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**PROCEEDINGS  
OF THE**

**SCIENTIFIC COMMITTEE ON OCEANIC RESEARCH**

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**REPORT OF THE 32nd EXECUTIVE COMMITTEE MEETING OF SCOR**  
**Zoology Department, University of Cape Town**  
**Cape Town, South Africa**  
**Tuesday, November 14 to Thursday, November 16 1995**

**1.0 INTRODUCTION**

**1.1 Opening Remarks and Administrative Arrangements**

The President of SCOR, I.N. McCave, opened the meeting, welcoming the participants and thanking host, Professor John Field, for local arrangements. These included opportunities for local sightseeing as this was a first visit to South Africa for nearly everyone. It was an auspicious time in South Africa's development and an appropriate time for a SCOR meeting as 1995 marked the centenary of marine science in the country and it was exactly twenty years since the last SCOR meeting there. A list of participants is given in Annex 1.

Throughout the meeting a program of scientific lectures was organized to highlight SCOR activities and to present related South African oceanographic research. The program for these appears in Annex 2.

The President noted the recent deaths of Klaus Voigt, Deputy Secretary of IOC, who had been closely associated with the SCOR Committee in the former East Germany and hosted the General Meeting in October 1990, and of Ray Beverton of the UK, well known to many in the SCOR community.

All acronyms and abbreviations used in this report are explained on the final page.

**1.2 Approval of the Agenda**

The agenda was adopted as distributed (see Annex 3), with the addition of item 7.1 to permit a brief discussion (proposed by Ian Jones, Australia) of an ocean monitoring system in support of the Complete Nuclear Test Ban Treaty.

**1.3 Report of the President of SCOR**

The report of the President focused on two major highlights of the period since the XXXII General Meeting in October 1994. The first of these was the completion of the Science Plan for SCOR and IOC's program on Global Ocean Ecosystem Dynamics (GLOBEC) for presentation to the Scientific Committee of the International Geosphere-Biosphere Program (IGBP) at its meeting in October 1995. As a result of this activity, GLOBEC has been adopted as a Core Project of the IGBP under the joint sponsorship of SCOR, IGBP and IOC. (See also item 2.3.3). The thanks of SCOR were extended to the members of the SCOR/IGBP Core Project Planning Committee who had undertaken the revision and completion of the GLOBEC Science Plan under the leadership of Brian Rothschild and Robin Muench.

A second highlight of 1995 was the successful mid-life review of the Joint Global Ocean Flux Study (JGOFS) which took place as part of an overall review of the IGBP conducted by the International Council of Scientific Unions (ICSU) and the International Group of Funding Agencies for Global Change Research (IGFA). The main opportunity for interactions between the JGOFS scientific community and the members of the evaluation panel came during the First International JGOFS Scientific Symposium which took place in Villefranche-sur-Mer, France in May. This meeting attracted over 150 scientists for a week of plenary lectures, extensive poster sessions and demonstrations of JGOFS models and data sets.

The President noted that with increasing frequency, participants in long term international oceanographic activities are looking to SCOR for some sort of formal association or sponsorship. This was an important issue for discussion by the Executive Committee at this meeting (see item 2.5). Four such requests had been submitted to SCOR for consideration.

#### 1.4 Appointment of an ad hoc Finance Committee

In accordance with the SCOR Constitution, a Finance Committee was appointed to review the administration of SCOR finances during the previous (1994) fiscal year and the current year. It was also charged to draw up a budget for 1996 activities based on the decisions taken during the meeting. The *ad hoc* Finance Committee was chaired by Colin Summerhayes (UK) and included Ian Jones (Australia), Wolfgang Fennel (FRG) and Shizuo Tsunogai (Japan). The Committee reported to the meeting under agenda item 3.3.

## 2.0 SUBSIDIARY BODIES

### 2.1 Arising from Former Working Groups

#### 2.1.1 *WG 78 Determination of Photosynthetic Pigments in Seawater*

The manuscript for the Monograph on *Phytoplankton Pigments in Oceanography: Guidelines to Modern Methods* had been delivered to UNESCO and was being prepared for printing at the time of the Executive Committee meeting. As a result of an agreement reached during the meeting, this editorship of this book will be credited to Shirley Jeffrey, R.F.C. Mantoura and Simon Wright. The logos of the Plymouth Marine Laboratory and the CSIRO will appear on the cover of the publication, along with those of SCOR and UNESCO, in recognition of the substantial resources contributed to its production by both institutions. Appreciation of the Executive Committee was expressed to the three editors for their effort to see this task to completion - the publication is expected to be a substantial contribution to the field of biological oceanography.

#### 2.1.2 *WG 80 Role of Phase Transfer Processes in the Cycling of Trace Metals in Estuaries*

A letter from the Chair of former WG 80, Michael Whitfield, informed the Executive Committee that he had not been able to complete the collation, editing and updating of the sections of the final report of his Working Group. New links to the International Union of Pure and Applied Chemistry (IUPAC) opened the possibility of a joint effort to complete this report. Whitfield expected to have more time to devote to this activity in the coming year.

### 2.2 Current Working Groups

#### 2.2.1 *WG 86 Ecology of Sea Ice*

The Executive Committee Reporter for WG 86, Jarl Stromberg, reported that the activities of WG 86 focused on three main areas during the past year:

- Activity on the final deliverable of the WG, a conference on Sea Ice Ecology, proposed as a Gordon Research Conference.
- Coordination with other international bodies, specifically the International Commission on Snow and Ice (of IAHS), and the Sea Ice Commission of IAPSO.
- Work with the SCAR Group of Specialists on Global Change in Antarctica (GLOCHANT) to involve studies of sea ice ecology in upcoming plans for the Antarctic sea ice zone, specifically the Antarctic Sea-Ice Processes, Ecosystems and Climate (ASPECT) program. The report of WG 86 presented information on ASPECT to the SCOR Executive for their information, consideration and comments at an early stage of planning to ensure early integration of SCOR's interests and concerns in this upcoming activity.

The application of WG 86 for funding for a Gordon Research Conference (GRC) on Sea Ice Ecology was approved and the Conference will take place in early 1997. The Executive Committee gave approval for a meeting of WG 86 in Prague in May 1996 in order for detailed planning for the conference to be initiated. A positive result of the long delay in obtaining the Gordon Conference funding is that support is now secure for a continuing series of conferences on polar marine science.

WG 86 has also made approaches to the International Commission of Snow and Ice of IAHS and the Sea Ice Commission of IAPSO with a view to improved coordination of polar science activities. These discussions were

held at the ICSI Bureau annual meeting held in Boulder, at the IUGG General Assembly and at the IAPSO General Assembly in Honolulu, Hawaii. The main interests of ICSI are in the snow and ice covers on land, however, there are coordination interests on floating ice and of relevance to WG 86, on snow ecology. ICSI was informed of the plans for the conference on Sea Ice Ecology and preliminary contacts were made to possibly follow on with a similar conference on Snow Ecology. Investigators in the two fields will be kept informed through the participation on ICSI of S.F. Ackley, Chair of WG 86.

Discussions were held with the President of the Sea Ice Commission of IAPSO, Matti Lepparanta. In 1994 SCOR provided support to the successful summer institute on the Physics of Ice-Covered Seas which involved two WG 86 members. The Commission is interested in incorporating sea ice ecology as a component of its future activities. This evolution fits naturally with the termination of WG 86, probably following the Gordon Conference. The Sea Ice Commission plans to add a member with interests in Sea Ice Ecology and will pick up some of the international coordination in this field as the activities of WG 86 wind down. The Sea Ice Commission may cosponsor and support the Sea Ice Ecology Conference and may schedule a meeting of the Commission at the same time providing the travel support for commission members to attend.

Two members of the Working Group 86 (S.F. Ackley and G. Dieckmann) participated in the SCAR Global Change in Antarctica (GLOCHANT) Planning Group for the Antarctic sea ice zone. From these activities a science and implementation plan for the role of the Antarctic sea ice zone in Global Change, called ASPECT (Antarctic Sea-ice Processes, Ecosystems and Climate) is being developed. Sea ice ecosystem activities are considered a core component of ASPECT and are being carefully coordinated to interact and complement and fill the sea ice ecology gap between SCOR activities proposed under JGOFS and SO-GLOBEC.

The background document for ASPECT was submitted to the SCOR Executive for consideration and comment as to an appropriate role for WG 86. In an informal way, ASPECT can be considered, in its proposed ecosystem activities, as a practical extension of WG 86 interests in the Antarctic. The Executive Committee agreed that the links between the SCAR GLOCHANT activity and the Southern Ocean components of JGOFS and GLOBEC need to be strengthened and it decided to ask WG 86 to cooperate with ASPECT and to facilitate links between it and other SCOR activities in the Southern Ocean.

#### **2.2.2 WG 89 Sea Level and Erosion of the World's Coastlines**

During 1995, WG 89 continued its work on a publication entitled "The Changing Level of the Sea and Predictive Models of Beach Responses". First drafts of assigned chapters have been completed, but it was found that many gaps in the coverage remained. The Chair of WG 89, Professor Komar reported that he hoped that a revision will be completed by the end of the year and sent to the WG members for another round of reviews. The Executive Committee was somewhat concerned about this delay and the Publications Officer agreed to write to the WG to urge completion of the final report as soon as possible.

#### **2.2.3 WG 93 Pelagic Biogeography**

Brian Rothschild reviewed the report of WG 93, noting that the work of this group is nearly complete. In 1994 it published a series of articles in *Progress in Oceanography*. The work on the Glossary of Biogeographic Terms is nearly complete. It will be made available on floppy disk: publication on paper or other electronic media is still undecided. The manual on pelagic collections is not progressing as rapidly. Although a fair number of questionnaires have been returned, there are still large gaps in the available information. An attempt will be made to fill these gaps by sending questionnaires to national SCOR representatives for distribution. This will be taken up after the work on the proceedings of the Conference on Pelagic Biogeography (see below) has been finished. The proceedings will be published in the *UNESCO Technical Papers in Marine Science*.

The Pelagic Biogeography Conference organized by WG 93 took place in July 1995, but had somewhat less attendance than foreseen; it is evident that many plankton researchers work in areas where resources are small.

The conference had talks and workshops to discuss the following topics:

Biogeography and global change;  
The nature of oceanic populations, species and the species concept;  
Boundaries: models for understanding large-scale interactions;  
Biogeography and global biodiversity studies.

The completion of the conference proceedings will fulfil the terms of reference of WG 93. The 1995 report from the WG contained a preliminary recommendation regarding establishment of a new SCOR WG to design an experiment to address some of the biogeographic issues raised by the WG in its deliberations. This will be developed for discussion at the next SCOR meeting.

#### **2.2.4 WG 95 Sediment Suspension and Sea Bed Properties**

The Executive Committee Reporter for WG 95, Professor Krishnaswami, noted that the group is in the process of completing its terms of reference. It has submitted a set of papers for publication in the *Journal of Marine Systems* in the spring of 1996.

The WG has been unable to arrange its final symposium as planned in combination with the conference of the International Association for Sediment-Water Interaction and has decided, instead, to organize a special session at a meeting on Computerized Modelling of Sedimentary Systems which will take place in Güstrow, Germany in October 1996. The Executive Committee agreed that SCOR should co-sponsor this symposium and provide some funds to enable the participation of those WG 95 members with specific modelling interests.

WG 95 has identified a list of questions to be addressed in its final report to SCOR or to indicate directions for future research:

- How do deep-water circulation and bottom topography affect Benthic Nepheloid Layers (BNL)?
  - coupling to circulation models
  - temporal and spatial scale of BNLs
  - sea mounts, mid ocean ridges
  - intermediate BNL
  - continental slope
  - tides
- Is resuspended carbon a missing carbon source?
  - production of benthic animals
  - Dissolved Organic Matter versus Particulate Organic Matter
  - lateral transport
- Which biological and chemical reactions are stimulated or inhibited during resuspension?
  - substrate uptake by bacteria
  - dissolution of carbonate and opal
  - adsorption and desorption of trace metals and others
  - behaviour of different radio tracers
- How important are processes in the BNL for mass balances?
  - remineralisation in the BNL
  - shallow water versus deep-sea
  - oxic versus anoxic conditions
  - lateral advection, depocenters
- How many and what type of particles are produced or destroyed in the BNL?
  - size class distribution
  - settling velocity
  - residence time

- biological production
- pellet production
- What is the role of benthic and benthic-pelagic organisms in exchange of matter between the mixed layer in the sediment and the BNL?
  - aggregate formation and destruction
  - bioresuspension
  - biodeposition
  - biogenic structures
- Is a multidimensional, coupled model needed for the description of sediment - suspended matter interactions?
  - verification
  - local and nonlocal mixing
  - lateral component
  - physical versus biological entrainment
  - particle size classes versus continuum

### 2.2.5 *WG 96 Acoustic Monitoring of the World Ocean*

Geoff Brundrit, a member of WG 96, presented its report. The group had expected to meet during 1995, but an unexpected delay in the implementation of the ATOC experiment (Acoustic Thermometry of Ocean Climate) made such a meeting impractical. Field activities in this international program had been suspended due to concerns in the environmental community about the effects of sound on marine mammals. Attention to marine mammal effects thus became an important component of SCOR WG 96 activities and information was gathered on different national approaches to this problem. The hiatus in field activities was imposed by the requirement for public hearings in association with the applications for permits to transmit at the two sites selected, Monterey and Kauai. It became apparent that there had been a significant misunderstanding on the part of some environmental groups as to the strength of the sound sources to be deployed in the ATOC experiment and about the properties of the transmission of sound in sea water (as opposed to air).

As a result of the uncertainty surrounding this issue it was decided to defer a WG 96 meeting until early in 1996 in order to allow time for this issue to be resolved. Since this decision, important progress was made. Specifically:

1. Both Federal and State permits were obtained for California and cable laying was underway at the time of the SCOR Executive Committee meeting.
2. For the Kauai site, the Federal permit was acquired, but the state permit was still pending at the time of this report in October 1995. [It was subsequently granted.]

Thus it was anticipated that transmissions would begin from the California site very soon, making a SCOR WG 96 meeting in early 1996 especially appropriate.

The Executive Committee agreed to the request to hold a SCOR WG 96 meeting in Hobart, 27-29 March, 1996. Since this will be the first meeting held at a time when acoustical transmissions will have begun, the WG wished to ensure that key international participants could participate, especially Chinese, Russian and Japanese representatives, and if possible, representatives from other Pacific nations. The WG and ATOC have longer term goals and plan future activities in the Indian Ocean and Atlantic; an Australian-Indian-South African plan is a probable successor to the Pacific program. SCOR support was committed to this meeting.

The themes of the Hobart meeting will be:



- Role of international participation in acoustic monitoring of the Pacific - summary of new results - plans for signal detection by Pacific nations - new approaches to signal analysis, transmission and detection - marine mammal issues
- Acoustic monitoring of the Indian Ocean - contributions by South Africa, India, Australia
- Acoustic monitoring of the Atlantic Ocean - status of proposal for acoustic transmissions in the Atlantic - international participation in an Atlantic program

The longer-term existence of WG 96, primarily as an international steering committee for the development of ATOC, was discussed under agenda item 2.5.

#### **2.2.6 *WG 97 Physiological Ecology of Harmful Algal Blooms***

The Reporter for WG 97, Jarl Stromberg, informed the Executive Committee that the WG had been successful in obtaining NATO funding for an Advanced Study Institute (ASI) to take place at the Bermuda Biological Station for Research in late May 1996. This 10-day program will involve about 85 participants and will include lectures, posters, round-table discussions, field and laboratory demonstrations. As with all NATO-funded events, a major publication will result from the ASI. A WG meeting in Tokyo in October 1995 held in conjunction with the Seventh International Conference on Toxic Marine Phytoplankton in Sendai (which was cosponsored by SCOR), was devoted primarily to the detailed planning of this workshop. The objectives of the ASI will be to assess our understanding of the fundamental physiological and ecological issues underlying harmful algal blooms, to identify inadequacies, impediments and promising areas for future research, and to advance and disseminate new approaches and technologies. Efforts will be made to summarize major advances in two areas: (1) the ecology of critical groups of phytoplankton (= "autecology"); and (2) the ecophysiological processes and mechanisms that affect toxic bloom formation and the production of phycotoxins. This approach was selected in order to elucidate critical factors that regulate blooms of related species as well as of toxic species in general.

The representative of IUPAC, P.S. Steyn, noted the interest of his organization in the chemistry of the toxins produced in certain algal blooms.

The Executive Committee congratulated WG 97 on receiving the funding for the ASI, welcomed the cosponsorship and support of IOC, and agreed to provide SCOR support to the event.

#### **2.2.7 *WG 98 Worldwide Large-scale Fluctuations of Sardine and Anchovy Populations***

The Executive Committee had before it the detailed report of the first meeting of WG 98 which took place in June 1994, and included a schedule for future activities.

This meeting developed a plan for satisfying the terms of reference of the WG. These include collation of historical information from the five regions of the world where sardines have been fished (Japan, west coast of North America, west coast of South America, west coast of southern Africa, Australasia) that is pertinent to understanding large ecosystem changes that have occurred in these regions; use of historical information to evaluate the sequence of events occurring at times of major change; development of hypotheses regarding the causes of the large changes; identification of mechanisms that may sustain large shifts in abundance over long periods; and examination of evidence for a worldwide cause of the major fluctuations.

WG members from each region undertook to collate historical biological and fisheries data for their region for submission to a central data bank to be established at the institute of the Chair, Daniel Lluich-Belda, the Centro de Investigaciones Biológicas del Noroeste, in La Paz, Mexico. The Executive Committee approved the request of WG 98 for support for a small workshop to merge the three data types (biological/fisheries, oceanographic and meteorological) into a single data base. This workshop will take place during the first half of 1996 and will be followed, in 1997, by the final meeting of WG 98.

Members of WG 98 are also developing descriptions of events and conditions during major regime changes for each region. Following the data merging workshop, the WG will focus on hypothesis formulation, identification of mechanisms important for regimes in each region and investigation of the possibility of a worldwide cause for the regime changes.

### **2.2.8 WG 99 *Linked Mass and Energy Fluxes at Ridge Crests***

Following its meeting in October 1994, WG 99 reported that it has undertaken two major activities:

- Production and distribution of a booklet, aimed outside the specialist, scientific, ridge research community to highlight the significance of ridge processes and fluxes within the context of marine, and earth, science as a whole.
- Organization of a SCOR WG 99 Symposium, to be followed by the publication of a scientific volume that would present the Symposium's proceedings.

The booklet will adopt a format which includes a one-page Executive Summary, followed by a series of sections as outlined in the 1994 report from WG 99, but expanded considerably, and aimed at a non-specialist audience. Thus not only the description of the scientific issues, but also the discussion of techniques and approaches appropriate for making progress will be explained in substantially greater detail than has been the case in other recently produced documents (e.g. for InterRIDGE) that are aimed at a specialist scientific readership. In addition the booklet will include information about the current and recent contributions to ridge research by individual countries.

This results in a planned layout for the booklet consisting of:

1. Executive Summary
2. Ridge Studies in a Global Context - Influence on the Environment over various Time Scales
3. Scientific Issues:
  - Magmatic Fluxes
  - Thermal Fluxes
  - Sea water-Rock Interactions
  - Concentration and Dispersal of Hydrothermal Products
  - Biological Productivity
4. Current and Future Research Efforts
  - InterRIDGE
  - ODP
  - National Programmes
5. Opportunities for the future -
  - Fundamental Science
  - Improving international collaboration on scientific research and information exchange.

The InterRIDGE office has offered assistance with both the production and distribution of the booklet.

The Executive Committee discussed WG 99's plans for a two-day symposium to be held either in association with the SCOR General Meeting at the Southampton Oceanography Centre in September 1996, or at the European Union of Geosciences meeting in April 1997. It felt that the second venue would be more appropriate, especially as plans were already underway for a session on air-sea interactions at the General Meeting. [These plans did not materialize, however, and WG 99 was later asked to cooperate with a group of British RIDGE researchers at Southampton to organize a two-day scientific session on interdisciplinary studies of mid-ocean ridges to accompany the General Meeting.]

WG 99 continues to provide the main link between SCOR and the InterRIDGE program (see also item 2.5) and the Executive Committee noted, with gratitude the willingness of InterRIDGE to cosponsor both the booklet and the symposium. It also approved financial support for these activities.

#### **2.2.9 WG 100 Sediment Coring for International Global Change - SCOR/PAGES IMAGES Program**

The report of WG 100 was introduced by the Reporter, I.N. McCave, and WG member, Wang Pinxian. The WG met in Halifax in September 1995, in conjunction with the International Conference on Paleoceanography, in order to complete the tasks originally assigned to it by SCOR. These included:

- To coordinate international efforts to collect good quality piston cores, Kasten cores and box cores from the world ocean suitable for collaborative studies of global change over the geologically recent past as required by the PAGES and JGOFS components of the IGBP.
- To advise on the description, curation and sampling of these cores and on protocols for the distribution of samples for specialist analysis.
- To promote the construction of a data base of available deep sea core material providing enough information to promote the efficient use by the international scientific community of existing, as well as new core material.
- To promote the increasing use of non-destructive tools for obtaining high resolution logs of deep sea sediment cores.

Recommendations concerning protocols and sampling policies were presented to SCOR in the IMAGES (International Marine Global Changes) report which was published by PAGES in 1994. To implement the much broader task of facilitating international cooperation in programs designed to collect and study a global array of long, high resolution marine sediment records necessary to address major questions concerning the evolution of Earth's climate, WG 100 has developed a Science Plan and has recommended the creation of the International Marine Global Changes (IMAGES) program under the joint sponsorship of SCOR and the Past Global Changes (PAGES) Core Project of the IGBP. The was accepted by both organizations in late 1993. Many of the WG 100 recommendations on sampling protocols were tested during the first IMAGES cruise on the *Marion Dufresne* in the spring of 1995. The cruise successfully collected 43 long, large diameter piston cores at 41 locations and showed that the IMAGES model for international cooperation is feasible.

The report of WG 100 recommended a management structure for IMAGES with a science steering committee to consist, initially, of the members of WG 100, with a membership rotation scheme to help provide new input to IMAGES development. The Chair of WG 100, Nick Pisias, will chair this initial steering committee and a subset of it will act as an executive group. An IMAGES secretariat will be established in France with Laurent Labeyrie serving as the first IMAGES Executive Director.

The Executive Committee agreed that WG 100 could now be disbanded with thanks for its timely completion of its terms of reference. The continuing affiliation of SCOR with the IMAGES program was discussed under agenda item 2.5.

#### **2.2.10 WG 101 Influence of Sea State on the Atmospheric Drag Coefficient**

The President-elect of IAPSO, Vere Shannon, acting for Robin Muench (Reporter for WG 101) and the WG Co-Chair, Ian Jones, introduced the WG report. An informal meeting of WG 101 took place in July 1995 in association with the Third International Air-Water Gas Transfer meeting in Heidelberg. It also held a joint session with WG 103. The WG is preparing a monograph entitled "Drag over the Ocean" which it expects to submit to a commercial publisher such as Cambridge University Press or Elsevier in early 1997. A final meeting of WG 101, to be held in mid-1996, was approved by the Executive Committee.

### **2.2.11 WG 102 Comparative Salinity and Density of the Atlantic and Pacific Ocean Basins**

The Chair of WG 102, Frank Millero, submitted to SCOR a report entitled "Effect of Changes in the Composition of Seawater on the Density-salinity Relationship" (see Annex 4) which satisfied the terms of reference of the WG. The Executive Committee agreed that this report should have formal endorsement from the relevant international organizations in order that its recommendations will be implemented by the oceanographic community. Allyn Clarke and Vere Shannon were requested to set up a panel of reviewers to comment on the report, request its publication in the UNESCO series, *Technical Papers in Marine Science*, and to draft a series of formal recommendations from SCOR, IAPSO and IOC as to the necessary modifications to the International Equation of State of Seawater (developed by JPOTS in 1980) for conversions from conductivity measurements to salinity and density. These should be disseminated in the form of an announcement to appear in the leading journals in the field of physical oceanography.

### **2.2.12 WG 103 The Role of Wave Breaking on Upper Ocean Dynamics**

The first formal meeting of WG 103 took place in July 1995, just prior to the Third International Air-Water Gas Transfer meeting. The agenda for the meeting was concerned primarily with a detailed, critical discussion of a draft document, developed in correspondence, with the aim of having a mature version by early 1996. The WG noted that several fundamental studies pertaining to wave breaking were presently in progress and may well impact on the substance and recommendations of the report. On these grounds, it was suggested that there may be some advantage in awaiting the outcomes of such studies. However, WG 103 resolved to finalize its report in the shorter term, and to review recommendations in the light of any new developments before submission of the final report to SCOR.

The Executive Committee urged WG 103 to publish its report in a traditional journal of oceanography, rather than relying completely on electronic publication via the World Wide Web. It also gave provisional approval for a meeting of the WG in 1996 if one should be required to complete the report for publication.

### **2.2.13 WG 104 Coral Reefs Responses to Global Change: The Role of Adaptation**

The Reporter for WG 104, Terry Healy, informed the Executive Committee that the WG has been very active in correspondence under the leadership of its Chair, Robert Buddemeier. The group has agreed that its title should be understood to include the role of physiological acclimation to climate change as well as adaptation in the genetic sense. Due to the interdisciplinary breadth of the subject, all of the members of WG 104 will undertake to stimulate, assemble and review contributions from colleagues outside the group, as well as producing individual contributions. The larger scientific community has been informed of the WG activities through announcements in publications such as *Reef Encounter* and *Wallaceana*, an information and discussion session at the 5th International Conference on Coelenterate Biology led by Buddemeier and Gattuso, and the establishment of a WG 104 World Wide Web Home Page (a first for SCOR: <http://ghsum1.kgs.ukans.edu/welcome.html>).

The Executive Committee approved the request of WG 104 for its first formal meeting to be held in association with the 8th International Coral Reef Symposium in Panama in June 1996. This meeting will specify the formats and schedules for the production of intermediate and final publications from WG 104. The addition of Professor Kiyoshi Yamazato as a Corresponding Member of WG 104 was approved in order to add some expertise in relation to the issue of reefs as sources or sinks of CO<sub>2</sub>.

### **2.2.14 WG 105 The Impact of World Fisheries Harvests on the Stability and Diversity of Marine Ecosystems**

Brian Rothschild (Reporter for WG 105) informed the Executive Committee that Dr. Michael Sinclair (Canada) has agreed to Chair WG 105. Following the 1994 General Meeting of SCOR, the terms of reference originally suggested for the WG have been modified as follows:

- Assess the current state of knowledge of ecosystem and food web dynamics, including numerical modelling tools, that would enable the investigation of the ecosystem effects of:
  - "overfishing" with particular respect to its definition and quantitative impacts

- "by catch"
- effects of fishing (e.g. trawling) on habitat
- Ascertain the relative importance of fisheries harvesting and climate variability on so-called regime shifts
- Sponsor a symposium on the topic and publish proceeding that summarize the state of knowledge and identify areas for future research and development.

The following individuals have accepted invitations to join WG 105:

Chair: Michael Sinclair Canada

Members:

Gabriella Bianchi	Norway
H. Gislason	Denmark
S.J. Hall	UK
John McManus	Philippines
Steve Murawski	USA
Daniel Pauly	Canada
Renato Quinones	Chile
Chris Reid	UK
Keith Sainsbury	Australia

Corresponding Members:

John Caddy	FAO
H.J. Lindeboom	Netherlands

Due to the length of time which had passed since the original submission of the proposal for the WG to SCOR, the Executive Committee urged the group to hold its first meeting in 1996, rather than 1997 as proposed in the brief report from the Chair.

#### **2.2.15 WG 106 Relative Sea Level and Muddy Coasts of the World**

The Chair of WG 106, Ying Wang, and the Reporter, Terry Healy, jointly presented the report of the first meeting of the WG which took place in Nanjing, China in October 1995. It included a mini-conference on Relative Sea Level and Muddy Coasts of the World, at which members of the WG presented aspects of the characteristics, research and problems of muddy coasts with which they were familiar. The WG devoted part of its meeting to a discussion of the classification and meaning of "muddy coasts". Subsequent to its meeting, the WG made an excursion to the coast and inspected three areas of coast north of the Yangtze River mouth. The WG was also exposed to some economic consequences of coastal developments on a muddy coast of a Developing Country (China).

The WG decided that it should plan to produce a book on muddy coasts including the following major sections:

- Statement of the problem of muddy coasts
- Definition and classification of worlds muddy coasts
- Sea level change effects
- Geographic occurrence
- Natural processes and controls - physical
- Natural processes and controls - biological
- Natural processes and controls - bio/geochemical
- Human influences and impacts
- Gaps in knowledge
- Recommendations
- Literature cited
- Contributed papers

Members of WG 106 are to prepare drafts for these various chapters by early 1996 and the Executive Committee gave its approval for a second meeting of the WG in South Carolina in September 1996, providing that significant progress has been made with this manuscript in the meantime.

Finally, addition, through the good offices of WG member, B. Flemming, the WG plans an international conference on Muddy Coasts of the World, to be hosted at the Senckenberg Institute at Wilhelmshaven, Germany. SCOR gave its approval to the group to proceed with planning for this conference which will also be sponsored by the Senckenberg Institute.

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At the end of this discussion of current Working Groups, Vice-President Krishnaswami raised several general issues pertaining to SCOR subsidiary bodies. He felt that many of the reports received were too bureaucratic and urged that Chairs be routinely instructed to include a section on the scientific achievements on their groups and how these have addressed the terms of reference. In some part, this should be the responsibility of the Executive Committee Reporter for each Working Group, and the Executive Director will contact Chairs, urging them to submit more informative reports and to maintain closer ties with the Reporter for their Working Group. Secondly, the Executive Committee agreed that more Chairs of subsidiary groups should be invited to attend annual SCOR meetings to present the results of their work. This should happen once in the life of each Working Group, meaning that three Chairs (or a member of a WG located close to the site of the SCOR meeting) should be invited to each annual meeting of SCOR.

## **2.3 Committees and Panels**

### **2.3.1 *Editorial Panel for the Ocean Modelling Newsletter***

The future funding of the Newsletter has now been secured through the European Community. The last issue published before the Executive Committee meeting was No. 109.

### **2.3.2 *Joint Global Ocean Flux Study Scientific Steering Committee***

The Chair of JGOFS, John Field, reviewed the preceding year's activities of his Committee, which had been extremely active as JGOFS passed the mid-point in its expected lifetime, and had been the subject of an external review by its sponsors. A number of reports and newsletter articles were submitted to SCOR as evidence of JGOFS' progress: some of these are found in Annex 5 including:

- "Overview of the Joint Global Ocean Flux Study" by John Field - excerpted from the most recent issue of the IGBP Newsletter. This document reviews the scientific accomplishments of the program since its inception, and was prepared for the external evaluation of JGOFS (see below).
- An article on the JGOFS Science Symposium for The Oceanography Society magazine, written by Steve Calvert.
- The summary report of the JGOFS Evaluation sub-group of the IGBP Evaluation Committee.
- New terms of reference for the JGOFS SSC, as approved following discussion by the SCOR Executive Committee.
- Current SSC membership (January 1 - December 31, 1996).

During the 1994-95 period the IGBP was evaluated by ICSU and the International Group of Funding Agencies for Global Change Research (IGFA). As part of this process, each of the Core Projects of IGBP, including JGOFS, was also reviewed by a sub-panel of the overall ICSU/IGFA Evaluation Committee. As one of the parent bodies of JGOFS, SCOR had agreed at its Executive Committee meeting in 1993, that it would welcome the results of this evaluation and Jarl Stromberg provided liaison with the reviewers throughout the process. The JGOFS Evaluation sub-panel was chaired by Devendra Lal (USA) and included Ken Mann (Canada), Wajih Naqvi (India)

and Anders Stigebrandt (Sweden). The JGOFS SSC will address the recommendations of this panel (see Annex 5) at its next meeting in April 1996.

Coincident with the evaluation process, JGOFS also passed the mid-point in its field program and this event was marked by the organization of the First International JGOFS Scientific Symposium which took place in Villefranche-sur-Mer, France in May 1995. This conference was designed to synthesize the main findings of JGOFS since its inception in 1988. The program consisted of a series of invited lectures with considerable time allocated for plenary discussion. Special emphasis was given to daily poster sessions which included guided tours with brief oral presentations by the poster authors. There were also demonstrations of JGOFS data bases and models. The Symposium was attended by three members of the evaluation sub-panel and thus served as the major point of interaction between JGOFS and the reviewers.

The JGOFS Core Measurement Protocols were published by IOC in 1995, for which SCOR is most grateful since it is critical that these protocols have the widest possible distribution, including institutions in the developing world where many of the JGOFS measurements can be made with the methods recommended in the protocols. In preparation for the Symposium, a bibliography of scientific publications arising from JGOFS was assembled and published as *JGOFS Report No. 18*. It is, of necessity, based on information received from national JGOFS committees and is incomplete, but was nevertheless felt to be a useful demonstration of the achievements of JGOFS since its establishment in 1988. This bibliography will be expanded and maintained by the JGOFS Core Project Office. Other JGOFS publications during the preceding year included a science plan for the Arabian Sea Process Study, a "Handbook of Methods for the Analysis of the Various Parameters of the CO<sub>2</sub> System in Sea Water", and 2 special issues of *Deep Sea Research*, one devoted to the Equatorial Pacific Process Study, the other to the Southern Ocean.

The JGOFS North Atlantic Planning Group met in Bergen, Norway in late May to continue planning for the final field component of the JGOFS program, an intensive process study in the North Atlantic, concentrating on the region which is now recognized to be perhaps the most significant sink for CO<sub>2</sub> in the oceanic carbon cycle. Since that meeting, however, adverse funding decisions in Europe and the US have thrown the future of these plans into considerable doubt. The SSC will discuss the implications of this problem at its next meeting.

Another disappointment has been the continuing failure to get the SeaWiFS ocean color sensor launched during the Arabian Sea Process Study. Events entirely beyond the control of the scientific community have led to the situation where this badly-needed tool, promised since the early days of JGOFS, has not been available during most of the major field components of the program. The launch of SeaWiFS is now expected in September 1996 which will mean that it will be available for much of the Southern Ocean Process Study. Other color sensors may also become available (the Japanese ADEOS, for example) before the conclusion of JGOFS.

The JGOFS Southern Ocean Planning Group met in Brest in September in conjunction with an international conference on Carbon Fluxes in the Southern Ocean which was cosponsored by SCOR. Detailed plans for Phase II of the JGOFS Southern Ocean Process Study were completed at this meeting.

Fifty-one scientists from nine countries participated in a NATO Advanced Research Workshop on the carbon cycle of the equatorial Pacific Ocean in Noumea, New Caledonia in June 1995. This was the first major opportunity for investigators in the JGOFS Equatorial Pacific Process Study to present and discuss their results, comparing the magnitude of the CO<sub>2</sub> fluxes and their controls in the central and western regions of the equatorial Pacific. It appears that primary, new and export production are all normally lower west of the international dateline and that the gradient in CO<sub>2</sub> across the air-sea interface is smaller and the food web is more oligotrophic in the west. These differences were found to be largely the result of differences in physical forcing, with the central region dominated by local winds that favor upwelling, while the nutrient content of the upwelled water depends on remote westerly winds in the western Pacific. In the western equatorial Pacific, winds are weaker and more variable. A low-salinity surface layer lies over an isothermal "barrier layer" that blocks the vertical transport of nutrients.

Preliminary plans were developed for a final JGOFS equatorial Pacific synthesis symposium to be held, possibly in 1997.

Another aspect of the JGOFS program which had advanced during 1995 is the joint effort with the Land-Ocean Interactions in the Coastal Zone (LOICZ) Core Project of IGBP on continental margins studies. A joint Task Team has been reconstituted under the leadership of Julie Hall (New Zealand) and Steven Smith (USA) in order to develop a JGOFS/LOICZ marginal seas study. The first meeting of this joint group will take place in Texel in April 1996.

Field also reported that, after much concern about the status of funding for the JGOFS Office in Kiel, and many discussions with possible alternate hosts for the office, arrangements were being concluded to move the JGOFS Core Project Office from Kiel University to the University of Bergen. The position of JGOFS Executive Officer will be filled by Dr. Roger Hanson (USA) [who took up his post very early in 1996]. The CPO will be supported primarily by the University of Bergen and the Norwegian Research Council; SCOR will continue to provide the funds for JGOFS planning meetings, publications, staff travel and so on.

Five members of the JGOFS SSC were due to rotate off the JGOFS SSC on December 31 and Professor Field sought the approval of SCOR for the following scientists to become members for three year terms, effective January 1, 1996: Alexander Bychkov (Russia), Hugh Ducklow (USA), James Murray (USA), Bronte Tilbrook (Australia) and Jürgen Willebrand (FRG - being renewed for a second term). This approval was given after consideration of the scientific expertise of each nominee. [All of these individuals accepted the invitation from SCOR and IGBP, joining the SSC at the beginning of 1996. The current membership of the SSC is given in Annex 5.]

Finally, IGBP had requested that all of its Core Projects adopt terms of reference and suggested a model for these which was much more detailed than the original scientific terms of reference assigned to the JGOFS SSC by SCOR in 1988. They give procedural details about the duties of SSC members, the functions of a Core Project Office, and so on. At the same time, the SCOR terms of reference for the JGOFS SSC are out-of-date. For example, they still refer to the preparation of a Science Plan, although this was published in 1990. Accordingly, the Executive Committee revised the SCOR terms of reference for the JGOFS SSC, appending the IGBP suggestions in the form of a set of "Operating Procedures for the JGOFS SSC". The complete document, as approved by the Executive Committee appears in Annex 5.

The Japanese SCOR member, Shizuo Tsunogai, commented on the presentation by the JGOFS Chair, regretting the lack of internationally-coordinated JGOFS activity in the north Pacific Ocean. He noted that much of the relevant Japanese research is not regarded as "core" research by JGOFS or the IGBP, although this region may be very important in the oceanic carbon cycle. Field responded that JGOFS does depend on contributions from national and regional research programs, in addition to the core program which is coordinated through the international SSC, and that if scientists from nations bounding the north Pacific Ocean wish to propose an appropriate JGOFS activity in the region, the SSC would be pleased to consider it: the present JGOFS program consists of components developed in this manner. John Field appealed to Tsunogai to promote more interaction between the Japanese JGOFS community and the international SSC and agreed to propose the establishment of a planning group for the North Pacific

### **2.3.3 SCOR/IOC Committee on Global Ocean Ecosystems Dynamics**

The Chair of GLOBEC, Brian Rothschild, reviewed the activities of the past year. During this period, the SCOR/IOC Global Ocean Ecosystem Dynamics program concentrated on the development of its Science Plan. From the original establishment of GLOBEC by SCOR, a major goal of all parties involved has been to have the program adopted as a Core Project of the International Geosphere-Biosphere Program (IGBP), thereby incorporating GLOBEC into the framework of the international global change research effort. A précis of the draft GLOBEC Science Plan was presented to the Scientific Committee for the IGBP in late December 1994. As a result,



the IGBP and SCOR established a "Core Project Planning Committee" which was charged with completing the Science Plan. This goal was achieved and Brian Rothschild presented the Plan to the IGBP at its meeting in Beijing in October. The IGBP agreed to adopt GLOBEC as a Core Project. The SC-IGBP suggested certain minor additions to the draft Science Plan prior to its formal publication in early 1996.

The SCOR Executive Committee expressed its appreciation for the effort required by the GLOBEC Chair, Rothschild, and the other members of the CPPC (Robin Muench - Chief Editor, John Field, Berrien Moore, John Steele, Jarl Stromberg and Takashige Sugimoto) and endorsed the Science Plan as presented to the IGBP. The full document will be available from the SCOR and IGBP Secretariats following its publication. The meeting also agreed that, with this stage of the GLOBEC planning process completed, it would now be appropriate to reconstitute the GLOBEC SSC which had remained unchanged since its establishment in 1991. The Officers of SCOR agreed to assume the responsibility for this matter, following discussions with the other two international sponsors of GLOBEC, IOC and SCOR. According to IGBP procedures, two major initial responsibilities of the new SSC will be to organize a GLOBEC Open Science Meeting and to develop an international Implementation Plan.

While these actions were underway, GLOBEC planning continued during 1995, primarily along two lines: modelling activities and the development of the program on Small Pelagic Fishes and Climate Change (SPACC). Two meetings of the Numerical Modelling Working Group took place during the year and a major report on the status of GLOBEC models is forthcoming. Particular emphasis has been placed on the linking of model development with new technology to create a GLOBEC "Advanced Modelling and Observational System".

The goal of the GLOBEC Small Pelagic Fishes and Climate Change (SPACC) program is to understand and ultimately predict climate-induced changes in the fish production of marine ecosystems. In addition to having broad economic importance, this goal is especially pertinent today because of the accumulation of greenhouse gases that will force changes in ocean climate over the next hundred years. Small pelagic fishes are an ideal subject for the study of climate variability and ocean forcing because they are globally distributed, constitute over a third of the global marine fish catch, and respond rapidly to changes in ocean forcing because of their brief lives and short, plankton-based food chains based primarily on the continental shelves and in coastal seas. The basis for a SPACC Science Plan was developed at a workshop involving more than 50 scientists which took place in La Paz, Mexico in June 1994. A draft document was in the final stages of preparation by a working group chaired by John Hunter (USA) and Jürgen Alheit (FRG). A SPACC planning workshop involving European and African scientists was about to take place in Namibia (December 3-8 1995), and a second such workshop, primarily for North and South Americans, will be held in Mexico City in mid-1996.

As for JGOFS (see 2.3.2 above), the Executive Committee agreed to a revised set of terms of reference and operating procedures for the GLOBEC SSC (see Annex 6), pending discussion by the reconstituted Committee at its first meeting. Lastly, the Executive Committee had before it the draft text for a Memorandum of Understanding to be signed by IOC and SCOR as to their sponsorship of GLOBEC. This as yet unsigned document, developed before the decision by the IGBP to adopt GLOBEC as a Core Project, defined the international sponsors of GLOBEC as SCOR and IOC (and potentially IGBP) and recognizes ICES and PICES as the sponsors and lead organizers of two important regional components of the international GLOBEC program. These are the ICES/GLOBEC study of Cod and Climate Change in the North Atlantic and the PICES/GLOBEC program on Carrying Capacity and Climate Change in the temperate and sub-arctic North Pacific. The text of this draft document was approved in principle, subject to further discussion with IGBP.

#### **2.3.4 SCOR/IGBP/WCRP ad hoc Planning Committee for the Global Ocean Euphotic Zone Study**

The Deputy Executive Director of IGBP, Neil Swanberg, provided information on the status of GOEZO (now suggested as SOLAS - Surface Ocean - Lower Atmosphere Study). Initial planning for GOEZO was carried out under the auspices of a SCOR/IGBP/WCRP *ad hoc* working group in the 1992-1994 period. The program as envisioned then was to build upon the results of JGOFS and WOCE in developing an interdisciplinary study of the complex interactions between the upper ocean and the atmosphere. Concerns arose about the capacity of the

oceanographic community to undertake detailed planning for another large-scale scientific program before its predecessors are satisfactorily completed. It has been agreed within IGBP that further planning should await the results of the new IPCC assessment. SCOR concurred with this view, especially as many of the individuals involved in the early GOEYS workshops were also authors of relevant chapters in the IPCC Scientific Assessment, due to be made public in early 1996.

#### **2.4 Proposals for New Working Groups**

The four proposals discussed below were circulated to all national committees for comments in preparation for the Executive Committee meeting. Following the detailed discussion of each proposal, a vote was taken (in accordance with the provisions of the SCOR Constitution), taking into account the financial limitations of SCOR, and it was agreed that the proposals on Improved Global Bathymetry and on Double Diffusion should be accepted.

##### **2.4.1 Improved Global Bathymetry**

This proposal was submitted to SCOR in 1994 and subsequently revised by the UK SCOR Committee following discussions at the 1994 General Meeting. It was presented by Colin Summerhayes who emphasized that the suggested working group was intended to investigate the needs of the scientific community, and especially the modelers and ridge researchers, for higher resolution, more accurate bathymetric information. Although image and topographic maps have already been made of the Moon, Mars and Venus, less than 10 percent of the 66% of the Earth's surface covered by the deep sea (>1km deep) has been mapped with equivalent resolution. It has recently become apparent that leaving out small details in bathymetry can have a big effect on the output of physical oceanographic models of the ocean's circulation. Detailed bathymetry is also increasingly required by the InterRIDGE community attempting to establish with high resolution the tectonic history and evolution of plate separation and hydrothermalism along the mid-ocean ridge.

Comments from Robin Muench and others supported the view that "our present bathymetric information is woefully inadequate. These inadequacies are felt in modelling, in attempting to plan field activities and in some cases, even in attempting to construct simple conceptualizations for physical processes." Responding to some concerns, Summerhayes assured the meeting that the intent of the proposal was not to develop a global bathymetric survey or to develop a long-term program - these activities should be the responsibility of the hydrographic agencies. Rather it is hoped that, through such a WG, the modelling community, and others who require it, will have an opportunity to specify where improved bathymetry is needed for scientific applications.

Colin Summerhayes accepted the request of the Executive Committee to Chair this new Working Group which will be WG 107. He agreed to finalize the membership list taking account of additional suggestions made during the meeting. The entire proposal, as approved by SCOR, is given in Annex 7.

##### **2.4.2 Double Diffusion**

Allyn Clarke introduced this proposal which was originally submitted by the Russian SCOR Committee in 1992 and revised for reconsideration by this meeting, taking into account progress in the field. He noted that the document under consideration called for a review of our current understanding of this small-scale physical process, a comparison of laboratory results with the real oceanic situation, a comparison of laboratory and field data with models, and the development of recommendations for further investigations in this field. Robin Muench provided comments which noted that double diffusion is an important process in much of the world ocean, particularly in the more quiescent central basins away from energetic boundary regions. Parameterizations of double diffusive processes are needed for numerical modelling and for a better understanding of the deep ocean distribution of certain variables.

The meeting agreed with Muench's view that this is a timely topic which lends itself to treatment by a SCOR Working Group. Although a few participants dissented from this view, the vote taken at the meeting resulted in the acceptance of the proposal. This will be WG 108, Co-chaired by Yuli Chashechkin (Russia) and Joe Fernando (USA) who will finalize the membership of the WG in consultation with Clarke who will act as its Reporter. The

proposal as accepted by SCOR is given in Annex 8.

#### **2.4.3 *Coupling Ocean Circulation and Ecosystem Development in Models***

This proposal, submitted by the German SCOR Committee, was presented by Wolfgang Fennel. He noted that eddy resolving modelling of the circulation of the oceans, self seas and semi-enclosed seas has made substantial progress in the last decade, but that ecosystem modelling is lagging behind owing to conceptual difficulties in mathematical formulation of the complex biogeochemical processes as well as to the important role of the physical control of the ecosystem. The fundamental rationale for the proposal was to carry out a careful investigation of the problems inherent in interfacing of biological and physical models and to identify gaps in the parameterizations of the relevant processes.

The discussion revealed various concerns about the potential for overlap between such a WG and the ongoing modelling activities within JGOFS and GLOBEC and in the research groups at the major modelling centers. In addition, the 1996 Liège Colloquium will address this topic and the resulting publication is likely to be of great interest. It was not felt that a SCOR Working Group was required to advance this particular field at this time.

#### **2.4.4 *Coupling Wind, Waves and Currents in Coastal Models***

Ian Jones introduced this proposal on behalf of Norden Huang, a member of WG 101, who had submitted it. He noted the increasing interest in coastal oceanography and the need to develop models which can incorporate data on wind fields and waves as well as currents in order to understand coastal circulation processes. Past research efforts have tended to focus on these features separately, whereas their dynamics are actually coupled. WG 101 has found, for example, that winds stresses cannot be parameterized without a complete knowledge of the underlying waves. The proposed group would examine the critical issues involved in the coupling between wind forcing, surface waves and currents in the coastal ocean, review existing data sets and define future needs. Lastly, the terms of reference proposed that the WG would extend its task to an examination of the role of coastal waters in global ocean dynamics and climate studies.

A major concern about this proposal was the potential for overlap with the WISE (Waves in Shallow Environments) group which developed out of the Wave Modelling (WAM) group after SCOR WG 83 completed its tasks and was disbanded. In many respects, WG 83 had provided an international steering group for WAM which was primarily a European effort. A number of SCOR national committees commented on the possible overlap with WISE whose mandate makes it the principal international focus for scientists interested in modelling and research on waves in shallow and coastal waters. WISE is considering, among other things, the results from spectral wave models with fully-coupled wave-current interactions, and the coupling of shallow water models of waves, hydrodynamics and sediment processes.

The Executive Committee agreed that the task of the proposed group should not be so broad as to include an examination of the role of the coastal ocean in global ocean dynamics and climate since this topic is being addressed in some of the large-scale international global change research programs such as LOICZ (IGBP) and some components of the World Climate Research Program.

In summary, the meeting recommended that Huang should consult with the WISE group for information on its activities. A suitably revised proposal could be considered at the General Meeting in 1996. Several membership nominations, including one which would ensure liaison with WISE, will be transmitted to Huang.

#### **2.5 *Mechanism for the Oversight and Sponsorship of Continuing Activities***

The President introduced this discussion, which continued one begun at the XXII General Meeting about a means of providing SCOR sponsorship to activities which are of a long-term nature and are therefore not suitable for a SCOR Working Group. A discussion paper was circulated to national committees for comment and the views of the members of the scientific groups involved with each of these programs have been sought.

From time to time, SCOR Working Groups propose activities which will extend beyond the normal life of the group and for which continuing SCOR sponsorship or oversight is appropriate. Examples of this are the Acoustic Thermometry of Ocean Climate (ATOC) program being planned by WG 96 and the International Marine Aspects of Past Global Changes Study (IMAGES) developing out of WG 100. In addition, groups external to SCOR may seek international endorsement of oceanographic programs. Current examples of this are the International Antarctic Zone (IANZone) coordinating group and the ongoing InterRidge study. Unlike existing large-scale programs of SCOR such as JGOFS and GLOBEC, funding for these programs is in place and the type of relationship proposed would not involve SCOR, or its Secretariat, in heavy commitments of funds or staff support.

The discussion paper proposed a mechanism for a new type of involvement of SCOR in programs such as these, referred to as SCOR-Affiliated Programs. This role for SCOR could be seen as one of service to the oceanographic community which is actively seeking SCOR sponsorship for existing activities coming from the community itself.

SCOR's role in relation to an Affiliated Program would be one of advice and occasional review. SCOR would wish to be involved in membership decisions, ensuring that the steering committees include appropriate international and disciplinary balance. SCOR's national contacts could be used to find new members in regions where there is a need, or to entrain new countries into projects. SCOR can assist in involving participants from developing countries in these activities by using SCOR-NSF funds as "seed money" for this purpose. Direct links to related programs can be made through SCOR - for example, JGOFS needs the historical information which IMAGES will provide and IANZone (primarily physical oceanographers) needs links to the Southern Ocean projects within JGOFS and GLOBEC. SCOR could also provide an independent mechanism for the review of planning documents such as Science or Implementation Plans.

The same rigorous criteria should be applied in any decision to give SCOR endorsement to an international activity as would be considered in establishing a new working group. That is, a proposal of 2 to 5 pages should be sent to SCOR at least three months before an Executive Committee Meeting or General Meeting of SCOR requesting Affiliated status for the program in question. It should include an outline of the program's science plan, the terms of reference and current membership of the steering committee and a statement of the need for international endorsement by SCOR. The program must be truly international in nature and the proposal should include a commitment to involving SCOR in membership decisions and to a plan for the routine rotation of membership and the chair of the steering committee for the program. Once a program has Affiliated status in SCOR, annual reports would be expected. At each biennial SCOR General Meeting these should be somewhat more substantial (and scientific lectures may be requested) in order that the decision to continue the relationship between SCOR and each program may be made. SCOR would not normally envision sponsoring an Affiliated program for more than ten years.

In order to strengthen the links with SCOR, the proposal suggested that the Chair of each Affiliated Program be made an ex-officio member of SCOR as a Scientific Rapporteur (see SCOR Constitution paragraph 4), a category of Representative Members which has not been used for some time.

There was an detailed discussion following the introduction of this proposal in which a set of criteria for programs seeking affiliation with SCOR was developed. The Executive Committee agreed that in order to become an Affiliated Program, an activity must:

- be truly international, with a membership that rotates periodically
- show evidence of existing financial and/or organizational support
- demonstrate a need for SCOR sponsorship
- have a scientifically well-integrated theme
- show that it is in SCOR's interests to establish this affiliation
- be of broad scale and global importance

- show, as appropriate, that any scheme of membership payments includes some nominal level so as to encourage the widest possible international participation by all countries
- be willing to adhere to the SCOR Publication Policy.

These criteria, coupled with the guidelines for the establishment of new SCOR Working Groups, should be applied in any decision about affiliation of a program with SCOR.

The Executive Committee gave its approval to this proposal, and moved to a consideration of each of the four current programs which had requested some sort of long term association with SCOR.

#### ***Acoustic Thermometry of Ocean Climate (ATOC)***

This international experiment is designed to use the special characteristic of the propagation of sound waves across very long distances in sea water to monitor small changes in the temperatures of oceanic water masses. It began with the Heard Island Feasibility Experiment in 1992, and plans are now being made for sound transmissions in several ocean basins. ATOC is primarily funded by the US, but for several years, WG 96 has served as a forum for involving participants from other countries in ATOC. This proved to be an invaluable mechanism, for example, for the design of a trans-Arctic ATOC involving US, Canadian and Russian scientists, and for the development of plans for ATOC in the Indian Ocean with the South Africans, Indians, Australians and others.

WG 96, however, is coming to the end of its life as a SCOR WG. Yet the need for an international steering committee for ATOC will remain for a number of years to come. The goals of the program are well known to the Executive Committee through presentations at SCOR meetings by the WG 96 Chair, David Farmer (and at this meeting by WG 96 member, Geoff Brundrit). In the discussion of the WG report for 1995 (see item 2.2.5 above), the Executive Committee gave its approval for the final meeting of WG 96 to be held in early 1996, following which the WG will be disbanded at the XXIII General Meeting. The Executive Committee approved in principle the transition of WG 96 into an international steering group for ATOC as an Affiliated Program of SCOR, provided that WG 96 submits a document outlining its plans for ATOC and addressing the criteria established above.

#### ***International Marine Global Changes (IMAGES) - joint program of SCOR and PAGES***

In 1993, in accordance with its terms of reference, SCOR WG 100 proposed a plan for an international study of the record of global climate change contained in marine sediments in order to fill a recognized gap in the ongoing global change research programs. IMAGES was accepted as a program under the IGBP Core Project on Past Global Changes (PAGES) and is cosponsored by SCOR. WG 100 agreed to act as an initial steering group for IMAGES, recognizing that some longer term arrangement would need to be found since the WG was due to be disbanded, having fulfilled its terms of reference. The report of WG 100 to the Executive Committee meeting recommended a management structure, including a fully-funded IMAGES office with an Executive Director, a steering committee, and an executive group. It also proposed a structure of fees for national participation in the IMAGES program.

The Executive Committee was concerned that this fee structure would effectively exclude the participation of developing countries in the IMAGES program. It agreed to refer the matter to the Chair of IMAGES, Nick Pisias, urging the development of a sliding scale of fees on which the lowest level would be a nominal contribution which would allow the participation of all countries, based on their relative abilities to pay and their infrastructure available to support the IMAGES plan (ships with large coring capabilities, etc.).

With this one condition, the Executive Committee approved a formal affiliation between SCOR and the IMAGES program.

### ***International Antarctic Zone Program (IANZone)***

This was originally a proposal for a new SCOR Working Group submitted for discussion at the General Meeting In Victoria in 1994. The need for a new mechanism for the association of SCOR with long-term programs became evident as a result of this proposal, since this activity is one which is likely to outlive the normal Working Group.

IANZone is an informal coordinating group in support of climate based research within the Antarctic Zone of the Southern Ocean. The Antarctic Zone is considered as the region south of the Antarctic Circumpolar Current, generally the region influenced by the presence of sea ice during at least part of the year. The Antarctic Zone is the site of significant interaction of deep water of the world ocean with the atmosphere. Research activities included within IANZone are: physical and tracer oceanography, sea ice physics and boundary atmospheric science, i.e. those pertaining to the physical basis of climate. A number of projects have been developed or have been expanded under the IANZone umbrella (the Ice Station Weddell project of 1992 and the AnzFlux project of 1994). Further, the IANZone meetings have provided fora which led to significant foreign participation in primarily national programs. For example, several German data buoys are being deployed during the US-sponsored AnzFlux program.

The main goal of IANZone is defined as:

to advance our quantitative knowledge and modeling capability of the seasonal cycle and inter-annual variability of the ocean and its sea ice cover, with emphasis on climate relevant fluxes which couple the Antarctic Zone to the atmosphere and to the global ocean.

The proposal before the Executive Committee reviewed the interactions of the IANZone group with other international programs. It noted that the WOCE Southern Ocean effort was disbanded and that the new WCRP program, CLIVAR, will have Southern Ocean interests but no body of Southern Ocean experts is envisioned. The WCRP program ACSYS has an Arctic focus, though they view their sea ice modeling interest as bi-polar. IANZone activities would be a great help in deriving the information needed to have the Southern Ocean processes represented in sea ice models. JGOFS has specific Southern Ocean interests, but these deal with the biological system, not the physical basis of Climate, the IANZone primary thrust. SCAR and IASC (International Arctic Science Committee) endorsed regional research programs which address the polar role in global change. IANZone would be in a position to recommend required Southern Ocean elements in that endeavor. WCRP project IPAB (International Program of Antarctic Buoys) is a narrowly defined project that contributes to IANZone goals and coordination of IANZone and IPAB would be sought.

In reviewing IANZone's request for SCOR sponsorship, the Executive Committee noted the lack of participants from the southern hemisphere in IANZone's activities. It did not appear that IANZone is a sufficiently international group to warrant the affiliation with SCOR. Concern was also expressed about the proliferation of formal bodies involved in Antarctic science. On the other hand, the Executive Director informed the meeting that she had provided the proposal to SCAR on more than one occasion, making the suggestion that a SCOR-SCAR joint sponsorship might be appropriate. No response was received from SCAR.

As a result of these two concerns, and the lack of supportive comments at the meeting, the Executive Committee decided that the IANZone activity should not become affiliated with SCOR at this time.

### ***Interdisciplinary Ridge Experiment (InterRIDGE)***

WG 99 (Linked Mass and Energy Fluxes at Ridge Crests) was originally established as a SCOR contribution to the InterRIDGE program, an international coordinated effort on interdisciplinary studies of mid-ocean ridges. It seemed appropriate to have a more formal affiliation between SCOR and the InterRIDGE program which has a coordinating office, existing national programs and an established international steering committee. The Executive Committee noted the offer of InterRidge co-sponsorship for both the booklet and the symposium being organized by SCOR WG 99. It agreed to seek more information on the membership structure of InterRIDGE to ascertain whether a formal affiliation with SCOR was desirable for both organizations.

### 3.0 ORGANIZATION AND FINANCE

#### 3.1 Membership

The Executive Director informed the Executive Committee meeting of the following changes in SCOR membership since October 1994:

##### *Nominated Members:*

- Canada: Professor Louis Hobson has been appointed as Canada's third Nominated Member.
- China: The Committee for SCOR located in Taipei has informed SCOR that Dr. Yu-Chia Chen and Dr. H.W. Li have replaced retiring Nominated Members, K.H. Chang and C.T. Wang.
- India: Dr. E. Desa and Professor Vinod Gaur have joined Professor S. Krishnaswami as Indian Nominated Members of SCOR.
- Ireland: Following the acceptance of the Irish membership application in 1994, Professor M. Orren, Mr. Ray Keary and Ms. Evelyn Murphy were appointed as Nominated Members.
- Japan: Professor Keiusuke Taira has replaced Professor Tomio Asai as a Nominated Member.
- Russia: Academician L.M. Brekhovskikh and Professor A.S. Monin, long-standing members of SCOR, have retired as Nominated Members and have been replaced by Dr. I.A. Basov and Professor S. Lappo.
- Thailand: Professor Manuwadi Hungspreugs and Vice-Admiral La-iad Sungchaya are newly-appointed Nominated Members.

In addition to these changes, the Executive Committee meeting was informed of the following changes by various national representatives:

- Germany: Professor Gerold Wefer has replaced Professor Gerold Siedler as one of the German Nominated Members of SCOR.
- Italy: The former Nominated Members of SCOR (Battaglia, Morelli and Mirabile) have been replaced by Drs. Roberto Meloni and Roberto Purini.

##### *Ex-officio SCOR Members:*

IAPSO has elected Dr. Vere Shannon (South Africa) as President-elect. He will take office in 1996, replacing Robin Muench as ex-officio member of the SCOR Executive Committee. Dr. Fred Camfield (USA) became Secretary-General and a member of SCOR.

IAMAS has elected Professor R. Duce (USA) as President. He becomes an ex-officio member of the SCOR Executive Committee. The new IAMAS Secretary, Professor R. List (Canada), becomes an ex-officio member of SCOR.

##### *Representative Members:*

Dr. R. Buddemeier (USA), Dr. M. Sinclair (Canada) and Professor Ying Wang (China) became members of SCOR as the Chairs of WG's 104, 105 and 106 respectively.

S. Krishnaswami, speaking as Membership Officer, reported that the effort to increase SCOR's membership continues and that correspondence has been exchanged with many representatives of the oceanographic community in many countries. In particular, discussions with individuals in Kenya and Tunisia seem especially promising. He suggested that, in view of preliminary plans to hold the 1997 Executive Committee meeting in Brazil, representatives from South American countries which are not members of SCOR should be invited to that meeting.

The Executive Director informed the meeting that Bangladesh was currently five years in arrears in payment of its membership dues and that, in accordance with SCOR policy, its membership should be terminated. Krishnaswami and others pleaded for sympathy in this case where the financial situation is so difficult. The Executive Committee referred this matter to the *ad hoc* Finance Committee for a recommendation.

Johannes Lutjeharms (South Africa) stated that SCOR should not be making a "stamp collection" in its membership efforts, but that there are countries where the encouragement of SCOR would be valuable in the development of their scientific communities.

### **3.2 Publications Arising from SCOR Activities**

The Executive Director presented a report on publications arising from SCOR activities since the XXII General Meeting:

#### ***IOC Workshop Reports***

First IOC-CEC-SCOR Workshop on Coastal Ocean Advanced Science and Technology (COASTS). Liège, Belgium. 8-9 May 1994. IOC Workshop Report No.102.

#### ***JGOFS Publications***

Report of the Ninth Meeting of the JGOFS Scientific Steering Committee and the Report for 1993/94 of the JGOFS Southern Ocean Planning Group. JGOFS Report No. 16. January 1995.

The JGOFS Arabian Sea Process Study. JGOFS Report No. 17. March 1995.

The Joint Global Ocean Flux Study: Publications, 1988-1994. JGOFS Report No. 18. April 1995.

First JGOFS International Scientific Symposium. Villefranche-sur-Mer, May 8-12 1995. Book of Abstracts.

Protocols for the Joint Global Ocean Flux Study (JGOFS) Core Measurements. IOC Manual and Guides No. 29.

Handbook of Methods for the Analysis of the Various Parameters of the Carbon Dioxide System in Sea Water. Version 2 - September 1994. Edited by Andrew G. Dickson and Catherine Goyet. ORNL/CDIAC-74. Published by Oak Ridge National Laboratory of the US Department of Energy.

Topical studies in Oceanography. A U.S. JGOFS Process Study in the Equatorial Pacific. Guest Editor, J. W. Murray. Deep-Sea Research Part II, Vol 42, nos. 2-3, 1995. pages 275-903. (28 articles)

Southern Ocean JGOFS: The U.K. "Sterna" Study in the Bellinghausen Sea. Deep-Sea Research Part II, Vol. 42, nos. 4-5, pages 905-1335. (22 articles).

#### ***GLOBEC Publications***

GLOBEC Southern Ocean Implementation Plan. GLOBEC Report No. 7.

An Advanced Modeling/Observation System (AMOS) for Physical-Biological-Chemical Ecosystem Research and Monitoring (Concepts and Methodology). A Working Paper/Technical Report prepared by the GLOBEC Working Groups on Numerical Modeling and Sampling and Observation Systems. GLOBEC Special Contribution No. 2. (in press)

#### ***Other Publications Arising from SCOR Subsidiary Bodies***

Dynamics and Modelling of Ocean Waves. The final report of SCOR WG 83. Cambridge University Press. 1994.

IMAGES - International Marine Global Change Study: Science and Implementation Plan. PAGES Workshop



Report Series 94-3. Prepared by WG 100 and published jointly by SCOR and PAGES.

Scientific Committee on Oceanic Research: Ecology of the Deep Sea Floor and Pelagic Biogeography. *Progress in Oceanography* Vol. 34, No. 2-3. The final report of WG 76 and a collection of papers from WG 93.

***Publications Arising from Other SCOR Activities***

Changes in Fluxes in Estuaries: Implications from Science to Management. Keith R. Dyer and Robert J. Orth (eds). Olsen and Olsen, Fredensborg 1994. The Proceedings of the Joint Symposium organized by the Estuarine and Coastal Sciences Association and the Estuarine Research Foundation, co-sponsored by SCOR and held at the University of Plymouth in September 1992.

Zooplankton Production. Proceedings of a Symposium held in Plymouth, England 15-19 August 1994. Guest Editor: Roger Harris. *ICES Journal of Marine Science*, Vol. 52, Nos. 3 and 4. This symposium was cosponsored by SCOR.

SCOR Proceedings, Volume 30. Report of the 22nd General Meeting of SCOR. Sidney, B.C., Canada. October 17-20 1994.

SCOR Handbook. July 1995.

Ocean Modelling Newsletter - Nos. 103 through 109 were published during this period.

The Publications Officer, Terry Healy, led the ensuing discussion, proposing a change to the Publications Policy as it currently appears in the *SCOR Handbook*. A sentence was added to the first clause to state that "Publication of results [of Working Groups] in the peer-reviewed literature is preferred." This clause, and the fourth, which states that "The SCOR Executive Committee should review each Working Group's publication plan at its mid-life point", will be added to section 8.2 of the Objectives and Procedures for SCOR Working Groups.

There was a suggestion that Working Groups should, where appropriate, the establishment of Home Pages on the World Wide Web for dissemination of information about their activities. This should not be a requirement since all Chairs may not have easy access to full electronic communication capabilities, and this should not limit SCOR's choice of Chairs for its groups. The Secretariat will urge WG Chairs to consider this issue as soon as possible.

In this regard, the Executive Committee agreed that a SCOR Home Page should be developed, but that to be effective it must be kept up-to-date. There should be "pointers" to any Home Pages established by Working Groups and other SCOR activities (e.g. the JGOFS Home Page).

**3.3 Finance**

The Chair of the *ad hoc* Finance Committee, Colin Summerhayes, presented its report. The Committee, working during the Executive Committee meeting, first reviewed the budget and final financial statement for the 1994 fiscal year, recommending acceptance of the auditors' report. [See Annex 9.]

The Finance Committee next reviewed the projections of income and expenses to the end of the 1995 fiscal year against the budget approved by the 1994 General Meeting and subsequently amended with the required approval of the President and Secretary of SCOR. They noted that the anticipated beginning balance (i.e. the cash on hand at the end of 1994) was \$15,000 less than budgeted, and determined that this resulted principally from a \$20,000 over expenditure by GLOBEC on meetings and publications in 1994. These changes in expenses were not noted until after the General Meeting at which a balance of \$83,000 had been estimated. Despite this shortfall, the overall income for 1995 was some \$50,000 more than expected, primarily because of unanticipated support for specific JGOFS activities from new sources.

The Finance Committee analyzed how the Executive Director had spent her time on different activities in 1995, determining that a substantial proportion had been spent in providing staff support to JGOFS and GLOBEC. It was decided to attribute this cost to those programmes, and to ensure that this was done systematically in future years. In previous years most of these costs appeared under general administration. In future years it would be advisable to estimate these costs in advance so that they could be included in the JGOFS and GLOBEC budgets to avoid those budgets being seen by the SSCs as entirely disposable. Following attribution of salary and benefits costs, expenditure on JGOFS and GLOBEC matched the tied income to those projects. In future years the tied income needs to be fully identified on the income statement.

Publications were around \$7,000 over budget because problems with the printer led to expenses being under-estimated, and costs (e.g. postage) had risen. To avoid problems with printing costs in future, the secretariat will acquire competitive quotes for major tasks.

Expenditure on Working Groups was \$40,000 less than expected, several having delayed their main meetings.

The Finance Committee drafted a budget for 1996 activities, taking into account the requests for Working Group meetings which had been approved by the Executive Committee. The starting balance was anticipated as \$101,000, being more than usual because of the carried over \$40,000 for working groups. A conservative view was taken of income, allowing for \$30,000 less in income for JGOFS in 1996 than in 1995 (see above). It agreed that there are enough funds in the SCOR budget to enable two new working groups to start in 1996, and this recommendation was considered in the actions taken on the proposals discussed under agenda item 2.4.

In allocating funds the Finance Committee took into account the following key points:

- there should always be a year end balance of at least \$30,000 to carry over to support SCOR operations and activities at the beginning of the next financial year before new moneys arrive.
- working groups should be encouraged in writing to organize their meetings in association with international scientific events for which other travel funds may be available to WG members, so as to keep SCOR's commitments down to around \$10,000 or less per meeting if possible.
- membership fees should be increased as far as possible in line with inflation, not (as recommended in the 1994 General Meeting) by ICSU's policy of 1.5-2.0% over OECD inflation. In this instance the Executive Committee recommended an increase of 3% (approximately in line with inflation) to meet the following requirements of the Finance Committee:
  - to ensure that there is a minimum year end balance of \$30,000
  - to ensure a healthy level of Working Group activity and to compensate for increases in fares;
  - to enable a long overdue increase in the salary of the Executive Director.
- the membership fees for Bangladesh should be waived for 1990, to enable them to retain membership, but every effort should be made to get them to pay their current fee (recognizing that it would be difficult if not impossible for them to come up with their arrears). This policy should not be continued indefinitely, however. Other arrears are almost negligible, but the effort to collect them should be continued nonetheless.
- efforts should continue to attract new members; currently discussions are taking place with Kenya and Tunisia.
- the President and Secretary, assisted by the Executive Director, should carry out by year end 1995 a comparative review of administrative salaries as the basis for setting new salaries for the secretariat, to take effect from 1.1.96. The Finance Committee's recommended budget for 1996 anticipates an increase of 8% in salary plus benefits, to compensate for the long period with lack of any increase; the increase will require an increase also in the overheads payable to Johns Hopkins University.
- a list of private foundations has been made by the Strategic Planning Committee under the Chairmanship

of Ian Jones. Working Group Chairs should be encouraged to write proposals for external funds from these foundations, but to ensure the application of a common standard, and to exercise some control, the proposals should go through the SCOR office.

- the Finance Committee supports the decision of the General Meeting to conduct a review of SCOR operations and urges that this include a review of the resources and staffing available for the secretariat.
- bearing in mind the difficulties faced by Norway in fully funding the JGOFS office in Bergen, consideration should be given to using the JGOFS Special Fund for this purpose if the problem becomes insurmountable.

The Executive Committee accepted the report of the *ad hoc* Finance Committee, thanking its Chair and members for their efforts.

### **3.4 Establishment of a Nominations Committee in Preparation for Elections at 1996 General Meeting**

The term of the President will expire at the XXIII General Meeting in 1996 and he is ineligible to be re-elected. The terms of the Secretary and the three Vice-Presidents expire at each General Meeting. Vice-Presidents Wang Pinxian and S. Krishnaswami are eligible to be re-elected for an additional two year term. Vice-President Terry Healy is not eligible for re-election, having served three two-year terms. While the recent amendments to the SCOR Constitution limit the Secretary and Vice-Presidents to serving two consecutive terms, it was agreed at the 1994 General Meeting that the changes should not apply to current officers. Therefore the Secretary, Brian Rothschild is also eligible to serve an additional (third) term in office.

In preparation for the elections at the 1996 General Meeting, the Executive Committee appointed a Nominations Committee to be chaired by the Past-President, Jarl Stromberg, and with Colin Summerhayes (UK) and Su Jilan (China) as members. SCOR Committees will be invited to send their nominations for the vacancies on the Executive Committee to the Nominations Committee for consideration.

## **4.0 RELATIONS WITH INTERGOVERNMENTAL ORGANIZATIONS**

### **4.1 Intergovernmental Oceanographic Commission (IOC)**

The Fourth Vice-Chairman of IOC, Ezekiel Okemwa (Kenya) informed the meeting about current structure and activities of the Commission, and in particular the progress in the development of the Global Ocean Observing System (GOOS) and in Training, Education and Mutual Assistance (TEMA). IOC provides some financial support to SCOR for activities of mutual interest.

The IOC continues its effort to be responsive to the issues raised at the United Nations Conference on Environment and Development (UNCED - the "Rio Conference", June 1992) and in Chapter 17 of the resultant document, Agenda 21, which emphasizes the protection of oceans, enclosed and semi-enclosed seas, and coastal areas and the protection, rational use and development of their living resources. At the Rio Conference the importance of an integrated planning and management approach for marine and coastal resources was recognized in order to ensure sustainable development. Much of the IOC effort in response to Agenda 21 is carried out through its Regional Subcommissions and Committees. As an example of one of these, Okemwa provided detailed information on the third session of the Intergovernmental Oceanographic Commission on the Investigation of the North and Central Western Indian Ocean (IOCINCWIO) which identified and prioritized regional activities in relation to IOC's international activities.

IOC's programs fall under several major categories:

- Capacity building through the TEMA activity;
- Development of the Global Ocean Observing System, in cooperation with ICSU and WMO;
- Integrated Coastal Management - OSLR, GIPME, Ocean Sciences and Non-living Resources (OSNLR), etc.

- Coastal zone protection, warning and natural disaster reduction through the tsunami warning system (ITSU), sea level observations (through GLOSS), etc.;
- Provision of data and information through GOOS and related programs (GLOSS, IODE, etc.);
- Public awareness of the oceans and marine issues;

The scientific programs of IOC include:

- Ocean Processes and Climate
  - Ocean circulation
  - Climate changes and physical ocean processes
  - Regional networks of sea level observing stations
- Ocean Sciences in Relation to Living Resources
  - Tropical demersal recruitment studies
  - Coral reef studies
  - Marine biodiversity research and data bases
  - Harmful algal blooms
- Ocean Sciences in Relation to Non-Living Resources
  - Beach Dynamics
  - Management of coastal resources
- Marine Pollution Control and Assessment
  - Land sources of marine pollution
  - Control and monitoring of marine debris
  - Control, monitoring and abatement of oil pollution

SCOR and IOC are cooperating on a number of joint activities, such as GLOBEC, JGOFS, the COASTS program of IOC, HAB (IOC's Harmful Algal Blooms program to which SCOR WG 97 contributes) and TEMA. Okemwa asked SCOR to assist in providing strong scientific leadership in the development of GOOS. In association with this request, Brian Rothschild reported that the Joint Scientific and Technical Committee for GOOS had requested SCOR to convene a workshop to facilitate the planning of the GOOS module on Living Marine Resources, and that he was organizing this under the leadership of John Shepherd (UK).

In conclusion, the IOC Fourth Vice-Chairman transmitted the wish of the IOC Secretary for a meeting between the Officers of SCOR and IOC during the 1996-97 period and for continued and strengthened interactions between IOC, SCOR and ICSU.

Okemwa suggested that SCOR Working Groups should attempt to provide more direct scientific input to IOC activities and requested SCOR to continue its cooperation with IOC in relation to TEMA. The SCOR Secretariat has been collecting information on laboratories and institutions which would be willing to provide training opportunities to oceanographers from developing countries. IOC has also provided support directly to the participants in some SCOR activities, for example a JGOFS training course in India on the use of remotely-sensed data. The IOC would like to further enhance this type of cooperation in the future, in line with the attempts to increase the IOC-SCOR cooperation with respect to building research capabilities in developing countries.

In response to a suggestion that SCOR should also consider the implications of Chapter 17 of Agenda 21, Brian Rothschild agreed to review this document with an informal group (Krishnaswami, Healy, Summerhayes and Okemwa) and make recommendations to the 1996 General Meeting.

#### **4.2 World Meteorological Organization (WMO)**

The report from WMO was noted by the meeting, but a lengthy section on the World Climate Research Program (WCRP) was considered separately under agenda item 5.2.2. The remainder of the WMO report, which is available from the Executive Director, provided information on its Marine Meteorology and Associated Oceanographic Activities Program.

#### **4.3 International Council for the Exploration of the Sea (ICES)**

Brian Rothschild reviewed the ICES report, much of which was closely related to GLOBEC interests. He noted, for example, that the next ICES Annual Science Conference will be held in late September 1996 in Reykjavik, Iceland. The Open Lecture will be presented by Bob Dickson who will talk on the physical and biological effects of the North Atlantic Oscillation and the programme will include a mini-symposium on "Ecosystem Effects of Fisheries". There are also a number of theme sessions with an oceanographic and environmental flavor, and include: "The North Atlantic Components of Global Programmes - Lessons to ICES-GLOBEC from WOCE and JGOFS" [SCOR agreed to cosponsor this event], "Reproductive Disturbances of Marine Species", and "The Shelf Edge Current and its Effects on Fish Stocks". Additional details of these events, and many other ICES activities can be obtained from the ICES Web Server on <http://www.ices.inst.dk>

ICES has continued to develop a firm role in GLOBEC, and looks forward to a continued close collaboration with IOC, SCOR and PICES on GLOBEC issues. During 1995 ICES hosted a GLOBEC CPPC meeting in its Copenhagen Headquarters aimed at finalising the GLOBEC Science Plan for the approval of the IGBP. ICES has also now received funding from the USA and Norway to allow for the establishment of a North Atlantic Regional Office for GLOBEC and plans are currently underway to recruit a suitable marine scientist to staff this Office. It is hoped that the Office will be opened in early 1996. Oversight and direction for this Office will be provided by a newly-established ICES/GLOBEC North Atlantic Regional Coordination Group. This Group will also seek to integrate national activities into a coordinated GLOBEC implementation plan, provide scientific direction for liaison with other regional bodies (e.g. PICES) and the relevant global organisations (IOC, SCOR, IGBP), develop plans for the design and implementation of an integrated data management system for the North Atlantic, and identify and direct the GLOBEC Office to implement appropriate ways to engage the widest possible involvement in scientific development and communication through workshops, the ICES Annual Science Conference, and special sessions at other scientific meetings.

In 1995 ICES/GLOBEC meeting activities have very much focused on Cod and Climate issues which have been steered by the ICES Consultative Committee and the ICES/GLOBEC Working Group on Cod and Climate Change. Two substantive workshops assessing the state of knowledge of the interactions between the environment and various life stages of cod have so far been held. The first of these, the AGGREGATION Workshop was held with SCOR cosponsorship in late 1994 and examined such issues as the statistical relationships between oceanographic models and cod growth and recruitment, mesoscale transport models, retentive circulation patterns, plankton production, and turbulence and feeding. Some of these issues were developed further at the Theme Session on the Influence of Intermediate-Scale Physical Processes on the Transport and Food Environment of Fish which was held at the 1995 ICES Annual Science Conference.

A second Workshop, the Backward Facing-Workshop, was held in early 1995 and examined past analogues for present and recent conditions of excessive cold from West Greenland to the Middle Atlantic Bight. This was undertaken using data from the early 1880s onwards in order to isolate the effects of fishing which dominate current data sets. A follow-up Workshop, focusing on the Barents Sea, is planned for early 1996.

Plans for a Workshop on Cod and Climate Database issues have been made for some time, but this workshop will not meet until November 1995. This Workshop will consider current and past analyses of the interrelationships between cod and the environment and will consider the data structures that are necessary to allow for a wide variety of analysis options. The Workshop will also consider a potential data management plan for GLOBEC, including investigating the pros and cons for distributed and centralised databases.

The report from ICES also summarized the recent accomplishments of its Advisory Committee on Fishery Management and the Advisory Committee on the Marine Environment. The report of the latter's Working Group on the Ecosystem Effects of Fishing Activities had a significant influence on the development of the terms of reference for SCOR WG 105.

#### **4.4 North Pacific Marine Science Organization (PICES)**

The PICES report, which also focused on a component of GLOBEC, the Program on Climate Change and Carrying Capacity, was reviewed by Brian Rothschild. At the third annual PICES meeting (Nemuro, Japan, October 1994), an Implementation Group was established to further develop this joint PICES- GLOBEC effort. The Executive Committee of the Implementation Group concluded a draft report which was accepted at the 1995 annual meeting in Qingdao. The ultimate goal of the CCCC Program is to forecast the consequences of climate variability on the ecosystems of the subarctic Pacific. To achieve this goal, the following Central Scientific Issues have been identified:

- Physical forcing: What are the characteristics of climate variability, can interdecadal patterns be identified, how and when do they arise?
- Lower trophic level response: How do primary and secondary producers respond in productivity, and in species and size composition, to climate variability in different ecosystems of the subarctic Pacific.
- Higher trophic level response: How do life history patterns, distributions, vital rates, and population dynamics of higher trophic level species respond directly and indirectly to climate variability?
- Ecosystem interactions: How are subarctic Pacific ecosystems structured? Do higher trophic levels respond to climate variability solely as a consequence of bottom up forcing? Are there significant intra-trophic level and top down effects on lower trophic level production and on energy transfer efficiencies?

The CCCC Science Plan presented at the third annual meeting describes four key research activities, to which was added a fifth, data management: (1) Retrospective analyses, (2) Development of models, (3) Process studies, (4) Development of observation systems, and (5) Data management. These research activities, which will be described in the report, apply to both basin and regional scales, although emphases and priorities will differ from project to project. The general role of PICES in these activities is to stimulate action, coordinate, and improve communication among participants.

PICES held a successful workshop on Okhotsk Sea and Adjacent Seas in Vladivostok (June 19-24, 1995). The proceedings will complement the report of WG 1 (PICES Special Publication No. 2 on The Okhotsk and Oyashio Region) published this year (copies are available on request to the PICES Secretariat).

#### **4.5 Other Intergovernmental Organizations**

##### ***International Arctic Science Council***

The introduction of information on the International Arctic Sciences Council (IASC) at this point in the meeting agenda was an error since it was confirmed that IASC is a non-governmental body. It is a relatively new organization which is developing its science program. Steve Ackley (Chair, WG 86) will represent SCOR at the first IASC scientific planning meeting. It was agreed that SCOR should maintain contact with IASC as appropriate once its scientific role is better known.

##### ***Commission on the Conservation of Antarctic Marine Living Resources (CCAMLR)***

It has been several years since SCOR was represented at a meeting of CCAMLR, however the Executive Director was informed that there was significant interest in the Southern Ocean component of the GLOBEC program among the member states of CCAMLR. Accordingly, the SO-GLOBEC Science and Implementation Plans were sent to the CCAMLR Secretariat and a member of the SO-GLOBEC planning group attended the recent meeting of the CCAMLR Scientific Committee to present information on this program.

## 5.0 RELATIONS WITH NON-GOVERNMENTAL ORGANIZATIONS

### 5.1 International Council of Scientific Unions

The Executive Committee noted that the next ICSU General Assembly will take place in Washington, D.C. immediately after the XXIII General Meeting of SCOR. The need for SCOR representation at the ICSU meeting will be decided by the Officers once the detailed agenda is available.

The Executive Director had been informed by the Executive Director of ICSU that "a suggestion has been received by ICSU that we ask SCOPE to undertake an assessment of the 'State of the Oceans' . . . if ICSU agrees that this is important . . . it would certainly ask that SCOR be involved." While it recognized that SCOPE has a long tradition and experience in conducting such assessments, the Executive Committee urged that SCOR be significantly involved as the main focus point within ICSU for marine sciences. The Officers and Executive Director will maintain contact with ICSU and SCOPE as plans for this assessment are developed.

### 5.2 ICSU Unions and Committees

Information received from the various ICSU bodies which have representatives to SCOR was brought to the attention of the meeting.

#### *Committee on Space Research (COSPAR)*

The Executive Committee agreed that SCOR should cosponsor the following scientific sessions at the 31st COSPAR Assembly, to be held in Birmingham, UK from 14 to 21 July 1996:

- Symposium on Applications of Satellite Data to Weather Forecasting, Climate Prediction and Climate Model Validation.
- Panel Discussion on Satellite Observations for Earth System Science and Progress in the establishment of GCOS, GOOS and GTOS
- Meeting on Satellite Altimetry for Ocean Circulation Studies

#### *Scientific Committee on Problems of the Environment (SCOPE)*

The interest of SCOR in participating in a significant way in the Assessment of the State of Ocean Science, which may be undertaken by SCOPE, was reiterated by the Executive Committee (see item 5.1).

#### *International Union of Pure and Applied Chemistry (IUPAC)*

Discussions have been ongoing between representatives of IUPAC and SCOR as to the possibility of greater cooperation between the two organizations in the field of marine chemistry. IUPAC was represented by P.S. Steyn (South Africa), who briefed the Executive Committee on IUPAC activities, especially those of its new Division VI on Chemistry and the Environment which provides focus to IUPAC's environmentally related activities and includes the following Commissions: Fundamental Environmental Chemistry; Atmospheric Chemistry; Soil and Water Chemistry; Agrochemicals and the Environment; Food Chemistry, and; Oils, Fats and Derivatives.

He reported that "IUPAC has expertise on chemical processes on macroscale and at the molecular level, whereas SCOR has much experience and knowledge on chemical processes and distribution on the macro level." IUPAC has a growing interest in the chemistry of environmental processes. In the SCOR-IUPAC discussions, it became evident that there are many opportunities for joint research projects, e.g. IUPAC's Division VI Commission on Fundamental Environmental Chemistry is involved in two projects: Fluxes and processes at the sediment water interface; and Processes at the air-water interface.

Steyn requested that SCOR liaise with IUPAC by means of Professor David Turner, Goteborg University, Sweden or else through Dr. M Williams, Executive Secretary of IUPAC. Turner is expected to attend the SCOR General Meeting in 1996.

The participants agreed that there are promising prospects for collaboration between SCOR and IUPAC and expressed its interest in receiving joint project proposals.

#### ***International Union of Pure and Applied Physics (IUPAP)***

The position of IUPAP representative to SCOR has been vacant for some time. In response to a query from the Executive Director of SCOR, the Secretary-General of IUPAP agreed that a formal liaison mechanism is not currently necessary. This can be reviewed in special projects are proposed in the future; in the meantime, reports and information will be exchanged at the Secretariat level.

#### ***International Union of Theoretical and Applied Mathematics (IUTAM)***

The IUTAM representative to SCOR, Steven Thorpe, reported that IUTAM sponsored a meeting on Physical Limnology in Australia in September 1995 which was well attended by, among others, physical oceanographers interested in turbulence, internal waves and mixing. The papers presented at the meeting are expected to be published within a year.

#### **5.2.1 International Geosphere-Biosphere Program**

Many issues relating to the IGBP, particularly with respect to JGOFS and GLOBEC had been discussed under earlier agenda items. The Deputy Executive Director of IGBP, Neil Swanberg, commented on a number of other issues.

The Scientific Advisory Council of the IGBP met in Beijing in October 1995. Although this was the occasion for the acceptance of GLOBEC as a Core Project of IGBP, there were few presentations at SAC-IV on the ocean science relative to global change research. Swanberg stated that there would be a special effort to redress this imbalance at the IGBP Congress in Germany in April 1996.

The Congress will be the first time that all of the Scientific Steering Committees for the IGBP Core Projects will meet in the same place. In addition to the separate SSC meetings, there will be plenary sessions and opportunities for inter-Core Project meetings. A major goal of the Congress is to facilitate such interactions in the expectation that more inter-Core Project research activities will result.

Swanberg also noted that IGBP is now collaborating more closely with WCRP than in the past and that this should lead to more cooperation between the physical and the biological/geochemical global change research programs.

#### **5.2.2 World Climate Research Program**

For the first time in recent years, a detailed report was received from the WCRP office. It presented information on CLIVAR, ACSYS and WOCE, the major oceanographic components of the WCRP, and was reviewed by Allyn Clarke, the member of the SCOR Executive Committee with responsibility for climate issues. The report is presented in Annex 10.

The WCRP report described the progress in planning for the Climate Variability and Predictability Program (CLIVAR) which has as its primary objective to describe and understand the physical processes responsible for climate variability and predictability on seasonal, inter-annual, decadal and centennial time scales. More detailed information on CLIVAR is given in Annex 10, and a CLIVAR Science Plan, published in 1995, is available from the WCRP office in Geneva. Allyn Clarke urged that close links be developed between CLIVAR and GLOBEC, either through the addition of a CLIVAR scientist on the GLOBEC SSC, or at the sub-committee level.

With respect to the World Ocean Circulation Experiment, which was originally conceived by the former SCOR/IOC Committee on Climatic Changes and the Ocean (CCCO), Clarke noted that the observational phase of WOCE has been extended to 1997 due to unavoidable delays in satellite launches and some shortfalls in resources



for *in situ* measurements. WOCE is now moving towards a phase of Analysis, Interpretation, Modelling and Synthesis until its completion in 2002. The objectives of this stage of the program are given in Annex 10, as are some of the major scientific accomplishments of WOCE to date. For example, WOCE observations reveal that estimates of oceanic heat flux differ significantly from model estimates, and tracer measurements are providing validation of model estimates of rates of circulation of water masses.

One major component of WCRP, the Tropical Ocean Global Atmosphere Program (TOGA), which also originated through the CCCO, was completed in 1995 with a Final International TOGA Scientific Conference cosponsored by IOC, ICSU, SCOR and WMO in Melbourne. One remaining component of TOGA, the Coupled Ocean-Atmosphere Response Experiment (COARE), now falls under the oversight of the CLIVAR Scientific Steering Group.

Lastly, the WCRP report reviewed the Arctic Climate System Study (ACSYS) which is designed to advance our understanding Arctic climate processes and their role in global climate. Benefits deriving from ACSYS include improved prediction of sea-ice distribution (for navigation and the oil and gas industry) and improved information on the water properties affecting the North Atlantic fishing grounds. The Initial Implementation Plan for ACSYS was reviewed at the WCRP Conference on the Dynamics of the Arctic Climate System in late 1994 and additional information on the status of planning for this activity is found in Annex 10.

### 5.3 Affiliated Organizations

Reports were received from the following Affiliated Organizations:

#### *International Association for Biological Oceanography*

Following the election of Professor J.F. Grassle (USA) as President and Professor J.B.L. Matthews (UK) as Secretary in August 1994, the following have been appointed to the IABO Executive Committee: Professor P. Lasserre (France) Past President; Professor A.D. McIntyre (UK) Past Secretary; Dr J.C. Castilla (Chile); Dr Makoto Omori (Japan).

Efforts have been made to update the list of National Correspondents by requesting nominations from the National IUBS Committees of member countries. Once the list is complete, the Executive Committee will consider, in consultation with National Correspondents, how the wider community of biological oceanographers may become more actively informed and engaged in the work of the Association.

Scientifically, IABO maintains its primary area of interest in Marine Biodiversity. It has noted research agendas of countries responding to the Biodiversity Convention, notably the US Programme, "Understanding Marine Biodiversity" (National Research Council, 1995), and the inclusion of this topic in the Marine Science & Technology (MAST 3) Programme of the EC. The report from IABO would draw attention to the resolution of ICSU to adopt the Diversitas Programme initiated by IUBS, SCOPE and UNESCO, in which there is an important marine element.

IABO wishes to support scientific initiatives by SCOR and other bodies that fall within its scientific remit. To this end it has endorsed plans for a scientific workshop entitled "Modelling across Scientific Disciplines: Integrating the Biology of Living Organisms into the Physical Oceanographic Environment" which has been approved for funding by the US Office of Naval Research. An international Planning Committee has been formed comprising Professor Jack Matthews (convener), Dr Mike Burrows, Professor Wolfgang Fennel, Professor Bill Gurney, Dr Simon Levin and Professor Jacquie McGlade. The meeting is to be organized by the Scottish Association for Marine Science and will be held in Dunstaffnage, Scotland, probably in July 1996. The topic is closely related to the rationale behind the preliminary proposal on "Coupling of Biological, Chemical and Physical Models" presented at the SCOR General Meeting in October 1994, and further developed in the proposal for a new SCOR Working Group, "Coupling Ocean Circulation and Ecosystem Development in Models". The Executive Committee agreed to IABO's request that SCOR cosponsor this meeting.

### ***International Association for Meteorology and Atmospheric Sciences***

The newly-elected President of IAMAS, Robert Duce, stated that he hopes to renew and strengthen the links between IAMAS and the oceanographic community through SCOR and IAPSO. He reviewed the existing Commissions of IAMAS and their various tasks, noting in particular that the International Global Atmospheric Chemistry Program, a Core Project of IGBP, has developed by the IAMAS Commission on Atmospheric Chemistry.

### ***International Association for the Physical Sciences of the Ocean***

The President-elect of IAPSO, Vere Shannon, introduced this report. The highlight of the past year was the IAPSO XXI General Assembly in Honolulu, Hawaii, USA, in August 1995. The General Assembly was co-sponsored by SCOR, IOC, IAMAS, IAG, and various other organizations. The Assembly was a financial success with over 700 registrants, the largest Assembly ever held by IAPSO. Based on early registrations and projected income, IAPSO was able to combine approximately \$55,000 from IAPSO funds with funds made available from the National Science Foundation and SCOR to provide partial travel support to a large number of ocean scientists from developing countries and the former Soviet Union (Confederation of Independent States). A Proceedings of the General Assembly will be distributed.

The IAPSO General Assembly included 13 Symposia and a number of workshops were also held. The Symposia were as follows:

- Large-Scale Ocean Circulation
- Decadal and Interdecadal Variations in the Ocean (With IOC)
- Circulation of Marginal Seas and Semi-Enclosed Seas
- Coastal Ocean (A): Interaction with the Open Ocean
- Coastal Ocean (B): Interaction with the Adjacent Land
- Carbon Dioxide in the Oceans
- Air-Sea-Ice Interactions and High-Latitude Ocean Processes
- Dynamics of the Open Ocean from New Satellites (With IAG)
- Marine Dispersion
- Spatial Structure of Short Ocean Waves
- Physical, Chemical and Geological Oceanography; Poster
- Ocean-Atmosphere Coupling: TOGA/COARE (With IAMAS and IAHS)
- Internal Waves & Small Scale Turbulence (With IAMAS)

A Joint IAMAS/IAPSO General Assembly is being organized to be held in Melbourne, Australia on 1 - 9 July 1997. Other IUGG Associations and Commissions have been invited to organize sessions, and some interest has been expressed by several of the other Associations. The IUGG Tsunami Commission, as an example, will convene a Symposium at this Assembly. A Preliminary Announcement has been distributed by the Local Organizing Committee. Suggestions for Symposia being reviewed by the IAPSO Executive Committee to determine a proposed IAPSO Program for the Assembly. The IAPSO report sought SCOR co-sponsorship of the 1997 IAMAS/IAPSO Assembly. This was agreed by the Executive Committee.

### ***Commission for Marine Geology***

I.N. McCave presented the regrets of the President of CMG, Yves Lancelot, who was unable to attend the Executive Committee meeting. He reported that CMG interests continue to focus in two areas: studies of soft sediments which involve many marine geologists in the IMAGES program (see item 2.5) and the Ocean Drilling Project, and research on "hard rocks", mainly through the InterRIDGE activity and deep ODP drilling.

#### **5.4 Corresponding Organizations**

Reports were received from the following organizations:

### ***Arctic Ocean Sciences Board (AOSB)***

The Arctic Ocean Sciences Board convened its Fourteenth Meeting in Bremerhaven, Germany in March 1995 and continues to promote Arctic Ocean projects and information exchange.

The Greenland Sea Program held its Symposium meeting in with many new and controversial results. Although there are some phenomena such as sea-ice extent and ice formation in Bukta/Odden that are still not completely understood, extensive follow-on investigations conducted by the ESOP (European Sub-polar Ocean Programme) of the European Union Mast II Programme are being organized.

The North East Water Polynya (NEW) programme is being conducted under the aegis of the International Arctic Polynya Programme (IAPP). A Symposium was held in May of 1995 in Denmark to discuss the data and results from the expedition. It is anticipated that the results from this meeting will be published in the *Journal of Marine Research*. Plans for a summer expedition in are currently being explored; if funding can be obtained, the expedition is planned in early 1997 using the research base at Eskimonaes.

Proposals have been submitted by a Canadian team of scientists to the Canadian Natural Sciences and Engineering Research Council (NSERC) for an expedition to the North Water Polynya (NOW) as early as 1996. If successfully funded, it is expected that twenty Canadian scientists will join with twenty scientists from other countries aboard the *CCS Louis St. Laurent* for approximately twelve weeks with a possible winter-over in the polynya. Plans for a follow-on expedition by US scientists in 1997 have also been submitted to the National Science Foundation.

General observation programmes of Japan and the United States in the Bering Sea are expected to be continued, but a larger-scale study of the St. Lawrence Island Polynya programme (SLIP) has been postponed.

The Board has set up an ad-hoc working group on Arctic Ocean data to further pursue discussion of the importance of archiving data and determining areas of greatest need. The Board emphasized the importance of preservation of data and access of data for research rather than commercial purposes. Discussions will continue on development and establishment of an "Arctic Marine Data Inventory Centre" which would serve as a focal point for inventoring and providing access to Arctic Ocean data.

The AOSB is exploring, as a focus for future AOSB research, paleo-river-discharge into the Arctic. Such research would likely include studies of the modern river discharge system and of post-glacial Arctic Ocean river discharge. Plans in this area may include a workshop or start-up pilot project. Additionally the AOSB has encouraged interaction with the IASC Working Group on Glaciers. This group is very interested in the second phase of the ACSYS Implementation Plan which will conduct studies on the importance of the hydrological cycle in the Arctic as run-off from Arctic glaciers and the Greenland ice sheet and iceberg calving.

### ***Engineering Committee on Oceanic Resources***

The move of the Secretariat of ECOR to the Ocean Engineering Research Centre (OERC) at Memorial University of Newfoundland, Canada, has revitalized ECOR and activity has increased substantially. At a recent ECOR meeting, a number of decisions were taken as part of this new ECOR effort. The category of membership International Member, for international organizations, was approved by ICSU at the rate of US \$ 500. It was decided to establish a WWW site on ECOR. A journal, possibly entitled *Oceanic Engineering International*, is to be started in 1996 to include ECOR news, reviews, summaries of Working Group reports, reviewed papers and technical notes and some advertising. Approval was given for the Japan ECOR Committee to get funding for an ECOR International Conference in 1997.

ECOR will strengthen and formalize its links with other international organizations such as IOC and IMO. The establishment of a working group on Ocean Engineering Education was approved, as was another on the direct disposal of CO<sub>2</sub> in the ocean (this proposal was forwarded to ECOR by SCOR).

## 5.5 Other Organizations

### *The Oceanography Society (TOS)*

The Oceanography Society (TOS), in cooperation with IGBP, WCRP, and the Human Dimensions Program (HDP) will hold its first European meeting next year in Amsterdam. The theme is "The Role of the Ocean in Global Change Research - highlighting oceanographic aspects and importance of the global change research agenda of WCRP, IGBP, and HDP", and the meeting will take place in Amsterdam from July 8 to 11 1996. In order to integrate all the cooperating global change research programs, the meeting program will be arranged by geographic categories (tropical, mid-latitudes, high latitudes/polar and costal) rather than by research program. The TOS report urged cooperating and other allied organizations are encouraged to hold meetings in conjunction with the TOS scientific meeting. The Executive Committee agreed to the TOS request for SCOR cosponsorship for this meeting.

A member of the SCOR Executive and President of IAMAS, Robert Duce, is the incoming President of TOS. The effort by TOS to encourage more international members is underway and an article about SCOR by Elizabeth Gross and Terry Healy will appear in the next issue of the Society's journal.

## 6.0 FUTURE MEETINGS

### 6.1 Future meetings of SCOR

The *XXIII General Meeting* will take place at the Southampton Oceanography Centre (SOC) during the week of September 16, 1996. After the Executive Committee meeting, plans were developed for a two day scientific symposium on interdisciplinary studies of mid-ocean ridges which will be organized jointly by SCOR WG 99 and the Ridge researchers at the SOC.

The Brazilian SCOR Committee confirmed its offer to host the *Thirty-third Executive Committee Meeting* of SCOR during the last quarter of 1997 and will make a final decision on the precise dates and location by mid-1996. Representatives of the Brazilian SCOR Committee will attend the XXIII General Meeting in order to discuss plans for the 1997 meeting.

The Executive Committee accepted, with thanks, the offer of the Netherlands SCOR Committee to host the *XXIV General Meeting* in September/October 1998.

### 6.2 Other meetings of interest to SCOR

In addition to meetings discussed under other agenda items, the Executive Director presented a list of international meetings of interest to SCOR during the next two years.

The XXII General Meeting in 1994 had agreed that SCOR should cosponsor the following meetings:

**Third Pacific Ocean Remote Sensing Conference (PORSEC '96):** Ocean Science and Probing.. August 13-16 1996, Victoria, Canada. Jim Gower, Chair.

**International Symposium on CO<sub>2</sub> in the Oceans.** January 22-26, 1996. Mayaguez, Puerto Rico. This is being planned in conjunction with the JGOFS CO<sub>2</sub> Panel.

The Executive Committee agreed to grant SCOR cosponsorship for the following meetings:

**28th International Liège Colloquium on Ocean Hydrodynamics. Modelling Hydrodynamically Dominated Marine Ecosystems.** May 6-10 1996. Liège, Belgium.

**Modelling across Scientific Disciplines: Integrating the Biology of Living Organisms into the Physical Oceanographic Environment.** July 1996, Dunstaffhage Marine Laboratory, Oban, Scotland.

Three scientific sessions at the COSPAR Assembly in Birmingham, UK from July 14 to 21, 1996 (see agenda item 5.2).

**Transport, Retention, Transformation Processes and their Biological Control in Estuarine and Coastal Systems.** September 16-20 1996, Middelburg, The Netherlands. Second joint symposium of the Estuarine and Coastal Sciences Association and the Estuarine Research Federation. SCOR funds must be used for the participation of scientists from developing countries.

**Computerized Modelling of Sedimentary Systems.** October 8-11 1996, Güstrow, Germany. SCOR WG 95 will organize a session at this meeting. Terry Healy and Gerhard Graf (WG 95) are members of the Scientific Steering Committee.

**International Symposium on Benguela Dynamics: Impacts of Variability on Shelf-sea Environments and their Living Resources.** November 25-27 1996. Cape Town, South Africa.

**IAMAS/IASPO Joint Scientific Assembly,** Melbourne, Australia, July 1997.

The following meetings may be of interest to SCOR Members; additional information about any of them is available from the SCOR Secretariat:

**7th Pacific Congress on Marine Science and Technology. Solutions for the Pacific Century.** June 17-22 1996. Honolulu, USA.

**International Coral Reef Symposium.** June 24-29 1996. Panama.

**Coastal Zone Canada '96. International Conference on Integrated Management and Sustainable Development in Coastal Zones.** August 12-17 1996. Rimouski, Québec, Canada.

**Marine Science in Southern Africa - Past Perspectives and Future Challenges,** University of Cape Town, 20-23 November 1996.

**International Conference on Natural and Technological Coastal Hazards.** December 2-5 1996. Tirupati, India.

**Symposium on the Antarctic and Global Change.** July 14-18 1997. Hobart Tasmania.

## **7.0 OTHER BUSINESS AND CLOSING**

Ian Jones presented information on a proposed *Ocean Nourishment Experiment* currently under discussion through a number of institutes and organizations in Japan, Australia, Canada, Denmark and the USA. The full title of the project is Photosynthetic Greenhouse Gas Mitigation and Sustainable Marine Food Harvesting (PGGM) and its overall objective is to demonstrate whether ocean nourishment with ammonia sequesters carbon dioxide and has the potential to increase fish catches. Preliminary plans involve nourishing about 100 sq km of the ocean mixed layer and using ship measurements and satellite observation to verify increased primary production and carbon fixing. This will be done in the vicinity of a drifting buoy, possibly within a mesoscale eddy. International endorsements of this project are sought from SCOR and the International Energy Agency.

The Executive Committee asked whether the criteria established for Affiliated Programs during the discussion on agenda item 2.5 could be applied to this activity. Jones agreed to discuss this with his colleagues

involved in planning for the project and to bring a proposal to the next SCOR meeting if appropriate.

Ian Jones also raised the issue of an *International Monitoring System in support of the Complete Nuclear Test Ban Treaty*. This would involve the use of hydrophones to listen for explosions associated with nuclear tests. A feasibility test showed that hydrophones were able to pick up a signal from French nuclear tests in the South Pacific over three thousand miles away. This new observing system, with its publicly available data, provides oceanographers with a useful tool for research on a number of topics.

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The President closed the Executive Committee meeting, extending the sincere thanks of the Committee to John Field and the South African Committee for SCOR for the provision of the meeting facilities, the logistic arrangements and their hospitality.

## ANNEX 1 - List of Participants

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**ANNEX 2 - Program of Lectures  
32nd SCOR Executive Committee Meeting  
Cape Town, November 14-16 1995**

*Monday, November 13:*  
Professor G.M. Branch

"Intertidal ecology of southern African shores: glimpses of the past, present and future"

*Tuesday, November 14:*  
Professor Vere Shannon  
Professor John Field

"Physical Oceanography of the Benguela system"  
"The Benguela Ecology Programme: some findings"

*Wednesday, November 15:*  
Professor Johann Lutjeharms  
Dr Robert Crawford

"The Agulhas Current system"  
"Regime shifts in sardine/anchovy populations"

Royal Society of South Africa Lecture at the South African Museum:

Professor I.N. McCave

"Geological evidence for deep flow in present and past ocean circulations".

*Thursday, November 16:*  
Professor Geoff Brundrit:

Professor John Gurney

"Acoustic Thermometry of Ocean Climate (ATOC): a South African perspective"  
"Marine diamonds"

## ANNEX 3 - Agenda

### 32nd EXECUTIVE COMMITTEE MEETING OF SCOR Niven Library, Zoology Department, University of Cape Town Cape Town, South Africa

Tuesday, November 14 to Thursday, November 16 1995

#### AGENDA

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#### 1.0 OPENING

- 1.1 **Opening Remarks and Administrative Arrangements**
- 1.2 **Approval of the Agenda** - additions or modifications to the Agenda as distributed may be suggested prior to approval of the final version.
- 1.3 **Report of the President of SCOR** - the President will briefly review activities since the XXII General Meeting (October 1994).
- 1.4 **Appointment of an ad hoc Finance Committee** - the Constitution requires that a Finance Committee be appointed at every SCOR meeting. It reviews the administration of SCOR finances during the previous fiscal year and the current year. It also works with the Executive Director to draw up a budget for the next year's activities based on the decisions taken during the meeting. The Committee will report under agenda item 3.3.

#### 2.0 SUBSIDIARY BODIES

- 2.1 **Arising from Former Working Groups**
  - 2.1.1 ***WG 78 Determination of Photosynthetic Pigments in Seawater***  
Publication of the monograph on pigment methods by UNESCO. Financial support from SCOR.
  - 2.1.2 ***WG 80 Role of Phase Transfer Processes in the Cycling of Trace Metals in Estuaries***  
Progress with the final report.
- 2.2 **Current Working Groups**
  - 2.2.1 ***WG 86 Ecology of Sea Ice***  
Plans for a Gordon Conference on "The Ecology of Sea Ice Biota" to be held in March 1997. Funds for this approved. This will be the final activity of WG 86. Request for an organizational meeting in 1996. Coordination of activities in the Antarctic sea ice zone - information on the ASPECT program of SCAR.
  - 2.2.2 ***WG 89 Sea Level and Erosion of the World's Coastlines***  
Detailed outline for final report and plans for publication.
  - 2.2.3 ***WG 93 Pelagic Biogeography***  
Report on the final meeting of WG 93 and the International Conference on Pelagic Biogeography, Amsterdam, July 1995. Recommendations for future SCOR activity. Plans for final publication.
  - 2.2.4 ***WG 95 Sediment Suspension and Sea Bed Properties***  
Progress with final report, a review for publication in *Journal of Marine Systems*. Plans for session at Conference on Computerized Modelling of Sedimentary Systems.

- 2.2.5 *WG 96 Acoustic Monitoring of the World Ocean***  
The final meeting of WG 96, which was approved for 1995, has been postponed to March 1996 due to the delays in implementation of ATOC because of the requirement for public hearings. The Executive Committee will discuss the issue of continuing SCOR sponsorship of the ATOC program.
- 2.2.6 *WG 97 Physiological Ecology of Harmful Algal Blooms***  
Report of second WG 97 meeting, Tokyo, July 1995. Funding has been approved for a NATO Advanced Study Institute at the Bermuda Biological Station in May/June 1996. Detailed plans and request for SCOR financial support of this event
- 2.2.7 *WG 98 Worldwide Large-scale Fluctuations of Sardine and Anchovy Populations***  
Extracts from the detailed report of the first meeting, June 1994, including a schedule for future activities. The schedule outlined in the report has slipped a little. The data merging meeting planned for 1995 has been postponed to 1996. Support has been requested for 5 or 6 members of the WG. The final meeting will take place in early 1997.
- 2.2.8 *WG 99 Linked Mass and Energy Fluxes at Ridge Crests***  
Report from the Chair. Plans for a symposium in 1996. Preparation of a "booklet" on ridge processes and fluxes. Closer ties between WG 99 and the InterRIDGE program will be discussed.
- 2.2.9 *WG 100 Sediment Coring for International Global Change - SCOR/PAGES IMAGES program***  
Report of a meeting in Halifax, September 1995. Progress with the plans for the International Marine Global Changes study. The Executive Committee will discuss the issue of continuing SCOR sponsorship of the IMAGES program.
- 2.2.10 *WG 101 Influence of Sea State on the Atmospheric Drag Coefficient***  
Report of an informal meeting in July 1995. Progress with a monograph on "Drag over the Ocean". Plans for a final meeting in 1996.
- 2.2.11 *WG 102 Comparative Salinity and Density of the Atlantic and Pacific Ocean Basins***  
Report of the working group. SCOR should decide how to disseminate this report, perhaps by publication in an appropriate journal.
- 2.2.12 *WG 103 The Role of Wave Breaking on Upper Ocean Dynamics***  
Report on the first meeting of WG 103, Heidelberg, July 1995. Provisional request for a meeting in 1996.
- 2.2.13 *WG 104 Coral Reefs Responses to Global Change: The Role of Adaptation***  
Report on work accomplished in correspondence, establishment of a Home Page, plans for a meeting at the International Coral Reef Symposium in 1996. Proposal to add Professor Kiyoshi Yamazato as a Corresponding Member in relation to the issue of reefs as sources or sinks of CO<sub>2</sub>.
- 2.2.14 *WG 105 The Impact of World Fisheries Harvests on the Stability and Diversity of Marine Ecosystems***  
Dr. M. Sinclair (Canada) has agreed to Chair WG 105. Modifications to the terms of reference have been suggested and approval is sought for the final membership list. Plans for preliminary activities will be discussed.
- 2.2.15 *WG 106 Relative Sea Level and Muddy Coasts of the World***  
Report on the first meeting of WG 106, Nanjing, October 1995. Preparation of a book on muddy coasts. Request for approval of a second meeting in South Carolina in 1996.

## **2.3 Committees and Panels**

### **2.3.1 *Editorial Panel for the Ocean Modelling Newsletter***

The future funding of the Newsletter has now been secured through the European Community. The last issue is No. 106.

### **2.3.2 *Joint Global Ocean Flux Study Scientific Steering Committee***

The Chair of JGOFS, Professor Field, will introduce this report. Highlights of JGOFS activities since late 1994: the First JGOFS International Science Symposium (May 1995), evaluation of JGOFS for ICSU and IGFA. Scientific achievements in 1994/95. Plans for future activities including a formal meeting of the SSC in April 1996 as part of a joint meeting of all IGBP Core Projects. Progress with development of continental margins studies in JGOFS, to be planned jointly with the IGBP Land-Ocean Interactions in the Coastal Zone program. New SCOR terms of reference for JGOFS SSC and operating procedures as proposed by IGBP. Nominations for membership vacancies. Other JGOFS issues.

### **2.3.3 *SCOR/IOC Committee on Global Ocean Ecosystems Dynamics***

Report by the Chairman of GLOBEC, Professor Rothschild. Presentation and approval of the GLOBEC Science Plan prepared by a joint SCOR/IGBP Core Project Planning Committee. The SC-IGBP agreed to Core Project status for GLOBEC at its meeting in late October 1995. Consideration of a draft agreement between SCOR, IOC and IGBP on the sponsorship of GLOBEC. Re-constitution of the GLOBEC SSC. Terms of reference. Progress with program planning.

### **2.3.4 *SCOR/IGBP/WCRP ad hoc Planning Committee for the Global Ocean Euphotic Zone Study***

The Deputy Executive Director of IGBP will provide information on the status of GOEZO (now suggested as SOLAS - Surface Ocean - Lower Atmosphere Study). It has been agreed that further planning should await the results of the new IPCC assessment.

## **2.4 Proposals for New Working Groups**

The following proposals have been circulated to all national committees for comments:

**2.4.1 *Improved Global Bathymetry*** - submitted and revised by the UK SCOR Committee

**2.4.2 *Double Diffusion*** - submitted and revised by the Russian SCOR Committee

**2.4.3 *Coupling Ocean Circulation and Ecosystem Development in Models*** - submitted by the German SCOR Committee

**2.4.4 *Coupling Wind, Waves and Currents in Coastal Models*** - submitted by Norden Huang, USA.

## **2.5 Mechanism for the Oversight and Sponsorship of Continuing Activities**

This will be a conclusion of the discussion begun at the XXII General Meeting about a means of providing SCOR sponsorship to activities which are of a long-term nature and are therefore not suitable for a SCOR Working Group. These include the program on Acoustic Thermometry of Ocean Climate (arising from WG 96), the IMAGES program (from WG 100), the InterRIDGE program (WG 99 is associated with this) and the proposed SCOR sponsorship of the Internal Antarctic Zone coordination effort. A discussion paper has been circulated to national committees for comment and the views of those involved with each of these programs have been sought.

### 3.0 ORGANIZATION AND FINANCE

#### 3.1 Membership

The Executive Director will report on changes in SCOR membership since October 1994. Other membership issues.

#### 3.2 Publications Arising from SCOR Activities

The Executive Director will present a report on publications arising from SCOR activities since the XXII General Meeting. The Publications Officer, Terry Healy may wish to raise issues relating to SCOR publications. Use of World Wide Web to disseminate information about SCOR and working group reports.

#### 3.3 Finance

The *ad hoc* Finance Committee and the Executive Director will review the state of SCOR finances for the past and current fiscal years. The *ad hoc* Finance Committee will report to the General Meeting on this review and will present a budget for 1996 activities and recommendations regarding the levels of membership contributions to SCOR for 1997.

#### 3.4 Establishment of a Nominations Committee in Preparation for Elections at 1996 General Meeting

The term of the President will expire at the XXIII General Meeting and he is ineligible to be re-elected. The terms of the Secretary and the three Vice-Presidents expire at each General Meeting. Vice-Presidents Wang Pinxian and S. Krishnaswami are eligible to be re-elected for an additional two year term. Vice-President Terry Healy is not eligible for re-election, having served three two-year terms. While the recent amendments to the SCOR Constitution limit the Secretary and Vice-Presidents to serving two consecutive terms, it was agreed that the changes should not apply to current officers. Therefore the Secretary, Brian Rothschild is also eligible to serve an additional (third) term in office.

#### 3.5 Other Organizational Issues

### 4.0 RELATIONS WITH INTERGOVERNMENTAL ORGANIZATIONS

#### 4.1 Intergovernmental Oceanographic Commission / Marine-Related Issues (UNESCO)

The representative of IOC will inform the meeting about current activities of the Commission which may involve SCOR, in particular the progress in the development of the Global Ocean Observing System (GOOS) and on other joint activities such as Global Ocean Ecosystem Dynamics (GLOBEC), harmful algal blooms, coastal oceanography, etc. Proposal for a joint coordinating body for interdisciplinary coastal ocean science. Joint SCOR - IOC effort relating to training. Other IOC issues.

#### 4.2 World Meteorological Organization

#### 4.3 International Council for the Exploration of the Sea

#### 4.4 North Pacific Marine Science Organization (PICES)

#### 4.5 Other Intergovernmental Organizations

*International Arctic Science Committee*

*Commission on the Conservation of Antarctic Marine Living Resources*

*Others*

### 5.0 RELATIONS WITH NON-GOVERNMENTAL ORGANIZATIONS

#### 5.1 International Council of Scientific Unions

Dates of 1996 General Assembly. Possible ICSU request to SCOPE for an assessment of the "State of the Oceans".

## 5.2 ICSU Unions and Committees

Information has been received from the following ICSU bodies which have representatives to SCOR. Matters of interest will be brought to the attention of the meeting.

*Scientific Committee on Problems of the Environment (SCOPE)*  
*Scientific Committee on Antarctic Research (SCAR)*  
*Committee on Space Research (COSPAR)*  
*International Union of Pure and Applied Chemistry (IUPAC)*  
*International Union of Pure and Applied Physics (IUPAP)*  
*International Union of Theoretical and Applied Mathematics (IUTAM)*  
*Others*

### 5.2.1 International Geosphere-Biosphere Program

The Deputy Executive Director of IGBP will summarize the action on matters of interest to SCOR at the recent SC-IGBP and SAC-IV meetings held in Beijing. SCOR-IGBP interactions will also be discussed in relation to JGOFS, GLOBEC and LOICZ.

### 5.2.2 World Climate Research Program

For the first time in recent years, a detailed report has been received from the WCRP office. It presents information on CLIVAR, ACSYS and WOCE - the major oceanographic components of the WCRP.

## 5.3 Affiliated Organizations

Reports have been requested from the following organizations and matters of interest will be brought to the attention of the General Meeting. The Presidents may also present verbal reports as *ex officio* members of the Executive Committee.

*International Association for Biological Oceanography*  
*International Association for Meteorology and Atmospheric Sciences*  
*International Association for the Physical Sciences of the Ocean*  
*Commission for Marine Geology*

## 5.4 Corresponding Organizations

Reports have been requested from the following organizations and matters of interest will be brought to the attention of the meeting.

*Arctic Ocean Sciences Board*  
*Engineering Committee on Oceanic Resources*  
*Confederation Mondiale des Activités Subaquatiques (Scientific Committee)*

## 5.5 Other Organizations

*The Oceanography Society*

## 6.0 FUTURE MEETINGS

### 6.1 Future meetings of SCOR

The *XXIII General Meeting* will take place at the Southampton Oceanography Centre during the last week of September 1996. The nature of the scientific component of this meeting must be decided.

The *Thirty-third Executive Committee Meeting* of SCOR: an expression of interest in hosting this meeting in September/October 1997 was received from the Brazilian SCOR Committee. Confirmation of this and a preliminary

consideration of location and dates.

The Netherlands SCOR Committee has offered to host the *XXIV General Meeting* in September/October 1998.

#### **6.2 Other meetings of interest to SCOR**

The Executive Director will present a list of international meetings of interest to SCOR during the next two years. In some cases the meeting will be asked to decide on requests for SCOR cosponsorship and/or support of these events.

### **7.0 OTHER BUSINESS**

Information on a proposed *Ocean Nourishment Experiment* will be presented by Ian Jones.

**7.1** The potential scientific uses of data from an ocean monitoring system established to support for Complete Nuclear Test Ban Treaty.



**Effect of changes in the composition of seawater on the density-salinity relationship**

Over the next 5-10 years the WOCE hydrographic program will generate reliable hydrographic data for the world oceans. The resultant conductivity salinity, temperature and pressure data will generate calculated densities that will be used to examine mixing processes along constant density surfaces. As first pointed out by Brewer and Bradshaw (1975) changes in the composition of deep waters due to the breakdown of plant material can effect the calculated densities at a given conductivity salinity. The increases in SiO<sub>2</sub>, nitrate, alkalinity, and TCO<sub>2</sub> (or pH) can change the density of seawater as well as the conductivity. For studies of the salinity and density fields over small spatial scales these changes will be small, but for large scale and ocean to ocean studies the differences can be significant. The salinity measurements based on conductivity should be adjusted for the offsets due to changes in the composition of seawater. This report describes how this correction should be made using existing information.

**Introduction**

Changes in the relatively constant composition of seawater have been examined by chemists for a number of years (see reviews by Culkin, 1965 and Wilson, 1975). A number of workers (Brewer and Bradshaw, 1975; Connors and Weyl, 1968) have pointed out that the changes in the composition of seawater in estuarine and ocean waters could result in changes in the conductance-density relationship. The limitations of the Practical Salinity Scale (UNESCO, 1981a,b) for estuarine system (Parsons, 1982; Sharp and Culberson, 1982; Gieskes, 1982; Millero, 1984) was thoroughly discussed in earlier publications. The limitations of the conductivity method to determine the salinity or density of seawater has been examined by several workers (Brewer and Bradshaw, 1975; Millero et al., 1976a, b; 1978; Millero and Kremling, 1976; Poisson et al., 1980, 1981). Studies to examine the limitations of the International Equation of State of Seawater (Millero and Poisson, 1981) have also been discussed (Millero; 1975; 1978; Millero et al., 1976a, b, c, d; Millero and Kremling, 1976, Poisson et al., 1980). As mentioned above, Brewer and Bradshaw (1975) were the first to estimate how changes in the composition of seawater would change the calculated density or sigma-T in ocean waters. They estimated that the changes in salinity could be 0.015 and the changes in  $\sigma_T$  of 0.012 due to changes in the composition of seawater are due largely to the oxidation of plant material. They estimated these changes in conductance and density using partial molar conductance (Poisson et al., 1979) and volume changes for the addition of salts to seawater. They postulated that the density error,  $\Delta\rho = \rho(\text{meas}) - \rho(\text{calc})$  in ppm, the result of these changes, could be given by

$$\Delta\rho = 53.7 \Delta TA - 9.6 \Delta TCO_2 + 42 \Delta SiO_2 \quad (1)$$

where  $\Delta TA$ ,  $\Delta TCO_2$  and  $\Delta SiO_2$  are, respectively, the changes in total alkalinity, total carbon dioxide and silica (mmol kg<sup>-1</sup>). It should be pointed out that the changes in TA and TCO<sub>2</sub> are normalized relative to the values for the surface seawater used to determine the

Equation of State of seawater ( $TA = 2.332$  and  $TCO_2 = 2.226 \text{ mmol kg}^{-1}$  when  $S = 35$ ). This equation was modified by Millero et al. (1976b) by using a more reliable partial molar volume for  $SiO_2$  and considering the effect of added  $NO_2$  as  $HNO_3$ . They obtained

$$\Delta\rho = 53.7 \Delta TA - 9.6 \Delta TCO_2 + 45 \Delta SiO_2 + 24 \Delta NO_3 \quad (2)$$

This theoretical equation was checked by Millero et al. (1976b) by measuring the density and conductivity of samples of seawater collected during the GEOSECS cruises. All the measurements were made relative to Gulf Stream seawater. They found that the excess densities were  $5 \pm 1.5$  ppm in the North Atlantic and  $16 \pm 3.6$  in the North Pacific. The differences between the measured and calculated (eq. 2) densities were found to be  $\pm 2.7$  ppm in the North Atlantic and  $\pm 4.0$  in the North Pacific.

Millero et al. (1978) made density measurements on 124 samples of seawater from stations at  $35^\circ N$  in the Pacific (Figure 1). The excess densities were  $3.8 \pm 3.0$  from 0 to 490m,  $12.5 \pm 4.2$  from 490 to 1000m and  $17.6 \pm 2.6$  from 1000 to 5834 m. The values for the deep waters are in good agreement with the earlier measurements ( $16.1 \pm 3.6$ ) of Millero et al. (1976b). The measured excess densities agreed with those calculated from eq. 2 on the average to  $\pm 5.2$  ppm. In the deep waters the measured values were 6 ppm higher than calculated from eq. 2. The excess densities were also calculated by assuming that the changes in salinity due to the added solids affect the density by the same amount as changes in weight diluted seawater  $\Delta\rho = 757 \Delta S$ . This assumption has been shown to yield reliable densities for rivers, lakes, and estuarine waters when the composition is similar to seasalt or the concentrations are low. This leads to the equation

$$\Delta\rho = 37.9 \Delta TA + 72.8 \Delta SiO_2 + 47.7 \Delta NO_3 \quad (3)$$

Since the changes in  $TCO_2$  are related to  $TA$  this equation can be modified by using the empirical relationship  $TCO_2 = 0.9 TA$ . The values of the excess density calculated from this equation agree with the measured value over the entire depth range to  $\pm 4.3$  ppm. These results indicate that the density changes in seawater due to changes in the composition can be accounted for by changes in the true salinity due to the mass of added dissolved solids

$$\Delta S = \sum M_i \Delta n_i \quad (4)$$

where  $M_i$  is the molecular weight and  $n_i$  is the change in moles of solute  $i$  in one kg of seawater.

The errors in salinity and density due to changes in the composition of seawater can be handled in two ways:

1. The salinity determined from conductivity can be corrected to give the "true", "total", of absolute salinity ( $S_T$ ) that can be used to determine the correct density of the seawater. This can be done using eq. 4 defined above. It assumes that the density is largely effected by changes in the mass of added solutes and that the effects on conductivity are minor. It means that all ocean waters will have the same properties of seawater at the same total

salinity (defined as the total mass of solutes/kg of seawater). From field and laboratory studies this appears to be correct for many of the physical properties including density. It works only if the added solute have similar partial specific properties as seasalt and the concentrations of added solutes are low (Poisson et al., 1980; Millero, 1984).

2. The changes in the density of seawater can be corrected for the added solutes using equations such as eqs. 2 and 3 that are based on theory or a semi-empirical correlations.

The task of the working group is to select one of these methods (or others) and provide a way to calculate the density from salinities determined on the Practical Salinity Scale and using the International Equation of State of Seawater. This may be the adoption of what is available or a recommendation of more density measurements on ocean waters collected from the major ocean basins. The corrections may be simply providing additional steps in the presently available computer code and input of a few chemical parameters or providing corrections for various areas of the oceans.

Through correspondence between the members of the committee, it was thought that an equation of the form of eqs. 2 and 3 should be adopted to correct for the changes in the density due to changes in the composition of seawater. The general form of the equation should be of the form

$$\Delta\rho = a \Delta\text{TCO}_2 + b \Delta\text{SiO}_2 + c \Delta\text{NO}_3 \quad (5)$$

The density measurements of Millero et al. (1978) (Figure 1) can be used to examine, the values of a, b and c in eq. 5. The values of  $\Delta\rho$  as a function of depth appear to be a smooth function of temperature with an uncertainty of 4 ppm in density as judged by a quadratic ( $\sigma = 4.6$  ppm) or cubic ( $\sigma = 3.9$ ) fit. The experimental values of  $\Delta\text{TCO}_2$ ,  $\Delta\text{SiO}_2$ , and  $\Delta\text{NO}_3$  as a function of depth (Figure 2) are quite similar to the excess densities ( $\Delta\rho$ ). The values of  $\Delta\rho$  as a function of  $\Delta\text{TCO}_2$ ,  $\Delta\text{SiO}_2$ , and  $\Delta\text{NO}_3$  are shown in Figure 3. The values of the slopes and intercepts are given by

$$\Delta\rho = 10.2 + 43.9 \Delta\text{TCO}_2 \quad (\sigma = 4.2 \text{ ppm})$$

$$\Delta\rho = 6.0 + 112 \Delta\text{TA} \quad (\sigma = 4.4 \text{ ppm})$$

$$\Delta\rho = 1.9 + 100.5 \Delta\text{SiO}_2 \quad (\sigma = 4.1 \text{ ppm})$$

$$\Delta\rho = 1.1 + 396 \Delta\text{NO}_3 \quad (\sigma = 4.1 \text{ ppm})$$

These empirical equations each give an adequate fit of the values of the excess densities that are within the scatter of the measurements ( $\pm 4$  ppm). The intercept is close to zero except for TA and  $\text{TCO}_2$  which is due to the difference in the surface values in the Atlantic and Pacific oceans. The slopes of these empirical equations are compared to those discussed above in Table 1. The individual slopes are larger than the theoretical values because they include the changes due to all the constituents in the solution. Since all of the equations adequately fit the experimental data, they can be used to make a reasonable

estimate of the changes in density due to changes in the composition. Since carbonate data are not always

**Table 1**

**A comparison of the relationships between the excess density and the changes in carbonate and nutrients in the waters**

Parameter	Theory <sup>a</sup>	Weight <sup>b</sup>	Emperical <sup>c</sup>
TA	53.7	37.9	112
TCO <sub>2</sub>	-9.6	44	43.9
SiO <sub>2</sub>	45	72.8	100.5
NO <sub>3</sub>	24	47.7	396
Standard Error	5.3 ppm	4.2 ppm	4.2 ppm

a) Millero et al., 1976b

b) Millero et al., 1978

c) This study

available, the equations using SiO<sub>2</sub> and NO<sub>3</sub> may be more useful. The use of equations requiring carbonate and nutrient parameters, although more correct, theoretically are not necessary to treat the measured densities. This may or may not be true for the entire oceans.

In summary, the experimentally derived equations can be used to estimate the changes in deep waters due to the oxidation of plant material. They should also give reasonable estimates for upwelled surface waters. The changes in the density of estuarine waters may be different due to changes in the inputs of various chemicals from a given river (Poisson et al., 1980, 1981; Millero, 1984) and the precipitation of minerals such as CaCO<sub>3</sub>. Further direct measurements of the densities of deep waters would be useful in improving the validity of the equations examined in this paper.

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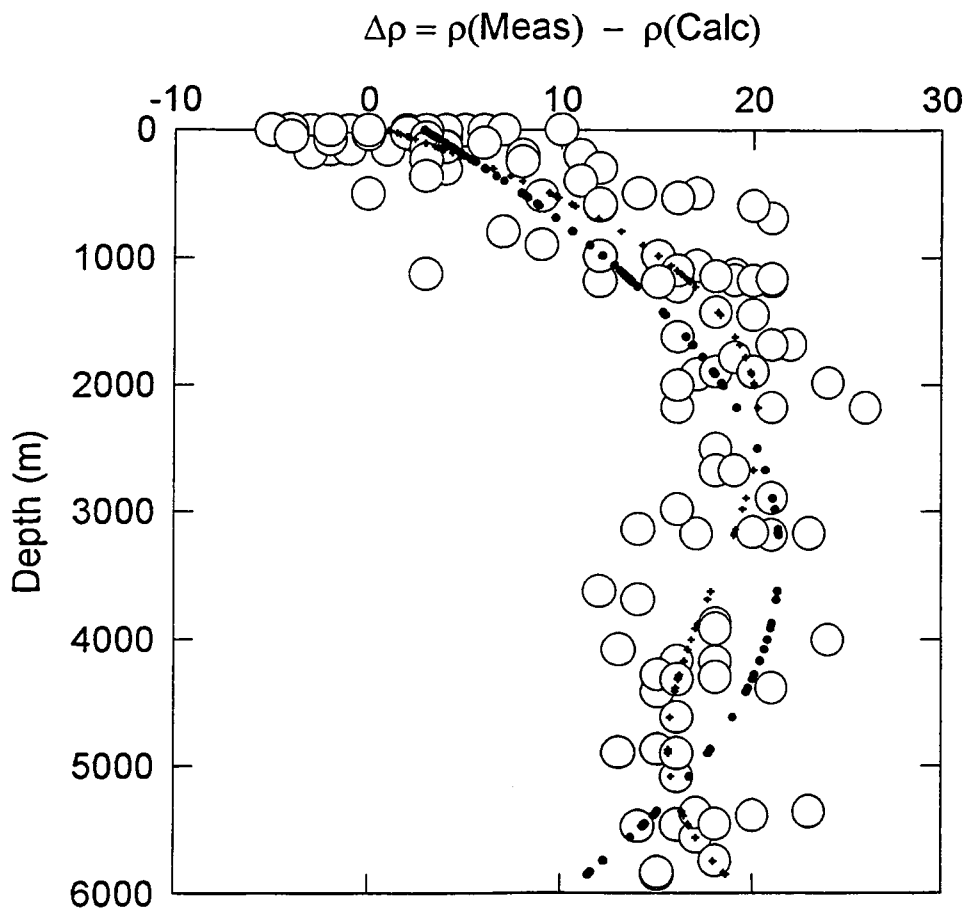
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## Captions For Figures

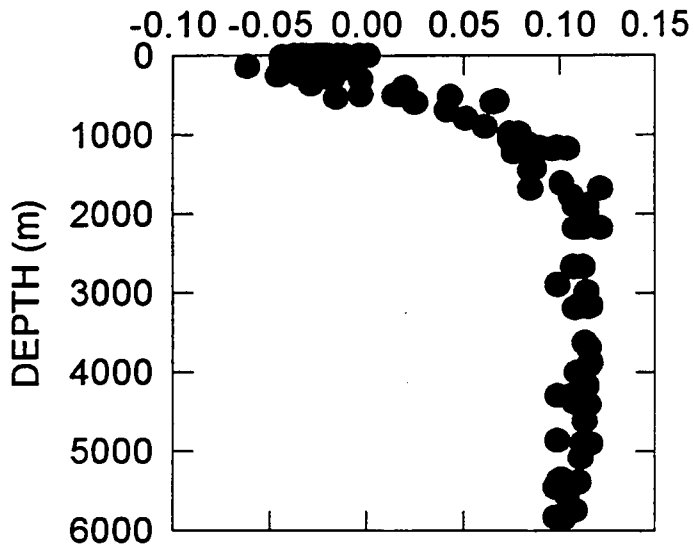
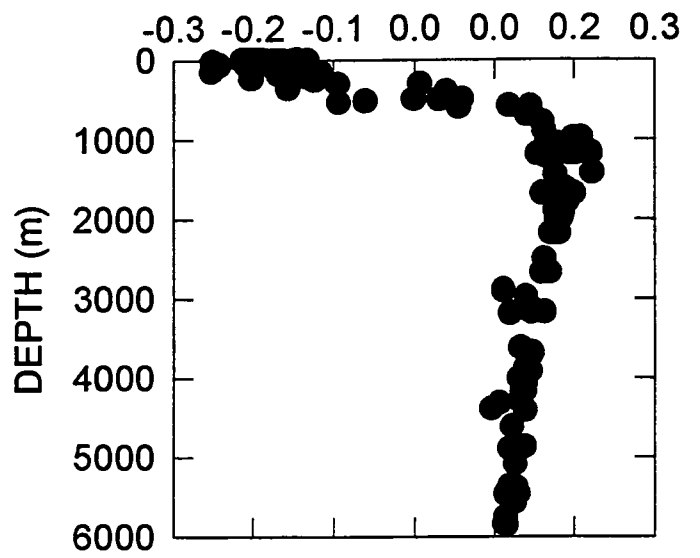
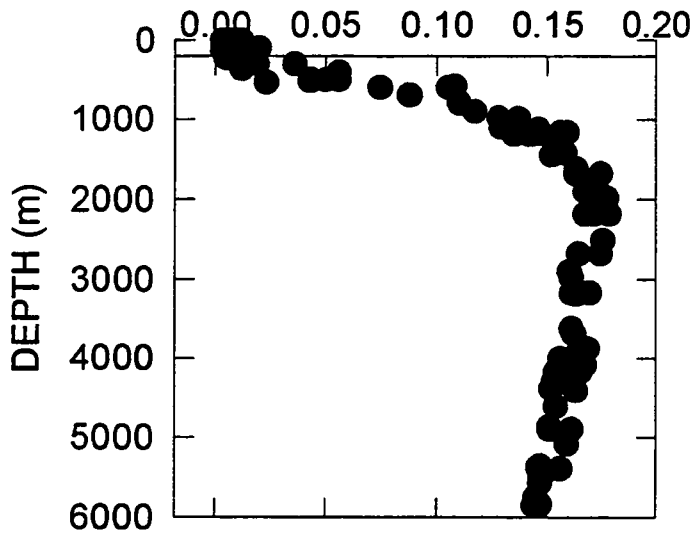
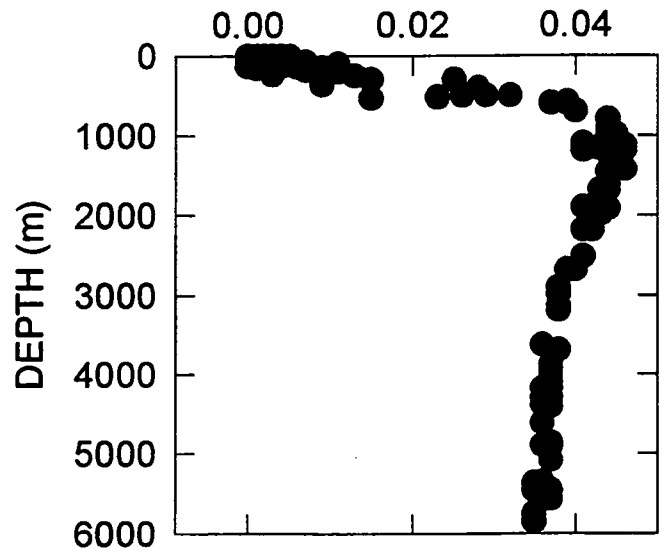
Figure 1. The measured excess densities,  $\Delta\rho = \rho(\text{Measured}) - \rho(\text{Calculated})$ , for the North Pacific (35N) as a function of depth. The lines are quadratic (+) and cubic (•) fits as a function of depth that have, respectively,  $\sigma = 4.6$  and 3.9 ppm.

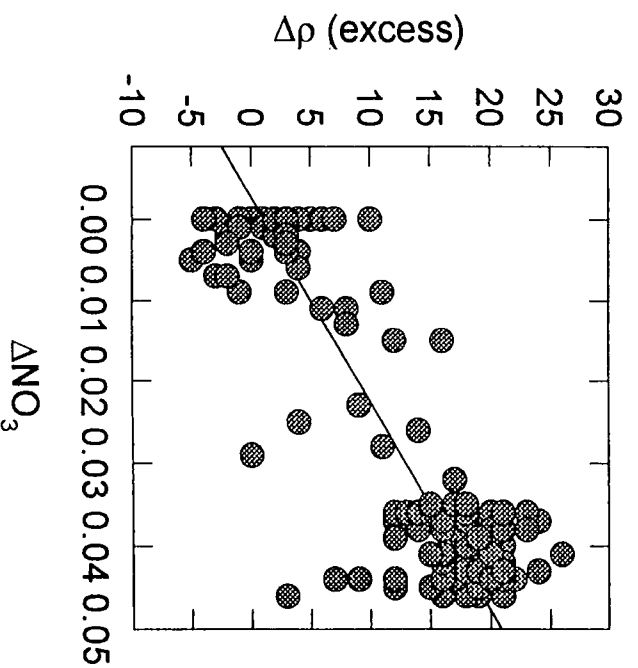
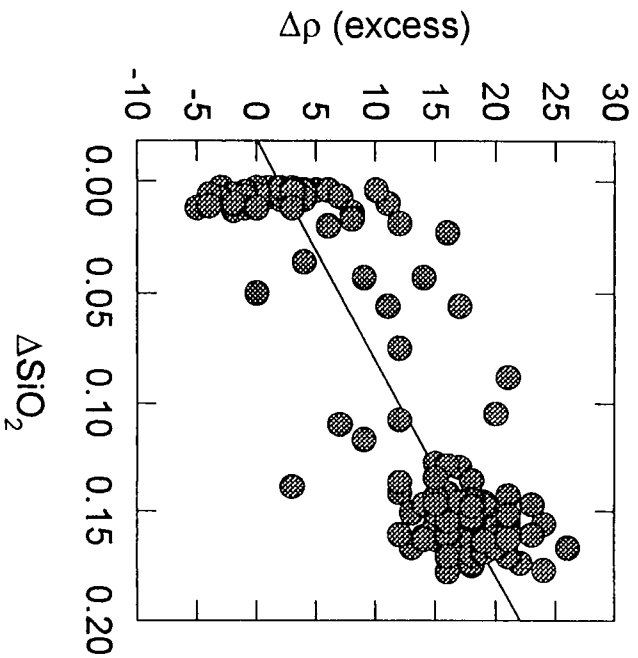
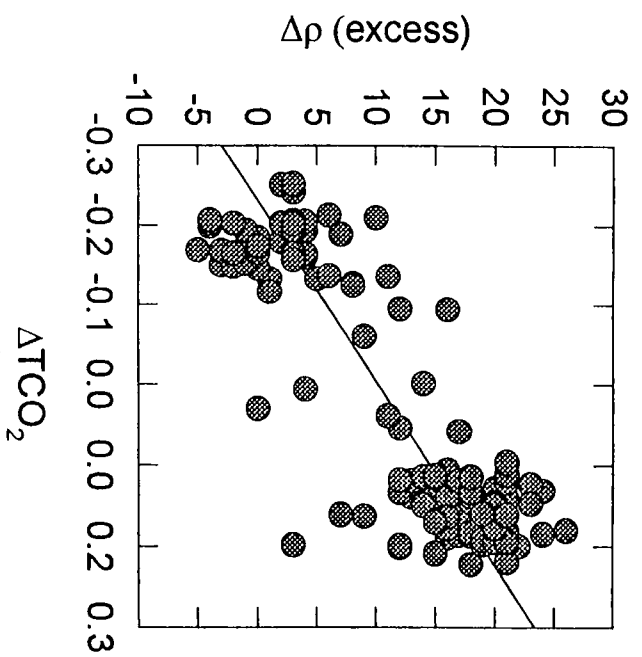
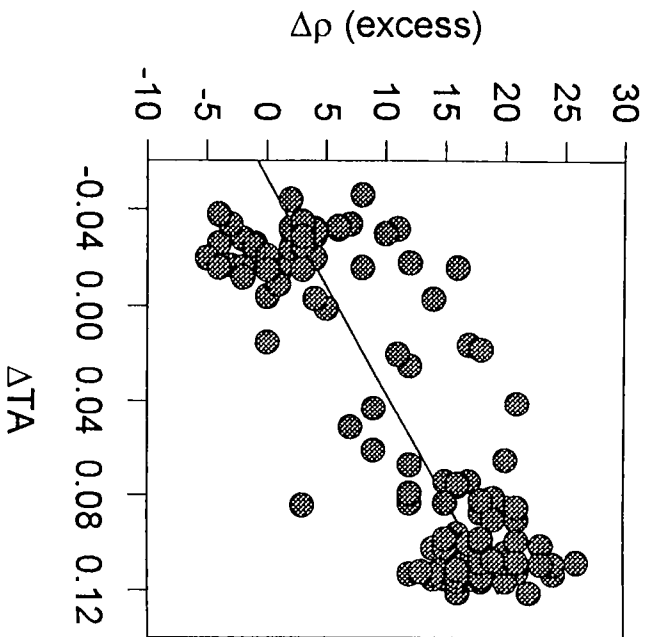
Figure 2. Profiles of the changes in total alkalinity ( $\Delta\text{TA}$ ), total carbonate ( $\Delta\text{TCO}_2$ ), Silicate ( $\Delta\text{SiO}_2$ ), and nitrate ( $\Delta\text{NO}_3$ ) for the North Pacific stations.

Figure 3. Linear plots of the excess density ( $\Delta\rho$ ) as a function of  $\Delta\text{TA}$ ,  $\Delta\text{TCO}_2$ ,  $\Delta\text{SiO}_2$ , and  $\Delta\text{NO}_3$  for the North Pacific stations.





$\Delta TA$  $\Delta TCO_2$  $\Delta SiO_2$  $\Delta NO_3$ 



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## ANNEX 5 - JGOFS Progress Report - 1995

This document contains a number of items referred to in the report of the discussion of JGOFS under Agenda item 2.3.2.

### *JGOFS OVERVIEW by J.G. Field: Chair JGOFS*

This brief Overview is being prepared as a personal opinion on JGOFS in relation to the terms of reference of the IGBP evaluation. It is bound to be incomplete and to emphasize more recent activities since I became involved in JGOFS personally.

JGOFS was initiated and organised by SCOR with major funding by that body. It later joined the IGBP stable as a Core Project but differs from others in having a different origin and in having "co-parentage" with continued input and major funding from SCOR. SCOR has deliberately started to reduce its input to JGOFS, with responsibility for financial management remaining with SCOR. The JGOFS Science Plan was published in 1990 with a clear goal and objectives relating to CO<sub>2</sub> and biogeochemical cycles. These goals were narrowed down in the Implementation Plan (1992) to concentrate on CO<sub>2</sub>, with studies on other elements only insofar as they affect the understanding of processes of CO<sub>2</sub> fluxes between atmosphere, upper ocean and deep ocean. This has helped to focus JGOFS activities.

**1. SCIENTIFIC HIGHLIGHTS:** JGOFS has stimulated international co-operation that would otherwise not have occurred. Some examples include:

**1.1. North Atlantic Bloom Experiment:** Following the "green carpet as it unrolls northwards" from low to high latitudes with the coming of spring was an important initial JGOFS activity which stimulated the development and publication of a set of protocols for observing the ocean. JGOFS provided the co-ordination that allowed multi-ship inter-calibration exercises to take place resulting in new international standards and method protocols being established. The fact that the spring bloom sediments out in a rapid event which can be detected in bottom sediments is also a significant finding. Further work is planned in a second phase of North Atlantic activity from 1997-2000 to study seasonal changes in both the formation of North Atlantic Deep Water at high latitudes, and biological and chemical CO<sub>2</sub> exchange processes.

**1.2. Time Series stations:** The Bermuda (BATS) and Hawaii (HOTS) time series stations have provided an invaluable time series of observations relevant to JGOFS with which to calibrate models. The BATS data, for example, have shown that a large part of carbon transport out of the photic zone, is by seasonal mixing of refractory dissolved organic carbon down into deeper water. The development and testing of new high temperature catalytic oxidation techniques for measuring dissolved organic carbon was due to JGOFS stimulation and needs in this area.

**1.3. Equatorial Pacific Study:** This study was planned because of the vast area of equatorial upwelling that occurs in the Equatorial Pacific, with accompanying outgassing of CO<sub>2</sub>, and the important role of ENSO in these processes. Initial results confirm the importance of ENSO in affecting rates of primary production and CO<sub>2</sub> flux in the Equatorial Pacific, and they confirm the Bermuda findings of DOC being an important component of carbon flux out of the photic zone. Furthermore, the High Nutrient Low Chlorophyll (HNLC) paradox of the region has given rise to the first large scale in situ Iron Fertilization Experiment, with JGOFS participation. This experiment showed enhanced primary production with iron fertilization, but the question of altered rates of CO<sub>2</sub> flux remains unresolved owing to subduction of the fertilized water mass.

**1.4. Southern Ocean:** The first phase of the JGOFS Southern Ocean study (1991-1995) put a new unity of purpose into various national Antarctic research plans, as they re-orientated previously-planned cruises to meet JGOFS objectives. The larger ships used in this region have permitted more exchanges of scientists than in other areas and many ships have accommodated scientists from other countries, promoting close international collaboration.

Preliminary results have been exciting and unexpected: the mosaic of water masses, fronts, seasonally moving marginal ice zones, and areas of subduction and upwelling has been intensively studied from a carbon flux angle. The first winter measurements of primary production and carbon flux have been made in the Southern Ocean, and the British results of 1992-3 suggest that in the areas encompassed by their cruises, the Southern Ocean was a net sink for CO<sub>2</sub>, whereas summer oceanic conditions were expected to provide a net source in the Southern Ocean. The southern summer of 1992-3 was an anomalous year, however (post-Pinatubo eruption, El Niño) and it remains to be seen whether these results are the norm or not.

1.5. Arabian Sea: This region was chosen because of the massive seasonal changes in upwelling caused by monsoonal reversals of wind and current. This had been dramatically demonstrated by the Nimbus Ocean Color satellite images, and unfortunately the delayed launch of SeaWiFS has hampered the work in this region. Early observations confirm that NO<sub>3</sub>-rich waters throughout the study region during the NE monsoon in January were depleted by March-April, with oligotrophic conditions prevailing during the most recent cruises. Thus initial results look promising and will be presented at the Villefranche Symposium.

1.6. Continental Margins: This joint work with LOICZ is only just getting off the ground, but has served the purpose of getting many new countries, which are unable to get significant funding for "blue water" research, involved in JGOFS. Thus scientists in Taiwan, Chile and South Africa, for example, have tailored their national research programmes to JGOFS objectives. This work is stimulated by the importance of continental shelves and slopes as regions of enhanced primary production and massive carbon sedimentation, and the need to study the dynamics of coastal upwelling as both a source and a sink for CO<sub>2</sub>. It seems from initial models that the intervals between and duration of upwelling pulses, and the degree of subsequent stratification are important factors in assessing the relative importance of outgassing and biological uptake of CO<sub>2</sub>. Further work on estuaries, cross-shelf transport, and other aspects of carbon flux are being planned for continental margins.

1.7. General: JGOFS has involved physical oceanographers, chemists, geochemists and biologists in planning and executing its research. These scientists would probably not all have co-operated without JGOFS. The disciplines have brought with them a range of techniques ranging from stable-isotope and radio-isotope methods, to physiological uptake experiments, to sediment traps, satellite remote sensing and ocean optics. Models range from geochemical box models to ecological models and to coupled ecological 3-D ocean general circulation models. The resulting interaction has promoted vigorous and healthy debate on issues such as the relative importance of physical, chemical and biological processes in carbon flux on scales ranging from the thermohaline circulation to coastal upwelling. JGOFS has caused scientists to view a range of processes in very different ocean regions from the common perspective of carbon flux. I believe that as a result, there have been paradigm shifts in areas such as understanding the role of DOC, in the importance of physical processes which drive the "biological pump" and in the "iron hypothesis" in HNLC regions. These ideas are now being further tested as hypotheses in the next phase of JGOFS. Many scientists have been stimulated to work on JGOFS science as a result of the excitement it has generated.

## **2. IMPLEMENTATION:**

2.1 Within JGOFS: Generally, JGOFS has implemented its Plans in a satisfactory manner. The various Task Teams have functioned well, they have been given tasks to perform within a limited period (usually 1-3 years) and then either reconstituted with new terms of reference, or disbanded. This modus operandi has been based upon the experience of SCOR working groups and instils a sense of urgency. Again, the performance of each Task Team has generally depended upon the leader. If the leader has been well-motivated and energetic, the group has normally done its job. The regional process studies mentioned above (1.1 - 1.5) have been organised by international Planning Groups of scientists, working with a lead time of two or more years before the studies have taken place. These have been able to focus on detailed implementation in each region in a way the SSC could never do, and have operated very successfully.

**2.2 Amongst Core Projects:** JGOFS has had good links with other marine Core Projects, or those being planned. A JGOFS-SSC representative was on the Core Project Planning Committees (CPPC) for both LOICZ and GLOBEC. JGOFS is also heavily involved in planning for a potential successor project, tentatively called GOEZO (Global Ocean Euphotic Zone Study) which would link upper ocean physics and biology using GOOS technology to understand and predict climate and weather patterns. There has been good collaboration with IGAC in the Biogeochemical Ocean Atmosphere Transfers workshop (BOAT) and with IGBP-DIS in compiling a global database of CO<sub>2</sub> measurements. Although there has been little initial marine activity in GAIM, some marine modellers with JGOFS links have been involved with GAIM and more JGOFS links are planned. There has been only limited contact with PAGES hitherto, but more is envisaged with the new IMAGES research initiative organised jointly by SCOR and PAGES. New multi-ship work in the North Atlantic (1997-2000) is being planned jointly with the potential Core Project, GLOBEC.

**3. SCIENTIFIC RELEVANCE:** I believe that JGOFS is still addressing the most important scientific issues involved in the role of the oceans in the carbon cycle. The Science Plan articulated the problem, and the Implementation Plan set the focus. Although we had initially planned to update the Implementation Plan annually, then biennially, plan development has proved to be generally stepwise on different JGOFS fronts (eg. particular regions of the world ocean) rather than steady, and it now seems more appropriate to update JGOFS plans topic by topic as the Task/Planning Teams report. The need to provide an overall update of JGOFS plans may change in future, but producing such reports would need improved staffing of the Core Project Office.

**4. LINKS TO OTHER PROGRAMMES:** We have co-operated well with the World Ocean Circulation Experiment (WOCE) in the WHP-JGOFS CO<sub>2</sub> survey in which WOCE ships have had at least one berth for CO<sub>2</sub> measurements. This survey of CO<sub>2</sub> provides extensive 3-D global ocean cover to complement the intensive regional process and time series studies on one hand and the satellite remote sensing of the ocean surface on the other. The IOC/JGOFS CO<sub>2</sub> Panel (sponsored jointly with the Intergovernmental Oceanographic Commission (IOC)) is strongly involved in the CO<sub>2</sub> survey and has published a handbook of analytical protocols to measure carbon compounds in sea water. It has also organised the 1994 international inter-calibration exercise to measure pCO<sub>2</sub> at sea. A global database for pCO<sub>2</sub> field data is being established in conjunction with IGBP-DIS (see 2.2 above). These activities of the Panel are central to one major goal of JGOFS: to quantify the capacity of the oceans to absorb atmospheric CO<sub>2</sub>.

**5. DATA SYSTEMS:** JGOFS adopted a policy of distributed databases early on and applied this with reasonable success in the North Atlantic Bloom Experiment. The Task Team remained fairly dormant until a new chair was appointed in 1993. The new direction emphasized the need for user-friendly databases, including meta-data on ordinary spreadsheets, which was achieved with rapid success. In some ways the oceanographic community has had a head start with the prior existence of the system of National Data Centres and World Data Centres but at the same time this has handicapped development by restricting them to old technology and old fixed formats, whereas we might have been better served by new GIS technology had we started from scratch. The lack of a full time data person in the JGOFS Core Project Office has severely restricted our development in recent years. The US-JGOFS data system is developing utilization of the World Wide Web, providing open, user-friendly access to the entire global community of computer users, not just oceanographers and other scientists.

**6. GLOBAL CHANGE MONITORING:** JGOFS has established links with GOOS through several individuals associated with JGOFS (e.g. O. Brown, A. Knap, N. Andersen, J. McCarthy) serving on GOOS Committees. Nevertheless, there is a general feeling amongst the SSC that JGOFS should have more direct and formal links with GOOS. For example, we should be asked to comment on proposals or to submit proposals with plenty of lead time to enable meaningful discussion to take place within JGOFS-SSC or to set up special sub-committees for this purpose.

**7. POLICY RELEVANCE:** JGOFS had rather little input into the 1992 IPCC assessment, a fact that disturbed many of us. We have rather more input into the 1995 assessment through JGOFS-associated individuals being lead authors of marine chapters, and through the review process.

**8. COMMUNICATION:** JGOFS has been generally successful in communicating its findings to the specialized scientific community through publications in the specialized literature, with special volumes of Deep Sea Research devoted to JGOFS intensive studies, articles in Science, Nature and other leading scientific journals. We have been much less successful in communicating with the general public and with policy makers. The Ambio volume on IGBP and Global Change was a step in the direction of the general public, but probably does not have a wide enough audience to be as influential as one would like to be. The Dutch film on an Antarctic JGOFS cruise is another limited step in the direction of general publicity. The Cambridge University Press IGBP series being planned, with one volume on the JGOFS Villefranche Symposium keynote addresses is another planned step in this direction. Clearly more needs to be done to bring JGOFS findings to the lay public and to policy makers. This may be a general problem within the IGBP. In the case of JGOFS, our staff limitations in the CPO have never allowed us to put much effort into the area of communications beyond the scientific community.

**9. FUNDING:** JGOFS science has been funded at the national level, with national committees and agencies paying for all the scientific activities, ships' time, computing, etc. With one or two notable exceptions, prioritization of research funding has been by good luck rather than by design. It seems that there have been sufficiently powerful JGOFS scientists on key national committees to influence decisions at national level in most countries, so that generally international regional studies have been reasonably well timed and co-ordinated. One notable exception has been that some Japanese scientists have been very dissatisfied that there has been no major JGOFS process study in the Northwest Pacific Ocean. Meetings, transport costs to meetings, and other co-ordination activities have been largely met by SCOR with some IGBP assistance. The Core Project Office in Kiel has had only 3 half-time staff (Executive Scientist seconded by Canada and then USA, an assistant scientist and secretary). This has been completely inadequate and when the Executive Scientist has been at sea, has resulted in a very heavy load upon the Chair and the SCOR Executive Director who manages the finances. In recent years virtually all communication has been by e-mail, with the CPO spread between Kiel, Virginia, Baltimore and Cape Town. 4-Way copies of messages have resulted in masses of correspondence which has been very time consuming. It is strongly recommended that the Core Project Office be re-centralised with 3 full-time staff, one a database specialist.

**10. CAPACITY BUILDING:** The early activities of JGOFS were largely by developed countries in "blue water" oceanography with little scope for capacity building. This has changed in the last few years with the Arabian Sea regional process study and with the Continental Margins joint project. Training workshops have been held in Halifax, Nova Scotia; in Mombasa, Kenya, and in Bangalore, India in association with the IOC and SCOR. SCOR has often funded participation in JGOFS meetings of individuals from developing countries and the former Soviet Union. In several cases these individuals have become entrained in JGOFS.

**11. LINKS TO NATIONAL RESEARCH PROGRAMMES:** Links to National Research Programmes are generally informal through JGOFS-SSC members and other science leaders also serving on National Committees. The Chair of JGOFS SSC and other SSC members are frequently asked to review proposals to national committees for funding: indeed this is a major time-consuming activity that was not mentioned when I was approached to take on the chair. This informal mechanism appears to work fairly well, in that most major national programmes provide important input to the overall JGOFS effort and these efforts have been fairly well co-ordinated. The publication of protocols for JGOFS measurements has helped maintain standards and compatibility of data amongst the national programmes. Another more formal mechanism is that chairs of National Committees are always invited to SSC meetings (at their own expense: unless assisted by the SCOR fund for developing countries mentioned in 10 above), and there are usually several non-SSC members present as a result of these invitations. Several such individuals have later been invited to join the SSC. The publication of JGOFS "White Reports" has also greatly assisted national programmes in tailoring their activities to JGOFS.

**12. SYNTHESIS OF JGOFS RESULTS:** I still have worries about whether the overall JGOFS synthesis activity, which must involve major modelling activities, will be adequately pursued, funded and co-ordinated by this informal mechanism once the field activities and data-gathering expeditions cease. The modelling community is a small one and is very stretched. Good modellers are continually being promoted to more and wider responsibilities

in the national context, so that it has proved very difficult to retain leadership for the JGOFS Synthesis and Modelling Task Team. It will be vital to the final JGOFS effort that the added-value of international co-operation is obtained by proper funding of synthesis and modelling activities for some 5 years after the data-gathering ends. There will need to be strong links with GAIM during this phase.

**13. ORGANIZATION AND STRUCTURE:** JGOFS has a good relationship with the IGBP and its Secretariat through their attendance at JGOFS-SSC and Executive meetings and through the periodic officers meetings. JGOFS itself has functioned well through having an annual SSC meeting which is also attended by the chairs of active Task/Planning Teams, and through a 4-person Executive Committee (Chair, Vice chair, and two others) who meet with the Core Project office personnel annually between SSC meetings. The smaller Executive meetings are essential to the practical running of the Project, whereas the SSC meetings are accompanied by scientific presentations which keep the JGOFS community in touch with both scientific and organizational matters. It is probably true that most JGOFS-SSC members have fairly limited knowledge of how the rest of IGBP operates and who its personalities are, but they do understand the scientific issues.

**14. JGOFS LEGACY:** As stated in the Implementation Plan, JGOFS plans to leave a legacy for marine Global Change research after the JGOFS sunset date in 2005. This legacy includes:

- an assessment of large-scale carbon fluxes, obtained from a greatly increased network of observations
- a set of models that express our understanding of processes controlling large-scale carbon fluxes
- a procedure for observing the ocean in a routine, synoptic manner to detect changes in the ocean carbon cycle in response to climate change
- a well cared-for data set comprising observations made to standard protocols and a system for making subsets of these data easily available to researchers
- knowledge and understanding of fluxes across continental margins to provide reliable boundary conditions for global ocean models
- an increased number of countries with an interest and skill in JGOFS-type activities and making appropriate measurements and global scale inferences.

**15. CONCLUSION:** JGOFS has operated in a generally satisfactory manner, largely on the basis of goodwill and voluntary contributions by the scientists and staff involved, including the SSC and the chairs of Task Teams. The Core Project Office is under-funded and under-staffed, and this needs urgent attention. New international co-operation and inter-disciplinary activity have been stimulated by JGOFS and exciting new findings have emerged, a few of which are touched upon in para 1. Further intensive process studies are needed until the year 2000, as are extensive surveys and remote sensing of ocean color and other ocean properties that assist in extrapolating from local to regional and global scales. It is likely that the joint Continental Margins project with LOICZ which is just starting, will need to continue beyond the lifetime of other JGOFS fieldwork. JGOFS is developing and planning its synthesis work; this will need a full time database manager and intensive modelling activity which will have to continue for at least five years after fieldwork is completed, with appropriate funding levels.

For me personally, serving on the JGOFS-SSC and the SC-IGBP have been demanding but very rewarding experiences from which I have learned a great deal. My interaction with the IGBP, SCOR, and JGOFS scientific communities has been a privilege which I greatly value. I thank my colleagues Liz Gross, Hugh Ducklow, Liliane Merlivat, Trevor Platt and Arthur Chen for commenting on a draft of this report, but emphasize that these are my personal views which may differ from theirs.

JGF 4.5.95



***First JGOFS Science Symposium***  
***An article for TOS magazine by Steve Calvert***

The international JGOFS program is now officially seven years old, having been started in 1987 under the auspices of the Scientific Committee on Oceanic Research (SCOR) of the International Council of Scientific Unions (ICSU). The principal aim of the project is to understand more fully the global fluxes of carbon and related biogenic elements in the ocean and their exchanges with the atmosphere, sea floor and margins, so that we will be able to detect changes in these cycles in relation to climate change. Considerable activity has ensued, with several internationally-coordinated field programs and many national projects in different oceanic regimes. JGOFS became a core project of the International Geosphere-Biosphere Program (IGBP) in 1989, and will continue until the end of this decade, while a period of data integration, synthesis and modelling will last a further three to five years.

The first comprehensive JGOFS Science Symposium was held May 9-12, 1995 in Villefranche-sur-Mer, France, and was hosted by Liliane Merlivat of the Université Pierre et Marie Curie, Paris, and Andre Morel and Paul Nival of the Observatoire Océanologique, Villefranche. This was designed to serve both as a mid-life review of the accomplishments of the international program over its first seven years and as part of a formal scientific evaluation of IGBP, performed under the auspices of ICSU and the International Group of Funding Agencies for Global Change Research (IGFA) during the past year. An evaluation team chaired by Devendra Lal of Scripps Institution of Oceanography, U.S., and including Wajih Naqvi of the National Institute of Oceanography in Goa, India and Kenneth Mann of Bedford Institute of Oceanography, Canada, was present. More than 130 participants from 20 countries attended the symposium, which was held in the magnificent lecture hall of La Citadelle, a Crusader fortress that dominates the Villefranche waterfront.

Keynote talks reviewing JGOFS achievements in time series programs, process studies, the global survey and modelling were presented during morning and late afternoon sessions, while more than 80 investigators contributed posters that were presented in the early afternoons in the gardens and the former "galley slaves dungeon" at the Station Zoologique.

James McCarthy of Harvard University, U.S. began with an overview of the paradigms developed in the 1950s and 1960s that led to the development of JGOFS. A number of talks highlighted the progress in topics fundamental to the success of JGOFS. Anthony Michaels of the Bermuda Biological Station for Research compared results from the Bermuda and Hawaii time-series sites. Hugh Ducklow, filling in for Richard Barber of Duke University, U.S. and Peter Liss of the University of East Anglia, U.K. reviewed the results of the first iron fertilization experiment, just as ships were returning once again to the waters off the Galapagos Islands in the equatorial Pacific, and Hein de Baar of the Netherlands Institute for Sea Research, Texel presented results of the iron fertilization experiments in the Southern Ocean. Peter Williams of the School of Ocean Sciences, University of Wales, Bangor, U.K. discussed problems inherent to the determination of primary and community production and respiration and N. Handa of Nagoya University, Japan examined the problems of determining primary and new production. Liliane Merlivat reviewed the status of the JGOFS CO<sub>2</sub> survey. Trevor Platt of Bedford Institute of Oceanography, Canada and Shubha Sathyendranath of Dalhousie University, Halifax, Canada presented results of studies of ocean colour and basin-scale production from satellite remote sensing. Graham Shimmiel of Edinburgh University, U.K. and Steve Calvert of the University of British Columbia, Canada assessed the current understanding of particle export, sedimentation and burial in the sea floor.

The results of the various JGOFS regional process studies were presented throughout the week. Hugh Ducklow reviewed the results of the successful JGOFS North Atlantic Bloom Experiment, and Truls Johannessen of the University of Bergen, Norway and Egil Sakshaug of the Trondheim Biological Station, Norway gave accounts of carbon cycling in the high latitude North Atlantic. Ulrich Bathmann of the Alfred Wegener Institut, Bremerhaven, Germany, and Paul Treguer of the Université de Bretagne Occidentale, Brest, France, summarized

the diverse and numerous observations from the first phase of the Southern Ocean studies. Margaret Leinen of the University of Rhode Island, U.S.A. reviewed the JGOFS Equatorial Pacific Process Study, Bernt Zeitzschel of the Institut für Meereskunde, Kiel, Germany gave an account of the development of the Arabian Sea Process Study with some results only a few days old. Kon-Kee Liu of the National Taiwan University, Taipei emphasized the importance of ocean margins in the global carbon cycle.

The presentations included several talks on modelling by Robbie Toggweiler of Princeton University, John Parslow of the CSIRO Division of Fisheries, Hobart, Australia and Michael Fasham of the James Rennell Centre, Southampton, U.K. Jean-Francois Minster of the Centre National d'Etudes Spatiale, Toulouse, France discussed the problem of data assimilation in global models.

The Symposium ended with a free-ranging discussion of the successes and short-comings of the program and the prospects for ocean biogeochemical research beyond JGOFS chaired by the President of SCOR, I.N. McCave of Cambridge University, and the Chairman of IGBP, Peter Liss of the University of East Anglia.

The Villefranche symposium served to highlight the important results so far obtained, the very wide range of research currently underway and also, importantly, provided a glimpse of the magnitude of the effort needed to reach JGOFS goals. This is a daunting task, but the participants left the symposium with a sense of renewed excitement about the final achievements of the program.

Some copies of the book of abstracts for the symposium are still available from the SCOR Secretariat (scor@jhu.edu, Fax: 410-516-4019). The keynote lectures will be published in a book by Cambridge University Press in its new IGBP Global Change series.

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*Excerpt from the Report of the ICSU/IGFA Evaluation Committee for the International Geosphere-Biosphere Program*

During 1994-95 an evaluation of IGBP was carried out under the Auspices of ICSU and IGFA (the International Group of Funding Agencies for Global Change Research). In addition to the review of the overall program, a member of the Evaluation Committee chaired a sub-group which assess each Core Project and Framework Activity. The JGOFS Evaluation Sub-group was chaired by Devendra Lal (USA) and included K.H. Mann (Canada), S. Naqvi (India) and A. Stigebrandt (Sweden). Three members of this group attended the JGOFS Science Symposium and had extensive interactions with the JGOFS SSC members and other participants. The following summary of their detailed report is taken from the overall IGBP evaluation report.

**D. Joint Global Ocean Flux Study**

The Expert Group found JGOFS (co-sponsored by IGBP and ICSU's Scientific Committee on Oceanic Research) to be a coherent, multi-disciplinary and well focused programme to learn about the atmosphere-ocean coupled carbon cycles. Several coordinated research programmes conducted to date clearly attempt to address the main objectives of the programme, based on field work since 1989. JGOFS has successfully carried out intensive process studies in selected geographic locations in the North Atlantic, Equatorial Pacific, Arabian Sea and the Southern Ocean. Results to date have already led to a better understanding of critical processes identified under the JGOFS programme, for example the draw down of CO<sub>2</sub> during blooms in the North Atlantic bloom experiment.

The JGOFS programme has also contributed to periodic sampling of the oceanic environment at several selected sites. The time series stations and the specific process-oriented experiments in selected geographical locations have contributed to the development of sampling protocols, and high quality data, which will no doubt go a long way in assessing the nature of the carbon cycle and its relation to climatic changes. No doubt the data will be used for a long time by the scientific community to validate oceanic models.

The JGOFS programme is producing extensive data on carbon fluxes, total production and new production. Concurrently, serious attempts are underway to model the data in a holistic fashion, to understand inter-relationships between these state variables, and to obtain predictive capabilities. It is heartening to see that the size of the modelling scientific community is growing rapidly.

The Group took note that JGOFS has contributed to training of scientists, and also that JGOFS has maintained close links with other IGBP projects, e.g. PAGES, IGAC and LOICZ.

The Group is convinced that the JGOFS programme will have an important impact on our understanding of the oceans as regulators of the global climate on a wide range of time scales. The legacy of JGOFS is the rich intellectual property contributed by the participating scientists, including those who also agreed to contribute to organising this activity on an international basis. The principal reasons for the success of JGOFS lies in the exciting and critical questions which are, in fact, the objectives of the programme, resulting in active participation from scientists the world over.

There are, however, some present difficulties (known to the JGOFS community), which must be looked at carefully:

- The lack of availability of ocean color data has no doubt imposed a severe limitation on the global assessment of productivity. It is hoped that SeaWiFS would be launched in September this year. At this stage, it seems necessary to chart out contingency plans should there be further delays, or technical failures.
- In the context of JGOFS objectives, carbon fluxes across the principal interfaces and in the ocean column are of course of great value. At present, however, there appear to be some ambiguities or uncertainties in obtaining these.
- The observational programme does not seek to make specific observations which would clearly delineate global changes, both natural and anthropogenic. This aspect should be considered carefully in future plans for the observational programme of time-series stations.

Although high quality global scale pCO<sub>2</sub> data are now being collected in coordination with the WOCE (World Ocean Circulation Experiment) programme, estimations of CO<sub>2</sub> fluxes still have considerable uncertainties. Urgent steps should be taken to improve on methods or algorithms for conversion of pCO<sub>2</sub> data to CO<sub>2</sub> fluxes.

There appears to be some grounds to doubt the carbon fluxes based on traps, which may be uncertain by up to factors of 4. There is a need to give high priority to studies of benthic fluxes in the programme.

It appears equally important to include studies in continental margins, either in joint programmes with the Land-Ocean Interactions in the Coastal Zone Project (LOICZ) or even independently.

*Recommendations:*

Thus, whereas the Group was very satisfied with the present status of the JGOFS programme, there are several concerns relating to acquiring data, specifically ocean color data, and there is an urgent need to improve on the present experimental and analytical methods for obtaining carbon fluxes at the air-sea and water-sediment interfaces, and within the water column.

- JGOFS should give highest priority to the detailed resolution of carbon fluxes at the air-sea interface, in the water column, and at the sediment-water interface specifically:
  - at the air sea interface, more research is needed to improve estimates of invasion rate of CO<sub>2</sub>. This will involve reducing present uncertainties associated with estimating the air-sea exchange fluxes based on measured pCO<sub>2</sub> values in the atmosphere and in the ocean.
  - in the water column, string attempts should be made to resolve conflicting estimates of fluxes made with traps and with tracers. Data from the BATS site suggest that the sediment traps underestimate the particulate flux by a factor of 2 or more.
  - at the sea floor, more attention should be paid to understand the mechanisms and quantify the rates of biogeochemical transformations.

JGOFS should also:

- give priority to assessing spatial and temporal heterogeneity of carbon fluxes in the ocean using remote sensing techniques. In the case that SeaWiFS is not available, contingency plans should be developed for alternative techniques of remote sensing.
- work vigorously with LOICZ to ensure that a strong effort is made to determine the exchanges between the continental margin and open sea.
- expand collaboration with IGAC to measure air-sea exchanges of climatically significant trace gases (N<sub>2</sub>O, DMS, etc.).
- work with GOOS (Global Ocean Observing System) to ensure an effective global monitoring system using the latest technology for automated analysis of nutrients and pCO<sub>2</sub> on moored instrumental arrange. One of the outcomes of the JGOFS programme may be the identification of “markers” to be used as indices of ocean climate change. A network of time-series stations in various biogeochemical provinces will be very useful.
- consider the importance of the nitrogen cycle in controlling carbon flux, and their sensitivity to global change, strong effort should be made to resolve the apparent imbalance in the oceanic nitrogen budget (nitrogen fixation, denitrification, etc.).
- make more effort to enhance the capability of developing countries by offering participation in JGOFS cruises to qualified personnel and by providing training in contemporary analytical techniques. JGOFS should cooperate with LOICZ in implementing coastal boundary studies which would be within the capability of countries that do not possess large ocean-going research vessels.
- appoint a data manager for the JGOFS core office as soon as possible, as the success of JGOFS hinges on efficient international data exchange.
- Finally, after the completion of field work that will end in 1999, JGOFS should continue in a synthesis phase until 2004. It is hoped that the remotely sensed (SeaWiFS) data, essential for achieving the objectives of JGOFS, will be available within the lifespan of JGOFS. It is refreshing to note that JGOFS is giving a time limit on its own lifetime.

### *Terms of Reference for the JGOFS Scientific Steering Committee*

The SSC for JGOFS is responsible for the overall scientific direction and management of the Core Project on behalf of SCOR and IGBP.

- To oversee the development and implementation of the Joint Global Ocean Flux Study in accordance with the published Science and Implementation Plans;
- To foster the integration of JGOFS activities in order to achieve the global synthesis required to meet JGOFS objectives;
- To ensure the appropriate collaboration with other IGBP Cored Projects (especially LOICZ and GLOBEC), WCRP programs (especially WOCE and CLIVAR) and other international activities, such as GOOS;
- To put in place the necessary data management policies so as to ensure the exchange and preservation of JGOFS data sets;
- To report regularly to SCOR, IGBP and related bodies on the state of implementation and accomplishments of JGOFS.

The JGOFS SSC, its Officers, subsidiary groups and Core Project Office shall operate in accordance with the guidelines established by SCOR and the SC-IGBP (see following document).

#### **Operating Procedures for the JGOFS SSC**

The Joint Global Ocean Flux Study (JGOFS) is a Core Project of the International Geosphere-Biosphere Program of ICSU. The Scientific Steering Committee of JGOFS (henceforth referred to as SSC) is sponsored by the Scientific Committee on Oceanic Research (SCOR) and the Scientific Committee of the IGBP (SC-IGBP). The two organizations are jointly responsible for the appointment of the Chairperson, Vice-Chair and members.

The primary functions of the JGOFS SSC are:

- to provide scientific guidance to and oversee the development, planning and implementation of the Core Project;
- to provide direction and set priorities for the core project office and subsidiary groups;
- to promote communication and collaboration among program participants;
- to encourage the publication of workshop, conference and research results in accordance with the SCOR publication policy;
- to encourage the promotion and wide awareness of JGOFS amongst the science community;
- to demonstrate progress and achievements of the project through the definition and monitoring of milestones and results;
- to provide on request, scientific advice to JGOFS and IGBP National Committees and START Regional Committees, in the planning of national and regional research which is designed to contribute to the overall goals of the JGOFS Core Project.
- to encourage national governments, regional and international funding agencies to support the implementation of Core Research and the achievement of Core Project goals through the provision of adequate documentation of scientific goals, means and needs and the establishment of an appropriate program infrastructure.
- to encourage collaboration between JGOFS and other IGBP Core Projects and International Programmes and Agencies concerned with the scientific study and assessment of global change; and
- to recommend to SCOR and the SC-IGBP:
  - members for appointment by SCOR and the SC-IGBP to the committee;
  - a Chairperson for appointment by SCOR and the SC-IGBP;

- a Vice-Chair for appointment by SCOR and the SC-IGBP; and,
- such amendments to these terms of reference as may prove necessary from time to time.

In undertaking these responsibilities the SSC shall collectively:

- prepare, approve and publish methodologies, protocols and data documentation and exchange standards to guide the data collection aspects of the program.
- meet at least once a year, to review progress in the development and implementation of the JGOFS and to advise the Chair and Core Project Executive Officer on the scientific developments which should be initiated or undertaken between meetings;
- prepare plans and guidelines for the conduct of meetings, workshops, and conferences designed to assist the SSC in executing its functions;
- prepare and revise, as necessary, criteria for the identification of national and regional research which contributes to the goals of JGOFS as: Core Research; Regional/National Research; or Relevant Research;
- develop guidelines for the preparation, publication and distribution of substantive and technical reports resulting from Core Research; from the work of the JGOFS Core Project Office; and, from related activities of JGOFS individually and collectively;
- develop and devise a methodology for monitoring and assessing progress;
- advise the Core Project Executive Officer on the necessary actions required of the Core Project Office in support of the work of the SSC and,
- consider such other matters as individual members or the Core Project Executive Officer bring to the attention of the SSC or are referred to it for consideration by SCOR or the SC-IGBP.

Members of the Scientific Steering Committee serve in their individual capacities and are expected to:

- attend in full, the meetings of the Scientific Steering Committee;
- be willing to expend considerable effort outside of SSC meetings;
- provide the best possible scientific information and advice concerning their field of specialization as it relates to the goals and Operational Plan for the Core Project;
- provide scientific advice to the Chairperson and Core Project Executive Officer on the development and implementation of the JGOFS program;
- represent the scientific interests of the Core Project at relevant scientific meetings;
- provide a written report to the CPO within one month of attendance at a meeting at the expense of the CPO;
- provide a two-way channel of communication between the Scientific Steering Committee and the national and where possible, regional and international research community;
- organize, convene, conduct meetings and provide reports for such Core Project Workshops as shall be agreed by the SSC;
- keep the Core Project Office and Chairperson of the SSC fully informed of all actions directly or indirectly related to the Core Project; and
- assist in securing financial and other support for the execution of Core Research, adopted and approved by the Committee.

The Chairperson of the Scientific Steering Committee is expected to:

- participate in the selection and evaluation of the Core Project Executive Officer;
- chair the meetings of the Committee;
- conduct the meetings in accordance with "good practice" guidelines to be established by the IGBP;
- undertake advocacy on behalf of the project and enlist wide international participation in the project;
- work closely with the Core Project Executive Officer in implementing agreed activities between meetings of the Committee;

- report periodically to SCOR and the SC-IGBP on progress implementing the project and seek the assistance of SCOR and the SC-IGBP in addressing difficulties encountered in the implementation.

The Vice-Chair of the Scientific Steering Committee is expected to:

- chair the meetings of the committee in the absence of the Chairperson;
- undertake advocacy on behalf of the project and enlist wide international participation in the project; and
- assist the Chair and the Core Project Executive Officer in implementing agreed activities between meetings of the Committee.

Responsibilities of the Core Project Office:

The Core Project Office (CPO) will assist the JGOFS Scientific Steering Committee in planning and carrying out new scientific research; it will also serve as a much-needed channel of communication between scientists working in different countries on various aspects of global change. An important early task of the CPO will be to assist the SSC in collating information on national and regional programmes of global change research relating to the Core Project to ensure that there is no unnecessary duplication of effort and that the project makes effective use of existing knowledge in its analysis of processes and change at global scales.

The general tasks of a Core Project Office are as follows:

- administering the project on a day-to-day basis, under the direction of the SSC
- coordinating research efforts, and planning and coordinating research campaigns and field programmes;
- providing project advocacy and promotion, enlisting wide international participation in the project;
- maintaining needed connections with relevant national and regional projects;
- ensuring effective co-ordination with other components of the IGBP, and other relevant international research programmes;
- disseminating information and research results;
- collecting the information needed by the SSC for their assessment of the progress of the project;
- securing support for the operation of the Office; and
- coordinating the development of a Core Project Data System Plan along the lines of the IGBP-DIS guidelines. This should address issues of data quality, data set creation, metadata and catalogues, data archiving, data standards, external co-operation and linkages to data agencies, networking and distribution of data, and future instrumentation needs.

In addition, the CPO is expected to

- provide day-to-day support to the work of the Committee both individually and collectively; and
- provide the technical Secretariat for the meetings of the SSC and other meetings convened by the SSC within the framework of the Core Project.

*JGOFS Committee Membership to December, 1996*

NAME	NAT.	1991	1992	1993	1994	1995	1996	1997	1998
Bychkov	Russia								
Ducklow	USA								
Field	S. Afr.	V	V	V	C	C	C	P	
Hall	N.Z.								
Krishnaswami	India								
Liu	China(T)								
Lochte	FRG								
McCarthy	USA					E	E	E	
Merlivat	France				V	V	V		
Moore	Canada								
Morel	France								
Murray	USA								
Sakshaug	Norway					E	E		
Shimmield	UK								
Takahashi	USA								
Tilbrook	Austral.								
Willebrand	FRG								

The JGOFS Executive Committee consists of the Chair (C), Vice-Chair (V) and two other members of the SSC (E).



## **ANNEX 6 - Terms of Reference for the GLOBEC Scientific Steering Committee**

- To oversee the development and implementation of the Global Ocean Ecosystem Dynamics program in accordance with the published Science Plan;
- To develop a detailed Implementation Plan for GLOBEC for presentation to the sponsors and the larger scientific community.
- To recommend to the sponsoring organizations the necessary actions to be taken in accordance with the GLOBEC Science and Implementation Plans and to coordinate and manage the resulting activities;
- To collaborate, as appropriate, with other related global change programs and planning activities, such as JGOFS, LOICZ, WCRP, the IOC/FAO program on Ocean Science and Living Resources, and the emerging Global Ocean Observing System;
- To establish appropriate data management policies to ensure sharing and preservation of the GLOBEC data set.
- To report regularly to SCOR, IGBP and IOC and to other bodies such as WCRP, ICES and PICES, on the state of planning and accomplishments of GLOBEC

The GLOBEC SSC, its Officers, subsidiary groups and Core Project Office shall operate in accordance with the guidelines established by SCOR and the SC-IGBP.

### **Operating Procedures for the SSC**

The Global Ocean Ecosystem Dynamics Program (GLOBEC) is a Core Project of the International Geosphere-Biosphere Program of ICSU. The Scientific Steering Committee of GLOBEC (henceforth referred to as SSC) is sponsored by the Scientific Committee on Oceanic Research (SCOR), the Intergovernmental Oceanographic Commission (IOC) and the Scientific Committee of the IGBP (SC-IGBP). The three organizations are jointly responsible for the appointment of the Chairperson, Vice-Chair and members. The sponsors of important regional components of GLOBEC (e.g. ICES and PICES) will be consulted about the nominations of members of the SSC.

The primary functions of the GLOBEC SSC are:

- to provide scientific guidance to and oversee the development, planning and implementation of the Core Project;
- to encourage publication of results with an appropriate form of acknowledgment of SCOR, IOC, IGBP and ICSU support;
- to encourage the promotion and wide awareness of GLOBEC amongst the science community;
- to demonstrate progress and achievements of the project through the definition and monitoring of milestones and results;
- to provide on request, scientific advice and assistance to the GLOBEC and IGBP national Committees and START Regional Committees, in the planning of national and regional research which is designed to contribute to the overall goals of the GLOBEC Core Project.
- to encourage national governments, regional and international funding agencies to support the implementation of Core Research and the achievement of Core Project goals through the provision of adequate support to the necessary national, regional and international research;

- to encourage collaboration between GLOBEC and other IGBP Core Projects and International Programmes and Agencies concerned with the scientific study and assessment of global change; and
- to recommend to SCOR, IOC and the SC-IGBP:
  - members for appointment by SCOR, IOC and the SC-IGBP to the committee;
  - a Chairperson for appointment by SCOR, IOC and the SC-IGBP;
  - a Vice-Chair for appointment by SCOR, IOC and the SC-IGBP; and,
  - such amendments to these terms of reference as may prove necessary from time to time.

In undertaking these responsibilities the SSC shall collectively:

- meet at least once a year, to review progress in the development and implementation of the GLOBEC and to advise the Chair and Core Project Executive Officer on the scientific developments which should be initiated or undertaken between meetings;
- prepare plans and guidelines for the conduct of meetings, workshops, and conferences designed to assist the SSC in executing its functions;
- prepare and revise, as necessary, criteria for the identification of national and regional research which contributes to the goals of GLOBEC as: Core Research; Regional/National Research; or Relevant Research;
- develop guidelines for the preparation, publication and distribution of substantive and technical reports resulting from Core Research; from the work of the GLOBEC Core Project Office; and, from related activities of GLOBEC individually and collectively;
- develop and devise a methodology for monitoring and assessing progress;
- advise the Core Project Executive Officer on the necessary actions required of the Core Project Office in support of the work of the SSC and,
- consider such other matters as individual members or the Core Project Executive Officer bring to the attention of the SSC or are referred to it for consideration by SCOR, IOC or the SC-IGBP.

Members of the Scientific Steering Committee serve in their individual capacities and are expected to:

- attend in full, the meetings of the Scientific Steering Committee;
- be willing to expend considerable effort outside of SSC meetings;
- provide the best possible scientific information and advice concerning their field of specialization as it relates to the goals and Operational Plan for the Core Project;
- provide scientific advice to the Chairperson and Core Project Executive Officer on the development and implementation of the GLOBEC program;
- represent the scientific interests of the Core Project at relevant scientific meetings;
- provide a written report to the CPO within one month of attendance at a meeting at the expense of the CPO;
- provide a two-way channel of communication between the Scientific Steering Committee and the national and where possible, regional and international research community;
- organize, convene, conduct meetings and provide reports for such Core Project Workshops as shall be agreed by the SSC;
- keep the Core Project Office and Chairperson of the SSC fully informed of all actions directly or indirectly related to the Core Project; and
- assist in securing financial and other support for the execution of Core Research, adopted and approved by the Committee.

The Chairperson of the Scientific Steering Committee is expected to:

- chair the meetings of the Committee;
- conduct the meetings in accordance with “good practice” guidelines to be established by the IGBP;

- undertake advocacy on behalf of the project and enlist wide international participation in the project;
- work closely with the Core Project Executive Officer in implementing agreed activities between meetings of the Committee;
- report periodically to SCOR, IOC and the SC-IGBP on progress implementing the project and seek the assistance of SCOR, IOC and the SC-IGBP in addressing difficulties encountered in the implementation.

The Vice-Chair of the Scientific Steering Committee is expected to:

- chair the meetings of the committee in the absence of the Chairperson;
- undertake advocacy on behalf of the project and enlist wide international participation in the project; and
- assist the Chair and the Core Project Executive Officer in implementing agreed activities between meetings of the Committee.

Responsibilities of the Core Project Office:

The Core Project Office (CPO) will assist the GLOBEC Scientific Steering Committee in planning and carrying out new scientific research; it will also serve as a much-needed channel of communication between scientists working in different countries on various aspects of global change. An important early task of the CPO will be to assist the SSC in collating information on national and regional programmes of global change research relating to the Core Project to ensure that there is no unnecessary duplication of effort and that the project makes effective use of existing knowledge in its analysis of processes and change at global scales.

The general tasks of a Core Project Office are as follows:

- administering the project on a day-to-day basis, under the long term guidance of the SSC
- coordinating research efforts, and planning and coordinating research campaigns and field programmes;
- providing project advocacy and promotion, enlisting wide international participation in the project;
- maintaining needed connections with relevant national and regional projects;
- ensuring effective co-ordination with other components of the IGBP, and other relevant international research programmes;
- disseminating information and research results;
- monitoring and assessing the progress of the project and the activities of the SSC;
- securing support for the operation of the Office; and
- coordinating the development of a Core Project Data System Plan along the lines of the IGBP-DIS guidelines. This should address issues of data quality, data set creation, metadata and catalogues, data archiving, data standards, external co-operation and linkages to data agencies, networking and distribution of data, and future instrumentation needs.

In addition, the CPO is expected to

- provide day-to-day support to the work of the Committee both individually and collectively; and
- provide the technical Secretariat for the meetings of the SSC and other meetings convened by the SSC within the framework of the Core Project.

## ANNEX 7 - Working Group 107 - Improved Global Bathymetry

### Preamble:

It has recently become apparent that leaving out small details in bathymetry can have a big effect on the output of physical oceanographic models of the ocean's circulation. Detailed bathymetry is also increasingly required by the InterRidge community attempting to establish with high resolution the tectonic history and evolution of plate separation and hydrothermalism along the mid-ocean ridge. Ocean bathymetry is like the proverbial curate's egg; good in parts. It is best where the world's navies have used multi-beam sounders to map the territory they may need to exploit in times of war. Given the nature of probable war over the past 50 years this means that navies have considerable knowledge of particular areas of the North Atlantic, North Pacific and Arctic, and not much else. Even though they have the data, not all of it is released, for security reasons. We are left with very patchy coverage of the bathymetry of most of the 66% of the planet that is covered by water. This coverage is very poor in parts (eg the Southern Ocean). Recognising the critical need of (a) the growing population of ocean modellers for accurate bathymetry in support of research on ocean circulation and climate change, and of (b) the InterRIDGE community for detailed bathymetry of the global mid-ocean ridge system, it is timely to consider such questions as: what is the state of the art of ocean bathymetry in the mid-1990s? what specifications are needed for improved ocean bathymetry? which regions are most in the need of further study? and what should the priorities be? It is classically SCOR's job to respond to these kinds of questions and to provide benchmarks against which to judge what gaps exist and to make recommendations about how to fill them. What we propose is not a global survey programme, nor any commitment to manage a long term programme to fill such gaps as are recognised; those sorts of things are the province of the hydrographic agencies or GEBCO.

What we propose SCOR does is erect a working group to provide guidance for the solution of the new and critical problem that has been thrown up recently, in particular by the rapidly growing demands of ocean modellers, which itself is a response to rapid growth in the technology of computing, and also by the mismatch between the growing body of high resolution satellite altimetric data, which tell us one thing about the shape of the ocean floor, and conventional bathymetric data which in poorly surveyed areas tell us another.

### State of the Art:

Although image and topographic maps have already been made of the Moon, Mars and Venus, less than 10 percent of the 66% of the Earth's surface covered by the deep sea (>1km deep) has been mapped with equivalent resolution. The echo-sounding coverage of the global ocean is patchy, and concentrated on isolated tracklines with large gaps between, except in the few areas where multi-beam surveys have been made by military or research vessels. Very few areas of the deep sea have been systematically surveyed, and most bathymetric maps are still based on random tracklines of data collected to different standards across the world. The quality and coverage of data from different sources are highly variable. Considerable scientific interpretative skill and imagination is required to compile meaningful bathymetric charts from this assortment of data. Most bathymetric charts are thus interpretations of reality, diverging from it in proportion to data quality and coverage. Coverage is poorest in areas away from trade routes, especially in the Southeast Pacific and Southern Ocean. Coverage is best in areas of military sensitivity, such as the NE Atlantic, but will remain useless for science until released (happily, much has been released in very recent years).

Where soundings are unavailable, satellite altimetry provides a reasonable approximation of the true shape of the ocean floor, and altimetric data have recently been used on British Southern Ocean cruises to identify the best sites for emplacing moorings to measure flows through gaps beneath the Antarctic Circumpolar Current (ACC) (the bathymetric charts being hopelessly inadequate for the purpose). Satellite data are not ideal, because differences in density between basement rocks and their sediment cover obscure the relationship between gravity and water depth.

**Needs of Ocean Modelling:**

Topography is a major controlling parameter on ocean dynamics. Our understanding of the effect of bottom topography on wave propagation, wave trapping, ocean circulation, eddy trapping, eddy shedding and other dynamics is rapidly developing. It is especially important that bottom topography is taken into proper account in numerical models. For large scale dynamics, correct representation of topography is necessary for flux control and for the conservation of potential vorticity. Work on the circulation of the Southern Ocean by UK scientists shows that many features of the ACC reflect steering or focusing by deep sea topography. It is becoming self-evident therefore that without accurate knowledge of the topography, especially the depth and position of sills in pathways between basins, the models of the ACC will be suspect. This same limitation must apply to currents in other ocean basins to a greater or lesser extent. Thus the ocean modelling efforts that underpin WOCE and that are integral to the coupled ocean-atmosphere modelling exercises leading up to climate prediction will lead to spurious results in the absence of correction for the underpinning global bathymetry.

For mesoscale dynamics, correct representation or parameterisation of topography is also vital for energy balance, entropy cascade, and momentum balance. For example, for Gulf Stream models, energy tends to become trapped to the scales of the bathymetry. There is thus a need to produce more accurate maps of the continental slopes so that the lateral boundary conditions on ocean circulation models can be properly defined, and so that the topographic control of the flux between the deep ocean and the shelf seas may be properly assessed.

Ocean numerical modelling is already at the stage of development where our knowledge of the bathymetry is a limiting factor. For instance, in the recent global ocean tide models, incorrect bathymetry in the Weddell Sea caused differences of 20% in the tides of the Gulf of Guinea. For ocean tidal predictions, bathymetric uncertainty is now the limiting factor.

Further in the future, accurate topography will be needed by the Global Ocean Observing System (GOOS) to underpin models for climate prediction, and models for ocean management.

**Needs of Earth Sciences:**

Many studies of the earth beneath the sea, at regional, basin or global scale, today depend on having available accurate maps of the shape of the seabed, along with digital bathymetric databases, gridded bathymetry, and digital interactive cartography. This is because seabed shape and texture (eg from side-scan sonar imagery) are the first clues to marine geological processes. Understanding these processes therefore demands accurate knowledge of seabed shape and texture. Furthermore, analysing seabed processes requires pin-point seabed sampling of the features to be analysed, an impossibility without an accurate knowledge of topography. In many parts of the world ocean topography is poorly known, and texture (from sonar imagery) is known only to first order, limiting geological interpretation. The earth science demand for global knowledge of seabed topography is particularly high from the interRIDGE community at this time, to underpin increased understanding of the operation of the world-encircling mid-ocean ridge system. It is for reasons like these that the UK has recently (a) fitted swath bathymetry to the RRS CHARLES DARWIN, and (b) modified GLORIA to provide swath bathymetry, and is now modifying its deep-tow side-scan vehicle TOBI to also provide swath bathymetry.

**Beneficiaries:**

Beneficiaries of an improved global bathymetry will include (1) the physical oceanographic community (for improved interpretation of the origin of currents and eddies, and for accurate ocean modelling and climate forecasting), (2) the biological community (through provision of accurate maps of the areas where deep sea fish abound, and where there may be potential for deep sea fisheries), and (3) the earth science community (for improved assessment of the location of mineral resources and of seafloor processes).

**Summary:**

There is thus a pressing scientific case and a longer term economic case for improving knowledge of the topography of the seabed. An improved digital bathymetric database is needed for the global ocean and continental shelves, but at what areal resolution and to what accuracy in the vertical? It seems likely that priority areas for bathymetric survey could be identified from ocean modelling sensitivity tests.

**Terms of Reference:**

A working group is needed with the following terms of reference:

- to establish the scientific needs for improved ocean bathymetry,
- to determine the specifications for accuracy and resolution in different areas,
- to recommend actions and priorities.

**Chair:** Colin P. Summerhayes

UK

**Members:**

Peter M. Hunter	UK
Bert Semtner	USA
C LeProvost	France
Hans-Werner Schenke	FRG
Gleb B. Udintsev	Russia
Walter H.F. Smith	USA
Ron Macnab	Canada
Kazuo Kobayashi	Japan
Chris Johnston	Australia

**Corresponding Members:**

Guy Pautot	France
Christian Andreasen	Monaco
Peter Killworth	UK
Anthony Laughton	UK
Albert Damain Gouveia	India
John K. Hall	Israel
Robert L. Fisher	USA

## ANNEX 8 - WG 108 - Double Diffusion

### Rationale:

The discovery of fine structure of the ocean stimulates detailed studies of small-scale physical processes and the mechanisms of its layering. Forty years ago it was shown that even for stable stratification, opponent distributions of two component species could drive convection if their diffusivities differed. Two main types of structures were observed - vertically directed narrow cells, i.e. thin salt fingers, and horizontally well-mixed layers separated by sharp interfaces. Recent advances in instrumentation show that the ocean is strongly unstable to double-diffusive processes and seems to be profoundly affected by them. Simple laboratory experiments have been carried out in different countries. They have continued to be important in identifying new phenomena and in their detailed studies, Sophisticated theoretical and numerical models are used for calculating flow structure and stability, fluxes of heat and matter.

Active research by sea-going oceanographers, theoreticians and laboratory experimentalists has shown the complicated nature of double diffusive convection in the real ocean and has clarified some important features of a sequence of related phenomena. While much of the basic physics is understood completely enough, theoretical description of the processes and their parameterization need considerable updating. The dependence of structure, geometrical parameters and fluxes upon external characteristics are to be established.

Recent field work has demonstrated that double-diffusive processes play a more important role in oceanic dynamics than was previously suspected. The broader issue of disagreement between measured vertical diffusivity and that derived from large-scale modelling, may be considered as the most important evidence within the impact of small-scale phenomena on the global transfer. Double diffusive convection plays a vital role in heat and mass transfer in enclosed seas and in the deep or polar ocean.

The subject is being studied in different countries (in the USA, UK, Australia, New Zealand, Russia, France and others), but the number of research scientists is not very large. Coordination of efforts will improve the working contact between participants, planning of costly field measurements, use of modern facilities in a few advanced laboratories for cooperative investigations and creation of an adequate description of the phenomenon including methods of extrapolation of laboratory data to the conditions of the real ocean and their assimilation by numerical models.

### Proposed Terms of Reference:

- Analysis of identification criteria of the double diffusive convection, rules of choice for main parameters and methods of their measurements in a laboratory and in the real ocean.
- Comparison of mathematical (analytical and numerical) models of double diffusive convection with data available from laboratory and field investigations directed to searching recommendation for extrapolation of laboratory data to natural conditions.
- Formulation of recommendations for further cooperative laboratory and field investigations of double diffusive convection and its interaction with small-, meso- and large-scale phenomena, oriented towards the testing and improvement of existing mathematical models of double diffusive convection.

**Co-Chairs:** Yuli D. Chashechkin (Russia) and Joe H. S. Fernando (USA)

**Members:**

Ann Gargett	Canada
Eric Kunze	USA
Dr. Paul F. Linden	UK
Trevor J. McDougall	Australia
Barry Ruddick	Canada
Raymond Schmitt	USA
Josef Tanny	Israel
Jiro Yoshida	Japan

**Corresponding Members:**

Lev N. Karlin	Russia
Rostislav V. Ozvidov	Russia
Emin Ozsoy	Turkey
Arcady Tsinober	Israel
Hendric Dijkstra	Netherlands
R. Pasquetti	Italy



**ANNEX 9 - Budget and Final Financial Statement for 1994**

**CASH AND INCOME**

	<b>Budget</b>	<b>Actual</b>
<b>BALANCE 1/1/94</b>	99,261.00	99,260.61
<b>FUNDS HELD IN JGOFS SPECIAL FUND</b>	<u>18,703.00</u>	<u>18,702.91</u>
		117,964.00
	117,963.52	
<b>INCOME:</b>		
Membership	185,000.00	195,015.00
ICSU Grant / JGOFS	25,750.00	25,750.00
ICSU Grant / GLOBEC	25,750.00	25,750.00
IGBP Grant / JGOFS	40,000.00	27,500.00
Royal Society Subvention	5,970.00	6,148.00
IOC Contract 1.	10,000.00	10,000.00
2.	25,000.00	0.00
3.	18,000.00	18,000.00
NSF Grant / Travel Awards	80,000.00	94,520.27
NSF Grant / Geosciences		145,441.44
JGOFS 65,000		
GLOBEC 40,000		
WGs 50,000	155,000.00	
Miscellaneous	<u>0.00</u>	35.00
<b>Total Income</b>	<u>570,470.00</u>	<u>548,159.71</u>
<b>TOTAL CASH PLUS INCOME</b>	<u><u>688,434.00</u></u>	<u><u>666,123.23</u></u>

## CASH AND EXPENSES

	Budget	Actual
<b>SCIENTIFIC EXPENSES:</b>		
WG 78 (manual completion)	8,000.00	7,008.02
WG 83 (book purchase & postage)	3,000.00	3,652.82
WG 95 (Neuchatel, 3.94)	12,000.00	12,212.95
WG 96 (Hobart, 10.94)	15,000.00	15,578.88
WG 98 (La Paz, 6.94)	15,000.00	14,706.44
WG 99 (Cambridge, 9/10.94)	5,000.00	2,986.17
WG 100 (Baltimore, 5.94)	12,000.00	8,650.01
WG 101 (Seattle 10.94)	8,000.00	8,671.81
JGOFS, incl. Admin.	148,750.00	151,751.71
GLOBEC, incl. Admin.	<u>65,750.00</u>	<u>86,314.70</u>
Total Existing Subsidiary Bodies	292,500.00	311,533.51
New WGs	10,000.00	0.00
General Meeting	20,000.00	17,361.94
Publications	8,000.00	7,393.86
Conferences ("pass through" for NSF)	0.00	5,000.00
Travel Awards (matched by income)	80,000.00	94,677.47
Representation	<u>10,000.00</u>	<u>8,096.95</u>
<b>TOTAL SCIENTIFIC EXPENSES</b>	<b>420,500.00</b>	<b>132,530.22</b>
<b>ADMINISTRATIVE EXPENSES</b>		
Salaries plus benefits	110,000.00	94,925.90
Communication	7,000.00	6,590.43
Audit & Tax Return	5,500.00	6,465.00
Office Equipment	1,000.00	1,259.95
J.H.U. overhead charges	18,000.00	17,041.90
Miscellaneous	2,700.00	4,014.29
SCOR Ties & Scarves	0.00	4,216.52
Bank Charges	0.00	204.11
Loss on Exchange	0.00	212.76
Total SCOR Administration	<u>144,200.00</u>	<u>134,930.86</u>
<b>TOTAL EXPENSES</b>	<b>564,700.00</b>	<b>578,994.59</b>
<b>BALANCE 31/12/94</b>	<b>105,031.00</b>	<b>68,425.73</b>
<b>FUNDS HELD IN JGOFS SPECIAL FUND</b>	<b><u>18,703.00</u></b>	<b><u>18,702.91</u></b>
<b>TOTAL CASH PLUS EXPENSES</b>	<b><u>688,434.00</u></b>	<b><u>666,123.23</u></b>

## ANNEX 10 - Report from the World Climate Research Programme (WCRP)

### Climate Variability and Predictability Programme (CLIVAR)

A CLIVAR Science Plan has been recently published (August 1995) and has been mailed to over 3000 scientists around the world with the aim that it will inspire the coordination and amalgamation of their many individual efforts into a global programme big enough to tackle the challenge of deciphering and predicting natural climate variability and human-induced changes. The Science Plan has been prepared over the last two years by the CLIVAR Scientific Steering Group, under the chairmanship of Dr Arnold Gordon (LDEO, Palisades), with input from many other scientists.

The overall CLIVAR programme objectives are:

- (i) To describe and understand the physical processes responsible for climate variability and predictability on seasonal, inter-annual, decadal, and centennial time-scales, through the collection and analysis of observations and the development and application of models of the coupled climate system, in co-operation with other relevant climate-research and observing programmes;
- (ii) To extend the record of climate variability over the time-scales of interest through the assembly of quality-controlled palaeo-climatic and instrumental data sets;
- (iii) To extend the range and accuracy of seasonal to inter-annual climate prediction through the development of global coupled predictive models;
- (iv) To understand and predict the response of the climate system to increases of radiatively active gases and aerosols and to compare these predictions to the observed climate record in order to detect the anthropogenic modification of the natural climate signal.

The Plan provides the scientific framework for a programme which will initially consist of three major sub-components:

- CLIVAR-GOALS: a study of seasonal to interannual climate variability and predictability of the global ocean-atmosphere-land system;
- CLIVAR-DecCen: a study of decadal to centennial climate variability and predictability; and
- CLIVAR-ACC: modelling and detection of anthropogenic climate change.

**CLIVAR-GOALS** aims to determine the variability and predictability of the Global Ocean Atmosphere Land System on seasonal-to-inter-annual time-scales, building on the successes of the TOGA programme, by:

- developing observational capabilities to describe seasonal to inter-annual climate variability, including continuation of the TOGA observing system;
- further developing models and predictive skill for SST and other climate variables on seasonal to inter-annual time scales around the entire global tropics;
- building understanding and predictive capabilities of the interaction of monsoons with the Indian Ocean, ENSO and land surface processes;
- understanding climate variability and predictability arising from the interaction between the tropics and extratropics;
- exploring the predictability of extratropical seasonal-to-inter-annual climate variability induced by the interaction of the atmosphere with oceans, land surfaces and sea ice, and developing the means to exploit any such predictability.

**CLIVAR-DecCen** aims to determine the mechanisms of variability and predictability of climate fluctuations on decadal-to-centennial time-scales with a special emphasis on the role of the oceans in the global coupled climate system:

- describing and understanding the patterns of global decadal-to-centennial climate variability in the instrumental, palaeo-climatic, and model records to the extent possible;
- extending the records of climatic variability by concerted efforts of data recovery, reanalysis of existing atmospheric, oceanic and palaeo-climatic data, finding new palaeo-climatic indices, and instituting new oceanographic monitoring sites;
- developing and implementing appropriate observing, modelling, computing, and data collection and dissemination systems needed to describe, understand, and predict global decadal variability;
- identifying and studying the oceanic regions and processes, such as water mass transformation regions, strong boundary currents and return path "choke points", through which the ocean and atmosphere interact to produce decadal-to-centennial climate variability.

**CLIVAR-ACC** will examine the nature of Anthropogenic Climate Change by:

- developing understanding, modelling and predictive capabilities of the response of the climate system to anthropogenic increases in radiatively active gases and changes in aerosols;
- identifying the patterns of climate change or modifications to the variability of the climate system that may result from anthropogenic forcing;
- using the understanding of natural climate variability derived from the other two CLIVAR components as a basis for detecting trends and signatures in the climate record associated with increases in greenhouse gases and the effects of other anthropogenic changes.

In developing the initial strategy for implementation planning, the SSG has aimed to facilitate the interactions between the sub-components, and, wherever possible, to set up a programme structure which will be cross-cutting.

Modelling is of central importance to CLIVAR and two numerical experimentation groups have been formed. CLIVAR NEG-1, co-chaired by Drs M. Cane (LDEO, Palisades) and N. Smith (BMRC, Melbourne), will focus on seasonal-to-interannual predictions and predictability. CLIVAR NEG-2, chaired by Dr L. Bengtsson (MPI, Hamburg) will develop strategies to improve models which can be used to determine climate variability and predictability, both natural and human-induced, on decadal to centennial time scales.

Recognizing the importance of measurements of upper ocean variables in support of short term climate predictions and for understanding atmosphere-ocean interactions which may effect longer term climate variability, the CLIVAR SSG has established an Upper Ocean Panel to develop an implementation strategy for measurements which will meet the scientific requirements of CLIVAR. One of the first tasks of this panel will be to analyze the various in situ and remote measurement techniques available and to recommend an appropriate observing system for CLIVAR. The ultimate goal of this Panel will be to improve the model-derived and analyzed products which are created using the observations. Dr. A. Leetmaa (NMC/NOAA, Washington DC) will chair this Panel which intends to work very closely with the OOSDP follow-on panel (Ocean Observations Panel for Climate) and related GCOS/GOOS efforts and to coordinate with existing WOCE activities.

The World Ocean Circulation Experiment will provide baseline measurements and a global ocean state against which future ocean variability can be measured. A WOCE/CLIVAR liaison team, consisting of representatives of the two project offices and the SSGs, will develop specific plans for WOCE follow-on activities, including continued or repeat observations, modelling efforts and data management.

The CLIVAR SSG has asked three of its members, Drs Schott (IFM, Kiel), Gordon (LDEO, Palisades) and Sarachik (U. Washington, Seattle) to organize scientific workshops in the coming 18 months to further develop the scientific outline of the DecCen component and to gather input for an international implementation plan. The underlying themes of the workshops will be the role of (1) water mass transformation, (2) large scale ocean

circulation and (3) large scale atmosphere-ocean interactions in producing climate variations on decadal to centennial time scales. Programmes, dates and venues for these workshops will be announced soon.

Paleodata provide a means to reconstruct past climate histories for studying climate variability and for model validation. A joint PAGES (IGBP programme on Past Global Changes) - CLIVAR workshop was held in November 1995. Many areas for collaboration and cross-fertilization were identified and a working group has been formed to promote and organize programme interactions. Dr J.C. Duplessy will chair a joint CLIVAR-PAGES working group.

A major concern of CLIVAR, and in particular the CLIVAR-GOALS component, will be the global monsoon system and its relationship with ENSO. A panel, chaired by Drs. A. Sumi (U. Tokyo) and R. Lukas (U. Hawaii, Honolulu), has been established to design a programme of observations, modelling and process studies to assess the variability and predictability of the monsoon/ENSO system. This group will also be charged to ensure that the efforts planned are well coordinated with the many ongoing or planned monsoon-related projects, in particular the GEWEX Asian Monsoon Experiment (GAME).

An International CLIVAR Project Office (ICPO) has been established in Hamburg, Germany. Dr Michael Coughlan, a meteorologist from the Australian Bureau of Meteorology, is the Director. Recognizing that CLIVAR must build on national plans and the efforts of individual researchers and research teams, the CLIVAR SSG has charged the ICPO with the early task of finding out what plans are already in place or are being proposed that are relevant to CLIVAR science. Accordingly, the ICPO will be polling national climate science committees and agencies which traditionally have supported and funded research relevant to CLIVAR's objectives.

#### **World Ocean Circulation Experiment (WOCE)**

The observational phase of WOCE is well on the way to completion (delay in launching earth observing satellites and shortfalls in available resources for in situ measurements have led to extension of the WOCE field phase until 1997). WOCE is now moving into an Analysis, Interpretation, Modelling and Synthesis Phase which will take it through to programme completion in 2002. The objectives of this final phase of WOCE are to produce:

- a WOCE climatology of oceanic property distributions for the 1990s;
- a state-of-the-art view of oceanic mass and property fluxes;
- a dynamically consistent view of the ocean and its interaction with the atmosphere;
- an assessment of how the WOCE 1990s climatology differs from previous (non-synoptic) climatologies of ocean basins;
- continued refinement of ocean models and model validation using WOCE data;
- dissemination of results to the scientific community at large and to other WCRP programmes in particular;
- demonstrating the benefits that have accrued from WOCE research.

By the end of 1996, when the Indian Ocean will have been surveyed, 80% of the WOCE global one-time hydrographic survey requirements will have been met. By the end of 1997, it is expected that over 85% of the global survey, as originally specified in the WOCE implementation plan, will have been completed. The remaining 15% are sections that have a lower priority or are no longer considered necessary following rationalization of the original plan. The survey, for the most part, has been carried out on an ocean-by-ocean basis in order to provide as far as possible a synoptic coverage of each ocean. However, the North Atlantic sections were spread over a considerable period and the target for the end of WOCE (1996-1997) is a rapid resurvey of this ocean. Most other aspects of the WOCE implementation plan have been well subscribed and it is anticipated that the WOCE data set, when fully assembled, will provide a unique and invaluable view of the world's ocean circulation for use by future climate researchers.

Already WOCE results have provided insight into many important oceanographic features. For instance, estimates of oceanic heat flux obtained from high-quality WOCE observations differ significantly from estimates obtained from models that are being used to provide forecasts of global climate change. The complete set of WOCE heat and freshwater flux determinations will provide a valuable basis for validating global flux estimates. Additionally, direct estimates of vertical diffusivity yielded values much lower than those used in numerical models. Moreover, tracer measurements (Tritium/Helium-3 and CFCs) collected during WOCE sections provide the possibility of enabling the "age" (the time since last contact with the atmosphere) of water masses to be determined, hence offering the opportunity to verify model estimates of circulation rates.

WOCE data sets can be compared with earlier measurements, and are beginning to reveal the magnitude (several tenths of a degree) and the spatial structure of ocean sub-surface temperature and salinity variations. Best documented are changes near 24°N in the Atlantic where a significant warming (up to 0.2°C over a three kilometre ocean depth) has been detected, compared to a cooling of similar magnitude in parts of the sub-polar North Atlantic since the International Geophysical Year (1957). Few time series stations have been maintained for periods of several decades, but one near Bermuda (now part of the WOCE observation network) shows warming since the 1920s at depths between 1500 and 2500 m consistent with the changes observed at 24°N.

WOCE studies are also providing new perspectives on a number of ocean processes, and it has been seen that several of these may have been poorly represented in ocean models up to now. In the North Atlantic Tracer Release Experiment, the horizontal and diapycnal spread of an inert tracer from its initial release point was observed. Diapycnal diffusion coefficients computed from these data are of the order of 0.1 cm<sup>2</sup>/sec, notably lower than from most indirect estimations. This suggests that mixing at much higher rates occurs near ocean boundaries. Furthermore, information on subduction of surface-modified water masses, hitherto poorly understood, can be deduced from the tracks of neutrally buoyant floats moving between the two density surfaces (i.e. supplying data on the slope and separation of the surfaces).

Significant changes have been made in the WOCE committee structure in the past year to reflect the changing emphasis to modelling and data analysis aspects. The WOCE Scientific Steering Group has been reduced in size, and a **WOCE Synthesis and Modelling Working Group**, reporting directly to the WOCE Scientific Steering Group, has replaced two of the WOCE core planning committees and the WOCE Numerical Experimentation Group with effect from 1 January 1995 as the primary science committee for WOCE. The WOCE Hydrographic Programme Planning Committee will continue to oversee the later stages of the global survey and repeat hydrographic measurements and to monitor the effectiveness of the Data Assembly and Special Analysis Centres. The WOCE Data Management Committee has been reconstituted as a **WOCE Data Products Committee** in recognition of the requirement to make useful data sets readily available in suitable formats rather than merely assembling them. The implementation of the Atlantic programme will be co-ordinated by a core planning committee until mid-1997. With the exception of those mentioned above (and the joint WOCE/CLIVAR Surface Velocity and XBT/XCTD Programme Planning Committees constituted in place of previous joint WOCE/TOGA committees), all other WOCE groups were disbanded at the end of 1994.

The WOCE Data Information Unit will continue to have a key role in the analysis, interpretation and synthesis phase of WOCE in maintaining a comprehensive overview of the disposition of WOCE data sets and their progress through the WOCE data system, and will prepare periodically updated versions of the WOCE Data Handbook describing the status of data sets. The WOCE International Project Office, which acts as the executive arm of the WOCE Scientific Steering Group implementing its recommendations and acting as the communication hub for the entire international project, will also continue to have a fundamental part to play.

Another essential element of this phase of WOCE is the establishment of "operational" ocean circulation modelling centres in order to meet the major requirements in terms of model development and computer resources for assimilation of the full range of WOCE multi-year global data sets to produce a dynamically consistent ocean

climatology for the 1990s (comparable to the resources devoted to data assimilation at centres such as ECMWF or NMC). After WOCE, such centres might become a component of the Global Ocean Observing System (GOOS). An important related aspect is to promote interaction between observationalists and modellers. In the early stages of WOCE, model development and data analysis were pursued independently to a large extent, but these activities must now continue to come together, particularly as models are now producing increasingly realistic simulations of the eddy-rich ocean bearing comparison with observational data sets.

WOCE will need to make known its achievements through meetings and scientific publications. Papers based on data collected in the early phase of WOCE are already appearing in the scientific literature and the number of these is expected to expand rapidly over the coming years. The strategy planned by the WOCE Scientific Steering Group is, firstly, to describe and inter-compare results from a particular ocean basin at a specifically organized scientific workshop, secondly, to present the results to a wider audience at a major scientific conference and, finally, publication of the accumulated results from that basin. Also, a major WOCE-dedicated scientific conference to highlight the overall success of WOCE is to be hosted by Canada in Halifax in mid-1998. Even though the analysis, interpretation and synthesis phase will not have been completed, there will already be (as there are now) substantial achievements to show to the scientific community and to the agencies that have funded WOCE.

### **Arctic Climate System Study (ACSYS)**

A WCRP project to study the role of the Arctic in global climate was initiated in 1994. This Arctic Climate System Study (ACSYS) is designed to advance understanding of Arctic climate processes which will improve our ability to predict, for example, local changes in climate, the sea-ice distribution (relevant, in particular, to navigation and oil and gas extraction, as well as other activities) water properties of the North Atlantic fishing grounds, environmental quality and contamination and other areas of concern which impact on society.

More than a hundred participants from twelve countries participated in the WCRP Scientific Conference on the Dynamics of the Arctic Climate System, held in Göteborg, Sweden in November 1994. The Conference considered a range of scientific issues related to the interaction of the Arctic with the global climate system including the hydrological cycle in the Arctic, polar atmosphere processes, sea-ice processes and Arctic Ocean circulation and its variability. The Conference also reviewed the Initial Implementation Plan for ACSYS (WCRP-85) and assessed the support that ACSYS could expect to receive from the Arctic science community. The Conference fully concurred on the importance of ACSYS goals and found ACSYS as proposed to be a well focused and technically feasible programme.

The scientific goal of ACSYS is to ascertain the role of the Arctic in global climate. To attain this goal, ACSYS develops and co-ordinates national and international Arctic science activities aimed at three main objectives:

- understanding the interactions between the Arctic Ocean circulation, ice cover and the hydrological cycle;
- initiating long-term climate research and monitoring programmes for the Arctic;
- providing a scientific basis for an accurate representation of Arctic processes in global climate models.

Substantial progress has already been made in the implementation of ACSYS. For example, the WCRP Arctic Ice Thickness Project has twenty-four upward-looking sonars which are now operational, providing sea-ice thickness data from regions of interest in the Arctic Ocean. It is expected that it will be feasible to maintain the array for a ten-year period. A network of six moored Arctic Ocean Climate Stations has been deployed in the Beaufort and Chukchi Seas. In support of the ACSYS Arctic Ocean Hydrographic Survey, a joint multi-disciplinary USA/Canada ice-breaker expedition completed a section across the Arctic Ocean from the Bering Strait to the Greenland Sea via the North Pole in 1994. From March to May 1995, a US Navy submarine has been employed as a sampling platform for basic studies aimed at increasing understanding of processes such as air-ice-ocean interaction, ocean circulation and chemistry in the Arctic Ocean. This campaign is expected to provide information on the surface heat budget, pack ice mechanics and thermodynamics, upper ocean dynamics, shelf-Arctic basin interaction, and open-ocean

convection. . In 1994, ACSYS-related shelf surveys were carried out by Norway in the Barents Sea, by a joint Norwegian-Russian expedition in the Kara and Barents Seas, and a joint German-Russian cruise in the Laptev Sea. Hydrographic observations and tracer measurements were taken at more than 250 points.

Many national and international research and field projects have already or are expected to contribute considerable amounts of valuable supporting data to ACSYS. These include particularly the international Surface Heat Budget of the Arctic Ocean (SHEBA) study (a 16 month experiment on a drifting sea-ice camp in the Beaufort Sea), the USA Department of Energy Atmospheric Radiation Measurement (ARM) programme (i.e., activities at the Alaskan North Slope site beginning in 1997 in parallel with SHEBA), and the USA FIRE-III Arctic Clouds Experiment to be conducted in 1997 (in conjunction with SHEBA). Among other important activities are the Siberian Marginal Seas Buoy Programme to be launched in 1995 in support of the International Arctic Buoy Programme, the International Arctic Cloudiness-Aerosol-Radiation project proposed by the Russian Federation with the aim of improving understanding of the radiation properties of Arctic clouds and aerosols, and a joint USA/Russian airborne hydrographic/hydrochemical survey in 1995-1996 for studying the large-scale circulation of the Arctic Ocean and its variability. The Beaufort Arctic Storms Experiment (conducted in 1994 in the southern Beaufort Sea and MacKenzie River delta by Canada, USA and Japan), the components of GAME in the Arctic zone of the Russian Federation, as well as various other European and Russian programmes studying the Arctic Ocean and sub-polar regions will also provide information of interest.

Several data projects have been initiated under ACSYS. An historical Arctic Ocean climate data base (containing information on temperature, salinity, oxygen and nutrients) needed for the study of basin-scale variability, and for validation of Arctic climate and circulation models is being collected at various institutes. An ACSYS Arctic Run-off Data Base will be constructed by the WCRP Global Run-off Data Centre in Germany containing all available readings of daily water discharges at Arctic gauge-sites from 1978 onwards. ACSYS plans also call for the development of an Arctic precipitation data archive containing daily, monthly and annual total precipitation (liquid and solid) from all observing stations in the Arctic from 1978 onwards.

An International ACSYS Project Office has been established in Oslo, Norway under the directorship of Dr. Roger Colony. A second ACSYS Conference is proposed in 1997-1998 to take stock of progress at the mid-point of ACSYS and exchange views on the main operational and data management aspects of planning for the second half of ACSYS.

### **Tropical Ocean Global Atmosphere (TOGA) Programme**

A final International TOGA Scientific Conference, sponsored by IOC, ICSU, SCOR and WMO, was hosted by Australia in Melbourne 2-7 April 1995. Over 300 scientists participated in the Conference which was structured around five themes: description of low frequency variability; theoretical basis of low frequency variability; TOGA-COARE and other process studies; simulations and predictability; predictions of low-frequency variability. A conference volume is in preparation.

Results from TOGA-COARE continue to provide exciting new insights into tropical ocean-atmosphere interactions. The international TOGA COARE Panel now reports to the CLIVAR Scientific Steering Group. Membership will be gradually modified to reflect the transition of activities to the assembly and analyses of COARE data sets and the multi-disciplinary research being undertaken using these data.

NASA's Physical Oceanography Distributed Active Archive Centre (PODAAC) at JPL has recently issued a set of CD-ROMs containing TOGA and other WCRP data sets for the period 1985-1990. PODAAC intends to generate and distribute further TOGA CD-ROMs, eventually covering the entire TOGA period (1985-1994).



## ANNEX 11 - Acronyms and Abbreviations

ACSYS	Arctic Climate System Study
ADEOS	A Japanese Satellite - Advanced Earth Observing System
AOSB	Arctic Ocean Sciences Board
ASI	Advanced Study Institute (NATO)
ASPECT	Antarctic Sea-ice Processes, Ecosystems and Climate
ATOC	Acoustic Thermometry of Ocean Climate
BNL	Benthic Nepheloid Layer
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CCC	Cod and Climate Change (of ICES/GLOBEC)
CCCC	Carrying Capacity and Climate Change (of PICES/GLOBEC)
CDIAC	Carbon Dioxide Information Analysis Center
CLIVAR	Climate Variability and Prediction program (WCRP)
CMAS	Confederation Mondiale des Activites Subaquatiques
CMG	Commission for Marine Geology
COARE	Coupled Ocean-Atmosphere Response Experiment (TOGA)
COASTS	Coastal Ocean Advanced Science and Technology Study (IOC)
COSPAR	Committee on Space Research (ICSU)
CPO	Core Project Office
EC	European Community
ECOR	Engineering Committee on Oceanic Resources
ESOP	European Sub-polar Ocean Program
GCOS	Global Climate Observing System
GIPME	Global Investigation of Pollution in the Marine Environment (IOC)
GLOBEC	Global Ocean Ecosystem Dynamics (SCOR, IOC, IGBP)
GLOCHANT	Global Change in Antarctica (a SCAR group)
GLOSS	Global Sea Level Observing System (of IOC)
GOEZO	Global Ocean Euphotic Zone Study (IGBP/SCOR/WCRP)
GOOS	Global Ocean Observing System (IOC, WMO, UNEP, ICSU)
GRC	Gordon Research Conference
GTOS	Global Terrestrial Observing System
HAB	Harmful Algal Blooms
HDP	Human Dimensions (of global change) Program
IABO	International Association for Biological Oceanography
IABP	International Arctic Buoy Program
IAHS	International Association for Hydrological Sciences
IAMAS	International Association for Meteorology and Atmospheric Sciences
IAnZone	International Antarctic Zone - an informal group
IAPP	International Arctic Polynya Project
IAPSO	International Association for Physical Sciences of the Ocean
IASC	International Arctic Sciences Council
ICES	International Council for the Exploration of the Sea
ICSI	International Commission of Snow and Ice (of IAHS)
ICSU	International Council of Scientific Unions
IGAC	International Global Atmospheric Chemistry (Core Project of IGBP)
IGBP	International Geosphere-Biosphere Programme (ICSU)
IGFA	International Group of Funding Agencies for Global Change
IMAGES	International Marine Global Changes Program (PAGES/SCOR)
IMO	International Maritime Organization
InterRIDGE	International Ridge Global Experiment
IOC	Intergovernmental Oceanographic Commission (of UNESCO)
IODE	International Oceanographic Data Exchange (of IOC)

IPCC	Intergovernmental Panel on Climate Change
ITSU	International Tsunami Warning System
IUGG	International Union of Geodesy and Geophysics
IUPAC	International Union of Pure and Applied Chemistry
IUPAP	International Union of Pure and Applied Physics
IUTAM	International Union of Theoretical and Applied Mechanics
JGOFS	Joint Global Ocean Flux Study (IGBP Core Project)
JPOTS	Joint Panel on Oceanographic Tables and Standards
LOICZ	Land-Ocean Interactions in the Coastal Zone (IGBP Core Project)
MAST	Marine Science and Technology (EEC)
MOU	Memorandum of Understanding
NATO	North Atlantic Treaty Organization
NEW	North East Water polynya project
NOW	Northwater polynya project
NRC	National Research Council
NRCT	National Research Council (Thailand)
NSCAT	NASA's Scatterometer
NSERC	Natural Sciences and Engineering Research Council (Canada)
NSF	National Science Foundation (USA)
ODP	Ocean Drilling Program
OECD	Organization for Economic Cooperation and Development
ORNL	Oak Ridge National Laboratory (USA)
OSLR	Ocean Science in Relation to Living Resources (IOC)
OSNLR	Ocean Science in Relation to Non-living Resources (IOC)
PAGES	Past Global Changes (IGBP Core Project)
PGGM	Photosynthetic Greenhouse Gas Mitigation and Sustainable Marine Food Harvesting
PICES	North Pacific Marine Sciences Organization ("Pacific ICES")
PORSEC	Pacific Ocean Remote Sensing Conference
RIDGE	Ridge Global Experiment
SCAR	Scientific Committee on Antarctic Research (ICSU)
SCOPE	Scientific Committee on Problems of the Environment (ICSU)
SCOR	Scientific Committee on Oceanic Research (ICSU)
SeaWIFS	Sea-viewing Wide Field Sensor for ocean color
SLIP	St. Lawrence Island polynya project
SO	Southern Ocean
SOLAS	Surface Ocean - Lower Atmosphere Study (IGBP/SCOR)
SPACC	Small Pelagic Fishes and Climate Change (of GLOBEC)
SSC	Scientific Steering Committee
TEMA	Training, Education and Mutual Assistance
TOGA	Tropical Ocean - Global Atmosphere program (WCRP)
TOS	The Oceanography Society
UNCED	United Nations Conference on Environment and Development
UNESCO	United Nations Educational, Scientific, and Cultural Organization
WAM	Wave Modelling Group
WCRP	World Climate Research Programme (WMO, ICSU, IOC)
WG	Working Group
WHP	WOCE Hydrographic Program
WISE	Waves in Shallow Environments
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment (WCRP)
WWW	World Wide Web