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13

The International Decade of Ocean Exploration (IDOE) 1971-1980

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PREFACE

In accordance with the decision of the Assembly of the Intergovernmental Oceanographic Commission at its eighth session, November 1973 (resolution VIII-1, see Annex I), this document:

(a) sets forth the basis of LEPOR, of IDOE and of the Commission's Co-operative Investigations, and the criteria for inclusion of programmes therein;

(b) explains the arrangements for certification and for the deposition and exchange of data and reports resulting from the projects;

(c) gives the latest available information on the current status of the component programmes of LEPOR, of the IDOE and of the Commission's Co-operative Investigations.

The document will be updated periodically.

Basis of LEPOR, of IDOE and of the Commission's Co-operative Investigations

The purpose of the IOC Long-term and Expanded Programme of Oceanic exploration and Research is:

> "to increase knowledge of the ocean, its contents and the contents of its subsoil, and its interfaces with the land, the atmosphere and the ocean floor and to improve understanding of processes operating in or affecting the marine environment, with the goal of enhanced utilization of the ocean and its resources for the benefit of mankind".

In brief, this programme is intended to increase man's knowledge of the ocean and its resources in order to enhance their utilization for peaceful purposes. This enhancement, as defined above, refers not merely to increased use of the ocean and its resources but also encompasses the concept of rational planning and management of such increased use.

By resolution 2414 (XXIII), 17 December 1968, the United Nations General Assembly endorsed the concept of a long-term programme of oceanographic research "designed to assist in a better understanding of the marine environment through science..." and requested "a comprehensive outline of the scope of this long-term programme". In the same session, by resolution 2467 (d) (XXIII), 21 December 1968, the United Nations General Assembly welcomed the concept of an International Decade of Ocean Exploration to be undertaken within the framework of LEPOR and invited Member States to formulate proposals for international scientific programmes and activities to be undertaken during the IDOE and to transmit those proposals to the Commission and to embark on such activities as soon as practicable.

A "Comprehensive outline of the scope of a Long-term and Expanded Programme of Oceanic exploration and Research, of which the International Decade of Ocean Exploration will be an important element" was forwarded by the Chairman of the Commission to the Secretary-General of the United Nations and acknowledged in General Assembly resolution 2560 (XXIV), 13 December 1969.

The same resolution "requests the United Nations Educational, Scientific and Cultural Organization and its Intergovernmental Oceanographic Commission to keep that programme up to date and consider its implementation in appropriate stages, in co-operation with other interested organizations, in particular the United Nations, the Food and Agriculture Organization of the United Nations, the World Meteorological Organization and the Inter-Governmental Maritime Consultative Organization"; it "urges Member States (of the United Nations) to co-operate with

the Intergovernmental Oceanographic Commission in the implementation of that programme in appropriate stages".

The Commission's Co-operative Investigations are separate from but closely linked to programmes under the LEPOR and IDOE. Since the inception of the Commission and until the development of LEPOR, the Co-operative Investigations were the major ocean science activities of the Commission. They are at present being reorganized so that they will both support and complement the component projects of LEPOR and the IDOE.

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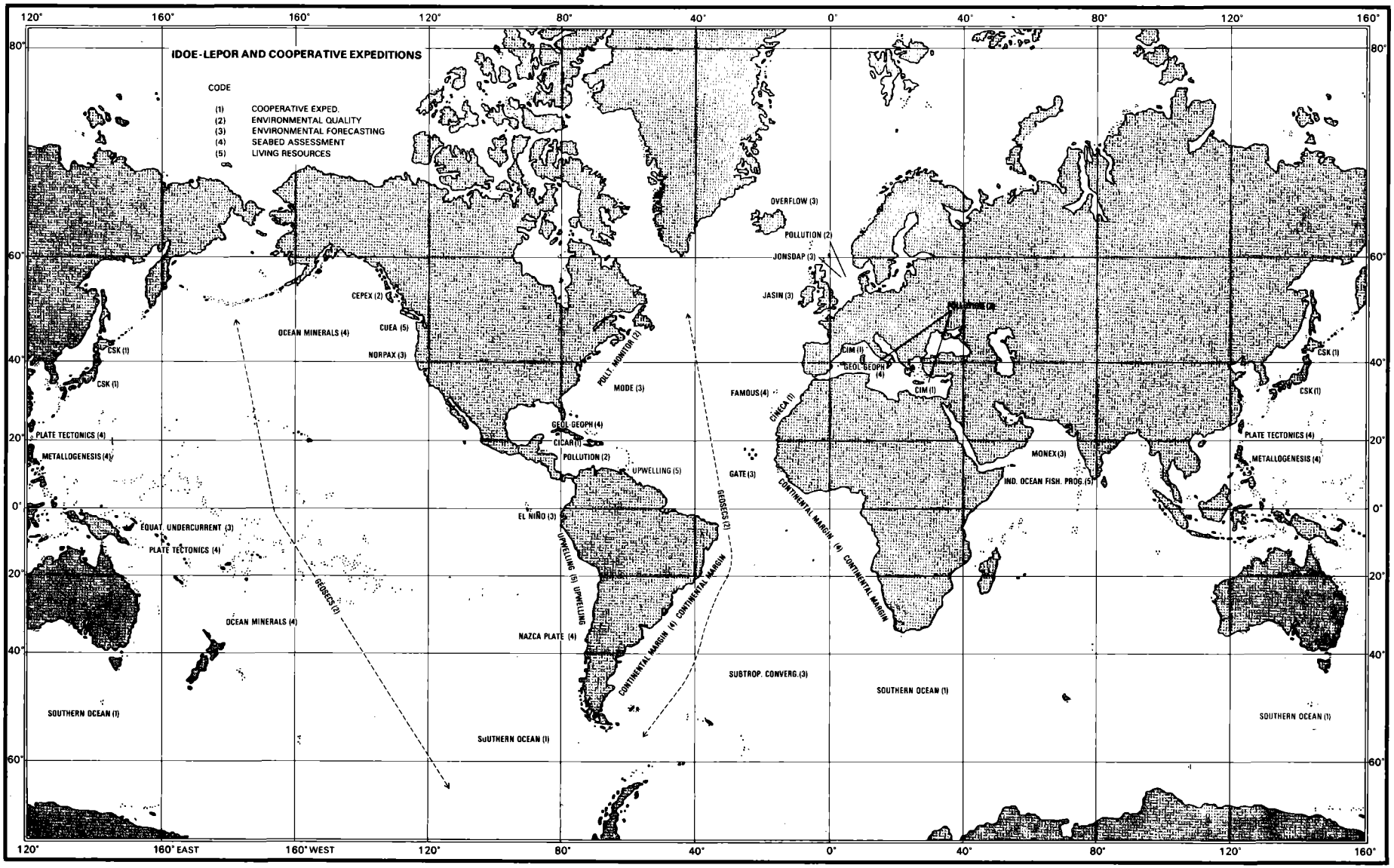
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INTRODUCTION

This publication constitutes the first formulation of a global, comprehensive programme for oceanographic research oriented toward a rational use of the oceans. It has been developed over a number of years through the assistance of the IOC scientific advisory bodies and with the active collaboration of its Member States.

In many ways the history of the programme reflects the growth of the Commission itself since its inception in 1961. During the intervening years hundreds of scientists and administrators drawn from over three-quarters of the maritime nations have given freely of their expertise in order to arrive at a sound programme of research and its applications. Their efforts have been stimulated not only by a desire to further our knowledge of the oceans but also through a realization that the immense potential of the marine environment runs a high risk of being destroyed unless man learns to use it wisely.

As an initial step toward achieving better use of the ocean, the members of the Commission, at its first session in 1961, expressed their conviction that it was indispensable to develop a scientific programme for a World Ocean Study, on which the future activities of the IOC would be based. The implementation of this programme would mean not only the promotion and co-ordination of scientific activities, but also mutual assistance between Member States to enable developing countries to participate fully in such activities. This also entails the provision through the IOC of the necessary oceanographic services.

At the second session of the Commission, Member States passed a resolution requesting its scientific advisory bodies to prepare a General Scientific Framework for the Study of the World Ocean (GSF). In successive stages, a draft of the GSF was published in 1965 and, three years later, the final version appeared as Perspectives in Oceanography, IOC Technical Series No. 6.

Although that publication was a direct ancestor of the present Long-term and Expanded Programme of Oceanic exploration and Research, it does differ in its overall approach. An analysis of how it was formulated provides some insight into the mood of the Commission at that time.

Perspectives in Oceanography presents a comprehensive list of the scientific problems that should be studied in the ocean, and suggestions as to how they should be tackled. Moreover, although some sections of the GSF deal with applied aspects of the problems included therein, as well as potential benefits to be expected from their solution, the listing along classical oceanographic discipline lines is an indication that the principal motivation of this exercise was purely scientific. In fact, it is a scientific guide which provides Member States with a basis for formulating their national and regional plans; no programme priorities nor Member States commitments are mentioned in it. The publication does not therefore constitute an international plan or programme but a general scientific framework, as its title implies.

The publication of a scientific guide reflects what IOC was at that time, a forum of governmental appointed scientists who wished to co-ordinate their international scientific activities with only one purpose in mind: to improve our knowledge of the world ocean.

But, even while Perspectives in Oceanography was being completed, the basic philosophy of the IOC was evolving, as reflected in a change in its statutes which enlarged the scope of IOC activities.

In 1968, the United Nations endorsed the concept of LEPOR, a long-term programme to further our understanding of the marine environment through science. Although requested by a political body, LEPOR has applied scientific goals in that its principal purpose is the rational use of the ocean and its resources.

Other Specialized Agencies of the United Nations with related marine activities have associated their efforts with those of the IOC, thus pooling their respective capacities in many programmes of common interest. This new philosophy is clearly reflected in the present composition of the IOC Secretariat and in the spectrum of marine science disciplines covered by the four scientific advisory bodies of the Commission.

The Commission reacted rapidly to the United Nations request, and its previous groundwork helped considerably in the advancement of the project. With the assistance of the scientific advisory bodies and co-operation from Member States, it was possible to prepare the Comprehensive outline of the scope of the Long-term and Expanded Programme of Oceanic exploration and Research (LEPOR) (IOC Technical Series No. 7) and later, the Report of the Group of Experts on Long-Term Scientific Policy and Planning (IOC/GELTSPAP-I/17).

This report was conceived by the group of experts as:

(a) the formulation of a set of scientific exercises and multinational experiments, including the IOC co-operative investigations;

(b) the corresponding oceanographic services (regional or global);

(c) a strong component in training, education and mutual assistance.

These three aspects of the future LEPOR would have to form at any time a coherent set. This concept of coherency, the basic philosophy behind GELTSPAP, has played a fundamental rôle in the formulation of the IDOE, the accelerated phase of LEPOR. The Commission's next step was to require from Member States a statement of their future involvement in IDOE, using GELTSPAP as a reference for reporting their scientific activities.

The task of the IOC Secretariat then became easier because it had available the three basic elements required for the formulation of IDOE, namely: (a) GELTSPAP; (b) criteria established by the Commission for the inclusion of projects, and (c) the activities reported by Member States. With this material, the Secretariat produced in late 1973, document IOC-VIII/11 "Compilation of Component Programmes of the International Decade of Ocean Exploration" (IDOE) which was approved by the Commission and has served as a basis for the preparation of the present publication.

I. The Programmes

On the basis of the guidelines suggested by GELTSPAP for selection of exercises which could be considered as part of LEPOR and for the assignment of their priority, the Commission at its seventh session established the following questions as the most important criteria to be met by LEPOR projects:

1. Is the purpose of the project to learn more about the nature and resources of the ocean in accordance with the purpose of the Expanded Programme as defined by the Commission?

2. Can the proposed research or supporting service most effectively be done or provided through international co-operation?

3. Does it call for concerted action by States and/or agencies?

4. Are a number of States in principle willing to support it by their active participation or by assisting or facilitating participation?

5. Will it enhance or otherwise relate with other elements of the Expanded Programme and thus contribute to its coherence?

6. Will its results help meet the needs of developing countries and will the participation of those which are interested be facilitated?

7. Does the field of research with which it is concerned require increased emphasis because of the economic potential of the resources, or ocean use, or the urgency of the human need to which it relates?

8. Do adequate scientific and technical manpower and facilities exist, and can they be made available?

In order to begin its implementation of LEPOR, the Commission decided to embark on an initial ten-year programme to accelerate the acquisition of scientific knowledge of the ocean and to improve the capability of all Member States to participate in oceanographic research activities. This initial programme, the International Decade of Ocean Exploration (IDOE) has been scheduled for the period 1971-1980. Member States were encouraged to participate in the IDOE and to present new projects to the Commission for endorsement as components of the IDOE. The Commission also encouraged those interested in the IDOE to move from individual, unco-ordinated efforts to probe the sea to new levels of scientific enterprise based on systematic planning and multidisciplinary approaches to whole ocean systems.

The Commission then invited Member States to submit to the IOC Secretariat detailed information as to their intention to participate in the IDOE, based on the comprehensive outline and the GELTSPAP report. From these replies, it was possible to select four areas of critical importance for man's "enhanced" use of the sea. Almost all of the long-range programmes to be carried out by Member States as a part of IDOE during the period 1971-1980 can be categorized within one or more of these four critical areas, which are the following:

1. Environmental forecasting, including the long-range prediction and analysis of weather and climate.

2. The quality of the marine environment.

3. The non-living resources of the sea-floor and the sea-bed.

4. The living resources of the sea, including the relationship between marine life and the marine environment.

In order to determine which programmes could be included in the IDOE, the Commission has developed a set of criteria which are listed below. These criteria reflect a recognized need that many of the oceanographic problems now before us are complex both in terms of the disciplines and the areas involved; they are not amenable to attack by single scientists or even single countries. They must be approached by teams of scientists from many disciplines, many institutions and many parts of the world. They are long-term co-operative studies which must link an understanding of mechanisms and processes in the marine environment to human endeavours. The active participation of competent scientists and the involvement of national resources from many countries are necessary for the success of the IDOE.

The IDOE criteria, which have been developed from IOC resolution VII-7, were listed in IOC Circular Letter No. 410 (dated 18 January 1973) and discussed at the eighth session of the IOC Assembly. They are as follows:

(1) All programmes must be multinational in character.

(2) The sponsors of each programme must assure that the data collected during the programme are submitted on a timely basis to the World Data Centre system.

(3) All programmes must have exclusively peaceful purposes.

(4) Projects must be scheduled to take place during the 1971-1980 period.

(5) Projects must involve such scientific substance and international co-operation as to "accelerate" our knowledge and understanding of the ocean more rapidly than if individual programmes were conducted separately and at a normal rate.

(6) Participation of scientists from other nations must be actively sought and achieved in the early stages of the programme.

I. 1 LEPOR and the IDOE

By resolution VII-7, the Commission invited "Member States to inform the Secretary of major projects which they wish to be considered as components of the IDOE". Details of all such projects received are examined by the IOC Secretariat to ensure that they meet the above criteria; those that do so are endorsed by the IOC (e. g. resolution VIII-1). The projects so far endorsed have been listed in this document in Section I "Programmes currently being conducted within the International Decade of Ocean Exploration". Section II "Other LEPOR programmes which are not part of the IDOE" contains a number of programmes which fall under the LEPOR but have not been declared as components of the IDOE.

In certain cases programmes which do not meet all the above criteria have been included. This has been done only when the sponsors of these programmes have indicated that the programmes in question are expected to qualify shortly, but do not yet do so because they were established only recently.

It should be emphasized that programmes have been selected for one list or the other on the basis of such criteria as their scope, their degree of international participation, and their schedule, but that inclusion in one list or the other does not imply any difference in the scientific quality of these projects.

Each programme that is listed in either section of this document is described in general terms. In addition, the countries which are known to be participating in each programme are

listed, as are the institutions within each country that are known to be involved. Information is also provided as available regarding the co-ordinating body for each programme and the contact point(s) for obtaining further information.

Those interested in obtaining more information or who wish to participate in any of the programmes listed in this publication should address themselves to the co-ordinating body or contact mentioned for the respective programme.

Countries and institutions are invited to inform the IOC Secretariat of any errors and omissions in the programmes listed herein.

I.2 Co-operative investigations of the Commission

The regional co-operative investigations, which have been major programmes of the Commission since its founding, were not originally conceived as IDOE programmes. However, they are generally the type of programme which would fully qualify in substance for inclusion within the Decade. Co-operative investigations are multinational in character, they are intended to accelerate our knowledge and understanding of the ocean, they involve participation by scientists from many countries early in the planning, they have exclusively peaceful purposes, and the data from these programmes are submitted to the World Data Centre system. The co-operative investigations have been listed separately in Section III of the document.

II. International co-operation

The success of the IDOE and LEPOR programmes depends in large part on the extent to which many nations contribute their expertise and capabilities. In order to achieve such international participation, the Commission encourages all those interested in the IDOE to co-operate at the scientist-to-scientist level, and at the government-to-government level. The Commission assists in the development of such co-operation at the government-to-government level; for some programmes, this is achieved through the establishment and support of intergovernmental International Co-ordination Groups (ICG's). The Secretariat of the Commission provides the necessary staff support for the activities of those ICG's and also effects liaison for them with the interested agencies.

To assist in building co-operation at the scientist-to-scientist and institution-to-institution level, the Commission is sponsoring a series of IDOE workshops which are intended to bring together working scientists to discuss possibilities for future IDOE programmes.

The first of these workshops was convened in Bangkok in September of 1973 under the joint sponsorship of the IOC and the Committee for Co-ordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas (CCOP) of the Economic Commission for Asia and the Far East (ECAFE). This workshop brought together scientists from approximately fifteen countries to consider the need for future studies of the geology and geophysics of West and South West Pacific.

A second workshop in late 1974 is scheduled to discuss activities on the phenomenon of El Niño in the South East Pacific. Similar workshops are expected to be convened to look at other oceanographic problems in the next two years. The Commission is also able, in some cases, to support the participation of scientists from developing countries in these workshops and in other IDOE-related conferences and study projects. Schedules of these activities are published whenever possible in the International Marine Science Newsletter of Unesco and in various international and national publications.

III. Dissemination of information

Very early in the history of the Commission, it was recognized that in order to obtain the maximum benefit from the scientific programmes, it would be necessary to ensure that the resulting scientific data and other information reach all interested scientific institutions and governments as rapidly as possible. Thus the Commission has placed great emphasis on the

development of effective methods for the exchange and dissemination of the scientific data and other results of its programmes.

This emphasis has been centred within the activities of the IOC's Working Committee on International Oceanographic Data Exchange (IODE). The Working Committee has, in co-operation with the International Council of Scientific Unions (ICSU), been responsible for development of the international system for the exchange of oceanographic data. This system now includes two World Data Centres for Oceanography (Centre A in Washington and Centre B in Moscow); regional centres, such as that managed by the International Council for the Exploration of the Sea (ICES), for data collected by ICES-sponsored programmes in the North Atlantic and its adjacent seas; and a series of national data centres and designated national agencies. A list of national oceanographic data centres and designated national agencies is given in Appendix 5 of the Manual on International Oceanographic Data Exchange (IOC Technical Series 9).

Through this system all data that results from declared national programmes, plus large amounts of data that are collected during many other programmes, are made available for use by scientists throughout the world. A convenient method for the immediate reporting of completed programmes has been developed by the Working Committee on International Oceanographic Data Exchange to facilitate the general inventory of collected observations. This is provided by the Report of Observations/Samples Collected by Oceanographic Programmes (ROSCOP). The data are submitted in standardized formats which have been developed and are continually being updated by the Working Committee and by ICSU. The Commission encourages all of its Member States to ensure that ROSCOP data forms and scientific results from all IDOE and other LEPOR programmes are similarly made available rapidly for international use, in accordance with the procedures outlined in the Manual on International Oceanographic Data Exchange and recommendations of the Working Committee regarding the new data formats.

In this regard, some States have established internal requirements that IDOE data be submitted to national data centres, and through these national centres to a World Data Centre, within fixed periods of time following the completion of IDOE projects or cruises. In these cases most data are thus available from the World Data Centres for international use within about one year following the end of each project. Particular efforts should be made during IDOE programmes to provide for rapid distribution of oceanographic data in real-time using BATHY and TESAC codes. The IGOSS procedures and formats, as adopted in the Manual on IGOSS Data Archiving and Exchange, should be utilized to provide for the final archiving of oceanographic data.

I. Programmes currently being conducted within the International Decade of Ocean Exploration (IDOE)

I.1 ENVIRONMENTAL FORECASTING

Long-range and accurate environmental forecasting depends on understanding the state of the oceans as well as conditions in the atmosphere. Thus, in order to enhance forecasting capabilities, it is essential to gain sufficient knowledge of the processes at work in the air and sea to permit their incorporation into predictive models. Our understanding of the processes and mechanisms is still fragmentary and incomplete; hence it is necessary to put major emphasis on studies of the ocean surface and its interaction with the lower atmosphere, and to determine the dynamic processes at work in the deep ocean that influence that interaction. The implementation of this major programme includes undertaking of the research projects recommended by GELTSPAP in the area of ocean atmosphere interaction, ocean circulation, variability and tsunamis (Projects 16 to 24). More detailed information about the nature and scope of this line of research is given in pages 9 to 12 of the Comprehensive outline of the scope of the Long-term and Expanded Programme of Oceanic exploration and Research - IOC Technical Series No. 7.

I.1.1 Investigation of the sub-tropical convergence in the South West Atlantic Ocean

Systematic coverage of the region in order to determine the distribution of physical and chemical properties, conditioning and processes affecting water masses, presence of oceanic fronts, oceanic upwelling and their relation to the general circulation of the region.

Participating countries

Argentina will carry out yearly cruises with RV "Goyena". Participation by Brazil and Uruguay is envisaged.

Co-ordination

Regional activity is planned by agreement between the participating countries. Detailed information on this programme as well as other arrangements can be obtained from:

Comité Nacional de Oceanografía
Consejo Nacional de Investigaciones Científicas y Técnicas,
Rivadavia 1917,
BUENOS AIRES, Argentina

I.1.2 Investigation of the equatorial undercurrent of the West Pacific

The study of the origin and dynamics of this undercurrent started in 1973.

Participating countries

Australia and France.

The laboratories involved are CSIRO Division of Fisheries and Oceanography (Australia) and Centre ORSTOM, BP A5, CEDEX, Nouméa, New Caledonia.

Co-ordination

Regional activity is being planned and co-ordinated by the participating laboratories. Additional information may be obtained from:

Division of Fisheries and Oceanography,
CSIRO,
P. O. Box 21,
Cronulla, NSW 2230,
Australia

or

Mr. H. Rotschi,
Centre ORSTOM
BP A5,
CEDEX; Nouméa,
New Caledonia

I. 1. 3 Investigation of the sea surface current field in the South West Pacific and Eastern Indian Ocean

Determination of the sea surface Lagrangian field of motion by tracking free drifting buoys from the ECOLE satellite, initially in the South West Pacific; but later in the Indian Ocean. This programme will terminate in 1973-1974. In late 1974 and during all of 1975 a similar tracking programme using the Nimbus F satellite is planned with NASA (U. S. A.) although in this programme information on sea surface temperature and wind will be added.

Participating countries

Australia, France and U. S. A.

Laboratories involved in this programme are: CSIRO Division of Fisheries and Oceanography (Australia), Centre National d'Etudes Spatiales (France) and NASA (U. S. A.).

Co-ordination

The regional programme is being planned and co-ordinated by the participating laboratories. Contact agencies:

Dr. G. R. Cresswell,
Division of Fisheries and Oceanography,
CSIRO,
P. O. Box 21,
Cronulla, NSW 2230,
Australia

or

Mr. H. L. Roblin,
CNES,
129 rue de l'Université,
75008 Paris,
France

I. 1. 4 "Overflow studies"

The purpose of this research is to investigate the overflow of water from the Norwegian and Greenland Seas into the Atlantic Ocean. It is known that the overflow occurs with extreme intermittency mainly at four locations along the Greenland-Scotland Ridge. This has been revealed by two International Council for the Exploration of the Sea (ICES)-sponsored international expeditions: the International Geophysical Year (IGY) Polar Front Survey in 1958 and the "Overflow 1960" Experiment in the Iceland-Faeroe Ridge area. At present there is virtually no information on the causes and on the space and time scales of the fluctuations. Because of recent improvements in observational techniques, however, it is feasible to initiate a new study of these key problems of oceanography in the North Atlantic:

(i) What are the dynamics and the kinematics of the water masses involved in the overflow process, e. g. what influences do atmospheric pressure fluctuations, advection, mixing and entrainment processes, and internal tides have on the overflow of Artic waters across the Greenland-Scotland Ridge?

(ii) What significance does the overflow have on the environmental conditions, e. g., are the distributions of nutrients, plankton, bottom and pelagic fish related to the fluctuations of the physical oceanographic field?

An international expedition was carried out during 1973.

Participating countries

Canada, Denmark, France, Germany (Fed. Rep. of), Iceland, Norway, USSR, U.K. and U.S.A.

The laboratories participating in this programme are:

Canada

Bedford Institute of Oceanography,
Dartmouth, Nova Scotia

Denmark

Institute of Physical Oceanography,
University of Copenhagen

Zoological Museum,
Copenhagen

France

Laboratoire d'Océanographie Physique,
CNEXO,
Brest

Germany (Fed. Rep. of)

Institut für Meereskunde,
Universität Kiel,
Düsternbrooker Weg 20,
23 Kiel

Iceland

Marine Research Institute,
Reykjavik

Norway

Universitetet i Bergen,
Geofysisk Institutt A,
5000 Bergen

USSR

Arctic and Antarctic Research Institute,
Fontanka 34,
Leningrad D-104

USSR Hydrographic Service,
11 Linija 8,
Leningrad V-34

U.K.

Marine Laboratory,
Department of Agriculture and Fisheries
for Scotland,
Aberdeen

Institute of Oceanographic Sciences,
Wormley

Scottish Marine Biological Association,
Oban

U.S.A.

Woods Hole Oceanographic Institution,
Woods Hole, U.S.A.

Up to the present time, Canada, Germany (Fed. Rep. of), Iceland, USSR and U.K. have declared this programme as a component of IDOE.

Co-ordination

This programme is being co-ordinated by:

Dr. Jens Meincke,
Institut für Meereskunde,
Universität Kiel,
Düsternbrooker Weg 20,
23 Kiel,
Federal Republic of Germany

I.1.5 Mid-Ocean Dynamics Experiment (MODE)

Detailed knowledge of ocean circulation has been limited largely to currents that follow the continental boundaries of the oceans such as the Gulf Stream and the Kuroshio Current. Although simple models of ocean circulation have treated the mid-ocean regions as essentially calm with only limited average flows, several observations indicate the presence of large fluctuations

that tend to obscure any average flow. Knowledge of whether the oceans have an identifiable average circulation is important for predicting the ocean's influence on weather, climate, and the dispersion of pollutants.

The purpose of the Mid-Ocean Dynamics Experiment (MODE) is to understand these fluctuations by establishing the dynamics and statistics of medium-scale eddies, their energy sources, and their rôle in general ocean circulation. Oceanographers have estimated that medium-scale eddies, if in fact they exist throughout in the oceans, would contain at least as much kinetic energy as the average ocean circulation, and possibly ten times more. Where this energy comes from, how much there is, and what it does are problems that must be resolved to refine the numerical models that are the basis of environmental prediction.

Participating countries

France, Germany (Fed. Rep. of), Sweden, USSR, U.K. and U.S.A.

The following laboratories are involved in this programme:

Germany (Fed. Rep. of)

University of Hamburg

Sweden

University of Gothenburg

USSR

Institute of Oceanology, Academy of Sciences

U.K.

University of Cambridge

Institute of Oceanographic Sciences, Wormley

U.S.A.

Institute of Geophysics and Planetary Physics and Scripps Institution of Oceanography, University of California

Florida State University

Columbia University

Harvard University

Johns Hopkins University

Massachusetts Institute of Technology

Atlantic Oceanographic and Meteorological Laboratories, NOAA

Nova University

University of Rhode Island

Woods Hole Oceanographic Institution

Yale University

Co-ordination

The MODE scientific council and special committees established by the council to deal with specific long-term problems are ensuring co-ordination. Contacts should be made with:

Information Officer
MODE Scientific Council
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139
U.S.A.

I.1.6 North Pacific Experiment (NORPAX)

The North Pacific Experiment (NORPAX) deals with substantial oceanic and atmospheric changes which involve time periods ranging from months to decades and which affect large parts of the earth's surface. The time scale is significant because, although man adjusts to day-to-day and seasonal changes and accommodates long-term changes in climate by almost imperceptible changes in his behaviour and habits, he is deeply affected by abrupt climatic fluctuations that are not only disruptive but frequently disastrous. The drought that turned parts of the United States into barren dust bowls during the 1930s is testimony to this.

The influence of the North Pacific on the weather and climate of North America has been a matter of scientific speculation for nearly fifty years. During the 1960s the Office of Naval Research (U.S.A.) sponsored research in the North Pacific aimed at identifying the ocean processes linked to unusual "weather" conditions over North America. Large areas of abnormally hot or cold sea surface temperatures, in terms of 30-year monthly averages, were identified in the North Pacific. Meteorologists and oceanographers postulated that these surface temperature anomalies influenced the atmosphere in a way that affected the climate from the Pacific eastward across the entire North American continent.

The goal of the North Pacific Experiment is to study and develop a basis for understanding the major physical processes responsible for the large-scale fluctuations in the ocean and atmosphere in the mid-latitudes of the Pacific. NORPAX will require simultaneous monitoring of the long-period fluctuations of the major oceanic and atmospheric field variables over the entire North Pacific Basin. Research efforts will concentrate on: (1) interactions between the major ocean/atmosphere systems; (2) interactions of regional ocean systems; and (3) interactions between major atmospheric systems.

Specific studies will include: (1) current systems as related to the three-dimensional thermal field; (2) atmospheric fluctuations in the Equatorial Pacific resulting from changes in the oceanic thermal field; (3) analysis of the mean properties of large-scale fluctuations of the North Pacific Current; (4) use of numerical modelling to concentrate on oceanic response to variable atmospheric stimuli; (5) descriptive formulation of relationships, processes and events that characterize large-scale air and sea patterns; (6) analysis of fluctuations in the equatorial region with emphasis on heat and momentum balances; and (7) the formulation of concepts relating to changes in the large-scale transport and characteristics of Sub-tropical and Sub-arctic Gyres in response to fluctuations in the atmospheric field.

Benefits realized from such understanding will have both immediate and profound long-term significance for: (1) improved long-range weather forecasting; (2) long-range oceanic forecasting; and (3) quantitative assessment of the naturally occurring changes in the environment against which mankind may judge his own impact on nature.

Participating countries

Australia, Canada, France, Germany (Fed. Rep. of), Japan, U.K., U.S.A. and other countries.

The laboratories involved in this project include:

Australia

Bureau of Meteorology

Canada

Physical Oceanography Branch,
Environment Board of Canada

France

ORSTOM, New Caledonia

Germany (Fed. Rep. of)

Meteorological Institute,
University of Bonn

Deutsches Hydrographisches Institut

U.K.

Institute of Oceanographic Sciences,
Wormley

and

British Meteorological Office

U.S.A.

University of California,
San Diego

University of Hawaii

Co-ordination

The project is managed through the Scripps Institution of Oceanography. Further inquiries should be directed to:

Attention: Project Manager
North Pacific Experiment,
Scripps Institution of Oceanography,
P. O. Box 109,
La Jolla, California 92037,
U. S. A.

I. 1. 7 Long-Range Investigation, Mapping and Prediction (CLIMAP)

CLIMAP focuses on climatic changes stretching back as long as 700, 000 years ago. Compared to the scanty record kept by man on changes in the oceans and atmosphere, the layers of sediment on the sea floor provide a rich source of data on changes in the geological past. Pieces of this chronological record have been captured in ocean bottom sediment cores and preserved in marine geological archives. Advances in dating techniques, automated analyses of individual sediment cores, and computer correlation of many features in the sediment strata may make it possible to generate truly global scale summary pictures of sea surface currents, temperatures, seasonal weather, and climatic conditions.

Defining these global changes on a continuous time scale for hundreds of thousands of years is important for several reasons. First, it may reveal for the first time the actual time series of events during the transition between what are currently considered the two stable states of global climate, the ice age and the temperate age. Second, knowledge of the nature of these transitions is critical for building models of global oceans and climates, e.g., were changes in climate due to changes in solar radiation or were they caused by the earth's hydrosphere? Moreover, if the mechanisms of natural climate changes are not understood, then it becomes virtually impossible to assess or anticipate the effects of man's activity on the global environment.

CLIMAP seeks to answer the above questions through the study of deep sea sediments. Researchers will examine changes in current patterns and water mass properties in the world oceans during the Quaternary, the current geological epoch. The goal of CLIMAP will be to determine in detail surface ocean climatic fluctuations associated with glacial and interglacial transitions. Plans are to construct four oceanographic maps showing sea surface temperatures from: (1) 6, 000 years ago, the warmest post-glacial period; (2) 17, 000 years ago, the last glacial stage; (3) 120, 000 years ago, the last interglacial period; and (4) 700, 000 years ago, the mid-Pleistocene base. Comparable maps for contemporary surface temperatures provide the basis for historical comparisons. By combining these sea surface maps with sea level, glacial extent, albedo, and winds (estimated from pollen records), a more quantitative check on the physical consistency of the palaeo-climate is possible with present day numerical models.

The sea surface maps will be put together from a variety of sources and will involve examination of existing cores to determine those most suitable for the initial interpretation of fossil and geochemical data. Following the elaboration and consolidation of present work on quantitative relationships between the ocean environment and fossils, scientists using multivariate analysis and computer contouring will generate oceanographic maps from the geological past. Finally, interpretation of these studies will take place along with examination of Greenland and Antarctic ice cores. These comparisons promise to yield critical information about high latitude glacial and interglacial climates and their effects on the temperature and salinity of bottom and surface ocean waters.

Participating countries

Denmark, Germany (Fed. Rep. of), Netherlands, Norway, Switzerland, U.K. and U. S. A.

The laboratories participating in this programme include:

Denmark

Physics Laboratory,
University of Copenhagen

Germany (Fed. Rep. of)

Geologish-Paleontologisches Institut
und Museum der Universitat Kiel

Netherlands

Hugo de Vries Laboratorium,
Universiteit van Amsterdam

Norway

Universiteit i Bergen

Switzerland

Eidg. Technische Hochshule,
Geologisches Institut, Zurich

U.K.

Sub-Department of Quaternary Research,
University of Cambridge

U.S.A.

Brown University,
Lamont-Doherty Geological Observatory
of Columbia University

Oregon State University

Co-ordination

The CLIMAP Executive Committee, Lamont-Doherty Geological Observatory, Palisades, New York, 10964, U.S.A. is ensuring co-ordination. Inquiries should be marked for the attention of the Administrative Assistant.

I.1.8 Joint Air-Sea Interaction Project (JASIN)

The U.K. Joint Air-Sea Interaction Project (JASIN) is designed to examine the structure of the oceanic and atmospheric boundary layers in sufficient detail to advance our knowledge of the fluxes of heat, momentum and water vapour through, between and within them on time scales up to one month and horizontal space scales up to one or two hundred kilometres. This is to be done partly with a view to examining whether these transfers can be parameterized to allow their inclusion in large-scale numerical models of the air-ocean system.

Following the sea trials in 1970, an account of which has been published, it was agreed that a further trial would be desirable before a major experiment was feasible. The purpose of the trial experiment in September 1972 was to include as much as possible of the content of the main project with the following aims:

(a) to examine the structure of the atmospheric boundary layer by making repeated vertical soundings simultaneously from three ships, two of which were using LOCATE equipped radiosondes;

(b) to make spatial and temporal measurements of temperature and currents in the oceanic mixed layer and the seasonal thermocline, in order to determine the rôle of of the mixed layer in buffering heat and momentum transfers between the atmosphere and the deep ocean;

(c) to make surface measurements from three buoys in order to estimate fluxes across the air-sea interface and their horizontal variability (including measurement of horizontal pressure gradients to allow calculation of the geostrophic wind);

(d) to test the practicability of measuring currents in the top 10 to 20 metres of the ocean in the presence of surface waves;

(e) to examine vertical gradients of currents and density at the bottom of the oceanic mixed layer and across the seasonal thermocline.

Further experience will be gained with the GATE C-scale oceanography programme in 1974 before the main project takes place in 1976.

(1) Area to be studied

September 1972 trial experiment: Equilateral triangle of 100 km. side, centred on Ocean Weather Station "Juliet" (52.5°N 20°W).

August/September 1976: Equilateral triangle of 150 km. side centred on a North-East Atlantic Weather Ship, probably at Station "India", for meteorological observations with three smaller triangles (20-25 km.) for oceanographic observations at its corners.

(2) (3) Techniques to be used and parameters to be measured

September 1972 trial experiment: Simultaneous meteorological observations were made from three vessels at the triangle corners and for some periods radiosondes (LOCATE and U.K. MkII) were flown at hourly or two-hourly intervals. Oceanographic observations of temperature and salinity related to depth were made throughout the period. An array of buoys was used to record surface meteorological parameters together with subsurface currents and temperatures. Twelve sorties were flown over the area by a Hastings aircraft fitted with an airborne radiometer and other equipment.

August/September 1976

Similar to above but on a large scale.

Participating countries

Netherlands, U.K. and U.S.A.

The laboratories involved in this project are:

Netherlands

Koninklijk Nederlands Meteorologisch Instituut de Bilt

U.K.

Institute of Oceanographic Sciences (IOS), Wormley

The Department of Oceanography, University of Southampton

The Marine Laboratory, Dept. of Agriculture and Fisheries for Scotland, Aberdeen

Imperial College of Science and Technology, London

U.K. (cont.)

Admiralty Research Laboratory, Teddington

The Hydrographic Department, Taunton

Royal Radar Establishment, Pershore

Marine Biological Association of the U.K., Plymouth

The Meteorological Office, Bracknell

U.S.A.

Rosenstiel School of Marine and Atmospheric Science, Miami University

Oregon State University

Co-ordination

JASIN is co-ordinated through the Air-Sea Interaction Sub-Committee (Chairman, Professor Charnock) of the British National Committee for GARP, under the auspices of the Royal Society of London. The Project Director is Professor H. Charnock, Institute of Oceanographic Sciences, Wormley, Godalming, Surrey, U.K.

I. 1. 9 Joint North Sea Data Acquisition Project (JONSDAP)

JONSDAP was designed as a co-operative international observational exercise, to gather related data on tidal levels, current velocity, marine chemistry and pollution in the southern North Sea. Of particular importance was the collection of data in simultaneous time series to serve as input to numerical models. Within the overall framework of current and tidal observations a number of special exercises were planned; sampling grids for measurements of turbidity, salinity, temperature and trace metals; the release of drifters; and diffusion of Rhodamine dye experiments. In addition, there was a study of the spatial variability of currents by means of an equilateral triangle of current meter rigs and also an intercomparison study of six current meters of four different types at a site near the coast of the Netherlands.

Area studied

Southern North Sea and Dover Strait starting 10 September 1973 for a period of 40 days.

Techniques used and parameters measured

It was planned that some 22 vessels would be involved for varying times during the period of the exercise and that approximately 90 current meters, 20 bottom mounted off-shore tide gauges and three automatic buoys would be deployed.

Participating countries

Belgium, Netherlands and U.K.

The following laboratories participated in this project:

Belgium

41 institutes, universities and laboratories

Netherlands

Koninklijk Nederlands Meteorologisch Instituut,
The Hydrographic Office,
The Rijkswaterstaat,
The Netherlands Institute for Sea Research

U.K.

Hydraulics Research Station

Hydrographic Department

U.K. (cont.)

Institute of Oceanographic Sciences

Medway Ports Authority

Ministry of Agriculture, Fisheries and Food, Fisheries Laboratory, Lowestoft

Port of London Authority

Research Vessel Base (Natural Environment Research Council)

University of East Anglia

University of Liverpool

Water Pollution Research Laboratory

Sir John Cass College

Co-ordination

JONSDAP took place under the auspices of the informal Joint North Sea Information Systems (JONSIS) Group which has members from scientific institutes in the U.K., Germany, Netherlands, Belgium and Sweden. For JONSDAP three national co-ordinators were appointed:

G. W. Lennon (Institute of Oceanographic Sciences, U.K.)

L. Otto (Koninklijk Nederlands Meteorologisch Instituut)

Ing. M. Pichot (University of Liège, Belgium).

Responsibility for overall co-ordination rested with the Institute of Oceanographic Sciences, Bidston Observatory, Birkenhead, Cheshire L43 7RA, U.K.

I. 1. 10 Joint North Sea Wave Project (JONSWAP)

In 1968 and 1969, research personnel of the Federal Republic of Germany, the Netherlands, the U.K. and the U.S.A. participated in a research project concerning dynamic processes at sea surface in the area near the Island of Sylt in the German Bight.

The initiative for this experiment, carried out under the name of JONSWAP, originated with Professor K. Hasselmann from the University of Hamburg; funds were made available by the German Government and also by German scientific institutes.

In 1973 a similar research project was carried out at the same site (JONSWAP-2); in addition to wave measurements and, at certain spots, current measurements, wind fluctuations immediately over the sea surface were measured at as large a scale as possible.

Participating countries

Canada, Denmark, France, Germany (Fed. Rep. of), Netherlands, U.K. and U.S.A.

The laboratories involved in this programme are:

Germany (Fed. Rep. of)

University of Hamburg

Deutsches Hydrographisches Institut, Hamburg

Netherlands

Koninklijk Nederlands Meteorologisch Instituut De Bilt

Technical University of Delft

U.K.

Institute of Oceanographic Sciences (IOS), Wormley

U.S.A.

Woods Hole Oceanographic Institution

Contact:

Dr. K. Richter,
German Hydrographic Institute,
Bernhard-Nocht-Str. 78,
2 Hamburg 4,
Fed. Rep. of Germany.

I. 1. 11 Investigation of the phenomenon known as El Niño

The purpose of this programme is to understand the environmental processes responsible for this anomaly in the oceanic circulation of the South East Pacific as well as its implications on the biological resources of the region. The area of interest embraces the region of Colombia, Ecuador, Peru and the north coast of Chile. The air-sea interaction of this programme will build on work already planned in conjunction with the NORPAX experiment. During 1965, the first international co-operative investigation was carried out with the participation of Chile, Peru, Ecuador and Colombia, sponsored by the Inter-American Tropical Tuna Commission. During 1969 the International Biological Programme (IBP) upwelling biome studies were made, which may provide a normal year baseline against which the phenomenon known as El Niño can be evaluated. The IOC, at the eighth session of its Assembly, directed the Secretary to organize, together with FAO and WMO, a scientific workshop to be held in 1974 which will focus on the meteorological, oceanographic and biological aspects of the problem and would, if necessary, formulate proposals for a co-operative scientific research programme.

Participating countries

Chile, Colombia, Ecuador and Peru.

Participation by U. S. A. and other countries is envisaged.

Co-ordination

At the present time, the contact organization is the IOC Secretariat.

I. 1. 12 Comprehensive investigation in the Arabian Sea on monsoon circulation (MONEX)

The purpose of the monsoon experiment is to study the summer monsoon in the northern hemisphere, that is, when there is a transport of air from the southern to the northern hemisphere. The main reason for this choice is because this monsoon is associated with large amounts of rainfall over many countries in South East Asia. Many countries neighbouring India, such as Burma and Bangladesh to the east, Sri Lanka to the south, and Pakistan, Somalia and other parts of East Africa are affected by this wind system. There is evidence to suggest that the monsoon also affects countries as distant as the Philippines, China and Japan.

Some oceanographic aspects are directly related to the atmospheric dynamic processes controlling the monsoon. Oceanographic efforts, particularly those aimed at studying the phenomena which control sea-surface temperature, must be explicitly planned as part of MONEX. For example, in connexion with the moisture and heat fluxes as well as the understanding of the evolution and morphology of the low-level atmospheric inversion in the western Arabian Sea, it will be important to ascertain the possible rôle of the Somali Ocean current, regions of upwelling and the existence and behaviour of the equatorial undercurrent. Study of these phenomena in more detail than required for MONEX will be of undoubted scientific and practical interest, and it is to be hoped that oceanographers will take advantage of the MONEX effort to do so. Sufficient data should be collected on the salinity and temperature distributions of the upper layer to define the thermo-haline structure on scales of importance (meteorological as well as oceanographic). The origin and nature of the Somali ocean current is a subject of much theoretical interest. Sufficient mapping at various times of the meteorological cycle should be accomplished to verify or reject hypotheses on the origin of the current. Upwelling phenomena are also extremely important in this region, in particular off the East African coast and along the equator. There is considerable uncertainty as to the very existence of the equatorial undercurrent and this phenomenon is now under study. Close attention should be paid to the results of this study in order to design a suitable observing programme for the time of MONEX.

Participating countries

This is now being assessed. The USSR and India carried out a joint expedition in 1973.

Co-ordination

This project is being organized by the Joint Organizing Committee (JOC) for GARP. Detailed information on this experiment is contained in the report of the eighth session of the JOC for GARP, London, 14-19 March 1973, which can be obtained from the World Meteorological Organization, Case postale no. 5, CH-1211 Geneva 20, Switzerland.

I. 1. 13 Study of the physical oceanography of the Caribbean and adjacent regions

This is one of the aspects being studied within the Co-operative Investigations of the Caribbean and Adjacent Regions (CICAR). For more detailed information see project III. 1 under "Co-operative investigations", page 47.

I. 1. 14 Study of the physical processes connected with the upwelling in the northern part of the Eastern Central Atlantic

This is one of the studies being carried out in the Co-operative Investigation of the northern part of the Eastern Central Atlantic (CINECA). For more detailed information see project III. 5 under "Co-operative investigations", page 49.

I. 1. 15 Global Baseline Data Project (GEOSECS)

The Geochemical Ocean Sections Study (GEOSECS) is intended to increase the understanding of the circulation and mixing processes in the world oceans making use of geochemical and physical oceanographic measurements. For more detailed information see project I. 2. 4 under "Environmental quality", page 27.

I. 1. 16 GARP Atlantic Tropical Experiment (GATE) - Oceanographic Sub-programme

The need for detailed studies in the topics prior to a full global experiment in the Global Atmospheric Research Programme (GARP) was recognized at an early stage during the development of this programme and considerable attention to the tropical atmosphere was given in the objectives of GARP. A GARP Atlantic Tropical Experiment (GATE) was adopted with the objective of conducting studies in the tropics, including the development of appropriate dynamic models, analyses of the rôle of convection in energy transformation and detailed observation programmes in low latitudes.

GATE was the first major international observational experiment of GARP. A main objective of GATE is to improve understanding of the convective and meso-scale systems and their organization, their relationships to the larger scale tropical disturbances, and improved parameterization of their feedback to larger-scale circulation in numerical models. GATE required observing systems which corresponded to several different time and space scales. Measurements by ships, aircraft, radar and geostationary satellites were combined to develop a composite picture of the tropical Atlantic atmosphere.

Although the experiment was conducted in the whole of the tropical Atlantic between 20°N and 10°S, most of the observing platforms were concentrated in the eastern Atlantic between 5° and 15°N. Ships in this region were spaced about 250 km. apart, forming a basic observational structure referred to as the "B scale". The total meteorological coverage for the experiment was completed by placing additional ships throughout the GATE area, spaced about 1, 000 km. apart. This expanded observational structure is referred to as the "A scale" (see figure 1).

Although less directly related to the main atmospheric programme, the GATE oceanic response studies are central to the GARP objective of developing coupled ocean atmosphere models for extended forecasting and investigations of climate. This was of course, also the primary motivation for the oceanographic component of GATE.

GATE took place in mid-1974 and the experiment was conducted in three phases, preceded by a shakedown cruise and intercomparison. The first phase was conducted from 26 June to 16 July, followed by an in-port period; the second phase from 28 July to 17 August, and the third phase from 29 August to 18 September. Intercomparison exercises were also held after each of the on-station phases.

A major contribution to GATE by the proposed oceanographic programme was the independent determination of the fluxes of heat, moisture and momentum across the air-sea interface on the B-scale by means of appropriate budget measurements in the mixed layer. Heat, salt and moisture budget studies were carried out in the B-scale, and within one of the B-scale grid triangles.

The B-scale studies included intensive oceanic survey operations by nearly all ships prior to and following each phase of GATE. These surveys will provide quasisynoptic maps of the B-scale area. The spatial information was complemented by measurements from moored buoys which also filled gaps in time during replenishment periods. During each observational phase, some B-scale ships were scheduled to make regular physical oceanographic observations using STD's, XBT's and current meters. These measurements provide the data from which the heat, salt, mass and momentum budgets, as well as adjustment processes taking place in the upper ocean, will be documented.

An A-scale experiment included studies of the equatorial current systems, and the variations of the belt of anomalous cold water at the equator, which is thought to be related to

atmospheric circulation both in the tropics and at mid-latitudes. There are relatively few measurements of surface current in the equatorial Atlantic, and still less is known of the sub-surface currents. Yet, Defant has called the equatorial current system "The backbone of ocean circulation". Therefore, a primary consideration was to obtain quantitative descriptions of the steady-state and transient components of the flow of the equatorial current system, and its response to the wind system. A second objective was to attempt to detect barotropic and baroclinic planetary waves. These waves are difficult to observe in the ocean, because they have small amplitudes and may easily be buried in noise. However, theoretical studies have shown that the equator may serve as a wave guide for planetary waves, and thus increase the probability of detection. Planetary waves are believed to be quite significant in terms of the total transport of momentum in the ocean.

Detailed information about the GATE oceanographic programme may be obtained from the report of SCOR Working Group 43 (SCOR Proceedings, Annex III, Vol. 9, 1973).

Participating countries

Brazil, Canada, France, Germany (Fed. Rep. of), Mexico, Netherlands, Portugal, USSR, U.K., U.S.A. and Venezuela.

Co-ordination

Through the International Scientific and Management Group (ISMG) of GATE. Chairman: Dr. J.P. Kuettner, Meteorological Office, London Road, Bracknell, Berkshire, U.K.

I.2 ENVIRONMENTAL QUALITY

The quality of the marine environment has always been important in human affairs, but it is only in recent years that the activities of man have begun to influence the quality of the oceans. The introduction of biologically-active chemicals, the release of excess heat, and the over-harvesting of marine life have added up to a significant impact on the oceans. The welfare of marine ecosystems and to some extent human welfare dictate that ways be found to understand, control and correct the deleterious consequences of these forces.

The implementation of this major programme includes the research projects recommended by GELTSPAP in the area of marine pollution (projects 42 to 47) - (GELTSPAP I/17). More detailed information about the nature and scope of this line of research is given in pages 16 and 17 of the Comprehensive outline of the scope of the Long-term and Expanded Programme of Oceanic exploration and Research - IOC Technical Series No. 7.

I.2.1 Baseline studies

This regional baseline data acquisition programme will consist of continuing research studies to determine inputs, dispersal paths and present levels of the synthetic halogenated hydrocarbons and of petroleum hydrocarbons in representative plants and animals of coastal and open ocean zones with the objectives of evaluating hazards to living processes and of defining sources of these materials.

In 1971-1972, regional baseline data acquisition projects were conducted in the Atlantic and Pacific Oceans, the Gulf of Mexico, and the Caribbean. Quantitative results were obtained on the occurrence and distribution of trace metals, chlorinated hydrocarbons (DDT, DDE, TDE), polychlorinated biphenyls, (PCB) and petroleum in the water, biota and sediment. The scientists participating in these projects held a Baseline Conference at Brookhaven National Laboratory in May 1972 to assess the data, evaluate the programme and make recommendations for future research. A report on the results of this Conference was produced, entitled "Baseline studies of pollutants in the marine environment and research recommendations, the IDOE Baseline Conference, 24-26 May 1972, New York". It was agreed that the highest priority should be given to determining the impact of pollutants (e.g. synthetic organic chemicals, petroleum, and metals) on the nearshore marine environment. It was also agreed that the readily identifiable contamination in the open ocean by synthetic halogenated hydrocarbons (such as PCB and DDT

and their metabolites) and petroleum hydrocarbons potentially constitute a problem of global concern. The report also recommended that a continuing research programme to determine inputs, dispersal paths and present levels of the synthetic halogenated hydrocarbons and of petroleum hydrocarbons in representative plants and animals of coastal and open ocean zones be immediately initiated with the objectives of evaluating hazards to living processes and of defining sources of these materials. Simultaneously and with high priority, research should be expanded in biological laboratories to evaluate the impacts of existing levels of these substances upon living organisms.

As a result of this conference, a group of scientists interested in heavy metal determinations undertook a careful comparison of lead analysis methods. The purpose is to ascertain a technique that is rapid and inexpensive, but which, nevertheless, gives the desired accuracy and sensitivity.

Participating countries

U.K. and U.S.A.

Participating institutions include:

U.S.A.

University of Rhode Island
University of Connecticut
Texas A and M University
University of Texas
Puerto Rico Nuclear Center
Skidaway Institute of Oceanography

Co-ordination

Programme Manager (Environmental Quality), Office for the International Decade of Ocean Exploration, National Science Foundation, Washington DC 20550, U.S.A.

I.2.2 Controlled Ecosystem Pollution Experiment (CEPEX)

CEPEX will be directed towards basic investigations on pollution ecology. A research facility has been established at Saanich Inlet, British Columbia, Canada, for the purpose of studying the effects of pollutants on marine communities which are maintained in large, carefully controlled experimental enclosures. The enclosures consist of plastic cylinders (diametre 2 metres x length 30 metres) which are suspended in the water column and which are open to the atmosphere but closed at the bottom (see figure 2). The enclosed community is the natural one. The CEPEX approach will permit long-term (up to 90-day) biological effect studies.

Participating countries

Canada, U.K. and U.S.A.

The laboratories participating in this experiment are:

Canada

Institute of Oceanography,
University of British Columbia

U.K.

Marine Laboratory,
Department of Agriculture and
Fisheries for Scotland,
Aberdeen

U.S.A.

Skidaway Institute of Oceanography
Scripps Institution of Oceanography
Woods Hole Oceanographic Institution
Rosenstiel School of Marine and
Atmospheric Sciences

Co-ordination

Through a Scientific Steering Committee: Chairman, Dr. David Menzel, Skidaway Institute of Oceanography, 55 West Bluff Road, Savannah, Georgia, U.S.A.

I.2.3 Pollution and ecological investigations along the Halifax-Bermuda section

This section crosses a variety of marine environments encompassing the productive continental shelf area and situated east and "downstream" of the industrial and densely populated Atlantic seaboard of North America. It offers a platform for a wide variety of studies which will provide information on oceanographic processes, on sampling methods and problems and on variability with respect to time and space. The parameters to be measured are:

dissolved and suspended hydrocarbons, tar balls at the sea surface, organochlorine residues in marine organisms (marine pollution). Particulate and dissolved organic carbon and nitrogen, nitrous oxide and organic carbon in marine aerosols (chemical oceanography);

particles in seawater, biomass, bathypelagic organisms, phytoplankton, photosynthesis, organic matter, etc. (marine ecology).

Quarterly cruises (January, April, July, October).

Participating countries

Canada, Germany (Fed. Rep. of), U.K. and U.S.A.

International participation is arranged at the scientist level.

Co-ordination

Planning and co-ordination is arranged between the participating laboratories through Dr. D.C. Gordon of the Marine Ecology Laboratory, Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada.

I.2.4 Global baseline data project

The Geochemical Ocean Sections Study (GEOSECS) is an international co-operative programme for the application of geochemical and hydrographic measurements to the study of circulation and mixing processes in the world oceans. The GEOSECS research plan is the detailed measurement of the oceanic constituents along Arctic to Antarctic sections at all depths, in the Atlantic and Pacific Oceans, to provide, for the first time, a set of physical and chemical data measured on the same water samples. These data will provide the input for quantitative studies not only of oceanic mixing but will serve as a baseline for the levels of metals and fission products in the deep sea.

The Atlantic transect was completed in April 1973. The in situ measurement systems for temperature, salinity, depth, oxygen, and turbidity functioned so well that all the preliminary cruise data has been worked up. The shipboard measurements, including salinity, NO_3, NO_2, PO_4, dissolved O_2, $CaCO_3$ saturation, and argon, functioned better than expected. A large water library has been established at Woods Hole and samples distributed to many shore-based laboratories for measurement of:

Total CO_2	Oxygen-18	Plutonium-238
Deuterium	Neon	Plutonium-239
Tritium	Silicon-32	Trace Elements
Helium-3	Strontium-90	Major Ions
Helium-4	Cesium-137	Particulate Chemistry
Organic Carbon	Barium	Radium-226
Carbon-13	Radium-228	Carbon-14

Research based on the GEOSECS cruises will be carried out at many institutions throughout the world for several years. The sampling transect of the Pacific Ocean was conducted during the period July 1973 to April 1974.

This project is significant to both the Environmental Quality and Environmental Forecasting Programmes.

Participating countries

Canada, France, Germany (Fed. Rep. of), India, Italy, Japan, U.K. and U.S.A.

The participating laboratories are:

Germany (Fed. Rep. of)

Astronomisches Institut der Universitat Tibungen

Institut für Argewardt Physik der Universitat Kiel

Institut für Meteorologie und Geophysik der Universitat Frankfurt

Institut für Radiometeorologie und Maritime Meteorologie and der Universitat Hamburg

Max Planck Institut für Chemie

Zweites Physikelisches Institut der Universitat Heidelberg

India

Physical Research Laboratory, Ahmedabad

Italy

Universita di Pisa

Japan

University of Tokyo

U.S.A.

Oregon State University

Scripps Institution of Oceanography

Woods Hole Oceanographic Institution

Co-ordination

This is maintained through the GEOSECS Executive Committee, Woods Hole Oceanographic Institution, Massachussetts, 02593, U.S.A. Inquiries should be directed to Ms. Phyllis Laking, Information Officer.

I.2.5 Global Investigation of Pollution in the Marine Environment (GIPME)

This major programme is in the planning stage and most of the pollution investigations being carried out by Member States have relevance to it.

A comprehensive plan is in preparation and, meanwhile, a number of other preparatory activities are being undertaken within the framework of GIPME.

Three important working groups on sources of pollution will meet soon: The SCOR/ACMRR/ECOR/IASH/Unesco Working Group on River Inputs to Ocean Systems (RIOS) will consider the input of pollutants to the sea from rivers; it will recommend the best methods of approaching the problem, taking as full advantage as possible of the experience gained from the International Hydrological Decade work, and will consider how the problem of determining the subsequent fates of pollutants in the ocean can be tackled.

Working closely with this working group will be the IOC's ad hoc group of experts on Pollution of the Ocean Originating on Land (POOL). This group will address itself to the problems of those pollutants entering the sea from land by other routes than rivers; that is, via domestic and industrial outfalls and pipes, by direct run-off, and by ocean dumping (the ship being considered as no more than an "extra long outfall").

The SCOR/ACOMR/IAMAP Working Group on Tropospheric Transport of Pollutants will concern itself fundamentally with the input of pollutants to the ocean from the land via the atmosphere.

Three ACMRR Working Parties are looking into questions of interaction between pollutants and aquatic organisms: ACMRR/IABO Working Parties on Ecological Indices and on Biological Effects of Pollutants, and the ACMRR Working Party on Biological Accumulators.

The IOC, in collaboration with other organizations, is organizing three regional marine pollution workshops in 1974 and early 1975. These will review the present status of marine pollution research and monitoring and propose pilot projects in order to provide a technical basis for eventual regional marine pollution monitoring programmes. The three regions to be covered are: the Mediterranean (IOC, GFCM of FAO, ICSEM), the Caribbean (IOC, FAO) and East Asia (IOC, IPFC of FAO).

Participating countries:

Most of the IOC Member States indicated their interest in participating but, until more concrete plans are developed, it will not be possible to assess their degree of participation.

Co-ordination

IOC has established an International Co-ordination Group for GIPME consisting of seven members representing States selected by the IOC Executive Council and of six scientific experts, one designated by each of the following organizations of the United Nations system: FAO, IAEA, IMCO, United Nations, Unesco and WMO. Each member of the Group should be a scientist actively involved in the conduct of marine pollution research monitoring programmes. The terms of reference of the GIPME Co-ordination Group are:

(a) the preparation of a comprehensive plan for implementation of GIPME, including specific recommendations for long-term co-ordination of the programme and the establishment of priorities for the projects contained in the plan;

(b) in the development of this plan for GIPME, the Group should give special consideration to the relevant recommendations of the Stockholm Conference, the report and recommendations of the ACMRR/SCOR/ACOMR/GESAMP Joint Working Party of GIPME, relevant sections of the GELTSPAP Report, the reports and recommendations of GESAMP, and the relevant recommendations of the IGOSS Working Committee;

(c) the Group should also carefully review the work accomplished in this area by the Commission and its various advisory bodies, other international organizations, regional bodies and Member States.

The present Member States of the Group are: Brazil, France, Germany (Federal Republic of), Japan, USSR, U.K. and U.S.A.

I.3 SEABED ASSESSMENT

The Seabed Assessment Programme is designed to increase understanding of those geological processes on and beneath the ocean floor which generate the raw material of industrial civilization - hydrocarbons and heavy minerals. It is generally accepted that the obvious deposits have already been found. To locate new sources the resource geologist needs a better understanding of the processes involved in their generation along the continental margins, the mid-oceanic ridges, island arcs, and the abyssal plains (see figures 3 and 4).

I.3.1 Continental margins on both sides of the Atlantic Ocean

The purpose of the continental margin studies is to understand the origin and evolution of the present-day margins and to reconstruct the geological conditions at each stage in the opening of the South Atlantic. The data obtained will facilitate the interpretation of the relationship

between the fracture zones and the thick accumulation of sediments, and between the aseismic ridges and the deposition of massive salt formations. Moreover, the existence of multi-million barrel oil fields beneath the continental shelves cannot be explained by present-day geological conditions.

Both sides of the Atlantic are being investigated simultaneously. All major geophysical methods, plus bottom sampling, are being used. Dr. K. O. Emery, Woods Hole Oceanographic Institution (WHOI), is serving as Chief Scientist aboard the "Atlantis II" investigating the zone from South Africa to Portugal, and from the coast out to the Mid-Atlantic Ridge. The field work was completed in 1973. Preliminary findings from the 1972 work off Africa indicated two potential sources of oil accumulation, one in a thick sedimentary section off the delta of the Orange River in South West Africa and another in a large diapiric salt basin off Angola. Within the delta are probably numerous stratigraphic traps capable of retaining oil and gas if they are present and within the diapir field are many structural traps caused by the upward movement of the salt.

On the South American Atlantic Assessment the work will extend from the Scotia Ridge in the Southern Ocean to the Caribbean. This co-operative programme involves scientists from the Lamont-Doherty Geological Observatory, the Woods Hole Oceanographic Institution (U. S. A.), Brazil, Argentina, Uruguay and France.

From May to July 1972, the RV "Robert D. Conrad" of Lamont-Doherty Geological Observatory made reconnaissance geophysical studies on the continental margin of Brazil together with Brazilian scientists from Petrobras and the National Department of Mineral Production. Dr. John Milliman, WHOI, is serving as Chief Scientist on a project supported by the Brazilian Government with emphasis on the location of detrital minerals. Dr. George Bryan is serving as co-ordinator for a team of Lamont-Doherty Geological Observatory scientists whose studies extend from the Scotia Arc to the Caribbean. Dr. Ian Dalzie of Lamont is carrying out complementary geological investigations on the island of South Georgia. Field work will continue through 1975.

Both WHOI and Lamont scientists are publishing results as they become available. One major goal of this co-operative effort will be a series of palaeogeographic maps, one for each successive "opening" of the South Atlantic Ocean. A preliminary stratigraphical correlation chart for Africa and South America is also planned. Reconstruction of geological conditions in this area where the "fit" of the continents is relatively straightforward should be applicable to other more complex parts of the world.

In the Caribbean Sea, Colombia and Venezuela plan to carry out activities on their continental margins. This work has relevance to project I. 3. 2.

Participating countries

Argentina, Brazil, Congo, France, Gabon, Germany (Fed. Rep. of), Ghana, Jamaica, Liberia, Nigeria, Portugal, Senegal, Sierra Leone, South Africa, Spain, U. K. and Uruguay.

Co-ordination

National Science Foundation, Office for the IDOE, Washington DC 20550, U. S. A.

I. 3. 2 Geological and geophysical investigations in the Caribbean Sea and adjacent regions

A scientific workshop on the geology and geophysics of the Caribbean Sea, including the continental margin, is being scheduled for 1975.

I. 3. 3 Geochemical studies in the Eastern Mediterranean

The Applied Geochemistry Research Group at Imperial College, London, U. K., has made three cruises to the Eastern Mediterranean. The last of these cruises was in October 1973, and material from this cruise and some collected in 1972 are still being worked up.

The aim of this research has been twofold:

(a) to investigate the dispersion of ore elements around mineralized islands as an aid to locating offshore bedrock mineralization or placer deposits;

(b) to investigate the nature of hydrothermal precipitates associated with volcanism, restricted circulation and tectonic activity.

The first of these projects is almost complete and the second is well under way.

Work on the Red Sea has indicated that metalliferous sediments can occur in areas of limited circulation where there are evaporite deposits and where submarine volcanic activity occurs. The Eastern Mediterranean has such conditions, although the tectonic situation is different. Preliminary data on one core from deep water in the Strabo/Pliny trench system indicates that the sediments are highly reducing and are being deposited under restricted conditions. Work elsewhere has demonstrated that metal sulphides can precipitate under such circumstances.

In order to examine the relationship between submarine volcanism and metalliferous sediment formation in shallower areas, it is proposed to continue work on iron and manganese rich sediments collected in 1973 around submarine fumaroles of the Santorini volcano.

Related to the Santorini study is the necessity of collecting sediments from deeper water in the Cyclades volcanic arc. Reports on Santorini eruptions since about 200 BC record that water discoloration extends for many miles away from the volcano during periods of activity. It was hoped to collect sediments in deeper water adjacent to the volcano during the 1973 cruise but bad weather prevented this. Attempts will be made to collect this material in 1974.

Participating countries

Greece and U.K.

The following laboratories are involved in this study: Greek Institute of Oceanographic and Fishing Research, and the Applied Geochemistry Research Group, Imperial College of Science and Technology, London, U.K.

Co-ordination

The Applied Geochemistry Research Group, Imperial College of Science and Technology, London, U.K. is arranging co-ordination of the project.

I.3.4 Plate tectonics and metallogenesis (Nazca Plate)

The concept of plate tectonics, which acts as a unifying force in all phases of geology, is now being applied to the study of the genesis of mineral deposits. Several marine phenomena have been cited as the source of the metals, notably the emanations from the active spreading centres of mid-oceanic ridges. The brines are considered to be an important force in mobilizing the metal sources.

The Nazca Plate in the South East Pacific has been recognized as suitable for a detailed investigation of the complete cycle from crustal formation along the East Pacific Rise to its consumption in the Peru-Chile Trench. The presence of major ore deposits in the Andes overlying the zones of subduction supports the thesis that they originated through this process (see figure 5). The Nazca Plate is small enough to be studied as a single geologic entity yet large enough to be representative of the great lithospheric plates which make up the surface of the earth. Since the spreading rate along the East Pacific Rise is among the most rapid yet measured, the volcanic processes producing metalliferous crust and sediments must be quite intense.

The Hawaii Institute of Geophysics, Oregon State University and the Pacific Oceanographic Laboratory of NOAA, all from U.S.A., are conducting a study of the plate margins using complementary geophysical, geochemical and geological techniques. Scientists from Colombia, Ecuador, Peru and Chile are all actively participating in the cruises and data analysis. Simultaneously, a large-scale geophysical study of the subduction zone under the Andes, as it extends from Colombia

south through Chile, is being carried out. Dr. George P. Woollard, Hawaii Institute of Geophysics (HIG), is Chief Scientist on the Nazca Plate study. HIG scientists are primarily studying processes along the East Pacific Rise. Dr. Laverne Kulm is co-ordinator of the Oregon State University portion of the programme. The Oregon State group is concentrating its efforts largely along the Peru-Chile Trench. Processes similar to those now operative along the margins of the Nazca Plate may have produced the porphry copper deposits in the Andes. This is one of the major theses being tested by the Nazca Plate study.

Participating countries

Bolivia, Chile, Colombia, Ecuador, Peru, U.S.A. and Venezuela.

Co-ordination

Inquiries should be addressed to the Nazca Plate Programme, Hawaii Institute of Geophysics, University of Hawaii, 2525 Correa Road, Honolulu, Hawaii 96822, Attn. Mr. Richard L. Longfield, Programme Administrative Officer, or directly to the scientists mentioned above.

Contact: through scientists indicated above.

I.3.5 Tectonic development of East and South East Asia and its relation to metalliferous ore and hydrocarbon genesis

This is a study of the relationship between tectonics and natural mineral resources. An IDOE workshop on the metallogenesis and tectonic patterns in East and South East Asia, in which scientists of about 20 countries participated, was convened jointly by the Committee for Co-ordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas (CCOP) of ESCAP (formerly ECAFE) and the Intergovernmental Oceanographic Commission and was hosted by the National Research Council of Thailand (Bangkok, Thailand, 24-29 September 1973). The results of the workshop, including a series of recommendations, have been issued in the form of a report. This report has been considered by SCOR at a meeting of its Executive Committee in January 1974 and was approved by the IOC Executive Council at its fourth session in June 1974.

Participating countries

The nine CCOP Member States: Indonesia, Japan, Khmer Republic, Korea (Rep. of), Malaysia, Philippines, Singapore, Thailand and Viet-Nam (Rep. of).

Scientists from the following countries attended the workshop: Australia, France, Germany (Fed. Rep. of), India, Israel, U.K. and U.S.A.

Contact: For further information, contact any of the following:

IOC Secretariat; Dr. C.Y. Li, ECAFE, Sala Santitham, Bangkok 2, Thailand; or Dr. J. Katili, from the Indonesian Institute of Sciences, Jakarta.

I.3.6 Mid-Atlantic Ridge (FAMOUS)

The Mid-Atlantic Ridge is the subject of a major study to understand the mechanism driving apart the plates of the earth, the formation of new crust along the rift valley, and the possible formation of hydrothermal rocks and metalliferous sediments (see figure 6).

A scientific workshop sponsored by the U.S. National Academy of Sciences was held at Princeton, New Jersey, in January 1972 to examine major questions concerning the processes operating along the crests. The workshop results, which summarize the present knowledge and outline a comprehensive programme for a concerted attack on the major problems, were published in a report entitled "Understanding the Mid-Atlantic Ridge. A Comprehensive Program", National Academy of Sciences, 1972, Washington, D.C. Dr. James Heirtzler, Woods Hole Oceanographic Institution (WHOI), and Dr. Xavier Le Pichon, Centre National pour l'Exploitation des Océans (CNEXO), are serving jointly as Chief Scientists for this study. A major feature

of the project will be the first-hand study of the ocean floor using submersible craft. Detailed, well-documented samples will be collected and long-term monitoring instruments set up. Substantial scientific data will be collected prior to dives from site surveys now being conducted. Dr. A.S. Laughton of the U.K. will survey the area using "Gloria", a side-scan radar system. Dr. T.J. Francis, also of the U.K., will help locate the most seismically active areas using ocean bottom seismometers. Between 2 August and 4 September 1973, the bathyscaphe "Archimède" made 7 dives 400 km. south west of the Azores. Dr. R. Ballard from WHOI has participated in this work; information on the scientific results can be obtained from Dr. Xavier Le Pichon, CNEXO, Paris.

Participating countries

Canada, France, Iceland, Portugal, U.K. and U.S.A.

Participating institutions include:

France

Centre National pour l'Exploitation des Océans
Paris and Brest

Iceland

Science Institute,
University of Iceland,
Reykjavik

U.K.

Institute of Oceanographic Sciences
Wormley

U.S.A.

Woods Hole Oceanographic Institution,
Woods Hole

and

Atlantic Oceanographic and
Meteorological Laboratories,
NOAA, Miami

Co-ordination

The participating laboratories are arranging co-ordination of the study.

Contacts: Dr. James Heirtzler, Woods Hole Oceanographic Institution, Woods Hole, Mass. 02543, U.S.A.

Dr. Xavier Le Pichon, Centre National pour l'Exploitation des Océans, Centre Océanologique de Bretagne, BP 337, 200. Brest, France

Dr. A.S. Laughton, Institute of Oceanographic Sciences, Wormley, Surrey, U.K.

Dr. T.J. Francis, Institute of Geological Sciences, Blacknest, Aldermaston, Berkshire, U.K.

I.3.7 Regional and specific studies of the structure of the oceanic - island arc - continental margins of the South West Pacific

The South West Pacific region includes some of the most significant major structural features of the earth's crust. Interest centres not only in the major anomalies of the Tonga-Kermadec Ridge and Trench system at the ocean plate boundary, but also in the basins, island arcs and trenches in the area west of the Tonga Ridge which result from complex interactions between crustal elements that are well expressed but poorly understood. The area to be covered extends from the South Western Pacific Basin in the east to New Guinea in the west and from latitude 10°S to 40°S. Field work will be through the customary geological and geophysical methods: continuous seismic profiling, seismic refraction, magnetics, gravity, heat flow. A specific subproject within the broad context involving the New Zealand Oceanographic Institute and University

of Washington was carried out in February 1974 to investigate the changing boundary conditions at the ocean floor margin in the Kermadec Trench region and its transition to the Hikurangi Trench. Newly developed profiling equipment was used and heat flow measurements made.

Participating countries

Marine geoscience institutions of Australia, France, New Zealand, USSR and U.S.A. have been involved in recent years; others may join in the future, including Fiji which has begun an offshore geological programme. The project would be carried out under the sponsorship of CCOP/SOPAC with New Zealand providing co-ordinating services.

The principal investigators for this sub-project are Dr. D.J. Cullen, New Zealand Oceanographic Institute, P.O. Box 8009, Wellington, New Zealand and Professor C. Lister, Department of Oceanography, University of Washington, Seattle, Washington 98105, U.S.A.

I.3.8 Ocean minerals

Manganese nodules, which are known for their widespread occurrence on the ocean floor, are considered a potential economic resource whenever they contain significant amounts of copper, nickel, and cobalt. In order to assess the knowledge of the nodules and their economic potential, Lamont-Doherty Geological Observatory, U.S.A., held a workshop in January 1972. The proceedings of the workshop have been published. Following the workshop the U.S.A.-IDOE supported a one-year baseline study in which 22 groups of scientists from ten institutions inventoried, analysed, and published substantial amounts of data which had accumulated in core laboratories and data banks. Dr. David Horn, Lamont, published several reports on the chemical and physical properties of the nodules, using samples obtained by Lamont over the past 25 years.

Frazer and Arrhenius, Scripps Institution of Oceanography, U.S.A., published data from the Sediment Data Bank on the world-wide distribution of ferromanganese nodules. Summaries of other work will appear in a volume which includes recommendations for future study. Three problem areas were covered during this baseline study: (1) origin and distribution of the nodules; (2) environmental impact of deep-sea mining operations; and (3) technical and legal problems of mining in 15,000 feet of water, hundreds of miles from any shoreline.

The New Zealand Oceanographic Institute conducted research on manganese nodule distribution in selected areas in the South Pacific in 1974. RV "Valdivia" of the Federal Republic of Germany has been engaged in similar studies.

Participating countries

France, Germany (Fed. Rep. of), New Zealand, U.K., U.S.A. and Venezuela.

Co-ordination

Co-ordination is achieved through direct contact among the institutions involved. For future information, please contact any of the following:

Ferromanganese Programme,
Lamont-Doherty Geological Observatory,
Palisades, New York 10969, U.S.A.
(Attn. Dr. Sam Gerard, Coordinator)

New Zealand Oceanographic Institute,
(Attn. Dr. Glasby)
P.O. Box 8009,
Wellington, New Zealand

Dr. F. Wilchers,
Valdivia Manganese Exploration Group,
Ministry of Research and Technology,
BONN,
Fed. Rep. of Germany

I. 3. 9 Occurrence, mode of formation and environmental factors of polymetallic nodule deposits, hot brines and metalliferous muds in the South West Pacific

Polymetallic nodule deposits are known from the Manihiki Plateau, the Tuamotu region, and are under study. Elsewhere in the South West Pacific little data is available on either the occurrence or environment of nodules. Because of their potential importance the possible occurrence of hot brines and metalliferous muds warrants investigation. The area to be covered is that of the basin areas of the South West Pacific. Observation will include: bottom sampling, bottom photography, sediment profiling and coring, temperature profiling and bathymetric studies. A specific sub-project was carried out in June 1974 by way of reconnaissance surveys in the area to the north and east of New Zealand. The U. S. A. and Federal Republic of Germany will participate, together with New Zealand.

Further projects involving the U. S. A. and New Zealand are under consideration.

Participating countries

There has been interest from a number of countries in this problem and marine geoscience institutions of Australia, France, Germany (Fed. Rep. of), Japan, New Zealand, USSR and U. S. A. have been involved in recent years. Other countries and institutions might be involved in the future and further co-ordination and co-operation at an international level would assist in the promotion of future activities.

Co-ordination

Principal New Zealand investigator and co-ordinator is Dr. G. P. Glasby, New Zealand Oceanographic Institute, P. O. Box 8009, Wellington, New Zealand.

The project would be carried out under the sponsorship of CCOP/SOPAC with New Zealand providing co-ordinating services.

I. 4 LIVING RESOURCES - ASSESSMENT AND ECOLOGY

Knowledge necessary for the intelligent use and management of living marine resources will come increasingly from the interdisciplinary study of the mechanisms which produce and sustain marine life. The ocean can provide a large amount of food, but the quantities which can be harvested on a sustained basis are limited. Thus, the optimal use of renewable marine resources depends on knowledge about the natural productivity of the seas; their regional differences; the efficiencies of transfer of energy from photosynthetic plants to harvested species; and the population dynamics and maximum sustainable yield of different species. Until more is understood about the influence of temperature, currents, pollutants, and weather on marine life, sensible decisions about the management of these resources will not be possible.

Currently, the Living Resources Programme as reported by Member States can be categorized in two areas: (1) assessment of biological resources and (2) ecological relationships.

I. 4. 1 Coastal Upwelling Ecosystems Analysis (CUEA)

One of the goals of the Living Resources Programme is to understand better the processes and relationships existing between the biological aspects of marine organisms and the chemical, physical, and geological environment in which they live. Currently, the programme is concentrating on marine ecosystems analysis through Coastal Upwelling Ecosystems Analysis (CUEA) projects. The basic goal of CUEA is to understand the Coastal Upwelling Ecosystem so that the response of the system to change may be predicted from monitoring a few biological, physical, or meteorological variables (see figures 7 and 8).

The foundation for the CUEA programme has been established by the work of physical and biological oceanographers in several preliminary experiments. MESCAL-I was conducted primarily as a biological cruise off Baja California in March 1972. It was designed to obtain time series measurements on variables like temperature, nitrogen, chlorophyll, and silicon, and to

examine associated biological processes in the developmental stages of an upwelling system.

During the summer of 1972, the first Coastal Upwelling Experiment (CUE-I) was conducted off the north western coast of the United States. The goals were to define the time and space scales of the upwelling process, test theoretical hypotheses and models, and prove out experimental hardware and techniques for future studies of upwelling ecosystems. Data from CUE-I and CUE-II provided the descriptive and theoretical basis for the JOINT-I experiment, which took place off the north west African coast in early 1974.

JOINT-I is the first full-scale integrated experiment conducted on a marine ecosystem. The selection of the north west coast of Africa for this first major experiment was based on the presence of a powerful upwelling system in that region and the extensive scientific foundation provided by the Co-operative Investigations of the Northern part of the Eastern Central Atlantic (CINECA) programme.

More than 20 cruises by oceanographic and fisheries research vessels of eight countries have been conducted in the CINECA region to date and an intensive multi-ship effort took place in 1973. This 1973 programme was the first of two related CINECA phases and was primarily devoted to a detailed physical, chemical, and biological assessment of the dynamics of the Canary current and the coastal upwelling system. A possible link between these systems will also be investigated during transects from the coast to 550 km. offshore. U.S. scientists from the CUEA project have taken part in seven co-operative cruises in this area and will lead the second major CINECA phase on upwelling process studies during 1974. The JOINT-I experiment will be a major attempt to understand each component of upwelling as it develops from the off-shore movement of surface water; surface water replacement by nutrient-rich waters from deeper, cooler layers; the growth of plants which feed on these nutrients; the growth of microscopic animals which feed on the plants; and finally, the influx and growth of fish which feed on these smaller organisms. More detailed information about the CINECA programme can be found in "Co-operative investigations", project III. 5, page 49.

Colombia, Ecuador and Venezuela have declared their interest to carry on investigations on coastal upwelling in certain areas of the South East Pacific and Caribbean Sea. As a preliminary step, and to learn from CINECA experiences, they plan to participate at the scientist level in CINECA.

The Scientific Committee on Oceanic Research (SCOR), a scientific advisory body of the IOC, has a working group on upwelling; its recommendations provide Member States with guidelines on the various aspects of this matter.

Participating countries

Canada, France, Germany (Fed. Rep. of), Japan, Mexico, Spain, USSR, U.K. and U.S.A.

Co-ordination

Between participating laboratories. For further information, contact any of the following:

France

Centre National pour l'Exploitation
des Océans,
Centre Océanologique de Bretagne,
BP 337
200. BREST

Germany (Fed. Rep. of)

Prof. Dr. G. Hempel
Institut für Meereskunde,
Universität Kiel,
Düsternbrooker Weg 20,
23-KIEL

Spain

Prof. R. Margalef,
Instituto de Investigaciones Pesqueras,
Paseo Nacional s/n,
Barcelona

U. S. A.

CUEA Executive Council,
Duke University Marine Laboratory,
Beaufort, North Carolina 28516
(Attn. Dr. Richard T. Barber, Chairman)

II. Other LEPOR programmes which are not part of the IDOE

II. 1 ENVIRONMENTAL FORECASTING

II. 1. 1 Variability of the sea surface temperature and salinity fields of the South West Pacific and Indian Ocean

Collection, analysis and dissemination of sea surface temperature and salinity by use of merchant ships. Ships of opportunity type of programme. In operation since 1966. Monthly charts of sea surface temperature and salinity are produced.

Participating countries

Australia, France, Japan and New Zealand.

The laboratories involved in this programme are: CSIRO Division of Fisheries and Oceanography (Australia), Centre ORSTOM, B. P. A5 Cedex, Nouméa (France), Fishery Agency (Japan) and Oceanographic Institute (New Zealand).

Co-ordination

Regional research and service programme under CSIRO Division of Fisheries and Oceanography. Contact agency:

Division of Fisheries and Oceanography,
CSIRO,
P. O. Box 21,
Cronulla, NSW 2230,
Australia

II. 1. 2 Study of the physical oceanography of the Kuroshio and adjacent regions

For more detailed information about this aspect of CSK, see Co-operative Study of the Kuroshio and adjacent regions (CSK), Co-operative investigations, project III. 2, page 47.

II. 1. 3 Study of the physical oceanography of the Mediterranean

For more detailed information on this aspect of CIM, see Co-operative Investigations in the Mediterranean (CIM), Co-operative investigations, project III. 4, page 48.

II. 2 ENVIRONMENTAL QUALITY

II. 2. 1 Saronikos system project

Development of an observational and modelling programme to interpret the effect of existing and proposed Athens waste disposal in the Saronikos Gulf. Several project areas remain without specific leadership, for example, higher trophic levels, and sea-bottom interface chemistry. The project will continue on a large scale for certainly three years, after which time it will continue but at an undefined level.

Participating countries

Greece and the U.S.A. with occasional participation of scientists from the Federal Republic of Germany and the U.K.

The laboratories involved are: the Institute of Oceanographic and Fishing Research (IOKAE), Greece, and the University of Washington, Seattle, U.S.A.

Co-ordination

Through: the IOKAE, Agios Kosmas, Ellinikon, Athens, Greece; Dr. R.C. Dugdale, Department of Oceanography, University of Washington, Seattle, Washington 98105, U.S.A.

II.2.2 Study of North Sea pollution

In recent years the International Council for the Exploration of the Sea (ICES) has been much involved in pollution studies. In 1970 and 1971 it published comprehensive surveys of the state of pollution in the North Sea and the Baltic respectively. As at that time only a few figures were available for assessment of the degree of pollution, these reports necessarily are largely qualitative; since then, however, much work - co-ordinated by ICES - has been carried out in the institutes of the member countries with the purpose of providing quantitative information, both concerning the input of various pollutants and the level of certain toxic substances in commercially important marine organisms and in seawater.

The pollutants to which it was decided to pay special attention in the North Sea are: (a) chlorinated aromatic hydrocarbons, such as DDT and its metabolites, Dieldrin and PCBs; (b) halogenated hydrocarbons; (c) metals, particularly mercury, lead, copper, zinc, cadmium and manganese; (d) petroleum.

Up to the present time, a baseline survey - an investigation of pollutant levels in food fish and shellfish of the North Sea - has been carried out. As an introductory step, a calibration exercise was undertaken to lay the basis for the comparison of results submitted by different laboratories. The baseline survey itself dealt with fish samples, taken in a number of areas, from specified year-classes of cod, plaice and herring. Also samples of shrimps and mussels of specified length were collected. All the samples were analysed for mercury and a varying number of other metals (Cd, Pb, Cu, Zu, Cr, Co, Fe, Mn) and for chlorinated hydrocarbon pesticides and PCBs. A report on the results is being produced by ICES.

Information on the input of pollutants to the North Sea has been received from all participating countries; a report is also being produced by ICES.

Participating countries

Belgium, Denmark, France, Germany (Fed. Rep. of), Netherlands, Norway, Sweden, U.K..

The Netherlands and the U.K. have declared this activity as a LEPOR project.

Co-ordination

Through ICES. Chairman of the ICES working group: Mr. A.J. Lee, Fisheries Laboratory, Lowestoft, Suffolk, England. ICES has established within its organization a machinery for giving scientific advice on pollution research to member governments, as well as to any intergovernmental organization for control of pollution which may request such advice. This machinery may soon be able to present periodic reports on the "Health of the Ocean" in the ICES area.

TABLE 1

GENERAL TIME-TABLE FOR CERTAIN IDOE PROGRAMMES

PROGRAMME	1973-1974	1975-1976	1977 onwards
ENVIRONMENTAL FORECASTING			
Equatorial Undercurrent West Pacific (I.1.2.)	Field operations started 1973		
Sea Surface Current Field SW Pacific (I.1.3.)	Field operations using EOLE satellite	Field operations using NIMBUS satellite	
Overflow (I.1.4.)	Expedition in 1973		
Ocean Dynamics MODE (I.1.5.)	Planning for an initiation of MODE I field work	Completion of MODE I field work; analysis of data and evaluation of results; co-operation with USSR in planning second Polygon experiment; planning of continental shelf research; planning of Antarctic Circumpolar Current studies	Completion of second Polygon field work; analysis of data and evaluation of results; initiation of continental shelf research experiments; modelling and field experiments on the Antarctic Circumpolar Current
Air-Sea Interaction NORPAX (I.1.6.)	Analysis of historical data; planning of ocean monitoring activities will be completed; Winter field experiment will be conducted	Analysis of historical data will continue; ocean monitoring activities will be initiated; second Winter experiment will be conducted	Analysis of data and development of models will be undertaken; monitoring activities will continue
JASIN (I.1.8.)	Studies of sea trial experiment in 1972. GATE will provide further experience	Main project, August-September 1976	
JONSDAP (I.1.9.)	Field operations from 10 September to 20 October 1973		
JONSWAP (I.1.10.)	Field operations in German Bight during 1973		
EL NIÑO (I.1.11.)	Scientific workshop, end 1974		
GARP-MONEX (I.1.12.)	Field work in 1973		Special observation period of six weeks during May-June 1979
GARP-GATE (I.1.16.)	Field work mid-1974, 26 June to 18 September		

GENERAL TIME-TABLE FOR CERTAIN IDOE PROGRAMMES

PROGRAMME	1973-1974	1975-1976	1977 onwards
ENVIRONMENTAL QUALITY			
CEPEX (I.2.2)	Quarter-scale experiments and engineering tests were completed in 1973; full-scale experiments in 1974; data processing initiated in 1974	Data processing will be completed and results will be evaluated	
HALIFAX-BERMUDA Sections (I.2.3)	Quarterly cruises	Quarterly cruises	Quarterly cruises
Baseline - GEOSECS (I.2.4)	The Atlantic field work was completed in 1973 and the data analysis and evaluation of results initiated in 1974; the Pacific field work was completed in 1974	The data analysis and evaluation of results of the Pacific field work will be done largely in 1975-76	Results of Atlantic and Pacific studies will be completed and scientific results of both sets of studies will be compiled
GIPME (I.2.5)	2nd session International Co-ordination Group, July 1974 International workshop on marine pollution in the Mediterranean, 9-14 September 1974	Regional workshops in marine pollution of the Caribbean Sea and of the South-East Asia	
SEABED ASSESSMENT			
East Atlantic Continental Margins Study (I.3.1)	Field studies were completed in 1973; data analysis and evaluation of results continued through 1974		
South-West Atlantic Continental Margins Study (I.3.1)	Field studies conducted in 1974	Field studies will be completed in 1975; data analysis and evaluation of results will be completed by 1976	
Caribbean Continental Margins Study (I.3.1)		Scientific workshop to be held in 1975	
Geochemical Studies in the Eastern Mediterranean (I.3.4)	One cruise in 1973. Another scheduled for 1974		
NAZCA PLATE (I.3.5)	Field studies conducted in 1973 and 1974; data analysis and evaluation of results are being initiated in this period	Additional field studies will be conducted in 1975 and 1976; data analysis and evaluation of results will continue	Data analysis and evaluation will be completed in 1977

Tectonic Development East and South-East Asia (I.3.6)	International workshop was held in 1973; analysis of available data in 1974 to assist in the evaluation of possible future programmes	Field studies may be undertaken if warranted by the completed evaluation	
Mid-Atlantic Ridge (FAMOUS) (I.3.7)	Field studies conducted in 1973 and 1974	Field studies will be completed in 1975; data analysis and evaluation of results will be completed by the end of 1976	
Oceanic island arc. Continental Margins of the South-West Pacific (I.3.8)	Field work started in 1974		
Manganese Nodules (I.3.9)	Field and laboratory studies in 1973 and 1974	Field studies will be completed in 1975 and 1976	Data analysis and evaluation will be completed in 1977
Polymetallic nodule deposits, hot brines and metalliferous muds in the South-West Pacific (I.3.10)	Field work in 1974		
LIVING RESOURCES			
Coastal Upwelling Ecosystems Analysis (CUEA) - (I.4.1)	A major multi-ship oceanographic field experiment (Joint-I) conducted off North-West Africa in co-ordination with CINECA in 1974	The Joint-I data will be analysed and evaluated in 1975; limited-scale upwelling field studies will be conducted in 1975 on a coastal system; a second major upwelling study is being considered for 1976, although a specific area has not yet been finally selected	It is expected that at least one more major upwelling study will be under taken, possibly in 1978; planning will be initiated in 1976 for studies of mesoscale ecosystems and selected studies will then be undertaken

Table 2. Countries Co-operating in IDOE Projects

Project / COUNTRY	Subtropical Convergence	Equatorial Undercurrent	Surface Current SW Pacific	Overflow	MODE	NORPAX	CLIMAP	JASIN	JONSDAP	JONSWAP	El Niño	MONEX
ARGENTINA	X											
AUSTRALIA		X	X			X						
BELGIUM									X			
BOLIVIA*												
BRAZIL												
CANADA				X		X				X		
CHILE											X	
COLOMBIA											X	
CONGO												
DENMARK				X			X			X		
ECUADOR											X	
FRANCE		X	X	X	X	X				X		
GABON*												
GERMANY (Fed. Rep.)				X	X	X	X			X		
GHANA												
ICELAND				X								
INDIA												X
INDONESIA												
ISRAEL												
ITALY												
JAMAICA												
JAPAN						X						
KHMER, Rep.*												
KOREA (Rep. of)												
LIBERIA*												
MALAYSIA												
MEXICO												
NETHERLANDS							X	X	X	X		
NEW ZEALAND												
NIGERIA												
NORWAY				X			X					
PERU										X		
PHILIPPINES				X								
PORTUGAL												
SENEGAL												
SIERRA LEONE												
SOUTH AFRICA												
SPAIN												
SWEDEN					X							
SWITZERLAND							X					
THAILAND												
USSR				X	X							
UNITED KINGDOM				X	X	X	X	X	X	X		
USA			X	X	X	X	X	X		X	X	
URUGUAY												
VENEZUELA												
VIET-NAM (Rep. of)												

* Countries which are not IOC members.

GATE	Baseline Studies	CEPEX	HALIFAX-BERMUDA Section	GEOSECS	Continental Margins	NAZCA PLATE	Plate Tectonics South-East Asia	Famous	Continental Margins South-West Pacific	Minerals	CUEA	Project / COUNTRY
					x							ARGENTINA
							x		x			AUSTRALIA
												BELGIUM
						x						BOLIVIA*
x					x							BRAZIL
x		x	x	x				x			x	CANADA
						x						CHILE
	x				x	x					x	COLOMBIA
					x							CONGO
												DENMARK
						x					x	ECUADOR
x				x	x		x	x	x	x	x	FRANCE
					x							GABON*
x			x	x	x		x			x	x	GERMANY (Fed. Rep.)
					x							GHANA
							x					ICELAND
				x								INDIA
							x					INDONESIA
							x					ISRAEL
				x								ITALY
					x							JAMAICA
				x			x				x	JAPAN
							x					KHMER, Rep.*
							x					KOREA (Rep. of)
					x							LIBERIA*
							x					MALAYSIA
x											x	MEXICO
x												NETHERLANDS
									x	x		NEW ZEALAND
					x							NIGERIA
												NORWAY
	x					x						PERU
							x					PHILIPPINES
x					x			x				PORTUGAL
					x							SENEGAL
					x							SIERRA LEONE
					x							SOUTH AFRICA
					x							SPAIN
												SPAIN
												SWITZERLAND
							x					THAILAND
x									x		x	USSR
x	x	x	x	x	x		x	x		x	x	UNITED KINGDOM
x		x	x	x	x	x	x	x	x	x	x	USA
	x				x							URUGUAY
x					x	x				x	x	VENEZUELA
							x					VIET-NAM (Rep. of)

II. 3 SEABED ASSESSMENT

II. 3. 1 Morphological charting of the sea floor

Improvement in the knowledge of the topography of the sea floor was one of the earliest activities in the investigation of the oceans. The original goal, which was to ensure the safe navigation of surface vessels, has been considerably broadened so as to encompass the production of scientific charts for the use of oceanographers and for other users of the oceans.

Most coastal States undertake hydrographic surveying work for charting purposes with special emphasis on shallow waters. Beyond the 100 fathom isobath, the General Bathymetric Chart of the Oceans (GEBCO) has been produced for many years under the responsibility of the International Hydrographic Bureau (IHB), now the International Hydrographic Organization (IHO). These bathymetric charts are on a scale of 1: 10 million and the plotting sheets from which they are produced are on 1: 1 million scale. Maintenance of the plotting sheets is the responsibility of certain volunteering hydrographic offices in co-operation with the IHO and the co-ordination, compilation and production of the final chart is the joint responsibility of IOC and IHO.

The new arrangements for the production of these charts were approved during the eighth session of the IOC Assembly. A Joint Guiding Committee for the General Bathymetric Chart of the Oceans has been formed by the IHO and the IOC, after consultation with SCOR, IAPSO and the Commission for Marine Geology (CMG) of the IUGS. SCOR (with IHO) also has a Working Group on Morphological Mapping of the Ocean Floor to provide scientific advice on this matter.

Participating countries

All Member States affiliated with IHO. Countries assigned with the responsibility of producing the 1: 1 million plotting sheets are: Argentina, Australia, Brazil, Canada, Chile, France, Germany, India, Indonesia, Japan, Netherlands, New Zealand, Philippines, Rep. of South Africa, Sweden, Turkey, United Kingdom, U. S. A.

Co-ordination

Through the International Hydrographic Organization, Av. Président J. F. Kennedy, Monte Carlo, Principauté de Monaco and the Secretary, IOC.

II. 3. 2 Studies of organic sedimentary processes on shelves slopes and the deep ocean floor of the South West Pacific

This project will encompass studies of plankton in the shallow water column and in the recent sediments. An examination of the uppermost sediments and sedimentary structures will help to explain faunal changes with time and varying hydrological environments. The area to be covered is the South Fiji Basin and adjoining areas and the observational activities will consist of plankton sampling by towed and hauled nets and by pumps as well as piston coring and continuous profiling. Foraminifera and coccoliths are to be examined first. An initial cruise by New Zealand took place in October 1973.

Participating country

New Zealand.

Co-ordination

Mr. J. V. Eade and Dr. D. A. Burns, both from New Zealand Oceanographic Institute, P. O. Box 8009, Wellington, New Zealand.

II.4 LIVING RESOURCES, ECOLOGY AND ASSESSMENT

II.4.1 Assessment of living resources in the North Atlantic

Programmes aimed at the assessment of the living resources co-ordinated through the existing regional organizations such as the International Council for the Exploration of the Sea (ICES), the International Commission for North West Atlantic Fisheries (ICNAF) and the North East Atlantic Fisheries Commission (NEAFC).

Participating countries

Canada, U.S.A., U.K. and several other European countries.

Co-ordination

Through the bodies indicated above.

II.4.2 Fish stock assessment in the South Atlantic

The scope of this project involves stock assessment through hydroacoustic methods and trial catches, as well as studies on the environmental oceanographic parameters and species, length, age, size, maturity and sex composition of fish. The second cruise of the research vessel Professor SIEDLECKI took place between August 1973 and January 1974.

Participating countries

Poland and at scientist level: Argentina, Indonesia, Senegal, with assistance of FAO.

Co-ordination

Dr. Ryszand Maj, Director Sea Fisheries Institute, skr. poczt. 184, 81-345 Gdnya, Poland.

II.4.3 Indian Ocean Fishery Survey and Development Programmes

The objectives of these programmes are as follows:

A. Long-range objectives

The long-range objective of the project is fishery development in the sense of contributing to general economic development, including especially the development and introduction of rational management systems and methods, and the stimulation of investment, from international as well as national sources, in the fishery sector; to provide a source of foreign exchange; to contribute to meeting various socio-economic needs; to provide a source of protein, and to lead to generally increasing standards of living and to the diffusion of economic well-being throughout the population.

B. Immediate objectives

The main purpose of the project, which is primarily investment-oriented, is to assist the countries around the Indian Ocean area in achieving long-range co-ordinated fishery development activities through the programme of staff activities and by conducting development-oriented surveys in selected areas in the Indian Ocean, as well as to promote rational utilization and management of resources.

In particular, the objectives are:

(i) to review and co-ordinate all fishery development programmes in the area in the framework of the Indian Ocean Programme;

(ii) to facilitate the flow of information to make project operations more effective and to avoid duplication of effort;

(iii) to identify and assist in development of country and regional pre-investment projects;

(iv) to prepare investment feasibility studies and to liaise with potential investors such as private industry, governments and development banks;

(v) to train personnel;

(vi) to monitor and assess work done by various projects developed under the Indian Ocean Programme;

(vii) to supervise and co-ordinate general resource surveys[1] which will mainly be implemented by mobilizing resources, particularly vessels and technical staff, through voluntary contributions from member countries of the Commission and by co-ordinating relevant activities of existing projects, as well as those of new projects to be developed; to conduct surveys under UNDP funding.

This project forms the second phase of the approved UNDP project INF/71/011 of the same title.

Participating countries

Bahrain, Bangladesh, Burma, Ethiopia, India, Indonesia, Iran, Iraq, Jordan, Kenya, Kuwait, Madagascar, Malaysia, Maldive Islands, Mauritius, Oman, Pakistan, Qatar, Singapore, Somalia, Sri Lanka, Tanzania, Thailand, People's Democratic Republic of Yemen, Yemen Arab Republic, United Arab Emirates and United Kingdom.

Co-ordination

Through the Department of Fisheries of the Food and Agriculture Organization of the United Nations (FAO).

III. Co-operative investigations

One of the principal activities of the Intergovernmental Oceanographic Commission since its beginning has been the creation and co-ordination of co-operative exercises in various regions of the world ocean where the exploitation of marine resources was of great importance for the bordering countries and where environmental information was deficient.

These co-operative exercises have been characterized by the multidisciplinary approach of the studies and their main purpose has been to gather oceanographic information of the region and to stimulate co-operation between the participating countries. Besides the classical marine science disciplines such as physical and chemical oceanography, marine biology and marine geology and geophysics, they have also included investigations into the fisheries aspects of the area.

Following the International Indian Ocean Expedition (IIOE) and the International Co-operative Investigations in the Tropical Atlantic (ICITA) which took place in the decade 1960-1969, the following co-operative exercises are presently in progress: the Co-operative Investigations of the Caribbean and Adjacent Regions (CICAR); the Co-operative Study of the Kuroshio

(1) The term "resource surveys" is used throughout in a very broad sense to include surveys which provide estimates of the magnitude of resources (sometimes known as "exploratory fishing") and surveys which provide information on catch rates (sometimes known as "experimental fishing"). The objective of resource surveys is to provide resource information pertinent to fishery development.

and adjacent regions (CSK); the Co-operative Investigations in the Mediterranean (CIM) and the Co-operative Investigations of the Northern part of the Eastern Central Atlantic (CINECA). Only CICAR and CINECA and the pollution studies of CSK and CIM are included in IDOE; other aspects of CSK and CIM are listed in Section II, "other LEPOR programmes which are not part of IDOE".

Because of the relevance of the various research projects to the IDOE programmes described in this work, cross-references are given in each of them when appropriate.

III. 1 Co-operative Investigations of the Caribbean and Adjacent Regions (CICAR)

A comprehensive study of the Caribbean Sea, the Gulf of Mexico and the adjoining areas of the Atlantic Ocean, CICAR is a multidisciplinary programme, concentrating its main scientific activities on the following:

1. Oceanic observations on standard sections including circulation, chemical studies and plankton, with emphasis on survey months.

2. Studies on upwelling phenomena.

3. Fisheries resources evaluation, including protection and conservation aspects.

4. Studies on marine pollution, including estuaries and coastal lagoons.

5. Studies on scientific aspects related to coastal aquaculture.

6. Oceanographic and ecological studies in view of the possible construction of a sea-level canal.

7. Studies in marine geology and geophysics.

8. Training of graduates, education and technical assistance in the field of marine research with special emphasis on the above topics and projects.

Field activities started in 1968 and are planned to terminate at the end of 1975.

Participating countries

Brazil, Colombia, Cuba, France, Germany (Fed. Rep. of), Guatemala, Jamaica, Mexico, Netherlands, Panama, Trinidad and Tobago, USSR, U.K., U.S.A. and Venezuela.

Co-ordination

Co-ordination is handled by IOC through an International Co-ordination Group. The International Co-ordinator is: Professor J. S. Kenny, University of the West Indies, St. Augustine, Trinidad and Tobago.

The Regional Data Centre for CICAR is the National Oceanographic Data Center, Washington D.C., U.S.A.

III. 2 Co-operative Study of the Kuroshio and adjacent regions (CSK)

This comprehensive study of the Kuroshio current system and adjacent regions, including the South China Sea, has the following objectives:

(i) CSK is an international co-operative study of the physical, chemical and biological structure of the entire Kuroshio current system and its seasonal, annual and multi-annual variability.

(ii) Studies are also carried out in the adjacent seas, with a first emphasis on the South China Sea, including the study of their environmental conditions productivity and fisheries resources.

(iii) Studies of marine pollution in the above areas are being developed.

Participating countries

China, France, Japan, Republic of Korea, Philippines, Thailand, USSR, U.K. (Hong Kong), and Republic of Viet-Nam.

Co-ordination

Co-ordination is handled by IOC through an International Co-ordination Group. The International Co-ordinator is: Dr. K. Wadati, Japanese National Commission for Unesco, Kasumigaseki, Chiqyodaku, Tokyo, Japan.

The Regional Data Centre is the Kuroshio Data Centre (KDC), affiliated with the Japanese Oceanographic Data Centre. The KDC issues the CSK Newsletter (No. 43 issued in January 1974) and Data Reports of CSK.

III. 3 Southern Oceans[1] (SOC)

The International Co-ordination Group for the Southern Oceans undertakes the following activities:

(i) Assembling and distributing details of firm oceanographic cruise plans in the southern oceans, preferably at least one year in advance.

(ii) Encouraging the pre-allocation of blocks of time for oceanographic research on Antarctic supply vessels whenever practicable.

(iii) Developing means of co-ordinating existing and planned oceanographic research programmes in the region.

(iv) Encouraging the evaluation of existing oceanographic data from the region with a view to fostering specific studies of limited extent to fill gaps in present knowledge and capable of being carried out in the foreseeable future.

(v) Encouraging and reviewing the development of relevant theory, methods and instruments, with particular reference to the problems of obtaining measurements in the winter and in the presence of ice.

(vi) Developing plans for the gradual evolution of a comprehensive study of the Southern Ocean.

Participating countries

Argentina, Australia, Belgium, Brazil, Chile, France, Japan, New Zealand, Norway, South Africa, USSR, United Kingdom, U.S.A.

Co-ordination

Co-ordination is handled by IOC through an International Co-ordination Group.

III. 4 Co-operative Investigations in the Mediterranean (CIM)

A comprehensive environmental study in the Mediterranean in the following basic fields of marine science:

(1) The term "Southern Oceans", as used here, indicates the southern parts of the Atlantic, Pacific and Indian Oceans.

physical and chemical oceanography
marine geology and geophysics
marine biology and fishery resources
marine pollution.

Participating countries

Austria, Egypt, Belgium, France, Germany (Fed. Rep. of), Israel, Italy, Lebanon, Malta, Monaco, Morocco, Romania, Spain, Switzerland, Tunisia, U.K. and USSR.

Co-ordination

The Co-operative Investigations in the Mediterranean (CIM), co-sponsored by the Intergovernmental Oceanographic Commission (IOC), the International Commission for Scientific Exploration of the Mediterranean (ICSEM) and the General Fisheries Council for the Mediterranean of FAO (GFCM/FAO), is co-ordinated by a Group for Technical Co-ordination (GTC) (to deal with logistic problems), composed of members from the three Secretariats, and also by the sessions of International and National Co-ordinators (to deal with scientific problems).

A permanent Operational Unit has been established in Monaco, composed of scientists seconded from member countries of CIM. The unit is responsible for preparing relevant information for promulgation to all the participating countries maintaining liaison between participating ships, taking care of data exchange matters and making available the scientific results of the expeditions. The Operational Unit is under the supervision of the International Co-ordinator for CIM. It publishes the CIM Newsletter. (No. 6 was published in 1974.) The Regional Data Centre for CIM is WDC-B (Oceanography), Moscow.

The International Co-ordinator is Dr. J. Joseph, Operational Unit of the CIM, 16, Bld. de Suisse, Monte Carlo, Principality of Monaco.

III. 5 Co-operative Investigations of the Northern part of the Eastern Central Atlantic (CINECA)

A comprehensive study of the oceanic area of the Atlantic Ocean, stretching between the latitudes of Gibraltar and Dakar and extending off the African coast approximately to the meridian 25°W.

Major elements of CINECA are the:

(i) compilation of available data to describe the meteorological, oceanographic and biological features of the area;

(ii) monitoring of environmental and biological parameters (including fisheries aspects) in the area over several years;

(iii) conducting surveys in order to provide synoptic pictures of the environmental and biological parameters in large parts of the area, including acoustic surveys and exploratory fishing;

(iv) conducting detailed co-operative studies in areas more limited in space than those covered by the surveys under (iii); and

(v) training, educating and assisting developing countries in the area.

Participating countries

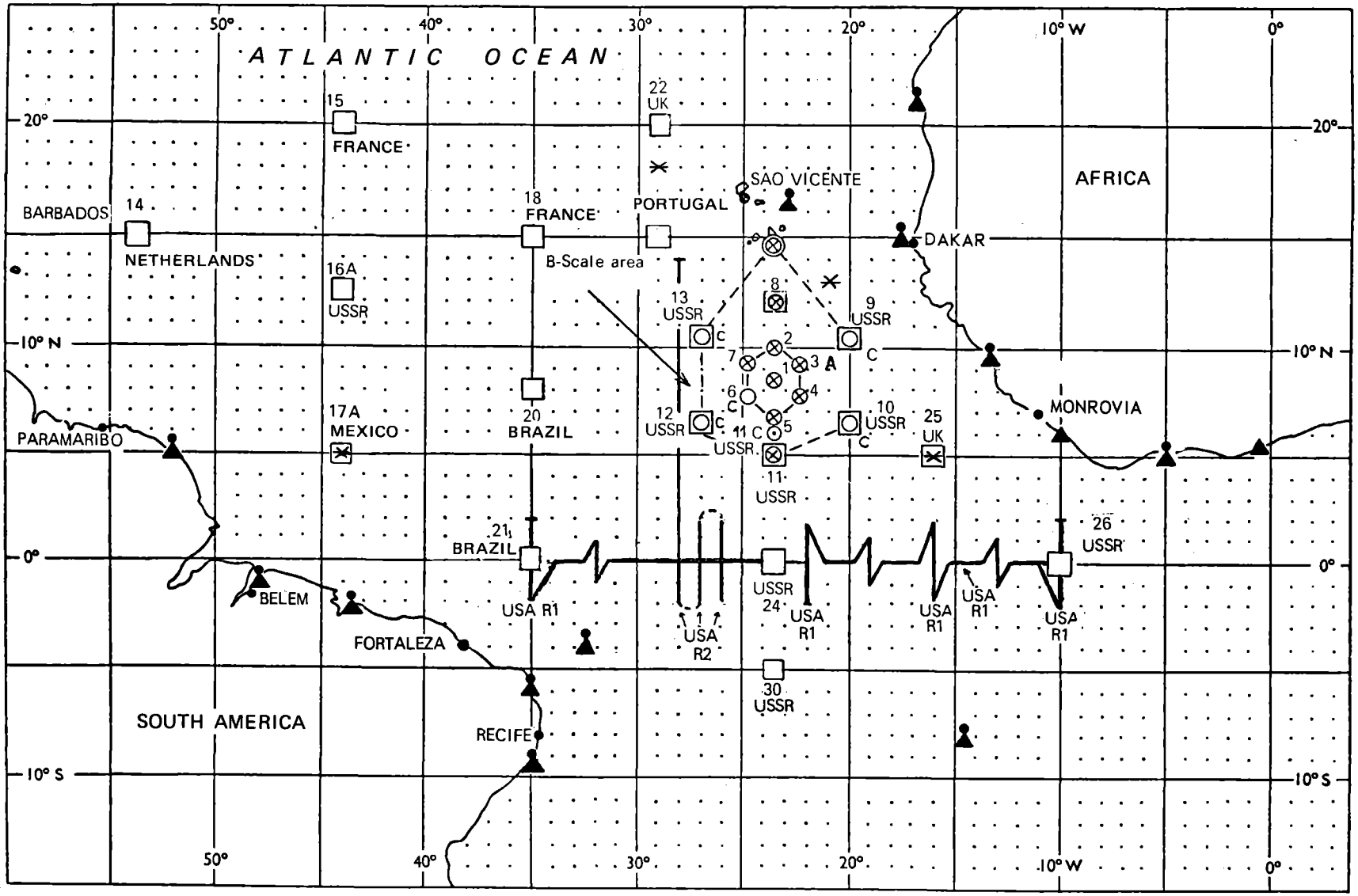
France, Germany (Fed. Rep. of), Rep. of Korea, Mauritania, Morocco, Norway, Poland, Portugal, Senegal, Spain, USSR, U.K. and U.S.A.

Co-ordination

Co-ordination is handled by the Joint ICES/IOC/FAO (CECAF) International Co-ordinating Group for the planning and execution of CINECA. The International Co-ordinator is Mr. R. Letaconnoux, Institut Scientifique et Technique des Pêches Maritimes, La Noë, Route de la Jonelière, F-44037 NANTES CEDEX, FRANCE.

The Regional Data Centre for CINECA is the Service Hydrographique of ICES. CINECA Newsletters are issued by ICES (No. 7 in 1974).

FIGURE 1. GATE OCEANOGRAPHIC SUB-PROGRAMME – PROJECT I.1.16



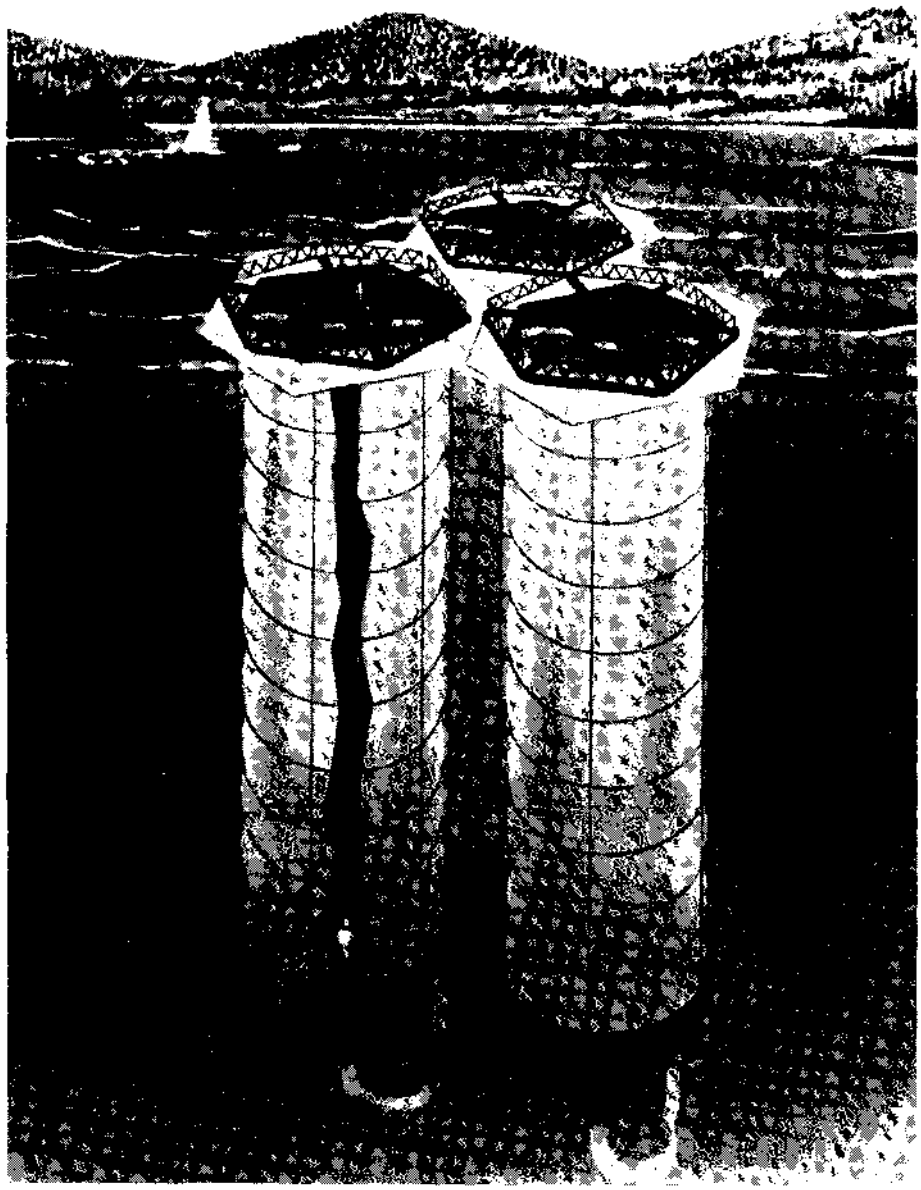
(Photo: World Meteorological Organization)

Ship and buoy distributions for the A-Scale Area, phase 1.

- ⊗ B – Scale radar ship-position
- ○ B–Scale ship-position
- ⊠ A/B–Scale radar ship-position
- ⊛ Possible radar
- ⊡ A/B–Scale ship-posiiton
- □ A–Scale ship-position
- ⊗ Land station with radar
- ⊙ Communications ship
- Station-position Radiowind/Radiosonde
- ▲ Station-position Radiowind only
- ⟷ Roving oceanographic ship
- ✳ Intercomparison Point

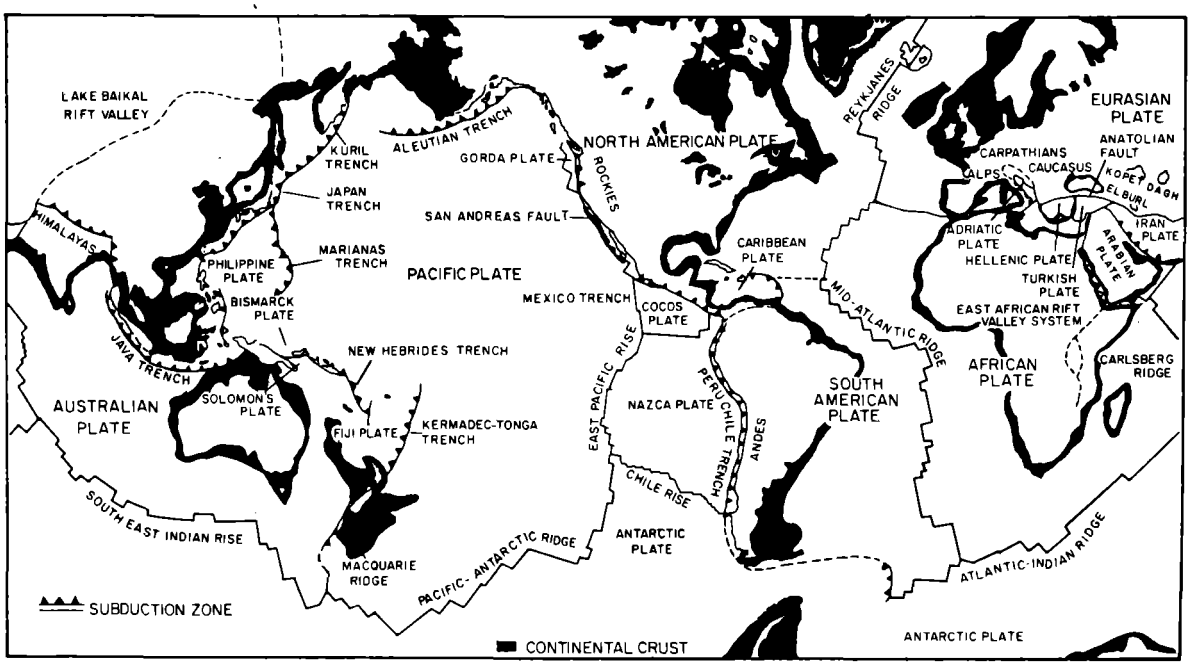
FIGURE 2. CONTROLLED ECOSYSTEM. POLLUTION EXPERIMENT (CEPEX)

PROJECT I.2.2



(Photo: National Science Foundation)

The Earth's crust is made up of a series of tectonic plates that originate at mid-ocean ridges and sink at ocean trenches. The knowledge of their motion and the related processes will provide guidelines as to where certain resources will be found and where certain processes will occur.



(Photo: Scientific American)

FIGURE 3. MOSAIC OF TECTONIC PLATES – SECTION I.3

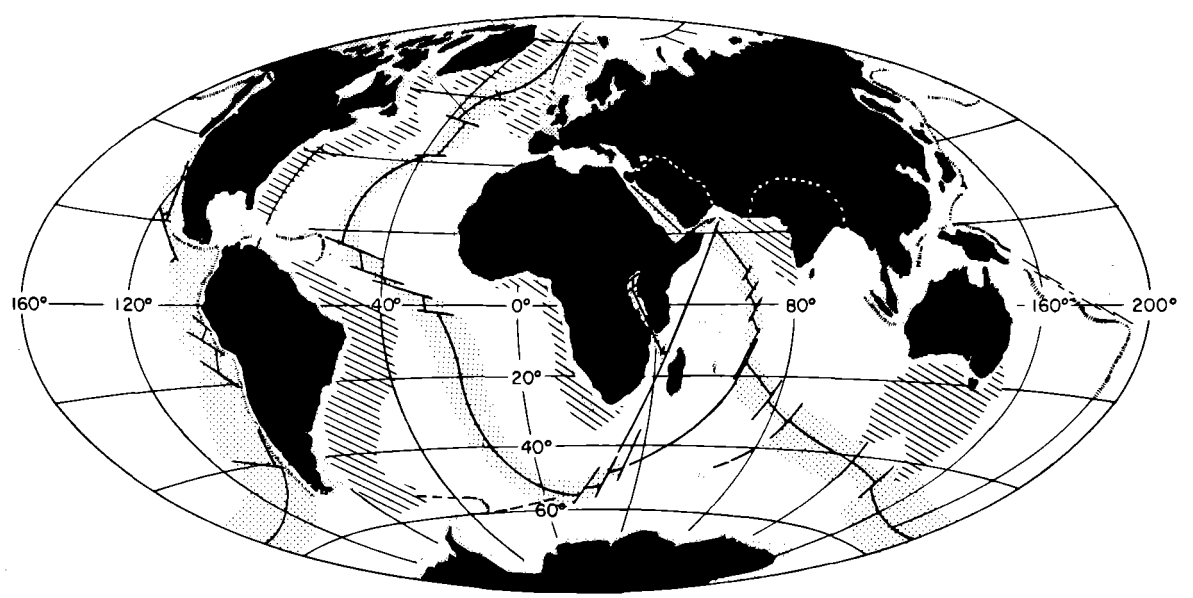
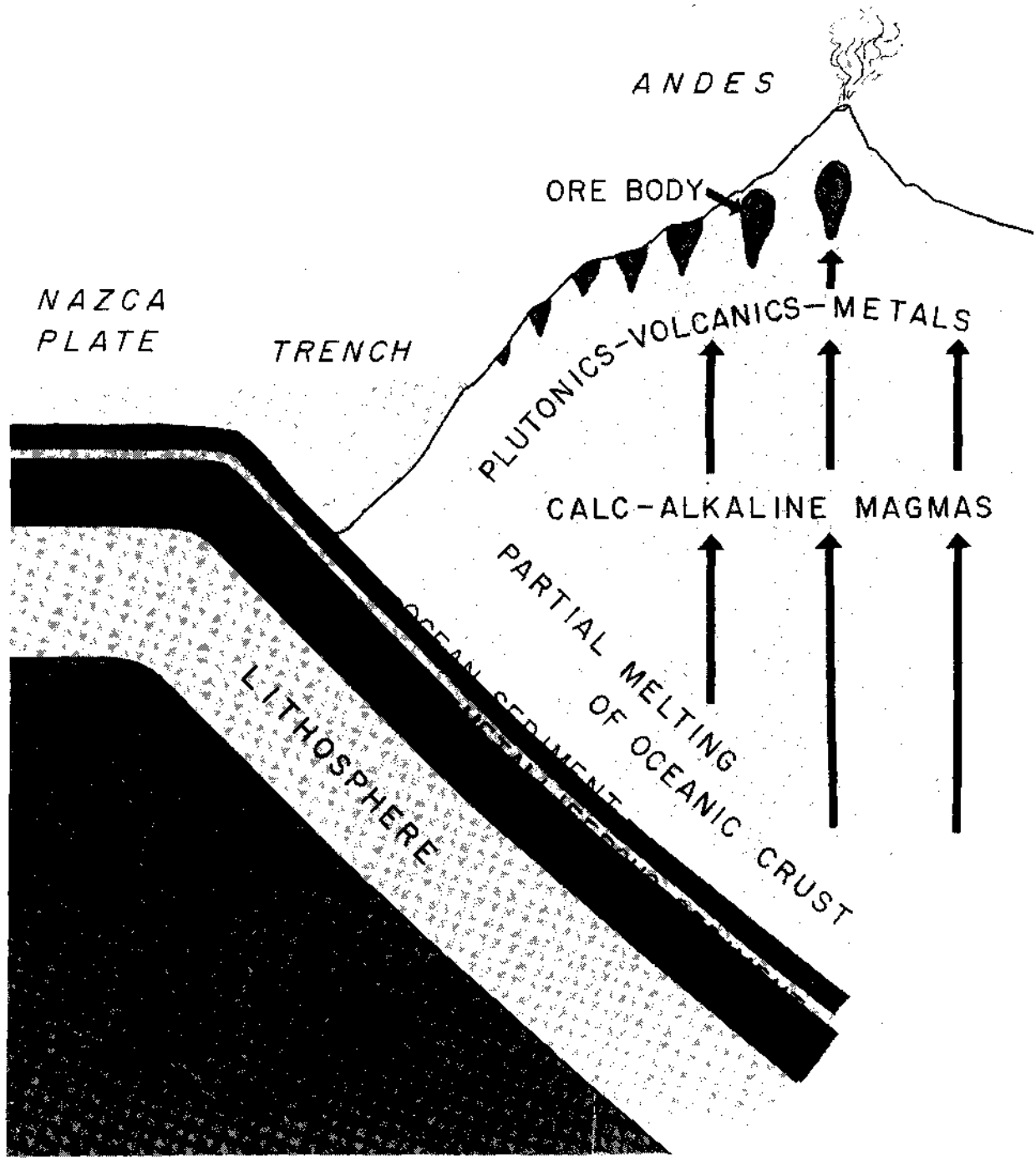


FIGURE 4. 50 M.Y. IN THE FUTURE – SECTION I.3: The Atlantic (particularly the South Atlantic) and the Indian Ocean continue to grow at the expense of the Pacific. Australia drifts northward and begins rubbing against the Eurasian plate. The eastern portion of Africa is split off, while its northward drift closes the Bay of Biscay and virtually collapses the Mediterranean. New land area is created in the Caribbean by compressional uplift. Baja California and a sliver of California west of the San Andreas fault are severed from North America and begin drifting to be northwest... (Diagram and caption courtesy of Scientific American.)

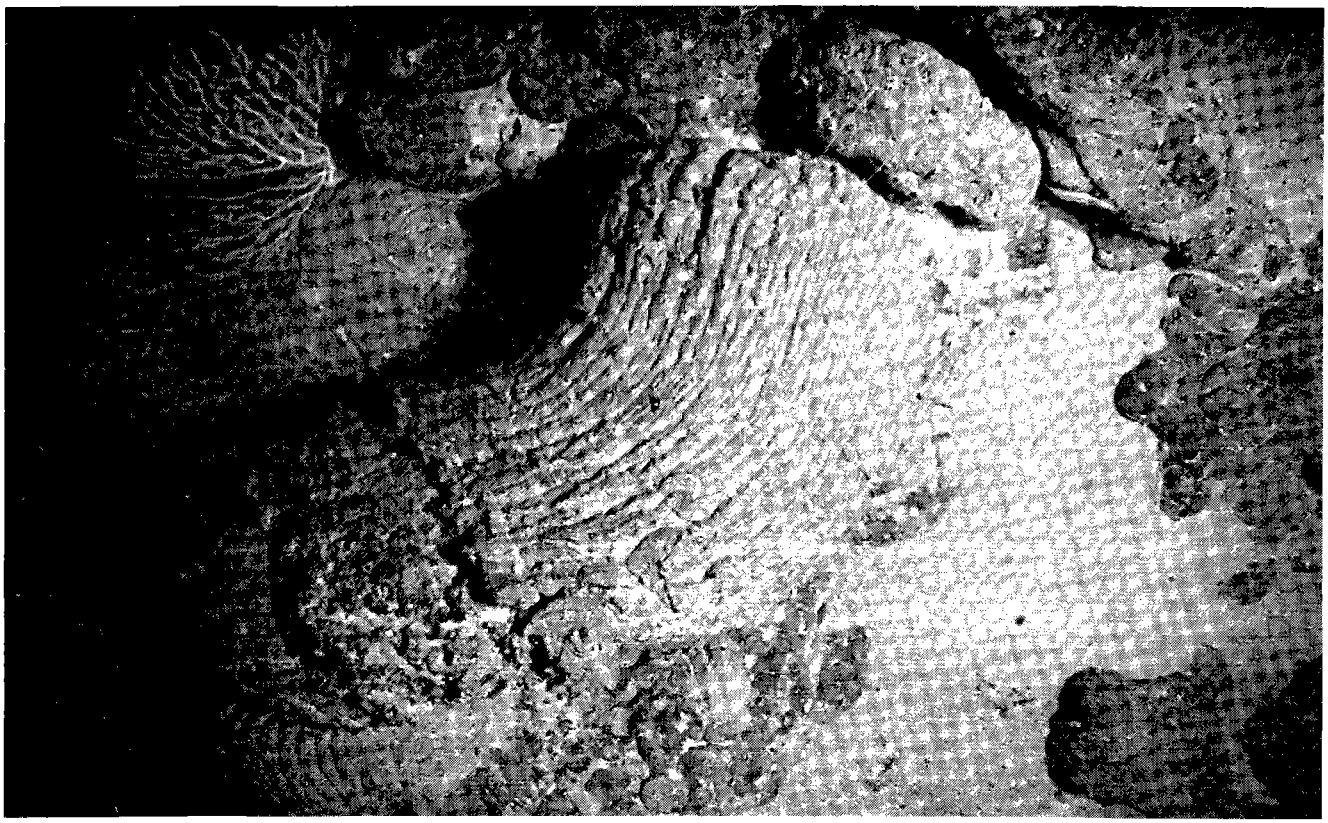
FIGURE 5 – PROJECT I.3.4



(Photo: Woods Hole Oceanographic Institution)

Model of ore-forming processes at a subduction zone. Melting occurs within the upper oceanic crustal plate where any subducted sediment and related melting concentrations are readily mobilized and transported by seawater, both in the sediments and the rocks.

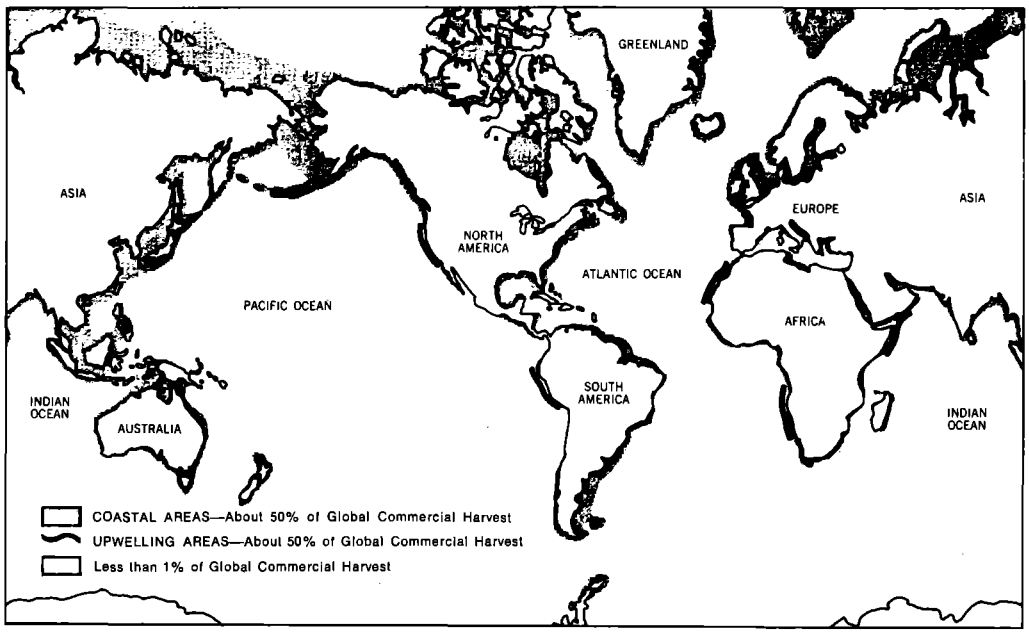
FIGURE 6. MID-ATLANTIC RIDGE (FAMOUS) – PROJECT I.3.6



(Photo Woods Hole Oceanographic Institution)

Tubular or "toothpaste" lava photographed at 1050 fathoms in axial valley of the Mid-Atlantic Ridge. The tube, roughly one foot in diameter, is probably less than 10,000 years old. The camera is looking directly down at the tube, which has erupted from the sea floor to a height of 2-3 feet and then broken off from its stump at the lower right (Atlantis II, Cruise 77).

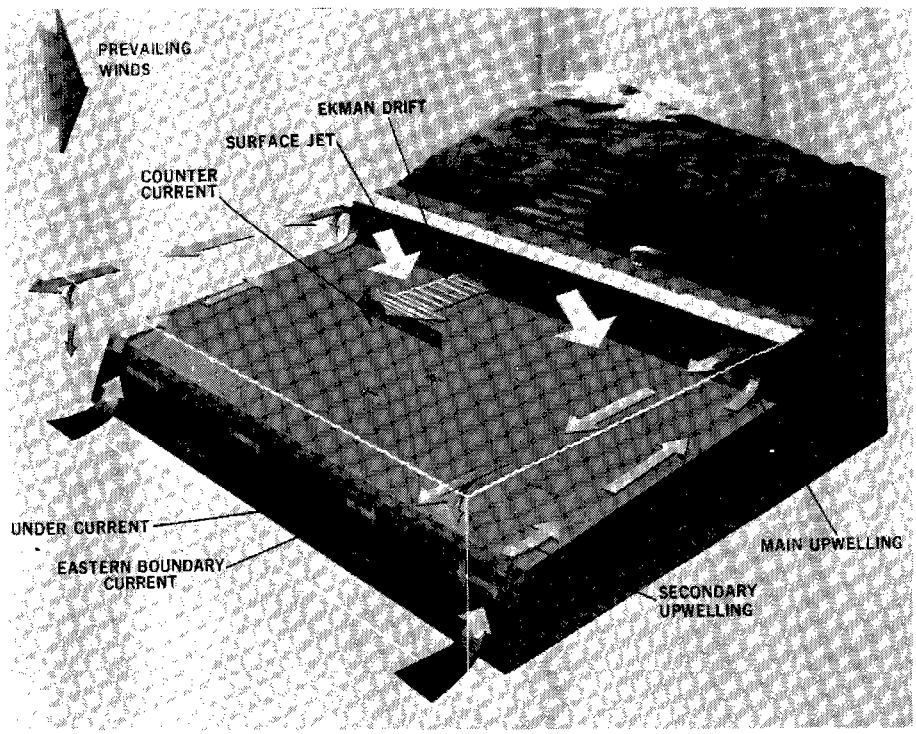
FIGURE 7. DISTRIBUTION OF THE WORLD'S FISHERIES.



(Photo: National Science Foundation)

The richness and importance of the global coastal areas are highlighted by a small number of intensely productive areas caused by upwelling.

FIGURE 8. COASTAL UPWELLING AND ITS IMPLICATION TO FISHERIES PROJECT I.4.1



(Photo: National Science Foundation)

TABLE 3

Countries participating in co-operative investigations of the Commission

COUNTRY	PROJECT				
	CICAR	CSK	Southern Ocean	CIM	CINECA
Argentina			x		
Australia			x		
Austria				x	
Belgium			x	x	
Brazil	x		x		
Chile			x		
China		x			
Colombia	x				
Cuba	x				
Egypt				x	
France	x	x	x	x	x
Germany (Federal Republic of)	x			x	x
Guatemala	x				
Israel				x	
Italy				x	
Jamaica	x				
Japan		x	x		
Korea (Republic of)		x			x
Lebanon				x	
Malta				x	
Mauritania					x
Mexico	x				
Monaco				x	
Morocco				x	x
Netherlands	x				
New Zealand			x		
Norway			x		x
Panama	x				
Philippines		x			
Poland					x
Portugal					x

COUNTRY	PROJECT				
	CICAR	CSK	Southern Ocean	CIM	CINECA
Romania				x	
Senegal					x
South Africa			x		
Spain				x	x
Switzerland				x	
Thailand		x			
Trinidad/Tobago	x				
Tunisia				x	
USSR	x	x	x	x	x
United Kingdom	x	x	x		x
United States of America	x		x		x
Venezuela	x				
Viet-Nam (Republic of)		x			

ANNEX I

RESOLUTION VII-7

INTERNATIONAL DECADE OF OCEAN EXPLORATION (IDOE)

The Intergovernmental Oceanographic Commission,

Recognizing the International Decade of Ocean Exploration as the acceleration phase and essential initial element of the Long-term and Expanded Programme of Oceanic exploration and Research,

Noting Resolution 2467 (D) (XXIII) of the United Nations General Assembly welcoming the concept of an International Decade of Ocean Exploration to be undertaken within the framework of LEPOR and inviting Member States to formulate proposals for international scientific programmes and activities to be undertaken during the IDOE and to transmit those proposals to the Commission and to embark on such activities as soon as practicable,

Desiring to accelerate LEPOR by the initiation of the IDOE on an international scale,

Proposes that the IDOE shall last from 1971 through 1980 and consist of appropriate national oceanographic activities of significant size and scope in which the participation of scientists from other nations is actively sought and achieved in the early stages of the programme,

Invites Member States to inform the Secretary of major projects which they wish to be considered as components of the IDOE,

Instructs the Secretary to bring such proposals promptly to the Executive Council so that they can be efficiently processed and co-ordinated.

RESOLUTION VII-8

PROGRAMMES OF MAJOR IMPORTANCE IN LEPOR

The Intergovernmental Oceanographic Commission,

Noting the existing IOC programmes either on a global or regional scale, such as IIOE, ICITA, CSK, CINECA, Southern Ocean, Systematic observations in the North Atlantic,

Considering the scientific significance of certain new programmes suggested in the Report of the first session of GELTSPAP and which are of major importance for LEPOR, the interest that many Member States will have in them, the possibilities that they provide for the participation of many Member States, especially including developing countries, and taking account of regional interest,

Recognizing that an important feature of most of these programmes is the extent to which essential work on them can be done at national level with results being used in regional and global contexts, while other aspects of them require regional and co-operative research,

Adopts the following new programmes (list in the order in which they appear in the GELTSPAP Report):

1. Upwelling, including the ocean-atmosphere interaction (paragraphs 18-21);

2. Survey of Living Resources (paragraphs 26 and 34);

3. Coastal Ecology and Mariculture (paragraphs 29 and 35);

4. Global Investigation of Pollution in the Marine Environment (paragraph 45);

5. Morphological Charting of the Sea Floor (paragraph 63);

6. Systematic Geological and Geophysical Surveys of Continental Margins, including the Marginal Seas (paragraphs 64-65);

7. River discharge of sediments and along-shore transport (paragraph 66);

8. Physical research related to IGOSS (paragraph 93).

RESOLUTION VIII-1

INTERNATIONAL DECADE OF OCEAN EXPLORATION (IDOE)

The Intergovernmental Oceanographic Commission,

Recalling resolutions VII-7 and VII-8 of the IOC seventh session, which respectively recognized the International Decade of Ocean Exploration (IDOE) as the acceleration phase of the Long-term and Expanded Programme of Oceanic exploration and Research (LEPOR) and adopted eight major programme areas for implementation,

Noting that resolution EC-II. 10 of the IOC Executive Council second session endorsed a number of major projects which Member States wished to be considered as components of IDOE and instructed the IOC Secretary to ensure that all Member States are kept abreast of scientific activities conducted under these programmes,

Desiring to achieve effectively implementation of the IDOE,

Having received from the Secretary, in response to resolution VII-7, a current compilation of IDOE major projects submitted by Member States,

Endorses the projects listed in document IOC-VIII. 11 Compilation of Component Programmes of the International Decade of Ocean Exploration (IDOE);

Urges Member States which have not yet submitted their projects to do so at an early date;

Calls upon the Member States involved to facilitate whenever possible participation by scientists and institutions from developing countries in these programmes;

Expresses its readiness, within budgetary and staff limitations, to develop appropriate IDOE co-ordinating mechanisms, if requested by Member States to implement such projects; and

Instructs the Secretary to adopt the necessary means to facilitate such co-ordination;

Directs the Secretary to arrange, on the basis of document IOC-VIII. 11 and other information, including discussion in Session Committee II - Ocean Sciences, of the eighth session of the Assembly, for the publication of a document in the IOC Technical Series which will:

(a) set forth the basis of LEPOR, of IDOE and of the Commission's Co-operative Investigations, and the criteria for inclusion of programmes therein;

(b) explain the arrangements for certification and for the deposition and exchange of data and reports resulting from the project;

(c) give the latest available information on the current status of the component programmes of LEPOR, of the IDOE and of the Commission's Co-operative Investigations;

Requests the Secretary to ensure that the publication is updated periodically.

ANNEX II

LIST OF ABBREVIATIONS

ACMRR (of FAO)	Advisory Committee on Marine Resources Research
ACOMR (of WMO)	Advisory Committee on Oceanic Meteorological Research
BATHY	Bathythermograph (instrument and code)
CCOP (of ECAFE)	Committee for Co-ordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas
CCOP/SOPAC (of ECAFE)	Committee for Co-ordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas
CEPEX	Controlled Ecosystem Pollution Experiment
CICAR	Co-operative Investigations of the Caribbean and Adjacent Regions
CIM	Co-operative Investigations in the Mediterranean
CINECA	Co-operative Investigations of the Northern Part of the Eastern Central Atlantic
CLIMAP	Climate: long-range investigation, mapping and prediction study
CMG (of IUGS)	Commission for Marine Geology
CNES	Centre National d'Etudes Spatiales de France
CNEXO	Centre National pour l'Exploitation des Océans (France)
CSIRO	Commonwealth Scientific and Industrial Research Organization (Australia)
CSK	Co-operative Study of the Kuroshio and Adjacent Regions
CUE	Coastal Upwelling Experiment
CUEA	Coastal Upwelling Ecosystems Analysis
DDT (TDE)	Dichlorodiphenylethane
DDE	Dichlorodiphenylethylene
DDT	Dichlorodiphenyltrichloroethane
ESCAP*	Economic and Social Commission for Asia and the Pacific
ECOR	Engineering Committee on Oceanic Resources
EOLE	French meteorological experiment with constant level balloons and satellite communication
FAMOUS	French/American Mid-Ocean Underwater Study
FAO (of United Nations)	Food and Agriculture Organization
FGGE	First GARP Global Experiment
GARP	Global Atmospheric Research Programme
GATE	GARP Atlantic Tropical Experiment
GEBCO	General Bathymetric Chart of the Oceans
GELTSPAP	Group of Experts on Long-Term Scientific Policy & Planning

* Formerly ECAFE (Economic Commission for Asia and the Far East)

GEOSECS	Geochemical Ocean Sections Study
GIPME	Global Investigation of Pollution in the Marine Environment
HIG	Hawaii Institute of Geophysics (U. S. A.)
IAEA	International Atomic Energy Agency
IAHS	International Association of Hydrological Sciences
IAMAP	International Association of Meteorology and Atmospheric Physics
IAPSO	International Association for the Physical Sciences of the Ocean
IBP	International Biological Programme
ICES	International Council for the Exploration of the Sea
ICITA	International Co-operative Investigations of the Tropical Atlantic
ICG	International Co-ordination Group
ICNAF	International Commission for Northwest Atlantic Fisheries
ICSU	International Council of Scientific Unions
IGN	Institut Géographique National (France)
IGOSS	Integrated Global Ocean Station System
IGY	International Geophysical Year
IHB	International Hydrographic Bureau
IHO	International Hydrographic Organization
IIOE	International Indian Ocean Expedition
IMCO	Inter-Governmental Maritime Consultative Organization
IOC	Intergovernmental Oceanographic Commission
IODE	IOC Working Committee on International Oceanographic Data Exchange
IOKAE	Institute of Oceanography and Fishing Research (Greece)
IOS	Institute of Oceanographic Sciences (U. K.)
ISMG	International Scientific and Management Group (GATE)
IUGS	International Union of Geological Sciences
JASIN	Joint Air-Sea Interaction Experiment
JOC	WMO/ICSU Joint Organizing Committee for GARP
JOINT	United States Project on Coastal Upwelling Ecosystem Analysis in the CINECA Region
JONSDAP	Joint North Sea Data Acquisition Project
JONSIS	Joint North Sea Information Systems
JONSWAP	Joint North Sea Wave Project
KNMI	Koninklijk Nederlands Meteorologisch Instituut (Netherlands)
LDGO	Lamont-Doherty Geological Observatory (U. S. A.)
LEPOR	Long-term and Expanded Programme of Oceanic exploration and Research
LOCATE	Type of Radiosonde
MESCAL	(United States biological cruise off Baja California, in 1972)

MODE	Mid-Ocean Dynamics Experiment
MONEX	Monsoon Experiment
NASA	National Aeronautics and Space Administrative (U. S. A.)
NEAFC	North East Atlantic Fisheries Commission
NIMBUS	United States Meteorological Satellite
NOAA	National Oceanic and Atmospheric Administration (U. S. A.)
NORPAX	North Pacific Experiment
NZOI	New Zealand Oceanographic Institute
ORSTOM	Office de la Recherche Scientifique et Technique Outre-Mer (France)
PCB	Polychlorinated biphenyls
POLYGON	USSR Oceanographic Experiment in the North East Atlantic
POOL	Pollution of the Ocean Originating on Land
RIOS	River Inputs to Ocean Systems
ROSCOP	Report of Observations/Samples Collected by Oceanographic Programmes
SCOR	Scientific Committee on Oceanic Research
SIO	Scripps Institution of Oceanography (U. S. A.)
STD	Salinity - Temperature - Depth
TDE	See DDT
TESAC	Temperature - Salinity - Current (code)
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WHOI	Woods Hole Oceanographic Institution (U. S. A.)
WMO	World Meteorological Organization
XBT	Expendable Bathythermograph

ANNEX III

COMPREHENSIVE OUTLINE OF THE SCOPE OF THE LONG-TERM AND EXPANDED PROGRAMME OF OCEANIC EXPLORATION AND RESEARCH

as approved by the Sixth Session

Unesco, Paris, 2-13 September 1969

INTRODUCTION

1. The General Assembly of the United Nations in December 1968 adopted resolution 2467 (XXIII), which contains the following request to the Intergovernmental Oceanographic Commission (Part D, Section 4 (a)):

> "4. Requests the United Nations Educational, Scientific and Cultural Organization that its Intergovernmental Oceanographic Commission:
>
> (a) Intensify its activities in the scientific field, within its terms of reference and in co-operation with other interested agencies, in particular with regard to co-ordinating the scientific aspects of a long-term and expanded programme of world-wide exploration of the oceans and their resources of which the International Decade of Ocean Exploration will be an important element, including international agency programmes, and expanded international exchange of data from national programmes, and international efforts to strengthen the research capabilities of all interested nations with particular regard to the needs of the developing countries;"

This programme will be referred to further in this document as the expanded programme.

2. A special working group of the IOC on the long-term and expanded programme, established by the IOC Bureau and Consultative Council at its 9th Meeting, met in Paris, 16-21 June 1969, and prepared a "Draft comprehensive outline of the scope of the long-term and expanded programme of oceanic exploration and research" (SC/IOC-VI/7 Appendix). The working group used as the basis of its work the report "Global ocean research" prepared by a joint working party of the Advisory Committee on Marine Resources Research of the FAO, the Scientific Committee on Oceanic Research of ICSU, and the AGOR of the World Meteorological Organization, and more than 30 national proposals.

3. The present "Comprehensive outline of the scope of the expanded programme" as adapted from the draft outline reflects comments received on the draft outline from Member States, the United Nations Committee on Peaceful Uses of the Sea-Bed and Ocean Floor Beyond the Limits of National Jurisdiction, and other interested international organizations. The report "Global ocean research" is attached as Appendix 1.(1) In adopting this outline, the sixth session of the Intergovernmental Oceanographic Commission recognized that, by the very nature of marine science, the outline cannot be exhaustive and that other programmes of equal merit may well arise during the course of the expanded programme.

4. The purpose of the expanded programme is recognized to be as follows:

> "to increase knowledge of the ocean, its contents and the contents of its sub-soil, and its interfaces with the land, the atmosphere, and the ocean floor and to improve understanding of processes operating in or affecting the marine environment, with the goal of enhanced utilization of the ocean and its resources for the benefit of mankind".

In achieving this purpose, the Commission should take into account the needs and interests of developing countries.

(1) Not included in this Annex to the Summary Report as it has already been widely distributed and also appears in IOC Technical Series No. 7.

5. The proposals for the expanded programme contained in the draft outline cover also the International Decade of Ocean Exploration as an important element of this programme as defined by United Nations resolution 2467 D (XXIII). In order to understand better the relationship between these programmes, the working group recommended that the implementation of the expanded programme be started as soon as feasible after its adoption, preferably in 1970, and that the International Decade of Ocean Exploration be recognized as the acceleration phase of the expanded programme.

6. Various steps are under way to broaden the base of the IOC and to strengthen the co-operation between IOC and other interested bodies of the United Nations system. The IOC sixth session decided that the broadened IOC, in close co-operation with other interested bodies, accept the proposed responsibilities to (1) develop the scientific content and form of the expanded programme, and (2) to co-ordinate its implementation.

7. During the early years of the expanded programme major emphasis must be given to detailed planning. Although it is not now possible to identify all the on-going and scheduled activities relevant to the purposes of the expanded programme, there are certain activities that can clearly contribute to its initial phases, such as:

(a) Co-operative investigations, such as that under way in the Kuroshio and adjacent regions, and those planned or projected in the Caribbean, Mediterranean, Southern Ocean and North Atlantic.

(b) Those elements of IGOSS that relate to the research on the scales and frequencies of oceanic phenomena, investigations of ocean-atmosphere interaction directed towards understanding of the ocean, and studies of variability required for the design of the eventual operating system.

(c) Those elements of World Weather Watch and the Global Atmospheric Research Programme that concern oceanic phenomena and the influence on them of atmospheric conditions and processes.

(d) Those elements of the regular and field programmes of international agencies dealing with scientific aspects of marine resources and their environment.

8. It was recognized that a number of co-operative investigations are being carried out by international organizations outside the United Nations system, such as ICES and ICNAF. Such investigations may be highly relevant to the purpose of the expanded programme and ways must be found to facilitate their co-ordination with programmes being implemented within the United Nations system. For example, an IOC/ICES/ICNAF Co-ordinating Group for the North Atlantic has already been established with this end in view.

It was also noted that a number of supporting activities within the United Nations system and by other organizations will contribute importantly to implementation of the expanded programme. These include activities related to data and information management; training, education and manpower; instrumentation and methods; technology and supporting facilities and services; assistance to developing countries; legal aspects of scientific investigation. Comment on these matters is given later in this document.

9. During the development of the expanded programme, new co-operative projects will be presented for possible inclusion. In the view of the IOC sixth session the following criteria could be applied as appropriate in the selection of co-operative projects:

1. Member States are willing to participate actively in the project.

2. The project can be carried out most effectively through international co-operative action.

3. The project has a sound scientific basis and is well designed to yield significant new information.

4. The project will provide information and understanding that will contribute to the goal of enhanced utilization of the ocean and its resources.

5. The project will help meet the needs of developing countries.

A project that satisfied all these criteria would be an extremely strong candidate for inclusion in the expanded programme. It will not be necessary in each case that all criteria be met, but the willingness of Member States to participate is clearly essential.

PART I

SCIENTIFIC CONTENT OF THE EXPANDED PROGRAMME

1. PROBLEMS OF OCEAN-ATMOSPHERE INTERACTION, OCEAN CIRCULATION, VARIABILITY, AND TSUNAMIS

Introduction

The ocean and the atmosphere are two parts of a vast thermal engine with a common source of energy, solar radiation. The two parts interact strongly and continuously with each other. Progress in many problems in oceanography and in meteorology is largely dependent upon close collaboration between oceanographers and meteorologists. For example, the transfer of heat, water and momentum between the earth's surface (over 70 per cent of the area being water) and the overlying atmosphere constitutes one of the major problems concerning the structure and behaviour of the ocean and the atmosphere.

This transfer has as components motions so small that they cannot be resolved by any foreseeable observation network; nor could they be analysed adequately by any foreseeable computer. Their magnitudes and properties must be expressed in terms of "average" values of atmospheric and oceanic parameters. In various ocean-atmosphere projects considerable effort is being applied to the measurement at isolated points and using elaborate instruments and equipment, of the fluxes of heat, water and momentum. Methods are also being sought for expressing these fluxes in terms of the larger scale parameters.

In research into problems of such complexity, simplification is generally an essential preliminary if progress is to be achieved. A major aim must be the development of an ocean-atmosphere model of global application. But first the feasibility of such models must be assessed and for this purpose it is best to choose problems which permit simplifying assumptions in order to develop and test the quantitative and predictive worth of comparatively simple numerical techniques. Such steps are valuable not only for theoretical work. Whenever possible they should be tried as an essential part of the planning of any large scale observational programme.

The development of ocean-atmosphere models must be a joint effort on the part of meteorologists and oceanographers. The weather systems which are generated and maintained by the fluxes of heat, water and momentum will affect the temperature structure of the ocean through the generation of turbulence and of currents in the sea. In turn, the air-sea interaction processes will be affected by changes in the temperature structure of the ocean. In some way or other all these changes must be taken into account in numerical models. Thus the air-sea interface is of importance to both meteorologist and oceanographer and must be considered in studies of any large scale aspects of the ocean or the atmosphere.

The horizontal and vertical movements of ocean waters are among the most striking manifestations of dynamic and heat interaction in the ocean and a most important link in the chain of its internal energy and matter exchange. Oceanic circulation serves to redistribute the heat and substance of the ocean between the various latitudes and depths and is thus a source of enormous reserves of heat. Similarly the large amount of heat released by the ocean to the atmosphere at high latitudes through freezing of the uppermost layers of the ocean, and the modified effect of the ice cover on the weather in these regions, are of great importance in the overall heat exchange balance.

Of particular importance is the investigation of frontal processes and frontal zones in the ocean, and of the associated upwelling and sinking phenomena. The frontal zones are also of interest because of the associated biological activity.

Study of many aspects of the variability of the oceanic environment depends on the results of research on ocean water circulation. The variability of the environment in time and space has a bearing on the dynamics of marine ecosystems. Knowledge of the short-term and long-term variability of physical characteristics, are important for forecasting weather conditions. Investigation of the internal waves and tides in the open ocean is also important since in a number of areas they determine the dynamics and intermingling of the waters.

The tsunami is among the most disastrous of ocean phenomena. Originating in areas where underwater earthquakes and volcanic eruptions occur and spreading over the ocean for many thousands of miles, this sea wave or series of waves ("tsunami"), marked by low-frequency oscillation, possesses enormous energy. In the open ocean the tsunami is barely noticeable; but at the coastline its height may reach 35 metres under certain conditions. The tsunami occurs most frequently in the Pacific Ocean, but is also to be observed in other oceans.

A. Ocean-atmosphere interaction

Project 1.1 - Small-scale ocean-atmosphere interaction studies

Programme outline - The programme includes investigation of the adjacent boundary layers of the ocean and the atmosphere and of their structure in relation to waves, heat, water and chemical elements exchange, including a closer study of oceanic turbulence and turbulent exchange of momentum and heat at all pertinent scales, the exchange of chemical elements such as halogens and carbon dioxide as affected by turbulence and breaking waves, as well as departures from geostrophic approximation at different levels within those layers. Small-scale vertical gradient measurements with modern methods in both the ocean and the atmosphere should be made and examined in relation to larger scale distributions and phenomena. Wind effect on the sea surface should be studied further. Multiship operations of various patterns, using arrays of buoys and masts, would be needed for these purposes. Upper-ocean data should be expeditiously exchanged. These investigations should be conducted in different regions. They are of particular interest in the equatorial and tropical regions where more stable winds and currents predominate.

In addition, instrumental measurements of wind waves will be organized to obtain wave spectra which represent the kind of data which has multiple uses, e. g. in ship-designing. Such data should include two dimensional wave spectra and statistical information on wave steepness. Consideration should also be given to the possibility of analysing in spectral form wave data from trawlers and also to the possibility of improving techniques of visual observations including those made on breaking waves and cross seas.

Project 1.2 - Investigations of the heat and water exchange through the ocean-atmosphere interface (medium scale)

Programme outline - The enormous accumulation of heat in the surface waters in low latitudes and its effect upon the formation of tropical storms should be a subject of special interest. Otherwise, detailed studies of the heat exchange through the surface are important in all areas for estimating the total heat budget of the ocean. Studies of thermo-haline structure would permit correlation between the heat exchange through the ocean surface and the peculiarity of the deeper water circulation.

Project 1.3 - Larger-scale ocean-atmosphere interaction studies from storm-surges to the coupling of quasi-permanent baric centres of the atmosphere with the major features of the oceanic circulation

Programme outline - Studies of storm-surges and development of prediction methods will require improved sea-level measurements (cf. also Project 1.16) and the establishment of files of compatible atmospheric and oceanic data. Such files covering entire oceans will permit important correlations between major dynamical features of the atmosphere and the ocean. The development of IGOSS (cf. Section 5) will contribute greatly to these large-scale studies.

Project 1.4 - Special study of scales and frequencies involved in ocean-atmosphere interaction

Programme outline - Numerous studies require a monitoring network. No network can be effectively designed without knowledge of the scales and frequencies of fluctuations of environmental characteristics, including wind and current velocity. Pilot studies are underway in some fields and should be extended to others. The same studies will contribute to the investigation of oceanic variability as such (cf. Project 1.14) and will allow determination of the required accuracy of measurements in the ocean as related to the scales of phenomena.

B. Water circulation and distribution of properties in the ocean

Ocean circulation redistributes heat and other properties between different latitudes and depths. Upwellings, which bring rich reserves of nutrients to the surface of the ocean, are parts of the general circulation which affect the biological productivity in a most radical way.

Little can be studied in the ocean without thorough knowledge of the circulation. So far, the general circulation of the world ocean is understood in a gross way. Knowledge of details is very uneven. Not only the major currents, but the less clearly defined and the less permanent features, need to be examined further.

Among the various projects suggested the most important are the following:

Project 1.5 - Studies of mixing, and diffusion, both vertical and horizontal, at all pertinent scales, and of the processes which cause them such as surface effects, turbulence, internal waves, convection, overturning etc. The degree or intensity of overturning in connexion with winter cooling should be studied thoroughly

Programme outline - Special observations and measurements will be required, of the type described under Projects 1.1 and 1.4. The orientation of the programme and the methods of data treatment would be different. The results obtained will be applicable in Projects 1.7 to 1.12.

Project 1.6 - Detailed investigations of the zonal flows recently discovered in middle and low latitudes

Programme outline - Arrays of buoys with current meters and sections repeated synchronously by several ships would constitute the backbone of such investigations. Important planning and coordination experience can be drawn from the EQUALANT expeditions conducted by the IOC during 1963-1964.

Project 1.7 - Investigation of the processes converting surface water into intermediate, deep and bottom water, of the rates of such conversion, and of the subsequent return path of these waters to the surface, including further transformation involved and particularly problems of underflows beneath eastern and western boundary currents

Programme outline - These investigations would be planned and conducted in accordance with the methodology developed for each specific case. Use of modern instrumentation, such as STDs or continuous chemical analysers, may be particularly desirable. In some areas research submarines may provide a means of conducting observations and measurements under ice.

Project 1.8 - Studies of budgets of water, heat, salt, and nutrients in various ocean basins

Programme outline - Depending upon the size of each specific basin and the character of the water exchange with neighbouring basins (through straits, passages, shallow areas, etc.) detailed surveys of physical and chemical properties would be designed to last shorter or longer periods of time. In certain cases the use of fast or continuously recording devices would be strongly recommended (e.g. STDs, expendable BTs, underwater cables, or buoys with continuously recording sensors).

Project 1.9 - Studies of coastal and oceanic upwellings and their relation to the general ocean circulation, large-scale ocean-atmosphere interaction, and local atmosphere and oceanic conditions

Programme outline - Studies of the immediate mechanisms of upwelling could be correlated with large-scale oceanic and atmospheric phenomena, i.e. zonal sub-tropical flows in the ocean and sub-tropical anticyclones. In addition, it seems probable that variations in sea surface temperature produced by changes in upwelling have important effects on the weather conditions in the littoral areas. Studies of such effects would be a valuable by-product of research on the upwelling process. There is also considerable geological interest in the sedimentology of such regions of high organic productivity and of the accumulation of organic matter and phosphorites. Great benefit to fisheries would result from an improved understanding, leading to prediction techniques, of the intensity and fluctuations of upwellings. Theoretical models can be developed to arrive eventually at prediction methods.

Project 1.10 - Investigation of frontal systems and convergence zones, their formation and variation, and their effect on living organisms

Programme outline - The same approach as in 1.9 should be followed and studies conducted in close correlation with the studies of large-scale atmospheric phenomena through detailed field surveys and theoretical models. Permanent or semi-permanent monitoring systems would be instrumental in following time variations.

Project 1.11 - Investigation of the vertical structure of oceanic currents

Programme outline - Velocity structure in some of the major oceanic currents has been examined but much still remains to be learned. The structure of slower and less regular currents has received less attention and should be examined, as should particulars of deep flows near the bottom, including the velocity structure between the bottom frictional layer.

Project 1.12 - Investigation of the chemical composition of sea water and use of chemical knowledge for studying the ocean circulation

Programme outline - Further studies on the composition of sea water and its variability in time and in space may reveal additional information on the formation, mixing, circulation and "residence time" of water masses at the surface or in the depths of the ocean. Knowledge of distribution of nutrient salts is indispensable for biological studies. There is still much to be learned from studies of salinity, dissolved oxygen, carbon dioxide, phosphorus, nitrogen, and silicone. More recently, deuterium, tritium, oxygen isotopes, and Carbon 14, as well as other radio nucleides and some trace elements, less affected by biological processes, have become recognized as having prospective rôles as tracers of circulation.

Project 1.13 - Studies of special problems of coastlines and estuaries: runoff, exchange with land, sediment transport, wave erosion, etc.

Programme outline - Coastal interactions with the marine environment are of growing concern to many nations since they have both direct and indirect effects on many coastal residents. These studies, because of their nature, will require complex multidisciplinary teams of scientists, including physicists, chemists, sedimentologists, coastal engineers and sanitary engineers. The results of these studies will have practical application in coastal protection, harbour construction, pollution prevention, etc.

Project 1.14 - Prediction of physical processes in the sea by means of hydrodynamic-numerical methods

Programme outline - These studies are aimed at the determination of currents, water levels, mass transports, density distribution in ocean basins or whole oceans under the influence of external and internal forces. Sufficient computer capacity and information on initial or marginal data are needed as well as the possibility of verification by a suitable network of ocean stations.

C. Variability, tsunami and tides

Project 1.15 - Investigation of variability of environmental characteristics in time and in space at all scales

Programme outline - It was traditional in the past to think of the ocean as being in a quasi-steady stage, considering even the seasonal variations as minor and limited to surface water. Now we find that we cannot progress in our study of the ocean without taking into account the variations which take place in it as a result of static and dynamic instabilities and a generally transient state of oceanic processes. Understanding of short-period and long-period variability of the oceanic characteristics, particularly the temperature, is important for estimating and forecasting thermal conditions of the ocean. Large-scale variations of oceanic conditions (particularly thermal) lead often to disastrous effects on living organisms, to their mass mortality or migration. The well-known El Nino near the Peruvian coast can serve as an example of such natural disasters. The total area of sea-ice cover which radically reduces the heat exchange through the ocean atmosphere interface is subject to large-scale variation from year to year. The following topics may be chosen when planning research in variability:

(a) Large-scale and long-term changes in surface conditions that take place in such areas as the North Pacific and the North Atlantic require more detailed and longer series of observations in order to be understood.

(b) Significant seasonal changes, such as those occurring under the influence of monsoons, as well as less-pronounced seasonal changes in other regions, should be studied.

(c) Small-scale and short-term variations, such as internal waves, should be investigated.

(d) Seasonal and annual changes of sea-ice cover should be monitored.

Project 1.16 - Further studies of tsunami

Programme outline - A different kind of variability is involved in natural disasters which occur as a result of underwater earthquakes. The latter produce a wave or a series of waves travelling great distances and producing rapid changes of sea level which in turn result in floods and destruction. This phenomenon is called tsunami. The disastrous effects of tsunamis on many coastal areas of the world have directed the attention of many people to the study of this phenomenon. The International Tsunami Warning System was established in the Pacific Ocean recently with the assistance of IOC. Further studies of the dynamics of the formation and propagation of tsunami waves are necessary. International exchange of all tsunami data is desirable.

Project 1.17 - Further expansion and improvement of the global tide station network and its extension into the open ocean

Programme outline - More sea-level recordings over longer periods of time and in many additional localities are needed in order to improve tidal prediction and tsunami warnings (cf. also Project 1.15). International co-operation can be instrumental in extending the global network of the tide gauges into the open ocean where recordings are particularly needed, through co-operative development, production and maintenance of deep sea tide gauges to be placed on the ocean floor.

2. LIVING RESOURCES AND THEIR RELATIONS WITH THE MARINE ENVIRONMENT

The scientific problems

Life probably originated in the ocean. Study of the immense variety of species now living in it throws light on the evolution of life on earth and its constantly changing composition. Investigation of the complex web of interrelations between these marine organisms, and between them and the medium in which they live, is a major part of ecological research. Through such research man hopes to understand, to control, and to turn to his own advantage, the general biological processes which give the face of Earth its special character.

Probably man's oldest, and certainly still his most compelling, concern with marine life is, however, as a resource of protein-rich food and food supplements for himself and his domestic animals and also for sport and as providing useful or attractive materials and drugs. He now extracts nearly 60 million tons of such products annually. Each year the food harvest is increased, as is the variety of products. Through the application of science and technology, and sufficient and wise investment, the harvest could be doubled, perhaps quadrupled, in the next few decades. This growth will be limited by the productive capacity of the sea for organisms of the kinds presently harvested. If uses can be found for the even more abundant, but smaller, animals and plants, and means devised for gathering and processing such "unconventional resources" efficiently and cheaply, the useful harvest could be increased many-fold, though by precisely how much more we do not yet know.

Future expansion of fisheries is, however, beset with economic, legal and technical problems, the solution of which will require appreciation and understanding of the population dynamics of the living resources, of their relations with the environment, and of the nature and behaviour of the organisms as individuals and as groups. Catches of many species tend to be highly variable and as yet largely unpredictable. The numbers and movements of young, and of animals of catchable size, are deeply influenced by large and small-scale features of the ocean circulation; these influences must be understood if reliable forecasting systems are to be developed and catching

operations made more efficient and sure. To find, aggregate and catch the animals we must understand their behavioural characteristics, and marry biology with engineering for the invention of better methods. Fishing itself affects greatly the size and composition of stocks; management of fisheries for sustained yields requires understanding of the dynamics of the exploited stocks and of the population of organisms which nourish or compete with them. To utilize them more fully we need to know more about their biochemistry.

With the above considerations in mind, projects are outlined dealing with the environmental relationships and assessment of the living resources. The lesser known-resources, particularly, would be mapped and measured, and research expanded on the dynamic processes in the ocean involved in the fixation, transfer, concentration and dispersion of organic matter and energy, and which thus determine the degree and nature of its biological productivity (Projects 1-5).

With one exception, this document mentions specific ocean areas only as illustrative examples. The Antarctic area is unique in that it contains the largest known unused resources, harvesting of which will require new methods of fishing and processing, as well as oceanographic studies to assist in locating concentrations, and weather and ocean forecasts for safety and efficiency of operation in a harsh environment far distant from centres of consumption. For such reasons the study of Antarctic seas is given special attention in the expanded programme (Project 6).

Changes in the marine ecosystem, and geographic exchanges, have special significance. Some of these originate in natural phenomena and others in human activities such as canal digging, dam building and shipping, as well as fishing and waste disposal (considered in another section of this document). More deliberately, man is becoming interested in manipulating the ecosystem to improve it from his point of view, but lasting success in such enterprises as transplantations and mariculture can spring only from scientific studies in depth to complement pilot experiments. Some biological communities need protection from change so that their study can provide a relatively stable basis (Projects 7-9).

Uncertainty as to the identity of the animals and plants in the ocean impedes progress in ecological research and can confuse predictions. Only a fraction of these is yet adequately described and classified; the status even of some otherwise quite well-known forms remains in doubt. Taxonomy, which has fallen into relative obscurity, must be revived and supported adequately (Project 10).

Equally important is the need for improved techniques of collecting and observing marine life. To a considerable extent this can be achieved by applying technology developed for other purposes. But new techniques must be developed especially for biological and ecological research. The biologist must not only be able to go to sea, but to go down into the sea and have adequate instruments for sampling all organisms in, and measuring all parameters of, his object of study. In Project 12 are set out suggestions for some priorities in this respect.

A large general increase is needed in the scale of biological and related physical measurements in the world ocean. Greatest advantage must therefore be taken of existing national laboratories, "ships of opportunity", island observatories, buoys, platforms established for other purposes, aircraft, artificial satellites, submersibles, underwater habitats and other new devices. At the same time a varied range of experimental work, at sea and ashore, will need to be conducted, and full advantage taken of modern data processing and analysis techniques in the construction and testing of mathematical models of the natural systems being studied.

Project and programme outlines

Project 2.1 - Fill gaps in knowledge of distribution in time and space and of abundance of primary and secondary carnivores, and in particular estimate biomass, sizes and availability of exploitable animals and their potential yields in several lesser known areas of potential interest, particularly some of the principal upwelling areas and the continental slopes.

Programme outline - Conduct systematic exploratory surveys in selected regions to determine the presence and concentration of animals of fishable size. Work should be concentrated on the principal upwelling areas and some of the continental slopes which appear to be highly productive yet remain little known.

Project 2.2 - Determine the abundance of organisms of each size, within each trophic level in the ecosystem, and evaluate the flow of energy and material through the various trophic levels to the pelagic and benthic communities and study the influence of variability in the environment on those processes.

Programme outline - Investigate the production at each trophic level, and especially the composition of the diets of the animals and the size distributions of organisms and their food at each level. At the same time, determine the seasonal patterns of the ecosystem. Parallel laboratory studies are needed of the reproduction rates of the algae, generation times of herbivores and carnivores and the food intake and growth efficiencies of major consumers. In particular these should be done in one or more areas in which there is little exploitation, such as the Arabian Sea, and areas with higher degrees of exploitation such as the Gulf of Guinea, Peru Current and Gulf of Thailand. Endeavour to trace energy pathways through the benthic-detritus system to the demersal populations.

Project 2.3 - Study

(a) the global distribution and seasonal variation in primary and secondary production;

(b) those herbivores and small carnivores that are found in large and dense concentrations and thus may evenutally be harvested.

Programme outline - Measure the radiant energy available for photosynthesis and the rate of carbon fixation throughout the world ocean, at various seasons and with accompanying environmental information. Concurrently herbivore and small carnivore biomass and production should be measured.

Project 2.4 - Investigate the effects of different levels of fishing and of changes in the environment on recruitment into stocks of fish and other useful species.

Programme outline - Studies of the stock and recruitment problem, including: construction of models of processes determining year-class strength; laboratory experiments for improving these models; estimation of density-dependent mortality at sea. Studies on long-term variability have to be accompanied by environmental monitoring. Special and interacting lines of investigation include (a) the construction of models of processes which might influence year-class strength, (b) laboratory experiments concerning e. g. growth, behaviour, density and mobility of the fish larvae, and (c) estimation of density-dependent mortality at sea.

Project 2.5 - Identify and investigate the physical, including the optical characteristics of the water, and biotic factors of the environment which affect the behaviour and availability of fish and other useful marine organisms.

Programme outline - Exploit information coming from the physical, biological and chemical studies under various projects with the aim of developing time/space forecasts of occurrence of concentrations of useful organisms; and to improving efficiency of harvesting (searching, aggregating, capture). This will require the employment in the field of instruments to be developed under Project 12 (a), (c) and (d) and parallel observations and experiments on behaviour and reactions of organisms confined in tanks or enclosures.

Project 2.6 - Determine abundance, distribution and interrelations of the principal organisms of the Southern Ocean, together with their life histories, aggregation and migration characteristics, particularly as related to the environment; lay the scientific basis for efficient and rational harvesting of such organisms.

Programme outline - Conduct a co-operative survey of the living resources of the Antarctic seas and study their environment. This work will involve basic research on the distribution of the principal organisms, their life histories and their aggregation and migration characteristics, particularly as related to the environmental conditions. Consideration should be given to the planning and initiating of broadly based international efforts in support of existing interdisciplinary programmes in the fields of meteorology, hydrography, biology, geology and other sciences.

Project 2.7 - Study the impact upon ecosystems of natural and man-made faunistic and floristic exchanges between one sea area and another.

Programme outline - Establish biological collecting and sampling schemes at stations strategically located in relation to regions (a) of natural exchanges and (b) where man is affecting or may soon significantly affect the environment through engineering works, transportations or transplantation, e. g. at both ends of important straits and sea canals and off mouths of major rivers, the outflows from which are modified by dam systems.

Project 2. 8 - Study the high biological production of coastal waters, estuaries, lagoons, mangrove areas and coral reefs, particularly in view of their potential for mariculture and algal harvesting.

Programme outline - Identify on the basis of environmental characteristics and survey, potential coastal aquaculture areas on a world-wide basis and select suitable species for culture, with a view to optimum utilization and improvement of the living resources, such as fish, molluscs, crustaceans and algae. Investigation should be made of the optimum conditions for culture of these organisms.

Project 2. 9 - Study the desirability and feasibility of establishing marine reserves for protection and study of natural marine communities.

Programme outline - Examine the scientific criteria and practical problems of selecting marine areas which contain representative communities and within which human activities would be restricted to observation and research.

Project 2. 10 - It is essential that there be no uncertainty about the identity of the organisms to be exploited or investigated, and it is necessary therefore to improve capabilities for classifying, identifying and cataloguing them.

Programme outline - Take steps to encourage the pursuit of taxonomic studies which are essential as support for ecologically oriented biological projects. Encourage biologists to engage in this field and facilitate world-wide collaboration between specialists and pooling of their efforts in using both conventional and modern techniques. Extend also the network of biological sorting centres and establish regional international collections. Improve and apply rearing techniques for identification of eggs and larvae. Assist through providing adequate means for publication of taxonomic and systematic work.

Project 2. 11 - Identify those marine plants and animals which are aggregated in sufficient abundance for commercial exploitation in order to use a wider range of marine organisms as sources of a greater variety of useful products.

Programme outline - Determine for each of those species its chemical composition (with special reference to toxicological and pharmacological components), its seasonal and regional variability and its ecological determinants.

Project 2. 12 - Investigations of dissolved organic matters and detritus and the remineralization of organic substances in the water and sediment.

Programme outline - The concentration of different organic substances in the sea waters and in the sediment must be measured. The quantity of suspended detrital organic matters must be examined to evaluate its possible usefulness as a food supply for the pelagic and demersal organisms including fish. Studies of heterotrophic organisms and their metabolic activities are needed, and these studies must be carried out not only in the sea, but also in the laboratory to clarify the reactions involved in the different decomposition processes.

Project 2. 13 - Develop new or improved, and preferably standardized methods, instruments and facilities for various purposes. Such developments are required in almost every aspect of marine biology. The following may serve as examples:

Programme outline -

(a) to increase the ability of scientists to make direct observations, in all parts of the marine environment by providing guidelines in technology through formulation of the specific requirements of biologists for underwater study by using habitats and submersibles and by diving;

(b) to measure the input of organic material to the sea-bed;

(c) to detect and assess fish and other organisms. In particular devise methods for the detection and estimation of (a) flatfish, shrimps and other animals living on the sea-bed, and (b) pelagic fish and squid, and perhaps also shrimps, living over continental slopes;

(d) to observe the behaviour of individuals and groups of fishes and other organisms, including their reactions to instruments and equipment operating in the marine environment; study possible adaptation and application of new techniques and the use of large observation tanks;

(e) to improve methods of sampling and measurement of the biomass and rate of production of marine organisms by application and adaptation of the most recent methods and techniques;

(f) to improve the processing and exchange of biological data by identifying those data which can be exchanged through data centres and by developing methods for handling data which at present do not lend themselves to routine exchange.

3. MARINE POLLUTION

Nature of the problem

The world ocean is receiving in increasing amounts and variety waste substances and energy from our civilization, but it does not have an unlimited capacity to absorb them. The levels reached by some pollutants in some parts of the ocean are already a matter of deep public and scientific concern, and dangerously high levels may be imminent with respect to others. Pollution affects many of man's economic and cultural activities in the marine environment. Noxious materials can be transported by physical and biological processes over vast distance from the site of their injection into the environment. Some pollutants stay a long time in the sea water and in marine organisms before they reach the sediments or decompose. Others, instead of being dispersed, may accumulate in certain organisms, including those of economic interest to man. Some pollutants, or certain concentrations of them, have acute and quickly noticeable effects on the biota; others have delayed or sub-lethal effects which are not immediately apparent, but may nevertheless be very important in the longer run.

There is a degree of control over the injection of some pollutants into the ocean but some reach it accidentaly and others are released indiscriminately. Many pollutants reach the ocean from many sources: rivers and coasts, particularly urban and industrial effluents; the atmosphere; ships and equipment operating in the marine environment, including underwater operations. Losses or impairment of use through contamination may only be prevented by rational policies based on research and monitoring. An effective monitoring programme could also deter pollution of one ocean area as a result of activities elsewhere. All the sources of pollutants mentioned above need to be monitored and eventually, as far as possible, controlled. At the same time the complex effects of each type of pollutant require detailed investigation. This involves study of their fates in the ocean environment, the selection and investigation of marine test organisms, the development and standardization of techniques of analysis and the establishment of the relevant material budget of the ocean. In some cases, wastes may be treated or disposed of in such a way as to cause benefit rather than harm. Even general scientific benefits can come from the study of pollution; thus, certain contaminants can, in principle, be used to elucidate the routes and rates of energy flow through the ecosystem (see especially living resources Project No. 2).

In view of the expected growth of the problem of pollution with the rise in human populations and increase in their industrial activities, and because of the broadly interdisciplinary nature of the scientific investigations required, the projects relating to this question are gathered in this document under a single heading. For the purpose of the expanded programme marine pollution should be defined as :

> Introduction by man, directly or indirectly, of substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as harm to living resources, hazard to human health, hindrance to marine activities including fishing, impairing of quality for use of sea water and reduction amenities.

Scientific studies under the following projects should lead to the preparation of periodic comprehensive reports on the health of the ocean. These would review the state of the ocean and its marine resources as regards pollution, and forecast long-term trends to assist governments individually and collectively to take the steps required to counteract its effect.

Projects

3.1 Study of changes in the marine environment with a view to understanding the effects of known pollutants and identifying presently unrecognized ones.

3.2 Study the impact of such changes on marine life, including studies on toxicity and accumulation of pollutants.

3.3 Investigate the delayed and sub-lethal effects of pollutants on growth, reproduction, and other biological processes. Such effects, unlike for example mass mortalities of fish, are not always immediately apparent. Nevertheless, they are among the most serious results of marine pollution.

3.4 Development of relevant physical, chemical, physico-chemical and radio-chemical methods of analysis with special consideration to the presently known pollutants.

3.5 Identification of a spectrum of species that are affected by pollutants in various ways and hence can be used as sensitive indicators of the level of pollution in a given area.

3.6 Standardization and intercalibration of methods of sampling analysis and of instrumentation.

3.7 Establishment of a world-wide system of monitoring of the constituants of marine pollution including the collection of samples from various environments and biota, their submission and analysis at analytical centres, the transmission of the results of analyses to oceanographic data centres and the evaluation, interpretation and publication of these results on a regular basis. Implementation of the monitoring programme has important legal aspects which are related to the problems of prevention and control of marine pollution; these urgently require study and solution by the competent organizations.

3.8 Review the sources of marine pollution and investigate the mechanism through which the pollutants reach the marine environment.

3.9 Investigate the fate of pollutants in the marine environment. This involves study of the physical, chemical and biological processes of transport, accumulation, dispersion and degradation of pollutant substances and energy.

3.10 Provide the scientific basis for devising methods of removing pollutants from the sea, of countering their deleterious effects or, where possible, of exploiting beneficial effects of these substances.

3.11 Study positive and negative effects on sea organisms by thermal waste water.

4. GEOLOGY, GEOPHYSICS AND MINERAL RESOURCES BENEATH THE SEA

Introduction

An understanding of the character and evolution of the earth's crust beneath the ocean is proving to be the key to global geology and heralds a new approach to the solution of geological problems on the continents as well as below the sea. This understanding can provide a basic scientific framework within which prediction, evaluation and exploitation of material benefits from the sea floor can be made. These benefits will be greatly diminished, if only haphazard exploration and empirical studies guide our programme.

Undoubtedly in the future the rich mineral deposits located on and beneath the sea floor will be exploited as an important source of industrial raw materials for the whole of mankind. Deposits of

ferro-manganese concretions, also containing cobalt, nickel, copper and other metals, and deposits of rock-phosphate, have already been identified. Judging from preliminary data, oil deposits may also be found deep in the sedimentary formations beyond the limits of the continental shelf. However, our knowledge of the ocean's mineral resources is still far from adequate, and prolonged study both of their geographic distribution and of the concentration of the various mineral resources will be required in order to determine which of them can be profitably exploited for the benefit of mankind.

The sedimentary sequence reflects the ocean's present and its past history. It is here that we can follow the processes of erosion and sedimentation and discover the comparative rate at which deposits have formed in different regions of the ocean. Here, too, we find clues as to the original nature of the material deposited and the transformation it has since undergone. Study of this sequence will reveal the processes of the formation and distribution of many mineral deposits.

There are, in may places on the ocean floor, outcrops of the underlying igneous rock. A knowledge of the relationship between the properties of these rocks and their geological framework and age will enable us to determine the nature of volcanic phenomena, the changes which have taken place through geologic time in the composition of the earth-mantle, the age and composition of the sub-oceanic earth crust and the mechanism of metamorphic processes within the crust. This, in turn, will provide us with a better understanding of the rocks located on and below the ocean floor, their mineral potential such as chromite and nickel, and enable us to answer a number of questions relating to the geological history of our planet.

However, new theories require testing, modification and elaboration. The broad divisions of scientific problems listed below do no more than categorize some of the detailed problems to which scientists will turn their attention. The list of research programmes which follows is considered to contain the most important to be pursued in the light of presently available methods and those that can be foreseen to be possible. But as the expanded programme proceeds, new developments both in techniques and knowledge will necessarily lead to modified research programmes.

Principal scientific problems:

A. Description, origin and dynamics of the crust and mantle in the oceans, including marginal seas, mediterranean seas and continental margins, and knowledge of the deep sources of material and energy for tectonic processes.

A.1 Fine structure of the crust and upper mantle of the mid-ocean ridges, both active and ancient, and their associated stress patterns (e. g. related to seismicity).

A.2 Nature and origin of aseismic ridges and rises (e. g. Wyvillo Thomson Ridge, Walvis Ridge, Chile Rise).

A.3 Identification, dating and history of material composing the oceanic crust and the upper mantle beneath the "stable" ocean basins, and their lateral variability.

A.4 Comparative studies of the structure and history of stable continental margins.

A.5 The dynamic processes in areas of unstable continental and crustal plate margins (trench, trench-arc and marginal sea systems).

A.6 The possible transformation between oceanic and continental crust in the marginal and mediterranean seas.

A.7 Vertical and horizontal movements of the oceanic crust and continental margins.

A.8 Processes and patterns of vulcanism.

B. Sedimentary processes in coastal regions, on continental margins and in the deep ocean.

B.1 Description of the nature, history, distribution and thickness of sediments on the sea floor and of the nature and distribution of suspended matter.

B. 2 Sources of sedimentary material.

B. 3 Dynamic processes of erosion, transportation and sedimentation in relation to environmental conditions including quantitative analysis of the energy balance, rates of sedimentation, etc.

B. 4 Physical, chemical and biological interaction between the ocean and the sediments and rocks on the sea floor, a most important interdisciplinary problem.

B. 5 Diagenesis and metamorphism of marine sediments.

C. Aspects of the sea floor with potential economic value.

C. 1 Assessment of the mineral and fuel resources of the various types of continental margins.

C. 2 Coastal and sea-floor engineering (e. g. coastal erosion, sediment movement, "soil" mechanical properties, sea-floor stability).

C. 3 Possibilities of mineral and fuel resources of the deep sea floor, in relation to areas of different origin, development and environment.

C. 4 Identification of geologic hazards in coastal areas and on the sea floor (earthquakes, rupture of sea floor by faults, earthquake-generated sea waves, etc.)

Research programmes proposed to solve the principal scientific problems

1. Morphological charting of the sea floor.
2. Systematic geological and geophysical surveys of continental margins.
3. Completion of magnetic survey over the world ocean.
4. Deep drilling at key sites.
5. Detailed studies near crests of the ridge-rift systems.
6. Ocean and land studies of trench-arc systems.
7. Investigation of anomalous deep ocean crustal areas.
8. Geological and geophysical studies of mediterranean and marginal seas.
9. Geotraverses across major crustal features and land-sea geologic transects in critical areas.
10. River mouth monitoring with emphasis on the nature of suspended materials and waters.
11. Meridional profiles of deep ocean sediments.
12. Manganese nodule and other mineral resource assays.

These research programmes may be categorized as major elements of five principal programmes:

I. Morphological charting of the sea floor.

Scientific aspects: Geological investigations require bathymetric charts at appropriate scales as base maps. Other marine disciplines use reconnaissance or detailed charts of sea-floor morphology in aspects of their research.

Practical aspects: Base maps for off-shore exploration for minerals and fuels; for bottom fisheries, or for engineering purposes. Bathymetric charts at appropriate scales are required for all aspects of mineral exploitation, fisheries, engineering construction, and other operations on or above the sea floor.

Scales: 1:1,000,000 for reconnaissance purposes. Preliminary charts for many regions, both shelf and deep ocean, can be made from available data. More precise charts at this scale will be required for deep ocean areas with spacing of 5 - 15 km between lines depending on complexity of the bottom morphology and on the nature and detail of the geological programme in the area. Scales of 1:250,000 or larger scale will be required in critical areas (where land-sea geological and geophysical transects are to be made).

II. Systematic geological and geophysical surveys of the continental margins.

These surveys include deep drilling and land-sea geologic transects, for the purpose of investigating the sediments, crust, and mantle of both stable and unstable continental margins. Emphasis is placed on comparative study of structure, geologic history, and mineral resources.

Scientific problems include A. 4, part of A. 7, parts of B., C. 1.

Scientific aspects: Better understanding of sedimentary, igneous and metamorphic crustal structures under the sea floor in the transition regions from oceans to continents and the geophysical characteristics of the underlying mantle. Processes of sediment transport from the coast to the deep sea. Distribution of benthic organisms with depth and latitude. Pliopleistocene sea levels and eustatic and tectonic changes in sea level from evidence of relic beaches, terraces and coral reefs.

Practical aspects: Reconnaissance surveys to find location and extent of thick sedimentary basins and structures for possible oil and gas accumulations; discovery of phosphorite deposits on the outer shelf, and placer and beach deposits and other minerals on both the inner and outer shelf; delineation of rock structures with mineral and fuel resources continuing from the continent. Sediment and geochemical maps for fisheries.

Methods: Reconnaissance survey, using underway and station observations, of the entire marginal area. Additional geological and hydrographic investigations of key areas of high potential for minerals, or areas such as those having arctic, humid, arid or tropical hinterlands with and without high relief, areas off river mouths, and regions where there are prolongations of great tectonic trends from the continent to its margin. Methods should include geological and geophysical land-sea transects and in later phases should be supplemented by drill hole information.

III. Geological and geophysical investigations of the oceans.

Investigations of sediments, crust, and mantle of deep ocean basins, ridge-rift systems, and trench-arc systems. Methods include deep drilling, land-sea transects across trenches and arcs, and related investigations and drilling on adjacent islands.

Emphasis is on history, tectonic processes ("dynamics of ocean floor"), present phenomena of seismicity, volcanism, geomagnetism, gravity and heat flow, and mineral resources.

Scientific problems included in this programme are A. 1, A. 2, A. 3, A. 5, part of A. 7, A. 8, parts of B., C. 3, part of C. 4

IV. Geological and geophysical investigations of small ocean basins (mediterranean and marginal seas).

Studies of sediments, crust, and mantle with emphasis on history relation to other deep oceans, possible transformation between continental and oceanic crust; and mineral resources.

Methods include land-sea transects and deep drilling.

Scientific problems included in this programme are A. 6, parts of B. and C.

V. Studies of sedimentary and geochemical processes.

Investigations in coastal regions, continental margins, and deep ocean, of the material and energy balance with respect to the coast and atmosphere; physical, chemical, and biological interactions between water column and sea floor; sub-marine erosion, transportation, sedimentation and diagenesis. Emphasis is on origin of surficial mineral deposits, such as placers, phosphorite

and manganese nodules, and on stability of sea-floor sediments ("soil" mechanical properties) and evaluation of geologic hazards.

Scientific problems included in this programme are B., and parts of A. and C.

5. THE INTEGRATED GLOBAL OCEAN STATION SYSTEM

(Programme Aspects)

5.1 The system for obtaining oceanographic and meteorological observations from the ocean, available at present, cannot satisfy the current and increasing requirements for scientific knowledge about the ocean and atmosphere and their interactions, nor does the system satisfy the requirements for operational information about the current and future condition of the ocean environment and the atmosphere above it as well.

5.2 Scientific investigations are necessary to determine the interrelations and dynamic development features of the ocean and atmospheric processes. Until these determinations are made, little progress can be made to satisfy the requirements for short-term and long-term meteorological and oceanographic forecasts. Environmental forecast services are required to enhance the efficiency of sea trade and navigation, protection of life and property at sea, successfulness of maritime industries (fishing, petroleum, chemical, etc.).

5.3 IGOSS, in conjunction with the World Weather Watch, will promote the further development of environmental sciences, it will aid in the improvement of ocean and weather forecasts, and will facilitate a better understanding of the ocean and atmosphere interaction processes. It will support countries in their exploitation of new regions in the ocean for the purpose of trade and increase the efficiency of agriculture in all countries from the resultant increased accuracy of weather forecasts and their application to food production.

5.4 IGOSS, which is being developed on the basis of scientific principles, includes the modern technical means for observations, radio-communication and data processing and is intended to provide, together with WWW, the synchronous and undelayed oceanographical and meteorological information from the whole ocean. It will benefit from research proposed for the expanded programme, since subsequent design of the system will require understanding of the scales and frequencies of oceanic phenomena and the perfection of models for forecasting oceanic conditions.

5.5 The purpose of IGOSS, in conjunction with the World Weather Watch, guided by the requirements of oceanography, is to provide oceanographic and meteorological information that will support all interested countries in producing forecast services and conducting scientific ocean investigations.

5.6 The main planning question to be resolved during the initial stage of IGOSS is to determine the distribution and content of meteorological and oceanographical observations by fixed and mobile observing stations.

5.7 The Integrated Global Ocean Station System is arranged exclusively for peaceful purposes and is based on the principle of voluntary participation of the interested States. IGOSS is a world system consisting of national facilities and services co-ordinated by the Intergovernmental Oceanographic Commission, in close collaboration with WMO, with the support of all interested organizations.

6. SPECIFIC INTERNATIONAL REGIONAL INVESTIGATIONS

6.1 International co-operation in studying systematically selected oceanic regions is of great importance. The extreme rapidity of time variations of the oceanic environmental characteristics requires rapid repeated surveys of oceanic conditions, which surveys cannot produce satisfactory data if conducted by a single vessel. In order to understand properly all physical, chemical and biological processes which take place in a particular region, their interrelation and interdependence, regular multiship synoptic surveys over the whole area of the region under investigation are necessary. Networks of buoys or other platforms may be indispensable when high degree resolution in space is required.

6.2 No country, however rich or developed economically, can provide the necessary number of research vessels and other means for such investigations. Only through international co-operation is it possible to concentrate in one region of the ocean such number of research vessels and other means as would meet adequately the requirements of synoptic or quasi-synoptic coverage.

6.3 The Intergovernmental Oceanographic Commission has already acquired great experience in organizing and conducting large-scale international expeditions: in the Indian Ocean, in the equatorial part of the Atlantic Ocean, and in the Kuroshio region of the Pacific. The Commission also planned or projected further international investigations in the Northern Atlantic, in the Mediterranean, in the Caribbean Sea and adjacent regions, and in Antarctic waters (Southern Ocean). The continuation of these co-operative investigations will be the first step of the long-term expanded programme.

6.4 A great many oceanic regions are still poorly known. Among them are the southern parts of the Atlantic, Pacific and Arctic Oceans, including some regions bordered by developing countries. Regions where more or less satisfactory data have been collected in the past require additional detailed investigations. It is appropriate, therefore, that, during the next five years, the large-scale international expeditions planned or projected by the Commission be complemented by detailed co-operative investigations of regional character aimed at assisting developing countries by studying their adjacent waters for the purpose of national fisheries development.

6.5 Plans for these regional investigations should be developed in close collaboration with the existing regional organizations, such as ICES, * ICNAF, ** etc., which have accumulated valuable experience in organizing co-operative investigations in their respective regions with great benefit for fisheries development there.

* ICES - International Council for the Exploration of the Sea.
** ICNAF - International Commission for the North-West Atlantic Fisheries.

PART II

PRACTICAL PROBLEMS OF IMPLEMENTATION

1. Training, education and manpower requirements

Development and implementation of the expanded programme will require a considerable strengthening of scientific and technical manpower. Such problems are of considerable importance particularly to the developing countries. Problems and approaches include the following:

increased reference to marine problems in natural science and engineering curricula;

development and strengthening of specialized curricula at the university and post-graduate levels;

more effective exchange of information on educational and training opportunities;

preparation and distribution of manuals, textbooks and other teaching materials in various languages;

organization of training courses for scientific, technical, and auxiliary staff;

expansion and more effective use of fellowships for professional study;

arrangements for exchanges of teachers and investigators between countries;

strengthening of existing centres for training and research and establishment of additional centres.

The following actions should be taken particularly for the benefit of the developing countries:

1. The IOC Working Group on Training and Education should develop further plans to meet training, education and manpower requirements for the expanded programme.

2. Unesco, FAO and other appropriate organizations should further strengthen and co-ordinate their fellowships and training programmes in marine sciences.

3. Member States should improve the opportunities for training and for employment of trained people in marine sciences, and should give increased support to international organizations involved in programmes of education and training, including ship-board training programmes.

2. Data and information management

Data and information will be one of the most important products of the expanded programme. Existing international systems for information and data management are not adequate to cope with the present flow of information and data. The lack of ready access to pertinent information and data presents particular difficulties to the growth of marine research in developing countries. The significant increase in the level of ocean research activity which will result from implementation of the expanded programme will overload these systems from the beginning. Problems that require solving include the following:

improvement and consolidation of bibliographic and related information services;

early exchange of plans and preliminary results of observational programmes;

integration of real-time exchange of oceanographic data with the meteorological system;

development of methods for storage and retrieval of biological, geological and geophysical data;

automation of international data banks and improved programmes and methods for making their contents available;

development of standardized and/or computer-compatible data formats;

timely establishment or improvement of international inventories of ocean data and samples and provision for centralized cataloguing of sea data available from various private and public sources;

strengthening system of sorting centres for biological material.

The following actions should be taken:

1. The IOC Working Group on Oceanographic Data Exchange in collaboration with WMO, FAO and other interested organizations such as ICES should examine the above problems and take requisite steps to meet the needs of the expanded programme. Certain aspects of this work can be assisted by the IOC advisory bodies.

2. Unesco, FAO and ICSU in collaboration with other interested organizations such as ICES should devote increased attention to the improvement of scientific information systems in the field of marine sciences.

3. Member States should give increased support to national, regional and world data centres as required for the expansion and improvement of their services.

4. Specific mechanisms should be sought for accelerating the flow of data through international exchange channels. And, all meaningful data and information resulting from projects and programmes of the expanded programme should be considered as Declared National Programmes (DNP) or their equivalent, to be exchanged or available for exchange and subject to inventories.

3. Instrumentation and methods

The expanded programme will require the development and availability of instruments and methods of high precision and reliability. In order for data from various sources to be pooled and processed automatically, the instruments must be intercalibrated or standardized where possible and methods must be compatible.

The following problems require solution:

there is little effective intercalibration of measurements made by one Member State, with any other Member State;

information on the performance of instruments and related equipment is not readily available to Member States;

standards information to ensure high quality data is not available to Member States;

information on appropriate facilities needed for the calibration of instruments is not available;

no effective mechanism exists for standardizing on those instruments which are worthy of such a designation.

The following actions should be taken:

1. IOC, Unesco, FAO, WMO, SCOR, ACMRR, ICES, and other interested bodies should jointly intensify their support for methodological work and for the improvement, intercalibration, and standardization of instruments and methods.

2. Member States should provide increased assistance in the conduct and publication of pertinent methodological investigations and encourage the production and adoption of standardized instrumentation where practical.

3. Member States should designate, where possible, an existing laboratory or facility that can act as a centre for information relative to that State's activities in oceanographic

measurement and for the co-ordination of instrument improvement, calibration, and standardization with other Member States.

4. Technology and supporting facilities

The investigation and exploration of the ocean and its resources require significant technological advances as well as the expansion and improvement of facilities. The development of such technology and facilities will require considerable investments at the national level.

The following actions should be taken:

1. Member States should encourage the development of advanced technologies for investigation and exploration of the ocean, which should be made generally available. In particular, the development should be encouraged of systems technology at all levels, providing for development of such systems as oceanographic buoys, research submersibles, instrumented spacecraft and aircraft, off-shore structures and under-sea habitats.

2. IOC and other interested international bodies should facilitate the dissemination of information on advanced technology.

3. Member States should increase the availability of adequate facilities of all kinds for investigation and exploration activities in the oceans. In this connexion appropriate assistance should also be provided to developing countries through bilateral and multilateral programmes including activities of Unesco, FAO, WMO, United Nations and other international organizations financed by UNDP and other international sources.

5. Supporting services

The expanded programme will require the widespread availability of precise navigational systems, improved communications, more complete and accurate forecasts of the marine environment, and the expansion of programmes of hydrographic surveys, mapping and charting. In particular, in order to solve a large number of oceanographic problems and make possible geological and geophysical research, it is indispensable to carry out world-wide bathymetric surveys as well as more detailed bathymetric investigation of high accuracy of limited specific areas.

The following actions should be taken:

1. Member States should strengthen and improve supporting services and integrate them internationally.

2. Member States should strengthen their efforts in the hydrographic field and co-ordinate their programmes in order to improve and increase the production of bathymetric charts at appropriate scales.

3. The Ocean Station System (Ocean Weather Ships in North Atlantic (NAOS) and North Pacific) should be used in the expanded programme of oceanic exploration and research as they provide unique opportunities for continuous observations of oceanographic parameters and may serve as an important step towards an Integrated Global Ocean Stations System.

4. The IOC, WMO, IMCO, IHB, and other appropriate international organizations should work closely together in developing international aspects of the supporting services.

6. Legal aspects of scientific investigation

The Commission should continue its studies pursuant to resolution V-6.

7. Integrated Global Ocean Station System (implementation aspects)

The implementation of IGOSS will draw heavily on all the supporting activities related to the implementation of the expanded programme listed in this part of the draft outline, with particular emphasis on:

(a) development of appropriate technology and instrumentation, standardization and unification of instruments and methods of observations for the IGOSS programme;

(b) standardization and unification of the format for the efficient exchange of data (real time and non-real time) obtained through IGOSS;

(c) standardization of procedures for use of the radio-telecommunication channels;

(d) organization of the oceanographic service in an integrated fashion and patterned after the World Weather Watch.

8. Organization for implementation of the expanded programme

It was agreed that the expanded programme, which would consist of certain on-going and proposed activities of IOC as well as those of other organizations, represented a new magnitude of effort and would require a periodic review and co-ordination by the proposed IOC Executive Council, taking into account the views expressed by the governing bodies of the other organizations involved. For this purpose certain meetings, or portions of meetings, of the Executive Council might be designated for matters pertaining to the expanded programme, thus ensuring that suitable scientific and technical competence is available on national delegations for such meetings or portions of meetings.

It was agreed that the international co-ordinators and the chairmen of the relevant subsidiary bodies should report to the Executive Council on these occasions.

In a discussion of the co-operation among international organizations, it was reported that the Unesco Executive Board had authorized the Director-General of Unesco to establish an inter-secretariat committee which would meet with the Chairman of the IOC to further common aspects of the work of the IOC and the participating agencies, to recommend to these agencies appropriate support action for the IOC and to co-ordinate such action. This committee has been formed and met in August 1969.

There was general recognition that the United Nations should continue to use the IOC's technical competence in the scientific aspects of ocean affairs. In this connexion, the responsibilities given to the IOC in United Nations resolution 2467 were welcomed. The IOC should continue, in co-operation with other organizations of the United Nations system, to assist the General Assembly in its consideration of matters related to the ocean.

In order to guarantee the effective participation of as many countries as possible, the possibility should be considered of bringing a number of their own national programmes within the general framework of the expanded programme.

It was agreed that there was a continuing important rôle for the scientific advisory bodies in the review and evaluation of programmes proposed and implemented during the expanded programme. The IOC has recognized the need to broaden the field from which scientific advice is drawn beyond that now covered by SCOR and ACMRR. In this connexion ICSU bodies are now considering alternative ways to strengthen and consolidate scientific bodies concerned with various aspects of marine science. Some steps are also being taken to establish an ocean engineering association under the World Federation of Engineering Organizations. In response to the request of the IOC Bureau WMO is giving further consideration to its scientific advice to the IOC in the field of meteorology.

9. Assistance to developing countries

An important goal of the expanded programme is enhanced utilization of the ocean and its resources for the benefit of all mankind. More than 70 developing countries border the oceans. Unused fishery resources and fuel and mineral deposits are known to exist off the coasts of a number of these nations; also many of them are dependent on maritime transport to link coastal communities and to provide the basis for foreign trade. In the past, the developing countries have had only limited opportunities to make use of the ocean and its resources; they have, therefore, a special interest in fully participating in the expanded programme and in applying its results to further their own development. The developing countries should also have the opportunity to participate in the

development of the resources of the deep ocean to the extent possible. To aid them in their efforts to participate and to reap the benefits arising from the expanded programme, the developing nations may need scientific, technical and material assistance, especially in training and education, technology and facilities, as indicated in various sections of this document.

The developing countries may also require assistance in the design and organization of scientific programmes as well as in the strengthening and improvement of existing programmes. It is essential that greater attention be given to the needs and interests of these countries to enable them to be meaningful partners in the expanded programme.

The following actions should be taken:

1. The IOC, through its co-operative activities, and Unesco, FAO, WMO, United Nations and other interested organizations, with the support of UNDP and other sources, should develop plans to meet the needs of developing countries arising from the expanded programme.

2. Member States should participate actively in technical assistance programmes for the mutual benefit of those concerned with the ocean.

3. The IOC should encourage work on oceanic regions of particular interest to developing countries, with due regard to any national programmes already established, and should encourage the effective association of these countries in studies of this sort. In particular, the IOC should encourage every means of enabling them to embark upon such studies themselves, by the training of specialists, the setting up or the improvement of local teams and local scientific institutes, and the development of an adequate material infrastructure.

These actions should include:

active participation by developing countries in planning and working out practicable arrangements for the expanded programme;

particular attention to providing developing countries with data and information obtained from ocean research and exploration;

participation by developing countries in ocean research conducted by vessels of other nations;

increased opportunities to developing countries to utilize oceanographic research facilities in developed countries;

increased availability of fellowships to ocean scientists and engineers in developing countries;

liberal assistance to developing countries in useful technician training programmes;

liberal provision of management assistance and technical assistance to developing countries in the establishment of marine science and technology facilities and in improved methods.