particular aspects of the work.

Composition

The Committee is now sponsored by SCOR as well as IAMAP and IAPSO and the terms of reference have been amended accordingly. It is also designated SCOR Working Group 28.

Coordination has been maintained with IOC and WMO and especially with the ICSU/WMO JOC for GARP. At the suggestion of JOC, Dr. K. Bryan and Professor S.S. Zilitinkevich have been co-opted to the Committee.

Symposia

No IAMAP/IAPSO/SCOR symposium on air-sea interaction has been held since the XIV General Assembly but two to three days will be devoted to this topic at the Moscow General Assembly.

Air-sea interaction has been discussed at many meetings, however; its importance to both meteorology and oceanography is now well appreciated.

The Committee urges that the strong links between IAMAP and IAPSO be maintained and regrets that there is to be no inter-Assembly meeting between them.

Activities

The intercalibration trials have proved valuable. Results from those at UBC (August 1968) have already been published.

The land trials in Australia have been followed by a series in the USSR.

Continuing efforts are being made to advise the JOC for GARP on the incorporation of the oceanic and atmospheric boundary layers into numerical models of the general circulation of the atmosphere. The difficulties involved, in both concept and technique, are being increasingly recognized; rapid progress is not to be expected.

Members of the Committee took part in a meeting of the Interim Planning Group on the GARP Tropical Experiment in the Atlantic (London, July 1970) and it is likely that the Committee will be asked to advise the Tropical Experiment Board when it is set up.

The Committee was represented at an IGOSS Executive Coordination Committee Meeting (Paris, July 1970) where attempts were made to put the IGOSS proposals into a more realistic basis.

Future Activities

It is hoped that the Committee will meet in Moscow at the XV General Assembly, where symposia on Air-Sea Interaction are being organized.

The terms of reference of the Committee require it to review the requirements and foster research within the field of air-sea interaction. This has so far been done by personal example and precept. Now individual work is gradually being integrated into national efforts and no opportunity for international collaboration is being lost.

Apart from this, the Committee's function is largely advisory, particularly to bodies like the JOC for GARP. The initial difficulties of specifying the problems and identifying realistic proposals have largely been overcome and this aspect of the work seems likely to be increasingly useful in the future.

H. Charnock, Chairman
Southampton, 1 September 1970

REPORT OF SCOR WORKING GROUP 29
MONITORING IN BIOLOGICAL OCEANOGRAPHY

Report of Meeting in La Jolla, 25-29 May 1970

The Working Group met at the Fishery-Oceanography Center of the U.S. Bureau of Commercial Fisheries, La Jolla, California, from 25-29 May 1970; the following members participated:

Dr. J.M. Colebrook	Oceanographic Laboratory Edinburgh, Scotland	IBP/PM
Dr. K. Grasshoff	Institut für Meereskunde, Kiel, Federal Republic of Germany	ACMRR
Mr. R.J. LeBrasseur	Fisheries Research Board of Canada Nanaimo, British Columbia	SCOR
Dr. A.R. Longhurst (Chairman)	Bureau of Commercial Fisheries La Jolla, California	SCOR
Dr. C.J. Lorenzen	Woods Hole Oceanographic Institute Woods Hole, Massachusetts	UNESCO
Dr. S. Nishizawa	Research Institute of North Pacific Fisheries Hokkaido University, Hokkaido, Japan	SCOR

The following terms of reference had been given for the Working Group:

> "Using the outcome of various relevant working groups of SCOR and other organizations, to review critically the present status of devices for (a) continuous observation of parameters such as pigments, particles, transparency, submarine irradiance, primary production, nutrients, and (b) continuous or intermittent sampling of organisms and to list suitable techniques and instruments for such measurements. The Working Group would work, where relevant, with the Chairman or rapporteurs of other SCOR Working Groups."

In a discussion of these terms, the following definitions were considered:

Continuous -- A series of observations or samples in space or time with intervals between them which are small compared with the smallest significant scale of variability of the parameter being measured. Thus, this term may be used either for analog or digital data outputs.

The term may be applied to continuous underway observations from research vessels or ships of opportunity, to continuous vertical profiling observations, to relatively short continuous horizontal transects, to relatively short period continuous in-situ observations and similar situations.

Monitoring -- A time-series of observations designed to provide information about major patterns of fluctuation extending, or intending to extend, over long periods of years in most cases. In particular, to be applied to observations of the results of climatic changes on marine biota.

Might be applied to observational series based on in-situ apparatus mounted on data buoys, piers, sea-bottom capsules, and so on, as well as to the regular and routine occupation of ocean stations, and to regular daily (or more frequent) measurements of biological parameters from satellites in near-earth space.

After accepting these, it was agreed that a more appropriate title for the working group would be "monitoring in biological oceanography". Participants further agreed that, as far as possible, they would confine themselves to consideration of monitoring systems which might be applicable to comprehensive networks of data buoys, aircraft or satellites, and ships of opportunity; they agreed to spend a minimum of time on consideration of systems developed for continuous sampling or observing from research vessels for special purposes.

BIOLOGICAL PARAMETERS TO BE INCLUDED IN OCEAN MONITORING SYSTEMS FOR THE PURPOSE OF:

Fishery research and services

Monitoring on an ocean-wide scale of such parameters as chlorophyll-a, C^{14} uptake, and zooplankton biomass have been much overemphasized in their direct application to fisheries. A number of examples were discussed to emphasize that application of primary and secondary production data differed very considerably from fishery to fishery.

During the recent METEOR work in the region of Cabo Blanco, a recently upwelled parcel of water, rich in nutrients, was observed to develop a very strong bloom of a *Phaeocystis*-like alga. Subsequently, no grazing herbivores developed, probably because few herbivore species are able to utilize these chain-form phytoplankton. In an ocean-wide chlorophyll-a monitoring system such patches would be difficult to assess without additional observations. Similar experiences have been noted off Peru where the *Engraulis* fishery does not correspond with regions of strongest upwelling, and off South West Africa where the Spanish distant-water trawler fleet has been observed far from upwelling centers, while in the northern Pacific Ocean it has been found that there was no direct relationship between the north Pacific spring bloom and the high seas salmon distribution. However, monitoring of the location and timing of events in production cycles could have importance in individual fisheries whose fishery-oceanography had been adequately investigated, such as the well-known case of the timing of the spring diatom bloom in relation to the spawning of herring in the North Sea and adjacent areas, and the less well-known dependence of the Ghana herring fishery on the occurrence of the late summer coastal upwelling.

Similar arguments were made concerning ocean-wide monitoring of parameters of zooplankton, though for some kinds of fisheries, at least, the relation between zooplankton and fish distribution would be more direct and useful than that between fish and chlorophyll-a.

The reference, by Working Group 32, to Working Group 29 for consideration of problems in relation to monitoring programs for ichthyoplankton (fish eggs and larvae) was then considered and the question of sampling scale and the scale of patchiness of the components of the ichthyoplankton was discussed, since it is known that fish eggs may be highly aggregated. Working Group 29 suggested that Dr. Paul Smith (BCF, La Jolla) be asked for a short statement since he is currently studying egg and larval aggregations.

It was noted that although ichthyoplankton was known to be highly aggregated, such patchiness was also characteristic of other planktonic parameters, and the whole question of variability due to aggregation of biota or biological products and effects had to be seriously considered in design of any monitoring system, in particular one based upon a series of ocean buoys, or other fixed-site platforms.

In discussing the question of the monitoring of benthic organisms, WG 29 regretted the apparent difficulty of designing a benthic fauna monitor for an ocean data system, especially because environmental effects produced on benthos are integrated over longer periods than in the ephemeral plankton and hence the effects of small-scale time and space variability are integrated.

The question was raised that perhpas the major fisheries role of any ocean data system including monitoring of ichthyoplankton and, perhaps, other biological variables might be to provide fishery-independent estimates of stock abundance that would assist in separating the effects of fluctuating fishing pressure and of fluctuating environmental conditions upon the resource, and it was agreed that the development of causal relations between ichthyoplankton and other monitored variables was highly desirable.

Consideration of direct monitoring of fish by acoustic means was proposed with the suggestion both that ships-of-opportunity on regularly scheduled runs might produce data of great interest to fisheries if fish-finding echo sounders and sonars were systematically deployed and that ocean data buoys could be equipped as sonobuoys to record the presence of fish schools within sonar range on a routine basis.

Cited were the Edinburgh plankton recorder operation as an example of a monitoring system that produced linear data of the same nature as that which would be produced by echo sounders on a ship of opportunity. There was not complete agreement in the Working Group that such data would be useful in fisheries prediction services; they might be more useful in exploratory research programs.

Pollution research and service

The Working Group agreed that there were two kinds of activities to consider:

(1) Monitoring of biological indicators of the effects of pollution: eutrophication, thermal pollution, etc.

(2) Monitoring of pollution by biological agents.

Under (1) there is a strong case for a system designed to monitor species composition of zooplankton and phytoplankton to detect changes in the abundance and structure of populations due to man-induced changes in the biotope. It was suggested that special attention needed to be given to micro-flagellates in this connection.

Under (2) it was found that the Working Group did not have the needed expertise to discuss what might be necessary in the monitoring of pathogenic organisms, especially bacteria. In one view, it seemed that present technology of marine bacteriology seemed relatively unevolved and far from ready for integration in automated monitoring systems and, in another view, relatively rapid techniques of estimation of fresh water bacterial floras were already available. It was recognized that other groups were active in this field already, reference being made to a committee of the NAS of United States, headed by Menzel of WHOI, and the matter was pursued no further.

Recreation

After short discussion, it was agreed that research and service needs of recreation-development agencies would be adequately covered in general by the topics covered above.

Research in biological oceanography

It appeared to the Working Group that many of the topics already covered in the discussions of fishery research above were relevant here also, and that differences were largely only of emphasis and scale. The Working Group discussed in some detail the reality of the frequently repeated statement concerning biological indicators of water masses and explored the possibility that such indicator species or communities might have real utility vis-a-vis physico-chemical indicators. They concluded that where boundaries are clear, then physical-chemical methods of detection are to be preferred. In some areas -- the temperate north Atlantic for example -- water mass boundaries are poorly defined, and a combination of physical, chemical, and biological indicators is probably required for a proper understanding of events. In addition, plankton boundaries are known for which there are no equally clear physical equivalents; these are probably due to non-linearity in the response of the organisms to environmental conditions.

One of the advantages of using biological indicators, particularly plankton, is that each sample provides an observation for each species of plankton in the sample, giving potentially more information than a single temperature or salinity measurement. The problems lie, of course, in high noise levels and in the interpretation of observed fluctuations.

However, in general biological procedures are likely to be operationally more complicated than the relatively simple techniques now available for the rapid determination of temperature, salinity and other chemical characteristics of water masses. When long-term historical trends in the marine ecosystem are being investigated, identification for both plants and animals down to specific and, if necessary, to subspecific levels is essential.

DIRECT VERSUS INDIRECT MONITORING OF BIOLOGICAL VARIABLES

The Working Group discussed a number of examples in which the use of deterministic models based on an understanding of the mechanism of systems in the ocean made indirect, simpler measurements of physical parameters preferable to the more complex direct measurements of biological parameters. However, an essential prerequisite is the demonstration of causatives in such processes and the complexities involved in the fact that in most instances there is a time constant to be considered from the lag of biological events behind their physical causes. Also, they recognized that in some cases an extremely simple physical measurement, such as a Secchi disc reading, could be used to estimate chlorophyll standing stock, and that such estimates might be sufficiently precise for a number of tasks.

The Working Group also discussed the utility of developing novel gear for this type of activity and, in particular, the desirability of the development of an expendable light extinction coefficient sensor which might operate in a manner similar to the XBT system, or might be incorporated within such a system.

The question of the use of ships of opportunity in such indirect monitoring of complex biological systems was discussed, and in particular American and Canadian experience with such a program in the North Pacific was examined. It was agreed that although such programs are in a very early stage of development at the present time, they had been shown to be practicable.

FEASIBILITY, RESEARCH AND DEVELOPMENT NEEDS OF INDIVIDUAL MONITORING SYSTEMS

Before discussing individual systems the Working Group identified some problems general to a number of these systems.

They noted, for instance, that it did not appear that a serious problem was likely to exist in the digitization, storage, transmission, and processing of data from any foreseeable system; it appeared to the Working Group that it was entirely feasible to handle data with presently available technology in any way that might be operationally desirable. They did not feel that deployment of any satisfactory sensor that might be developed in the foreseeable future would be delayed or prevented by a lack of communications engineering.

Many of the systems discussed included underwater optical systems and it was recognized that there was presently no way in which optical standards could be maintained for more than very brief periods in such underwater systems because of fouling of the glass/water interfaces by bacterial and other films initially and by other, more complex, fouling organisms subsequently. This was regarded as a general area requiring serious attention before several of the systems discussed below could be deployed.

Several of the systems required the pumping of subsurface water through filtration systems and the taking of samples of zooplankton which included many species capable of active avoidance of pump orifices. It would greatly add to the difficulty of this and other pumping systems if the pump orifice could not be maintained in a stable position in the water column; if it were being deployed from a surface-following buoy, vertical oscillation of the pump intake might present insoluble problems. There are probably a number of reasons to suggest that a spar buoy might be preferable to a surface-follower of whatever form. The spar buoy has the advantage of vertical stability and offers the possibility of distributing intake orifices down to at least shallow depths.

Chlorophyll-a sensors to be mounted on ocean buoys

Chlorophyll-a in intact cells may be estimated in a number of different ways. Techniques that might be used utilize either the characteristic absorption or fluorescent spectrum of the plant pigments. An absorption method might be one similar to an alpha meter using red light in the region of 675 mu. The light band might be isolated by either a monochrometer, color filter, or an interference filter. All of these techniques seem feasible at the present time. Problems of sensitivity are envisioned, but could be readily solved with the use of either laser technology or perhaps a strobe light.

Fluorometry is already in use and is more sensitive than an absorption spectrophotometer. Chlorophyll-a has a characteristic flourescent spectrum, one which probably is quite unique when compared with other material that might be encountered in sea water, and it seems that a system could be assembled without too much difficulty.

Questions that have to be answered before a system could be deployed are: (1) should the sample be brought to the sensor, or should the sensor be brought to the sample, (2) should the sensor measure chlorophyll-a only at the surface, should it obtain a profile, or should the sensor integrate the chlorophyll content of the euphotic zone or to some predetermined depth, and (3) what should be the frequency of sampling?

The last question is readily answered. It is obvious that the sampling frequency must be dependent on the variability of the immediate environment of the buoy. In the open ocean, where variability seems to be minimal, sampling once a day may be sufficient. In regions of frontal systems this frequency may be increased to four times a day. In coastal areas under the influence of tidal action and/or river outflow, the frequency may have to be increased to once every 2 hours.

The other questions may be answered by considering what the ideal system might be. The sensor should be mounted in a vehicle that would move up and down. The readings of the instrument should be integrated over the euphotic zone to obtain the quantity of chlorophyll under a square meter of sea surface.

Chlorophyll-a sensors to be deployed on ships of opportunity

Instruments to sense chlorophyll from ships of opportunity would or could be the same as discussed above. Two different mounting methods are available; the sensor could either be included in a towed fish, or water could be brought aboard and passed by the instrument. In the former case, it is envisioned that an optical system, using either absorption or fluorometric techniques, be incorporated into a towed fish. The data could be either stored aboard the ship in a "black box", or stored in the towed fish. If it proved too cumbersome to incorporate the sensor in a fish, water could be pumped aboard either from a towed pump, or taken from a water supply through the hull. This would also be advantageous if the water collected could be used for some other purpose, i.e., chemical analysis, zooplankton collections, etc.

Another possibility would be a remote sensor mounted on the deck of the ship "looking" over the side. This type of sensor will be discussed below.

Chlorophyll-a sensors to be mounted in sea floor capsules

It seems that chlorophyll-a sensors would be useless if they were mounted in sea floor capsules unless the water depth was fairly shallow, since interest is mainly in the surface levels of chlorophyll. In some situations, especially in nearshore areas with heavy ship traffic, it may be better from a practical point of view to invert a buoy. That is to say, have a package on the bottom and periodically send the sensor up to the surface to collect the data. Other than this case, it does not seem as desirable to mount chlorophyll-a sensors in sea floor capsules.

Chlorophyll-a sensors to be deployed in aircraft or satellites

The possibility of deploying a sensor to monitor chlorophyll-a from either an aircraft or satellite is quite exciting. Not only would the monitoring be near-synoptic, which could also be achieved with a buoy network, but the geographical coverage would be very great.

At the present time, research is progressing along a number of different avenues in search of a satisfactory sensor. All of the proposed techniques would utilize the quantity and quality of the backscattered light as a measure of the quantity of chlorophyll-a present in the surface and near-surface waters. Basically, the color one observes from above the surface is light that is backscattered from the water as modified by suspended and dissolved substances. In the open ocean, and in areas unaffected by land run-off and tidal mixing, the signal received above the surface is a reasonable estimate of the surface chlorophyll content. One should expect interference if the sediment load is heavy, as near the mouths of large rivers.

Promising techniques under development at the present time include: (1) multi-spectral scanners, either television, or film packs incorporated with light filters, and (2) photomultipliers coupled with prisms or diffraction gratings by which a complete scan is received of the backscatter light.

These instruments work at reasonably low altitudes, that is from 10,000 feet down, and it appears that they should also work at satellite heights.

C^{14} uptake recorders to be mounted on ocean data buoys

The measurement of C^{14} uptake by plankton algae is still plagued by operator-induced variability. In addition there is no accepted consensus on the proper method of exposing the water sample to light conditions, duration of the experiment, and indeed the interpretation of the resulting counts. These apparent difficulties with the technique led the Working Group to the conclusion that the method, if it was to be useful, must be standardized. In addition, to be useful on a buoy it must also be automated which in itself may also standardize the method. The Working Group did not concern itself with the problem of obtaining "absolute" estimates since it was appreciated that relative numbers are perfectly satisfactory for monitoring purposes.

A package that might be able to accomplish the task was envisioned as an instrument having the capability of drawing a water sample, inoculating it with a standard amount of C^{14}, incubating it for the proper amount of time (in situ?), and then counting the quantity of C^{14} incorporated within the phytoplankton. The question was brought up if such an instrument could be made reliable enough, and the consensus was that it was not outside the realm of possibility. Perhaps a more significant question is: Do we need to go to such extreme efforts to measure a parameter? Maybe the estimate could be made using a simpler technique such as estimating the chlorophyll content of the euphotic zone.

C^{14} uptake recorders to be mounted on ships of opportunity

This item follows in the same vein as above. There is still a need for standardization of the technique, and if the money and energy were expanded, an automated package could be produced. This package could be used aboard a ship just as readily as on a buoy.

C^{14} uptake recorders for ocean floor capsules

An automated C^{14} package mounted on the ocean floor would be limited in its application in the same manner as a chlorophyll-a sensor.

Alternative techniques for measurement of primary production to be deployed on buoys, ships, and ships of opportunity

According to the equation, $n\ CO_2 + n\ H_2 = [HC(OH)]n + n\ O_2$, it should be possible to estimate the primary production in sea water by means of the CO_2 consumption or the oxygen production, assuming that empirical quasi-stoichiometric relations exist which take the average composition of plankton and the deviation from the ideal primary production equation into consideration. The most feasible way seems to be the application of oxygen electrodes in connection with the incubation technique as used for C^{14} measurements of the primary production. It is obvious however that the same restrictions are valid about the comparability of primary production as determined in incubation experiments in, for instance, bottles with real production. There are many different oxygen electrodes on the market, most of them based on the principal of the amperometric membrane electrode; most of them do not have long-term stability. For the application in connection with primary production, the electrodes must be rather sensitive to small changes (detect a change of $\pm$ 0.01 mo/1) and have a reasonable long-term stability. They should be operable over periods of weeks and months without service. Attention should be paid to a new measuring technique of the oxygen tension by means of the double layer effect at the surface of a spiked germanium crystal. These sensors seem to have a high long-term stability, are not influenced by the temperature dependence of the diffusion process, and can work under static conditions. (The firm Hydrobios, Kiel, has contact with the inventors at the Technical University, Berlin.) These types of electrodes have been successfully applied for in vivo measurements of oxygen in blood and are in the experimental state for application in sea water. The principal, however, seems to be superior to all existing sensoring techniques for oxygen tension in sea water. As regards the CO_2 consumption, the shift of the pH in the incubation bottle itself or the decrease in the CO_2 tension could theoretically be a measure for the primary production. There is a measuring technique existing for the CO_2 partial pressure by means of the combination of a membrane electrode and a glass electrode. Because of the strong buffering capacity of sea water for CO_2, the sensitivity and accuracy of the direct or indirect CO_2 sensors might not be sufficient to obtain measurable changes during the incubation period. The relative simplicity of this approach, taking the existing hardware into consideration and the application for monitoring purposes, makes it desirable that more efforts should be made to prove these techniques. The panel discussed briefly other methods for measuring primary production such as nutrient consumption, particle development, increase in fluorescence, etc., but could not see ways to automate such methods or make them sensitive enough to follow the primary production process.

Recorders of particulate and dissolved organic carbon and nitrogen for ocean data buoy deployment and for deployment on ships of opportunity

The determination of particulate and dissolved organic carbon and nitrogen involves wet chemical procedures and digestion of the samples prior to the analysis. Therefore, the most feasible approach for the realization of such determinations from buoys or ships of opportunity would be the application of an automatic water-sampling device involving storage in a suitable ampoule or bottle. For collection of the particulate material each ampoule should have its individual filter unit. The ampoules should contain about 250 ml. of water (or less) depending on the number of different chemical analyses to be carried out from these samples. The ampoules must contain a suitable preservative before they are filled with a sample or a preservative must be injected after the sampling procedure. The filters must also be preserved in a suitable way to prevent any deterioration of the organic material which has been collected. The sampling frequency must be programmable; the panel felt that the capacity of about 200 samples would be sufficient, thus providing a frequency of eight samples a day for a period of about 6 weeks. The sampler should be independent from outer power sources, that is either battery operated or connected to the central power system of the buoy. As regards application from ships of opportunity the water should be taken from a suitable intake or pumped into the sampler from an independent pumping system. The collection of individual samples should allow integration over a preset period of time so as to be as independent from small scale variations as possible. A sample identification system should indicate time and duration of the sampling together with a sample identification number. The samples will be brought to the shore laboratories for further analysis. The application of automatic micro-techniques will allow a variety of analyses to be performed from one sample. Many of such samples could be serviced by one automated laboratory. The hardware for such automated analysis as well as digital data logging systems is available or will be available soon. Methods for the automatic analysis of organic particulate and dissolved carbon or nitrogen are available using an average amount of 5 ml. of sample for each component. The same is true for the analysis of nutrients. The sample can, of course, also be used for the analysis of chemical pollutants.

Aircraft or satellite mounted sensors of other biota

Several systems are being investigated for the detection by remote sensors of fish in the upper waters of the ocean. The Bureau of Commercial Fisheries (USA) is investigating the practicability of detecting schooling fish at night by the use of bioluminescence detected by extremely sensitive photo-multiplying images developed for military purposes. It appears that fish schools can indeed be detected at some thousands of feet altitude from aircraft and it appears to be theoretically possible to develop this technique considerably, even for space platform mounting. However, the Working Group felt that ultimate success in developing the system into a reliable, wide-scale monitor of the presence and abundance of schooling fish depended upon the interaction of two biological variables (one of which -- the occurrence and nature of bioluminescent plankton -- was extremely non-uniform in response) and a number of physical variables. It was felt to be a system whose application in time and space to monitoring would be extremely limited.

Some investigators are known to be interested in the detection of schools of fish by detection and analysis of characteristic spectral absorption bands in oil slicks left behind by schools (Hornig, MS; Barringer, 1970). However, again the Working Group doubted the validity of this technique since all experimental work on the system so far (known to them) depended on light transmitted through fish (and other) oils rather than on reflected light.

Particle sizing and counters to be deployed in buoys and towed vehicles

The Working Group considered first the question of turbidity as a measure of this variable.

To monitor variation in overall (total) amount of particulate material suspended in a unit volume of water, a turbidity beam attenuation meter system is considered to be most suitable. This system requires a minimum of sophistication in instrumentation and gives a measure of attenuation coefficient of light passing through the water. The attenuation coefficient thus obtained has a good correlation with the total load of suspended solid if an appropriate range of wave length of light is utilized. Strict standardization of the optical system is a prerequisite. Adoption of a double-beam system with a compact monochrometer is most preferable in obtaining long-term stability of operation and also versatility in obtaining information other than the overall load of particles, such as the size spectrum of particles and absorption coefficient of particles. The main use of this sort of instrument, however, is in continuously monitoring the variation in overall amount of particulate material, so for concurrent monitoring of particle size and particle number the use of a suitable counter system such as the Coulter Counter is desirable. A chlorophyll monitor system and a particulate organic carbon monitor system will supply important information on the gross qualities of particles that the beam attenuation meter does not provide.

The number and volume (or equivalent volume) of individual particles in a particular range of size categories may be recorded to produce a continuous size spectrum of biomass in which the principal components of a sample of water are identified by the height and position of a peak in the spectrum. The value of this method is that it is possible to express community structure in quantitative terms using a single technique. The more conventional techniques, biomass measurements, production estimates and taxonomic studies, have tended to view a community at a particular production or trophic level with the subsequent difficulty of attempting to associate one group of organisms with another. In practice, the use of particle size spectra and conventional techniques may be carried out concurrently to describe an aquatic community. Parsons (1969) discusses the relevance of particle size spectra to plankton community structure and gives examples of its application to studies of nannoplankton and microplankton. In another report, Parsons and LeBrasseur (1970) demonstrate the use of the particle size spectra concept in a community which ranges in size from primary producers through to juvenile fish. In the latter example, however, several techniques were used to measure size.

Ideally, instrumentation is desired which would provide in situ measurements of all particulate material ranging in size from bacteria to adult fish. With suitable engineering the existing instrumentation could probably be adapted to provide continuous size spectra for material ranging in size from 2 μ to 2,000μ, i.e., from bacteria to adult euphausiids. The size spectrum as envisaged here would give equal spacing to various plankton groups, from ultra nano- to megaplankton, following Dussart's (1965) size classification.

Two systems currently in use are based upon optical and/or electrical sizing techniques. In the former, a transmitted light source and photocell arrangement is used to measure length or area of particles. In another optical system, size is determined by the scattering of light. Volume of the particles is empirically determined. These two optical systems fail to cover the complete size spectra; the reflected light system measures particles in the 2 to 100 μ range (Liquid Borne Particle Sensor, Model 2100, from Particle Technology Incorp., California), while the transmitted light system has been used only to measure particles greater than 500 μ (Cooke et al., MS, 1970). It would appear feasible at least to expand the size range presently covered and to modify the equipment for in situ observations.

Electrical sizing techniques make use of changes in conductivity or capacitance as particles pass through a theoretically uniform electrical field. In general, the particle size must be small in relation to the area of the field and its resistivity to the resistivity of the electrolyte solution must be large. These qualifications imply certain practical limitations; for example, flow rate must be controlled since some systems are rate sensitive. No one sizing apparatus is presently suitable for all particle sizes. However, several instruments have been developed which collectively sample most of the range from 1 to 2,000μ. For example, use of the Coulter Counter for measuring particles in the 10 to 500 μ range has been well documented. Sheldon and Parsons(1967) have prepared a manual outlining the operation of the Coulter Counter and give examples of its use in culturing phytoplankton and in grazing experiments with zooplankton. Maddux and Kanwisher (1965) and Boyd and Levin (MS) have developed apparatus based on the Coulter Counter principle for measuring particles in situ. The latter instruments are not commercially available, but several companies are reportedly examining the likely market for such devices.

In all automated or semiautomated counting systems, there is an obvious requirement for electrical power. Furthermore, use of such systems carries with it the implication that the user has relatively sophisticated systems for data processing, i.e., access to computers.

Plankton recorders for deployment in towed vehicles

A number of systems are already in use. The Continuous Plankton Recorder (Hardy, 1939) has been used in a long-term survey of the North Atlantic and the North Sea for a number of years (Glover, 1962). The Longhurst-Hardy Plankton Recorder has been used in the CalCOFI investigations (Longhurst, et al., 1966). An automatic sampler designed by D.I. Williamson (Williamson, 1963) has been used in the Irish Sea. These three systems use a fairly coarse mesh gauze to filter plankton from the water and do not sample the smaller phytoplankton species satisfactorily. No methods exist for sampling micro-zooplankton or nannoplankton.

The filter system of the Continuous Plankton Recorder is being redesigned for incorporation in a proposed undulating towed vehicle; one of the main design objectives being an improvement in the condition of the collected material. Both this and the Longhurst-Hardy filter system could provide a satisfactory basis for the continuous sampling of zooplankton and the larger phytoplankton organisms from towed vehicles.

There would not appear to be any major difficulty in principal in designing a phytoplankton sampler, based on a continuous band of membrane filters. Some suction pressure would be required which could probably be provided by a propeller-driven pump or a venturi pump. A sampler for very small organisms would probably require the collection of water samples. The main problem is one of fixation of these organisms, many of which disintegrate or are at least rendered unrecognizable following treatment with the normal chemical fixatives.

Collecting plankton samples from manned ships of opportunity presents few problems. Engine intakes can be used as a source of water samples, and a number of highspeed underway plankton samples are available (see, for example, UNESCO, 1968).

Plankton recorders for deployment from ocean data buoys

One problem is common to all methods of sampling plankton from fixed stations, and this is the problem of obtaining reasonably representative samples due to the extreme spatial variability of plankton populations. This difficulty can only be overcome by sampling over a fairly long period of time and relying on advection to smooth out some of this variability. This implies a relatively slow rate of intake of water which will lead to problems of avoidance of the intake by active organisms. This problem may be solved by pulsing the intake and combining the organisms collected in a number of pulses into a single sample.

In order to further reduce avoidance of the intake aperture by active organisms it will be necessary to arrange for the intake to be reasonably stationary.

An ingenious start towards solving some of the problems of sampling from a buoy has been made by Professor Isaacs of the Scripps Institution of Oceanography. He is employing the wave-induced vertical motion of the buoy to pump water through a Longhurst-Hardy filter mechanism. It is quite possible to visualize this system developing into a satisfactory buoy-mounted plankton sampler.

If the pumping problems can be solved, the filtration and storage of reasonable numbers of samples presents no serious difficulty. The Continuous Plankton Recorder or Longhurst-Hardy filters could be used for the zooplankton, membrane filters for the phytoplankton and, if the fixation problem can be solved, small volume water samples could be used for the micro-zooplankton and nannoplankton.

Unconventional or novel techniques for measurement of biological parameters

Parsons and Seki (1969) offer a brief review of some of the more recent developments for sizing particles in sea water. On the basis of their review it would appear that laser-holography holds the most potential for sizing particles over the 1 μ to 2,000 μ range. Stat Volt. Co., California, advertises laser-holographic equipment for measuring particles in the 4-1,000 μ range, but to date there are no data available showing the use of this equipment.

McNaught (1968) has reported on studies in which high frequency sound waves are used to determine fresh water zooplankton biomass and distribution, while in fisheries, there are a variety of systems under development for digitizing echo returns, e.g., Thorne and Lahore (1969). This instrument can either be buoy-mounted or towed. The length of light path required depends on turbidity: for clear oceanic waters the maximum permissible length is about 10 m. and for turbid coastal waters about 10 cm.

Turbidity can also be measured by a simple system of scattering meter, although this is a relative measure. However, a well standardized beam attenuance meter gives absolute measurement of light attenuation coefficient, one of the basic optical properties of water medium.

Hydroacoustic apparatus to be mounted in ocean data buoys

The Working Group discussed the use of high frequency acoustic techniques for small particle counting, noting recent work with sounders of 200 and 600 kc. in the detection of particles in the upper mixed layer and concluded that there was an engineering need to determine the feasibility of acoustically counting, and sizing, particles in small insonified volumes of water. They also discussed the use of sonobuoys in fisheries services, concluding that there was probably a limited role for classical sonar techniques as a tactical tool, or as an "event marker" in certain fisheries situations: the location and timing of herring spawning on grounds previously known as spawning areas was cited as an example. However, the sometimes-expressed ideal of a general fisheries application of acoustic buoys was unlikely to be feasible.

RECOMMENDATIONS TO SPONSORING ORGANIZATIONS

(1) The Working Group is of the opinion that it is feasible to monitor various biological parameters either through in situ analyses or through in situ sampling and subsequent laboratory based analyses. The observations might range from simple event markers to sophisticated instrument packages requiring the attention of a technician. The major problem would seem to be to establish standards to meet a variety of needs ranging from pollution monitoring to fisheries predictions; i.e., in some situations relative measurements are adequate, in others absolute units will be required.

(2) The Working Group is further of the opinion that research on and development of monitoring systems must be broadly based so that adequate consideration is given to the nature and use of the data output in biological oceanography and in oceanographic services to real situations in fisheries, pollution, recreation, and so on. The expressed objectives of any system should be very clearly defined and preferably should have been previously generated by the potential user community.

To the degree to which the measurement of any parameter is empirical, the methods by which that measurement is made should remain unchanged during monitoring programs extending over long periods. For example, the escapement of zooplankters from the intake of a pump is probably impossible to define precisely, and any change in pumping techniques will introduce requirements to use conversion factors in data processing which themselves would be difficult to determine.

(3) Because the Working Group identified situations in which it appeared essential that intakes for pumping systems and optical and acoustic sensors of various parameters should remain motionless in the water column, it recognized the desirability of the vertical spar-form over surface floating buoys and suggests that IGOSS give due attention to this factor in design of ocean data buoy systems.

(4) All optical systems envisioned for use either on buoys or towed bodies have common problems of fouling. Research and development in maintaining the cleanliness of optical systems should be encouraged.

(5) Recognizing that under some conditions zooplankton monitoring systems will involve pumping water from depth to filtration systems in surface vehicles, the Working Group is of the opinion that knowledge of the mechanism of active avoidance of pump orifices by zooplankters must be advanced and suggests that consideration of this be given by IGOSS.

(6) The Working Group requests WG 23 for advice on methods of in situ fixation and preservation of plankton samples stored in towed vehicles and ocean data buoys.

(7) Because of the lack of standardization of C^{14} measurement techniques, it is recommended that engineering studies be undertaken to standardize and automate the techniques. It is the opinion of the Working Group that only after such developments are completed would it be feasible to incorporate such a system in a buoy network and/or a ship of opportunity program.

(8) With regard to monitoring particulate and dissolved organic carbon and nitrogen, the Working Group identified a serious deficiency in present technology that would have significance wider than these two items: it will be necessary to obtain, preserve, and store for subsequent analysis small volume serial samples of water at ocean data buoys, and systems to obtain such samples do not appear presently to exist. The Working Group therefore suggests that IGOSS take this matter under consideration.

WG 29 noted that various laboratories have shown that it is feasible to count and size the particle spectrum in the range from 2 to 2,000 μ but there is no single instrument which measures the complete range. The Working Group is of the opinion that an integrated system applicable to buoys and ships of opportunity is within present engineering capability and recommends that IGOSS support development of such a system.

(9) Working Group requests WG 23 and 33 consider the problems of fixation and preservation of nannoplankton and microzooplankton, as systems for performing this will have to be deployed in ocean monitoring systems.

FUTURE ACTIVITIES

In addition to the above series of recommendations for various activities which the Working Group wished to make to other organizations, its members will undertake the following tasks before meeting again:

(1) Dr. Grasshoff will ask the Applied Physics group of the University of Kiel to investigate theoretically the feasibility of acoustic particle counting and sizing in the smaller size ranges of particles and volumes.

(2) Dr. Grasshoff will investigate the availability of bacteriostatic materials of application in the construction of sensor systems.

(3) Drs. Colebrook and LeBrasseur will review the present situation in the design of towed vehicles suitable for deployment from ships of opportunity.

(4) Dr. Colebrook will investigate theoretically the suitability of the Edinburgh plankton recorder as presently being redesigned for deployment in low productivity ocean waters, such as the tropical gyral systems.

(5) Drs. Lorenzen and Longhurst will review the present situation and progress in remote sensing of biological parameters in the ocean.

(6) Drs. LeBrasseur and Longhurst will review the present situation and progress in monitoring systems based upon novel techniques such as holography.

(7) Dr. Longhurst will review a number of possible applications and deployment patterns for ocean monitoring systems in the solution of real fisheries research and services problems.

The Working Group considered the nature of its final report and agreed that this would desirably be a document published in a medium such as the UNESCO Technical Papers in Marine Sciences, and that this should be designed to be a source document for data useful to designers of ocean monitoring systems with regard to biological parameters.

The Working Group discussed the agenda and place/time of a second meeting and agreed that it would be desirable to meet again for the following purposes:

(1) To review the question of time and space in sampling for biological monitoring in the ocean, a subject inherent in all of the systems discussed in the first meeting. Members of the Working Group would have reviewed this aspect of the subject prior to the second meeting.

(2) To draft and edit preliminarily the final report of the Working Group.

It was proposed that this meeting should take place about January 1972, in La Jolla, California.

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CONSTITUTION OF THE
SCIENTIFIC COMMITTEE ON OCEANIC RESEARCH (SCOR)

PURPOSE AND FUNCTIONS

1. SCOR is a Scientific Committee of ICSU. Its purpose is to further international scientific activity in all branches of oceanic research. To achieve this purpose, SCOR should perform the following functions:

(a) Examine problems of oceanic research and identify elements that would benefit from enhanced international action. For this purpose, organize scientific meetings on topics of broad interest and importance for progress in the marine sciences. Develop plans for appropriate kinds of international action and promote their implementation.

(b) Establish working groups or other kinds of subsidiary bodies, either alone or in conjunction with other appropriate organizations, for detailed examination of problems related to international ocean activities and studies of the marine environment, including improvement of scientific methods, design of critical experiments and measurement programs, and relevant aspects of science policy.

(c) Foster recognition of the contribution of individual marine scientists and laboratories, bringing to their attention specific problems requiring their consideration and encouraging an adequate level of support for their activities.

(d) Ascertain the views of marine scientists and interested ICSU bodies on scientific aspects of international ocean activities, and represent these views in appropriate international discussions. Develop support among marine scientists for international ocean research programs.

(e) Cooperate with national and international organizations concerned with scientific aspects of ocean affairs. Review and comment on scientific aspects of international ocean programs. Cooperate with and support Affiliated Organizations and interrelate their activities with those of SCOR.

MEMBERSHIP

2. SCOR is composed of three categories of members:

(a) Nominated Members
(b) Representative Members
(c) Invited Members

3. Nominated Members are nominated by National Committees for Oceanic Research as defined in Article 6 (a). In order to provide broad disciplinary representation, each such body may nominate up to three scientists as Nominated Members.

4. Representative Members are the elected Presidents and Secretaries of Affiliated Organizations (ex officio), the Chairman of active SCOR subsidiary bodies (ex officio), and the nominees of ICSU and of its Scientific Unions and its Scientific and Special Committees that wish to participate in SCOR.

5. Invited Members are individual marine scientists who have been invited by the Executive Committee from countries that have not established a National Committee for Oceanic Research.

ORGANIZATIONAL RELATIONSHIPS

6. In cooperating with organizations concerned with the scientific aspects of ocean affairs, SCOR will maintain particularly close relationships with the following kinds of organizations and will invite their representatives to appropriate meetings:

(a) National Committees for Oceanic Research which have been accepted as national corresponding bodies to SCOR.

(b) Affiliated Organizations, as defined in Article 7.

(c) Sponsoring Organizations, which are intergovernmental organizations that provide financial support and other services to SCOR or for which SCOR may perform functions specified by mutual agreement.

7. Affiliated Organizations are international non-governmental organizations devoted to some aspect of marine science and engineering and wishing to interrelate their activities with those of SCOR. Upon designation of such organizations by SCOR, their elected Presidents and Secretaries will become Representative Members of SCOR (Article 4); their Presidents will become ex officio members of the Executive Committee (Article 8). These Organizations will normally maintain their usual links with their parent bodies. They will collaborate with SCOR in organizing scientific meetings and other appropriate activities, will assist SCOR in evaluating scientific problems related to intergovernmental programs, and will help in identifying experts to serve on SCOR working groups and other subsidiary bodies. They will meet jointly with SCOR in oceanographic assemblies, in addition to holding their own meetings.

EXECUTIVE COMMITTEE

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

(a) At appropriate General Meetings SCOR shall elect from amongst its Nominated Members a President, two Vice Presidents and a Secretary. The Past President shall also be considered an elected member of the Executive Committee.

(b) The President of each Affiliated Organization shall be an ex officio member of the Executive Committee.

9. The maximum period of office of the President is four years; the Vice Presidents and the Secretary shall each be eligible for one further four-year term. Normally, no elected member should remain in the same office for more than eight consecutive years.

10. The Executive Committee shall be responsible for dealing with all matters concerning SCOR's work between General Meetings.

SUBSIDIARY BODIES

11. Working groups and other subsidiary bodies may be established at any General or Executive Meeting on the basis of proposals from Members, National Committees, or Affiliated or Sponsoring Organizations. Subsidiary bodies may be sponsored by SCOR alone or jointly with other organizations prepared to contribute toward their support. In consultation with other sponsors, the Executive Committee is responsible for formulating appropriate terms of reference and for selecting members and chairmen.

12. At General Meetings, the progress of each subsidiary body will be reviewed, and a decision will be made on its continuation or reconstitution.

. MEETINGS

13. General Meetings will normally be held at two-year intervals; between General Meetings, there will usually be two meetings of the Executive Committee. At appropriate intervals, the General Meeting of SCOR will be held in conjunction with a joint oceanographic assembly, organized by SCOR in collaboration with the Affiliated Organizations and other appropriate bodies.

14. The agendas of General and Executive Meetings shall normally be submitted to Members, National Committees, and Affiliated and Sponsoring Organizations at least two months in advance of the date of such meetings. Recipients may present additional items for inclusion in the agenda.

15. Authorized travel and subsistence expenses incurred by members of the Executive Committee in attending meetings of that body may be paid by SCOR. However, SCOR funds shall not normally be used to pay such expenses for the participation of Members in General Meetings.

FINANCE

16. Funds for the administration and activities of SCOR may be received from its National Committees, ICSU and its constituent bodies, UNESCO and other Sponsoring Organizations, foundations, and other sources. These funds may be deposited with ICSU or in designated SCOR accounts.

17. The Executive Committee shall prepare annual budgets, which shall include estimates of the contributions required from its National Committees and Sponsoring Organizations; budgets shall be forwarded to ICSU for information.

18. The President or Secretary shall be responsible for budgetary control. The President or Secretary shall inform the Executive Committee of the financial situation of SCOR every eight months, or more frequently if necessitated by a foreseeable deficit. The Executive Committee shall be consulted on all questions concerning the search for additional resources.

19. At every General Meeting, an ad hoc finance committee comprising two Nominated Members, not members of the Executive Committee, together with the Treasurer of ICSU ex officio, shall be established to examine and to report on financial statements and budget estimates.

20. Accounts shall be maintained in accordance with regulations established by the Officers of ICSU. Audited accounts shall be submitted annually to the Treasurer of ICSU.

GENERAL

21. For the purpose of elections and other occasions when a vote is taken at a General Meeting, only one Nominated Member from each National Committee shall have a vote. One Representative Member from each Affiliated Organization may also vote.

22. For any questions not covered by this text, the ICSU Statutes and Rules for Scientific and Special Committees will apply.

23. This Constitution can be amended by agreement of two thirds of voting members, as defined in Article 21, present and voting at a General Meeting, with subsequent approval by ICSU.

Adopted at the 10th General Meeting of
SCOR in Tokyo, 23 September 1970.

"THE OCEAN WORLD"

REPORT ON THE JOINT OCEANOGRAPHIC ASSEMBLY

Tokyo, 13-25 September 1970

The Joint Oceanographic Assembly was sponsored by the following organizations and incorporated their meetings:

The International Association for the Physical Sciences of the Ocean (IAPSO) - 15th General Assembly

The International Association of Biological Oceanography (IABO) - 2nd General Meeting

The Commission of Marine Geology (CMG/IUGS) - 4th General Meeting

The Scientific Committee on Oceanic Research (SCOR) - 10th General Meeting

The 15th General Assembly of IAPSO and the scientific sessions of the Joint Oceanographic Assembly were arranged by the Science Council of Japan. Business meetings of SCOR, IABO, CMG and ACMRR were arranged by the Oceanographical Society of Japan.

Certain symposia were organized in cooperation with the International Association of Geochemistry and Cosmochemistry (IAGC), the Scientific Committee on Antarctic Research (SCAR), and the Upper Mantle Committee (UMC). The meetings were also sponsored by the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI).

The Joint Oceanographic Assembly was assisted by the United Nations Educational, Scientific and Cultural Organization (UNESCO), the Food and Agriculture Organization (FAO), and the World Meteorological Organization (WMO).

Two volumes of abstracts were made available to participants. Abstracts of invited papers for general and special symposia were prepared by the FAO Fishery Resources Division and were printed by the Science Council of Japan; abstracts of contributed papers were prepared and printed by the Science Council.

The scientific sessions included general and special symposia, and sessions of contributed papers. The following symposia were presented:

GENERAL SYMPOSIA

Man's Intervention in the Sea
convened by E.D. Goldberg (IAPSO/IAGC) and H. Steinitz (IABO)

Deep-Sea Drilling
convened by M.N. Peterson (IAPSO) and B. Heezen (CMG/UMC)

Remote Sensing of Ocean Variables
convened by L.R.A. Capurro (SCOR)

Engineering Problems in Monitoring the Oceans
convened by G. Siedler (SCOR)

Antarctic Ice and Water Masses
convened by H. Mosby and S. El Sayed (SCAR)

The Benthic Boundary
convened by W.H. Munk (SCOR)

Long-Term Air-Sea Interaction
convened by J. Bjerknes (IAPSO)

Environmental Data and Forecasting for Fisheries
convened by A.R. Longhurst (IABO/ACMRR) and A.J. Lee (IAPSO)

SPECIAL SYMPOSIA

Distribution of Chemical Species
convened by R. Fukai (IAPSO/IAGC)

Oceanic Microstructure
convened by H.L. Grant (IAPSO)

Tropical Circulation
convened by K. Voigt (IAPSO)

Ocean Circulation Models
convened by V.M. Kamenkovich (IAPSO)

Nutrient Limitation and the Nitrogen Cycle
convened by R. Dugdale (IABO)

Life in the Deep Sea
convened by N.B. Marshall (IABO)

Vertical Structure of Ecosystems
convened by S. Motoda (IABO)

Sedimentation of Marine Organisms
convened by E. Seibold (CMG) and J. Hedgepeth (IABO)

Global Tectonics and Sea Floor Spreading
convened by J.T. Wilson (CMG/UMC)

Marginal Seas of the Western Pacific
convened by H. Niino (CMG/UMC)

MEETINGS OF SCOR AND ASSOCIATED ORGANIZATIONS IN 1971

5 - 13 January	Malta	IOC Group of Experts on Mutual Assistance, and Group of Experts on Training and Education, Joint Meeting.
14 - 16 January	London	Special Committee on Problems of the Environment (SCOPE), 2nd Meeting.
22 - 27 February	Rome	Group of Experts on Scientific Aspects of Marine Pollution (GESAMP), 3rd Meeting.
1 - 6 March	Bordeaux	IOC Bureau with Consultative Council, 12th Meeting.
10 - 17 March	Rome	ACMRR, 6th Meeting.
31 March - 6 April	Kiel	SCOR/IBP/PM Symposium on Biology of the Indian Ocean with particular reference to the International Indian Ocean Expedition.
May	?	SCOR Executive Committee, 15th Meeting.
10 - 13 May	Reykjavik	International Arctic Sea Ice Conference.
18 - 29 May	Paris	IOC, 7th Session.
30 July - 14 August	Moscow	IUGG, 15th General Meeting.
18 August - 3 September	Canberra	Pacific Science Congress, 12th Session.
29 - 30 September	Ottawa	ICSU Executive Committee, 12th Meeting.

ABBREVIATIONS

ACMRR	Advisory Committee on Marine Resources Research (of FAO)
BCF	Bureau of Commercial Fisheries
CalCOFI	California Cooperative Oceanic Fisheries Investigations
CMG	Commission on Marine Geology (of IUGS)
CNRS	Centre National de la Recherche Scientifique (France)
COSPAR	Committee on Space Research
CSIRO	Commonwealth Scientific and Industrial Research Organization (Australia)
ESSA	Environmental Science Services Administration (USA)
FAO	Food and Agriculture Organization of the United Nations
FRG	Federal Republic of Germany
GDR	German Democratic Republic
GESAMP	Group of Experts on Scientific Aspects of Marine Pollution
IABO	International Association of Biological Oceanography (of IUGS)
IAGC	International Association of Geochemistry and Cosmochemistry
IAMAP	International Association of Meteorology and Atmospheric Physics (of IUGG)
IAPSO	International Association for the Physical Sciences of the Ocean (of IUGG)
IAVCEI	International Association of Volcanology and Chemistry of the Earth's Interior
IBP/PM	International Biological Programme/Productivity Marine
ICES	International Council for the Exploration of the Sea
ICSU	International Council of Scientific Unions
IGOSS	Integrated Global Ocean Station System (of IOC)
IGU	International Geographical Union
IOBC	Indian Ocean Biological Center
IOC	Intergovernmental Oceanographic Commission
IUB	International Union of Biochemistry
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
MODE	Mid-Ocean Dynamics Experiment
NSF	National Science Foundation (USA)
ONR	Office of Naval Research (USA)
PREMODE	Pre Mid-Ocean Dynamics Experiment
SCAR	Scientific Committee on Antarctic Research
SCIBP	Special Committee for the International Biological Programme
SCOPE	Special Committee on Problems of the Environment
SCOR	Scientific Committee on Oceanic Research
SIO	Scripps Institution of Oceanography (California, USA)
STD	Salinity-Temperature-Density
UMC	Upper Mantle Committee
UNESCO	United Nations Educational, Scientific and Cultural Organization
WG	Working Group
WHOI	Woods Hole Oceanographic Institution (USA)
WMO	World Meteorological Organization
XBT	Expendable Bathythermograph