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**SCOR Proceedings, Volume 35**  
**REPORT OF THE 34<sup>TH</sup> EXECUTIVE COMMITTEE MEETING OF SCOR**  
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**REPORT OF THE 34<sup>th</sup> EXECUTIVE COMMITTEE MEETING OF SCOR**  
**National Institute of Oceanography and the International Center**  
**Goa, India**  
**October 25-28 1999**

**1.0 INTRODUCTION**

**1.1 Opening Remarks and Administrative Arrangements**

The opening ceremonies of the 34<sup>th</sup> Executive Committee meeting of the Scientific Committee on Oceanic Research (SCOR) took place at the National Institute of Oceanography in Goa, India on the morning of October 25 1999. In addition to the institute, the meeting was hosted by the Indian National Science Academy which is the sponsor of the Indian National Committee for SCOR (INSA/SCOR).

The participants were greeted by Dr. Ehrlich Desa, Director of NIO and by Professor B.L.K. Somayajulu, Chairman of INSA/SCOR who also spoke on behalf of Professor G. Mehta, President of INSA. Dr. Desa noted that his institute was born out of the International Indian Ocean Expedition in the 1960s, SCOR's first major international initiative.

The days of the meeting included four sessions of scientific talks by both Indian scientists and visiting SCOR members. The business sessions of the Executive Committee meeting took place at the International Center, but a half-day visit to the NIO provided an opportunity for tours of research laboratories and the computer center and for interactions with NIO scientists in addition to scientific lectures.

The Executive Committee meeting was chaired by Professor John Field, the President of SCOR, who welcomed several new members of the Committee to their first meeting: Peter Burkill (UK), Wolfgang Fennel (Germany), Cintia Piccolo (Argentina) and Shizuo Tsunogai (Japan). Field noted with pleasure the presence of several members of the Indian National Committee for SCOR at the meeting.

A list of participants in the Executive Committee meeting is given in Annex 1. The program of scientific lectures during the week appears in Annex 2.

**1.2 Approval of the Agenda**

The Draft Agenda was distributed prior to the meeting and it was approved with one addition: Item 3.2.3, a report of the progress of the "Bellagio initiative" to enhance graduate education in marine science in developing countries through a regional graduate school approach. This report follows the format of the agenda as approved by the meeting. A list of acronyms and abbreviations used in this report appears on its last pages.

**1.3 Report of the President of SCOR**

The President made a brief review of SCOR activities since the 24<sup>th</sup> General Meeting (November 1998). He noted, with appreciation to Roger Harris, the Chairman of the SCOR/IOC/IGBP program on Global Ocean Ecosystem Dynamics (GLOBEC), the Natural Environmental Research Council of the UK and the University of Plymouth, the long-awaited establishment of an International Project Office for GLOBEC at the Plymouth Marine Laboratory. Dr. Manuel Barange has been appointed as the GLOBEC Executive Officer.

The year since the last SCOR meeting saw a lot of activity in the JGOFS program. The first synthesis volume, a mid-life synthesis of JGOFS results, was sent to the publishers and was expected to appear late in 1999. The SSC devoted much of its attention to planning the JGOFS Open Science Conference which is to take place in Bergen, Norway in April 2000. A second synthesis volume will result from this conference. Several other products of the international JGOFS program are being planned (see item 3.1.1). Field reported that funding for the JGOFS International Project Office was renewed by the University of Bergen and the Norwegian Research Council, thereby ensuring that the program will be well-staffed for the rest of its expected lifetime, i.e. until 2003.

The President also drew attention to the work of the International Ocean Colour Coordinating Group which is an Affiliated Program of SCOR. He noted that the IOCCG published two reports during 1999 and organized a workshop on the problems of dealing with ocean color data from Case 2 (generally coastal) waters from which another report would result. The Group was responsible for a major training workshop on the Applications of Marine Remote Sensing which was to be held in Bangkok during the two weeks following the SCOR Executive Committee meeting. (For more on IOCCG, see item 3.3.5.)

SCOR's advisory relationship to the Intergovernmental Oceanographic Commission of UNESCO was reinforced during 1999 by the organization of a workshop to assess the current state of marine science and its capacity to respond to problems of sustainable development. This effort is being undertaken jointly by SCOR, IOC and the Scientific Committee on Problems of the Environment (SCOPE) of ICSU.

Looking forward to the next year, Field noted that the development of the SCOR/IGBP activity known as the Surface Ocean - Lower Atmosphere Study (SOLAS) will advance considerably with a major Open Science Meeting in February 2000. He announced the plans of the Executive Director to retire from her position at the time of the General Meeting in 2000 and remarked that this would have an impact on the administration and financial management of SCOR.

In closing, the President expressed his gratitude to the members of the Executive Committee and the Executive Director for their support during the past year.

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

The Constitution requires that a Finance Committee, consisting of three Nominated Members of SCOR who are not members of the Executive 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 participants approved the establishment of an *ad hoc* Finance Committee under the Chairmanship of Ian Jones (Australia) with Gerald Ganssen (Netherlands), Fred Herms (Brazil) and Robert Knox (USA) as members. The Committee reported to the meeting under agenda item 4.3.

## **2.0 WORKING GROUPS**

See Annex 16 for a complete list of all current SCOR scientific activities discussed in this report.

### **2.1 Arising from Former Working Groups**

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

Correspondence between the Chair of the WG and the Executive Committee Reporter, Fred Grassle, indicated that there will be no further activity by the WG. The Executive Committee agreed to disband WG 86.

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

On the recommendation of the Executive Committee Reporter, I.N. McCave, the Executive Committee agreed to disband WG 89. It appeared that an expanded publication, based on an article published by the WG in 1991 (The Response of Beaches to Sea-Level Changes: A Review of Predictive Models. *J. Coast. Res.* 7(3): 895-921), would not be forthcoming.

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

The final publication of WG 98 was in press, in the form of a special issue of the *South African Journal of Marine Science*, at the time of the Executive Committee meeting. It was agreed that the WG should be disbanded.

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

The Executive Committee Reporter, I.N. McCave, was unable to get information from the Chair, Martin Sinha, on

the progress of the WG in preparing a brochure about ridge research and a report on the topic. The InterRidge Coordinator reported that a WG member, Kim Juniper (Canada), was preparing a review paper which was expected to appear in the *Reviews of Geophysics*. The meeting accepted the recommendation of McCave that the funds committed by SCOR for the production of the brochure should be withdrawn until further information is available.

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

Ian Jones, the Chair of WG 101 stated that its report was in press at Cambridge University Press. It was agreed that SCOR funds committed for the purchase of a number of copies of this book for distribution to libraries in developing countries should be carried forward to the next year's budget. The WG has already been formally disbanded.

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

The Executive Committee Reporter, Cintia Piccolo, informed the meeting that the manuscript arising from this WG has been accepted for publication in *Deep Sea Research*. The WG was disbanded by the Executive Committee.

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

The final publication of WG 104 appeared as a special issue of *American Zoologist* (Vol. 39:1, February 1999). The meeting accepted the suggestion of the Executive Committee Reporter, Bjorn Sundby, that the WG be disbanded with thanks to its Chair, Robert Buddemeier, for its effectiveness and to the LOICZ program for its co-sponsorship and support of the group.

## **2.2 Current Working Groups**

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

Wolfgang Fennel, introducing the report from the Chair of WG 103, Michael Banner, noted that the terms of reference for the WG had been modified at the General Meeting in 1998 and that the group had organized its final meeting and a workshop in conjunction with the Air-Sea Interface Symposium in Sydney, Australia in January 1999. Participants in this special session were the Working Group members and interested ASI Symposium participants. About 40 participants attended the workshop. Its aims were to discuss:

- the present status of our knowledge of wave breaking on the wind driven sea surface in the light of very significant recent advances in theoretical and observational techniques, particularly the quantification of its dynamical and interfacial flux implications for air-sea interaction.
- the formulation of strategies for future modeling and experiments arising from these recent significant theoretical and instrumentation developments. These exciting advances included
  - new insight into the onset of breaking in nonlinear modulating gravity wave groups, both unforced and wind-forced, for irrotational waves and waves on a vertical shear current. This has generated new quantitative formulae for predicting wave breaking statistics and wave breaking influence in spectral sea state prediction models for deep water. Extension to the case of shallow water waves appears feasible.
  - the use of infra-red imagery for detection and quantification of wave breaking events, both whitecaps and even micro-scale breakers, through the thermal signature of these structures and to provide a measure of the strength of these events.
  - several major refinements to our understanding of micro-scale breaking waves and their implications for air-sea interfacial fluxes.
  - new developments in modeling upper ocean mixing processes enhancement due to interfacial wave breaking
- the contributions made to larger scale atmosphere and ocean modeling from research on wave breaking and the outstanding needs of the larger scale atmosphere and ocean modelers for more realistic parameterization of physical processes in which interfacial wave breaking plays a significant role.

The overall goal of the WG is to prepare an authoritative paper for publication in the open literature encapsulating the above issues, to be submitted within twelve months following the meeting. This goal is well underway and a manuscript is now in preparation.

It was agreed to await the publication of this paper before disbanding the WG at the General Meeting in 2000.

**2.2.2 WG 105 *The Impact of World Fisheries Harvests on the Stability and Diversity of Marine Ecosystems***  
In March 1999, WG 105 was responsible for the organization of an ICES/SCOR symposium on the Ecosystem Effects of Fishing which attracted more than 300 participants from 54 countries. A meeting of the working group was held during the symposium, which was attended by the President of SCOR, John Field, who is also the Executive Committee Reporter for the WG. It was concluded that the publication of the invited papers presented at the symposium (as well as some of the manuscripts developed from posters), in the *ICES Journal of Marine Science*, would be the major component of the final report of the WG.

The follow-up actions identified at the Symposium at WG meeting include the need to define performance measures and reference points for ecosystem objectives of oceans management. These overarching objectives could be addressed in fisheries management plans, as well as in other sectoral plans. It was proposed that a formal communication network be established among scientists in various countries in which ecosystem considerations are being incorporated into fisheries management activities. It was also recommended that the Panel for the Living Marine Resources module of GOOS (LMR-GOOS) should develop their monitoring program in relation to the ecosystem objectives and performance measures which were articulated during the symposium. LMR-GOOS met in Montpellier immediately following the symposium to consider this recommendation. There is some thought being given to the benefits of an FAO consultation on approaches to incorporating, in an operational manner, ecosystem considerations into fisheries management plans (and into other ocean use activities). This latter follow-up action will be addressed in the final report of the WG, which will be prepared for the SCOR General Meeting in 2000. Proposals for one or more new SCOR Working Groups may arise from these recommendations.

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

I. N. McCave reported to the meeting that a book arising from the scientific deliberations of WG 106 on the issues of muddy coasts of the world will be published by Elsevier as part of a new series, entitled *Proceedings in Oceanography*. It was expected that the manuscript for this volume would be delivered to the publisher before the end of 1999. A second volume, containing additional conference papers from the Muddy Coasts conference held in 1997 and co-sponsored by SCOR will be a sister volume in the new series.

Terry Healy, a member of WG 106 and co-editor of its book, had also informed the Executive Director of SCOR that, as part of the final wrap-up of the WG106 activities a special section of the International Coastal Symposium 2000 (New Zealand, April 2000) would be devoted to "Muddy Coasts" and that many members of the WG would attend this meeting.

The meeting agreed that 1999 SCOR funds designated for the purchase of copies of the WG 106 volume should be carried forward to the next fiscal year, and that the WG should be asked to submit its final report to the General Meeting in 2000.

**2.2.4 WG 107 *Improved Global Bathymetry***

The Chair of WG 107, Colin Summerhayes, had informed the SCOR Secretariat that he was in the process of completing the final report to be published by IOC/UNESCO, with some sections of it for possible publication elsewhere in the scientific literature. The Executive Committee requested that this be completed, and the final report submitted to SCOR, in time for the General Meeting in 2000 at which time the WG could be disbanded.

**2.2.5 WG 108 *Double Diffusion***

The role of WG 108 is to bring together scientists working in disparate areas of research with a common focus on double diffusive convection. The major emphasis of the working group has been the applications of the theory, experiment and numerical results to understand oceanic double-diffusive processes, for example, small-scale mixing and intrusions. The activities and articles in preparation of the working group are posted on a web site at <http://www.phys.ocean.dal.ca/programs/doubdiff/doublediffusion.html> which is maintained by Professor Barry Ruddick.

The final meeting of WG 108 which was originally planned for earlier in 1999 had been postponed, but was about to take place at Arizona State University, the home institution of the WG Co-Chair, J.H.S. Fernando.

### **2.2.6 WG 109 Biogeochemistry of Iron in Seawater**

The Executive Committee Reporter for WG 109, Shizuo Tsunogai, referred to the symposium organized by the WG in conjunction with the SCOR General Meeting in 1998. At the same time, the WG met to review draft chapters for the planned publication of a book by IUPAC. This editorial process has continued and Tsunogai reported that the manuscript would be delivered to the publishers in late 1999, with publication expected to take place about 7 months after submission.

Outline of WG 109 book:

1. Introduction D.R. Turner and KA. Hunter
2. Iron limitation in the ocean A.J. Watson (UK), Lead reviewer: F.M.M. Morel (US)
3. Bioavailability and bioaccumulation of iron in seawater W.G. Sunda (USA), Lead reviewer: P. Boyd (New Zealand)
4. Atmospheric iron inputs to the oceans T. D. Jickells and L.J. Spokes (UK), Lead reviewer: R.A. Duce (US)
5. Sources, sinks and distributions of iron in seawater H.J.W. de Baar and J. de Jong (The Netherlands), Lead reviewer: P. Buat-Ménard (France)
6. Determination of iron concentration and speciation in seawater K.W. Bruland and E.L. Rue (USA), Lead reviewer: J. Buffle (Switzerland)
7. Iron thermodynamics in seawater T.D. Waite (Australia), Lead reviewer: M. Whitfield (UK)
8. Transformation between different forms of iron in the ocean J. Moffett (US), Lead reviewer: B. Sulzberger (Switzerland)
9. Conclusions coauthored by the entire Working Group

The topic of standards for measurements of low concentrations of iron in seawater was addressed in a dedicated afternoon meeting also held at the time of the SCOR General meeting in Amsterdam. The meeting had about 15 participants from several countries including nearly all researchers currently active in analysis of Fe in oceanic waters. A number of initiatives towards the development of low level iron standards were reviewed, and the need for international coordination was discussed. It was agreed to write an article for publication in EOS highlighting the problem and asking interested scientists to make themselves known to the *ad hoc* coordinating group: Kenneth Coale (USA), Paul Worsfold (UK), Hein de Baar (the Netherlands) and David Turner (Sweden). This article was published in EOS vol. 80 no. 34 (24 August 1999). In order to promote international coordination of different national and regional initiatives in the development of low level iron standards, SCOR had agreed to provide support for a workshop meeting which had not yet taken place, partly due to the urgent need to write the necessary research proposals. The Executive Committee meeting confirmed the continuing availability of support for the workshop to discuss the development of the standards for low level iron measurements in seawater. [This took place in January 2000.] The report from the Co-Chairs of WG 109 (David Turner and Keith Hunter) included information on various initiatives to secure research funds for Fe certification work.

### **2.2.7 WG 110 Intercomparison and Validation of Ocean-Atmosphere Flux Fields**

The report of the SCOR/WCRP working group on air-sea fluxes was introduced by the Reporter, Sergei Lappo. During the year leading up to the Executive Committee meeting, the WG focused on developing the catalogue of flux products, summarizing the most important achievements in flux field validation and drafting the final report of the WG. To this end, the WG held its second meeting in De Bilt, The Netherlands (14-17 April 1999). The report of the group is being prepared at the request of the Joint Scientific Committee for the World Climate Research Program and is to be submitted for their next meeting in March 2000. It is expected to be of great interest to the emerging climate programs such as CLIVAR and SOLAS.

The final report of WG 110 will address all aspects of intercomparison and validation of flux fields, considering different sources of the flux data on a comparative basis, the requirements for the flux products from different scientific disciplines, the accuracy of measurements of fluxes and flux related parameters, and reliability of the

currently available flux products. A final meeting of the WG, to be held at the Southampton Oceanography Center in December 1999, will complete the task of preparing this report. It will be published as a WCRP document with wide distribution.

The Co-Chairs, Sergey Gulev (Russia) and Peter Taylor (UK) suggested in their report to SCOR that the work of the WG should be concluded by an international symposium or workshop to be held in late 2000. The Executive Committee agreed that SCOR and WCRP should provide support for such a meeting due to its relevance for future climate research programs and for the understanding of the mechanisms driving the upper layer of the ocean in ocean GCMs.

The WG has also suggested that there is a need for an ongoing group or panel in this field and sought a reconstitution of the WG or the establishment of some new mechanism. The SCOR meeting, having discussed this matter, recommended that any proposal for future action on this topic should be presented to SCOR and WCRP only after more extensive discussions within the appropriate scientific community at the international meeting discussed above.

#### **2.2.8 *WG 111 Coupling Winds, Waves and Currents in Coastal Models***

Speaking as the Executive Committee Reporter for this WG, Wolfgang Fennel noted that it gathered momentum during the past year with a first meeting at the International Conference on Coastal and Ocean Modeling, in November 1998 in Malta and a second meeting at the Gordon Research Conference on Coastal Ocean Modeling, in June in New Hampshire, USA.

In the course of its work the group has found a lack of communication between various scientific communities dealing with coastal waves, turbulence, and circulation. The present situation regarding these topics has been summarized by the WG Co-Chairs, Norden Huang and Christopher Mooers, in a Concept Paper, which will serve to define the content and participants for a major workshop planned for the year 2000, from which a coherent book will be derived. The meeting agreed that this document provides a good guide to the current problems in the field and that it should be published as an Annex to this report (see Annex 3) and on the SCOR Home Page. Fennel recommended that SCOR should support the workshop to be held in 2000.

#### **2.2.9 *WG 112 Magnitude of Submarine Groundwater Discharge and its Influence on Coastal Oceanographic Processes***

The report from the Chair, Bill Burnett, reviewed the activities of WG 112 during the past year. The Reporter, Bjørn Sundby, reminded the meeting that the overall goal of the WG is to define more accurately the magnitude of submarine groundwater discharge (SGD) and how it may influence chemical and biological processes in the coastal ocean. To this end, the members of the working group have organized themselves into three task-oriented units based on the following goals: Calculation and Modeling; Measurement, Sampling, and Experimental Design; and Typology, Integration and Globalization. The group's activities are summarized on the SCOR Home Page (<http://www.jhu.edu/~scor/WG112.html>). In addition, several articles about the SGD problem and the WG have appeared in *EOS* and in several Japanese journals.

At its first meeting the WG identified a major problem of the varying methodologies used to measure groundwater discharge and agreed to design a series of intercalibration experiments. It prepared a proposal to the Intergovernmental Oceanographic Commission which agreed to support a planning workshop for this activity in the context of its Integrated Coastal Area Management program. Numerous other tasks were assigned to the WG members

The WG requested support for a meeting in 2000 to be held in association with "Hydro-2000" Meeting in Perth, Australia, Nov. 20-23, 2000. The expectation is that the first intercalibration exercise will take place in Cockburn Sound near Perth at this time, providing that support is found for it. SCOR agreed to allocate a budget for the WG meeting itself. The WG is cosponsored by the LOICZ program which will contribute half of the expenses of the meeting. Sundby commended the WG for its enthusiasm and level of activity. The Vice-Chairman of GESAMP, (Group of Experts on the Scientific Aspects of Marine Environmental Protection) Robert Duce, noted that the WG is also providing valuable input to that body.

### **2.2.10 *WG 113 Evolution of the Asian Monsoon in Marine Records: Comparison between Indian and East Asian Subsystems***

This WG, known as SEAMONS (SCOR-IMAGES Evolution of Asian MONSOON), held a workshop on monsoon proxies in Amsterdam in May 1999. It focused on proxies for seasonal and interannual variability of the monsoon system, and its outcome will be a manuscript which was in the process being completed and finalized. This manuscript seeks to define the seasonal and interannual monsoon dynamics that can be studied in the paleoclimate record through analysis of marine sediments, to assess the current status of sediment proxies available to study these dynamics and make recommendations for further proxy development, including age control, analysis protocol, and the development of model-compatible (quantitative) paleoclimate proxies.

I.N. McCave, the Executive Committee Reporter for WG 113, found the group to be an active and productive one. He recommended the approval of support for a SEAMONS meeting to be held in Beijing in October 2000 [later changed to early 2001] jointly with the Ocean Drilling Program Leg 184 (South China Sea) post-cruise meeting. In accordance with the plans approved by the 1998 SCOR General Meeting, the subject of this meeting will be "Asian monsoons and global linkages on Milankovitch and sub-Milankovitch time scales", for which the Leg 184 studies were especially significant. The IMAGES and PAGES programs contribute to the expenses of some members of the WG.

The meeting also approved several changes in the membership of the WG. Two new members were added: Pascale Braconnot (France, modeling) and An Zhisheng (China, loess, PAGES representative). Joan Grimalt (Spain, originally full member) was appointed as an Associate Member.

### **2.2.11 *WG 114 Transport and Reaction in Permeable Marine Sediments***

The Reporter, Bjørn Sundby reminded the meeting that as 1998-1999 was its first year of existence, most of the activities within WG 114 have been organizational. From November until March, the main preoccupation was the nomination and approval of the membership. The membership was finalized in consultation with the Chair of the group after the 1998 General Meeting, and was approved by the SCOR Officers as follows:

#### **Members:**

Bernard P. Boudreau (Chair) - Canada  
Markus Huettel - Germany  
Peter Nielsen - Australia  
Wim Van Raaphorst - The Netherlands

Ian Webster - Australia  
Gary Taghon - USA  
Anton McLachlan - Sultanate of Oman  
Pat Wiberg - USA  
Jan Marcin Weslawski - Poland

#### **Associate Members:**

Stefan Forster - Germany  
Frank Sansone - USA

Richard A. Jahnke - USA  
Jack J. Middelburg - The Netherlands

The WG's first meeting was held at the Max-Planck Institute for Marine Microbiology in Bremen, Germany in late September, 1999. Background papers were distributed and members each prepared a short scientific exposé on a research problem of importance to the group. The report of this meeting was not yet available to the Executive Committee.

In order to address one of the proposed aims stated in its Terms of Reference, the WG has created a web site (<http://www.mpi-bremen.de/SCOR-WG114/>), linked to the SCOR home page. It contains much of the information in the original proposal to SCOR, plus new figures and photographs that should give the reader/browser a better idea of the focus of the WG. The site will eventually contain a full bibliography on the topic and links to online papers and sites that deal with marine permeable sediments.

The LOICZ program was requested to co-sponsor WG 114, but they declined, citing financial strictures and a perceived difference in scientific emphasis. Sundby recommended that the 2000 SCOR budget include funds to support a meeting of WG 114, pending more information on its program, venue and dates.

*In closing the discussion of Current Working Groups, the President noted their especially high level of activity and he suggested that the Executive Committee Reporters should communicate this satisfaction to the WG Chairs.*

### **2.3 Proposals for New Working Groups**

The following four proposals for new Working Groups were circulated to all national committees of SCOR for comment two months prior to the Executive Committee meeting.

#### **2.3.1 Standards for the Survey and Analysis of Plankton**

The 1998 General Meeting recommended revision and re-submission of this proposal for consideration by the Executive Committee meeting. The revised proposal, with the full title "Standards for the Survey and Analysis of Plankton Focusing on High Speed and Long Term Sampling Systems, was presented by Peter Burkill. The following information is extracted from the proposal, which is found in its entirety in Annex 4.

It is now recognised that sampling zooplankton at large spatial and long time scales is crucial to help assess the carrying capacity of regional seas, provide input at appropriate scales to global, basin scale and regional sea models and provide a baseline and time series against which natural and anthropogenically forced change can be assessed. There are few existing monitoring surveys of zoo or ichthyoplankton that satisfy the above requirements. The most representative is the Continuous Plankton Recorder Survey in the North Atlantic which has been in nearly continuous existence for more than sixty years. The CPR Survey was recently incorporated into the GOOS Initial Observing System and it is likely that this approach to monitoring the oceans of the world is likely to expand further over the next decade.

There are now a number of different sampling and measuring systems for large-scale zooplankton survey in use, with two contrasting approaches:

- The historical CPR approach with added instrumentation as well as new developments of Continuous Plankton and Environmental Recorders (CPEs) (These instruments are not yet sufficiently rugged for use in operational survey mode from ships of opportunity).
- Instrumental measurement of zooplankton using optical particle counters, video and acoustic systems. In this category a number of designs and manufactured systems are already being used.

Problems exist in maintaining consistent sampling within these different approaches through time so that records give an accurate indication of changes in plankton abundance and the different surveys are inter-comparable. There is thus a need to establish standards of careful collection, of quality controlled analysis of collected material and data, of curation and archiving, of the development of associated instrumentation, and of the inter-comparison of methods of collection and analysis, to ensure that data or data products are reliable, properly quantified preserved and inter-comparable.

The proposal recommended that a SCOR Working Group be set up to address the above topics focusing in parallel on 1) the CPR approach and 2) other forms of sampling zooplankton with an integration of the products of the studies as an important contribution to GOOS, GLOBEC and national plankton research and monitoring initiatives at a regional scale.

Burkill reviewed the challenges presented in the proposal, namely how to measure the responses of marine populations and their ecosystems to global change and how to deal with the problem of natural spatial variability in the distributions of marine organisms. He also reviewed the proposed terms of reference for the WG and concluded that the topic is timely, has significant international relevance and that it addresses fundamental questions related to global change.

In general the participants were in favor of establishing this working group. Some comments recognized the importance of calibrating the older CPR technology against the new systems, and of "translating" the existing CPR time series into a more quantitative form. Burkill and E. Fernandez (Spain) noted the importance of quantitative information on zooplankton for estimating secondary production and vertical fluxes of carbon.

The meeting agreed that this group should be established. During the meeting the terms of reference were revised by Burkill and Fernandez as follows:

- To review the present methods of collection, analysis and curation of samples using Continuous Plankton Records by the different agencies involved and the use which is made of CPR data products.
- To overview the different instrumental approaches to measuring zooplankton, and identify improvements that can be made to sampling strategies and make recommendations on how instruments can be improved and integrated with direct sampling systems such as the CPR for calibration.
- To establish a strict methodology for inter-comparison/calibration of different sampling systems.
- To recommend a standard package of additional measurements that should be taken in association with CPR survey to enhance the resulting products and assess logistical requirements, identify improvements that could be made in existing instrumentation for use in or attached to towed bodies for plankton survey.
- To develop methods to transform historical, contemporary and future zooplankton data from high speed surveys into carbon concentrations suitable for modeling biogeochemical fluxes.
- Encourage the use of the products of long established surveys and the application of new strategies for large scale and long-term sampling of zooplankton by organizing an international symposium. Publish the products of reviews by members of the Working Group, selected presented papers and workshop reports in an internationally recognized, peer reviewed, journal or SCOR sponsored book.

Peter Burkill agreed to be the Executive Committee Reporter and to lead the search for an individual to chair this WG which will be WG 115. The membership will be established in consultation with this Chair, taking into account the list submitted with the proposal and the suggestions received from national committees and participants at the Executive Committee meeting.

### **2.3.2 *Synthesis of Decadal to Millennial Climate Records of the Last 80ky***

This proposal from the IMAGES program received preliminary consideration in 1998, but was not ready in time for circulation to National Committees prior to the General Meeting. Accordingly it was resubmitted to SCOR in 1999 by M. Sarnthein and J. Kennett and was presented by the Past-President, I. N. McCave.

McCave identified one of the key problems in investigations of rapid climate changes over geologic time scales; the lack of the understanding needed to relate the records of climate change found in Greenland ice cores compared to those from marine and terrestrial sediments.

In recent (Holocene) times, these records show fluctuations lasting from 300 to 1,500 years with onsets in periods as short as a few decades to 150 years. These rapid changes were originally detected through observations of the Deuterium:Oxygen ratios in the Greenland ice cores and are now also observed in marine and terrestrial sedimentary records. However, for unknown reasons, these cycles of D/O variations do not appear in the Holocene polar ice core records. D/O cycles represent an extremely important component of late Pleistocene climate change. However, the origin of these episodes of rapid climate change remains largely a mystery. The discovery of the origins represents a key to understanding climate change in the late Pleistocene.

Fundamental understanding of the origin of the D/O cycles is in large measure a stratigraphic and chronologic problem. It is essential to understand the leads and lags and the potential subharmonics of these cycles for the different parts of the global climate/ocean system associated with the D/O cycles. Therefore, the stratigraphy and chronology of the D/O cycles represent a fundamental base for further advancement.

Yet the chronological framework of climate change during the last 80,000 years is by no means sufficiently well established to provide the required stratigraphic and chronologic foundation to enable global correlation and links of the various types of paleoclimatic records. For example, a major stratigraphic problem is reflected in a general inability to place marine stratigraphic records of the D/O cycles within the same chronological framework used in the ice core records, which themselves reveal age discrepancies reaching more than  $\pm 5-10\%$ . Such an error confounds scientists' abilities to identify changes taking place on time scales of a few decades.

The proposal identified an urgent need for an international working group to create a common canonical time series of short-term and abrupt climatic events documented in marine sediment records and to tie the ultra-high resolution climate records to ice core and other varved records of climate change measured on the calendar year time scale.

McCave noted that, in fact, a workshop to address some of these problems was already planned for February 2000. The task of proposed group would be to integrate and synthesize the workshop results, to prepare the resulting publications and to formulate specific key questions about future studies on oceanic decadal-to-millennial-scale climate change and the links between marine and terrestrial and ice records. The proposed group should be cosponsored by the PAGES program of IGBP and by IMAGES.

The comments from SCOR National Committees and participants in the meeting were generally supportive of the proposal and it was agreed that Drs. McCave, Ganssen, Somayajulu and Krishnaswami should modify the terms of reference. They were later approved as follows:

- Establish the record of short-term climatic events in marine sediments, recorded by proxies of isotopic, elemental, paleontological, sedimentological and magnetic properties.
- Evaluate the dating of the various records involving assessment of a) spatial and temporal variability in C-14 production rate and reservoir ages, and b) errors associated with  $^{230}\text{Th}$  ages. Estimates of both precision and accuracy must be made for all methods and dates proposed.
- Marine records must be correlated a) among themselves and b) with ice-core and other (e.g. coral, varve, loess) records of climate change.
- Develop better understanding of telecommunication processes on sub-orbital time scales though frequency analysis of robust cyclicities to determine leads and lags.

The Working Group (which will be WG 117) will be Co-Chaired by Michael Sarnthein (Germany) and James Kennett (USA). The final membership will be agreed between them and the Executive Committee Reporter, I. N. McCave, taking into account SCOR's concern with the group should include a C-14 specialist and a paleomagnetist in place of one of the proposed isotope paleoceanographers.

### **2.3.3 Sediment Trap and $^{234}\text{Th}$ Methods for Carbon Export Flux Determination**

This proposal, introduced by Peter Burkill, arose from discussions at the JGOFS Arabian Sea synthesis symposium (Bangalore, India, January 1999). The participants there recognized that, in spite of debate throughout the lifetime of the JGOFS, program, there is still uncertainty about the interpretation and intercomparability of the two major methods for estimating carbon export fluxes.

The flux of biogenic matter through the ocean water column, especially from the base of the photic zone to ocean interior is known as "export production" and includes settling particulate matter of plant and animal origin and advective/diffusive transport of Dissolved Organic Matter (DOM) produced by the decomposition of organic matter in the photic zone. The removal of carbon from the photic zone, is at least partly replenished by drawdown of atmospheric  $\text{CO}_2$ . Thus knowledge of export production and its variability is important to assess the role of oceans in sequestering atmospheric  $\text{CO}_2$ . Further, at steady state, export production is expected to be the same as new production, a key parameter in marine biogeochemical cycling models. Thus the determination of export production of carbon and its relation to primary and new production has gained considerable importance in JGOFS and related studies.

Two methods are commonly used to measure export production; (i) sediment trap and (ii)  $^{234}\text{Th}$ -. $^{238}\text{U}$  disequilibrium. Sediment traps are used for the measurement of settling fluxes of particles and their collection for chemical and biological analyses, but there are concerns about their ability to quantitatively collect unbiased samples of settling particles. (For more information, see the full text of the proposal in Annex 5.)

The second method used for determining settling fluxes is based on  $^{234}\text{Th}$ -. $^{238}\text{U}$  disequilibrium.  $^{234}\text{Th}$ , a short lived radionuclide, is produced continuously in sea water at a nearly uniform rate from the decay of  $^{238}\text{U}$ .  $^{234}\text{Th}$  thus

produced gets quickly attached to particles and is removed out of surface water with the settling particles and is therefore deficient relative to its parent  $^{238}\text{U}$  in the upper water column (~150-200 m). The extent of this deficiency, in conjunction with data on POC/ $^{234}\text{Th}$  in particulate material has been used to determine the export production in many of the JGOFS process study regions. Several factors affect the accuracy of this method.

After considerable discussion, the proposal was approved. Several participants commented on the proposed list of membership, in particular the need for a specialist in hydrodynamics in relation to the efficiency of traps was identified. They agreed that Ken Buesseler (USA) should be invited to chair the WG. The membership will be finalized in consultation with him and the Executive Committee Reporter who will be I. N. McCave.

#### **2.3.4 Oceanic Salts Project**

This proposal was sent to SCOR by the International Union of Pure and Applied Chemistry as a possible joint SCOR-IUPAC activity.

The proposal, reviewed by Shizuo Tsunogai, noted that the 1933 bibliography and compilation of primary data for solubilities of oceanic salts published by d'Ans, has never been updated despite the importance of the data in constructing models of seawater and brackish water, in the solution of environmental problems in oceanic and brackish environments, in mining of salt deposits, and in interactions between the oceans and the atmosphere. While many partial models of seawater have been reported in the literature, these make use of only limited sets of data. Thus the overall goal of a detailed theoretical description of solutions of oceanic salts, based on a complete set of carefully-evaluated data over wide ranges of temperature and pressure, does not exist at present. Methods for treatment of the thermodynamic properties of aqueous systems (including sea water) are well advanced, and these could form the basis of improved methods of achieving this description.

The goals of the proposed WG would be to produce up-to-date compilations of data (with bibliography), constructed in the format of the IUPAC Solubility Data Series (SDS); to publish compiled data both in printed form (via the IUPAC Solubility Data Series) and possibly in the form of a computerized on-line database and to devise and document appropriate methods for critical evaluation of the data, and to publish these, again via the IUPAC Solubility Data Series.

The comments made at the Executive Committee meeting were generally not in favor of accepting this proposal. The topic, while possibly of interest to chemists, was not felt to be a timely one of central importance to ocean science. The consensus of the meeting was that SCOR should offer assistance with the review process for any resultant publication if that would be helpful to IUPAC.

#### **2.3.5 New Technologies for Observing Marine Life**

This proposal was submitted by David Farmer on behalf of the steering committee for the Alfred P. Sloan Foundation's Census of Marine Life. It was received too late to be circulated to National Committees for comments, but the Executive Committee agreed to discuss it during the meeting, seeking comments and feedback from National Committees if the proposal were accepted in principle.

The Executive Director, who is familiar with the Census of Marine Life (CoML), presented the proposal (see Annex 6) which was developed as a result of the first meeting of the Committee for the CoML. This initiative has as its objective the quantification the abundance of marine organisms and an assessment of their patterns of distribution. The CoML has recognized the need for much improved technologies and biological instruments if such a global survey is to be feasible. This need is generally recognized in the fisheries and biological oceanography communities. Particular attention will be paid to those instruments which may have been developed in a single laboratory, but which, with further development, could be made economically practical for much wider use. Readers are referred to Annex 6 for more information on the Census of Marine Life initiative and its relationship to this SCOR proposal. However, observational technologies are a crucial part of the initiative and the proposal was based on the belief that this is an opportune topic for a SCOR focus.

New techniques, or improved ways of using existing techniques, often arise in research groups that do not have traditional commitment to the measurement of marine life, but depend on innovative application of concepts

developed for different reasons. To cite just one example, the development of optical sensing of fish using airborne lidar evolved in a group that was developing optical techniques for atmospheric measurement. Subsequent collaboration with fisheries scientists demonstrated the remarkable potential of this method and its future success will be based on this interdisciplinary link. At present the technology remains largely inaccessible and probably largely unknown to the vast majority of scientists who could benefit from it. But there is no reason why this should remain so, and wider knowledge and discussion of such approaches will almost certainly lead to wider use. Similarly, acoustic methods for stock assessment are in varying states of development in different countries.

The proposal touched upon a variety of promising techniques: the use of acoustic, optical and statistical methods, as well as new deployment approaches such as the use of autonomous vehicles and drifters communicating their results by satellite, DNA sequencing, behavioral approaches such as relating seabird activity to fish populations, concentration of sparsely distributed fish by night time illumination to facilitate assessment and passive detection through bioluminescence stimulated by high fish concentrations.

The Executive Committee accepted this proposal in principle, agreeing that it would be a timely topic for SCOR's attention, but taking into account the fact that full financial support for its activities was likely to be provided by the Sloan Foundation. Since a funding request would have to be submitted to the Foundation very soon after the Executive Committee meeting, the Executive Director was requested to work with David Farmer (Canada), who will be invited to Chair the WG, to draft terms of reference and to draw up a list of membership suggestions, to send it to National Committees for comments immediately, to seek input from the GLOBEC Steering Committee and to arrange for review and final approval by the SCOR Officers. This will be WG 118.

### 3.0 SCIENTIFIC PROGRAMS

#### 3.1 SCOR Committees

##### 3.1.1 *Joint Global Ocean Flux Study Scientific Steering Committee (JGOFS)*

The President, John Field, relinquished the chairmanship of the meeting to the Secretary, Bjørn Sundby, in order that he could lead the discussion of JGOFS in his capacity as Executive Committee Reporter for that program. The extensive written report is given in Annex 7.

Field drew attention to the scientific accomplishments arising from the JGOFS program during the past year, noting in particular the new global map of the sources and sinks of CO<sub>2</sub>, the Southern Ocean Iron Enrichment Experiment (SOIREE) conducted under extremely difficult conditions, and the ongoing comparison of 12 ocean carbon models in cooperation with the GAIM program of IGBP.

Other highlights included the first JGOFS synthesis workshop, which initiated the important final phase of the program in which research and field results must be analyzed, integrated and synthesized in cooperation with modelers and others in order to obtain the global view of the oceanic biogeochemical cycles which is the major objective of JGOFS. The products of this synthesis were defined: they will include a glossy brochure entitled "Ocean Biogeochemistry and Climate Change" and the 2<sup>nd</sup> synthesis book which will present JGOFS' understanding of the ocean biogeochemistry. Finally, the workshop considered in detail the organization of the Open Science Conference to be held in April 2000 in Bergen. The science program will parallel the themes of the JGOFS Synthesis Book.

Field expressed SCOR's appreciation to the Norwegian Research Council and the University of Bergen for having renewed their financial support for the JGOFS International Project Office for the next four years, that is, to the end of the formal lifetime of the JGOFS program. He also noted that several members of the JGOFS SSC were actively participating in the development of SOLAS (see below). However, in recognition that, with its focus on the upper ocean and lower atmosphere, SOLAS will not adequately address all aspects of the carbon cycle in the ocean, JGOFS has recommended the formation of a small group to consider the issues relating to ocean biogeochemistry that will remain unresolved when JGOFS is completed and the design of a future program to address them. This topic was addressed in a discussion meeting during the IGBP Congress, which was also the venue for the JGOFS SSC meeting.

The review of JGOFS activities by Field included all of the subsidiary synthesis groups and task teams. Detailed information on these is available in Annex 7. All of the regional groups have now been restructured and reoriented towards the synthesis effort. They will each contribute to the global JGOFS synthesis which will be carried out by the SSC itself. The Executive Committee took note of the numerous JGOFS publications and other products that were produced during the past year.

Several members of the JGOFS SSC were due to complete their terms of membership at the end of 1999 and the nominations received with the JGOFS report were considered by the SCOR meeting. Firstly, Michael Fasham has provided excellent leadership for the JGOFS SSC and its Synthesis phase since 1998, but health problems have forced him to resign this position. He will, however, continue to take the lead as editor of the synthesis book and brochure discussed above. The SSC nominated Hugh Ducklow (USA) to succeed Fasham as JGOFS Chair. This suggestion was readily approved by SCOR (following the approval of IGBP, the JGOFS cosponsor), since Ducklow has had a long involvement with JGOFS as an SSC member and Vice-Chair, Chair of the North Atlantic Planning Group and Chairman of the US JGOFS Committee.

Other members leaving the SSC included Toshiro Saino (Japan) and Egil Sakshaug (Norway). SCOR approved the suggestion that Saino be invited to serve a second term on the SSC in view of his position as co-Chair of the North Pacific Task Team and the enthusiasm with which he has served the Committee. Sakshaug could not be reappointed, have served two terms and his service to JGOFS was noted with great appreciation. The nomination of Peter Haugan (Norway) was welcomed and approved by SCOR. His main interest is research on ocean-climate processes by combining the analysis of observational data with theory and numerical modeling. He will also provide a critical link with the GOOS/GCOS/WCRP Ocean Observations Panel for Climate (OOPC) for JGOFS.

### **3.1.2 SCOR/IGBP/IOC Committee on Global Ocean Ecosystems Dynamics (GLOBEC)**

The detailed written report from the GLOBEC program is given in Annex 8 and was presented by Peter Burkill. He reviewed the goal of the program:

“To advance our understanding of the structure and functioning of the global ocean ecosystem, its major subsystems, and its response to physical forcing so that a capability can be developed to forecast the responses of the marine ecosystem to global change”.

Burkill noted that the GLOBEC program is about to significantly increase the range and pace of its activities due to the establishment of a fully-staffed International Project Office (IPO) and the appointment of Dr. Manuel Barange as the GLOBEC Executive Officer in October 1999. A Deputy Executive Officer is being sought. For the first time, the existence of scientific and administrative staff support made it possible to develop detailed plans for the implementation phase of the program.

The highlight of the year was the publication of the GLOBEC Implementation Plan which moved the program from its planning phase towards implementation or execution of the scientific plans which were described in the Science Plan published in 1997. The Plan describes in detail the structure of the GLOBEC program which includes four Research Foci, several Framework Activities, four Regional Programs and an Integration effort. The SSC has now established working groups for each of the research foci which form the scientific core of the program. Their activities are beginning in 2000 and they will certainly propose further meetings and activities in order to accomplish their goals. The four foci and their major activities are listed below:

#### **Focus 1: Retrospective analyses and time series studies**

- Activity 1.1 Preservation of existing long time series studies and data
- Activity 1.2 Analyses of existing retrospective data
- Activity 1.3 Creation of new, retrospective, data sets
- Activity 1.4 Development of new data sets for future comparisons

#### **Focus 2: Process studies**

- Activity 2.1 Research on life histories and trophodynamics and their modeling in ecosystems
- Activity 2.2 Identification and understanding of multiscale physical-biological interactions

Activity 2.3 Response of marine ecosystems to fishing and species introductions

Focus 3: Predictive and modeling capabilities.

Activity 3.1 Design and testing of relevant sampling and observational system capabilities

Activity 3.2 Develop relevant modeling capabilities

Activity 3.3 Develop coupled modeling-observational capabilities and applications

Focus 4: Feedback from Changes in Marine Ecosystem Structure.

Activity 4.1 The climate interaction on multiple scales and its consequences for basic biological processes through the food web

Activity 4.2: The earth system impacts resulting from changes in marine ecosystems

Activity 4.3 Social impacts of changes in marine ecosystems

The GLOBEC Framework Activities will be developed during 2000 and 2001 as the focus working groups make progress. Some of the tasks will be assigned to the GLOBEC International Project Office while the SSC must consider how best to implement others. They include:

Activity 5 - Sampling and models: protocols and intercomparisons

Task 5.1 Core sampling protocols and methods intercomparison

Task 5.2 Model intercomparison

Activity 6 - Data Management - a specific responsibility of the International Project Office.

Activity 7 - Scientific Networking

Task 7.1 Establishment of GLOBEC research networks

Task 7.2 Establishment of Focus Working Groups

Task 7.3 GLOBEC publications

Task 7.4 GLOBEC Open Science Meetings

Task 7.5 Interactions with other Global Change Research Programs

Activity 8 - Capacity Building

Task 8.1 Scientific training

Task 8.2 Development of scientific infrastructure and enhancement of capacity building in developing countries.

Task 8.3 Interdisciplinary training of students and especially post-doctoral fellows in both observational and modeling methods.

GLOBEC has four active regional programs. Two of them are coordinated and funded from outside GLOBEC: the GLOBEC-PICES Climate Change and Carrying Capacity Program (CCCC) and the GLOBEC-ICES Cod and Climate Change Program (CCC). Working plans for both programs are contained in the GLOBEC Implementation Plan and are being activated under the leadership of the regional sponsors. The other two GLOBEC Regional Programs, the Southern Ocean GLOBEC (SO) and the Small Pelagic and Climate Change Program (SPACC) are coordinated and supported by the GLOBEC SSC and the IPO.

Finally, the GLOBEC Integrating Activities are described in the Implementation Plan and the SSC is beginning to consider how best to carry out integration and synthesis throughout the GLOBEC program. Having started much later than most of the other IGBP programs, GLOBEC has the advantage of learning from their experience and being able to keep the need for true synthesis foremost from an early stage.

### Activity 9 - Towards a GLOBEC synthesis: ecosystem comparisons

- Task 9.1            Development of marine ecosystem typologies and classification of ecosystems.  
Task 9.2            Identification and prediction of responses of marine ecosystem types to global changes

The GLOBEC SSC had submitted nominations for the replacement of Committee members whose terms were expiring for consideration by the program's sponsors, SCOR, IGBP and IOC. At the end of 1999 seven members of the GLOBEC SSC will complete their initial terms (see the table at the end of Annex 8). Four members were proposed for a second term:

Jürgen Alheit (Germany) - for his responsibilities regarding the SPACC Regional Program.

Roger Harris (UK) - currently Chairman of the SSC

Eileen Hofmann (USA) - the very active Chair of the Southern Ocean Planning Group

Ian Perry (Canada) - Vice-Chair, and links with the PICES Regional Program

In order to fill the three remaining vacancies and to bring new disciplinary expertise and geographic representation to the committee, the following nominations were approved by SCOR (they had already been approved by IGBP):

Francisco Werner (USA) -satisfies the need to strengthen the SSC in the area of Modeling and Sampling. Werner is the new Chair of the reconstituted GLOBEC Modeling and Sampling Working Group.

Patrick Lehodey (New Caledonia) - expertise in the area of migratory fish species., tuna populations and the relations between ENSO and fisheries. Also provides expertise in the South Pacific, an area for development by GLOBEC.

Geir Ottersen (Norway) - re-establishes a good link with the GLOBEC research community of the North Atlantic, particularly the Cod and Climate Change regional program being co-ordinated by ICES. Provides expertise in physical oceanography and retrospective time-series analysis, particularly in relation to the Nordic Sea.

The Deputy Director of IGBP urged the GLOBEC SSC to ensure that a Japanese scientist is added to the Committee at the next opportunity. Other participants reinforced this view.

Lastly, SCOR urged the GLOBEC SSC to develop activities and links to the appropriate research activities in Southeast Asia. GLOBEC should consider initiating capacity building activities in that region as well.

The discussion of GLOBEC concluded with an expression of thanks to Roger Harris, the Chair of the SSC, at the conclusion of his first term in that position, for leading the program through this important phase of its existence.

#### **3.1.3 SCOR/IOC Scientific Steering Committee on Global Ecology and Oceanography of Harmful Algal Blooms**

The report received from GEOHAB was introduced by Bjørn Sundby, the Executive Committee Reporter for this newest SCOR program, which was approved at the 1998 and General Meeting and is cosponsored by the IOC. The first meeting of the GEOHAB SSC was to take place in Brest, France during the week following the SCOR Executive Committee meeting. The immediate challenge for the SSC is to build upon the report of the SCOR/IOC workshop held in 1998 to develop a detailed Science Plan for the new program.

The final membership of the SSC was approved by the SCOR Officers as follows :

Patrick Gentien (France) Chair  
Yasuwo Fukuyo (Japan) Vice-Chair  
Donald Anderson (US)  
Susan Blackburn (Australia)  
Allan Cembella (Canada)  
John Cullen (Canada)  
Malte Elbrachter (Germany)  
Marta Estrada (Spain)  
Wolfgang Fennel (Germany)

Richrd Geider (UK)  
Patricia Glibert (US)  
Kaisa Kononen (Finland)  
Nestor Lagos (Chile)  
Thomas Osborn (US)  
Grant Pitcher (S. Africa)  
Arturo Sierra-Beltran (Mexico)  
Steven Thorpe (UK)  
Zhang Jing (China)  
Adriana Zingone (IOC)

The GEOHAB SSC is striving to form links to other international programs and to the many emerging national coastal ecology programs. For example, the new Executive Officer of GLOBEC will attend the first meeting of the SSC with a view to planning collaborations between the two activities. Similar efforts will be made to develop links between GEOHAB and C-GOOS and LOICZ.

The 9<sup>th</sup> International Conference on Harmful Algae will take place in Hobart, Australia in February 2000. The GEOHAB SSC will seize this opportunity to present the GEOHAB Science Plan to the scientific community for feedback. This may also provide an opportunity for a second meeting of the SSC; if not, an SSC meeting will be needed later in 2000.

The representative of the IOC, Maarten Kuijper, emphasized the commitment of the Commission to support the GEOHAB program. Bjørn Sundby, while recognizing that the SSC had not yet held its first meeting, noted that SCOR has accepted a major commitment by establishing this program, and asked that the report submitted to the General Meeting in 2000 contain substantially more information about the progress and future plans of GEOHAB.

### 3.2 Scientific Programs under Development

#### 3.2.1 *Development of a SCOR/IGBP/WCRP Surface Ocean Lower Atmosphere Study (SOLAS)*

Peter Burkill reviewed the history of the development of the SOLAS program (see former issues of *SCOR Proceedings*), the progress with the development of a SOLAS Science Plan, and the plans for an Open Science Meeting in early 2000 at which these plans would be presented to the wider scientific community for the first time.

Since late 1996 SCOR and IGBP have jointly supported the preliminary development of a potential new international research program on ocean/atmosphere biogeochemical coupling, with the acronym SOLAS. The primary goal of SOLAS would be to address key interactions among the marine biogeochemical system, atmospheric chemistry, and climate, and how the marine and atmospheric biogeochemical system affects and is affected by past and future climate and environmental change. Examples of the types of issues that might be addressed include the affects of marine sulfur emissions on climate through influence on cloud albedo; the impact of changing patterns of atmospheric nitrogen deposition to the ocean on marine biota; and the influence of changes in marine biogeochemistry on open ocean uptake of anthropogenic carbon dioxide. The program would be a highly interdisciplinary effort involving chemists, physicists, and biologists with expertise in the oceanic and atmospheric sciences.

After meeting with the scientific steering committees of several related international research efforts (e.g., WCRP, JGOFS, IGAC), and after the SCOR Meeting in Amsterdam in November, 1998, a Planning Committee for the further development of SOLAS met in Norwich, England in December, 1998 to plan for a SOLAS Open Science Meeting to take place near Kiel, Germany in late February 2000 and it is expected that 200-250 scientists will attend .

The report from the Co-Chairs of SOLAS, Bob Duce (USA) and Peter Liss (UK) requested continued support from SCOR for the development of this program in ocean/atmosphere biogeochemical coupling. Of particular importance during 2000 and early 2001 will be the completion of the SOLAS Science Plan and an editorial meeting will be needed in 2000.

In view of the ongoing preliminary synthesis and possible re-structuring of IGBP, it was not yet clear to the sponsors how SOLAS would fit into these plans. For the time being it is being treated as an "inter-project activity" involving the JGOFS and IGAC programs. The Executive Committee encouraged the SOLAS planning group to continue to define the important scientific issues while the future structure of international global change research programs is discussed among the sponsors.

### **3.2.2 *Future Ocean Biogeochemistry Programs***

The President of SCOR informed the participants that as JGOFS nears its completion, discussions have been taking place as to the future directions for research in the field of ocean biogeochemistry. Simultaneously, new directions and scientific priorities are being considered for the IGBP. Field convened a discussion group during the IGBP Congress in Japan (May 1999) at which a number of representatives of IGBP, JGOFS, IGAC, SOLAS, and others considered the scientific and organizational issues involved in the development of future programs in the field of ocean biogeochemistry.

All participants agreed that the future requires a fully integrated approach, including studies of ocean-atmosphere exchanges, fluxes throughout the entire water column to the sea floor, physical processes, climate interactions, feedbacks and so on. This approach should take advantage of the results of the JGOFS and IGAC syntheses, as well as the scientific directions emerging from the SOLAS Open Science Meeting in February 2000. Lastly, aspects of our understanding of climate variability and of marine ecosystem dynamics will be required from GLOBEC and CLIVAR.

The discussion meeting acknowledged the need for a new organizational model within the IGBP and in national programs and funding agencies, in order to carry this out. Such a mechanism, which is not constrained by traditional disciplines, should be developed in the next year or so. IGBP, SCOR and WCRP will continue this discussion during the months ahead. The meeting concluded with an agreement that SCOR and IGBP should sponsor an international workshop on this topic in 2000.

Several participants in the SCOR meeting noted the need to involve scientists in this workshop who are experts in biogeochemical cycling in the deep ocean, sediments and paleoceanographers. The focus of the workshop should not be solely on carbon. These comments were noted by the SCOR President who, along with Patrick Buat-Ménard (France) for the IGBP, will co-Chair the workshop.

### **3.2.3 *Graduate Education in Marine Science in Developing Countries: a Regional Approach***

Cintia Piccolo reviewed the progress with this initiative. Readers are referred to *SCOR Proceedings*, volume 34 for background information. In 1999, funding was obtained from the Rockefeller Foundation for two follow-up activities to the workshop held at the Foundation's International Study Center in Bellagio, Italy in 1998: a survey of funding sources for graduate-level educational activities in developing countries, and a review of resource material for teaching marine science in a regional context. Once these surveys have been completed, additional funding may be available from the Rockefeller Foundation for a second meeting.

Ian Jones (Australia and a member of the first Bellagio study team) reported that in the meantime, a number of regional initiatives have been undertaken. The graduate program at the University of Concepción in Chile is being strengthened through an agreement with the University of Sydney. The IOC sub-commission for WESTPAC passed a resolution encouraging the development of a regional school of oceanography and a group has been formed to advance this initiative. Some progress was also made in encouraging the establishment of a regional center for graduate education in oceanography in southern Africa at the University of Cape Town. The Chairman of the Indian SCOR Committee, B.L.K. Somayajulu, mentioned a similar undertaking at the National Institute of Oceanography in Goa.

I.N. McCave reported on his experience with a similar effort in Brunei in which the local university was linked to a British academic institution, much as in the agreement mentioned by Jones. In his view, this partnership between universities or between a university and a research institution was an excellent means of enhancing the existing capabilities of post-graduate education programs in developing countries.

### **3.3 Affiliated Programs**

The President reminded the participants that since SCOR has agreed that the Affiliated Programs will be reviewed biennially at General Meetings, the reports on these activities were being presented primarily for information.

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

The report from the Chair of ATOC (also now known as Acoustic Monitoring of the Global Ocean), Andrew Forbes, is to be found in Annex 9. Cintia Piccolo, the Reporter for ATOC, reviewed the report briefly.

While SCOR Vice-President, Wolfgang Fennel, welcomed the recommendation contained in the report that ATOC should develop closer ties with CLIVAR and GOOS, other participants felt that the ATOC program was widely regarded as being outside the "mainstream" of GOOS observations. The program should do more to promote the value of the ATOC methodology for GOOS.

#### **3.3.2 *PAGES/SCOR International Marine Global Changes Study (IMAGES)***

No report was available from the IMAGES program. The Executive Committee Reporter, I.N. McCave, noted that the IMAGES office was expected to move to Germany during the next year. Noting concerns about the continuation of financial support for the program from various national sources, McCave agreed to contact the current Executive Director of IMAGES regarding a letter of SCOR support. PAGES and IGBP should join in sending similar expressions of support.

#### **3.3.3 *InterRidge - International, Interdisciplinary Ridge Studies***

Noting that the InterRidge office would shortly be moving to Japan, the current InterRidge Coordinator, Cara Wilson, reviewed recent activities in the program. There are currently 25 countries associated with the program which has three major thrusts on ridge studies: global studies, mesoscale studies and studies of active ridge processes. She reported that InterRidge had held a workshop on Arctic Ocean ridge research and another on Monitoring of the Mid-Atlantic Ridge. InterRidge has begun to plan for an international workshop on the management of hydrothermal vent ecosystems, and issue of growing concern as proposals emerge to exploit these fragile systems.

#### **3.3.4 *International Antarctic Zone (iAnZone)***

Cintia Piccolo summarized the report received from the iAnZone Program (see Annex 10). Its primary goal is to provide a mechanism for coordination and integration of Antarctic oceanographic research programs that emphasize climate interactions. iAnZone has developed several research thrusts which are described in its report,

in particular, the DOVETAIL project (Deep Ocean Ventilation Through Antarctic Intermediate Layers), research on polynyas, shelf and slope circulation and the topic of bottom water formation and modification through shelf-slope density flow and deep ocean convection

### **3.3.5 International Ocean Colour Coordinating Group (IOCCG)**

John Field referred the participants to the report submitted by IOCCG (see Annex 11). He especially noted that there were five satellites currently carrying ocean color sensors. A common misconception exists in the scientific community that these instruments are redundant when, in fact, they have different orbits, frequencies, spectral bands and "footprints".

Field also made special mention of the valuable service that the IOCCG provides to the remote sensing community through its informative Home Page, its publications and its commitment to training. An IOCCG training course on "Applications of Marine Remote Sensing" was scheduled to take place in Thailand just after the SCOR Executive Committee meeting.

## **4.0 ORGANIZATION AND FINANCE**

### **4.1 Membership**

The Executive Director informed the meeting of the following changes in SCOR membership since November 1998:

**Spain** Emilio Fernandez is a new Nominated Member from Spain.

**Sweden** Agenta Andersson-Nordström and Edna Granéli join David Turner as the three Swedish Nominated Members.

**IAMAS** Huw Davies (Switzerland) is the new President of IAMAS, thereby becoming a Member of SCOR and an *ex-officio* member of the Executive Committee. He has, however, designated Robert Duce (USA) to act in these capacities on his behalf.

**IAPSO** Paola Rizzoli (USA) has replaced Vere Shannon (South Africa) as President of IAPSO. She therefor joins SCOR as a Member and *ex-officio* member of the Executive Committee

The Committee for SCOR located in Taipei has increased its level of membership in SCOR from Category I to II.

Emilio Fernandez, representing the Spanish SCOR Committee, will try to increase the level of that country's membership in SCOR.

The Officers of SCOR will appoint a Membership Officer to assist the Executive Director in the effort to persuade more countries to become involved in SCOR activities.

### **4.2 Publications Arising from SCOR Activities**

The Executive Director presented the following report on publications arising from SCOR activities since the 24<sup>th</sup> General Meeting.

**JGOFS Publications:**

**Books**

*The Changing Ocean Carbon Cycle: A midterm synthesis of the Joint Global Ocean Flux Studies*, eds. R.B. Hanson, H.W. Ducklow & J.G. Field, was submitted to Cambridge University Press in June 1998. Publication is scheduled for fall 1999.

**Articles in Newsletters**

*Developing an information management system for IGBP*. B. Baliño. US JGOFS News Vol. 9 (3), December 1998.

*JGOFS data managers and modellers address common concerns*. B. Baliño and R. K. Lowry. US JGOFS News Vol. 9 (4), February 1999.

*The global survey of pCO<sub>2</sub>*. A. Watson. IGBP Newsletter No. 37, March 1999.

*South East Asia Time-series Station established in the South China Sea*. Juh-Kwo Shiah, Kon-Kee Liu and Tswen Yung Tang. US JGOFS News Vol. 10 (1), June 1999.

*JGOFS highlights from the Second IGPB Congress*. Roger B. Hanson. US JGOFS News Vol. 10 (1), June 1999.

*New Data and Information System Steering Group Sets Agenda*. Beatriz Baliño. US JGOFS News Vol.10(1), June 1999.

*JGOFS celebrates millennium with Open Science Conference*. US JGOFS News Vol. 10 (1), June 1999.

**JGOFS Report Series**

JGOFS Report No. 27. Parameters of photosynthesis: definitions, theory, and interpretation of results. August 1998

JGOFS Report No. 28. Eleventh meeting of the JGOFS Scientific Steering Committee, Bad Münstereifel, Germany 18-22 April 1996; Twelfth meeting of the JGOFS Scientific Steering Committee, Oban, Scotland 17-19 May 1997; Second meeting of the North Pacific Task Team, Pusan, Korea 16 & 19 October 1997. November 1998.

JGOFS Report No. 29: JGOFS Data Management and Synthesis Workshop, 24-25 September 1998, Bergen, Norway. Meeting Minutes. Edited by R. Lowry & B. Baliño. January 1999.

**Electronic data publications**

**CD-ROM: JGOFS International Collection, CTD, XBT, and SeaSoar Data Arabian Sea Process Study 1990-1997.** The German JGOFS Data Management Office, Kiel produced the data set supported by the data assembly efforts of the members of the JGOFS Data Management Task Team. The University of Bergen, Norway through the JGOFS International Project Office, supported the reproduction (copies). Distributed by the International Project Office.

**CD-ROM: NOPACCS, Northwest Pacific Carbon Cycle Study.** Japan contribution to the North Pacific Process Study. Distributed by Japan Oceanographic Data Center (JODC)

**CD-ROM: MASFLEX, Marginal Sea Flex Experiment, and A Japanese contribution to JGOFS.** Distributed by Japan Oceanographic Data Center (JODC)

**CD-ROM: JGOFS – INDIA, Arabian Sea Process Study, Data & Information.** This CD was prepared by National Oceanographic Data Center, at the National Institute of Oceanography in Goa, India. Distributed by the International Project Office.

Note: JGOFS publications are available directly from the Bergen Office or via the JGOFS Web-Site (<http://ads.smr.uib.no/jgofs/jgofs.htm>).

**GLOBEC Reports and Publications:**

GLOBEC Report 13. Global Ocean Ecosystem Dynamics, Implementation Plan (IGBP Report 47) 207pp.

GLOBEC Special Issue. *Fisheries Oceanography* 7 (3/4): September / December 1998. This special volume contains a collection of papers presented at the GLOBEC Open Science Meeting, Paris, 17-20 March 1998.

Two issues of the GLOBEC Newsletter have been published and mailed to a mailing list of over 750 scientists world-wide.

Note: GLOBEC Reports are available directly from the Plymouth Office or via the GLOBEC Web-Site (<http://www1.npm.ac.uk/globec>).

***GEOHAB Publications:***

The Global Ecology and Oceanography of Harmful Algal Blooms: A Plan for Coordinated Scientific Research and Cooperation to Develop International Capabilities for Assessment, Prediction and Mitigation. The report of a Joint SCOR-IOC Workshop held in Havreholm, Denmark, 13-17 October 1998. Available from the SCOR Secretariat.

***Publications Arising from SCOR Working Groups:***

SCOR Working Group 104 Coral Reefs and Environmental Change - Adaptation, Acclimation or Extinction. Robert W. Buddemeier and Howard R. Lasker (eds). *American Zoologist* 39 (1). February 1999. The papers presented in a special symposium organized by WG 104.

Kleypas, J. A., Buddemeier, R. W., Archer, D., Gattuso, J.-P., Langdon, C., and Opdyke, B. N., 1999, Geochemical consequences of increased atmospheric carbon dioxide on coral reefs: *Science*, v. 284, no. 2 April 1999, p. 118-120.

SCOR Working Group 98. Worldwide large-scale fluctuations of sardine and anchovy populations. *S. Afr. J. Mar. Sci.* (In press).

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

IOCCG Report No. 2 Status and Plans for Satellite Ocean-Colour Missions: Considerations for Complementary Missions.

Ocean Modelling Newsletter - the final issue (No.116) was published in September 1998. The Newsletter is being replaced by an web-based, quick response, refereed journal under the auspices of Elsevier. This electronic publication is available at <http://www.elsevier.nl/locate/omod>

Marine Turbulence Revisited. A Special volume of the *Journal of Marine Systems* 21 (1-4). J.-M. Beckers (ed). The papers presented at the Liège Colloquium in May 1998, which was cosponsored by SCOR.

*SCOR Proceedings*, Vol 34. The report of the 24<sup>th</sup> General Meeting of SCOR, November 1998.

The SCOR Home Page has been substantially revised and updated. See <http://www.jhu.edu/~scor>

**4.3 Finance**

The Chair of the *ad hoc* Finance Committee, Ian Jones, presented a brief review of the state of SCOR finances for the past and current fiscal years, i.e., 1998 and 1999. The Committee had examined the auditor's report for the 1998 fiscal year and found it to be in agreement with the more detailed financial statements prepared by the Executive Director. The final (post-audit) financial statement for 1998 is given in Annex 12. The Finance Committee recommended that the long-standing membership arrears of the SCOR National Committee in Bangladesh should be forgiven in recognition of the extremely difficult financial conditions in that country. The Chairman of the Indian SCOR Committee agreed to contact the committee in Bangladesh, sending them information from this SCOR meeting as a demonstration of the potential value of membership in SCOR and requesting that they make contact with the Executive Director with a view to re-establishing their membership on a

new basis. [This "write-off" of the past due membership fees of Bangladesh was overlooked during the 1999 audit process and will be done in 2000.]

The Finance Committee also reviewed the modifications to the 1999 budget approved by the 1998 General Meeting so as to take account of new income, various changes in existing income items and in plans for working group meetings and other activities throughout the year.

The major task of the *ad hoc* Finance Committee was to draft and present a budget for 2000 activities taking into account requests for support contained in the reports of subsidiary bodies which had been discussed during the meeting. Jones noted that discretionary funds form a very small portion of SCOR's budget and must be used to cover the administrative costs which cannot come from grant income. Committee member Robert Knox agreed to undertake a study of SCOR national members and their annual membership dues in relation to some common economic index such as Gross Domestic Product in order to identify those countries which should be encouraged to increase their levels of membership in SCOR.

Various participants in the Executive Committee meeting suggested that some administrative costs should be recovered through modest overhead charges on grants to SCOR. This will be explored by the Executive Director as she prepares new proposals to funding agencies and private foundations in the future.

The budget proposed for 2000 included approximately \$625,000 in income and nearly \$635,000 in expenses, resulting in a deficit for the year of about \$10,000. However, the resulting reduction in SCOR's cash balance (or capital fund) was not a matter of major concern since the expense allocation of \$10,000 for the costs of recruiting a new Executive Director was seen as a one-time cost to SCOR. The budget allowed funds for a meeting of one of the new Working Groups established by the Executive Committee (WG's 115 and 116), if one of them is ready to meet in within a year. A third new WG is to be supported by the Sloan Foundation and the fourth was not to be allocated funds for a meeting until 2001. It was suggested that JGOFS should be invited to contribute to the expenses of the WG on Sediment Trap and <sup>234</sup>Th Methods for Carbon Export Flux Determination since this topic originated with JGOFS and is so closely tied to its interests.

Finally, the *ad hoc* Finance Committee recommended that the levels of the five categories of SCOR membership dues for the year 2001 should only be increased by an amount equivalent to the increase approved by ICSU for its members.

The participants in the Executive Committee meeting approved the report of the *ad hoc* Finance Committee.

#### **4.4 Establishment of a Nominations Committee**

The terms of office of the President, Secretary and one of the Vice-Presidents all expire at the General Meeting in the year 2000. Two other Vice-Presidents are eligible to be re-elected. A Nominations Committee, chaired by the Past-President, I.N. McCave, was appointed to oversee the nomination and election process in preparation for the 25<sup>th</sup> General Meeting. S. Krishnaswami (India) agreed to serve on the Nominations Committee and one other SCOR member will be invited to join it, in accordance with the new procedures for nomination and election of SCOR Officers which were adopted at the 1998 General Meeting.

#### **4.5 Improving the Process of Proposals for Working Groups**

The President recalled discussions at recent SCOR meetings in which concern was expressed about the quality of working group proposals received by SCOR and the process by which they are considered and approved or rejected. He felt, however, that the quality of the proposals presented in the past two or three years had improved

considerably. Several other members of the Executive Committee agreed. Ian Jones (Australia) objected that the current process is undirected and may leave large areas of scientific importance unrepresented among SCOR working groups. He suggested that SCOR should identify such areas and point them out to national committees each year when proposals are solicited.

The Executive Committee agreed that at all future SCOR meetings an agenda item should be added after the consideration of WG proposals in which the current disciplinary balance of SCOR groups is assessed. Scientific gaps should be identified and communicated to national committees when the next request for working group proposals is sent.

#### **4.6 SCOR Secretariat**

The President informed the meeting that the Executive Director has notified the Officers of her intention to retire, or to significantly reduce her work load for SCOR, at the time of the General Meeting in October 2000. The Executive Committee agreed to establish a Search Committee consisting of the President and Secretary with the possible addition of one or two other members. There was a consensus that the location of the Secretariat in an academic department is beneficial and that no decision to move it should be taken lightly. A schedule for advertising the vacancy and interviewing candidates was established in hopes that there could be a short period of transition before the General Meeting and that the new Executive Director would assume the post at the end of that meeting. The qualifications required for the position of SCOR Executive Director were identified: a background in science, with a PhD degree preferred, excellent organizational and communication skills were considered essential.

#### **4.7 Other Organizational Issues**

The SCOR Constitution (Paragraph 4) states that "Representative Members are the elected Presidents and Secretaries of Affiliated Organizations . . .". Paragraph 8.(c) states that "the President of each Affiliated Organization shall be an *ex-officio* member of the Executive Committee." A situation has arisen in which the newly-elected President of IAMAS wishes to delegate this responsibility to a representative with strong oceanographic interests. The participants agreed that this requires a modification of the SCOR Constitution, paragraph 8(c) to permit the President of an Affiliated Organization "or his or her delegate" to become an *ex-officio* member of the SCOR Executive Committee. This revision should be drafted for circulation prior to the General Meeting in 2000.

A second constitutional issue was identified. The amendments to the Constitution that went into effect in 1996 resulted in the terms of the Secretary and President expiring at the same time. This situation will recur every four years unless some change is adopted. One suggestion was that the next Secretary should be elected for two years only. This should be resolved by the SCOR Officers and, should a change in the Constitution be needed, national committees will be informed accordingly.

### **5.0 RELATIONS WITH INTERGOVERNMENTAL ORGANIZATIONS**

#### **5.1 Intergovernmental Oceanographic Commission**

The representative of the IOC, Maarten Kuijper, stated that after two decades of progress in studying major physical and biogeochemical processes in the ocean, ocean science is undergoing a major conceptual evolution and it is now feasible to undertake important interdisciplinary studies that were previously intractable. In this regard, the IOC: (i) has a key role in initiating, promoting and coordinating global ocean science; and (ii) has the responsibility to ensure that these scientific efforts are supplied with a necessary intergovernmental dimension so that emerging research issues, developments and scientific results are properly assessed and transmitted to Member States. As such, the IOC and SCOR complement each other in their respective efforts to promote marine science and its interdisciplinary nature. In this context, the IOC organized for a comprehensive review of the entire IOC

science program called for by the Twentieth General Assembly (June 1999). The President of SCOR is participating in this review process.

In January 1999 IOC organized an Expert Consultation for the Coastal Ocean Advanced Science and Technology Studies (COASTS) Programme, which was chaired by Alan Robinson. The fundamental goal of the COASTS program is to develop the scientific and technical basis necessary for the management and health of the coastal seas. The purpose of the meeting was to initiate the ground work for an overview and synthesis of interdisciplinary global coastal ocean science. As a result, it was decided to organize the second comprehensive COASTS Global Workshop. The First COASTS Global Workshop (CGW-1) focused on physical processes and circulation and was co-sponsored by SCOR, the European Commission and IOC. Now, a second Workshop (CGW-2) is foreseen that should be fully interdisciplinary and deal with interactive and coupled physical-biological-chemical geological scientific processes on a global basis. A goal of the proposed workshop is to provide the scientific basis and technical development requirements for coastal management models, subsequently to be published as Volumes of "The Sea" on Coastal Oceans. Kuijper invited SCOR to cosponsor this initiative, name a representative to the COASTS workshop steering committee, and participate in the implementation of the COASTS program. The second COASTS Workshop is scheduled to take place in the second part of June 2000, in Paris and will be attended by approximately 75 international participants.

In recent years, there have been many new developments in the Global Ocean Observing System (GOOS). Two landmark documents, *The Strategic Plan and Principles for GOOS* and the *GOOS 1998 Prospectus*, were published in 1998 and are playing important role in guiding the planning and implementation as well as fund raising for various GOOS activities. These documents are available from the GOOS Support Office in the IOC Secretariat. Another development related to GOOS is the establishment of the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM). A new regional IOC office has been established in Perth, Western Australia. Established with support from the government of Western Australia, this office will focus on GOOS-related matters in the Indian Ocean basin.

One new area of cooperation between IOC and SCOR was initiated at the IOC General Assembly in June 1999. That meeting adopted a resolution calling for the establishment of a Project on Measurement and Management of Submarine Groundwater Discharge in the Coastal Zone. This initiative is closely linked to the work of SCOR WG 112. IOC was planning to have a consultation meeting in January 2000, together with SCOR, LOICZ and IHP/UNESCO.

Following a review of the Training, Education and Mutual Assistance Programme (TEMA), IOC has changed the structure of capacity building the IOC. TEMA is no longer considered as a separate program but rather as an essential component of all three IOC sections, those being, science, ocean services and observing systems.

Kuijper noted that IOC is willing to follow up on the SCOR Bellagio Workshop initiative that aims to establish graduate education in oceanography and environmental marine sciences in developing countries (see item 3.2.3). The need for this was discussed in both the IOC/WESTPAC Sub-Commission and the General Assembly.

In relation to SCOR's large-scale scientific program, the IOC wishes to report that the joint IOC-JGOFS Ocean CO<sub>2</sub> Advisory Panel had successfully completed its task to oversee the assembling of the most accurate and consistent global data set of CO<sub>2</sub> ever attempted via a global ocean CO<sub>2</sub> survey, in co-operation with WOCE. In view of the needs of the GOOS program, and others, for scientific support and advice in this area, and of the impending end of the JGOFS program, IOC and SCOR have agreed that this Panel should be reconstituted as the Joint IOC/SCOR Ocean CO<sub>2</sub> Panel. The new terms of reference (TOR), which were reviewed by JGOFS, were approved as follows:

### General Terms of Reference:

1. To advise SCOR/JGOFS, GOOS and OOPC on CO<sub>2</sub> observations, data management and modeling needed for studies of the global ocean carbon cycle.
2. To provide an international forum for initiatives to promote good quality observations of CO<sub>2</sub> in the oceans.

### Specific Terms of Reference:

1. To identify gaps and weak links in the present CO<sub>2</sub> observation system needed for understanding and predicting global change.
2. To identify opportunities that can be used to further develop the observing system (e.g. piggy-backing on the climate observing system).
3. To aid the synthesis of JGOFS and IGBP results with respect to marine CO<sub>2</sub> observations, data management and modeling:
  - 3.1 by initiating and facilitating the assembly of CO<sub>2</sub> data bases,
  - 3.2 by interacting with ocean modelers with respect to the weaknesses and appropriate uses of CO<sub>2</sub> data,
  - 3.3 by encouraging and facilitating the collaborative analysis of CO<sub>2</sub> datasets and supporting data.
4. To maintain a watching brief to advise IOC and SCOR on CO<sub>2</sub> sequestration into the ocean.
5. To advise GOOS and OOPC on appropriate technology development for CO<sub>2</sub> monitoring.
6. To advise GOOS and OOPC on the observational strategies needed to assess, model and predict global ocean CO<sub>2</sub> fluxes.

The chairmanship and membership of the Panel will be agreed in discussions between the IOC and SCOR, taking into account suggestions received from JGOFS and elsewhere.

The IOC representative reiterated the Commission's continuing commitment as a cosponsor of the GEOHAB program and noted that the French IOC delegation has made an offer to host and provide partial funding for an international project office for GEOHAB in Brest.

Finally, a major workshop was held in Potsdam, Germany from 2-7 October within the framework of the Joint IOC/SCOR/SCOPE Assessment of the State of Marine Science and its Contribution to Sustainable Development. The meeting was attended by some 60 people and produced a wealth of information. It is now planned to publish the results in a book with SCOR and SCOPE which will be edited by John Field and Gotthilf Hempel.

## **5.2 World Meteorological Organization**

The Executive Director drew attention to the written report from WMO which reviews two activities of special interest to SCOR: the Data Buoy Cooperation Panel and the Ship of Opportunity Program (see Annex 13). It also noted the formation of the Joint IOC/WMO Commission for Oceanography and Marine Meteorology (JCOMM) referred to by the IOC representative. JCOMM will provide a more coordinated approach to operational ocean monitoring and ocean services by its sponsors, doing away with two former groups and linking more closely the marine programs of WMO with those of IOC.

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

The 1999 meeting of ICES was the first since its restructuring over the last two years. A group of Science Committees has been established covering a range of topics falling under the ICES mandate (see Annex 14 for details). The organization is responding to the growing demand for management advice based on whole ecosystems rather than the traditional single species stock assessment approach by conducting a review of its advisory structures and procedures. ICES will celebrate its centenary in 2000-2001 and the SCOR Executive Committee agreed that SCOR should cosponsor the ICES Science Conference in 2000. The ICES report also provided information on a range of ICES symposia being planned and on the involvement of the Council in GLOBEC

through its Cod and Climate Change program, and the Trans-Atlantic Study of Calanus (TASC). An ICES office for GLOBEC-related activities provides strong liaison with the international GLOBEC program.

## **6.0 RELATIONS WITH NON-GOVERNMENTAL ORGANIZATIONS**

### **6.1 International Council for Science (ICSU)**

The Executive Director noted that SCOR was not represented at the ICSU General Assembly in Cairo in September 1999 since few, if any, of the agenda items had direct impacts or relevance for SCOR. Concern was voiced about the reduction of ICSU support to SCOR (and many other ICSU bodies) through its grant program and the continuing weakening of the position of interdisciplinary bodies within the ICSU structure. For example, some resolutions of the General Assembly ignore bodies like SCOR, SCOPE and SCAR in a listing of ICSU's global environmental change activities or of ICSU's educational activities.

ICSU put a great deal of effort into the World Science Conference which it cosponsored with UNESCO. The Conference statements, were adopted by the ICSU General Assembly, but with some reservations about parts of the documents adopted by the Conference, notably paragraph 26 of the *Declaration on Science* and section 3.4 *Modern science and other systems of knowledge* of the *Framework for Action*. Of particular concern was the phrase "traditional and local knowledge systems". The importance of empirical knowledge built up over generations and grounded in practical evidence is acknowledged but such knowledge must be distinguished from approaches that seek to promote anti-science and pseudo-science, and which degrade the values of science as understood by the ICSU community. ICSU reaffirmed its support for the values and methods of verifiable science. These documents have been circulated to all ICSU members.

A new Executive Director of ICSU will be appointed in January 2000.

### **6.2 ICSU Unions and Committees**

#### **6.2.1 International Geosphere-Biosphere Program (IGBP)**

The Deputy Director of IGBP, Neil Swanberg, gave a presentation of the state of plans for a re-organization of the program as the synthesis of some of its more mature components, such as JGOFS, continues. There are likely to be three major scientific themes or "cross-cutting activities": Carbon, Food and Fibre, and Water. Existing IGBP projects will address these issues in the context of the oceanic, atmospheric and terrestrial regimes, while newer activities, such as SOLAS, span these boundaries. This structure would reflect the flows within the three major components of the biosphere as well as permitting studies of the interactions between them. In general, the components of IGBP will be much more tightly linked and the scientific results will be more easily integrated.

Many other IGBP-related issues had been covered in the discussions of the JGOFS, GLOBEC, SOLAS and Future Ocean Biogeochemistry activities, all of which are cosponsored by IGBP.

#### **6.2.2 World Climate Research Program**

The report from the WCRP is given in Annex 15. Several WCRP programs are very closely related to SCOR interests, for example, the World Ocean Circulation Experiment which is now well into its Analysis, Interpretation and Modeling (AIMS) phase. A final WOCE Conference is being planned for 2003. A more recent WCRP activity in the CLIVAR program which is described in the report. Close ties will be required between CLIVAR and SOLAS.

### 6.2.3 *Scientific Committee on Antarctic Research*

The report from SCAR provided an update of the information submitted to the SCOR General Meeting in 1998 (see Annex 15, *SCOR Proceedings*, vol. 34). SCAR sets its scientific priorities and establishes some focused multinational programs through discipline-based working groups and through shorter-lived specialist groups. At present, there is no working group on oceanography. Oceanographic research is supported largely through the Group of Specialists on Global Change and the Antarctic (GLOCHANT), together with programs under the Working Groups on Biology and Glaciology. The report reiterated SCAR's wish to build on the developing collaboration with SCOR in Southern Ocean studies.

SCAR is a cosponsor of the Southern Ocean regional studies in GLOBEC and JGOFS and these two activities continue to play an active role in SCAR's global change group, GLOCHANT. SCAR has agreed to offer financial support to the symposium organized as part of SO-JGOFS in 2000, to be held in Brest, France.

GLOCHANT acts as a forum for interaction between programs. The group is actively stimulating collaborative activities in order to address cross-disciplinary problems such as the links between the paleoenvironmental record and contemporary processes, and the links between physical forcing and biological response. Interaction is through shared expeditions and research cruises, and collaborative workshops and symposia. Three such workshops with oceanographic foci were described to the 1998 SCOR meeting, and the first of these has now taken place. This was the Workshop on Interannual Variability in the Southern Ocean (Cambridge, UK, August 1999), which addressed the pattern of interannual variability from both physical and biological perspectives. SCOR was a cosponsor of the workshop which included over 60 participants from 12 countries. Scientists' interests spanned a broad spectrum from meteorology and physical oceanography to sea-ice ecology and fisheries. The workshop was organized around three main themes - the character of interannual variability, the nature of teleconnections and underlying mechanisms, and the impacts of variability. A number of syntheses were accomplished, based on input from a wide range of participants. The workshop identified teleconnections to ENSO, with the identification of a potential mechanism for the linkage between atmospheric circulation over the southern Pacific Ocean and over the Southern Ocean. There is also good evidence for an intrinsic mechanism for Southern Ocean variability, and the patterns observed suggest an interplay between the two mechanisms. Ecological data indicate that the variability in the physical environment has profound effects on the pelagic ecosystem, especially the composition of the zooplankton community. The impacts of these changes were explored, and their possible use as an indication of the effects of long-term secular environmental change. The output from the workshop will consist of a series of papers to be submitted to a suitable peer-reviewed journal.

A planned SCAR workshop on Coupling Biology and Physics in Sea-ice Systems (ASPeCt and GLOBEC) will build on the achievements of SCOR WG 86 on Sea Ice Ecology. The ASPeCt program is building up a strong set of observations of the physical environment, whereas SO-GLOBEC has strong interests in the sea-ice ecosystem within the context of Southern Ocean ecosystem dynamics. There is considerable scope for shared cruises, as well as for undertaking innovative theoretical ecological research.

Finally, a third meeting on the Overwintering Strategies of Antarctic Marine Organisms (EASIZ and GLOBEC) will consider the ability of organisms to survive the winter period in the Southern Ocean. This is a key element for understanding the functioning and response of the ecosystem. EASIZ is a SCAR marine biological programme which capitalises on the large body of data generated from near-coastal marine biological research to undertake comprehensive ecological and physiological studies.

#### **6.2.4 *International Union of Theoretical and Applied Mechanics***

A brief written report from the Secretary General of IUTAM requested information on SCOR activities of relevance to this field. The Executive Director will seek the assistance of the IUTAM representative, Stephen Thorpe (UK), in identifying these.

#### **6.2.5 *International Union of Pure and Applied Chemistry***

A report from the IUPAC representative to SCOR, David Turner (Sweden), noted that the major focus of IUPAC's collaboration with SCOR is currently the joint Working Group on "The Biogeochemistry of Iron in Seawater" (WG 109) which had been discussed earlier (see item 2.2.6).

Two further areas of potential SCOR-IUPAC collaboration were identified: the WG proposal on the Solubility of Sea Salts which was discussed under item 2.3.4, and the new topic of Estuarine Particles. At the 1998 SCOR General Meeting in Amsterdam, IUPAC was asked to consider whether this would be a suitable topic for a future joint Working Group. This suggestion was received very positively at IUPAC's General Assembly in Berlin in August 1999. The next stage is to develop a project proposal that can be submitted to both SCOR and IUPAC. To this end, SCOR was asked to identify one or more individuals to develop this proposal in cooperation with David Turner.

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

The Executive Director pointed out that several SCOPE projects have marine components, such as those with a focus on:

- soils and sediments - biodiversity and ecosystem functioning; this activity has a marine sediments component
- land-ocean nutrient fluxes with special attention to silica cycle; the coastal zone component of this project is carried out in collaboration with LOICZ
- development of a project on the implications of aquaculture and mariculture on biodiversity and ecosystem processes

In addition to these activities, SCOPE is a cosponsor, with SCOR, of the IOC Ocean Assessment referred to under item 5.1. SCOPE also represents ICSU in the Global International Waters Assessment being carried out by the Global Environmental Facility and UNEP.

### **6.3 *Affiliated Organizations***

#### **6.3.1 *International Association for Biological Oceanography***

The report from IABO contained an expression of interest in cosponsoring the new WG on Standards for the Survey and Analysis of Plankton (which was established - see item 2.3.1) and in suggesting one or two members. This interest will be communicated to the Chair of the new WG.

For some years the scientific priority of IABO has been Marine Biodiversity. Following their adoption of the Biodiversity Convention, many countries have produced National Action Plans, but marine elements have tended to receive proportionately little attention. The President and Secretary have worked to help redress the balance by taking part in scientific meetings on the subject, particularly in support of the International DIVERSITAS Programme, and publishing statements on the need for greater attention to marine aspects. In the course of the year they published the report of the Workshop on Marine Biodiversity held at the Fourth International Marine Biotechnology Conference in Italy in 1997.

Preparations are being made for a major event in 2001, in conjunction with the International Association for

Physical Sciences of the Oceans (IAPSO). This Joint Assembly will be held at Mar del Plata (Argentina) in the week of 21-28 October 2001. The meeting will focus on a range of contrasting marine environments in order to illustrate and define the multi-disciplinary responses to environmental challenges that are already with us or may arise in the new millennium. It is provisionally entitled: "2001 Ocean Odyssey". For further information, see the web page: [http://www.criba.edu.ar/2001\\_ocean](http://www.criba.edu.ar/2001_ocean).

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

IAMAS has continued to devote a significant amount of time to the development of "ACT", the WMO-IUGG "Alliance for Capacity Transfer" in meteorology and the atmosphere-related sciences, including hydrology and oceanography. IAMAS, with the sponsorship of IUGG and SCOR, developed a proposal to ICSU for the support of ACT which was funded to the extent of \$30,000. A committee being formed from IAMAS including individuals from developing countries will meet in late 1999 or early 2000, likely in Trieste, Italy. At this meeting it is planned to develop several pilot programs for ACT with developing countries and regions.

IAMAS has been following with interest the development of the Surface Ocean-Lower Atmosphere Study (SOLAS), whose planning has been sponsored by SCOR and IGBP. The President of IAMAS, Robert Duce, has been co-chair of the Planning Committee for SOLAS. The IAMAS Commission on Atmospheric Chemistry and Global Pollution (CACGP) is considering being a co-sponsor of SOLAS (it is a co-sponsor of the International Global Atmospheric Chemistry (IGAC) activity with IGBP).

The representative of IAMAS, Robert Duce, reported that the IUGG General Assembly, which was held in Birmingham, England from 18-30 July 1999, was a very successful meeting. IAMAS was involved in 5 of the 7 Union Sessions, participated in 27 Inter-Association Symposia (lead in 10), and it had 12 Inter-Commission Symposia, 11 Commission Symposia, and 8 Workshops. IAMAS elections were held in Birmingham: the new President of IAMAS, and thus the new *ex officio* member of the SCOR Executive Committee, is Professor Huw Davies (Switzerland). The next IAMAS General Assembly will be held in Innsbruck, Austria in July, 2001.

### **6.3.3 International Association for the Physical Sciences of the Ocean (IAPSO)**

IAPSO also was an active organizational participant in the IUGG Assembly (see previous item). Elections were held on this occasion and Vere Shannon (South Africa) was succeeded as President of IAPSO by Professor Paola Rizzoli (USA). She was unable to participate in the SCOR Executive Committee meeting, but submitted many comments regarding Working Group proposals.

## **6.4 Corresponding Organizations**

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

A report of the most recent AOSB meeting was distributed to all participants. Particular note was taken of the Arctic Science Summit Week being organized in Cambridge, UK in April 2000 which would also be the occasion of the next meeting of the Board. AOSB reports and Newsletters are distributed to scientists with Arctic research interests suggested by the SCOR Secretariat.

The new Chair of AOSB is Leif Anderson (Sweden). Detailed information on the activities of the Board, including the International Arctic Polynya Program, The Greenland Arctic Ocean Shelf Project, Arctic Paleo-River Discharge, Freshwater Balance in the Arctic, Variability of Exchanges in Northern Seas, and others are available at its website: <http://www.aosb.org>. AOSB has agreed that the theme of "Arctic variability and global change: Arctic Ocean linkages" should be a focus of its future efforts and a discussion paper is being prepared.

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

The report of the Working Group on Wave Energy Conversion (which arose from a proposal forwarded to ECOR by SCOR several years ago) is soon to be completed. Details are available from the Chair, John Brooke, at brookej@glinx.com The ECOR journal *Oceanic Engineering International* is now into its third year and volume.

#### **6.4.3 Confederation Mondiale des Activités Subaquatiques (Scientific Committee)**

No report was available from this organization.

### **6.5 Other Organizations**

#### **6.5.1 The Oceanography Society (TOS)**

The Past-President of the Society, Robert Duce, noted that TOS was in a period of review and restructuring at the time of the SCOR meeting. No TOS Scientific Meeting was planned for the year 2000, however, plans are being made for a meeting the following year.

#### **6.5.2 POGO - the Partnership for Observation of the Global Oceans**

Robert Knox (USA) presented information on this new partnership between major oceanographic institutions. Not yet formally established at the time of the SCOR meeting, POGO was proposed as a forum for directors of oceanographic institutions to work together to promote global oceanography, particularly the implementation of an international and integrated global ocean observing system. Senior representatives from 17 institutions in 12 countries and 7 international organizations participated in a preliminary meeting in March 1999 at UNESCO/IOC, but the first formal meeting was scheduled to take place at the Scripps Institution of Oceanography in December 1999. The Executive Director of SCOR will participate.

POGO is a partnership of institutions performing oceanographic observations, operating ships, building sensors, collecting and processing data, conducting scientific research, and in some cases providing operational services to the ocean and Earth science communities. Many of these institutions are also involved in teaching and training. As the scale of these activities has become increasingly global, there is an increasing value in coordinating our programs at the detailed implementation level. Through joint planning and exchange of information, the community makes better use of the limited resources available from governments and other sources for ocean observations. POGO will help focus attention on implementation issues such as technical compatibility among observing networks; shared use of support infrastructure, such as ships visiting automated platforms or telecommunications systems to relay data from remote locations; and in public outreach and education.

The premise of POGO is that many programs and initiatives are addressing different aspects of an integrated global observing strategy. While national governments set policy and provide funding, it is the universities, government laboratories and private research institutes that make the observations and conduct the research required for the successful implementation of a Global Ocean Observing System (GOOS). Other partners in GOOS include the non-governmental scientific organizations, like SCOR, which define research programs and observational requirements, and intergovernmental bodies, like IOC, which coordinate observing programs and establish international agreements through their formal intergovernmental structures. Within the IOC, the GOOS Support Office oversees planning and coordination for GOOS.

More information on POGO, including the terms of reference adopted at the December 1999 meeting, may be found at [www.sioworld.ucsd.edu/pogo.html](http://www.sioworld.ucsd.edu/pogo.html).

## 7.0 FUTURE MEETINGS

### 7.1 Future meetings of SCOR

In accordance with the discussion at the General Meeting in 1998, the SCOR Officers decided to accept the invitation of the US Ocean Studies Board of the National Academy of Sciences (which serves as the US National Committee for SCOR) to host the 25<sup>th</sup> General Meeting of SCOR. It will take place at the National Academy of Sciences in Washington, DC during the week of October 9, 2000. The US National Committee has begun to organize an interdisciplinary scientific symposium on the topic of coastal eutrophication to be held in association with the General Meeting. The Executive Committee requested the Secretary, Bjorn Sundby, to act as a liaison with the OSB in the organization of these events.

The Executive Committee agreed that the 35<sup>th</sup> Executive Committee meeting in 2001 should take place in Mar del Plata, Argentina in conjunction with the joint IABO/IAPSO "2001 Ocean Odyssey" during the week of October 21-28 2001. The SCOR liaison for this meeting will be Cintia Piccolo.

The President issued a call for National Committees to consider hosting the 26<sup>th</sup> General Meeting in 2002

### 7.2 Other meetings of interest to SCOR

The Executive Director presented a list of international meetings of interest to SCOR during the next years. The participants considered requests for SCOR cosponsorship and/or support of these events. In general, SCOR support for an international meeting means that some funds will be available to facilitate the participation of scientists from developing countries, and former communist states.

#### 2000

February 7-11	9 <sup>th</sup> International Conference on Harmful Algal Blooms This conference will be cosponsored by SCOR.	Hobart, Australia
March 23-26	Beyond El Nifio: A Conference on Pacific Climate Variability and Marine Ecosystem Impacts from the Tropics to the Arctic SCOR sponsorship of this event, approved in 1998, contingent upon the availability of funds, was confirmed.	La Jolla, USA
April 24-28	6 <sup>th</sup> International Coastal Symposium: Challenges for the 21st Century in Coastal Science, Engineering and Environment SCOR sponsorship was approved in 1998.	Rotorua, New Zealand
May 9-12	Liège Colloquium on Exchange Processes at the Ocean Margins. SCOR sponsorship was approved.	Liège, Belgium
May 20-25	6 <sup>th</sup> Indo-Pacific Fish Conference SCOR sponsorship was approved.	Durban, South Africa
May 25-27	Oceanography, Meteorology and Marine Resources in the Context of Global Environmental Change and Ecosystem Sustainability. SCOR sponsorship was approved.	Vigo, Spain
June 5-8	4 <sup>th</sup> International Symposium on Gas Transfer at Water Surfaces. SCOR sponsorship was approved.	Miami, USA

July 16-23	COSPAR Scientific Assembly - several symposia are relevant to SCOR's interests. SCOR sponsorship was approved.	Warsaw, Poland
July	6 <sup>th</sup> International Conference on Model Estuaries SCOR sponsorship was approved.	Ispra, Italy
August 1-3	100 Years of Science under ICES SCOR sponsorship, approved in principle by the 1998 General Meeting pending financial review in 1999, was confirmed. No funds were allocated for organizational purposes, however.	Helsinki, Finland
October 2000	First Latin American School in Ocean and Climate Modelling SCOR sponsorship was approved providing that this course is linked in some way to the regional graduate program in oceanography at the University of Concepción.	Concepción, Chile
December 5-8	PORSEC 2000 (Pacific Ocean Remote Sensing Conference) SCOR sponsorship was approved.	Goa, India

## 8.0 OTHER BUSINESS

The representative of the Dutch National Committee for SCOR, Gerald Ganssen, informed the Executive Committee that his national committee would be submitting a proposal for a working group on the *Phaeocystis* species cluster as a model for study of the role of marine phytoplankton in global climate regulation in time for the General Meeting in 2000.

The President reminded participants to submit nominations for any of the new working groups to the Executive Director before the end of November 1999. He also called for suggestions of possible candidates for the position of SCOR Executive Director,

In closing the 34<sup>th</sup> Executive Committee meeting of SCOR, the President extended his thanks to all participants for their commitment to SCOR. Field especially thanked the host Indian National Committee for SCOR, the Indian National Sciences Academy and the local organizers at the National Institute of Oceanography for their hospitality to all of the visitors to Goa.

## ANNEX 1 - List of Participants

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## ANNEX 2 - Program of Scientific Lectures

**34<sup>th</sup> Executive Committee Meeting  
of the Scientific Committee on Oceanic Research (SCOR)  
International Centre and National Institute of Oceanography, Goa  
NIO = NIO Seminar Room      IC = International Center**

<b>Date, Time</b>	<b>Title and Speaker</b>	<b>Venue</b>
<b>Mon Oct 25</b> 0940 - 0950	<i>Brief on SCOR Structure and Activities</i> Elizabeth Gross, Executive Director, SCOR	NIO
<b>Mon Oct 25</b> 0950 - 1030	<i>Role of the Oceans and Global Climate Change</i> Prof. John Field, University of Cape Town, President of SCOR	NIO
1100-1200	<i>The System of Seasonal Coastal Currents around India</i> S.R. Shetye, NIO	NIO
<b>Tues Oct 26</b> 1515-1615	<i>The History of Goa</i> Charles J. Borges, Xavier Centre of Historical Research	IC
1615-1645	<i>Unstable Air-sea Interactions and Discovery of an East-west Dipole Mode in the Indian Ocean</i> B.N. Goswami, Institute of Science, Bangalore	IC
1645-1715	<i>Atmospheric Nitrogen and Oceanic Productivity : Is there a Connection?</i> Robert Duce, Texas A&M University, USA	IC
<b>Wed Oct 27</b> 1400-1430	<i>Presentation on NIO's Activities</i> E. Desa, Director, NIO	NIO
1430-1500	<i>Land Ocean Atmospheric Interactions of Carbon-dioxide with Implications to Climate</i> Dileep Kumar, NIO	
1515 - 1545	<i>Sub-Milankovich Climatic Cycles</i> R. Ramesh, PRL, Ahmedabad	NIO
1545 - 1615	<i>What Controls Production during Upwelling in the Arabian Sea?</i> Peter Burkill, Plymouth Marine Laboratory, UK	NIO
<b>Thurs Oct 28</b> 1330-1400	<i>Changes in Deep Ocean Flow Dynamics on Millennial to Milankovitch Time Scales</i> I.N. McCave, Cambridge University, UK	IC
1400-1430	<i>The InterRidge Program: International, Interdisciplinary Ocean Ridge Studies</i> Cara Wilson, University of Paris, France	IC

### ANNEX 3 - SCOR WG 111 Concept Paper

## ON THE COUPLING OF THE COASTAL OCEAN, COASTAL ATMOSPHERE, AND WIND WAVES & SWELL

**INTRODUCTION.** This concept paper is a mid-term report from SCOR WG 111 which serves to define more fully the nature and scope of its assigned topic, and the current status of knowledge about this topic. It also serves as the basis for designing a workshop to prepare the final SCOR WG 111 product.

**COASTAL OCEAN CIRCULATION.** Coastal ocean circulation studies are advancing rapidly due to increased scientific understanding; improved numerical models; expanded use of numerical models; increased horizontal and temporal model resolution (10 to 1 km and 1 to 0.1 hour or finer) and vertical resolution (15 to 30 or more depths); increased long time series of observations at fixed points; deployment of more numerous Lagrangian drifters; new observing technologies (e.g., coastal HF radars, undulating towed sensor packages, high resolution profilers for velocity, temperature, salinity, and turbulence variables); better integration of modeling and observing system activities; and improved atmospheric forcing information due to improvements in NWP, increased deployment of meteorological buoys and coastal meteorological stations, and nested-grid, mesoscale atmospheric models operated in both the research and real-time forecast modes. The key trends include focus on realistic regional simulations and hindcasts; more effort in model-data comparisons (validation, verification, evaluation, and/or skill assessment); performance of diagnostic and prognostic studies; initiation of coastal ocean data assimilation; utilization of inverse methods; more real-time data acquisition and nowcasts; advances toward operational coastal ocean prediction; the addition of various ecosystem and sediment transport submodels; exploration of coastal-ocean-and-coastal-atmosphere coupling; and simulation of Lagrangian trajectories (both pathways and rates). Several numerical ocean circulation models have been developed over the past two decades that can address the coastal ocean with its highly variable bottom topography. (A similar statement can be made about numerical atmospheric circulation models and their ability to address the coastal atmosphere including steep coastal orography.) With time, they have become more comprehensive, and there is a tendency for them to coalesce in design. Yet, there is some diversity, for example:

- finite differences versus finite elements
- the order of the differencing schemes
- z-level versus sigma-level versus layered/isopycnal coordinates
- Cartesian versus curvilinear coordinates
- variety of vertical and horizontal turbulence closure schemes
- hydrostatic versus non-hydrostatic dynamics
- variable resolution versus nested grids
- explicit versus implicit treatment of tidal phenomena and their effects
- free surface versus rigid lid

There have been few model-model comparisons for the coastal ocean, and not enough model-observed data comparisons under controlled conditions.

**ATMOSPHERIC FORCING.** However, it is still not known how accurate the atmospheric forcing must be estimated to achieve a specified level of accuracy in circulation estimation. (For that matter, it is still not known how accurate the circulation estimation must be to be useful in particular applications.) Here accurate pertains not only to the amplitude and variance of air-sea transfers but also the spatial and temporal scales delineating the space-time structure of weather systems, etc. At this stage, benefits have been recognized for hourly and ca. 10 km resolution winds, but there has been little systematic effort to quantify these points. Due to nonlinearities, even less is known about amplitude accuracy requirements. In general, little attention is paid to drag law sensitivity and, in particular, fetch-limited drag laws and explicit wave field information are not generally incorporated. Wind stress

estimates are needed over the full range of wind speeds, especially for storm conditions associated with tropical and extratropical cyclones crossing and paralleling coastlines. Far less is known about the heat and moisture flux accuracy requirements.

**COASTAL OCEAN RESPONSE.** Storm surge is a major response with societal impact; however, other factors are important too, e.g., storm waves, beach erosion by storm currents, mixed-layer deepening and cooling, coastally-trapped (topographic) waves, and coastal upwelling/downwelling.

**COASTAL ATMOSPHERIC PROCESSES.** Coastal atmospheric processes are receiving increased attention due to concerns for improved coastal weather prediction. For example, the topographic trapping of atmospheric low-level jets along mountainous coasts has been studied in recent years, the sudden intensification of land-falling tropical cyclones is now receiving priority attention, and there are continuing investigations of coastal fog generation and dissipation. Issues of coastal atmosphere-ocean coupling are subjects of renewed interest. In addition to the customary concern with the influence of large scale SST on air-sea transfers of heat and moisture, the influence of oceanic mesoscale variability of SST and surface roughness are now under analysis. Generally, coastal atmospheric regimes will have a regional and seasonal dependence, depending upon whether the region is an east or west coast, and whether it is in the tropics or subtropics, for example. During the winter and spring seasons, extratropical cyclones are a dominant influence in air-sea interaction at mid-latitudes, and are landfalling on west coasts and land-leaving or paralleling on east coasts. The diurnal seabreeze/landbreeze system is a classic example of coastal atmosphere-ocean coupling from the coastline to the order of 50 km offshore and a similar distance onshore. Fundamentally, this system exists due to the differential heat capacity of the continents and the oceans and the convective effects of diurnal heating and nocturnal cooling over land. The coastal seabreeze/landbreeze system is modulated by large-scale processes; e.g., wind-driven coastal upwelling of cool water to the sea surface (which enhances the land-sea temperature contrast) and the Trade Winds and Westerlies or mesoscale weather systems (which can disrupt the sea/land breeze system by strong atmospheric advection). Some modeling research groups are already investigating two-way (strong) coupling with coastal atmospheric and oceanic models exchanging information at frequent time steps.

**AIR-SEA COUPLING.** Other modeling groups are investigating bi-directional (strong) and one-way (weak) coupling because the nature, extent, and intensity of the coupling are poorly understood. The use of mesoscale atmospheric numerical models (e.g., ETA, MM5, COAMPS, ARPS, and RAMS) for the coastal atmosphere (in both the research and operational modes) has increased recently, enabling the use of their output surface fields for driving coastal ocean models. For these purposes, it is especially important to understand and characterize the oceanic and atmospheric surface boundary layers, including the oceanic mixed layer heat content and the momentum transfer from the free atmosphere through the atmospheric surface boundary layer to the sea surface. An example of positive feedback is the fog generated by the advection of warm marine air over cool coastal-upwelled waters and the consequent reduction in radiative heating of the sea surface.

**SURFACE WAVES and TURBULENCE.** Of special interest in coastal ocean circulation modeling is the influence of surface waves and the dynamical role played by turbulence. The traditional approach to modeling coastal ocean dynamical phenomena is simple and straightforward: the wind generates the waves and the wind also generates the currents. The two are treated as totally separate and unrelated. This approach is accepted for its convenience only, and might even be correct to the first order of approximation, but it certainly does not reflect the physics, for the dynamics of the coastal system is coupled. The wind generates both the waves and the currents but on different time scales. As soon as the wind starts, short waves and surface currents are generated. The waves grow and mature on the order of a few hours, while the currents deepen and mature in a few inertial periods. The dynamics of these two types of motions are also very different: The waves consist of circular orbital motions in the vertical plane that are high in energy density, but retain little momentum; the currents consist of linear motions mainly in the horizontal plane that are high in momentum but low in energy. Therefore, the fluxes of energy and

momentum across the air-sea interface are divided differently. As the waves and currents evolve, the partition of energy and momentum also changes accordingly in a complicated and yet still unknown way. But this much is clear: In the surface layer, most of the energy is retained in wave motions and most of the momentum is retained in currents. Even though the waves retain very little momentum, they are of critical importance in determining the momentum flux across the interface. The role of waves in the coupled dynamics can be summarized as follows:

The surface layer of the ocean, through which the transfer of many critical quantities occurs (momentum, energy, turbulent kinetic energy, heat, light, & gas), is mobile and turbulent, affected by processes (largely unique to the layer) such as wave-breaking, Stokes drift, and Langmuir circulation. The surface layer provides the surface boundary conditions, in some ill-defined average sense, for circulation and biogeochemical models. Though it provides the forcing for most ocean dynamics, the layer is not well understood. For example, recent results suggest that the sea surface roughness length is three to four orders of magnitude larger for the ocean than the atmosphere.

There are two ways the surface waves can influence the coastal the coastal ocean circulation: the direct and the indirect. First, the direct ways must be discussed. In ocean modeling, the complex process of momentum transfer from the atmosphere into the water is simplified to the specification of an engineering-style drag coefficient. The stress,  $T$ , acting on the water surface is most commonly specified as

$$T = C_d * \rho_a * U * U,$$

where  $\rho_a$  is the air density,  $U$  the wind velocity at some reference height (usually 10 m), and  $C_d$  an empirical drag coefficient, usually stated as a function of wind speed, and sometimes (but rarely in coastal ocean modeling) marine boundary layer (MBL) stability and even wave height, wave age, etc. But no attention is paid to the direction of the waves. Unfortunately, this approach is oversimplified. Stress is a tensor; therefore, it needs to be defined and determined as such. When the stress is simplified to a vector parallel to the wind, essentially only one component of the whole quantity is represented. In spite of, or, perhaps, because of this simplification, the value of this drag coefficient has been an elusive goal ever since the concept was borrowed from engineering applications. Some fine-tuning has been performed by ocean scientists. For example, the dependence of the drag coefficient as a function of the instability condition of the MBL is accepted. Yet the dependence of the drag upon the roughness elements is still controversial. Most of the existing formulae treat the wave effects implicitly by assuming that the sea state is in equilibrium with the local wind. Due to the dominant influence of swell, this assumption is not fully acceptable for open ocean regions, but it is certainly unacceptable for coastal regions, where the sea state is seldom in equilibrium with the local wind. The reasons are simple; for example, the coastal regions always have swell coming from other regions. Even if there was no swell, the frequently occurring limited-fetch conditions in coastal regions would not allow the waves to develop to an equilibrium stage. This condition is further complicated by the existence of strong coastal currents, where wave-current interaction will change the characteristics of the waves. As a result, the coastal sea states are seldom uniform; therefore, even with a uniform wind, a non-uniform stress field should be expected.

Also, surface waves alter the roughness of the sea surface and, hence, the winds.

Next, the indirect ways the waves can influence the current will be listed. As the most energetic motion at the ocean surface, wave breaking perhaps is the most effective way to generate turbulence in the upper layer. This turbulent energy is the main agent to cause mixing of the surface layer; thus, it affects the SST field, which in turn affects the wind field and that will certainly influence the wind-induced currents.

Still other indirect ways exist for the waves to influence the current field. First, the waves can induce current through wave-induced mass transport. Though this transport is only of second order, its magnitude is comparable to the surface drift current when the waves are actively breaking in a young sea. Most importantly, this wave-induced mass transport is the key to generating the Langmuir circulation, a dominant form of surface drift current. Secondly, the non-uniform wave field has a gradient of radiation stress, which forces a weak current, too. An

important example is the alongshore current near the breaker zone. Finally, breaking waves and wave-current interactions can form Reynolds stresses, which will further influence the current field.

The actions of these processes are not in one direction only; for once the current is formed, the current can also influence the waves through the simple conservation of action principle. Then, the waves can receive energy from the current. Unfortunately, these complicated actions and feedback mechanisms are only poorly understood, and, thus, have never been taken into serious consideration in the modeling of coastal ocean circulation. Water movement at the surface creates shear, generating turbulence, which spreads momentum from the surface down into the water column. At the very surface, breaking waves also generate turbulence in the water, enhancing the downward transfer of momentum. General turbulent processes that transfer momentum vertically are represented in models by turbulence closure schemes that parameterize high-frequency, high-wave number turbulent motion in terms of bulk model variables. All schemes in common-use simulate vertical turbulent transfer by means of an eddy viscosity that is in some way dependent on the local shear and buoyancy. The main difficulty faced for this complicated problem is the lack of data for parameterization of the process quantitatively. For the sake of convenience, most of these processes have been totally neglected. But the dynamics of the turbulence in the top layer is too critical to be neglected.

**BOTTOM BOUNDARY LAYER, VARIABLE TOPOGRAPHY, AND INTERNAL WAVES.** Finally, there is another complication for coastal ocean modeling: the influence of the bottom. At the sea-bed, water movement is retarded by friction. Here, momentum is removed from the water. Since models do not normally have the vertical resolution for the bottom boundary layer (10 s of cm), this process is again parameterized by the specification of an empirical drag coefficient. The drag coefficient is empirically dependent on the roughness or structure of the sea-bed. In shallow coastal waters, high-frequency oscillatory motion due to surface waves may penetrate to the sea-bed. If these orbital velocities are significant relative to the lower frequency motion, they increase the mean shear in the bottom boundary layer, and thereby enhance the impact of bottom drag on the mean flow. This enhancement is parameterized by relating the drag coefficient to the surface wave amplitude.

The strongly variable bottom topography characteristic of the coastal ocean, of course, plays a major role in refracting, diffracting, and reflecting the incident wave fields. Dynamical models appear to be mercifully robust to the detail of the vertical eddy viscosity representation. However, the most common test for such schemes - the rate of mixed-layer deepening - is less relevant for coastal oceans than for deep oceans. Under conditions of strong stratification, the models are less-well verified. In particular, estuarine dynamics with a strong, thin, mobile halocline challenge both model resolution and turbulence closure. Highly stratified and nonlinear dynamics, such as internal waves, are a similar challenge. The loss of internal wave energy near coastal boundaries is significant for coastal mixing. Subgrid-scale mixing due to internal waves is acknowledged to be poorly represented by present turbulence closure schemes. Lack of resolution (due to limited computer resources) of the circulation models may be often the factor limiting the internal wave problem. Also, for internal solitons, a non-hydrostatic model (again, more demanding of computer resources) will generally be needed.

Improvements in understanding of turbulent processes will follow new-generation instrumentation that can both survive ocean conditions and resolve turbulent quantities and turbulent scales with sufficient repetition for statistical rigor. Many of the biogeochemical and ecological processes that are controlled by physical processes are also inherently stochastic. It is a challenge for deterministic physical models to accommodate the different scales of uncertainty, from subgrid-scale turbulence, to large-scale ecological variability.

**SUMMARY.** Several unsettled scientific issues concerning coupling of the coastal ocean and atmosphere through wind waves and swell have been identified and described qualitatively. The SCOR WG 111 workshop will have the task of quantifying these issues and shedding light on their resolution.

## **ANNEX 4 - Working Group Proposal on Standards for the Survey and Analysis of Plankton Focusing on High Speed, Large Scale and Long Term Sampling Systems**

### **Background and Significance**

It is now recognised that sampling zooplankton at large spatial and long time scales is crucial to help assess the carrying capacity of regional seas, provide input at appropriate scales to global, basin scale and regional sea models and provide a baseline and time series against which natural and anthropogenically forced change can be assessed. There are few existing monitoring surveys of zoo or ichthyoplankton that satisfy the above requirements. The most representative is the Continuous Plankton Recorder Survey in the North Atlantic, which is currently in its 67th year (SAHFOS, 1999). It is the only long term and ocean basin wide operational survey of plankton in the world. Two smaller sister surveys operate respectively on the eastern margin of the USA and in Antarctica. There has been an increasing recognition of the uniqueness of the CPR time series as a 'barometer' against which to assess climate change and the effects of pollution on the natural variability of marine populations, and as environmental input to fisheries assessments. The methodology enables a large number of taxa to be identified over wide sea areas using ships of opportunity. It is a cost-effective approach to obtaining large numbers of samples over extensive regions to enable the construction of time series

A range of other level flight and undulating towed sampling systems and sensors and unattended submarines have been or are under development for the study of regional ecosystems (GOOS, 1998). Self-contained auto-logging instrumentation packages may also be fitted on merchant, research and naval vessels. At present none of these systems routinely incorporate plankton sampling devices. Sensing systems to determine zooplankton biomass and size used on these platforms include optical particle counters, video and acoustic systems (e.g. US GLOBEC, 1991). Line-scan video and larger systems are also under development which give size and shape as well as counts for individual particles in real time, sampling volumes at a similar rate to the CPR of  $\sim 3\text{m}^3 \text{hour}^{-1}$ .

New sister CPR surveys are becoming established at a number of sites around the world, and the CPR approach is being promoted in GOOS (GOOS, 1998), GLOBEC (IGBP, 1997) and Large Marine Ecosystem (LME) studies (Sherman, 1996) of regional seas funded by the Global Environment Fund (GEF). The CPR Survey was recently incorporated into the GOOS Initial Observing System and it is likely that this approach to monitoring the oceans of the world is likely to expand further over the next decade.

It is clear that there is a wide heterogeneity of sampling and measuring systems for large-scale zooplankton survey in use, with two contrasting approaches at this time:

- The historical CPR approach with added instrumentation as well as new developments of Continuous Plankton and Environmental Recorders (CPEs) (These instruments are not yet sufficiently rugged for use in operational survey mode from ships of opportunity).
- Instrumental measurement of zooplankton using optical particle counters, video and acoustic systems. In this category a number of designs and manufactured systems are already being used.

Problems exist in maintaining consistent sampling within these different approaches through time so that records give an accurate indication of changes in plankton abundance and the different surveys are inter-comparable. There is thus a need to establish standards of careful collection, of quality controlled analysis of collected material and data, of curation and archiving, of the development of associated instrumentation, and of the inter-comparison of methods of collection and analysis, to ensure that data or data products are reliable, properly quantified preserved and inter-comparable. These requirements are as relevant to the CPR as to the other instrumental approaches to the measurement of zooplankton. All of these sampling systems and their associated instrumentation produce large quantities of data

that require careful planning in all aspects of data management. It is recommended that a SCOR Working Group be set up to address the above topics focusing in parallel on 1) the CPR approach and 2) other forms of sampling zooplankton with an integration of the products of the studies as an important contribution to GOOS, GLOBEC and national plankton research and monitoring initiatives at a regional scale.

### **Scientific, Operational and Technological Challenges**

World marine fishery resources are heavily over exploited, and clear evidence exists for a global expansion, of non-indigenous species and harmful algal blooms and of detrimental effects such as eutrophication and pollution. The oceans and seas which comprise >70% of the surface of the Earth also play an important role in climate change through the interface of plankton. It is recognised that to evaluate these impacts, put in place procedures for amelioration and achieve sustainability in the future, both research to develop a better understanding of the functioning of marine planktonic ecosystems and monitoring to establish rates of change needs to be carried out. Because of the temporal and spatial scales involved a sampling strategy which provides large-area and seasonal or year-long coverage as a basis for the production of time series must form the core elements of any monitoring programme. These scales also fit the grids and time events for modelling at regional sea and ocean basin scales and allow integration with the products of satellite remote sensing. Herbivores and primary carnivore zooplankton (including ichthyoplankton) are key trophic levels that process the primary production of phytoplankton to provide energy and nutrients for longer lived species. They are central to energy transfer to fish and modulate biogeochemical cycling in marine systems. A great diversity of trophic strategies exists within the plankton so that energy pathways are complex, and while average biomass results are of use to some studies, information on species and communities is also needed to fully understand ecosystem dynamics.

Two international initiatives are under development to address these issues on a global scale: the Global Ocean Observing System (GOOS) and the Global Ocean Ecosystem Dynamics (GLOBEC) programmes. An initiative of IOC, GOOS is envisaged as a comprehensive and integrated operational observation system that will provide data needed for oceanic and atmospheric forecasting and management and addresses the needs of global environmental change research. Co-sponsored by SCOR and IOC, GLOBEC in contrast is a research initiative to try and differentiate anthropogenic from naturally occurring changes in marine ecosystems and specifically to address the question of how global climate change may affect the abundance and production of animals, and especially fish, in the sea. Zooplankton are the primary focus of GLOBEC because of their key link in the food web between phytoplankton and higher trophic levels.

The Continuous Plankton Recorder survey has been given a high profile in the developing plans for GOOS and GLOBEC. This survey has monitored the plankton in the North Sea and North Atlantic with a consistent methodology since 1948. The survey has provided information on large-scale plankton distributions, seasonal, interannual and decadal variability and more recently the effects of climate change and an ecosystem regime shift. However, whilst the sampling device and analytical protocols have produced an internally consistent data set there are limitations to these data which reduce its wider applicability. The CPR samples at a constant, near surface depth of about 7m which may not be fully representative of the mixed layer plankton communities, water flow through the device is generally not measured so that absolute abundances of organisms are unknown, the size of the filtering mesh, at 270µm, prevents the quantitative recording of smaller organisms and gelatinous plankton are not well sampled or destroyed. There is an urgent need to develop appropriate sampling systems for gelatinous plankton because of the important role they can play as predators at times.

A number of initiatives have been put in place to address these limitations including, the development of undulating towed bodies, a water sampler that collects and preserves fifty samples of microplankton and electromagnetic flow meters. Within the context of a wider development of CPR type surveys there is a need for a critical assessment of the design of the CPR survey and development of ideas for a minimal package of associated instrumentation. Existing surveys use different methods of analysis and data processing which means that the databases can not be presently

integrated. Archived preserved samples are a huge asset available for future research. In the past this resource has been undervalued, underused and maintained in inappropriate conditions. Minimal standards for archiving and curation need developing.

Optical particle counters have been developed specifically to sample plankton and currently operate with a lower size limit of about 250 $\mu$ m which is comparable to the net mesh of the CPR. New laser sensors are under development that will record particles down to 50 $\mu$ m. Neither of the electronic sensing systems for zooplankton have so far been used in large scale synoptic survey. Plans for the development of a pilot survey building on the logistical expertise of the CPR survey should be initiated.

The addition of instrumentation to CPRs generates large volumes of data output which are of considerable value in helping to interpret observed changes in plankton, but require more staff input to operate and down load data as well as complicating the logistical operation of the survey. The data produced by other electronic forms of zooplankton enumeration is vastly greater. Managing such data flows is no small issue and will require the development of new data minimalisation and synthesis techniques with associated quality control. Quality control of measurement when a suite of instruments is deployed on one platform is a major issue and intercalibration between instruments an even greater problem. Microscopic analysis of CPR samples has changed little over a fifty year period. While high quality results are obtained the main limitation is that it is labour intensive. Video systems are similarly labour intensive. As new surveys come on stream the application of image analysis techniques for identification and enumeration are an increasingly feasible proposition. An overview of available techniques and their potential application to large-scale zooplankton survey is needed. An evaluation of the minimum and optimal requirements for a plankton survey at an ocean basin scale has already been initiated (Planque and Reid, 1997). Further development of this approach using instrumented and direct plankton sampling systems is needed

“The present systems of plankton observation, data storage, analysis, promulgation of findings and utilisation of relevant biological information at an international level is weak or non-existent” (Warren Wooster). This working group would help to stimulate international collaboration and progress in these areas.

#### **Proposed Terms of Reference**

This Working Group will help develop standards for sampling, analysis and storage of data and samples obtained by high speed and extensive sampling systems and assess current and future technological needs as a contribution to GOOS and GLOBEC. To achieve these objectives the working will address the following activities:

- *To review the present methods of collection, analysis and curation of samples using Continuous Plankton Records by the different agencies involved and the use which is made of CPR data products.*

**Rationale:** A complete manual for the operation of any of the existing CPR surveys does not exist. Both the surveys in the USA and Australia (Antarctica) were established initially using CPR machines provided by the main survey based in the UK and now operated by SAHFOS. Considerably modified, locally manufactured, machines are now being used in Australia and the procedures for analysis differ in a number of important respects between all three existing surveys. SAHFOS is currently helping to establish a new survey in the Baltic to be operated eventually from Finland. This initiative plans to wash samples off the filtering silk rather than traditional on silk analysis. Other new surveys are already being planned in the North Pacific and Antarctica (Japan). There is an urgent need to standardise, as best possible, approaches to all aspects of CPR survey so that results within and between different operational programmes are inter comparable and produced to the highest quality standards. An evaluation of the use made by the products produced by the different existing surveys and how they could be improved by integration of databases is also needed.

- *To overview the different instrumental approaches to measuring zooplankton, and identify improvements that can be made to sampling strategies and make recommendations on how instruments can be improved and*

*integrated with direct sampling systems such as the CPR for calibration.*

Rationale: In one of the first reports of GLOBEC (GLOBEC INTERNATIONAL, 1993) a critical review was produced of sampling and observational systems available and needed to link measurement and modelling at a range of scales. While identifying the importance of wide-area synoptic monthly/seasonal sampling and the need to take physical and biological measurements concurrently it did not look in detail at sampling approaches at these scales. This is a technological area of marine science that is developing rapidly both at the level of direct sampling of zooplankton using CPERs and by instrumental measurement. An analysis of the different sampling approaches used, their positive and negative attributes and how improvements might be made will help establish guidelines for further technological development and instrumentation packaging.

- *To establish a strict methodology for inter-comparison/calibration of different sampling systems*

Rationale: Quality control procedures already exist for the SAHFOS CPR survey, but are unlikely to have been developed for other laboratories or for the instrumental zooplankton surveys which are still largely in a developmental, research and pre-operational state. If appropriate methodologies are put in place to allow integration of the products of different sampling systems it will be possible to input data to models and apply it in new ways not presently feasible.

- *To recommend a standard package of additional measurements that should be taken in association with CPR survey to enhance the resulting products and assess logistical requirements, identify improvements that could be made in existing instrumentation for use in or attached to towed bodies for plankton survey.*

A limited number of CPRs operated by SAHFOS currently have attached CT/fluorometers, temperature sensors or electromagnetic flow meters. Advice on new determinands to be measured, improvements in instrumentation and packaging and deployment within varying logistical constraints is needed to improve survey design.

- *Encourage the use of the products of long established surveys and the application of new strategies for large scale and long-term sampling of zooplankton by organising an international symposium. Publish the products of reviews by members of the Working Group, selected presented papers and workshop reports in an internationally recognised, peer reviewed, journal or SCOR sponsored book.*

Rationale: This working group is of high relevance to developing plans of GOOS LMR and GLOBEC. The production of a manual on the topic as a book or a special edition of a journal would become a standard reference source and manual for good practice in zooplankton survey.

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## **ANNEX 5 - Working Group Proposal on Sediment Trap and $^{234}\text{Th}$ methods for Particulate Organic Carbon Export in the upper ocean: Current Status**

One of the primary goals of the Joint Global Ocean Flux Study (JGOFS) is to obtain a better understanding of the cycling of carbon and associated biogenic elements in the ocean. A major component of this study is the determination of the fluxes of biogenic matter through the ocean water column, especially from the base of the photic zone to ocean interior. This flux, termed as "export production" includes settling particulate matter of plant and animal origin and advective/diffusive transport of Dissolved Organic Matter (DOM) produced by the decomposition of organic matter in the photic zone. The removal of carbon from the photic zone, is at least partly replenished by drawdown of atmospheric  $\text{CO}_2$ . Thus knowledge of export production and its variability is important to assess the role of oceans in sequestering atmospheric  $\text{CO}_2$ . Further, at steady state, export production is expected to be the same as new production, a key parameter in marine biogeochemical cycling models. Thus the determination of export production of carbon and its relation to primary and new production has gained considerable importance in JGOFS type studies.

Two methods are commonly used to measure export production; (i) sediment trap and (ii)  $^{234}\text{Th}$ : $^{238}\text{U}$  disequilibrium. Both these are designed to quantify export associated with the vertical flux of settling particulate biogenic materials (i.e. advective/diffusive transport of DOM and lateral transport are not included).

Sediment traps are commonly used in oceanographic research for the measurement of settling fluxes of particles and their collection for chemical and biological analyses. In spite of their wide use, there are concerns about their ability to quantitatively collect unbiased samples of settling particles. These concerns are heightened in traps deployed at the base of the photic zone where current velocities could be quite high. Further, contamination from "Swimmers" and solubilisation of POC in traps could contribute to additional uncertainties in flux data.

The status of sediment trap sampling in surface waters to determine settling flux of particles, especially organic carbon was discussed during the first International JGOFS Scientific Symposium held at Villefranche, 1995 and a report of this is available on the JGOFS web site (for its exact location please send an enquiry to Beatriz Balino at the JGOFS International Project Office - [Beatriz.Balino@jgofs.uib.no](mailto:Beatriz.Balino@jgofs.uib.no)).

The second method used for determining settling fluxes is based on  $^{234}\text{Th}$ : $^{238}\text{U}$  disequilibrium.  $^{234}\text{Th}$ , a short lived radionuclide, ( $t_{1/2}$  24.1 days) is produced continuously in sea water at a nearly uniform rate from the decay of  $^{238}\text{U}$ .  $^{234}\text{Th}$  thus produced gets quickly attached to particles and is removed out of surface water with the settling particles. This preferential removal of  $^{234}\text{Th}$  causes its activity to be deficient relative to its parent  $^{238}\text{U}$  in the upper water column (~150-200 m). The extent of this deficiency, in conjunction with data on  $\text{POC}/^{234}\text{Th}$  in particulate material has been used to determine the export production in many of the JGOFS process study regions, in the North Atlantic, Equatorial Pacific and the Arabian Sea. The accuracy of this method depends on (i) how well the  $^{234}\text{Th}$  deficiency can be determined and (ii) the reliability of  $\text{POC}/^{234}\text{Th}$  used in calculation. The  $\text{POC}/^{234}\text{Th}$  ratio shows considerable variation among various particle classes and over short time intervals of a few weeks.

During the recent International Scientific Symposium on "Biogeochemistry of the Arabian Sea: Synthesis and Modelling" held at Bangalore - January 18-20, 1999, it was felt that there is a need to better understand the reliability of export flux determined based on traps and  $^{234}\text{Th}$  studies and how they intercompare.

Considering this suggestion and the importance of export production in biogeochemical models, we propose, that SCOR establishes a working group on "Sediment Trap and  $^{234}\text{Th}$  methods for carbon Export Flux Determination: Current Status" with the following terms of reference.

- To explain the terms export production and new production and their inter-relation. How does the carbon flux determined using traps and  $^{234}\text{Th}$  relate to export production?
- To review the current status of carbon export flux determination using moored and floating sediment traps, their advantages and problems, associated uncertainties and their magnitudes. To suggest suitable trap designs and necessary protocols to get reliable flux data.
- To review the basis of  $^{234}\text{Th}$  based carbon export flux measurements, models, assumptions and parameters used in the calculations. To assess the reliability of these assumptions/parameters, the sources and magnitudes of associated uncertainties. (For example: How do the time scales of sampling, temporal variability in  $^{234}\text{Th}$  fluxes,  $\text{POC}/^{234}\text{Th}$  ratio in different particulate pools affect the flux data?).
- To intercompare the carbon export fluxes determined by trap and  $^{234}\text{Th}$  methods. If they differ, what are the main causes of discrepancy and how can they be resolved?
- To suggest experimental design and protocols to be followed to obtain quantitative and reliable carbon export fluxes based on the above methods. Can  $^{234}\text{Th}$  serve as a global survey tool to determine carbon export fluxes?
- To prepare a final report within 4 years and interim report within 2 years.

## **ANNEX 6 - Working Group Proposal on New Technologies for Observing Marine Life**

### **Introduction**

This is a proposal for a SCOR Working Group on New Technologies for Observing Marine Life. The proposal is consistent with a well developed, active interest among the fisheries and biological oceanography communities, but receives added stimulus from the Sloan Foundation's Census of Marine Life (CoML) initiative and was identified as a highly desirable goal at the 20 September 1999 CoML Steering Committee meeting. The Census has focus on the broader range of marine life extending through plankton, benthic organisms, jellies, fish and marine mammals with the emphasis on technologies that can be transitioned to practice within the next 5-8 years. Some background on the Census of Marine Life is briefly summarized below.

### **Census of Marine Life initiative and its relationship to this SCOR proposal**

The goals of the Census include the comprehensive measurement of marine life. Realistic implementation of the Census will begin with pilot projects in particular locations; detailed planning of such a project in the Gulf of Maine is already underway. While the Sloan Foundation is committed to significant financial support of the Census and this is already beginning to happen through Broad Agency Announcements in the National Oceanographic Partnership Program (NOPP), the intention is that this support be catalytic, in the sense of encouraging participation of existing fisheries monitoring and science programs, along with other research initiatives.

The larger goals of the Census of Marine Life will depend on the mobilization of international interest, the active participation of researchers from around the world and the commitment of a wide range of sponsors from organizations such as the World Bank to various national fisheries organizations and research groups. A key web link and reference are listed below.

The present moment marks an important transition from a phase during which a series of preparatory workshops were held to help establish the potential value and goals of a Census, to the planning of pilot programs and the initial funding of projects through NOPP. Although the Steering Committee has only recently been formed, the pace is quickening and the Census will soon become a much more visible and widely noticed entity. Reaching out to the international community is essential to the success of the program and SCOR is seen as a particularly appropriate organization to facilitate this.

The implementation of new technologies for observing marine life represents only one component of Census goals and it is likely there will be other ways in which Sloan's initiative will interact with SCOR activities. However, observational technologies are a crucial part of the initiative and we believe this is an opportune time for SCOR focus.

### **The role of new observational technologies**

Measurement of marine life over the range of interest discussed here is not motivated by the specific need for assessing commercial stocks, but neither can it be divorced from this important requirement. Although the 'tragedy of the commons' is surely responsible for many of the collapsing fish stocks around the world, knowledge of marine life remains a crucial ingredient of successful conservation. Among marine scientists, this is a statement of the obvious. But the practical means for achieving improved knowledge of what lives in the ocean, which is an essential requirement for scientific understanding of marine ecology, involves technological challenges. We contend there are many technologies presently in researchers' hands or on the point of implementation, which are badly needed by the larger community of scientists studying and monitoring marine life, yet remain generally inaccessible. There are several reasons for this.

National fisheries interests tend to be very conservative in their approach to measurement. This is understandable, since the setting of fishing quotas and regulations is highly political: consistency in measurement technique from one year to the next is seen as an essential virtue. But such an approach does not always favor development of innovative techniques. For example, the application of acoustic technology to stock assessment remains patchy around the world. Commitment to innovative developments is not just a matter of technological development or economic importance of fish but often has historical, jurisdictional or other reasons.

New techniques, or improved ways of using existing techniques, often arise in research groups that do not have traditional commitment to the measurement of marine life, but depend on innovative application of concepts developed for different reasons. To cite just one example, the development of optical sensing of fish using airborne lidar evolved in a group that was developing optical techniques for atmospheric measurement. Subsequent collaboration with fisheries scientists demonstrated the remarkable potential of this method and its future success will be based on this interdisciplinary link. At present the technology remains largely inaccessible and probably largely unknown to the vast majority of scientists who could benefit from it. But there is no reason why this should remain so, and wider knowledge and discussion of such approaches will almost certainly lead to wider use.

Several emerging measurement approaches were discussed at a CoML funded workshop held at Scripps in 1997 under the chairmanship of Dr Jules Jaffe. These included the use of acoustic, optical and statistical methods, as well as new deployment approaches such as the use of autonomous vehicles and drifters communicating their results by satellite, DNA sequencing, behavioral approaches such as relating seabird activity to fish populations, concentration of sparsely distributed fish by night time illumination to facilitate assessment and passive detection through bioluminescence stimulated by high fish concentrations.

Inevitably acoustic concepts become an important and generally dominant part of such discussions, since the ocean is relatively transparent to acoustical energy in contrast to electromagnetic radiation. Particularly important advances can be expected from the collaboration of marine biologists and fisheries scientists with specialists in underwater acoustics. At the CoML workshop there were presentations on the study of benthic habitats, 3-d underwater imaging, the use of low frequency attenuation of sound over longer ranges by fish, and horizontally imaging sonars that can identify individual fish at ranges of several km. Acoustical methods show particular promise in overcoming one of the most severe difficulties of measurement: the limited sampling volume achieved by traditional approaches.

Species identification is one of the most challenging aspects of remote fish detection. Multiple frequency sonars have proved highly effective at providing size and other information about zoo-plankton, larval and adult fish. Since fish recruitment is one of the most perplexing fisheries estimation problems, there seems to be special opportunity for developing this approach and making it more readily available. In acoustic measurement, the development of adequate scattering models is just as important as development of measurement hardware, and just as neglected. The combination of better models with new instruments will lead to the greatest advances. This will be especially true with the introduction of low frequency parametric systems that exploit the swim bladder resonance to distinguish size and species.

Innovative deployment technologies will be essential for many of the applications envisaged in the Census. Autonomous underwater vehicles, whether powered or drifting, are becoming available. How will marine biologists use these new platforms? Systems that can maintain a constant height over the sea-floor, allowing the accumulation of high resolution photography, are already being tested and will add immeasurably to our knowledge of benthic communities. Powered vehicles with multi-beam sonars developed for mine detection have obvious application in the study of marine life, and are already available for this use. In summary, there are a great many new concepts and technologies that have become available, but they remain untried and largely unknown by the community of marine biologists who could take advantage of them. Acceptance will only come from detailed

assessment of their strengths and weaknesses relative to traditional approaches. Often the newer approaches will prove complementary to established methods.

### **Purpose of the Working Group**

The purpose of a SCOR working group on this topic would be to bring to the attention of the international community of fisheries scientists, marine biologists and others, the potential benefits of emerging technologies in the detection of marine life. The Committee would meet on an annual basis, but the meetings would be open to the larger community of scientists and encourage their input. The discussions would focus on the possibilities and practicalities, both technical and economic, of these technologies, and prepare a report that would be available for widespread dissemination. This report would be in the spirit of discussions begun at the Scripps conference, evaluating the broad range of possibilities, highlighting particular technologies that would lead to rapid application and areas that would be especially worthy of investment. A focus on those techniques that are either already available in a developmental form, or which are within a very years (5-8) of becoming so, are those identified as of particular interest here. We also identify here a particular interest in those technologies applicable to larger or synoptic scale distributions, while recognizing that the key scientific issues relating to these distributions can, and often should be studied on small scales.

We believe the working group's impact will be substantial, especially if it is widely publicized, draws in participants from many countries (especially including the less developed world where some of the richest and most diverse marine life occurs) and leads to a report that will be widely disseminated. The underlying interest of the Census of Marine Life in the working group's activity can only increase the chances of success.

### **Terms of Reference**

At the Goa meeting, the SCOR Executive Committee approved the following terms of reference for the Working Group:

- *To identify and bring to the attention of the international community of fisheries scientists, marine biologists and others, the potential benefits of emerging technologies in the detection of marine life.*

The Working Group would be concerned with technologies applicable to the range of marine life extending from zooplankton to whales. In this sense there will be a close link between the goals of the Working Group and those of the Census of Marine Life. Links would be established through appropriate selection of Working Group members, with the separate SCOR Working Group "Standards for the survey and analysis of plankton focusing on high speed, large scale and long term sampling systems", so as to ensure that activities are complementary and to increase exchange of information and ideas. Another activity with which close links should be developed is the SCOR/IOC Global Ocean Ecosystem Dynamics (GLOBEC) program. GLOBEC also has a strong interest in improved instrumentation in biological oceanography.

- *To explore the relative merits of different technologies and identify those that deserve further research based on their potential for making significant contributions to the detection of marine life.*

The discussions would focus on the possibilities and practicalities, both technical and economic, of these technologies. Of particular interest would be those techniques that are either already available in a developmental form, or which are within a very few years (5-8) of becoming so. We also identify here a particular interest in those technologies applicable to larger or synoptic scale distributions, while recognizing that the key scientific issues relating to these distributions can, and often should be studied on small scales. We believe the Working Group's impact will be substantial, especially if it is widely publicized, draws in participants from many countries (especially including the less developed world where some of the richest and most diverse marine life occurs) and leads to a report that will be widely disseminated. The underlying interest of the Census of Marine Life in the Working Group's activity can only increase the chances of success.

- *To prepare a summary of the results of the Working Group's discussion so as to make it as widely available as possible.*

Involvement of the larger community of marine biologists and fisheries scientists is recognized as being essential to the success of the Working Group. This can be achieved by inviting interested members of the community to the SCOR meetings, by maintaining web page describing the group's activities and by publication of the results of the Working Group's deliberations. While the precise form of publication must be decided by the group itself, possibilities for discussion include a book, with different chapters contributed by various Working Group members, a special issue of a journal or a major conference proceedings. This report would be in the spirit of discussions begun at the Scripps conference, evaluating the broad range of possibilities, highlighting particular technologies that would lead to rapid application and areas that would be especially worthy of investment.

### **Participants**

Discussions have been held with Dr Van Holliday, a leading proponent and practitioner of technologies for measurement of marine life. Some potential names have been assembled. It was felt essential that the working group represent *users* of the technologies, such as marine biologists and fisheries scientists, as well as those actually involved with their development. It was also thought desirable to involve young scientists and not be top-heavy with the those of us who are fully established in the field. Finally, there needs to be geographic balance.

### **Link & Reference**

Census of Marine Life Web Page <<http://core.cast.msstate.edu/censhome.html>>

This page links to reports, concept papers and related information, including the Broad Area Announcement by the National Oceanographic Partnership Program relating to CoML.

A special issue of The Oceanography Society's journal *Oceanography*, due to appear shortly, will be devoted to reports from the Census of Marine Life workshops that have been held under Sloan Foundation sponsorship over the past 18 months, including the article "The Technology Workshop for the Census of Marine Life, Oct 16-17, 1997".

### **Proposer**

This proposal has been submitted by David Farmer, Institute of Ocean Sciences, PO Box 6000, Sidney, BC, Canada, V8L4B2 (ph:1-250-363-6591, <[farmerd@dfo-mpo.gc.ca](mailto:farmerd@dfo-mpo.gc.ca)>). The proponent is an oceanographer with a strong interest in innovative technology, including that required for biological and fisheries measurement. From its inception until 1998, he was Chair of SCOR WG 96 on Acoustic Measurement of the World Ocean. His research activities are described in the web page <http://pinger.ios.bc.ca/> which also includes a detailed CV.

## **ANNEX 7 - Joint Global Ocean Flux Study (JGOFS)**

### **1999 Annual Progress Report**

**Roger B. Hanson, Executive Officer, International Project Office, Bergen, Norway**

**on behalf of the Scientific Steering Committee**

## **INTRODUCTION**

The Joint Global Ocean Flux Study (JGOFS) began in 1988 under the auspices of the Scientific Committee on Oceanic Research (SCOR) and later became a Core Project of the International Geosphere-Biosphere Programme (IGBP). The goal of the project is to understand better the ocean carbon cycle and feedbacks between the atmosphere and the deep ocean basins through biogeochemical and physical measurements of the vertical transport of carbon dioxide. During this period, the Scientific Steering Committee (SSC) coordinated the field activities of over 20 international programs. With exception of the North Pacific Process Study and several Time-Series Stations, the field phase is complete. In 1998, the SSC restructured itself to meet the goals of the synthesis and modelling phase. This report summarises SSC activities over the past year and JGOFS plans for future activities and ocean biogeochemistry.

## **SCIENTIFIC HIGHLIGHTS**

### **Improved Global Ocean CO<sub>2</sub> Synthesis (Takahashi)**

The distribution of the oceanic sink and source areas for atmospheric CO<sub>2</sub> and the magnitude of the net CO<sub>2</sub> flux across the sea surface are important for understanding the global ocean carbon cycle and constraining ocean carbon models. For the new reference year 1995, representing non-El Niño conditions, an improved estimate of the net CO<sub>2</sub> uptake by the global ocean was reported at about 2.2 Pg C/yr. (Takahashi et al., 2nd CO<sub>2</sub> in Oceans Symposium, January 1999, Tsukuba, Japan). This estimate is consistent with estimates obtained based on ocean-atmosphere models with constant biology and is about 0.7 Pg C/yr. greater than the 1990 estimate. This difference is partly the result of improvements in observational database and the effect of an increase in the atmospheric p CO<sub>2</sub> that occurred from 1990 to 1995. The new flux values show that the Atlantic Ocean is the largest net sink for atmospheric CO<sub>2</sub> (39%); the Southern Ocean (22%) and the Indian Ocean (22%); and the Pacific (11%) is the smallest. The large sink flux of the northern oceanic areas is attributed to the intense biological drawdown of CO<sub>2</sub> in the high latitude areas of the North Atlantic and arctic seas during the summer months. This is also due to low CO<sub>2</sub> concentrations in upwelling deep waters, which are caused primarily by the short residence time of the North Atlantic Deep Waters. The small uptake flux of the Pacific can be attributed to the combined sink flux of the northern and southern subtropical gyres are roughly balanced by the source flux from the equatorial Pacific. The equatorial Pacific CO<sub>2</sub> source flux may be totally or partly eliminated during El Niño events. This effect alone could increase the global ocean uptake flux up to 0.6 Pg C/yr. during an El Niño year.

### **Southern Ocean Iron Fertilisation Experiment (Julie Hall)**

Twenty-six scientists from six countries took part in the Southern Ocean Iron Release Experiment (SOIREE) to test the iron limitation hypothesis in cold Antarctic waters. The experimental site was located Southwest of New Zealand near 141° E and 61° S in a region within the Antarctic Circumpolar Current, south of the Antarctic Polar Front. Upon arrival at the site, a 72-hour hydrographic survey was carried out with CTD and XBT profiles that provided vertical profiles for temperature, salinity, chlorophyll fluorescence, and biophysical characteristics of algal populations. The release of iron and the tracer SF<sub>6</sub> occurred on 10 February 1999. The site had a mixed layer roughly 65 meters deep and low chlorophyll a levels, and the dissolved iron concentrations were raised to levels considerably greater than ambient over 50 square kilometres. The added dissolved iron was removed quickly, necessitating three additional infusions during the 13-day experiment. Conditions on deck were cold, air temperatures between 0° and 3° C, with occasional showers of sleet and snow. Despite winds up to 60 knots and seas up to 10 meters, a coherent iron-enriched patch was maintained over the period of the experiment. The patch

moved about 40 nautical miles, generally east-southeast, and expanded in size to about 150 square kilometres over this period. As expected, the response of the biota to iron fertilisation was slow in comparison to that encountered during IronEx I and II (Coale et al., *Nature* 1995, 379:621-24; deBaar et al., *Nature* 1995, 373: 412-15). Five days elapsed before significant increases in algal photosynthetic competence and then algal biomass was observed. Chlorophyll a levels increased markedly, and macronutrient levels and the partial pressure of CO<sub>2</sub> decreased from the levels observed at the beginning of the experiment. In contrast, upper-ocean levels of dimethylsulfide increased during the experiment. Daily underway surveys and sampling outside of the patch indicated little change in biomass, photosynthetic competence or macronutrient concentrations. Preliminary results suggest that, at least in this part of the Southern Ocean, iron availability plays a fundamental role in controlling the photosynthetic competence of the algae. An increase in available iron appears to bring about a substantial elevation of phytoplankton biomass, despite a relatively deep mixed layer, low seawater temperatures and the presence of grazers.

### **Ocean Carbon Modelling (Jim Orr and Patrick Monfray)**

The second phase of Ocean Carbon-cycle Model Intercomparison Project (OCMIP-2, 1998-2000) was marked by its midway workshop (Paris, May 1999). Efforts prior to that workshop were mostly preparatory. That is, extensive discussions lead to finalised protocols and boundary conditions. Analysis routines and presentation software were developed. Detailed information concerning those efforts was disseminated via the OCMIP Web page (<http://www.ipsl.jussieu.fr>). At the workshop, results were also presented for the first OCMIP-2 comparison for CFC-11 and CFC-12. That presentation, and the ensuing discussion, illustrated the emphasis of model-data and model-model comparison that is the focus for the second half of OCMIP-2. Since the Paris workshop, the general emphasis on the carbon cycle has become clearer. Modellers have implemented related protocols, made simulations, and submitted results to the OCMIP-2 database. Carbon-cycle simulations include equilibrium runs to estimate conditions of the non-perturbed, pre-industrial ocean, while separating solubility and biological components. The latter is modelled with a common phosphate restoring model. Carbon-cycle simulations also include transient runs for anthropogenic CO<sub>2</sub>, forced by historical observations and IPCC future scenarios. Highlights of the first OCMIP-2 comparison of carbon-cycle models will be presented at the AGU Ocean Sciences 2000 (JGOFS session OS23, Invited) in January 2000. OCMIP also recently held a special session at the IUGG meeting (July 23, 1999, Birmingham, UK). There were seven presentations. Six focused on modelling natural and anthropogenic carbon, oceanic transport of riverine carbon, C-14, CFC's, interannual variability, and the impact of climate change on ocean carbon and ocean productivity. Another presentation detailed a promising new technique using a model-based approach to estimate regional uncertainties for derived, data-based estimates of anthropogenic CO<sub>2</sub>.

### **OTHER HIGHLIGHTS**

#### **First JGOFS Synthesis Workshop**

The First SSC Synthesis Workshop took place at the Southampton Oceanography Centre, October 1998. Michael Fasham chaired the workshop, and in his absence, John Field or Hugh Ducklow moderated the proceedings. The full JGOFS synthesis effort includes a) regional syntheses with publications of refereed articles in international journals and data sets in CD-ROM, b) a global synthesis under relevant ocean biogeochemical themes to be published in a book, c) an integration of JGOFS activities within IGBP-wide synthesis and finally d) archival of all JGOFS data sets at World Data Centres-A for Oceanography to take care of long-term stewardship. At the workshop, the participants focused on:

- Contents and production of a glossy brochure entitled "Ocean Biogeochemistry and Climate Change". A compilation of JGOFS highlights over the past 10 years. Publication planned in early 2000.
- Contents and organisation of the 2nd JGOFS Synthesis Book. The themes were reviewed and guidelines with timelines for the authors were established. This book will present JGOFS understanding of the ocean biogeochemistry. Publication planned for mid-2000.

- Organisation of the Open Science Conference to be held in April 2000 in Bergen. The science programme will parallel themes of the JGOFS Synthesis Book.

### **International Project Office (IPO)**

With host approval from the University Director, the IPO approached the Research Council of Norway (NRC) to seek an extension of its financial support of the office for another 4 years, with the submission of a document in August 1998. In January 1999, during a meeting at NRC headquarters in Oslo, Fasham, Hanson, and Ulf Lie gave the NRC presentations on the scientific scope and long-range plans for JGOFS, the functions and benefits of the IPO in Norway, and the Norwegian activities in JGOFS. In March, a formal proposal was submitted to NRC. A month later, the Research Council announced its financial support of the IPO for four additional years, i.e. until 31 December 2003. JGOFS announced the NRC support at the 2nd IGBP Congress to the entire community.

## **SCIENTIFIC STEERING COMMITTEE ACTIVITIES**

### **Executive Committee Meeting**

The meeting of the 1998 Executive Committee took place immediately before the First Synthesis Workshop at the Southampton Oceanography Centre (see Highlights). From recent developments within the regional synthesis groups, normal SSC rotations and personal commitments, the Executive were forced to modify its earlier nomination proposal in order to achieve national balance in the SSC and asked SCOR and IGBP for special consideration. It was granted and the sponsors approved Paul Falkowski (USA) and Robert Anderson (USA) for the 1999 SSC (see Appendix I). All JGOFS scientific activities for 1999 were reviewed and only a few were approved with partial or full JGOFS funds (see Appendix II). All second meetings of the regional synthesis groups were deferred to year 2000, unless funds were secured nationally or elsewhere. With help of the Executives, Fasham selected Karin Lochte, Egil Sakshaug, Bronte Tilbrook, and KK Liu for the 1999 Executives.

### **14th Scientific Steering Committee Meeting**

The 14th Meeting of the Scientific Steering Committee took place at the Second IGBP Congress in Yokohama, Japan. The Vice-Chair, KK Liu, chaired the meeting because Fasham could not make the trip due to health reasons. All JGOFS regional synthesis groups and scientific task teams were reviewed and preliminary plans for activities in 2000 considered (see Appendix II). To accommodate SSC business agenda fully, much of the SSC business process was done during the Congress breaks and evenings. For example, the lead authors of the textbook met and reviewed the outlines of their respective chapters, and they agreed to submit these outlines to the IPO by 31 June 1999. The program committee for the Open Science Conference developed a tentative science program. Moreover, SCOR lead by John Field arranged a lunch discussion with representatives from both secretariats, relevant IGBP program elements and representatives from SOLAS with the purpose of exposing the scientific and organisational issues involved in the development of future programs in ocean biogeochemistry. On the last day, the SSC invited Robert Duce to make a presentation of SOLAS with discussion. Although the SSC supports the science focus of SOLAS, it does identify a series of gaps especially on the topics of carbon exchange and cycling in the ocean. Therefore, the SSC recommended the formation of a small group of JGOFS scientists to study the feasibility of constructing a new programme in ocean biogeochemistry that capitalises on the advances and infrastructure developed through JGOFS.

## **REGIONAL SYNTHESIS GROUPS**

### **Scientific Meetings**

The regional synthesis groups (4) developed from the restructure of the earlier planning groups with new members (10) to address the new Terms of Reference and regional objectives over next four years.

At the end of 1998, Veronique Garcon (France) took over the chair of the *North Atlantic Synthesis and Modelling Group (NASG)* from Michael Fasham (UK). Since then, Garcon has arranged national financial support for their second meeting of the NASG in Toulouse, France, September 1999. A special volume of Deep-Sea Research on the North Atlantic Synthesis is on schedule for publication before the Open Science Conference.

The *Indian Ocean Synthesis and Modelling Group (IOSG)* held its first meeting in January 1999, in the occasion of the Symposium on the Biogeochemistry of the Arabian Sea: Synthesis and Modelling in Bangalore, India. Future tasks and publications include (1) a JGOFS Report on recent advances in the Arabian Sea (December 1999), (2) a list of national data centres storing JGOFS core measurements obtained during cruises in the Arabian Sea, (3) a brochure on highlights of the Arabian Sea Process Study, and (4) a volume to be published in either Deep-Sea Research or Progress in Oceanography. The three-day symposium, convened by Burkill (UK), attracted scientists from all countries that participated in the regional fieldwork. In total, eighty-seven participants from 23 countries attended the symposium. The scientific programme was comprised of sessions on air-sea exchange, remote sensing, hydrography and nutrients, phytoplankton, bacteria, zooplankton, export from surface to deep waters, oxygen minimum zone, ocean-colour algorithms and modelling of primary productivity and biogeochemical cycles. Thirty-three papers were presented orally while a poster session of nearly 20 papers gave young researchers an opportunity to present their work.

The *Equatorial Pacific Synthesis and Modelling Group (EPSG)* held its first meeting in Seattle, September 1998. The first meeting focused on the synthesis of the Equatorial Pacific and its publication in a special volume of Deep-Sea Research. The Guest Editors are Le Borgne, Feely, and Mackey with 16 chapter leaders, who will organise the contents of their own disciplines. The group sought international diversity and invited other leaders and co-authors. The deadline for manuscripts is April 2000 for publication in 2001. The gathering of the data sets among all participating countries is underway and will be eventually published in a series of CD-ROMs. In October 1998, the SSC Executives approved Murray's recommendation to step down and for Robert Le Borgne (France) to take over the chair of the EPSG.

The *Southern Ocean Synthesis and Modelling Group (SOSG)* held its first meeting in Bremerhaven, September 1998. The focus was on redefining the original bio-geographical provinces in the Southern Ocean as functional units, developing new terms of reference, and restructuring its membership. The SOSG also proposed an international Southern Ocean symposium in France, July 2000.

## SCIENTIFIC TASK TEAMS

### Scientific Meetings

The *Global Synthesis and Modelling Task Team (GSMTT)* held a 10-day Training Course in biogeochemical modelling of the ocean, which immediately followed the Bangalore symposium. The course was organised by Trevor Platt and Shubha Sathyendranath (Canada) and financial support came from SCOR, START, IOC US-JGOFS, INDIA JGOFS, and International JGOFS. More than forty students (selected from more than 80 applicants) and eight instructors came from twenty different industrialised and developing countries. All of the students and most instructors also participated in the symposium, where they were exposed to much of the data collected in the JGOFS Arabian Sea Process Study and to the interpretation of these results. Thus, the event provided a context for the course to follow, especially for those participants lacking experience in working with oceanographic data. The students ranged from graduate level to senior researchers wishing to enhance their modelling skills. The course dealt with conceptual bases, analytical methods, numerical simulation, software, and the use of remotely sensed data on ocean colour as a tool for extrapolation. Practical experience in testing, using and developing various types of models was gained in day-long sessions spent at the Centre for Mathematical Modelling and Computer Simulation in Bangalore (C-MMACS). This was the last task of the GSMTT, which was officially disbanded in 1998.

The *Data Management Task Team (DMTT)* met alongside of the Data Management and Synthesis Workshop in Bergen, September 1998. The issues discussed at the meeting were: (i) to ensure that all JGOFS observations are lodged with organisations, which can guarantee long-term stewardship; (ii) provide Web-based information on the availability and access mechanisms to all JGOFS data; and (iii) encourage the development of Web-based data delivery systems. The DMTT abandoned its earlier plan to develop a JGOFS Inventory Index (JDI) due to lack of resources and is now investigating an existing metadata search technology to see whether it can deliver JGOFS requirements. The Executives approved two new members of the DMTT: Ms. Marie-Paule Labaied in charge of the French JGOFS database initiative, and Brian Griffiths in charge of centralising the JGOFS Australian data sets in a databank. The venue for the next DMTT has been provided by the German-JGOFS data management office in Kiel, spring 2000. The goal of the *Data Management and Synthesis Workshop* was to establish communication between the DMTT and scientists actively working in the JGOFS synthesis and modelling. They addressed the following issues: the JGOFS metadata catalogue, communication, management of synthesised data sets, management of model data, timeliness of data delivery, relational database technology and protocols for data citation. The workshop minutes are published in the JGOFS Report Series (Report Nr. 29), distributed to the JGOFS community and available online at the IPO homepage.

The *Joint LOICZ/JGOFS Continental Margin Task Team (CMTT)* met at the IGBP Congress, and reviewed its geographical regions and prepared its future synthesis plans. The SSC recently approved its modified Terms of Reference, and its restructured membership. The overarching framework focuses on CO<sub>2</sub> sequestration and on C, N, and P fluxes across continental margins, including polar margins. The objectives identify key processes within these margin typologies. In the future, the team identified meetings where future sessions on continental margin will occur. These include the LOICZ Open Science Meeting (Argentina, 1999), the AGU Ocean Science Meeting (USA, 1999), the JGOFS Open Science Conference (Norway, 2000) and the IGBP Open Science Meeting (The Netherlands, 2001). Finally, the CMTT plans to organise a synthesis volume.

The *North Pacific Task Team (NPTT)* met for the fourth time during the North Pacific Process Study Workshop and SEATS Planning Meeting in Taipei, March 1999. Plans are now underway to launch the South-East Asia Time-series Station (SEATS) in South China Sea in 2000. With financial support from Japan, the fifth meeting of the NPTT is planned with the North Pacific Synthesis Workshop in Japan, February 2000. The co-Chairs proposed to strengthen the modelling component in NPTT by restructuring the membership to match its new Terms of Reference (approved October 1998). A product of the workshop is a synthesis volume of the North Pacific Process Study to be published in 2003. In addition, a sixth NPTT Meeting is planned in conjunction with the proposed North Pacific CO<sub>2</sub> Data Workshop in Japan, October 2000.

The *Joint IOC/JGOFS Carbon Dioxide Advisory Panel (CO<sub>2</sub> AP)* met in Japan, January 1999. SCOR and IOC have drafted new terms of reference for the new panel in Paris, July 1999. Based on input from the present CO<sub>2</sub> Panel, JGOFS SSC, and others, it is suggested that the membership should be altered slightly to reflect the two parent bodies, SCOR, and IOC. Restructuring should also take a view to the future as JGOFS closes and Global Ocean Observing System begins.

The *Photosynthesis Measurement Task Team (PMTT)* did not meet in 1998 and has not yet made any progress on the techniques manual drafted last year. However, the PMTT still plans to print the manual as a JGOFS Report in early 2001.

Lochte and Shimmield chair the newest JGOFS task team, *Deep Ocean Flux Task Team (DOFTT)*, which is now renamed *Palaeo-JGOFS Task Team (PJTT)*. JGOFS and PAGES made great progress towards forming a joint DOFTT at the IGBP Congress. The next steps will be to nominate members and propose Terms of Reference to JGOFS and PAGES in 1999 and organise a synthesis workshop in 2000.

The *Remote Sensing Task Team (RSTT)* did not hold any meetings in 1998. In view of existence of the International Ocean Colour Co-ordinating Group (IOCCG) chaired by T. Platt, the SSC questioned during its 13th meeting in South Africa, whether JGOFS needs to maintain this group any longer even though RSTT activities go beyond ocean colour. There was consensus to disband the team with Platt as liaison with JGOFS. The RSTT was then officially disbanded in 1998.

## **FINANCES**

The IPO falls under the direct supervision of the Scientific Steering Committee and receives full financial and infrastructure support from the Research Council of Norway (NRC) and the University of Bergen for the administration of the international JGOFS. In addition, the IPO receives funds from SCOR and IGBP in support of JGOFS SSC regional synthesis groups and task teams activities. SCOR is the lead sponsor (\$95,000 in 1999). Over the past years, as SCOR's sponsors have decreased their financial support for its two major ongoing research projects (e.g. JGOFS and GLOBEC), the chairs of JGOFS group activities have assisted in fund raising from national agencies and other organisations. Notable examples are the NPTT/SEATS Planning Workshop in Taipei, Taiwan, the second NASG meeting in Toulouse, France in 1999, and the DMTT meeting in Kiel in 2000, Germany and the North Pacific Synthesis Workshop/NPTT Meeting in Nagoya, Japan. Even still, due to the financial responsibility of the Second JGOFS Open Science Conference planned in 2000, the Executives were forced to make serious cuts in synthesis groups and task teams requests for SCOR funds in 2000.

## **PUBLICATIONS**

JGOFS publications over the past 12 months include a midterm synthesis book, seven articles in USJGOFS and IGBP newsletters, three JGOFS Reports, and four electronic data publications on CD-ROM (Appendix IV). In addition, the IPO received 182 references of refereed journal articles for the update of the JGOFS publication list (<http://ads.smr.uib.no/jgofs/publications/index.htm>).

For further information about JGOFS or any of the activities discussed in this report, please contact: Roger B. Hanson, Executive Officer, JGOFS International Project Office, Centre for Studies of Environment and Resources, University of Bergen, Bergen High-Technology Centre, 5020 Bergen, NORWAY, Tel: +47-5558-4244, FAX: -9687, E-mail: [roger.hanson@jgofs.uib.no](mailto:roger.hanson@jgofs.uib.no).

## JGOFS APPENDIX I: SCIENTIFIC STEERING COMMITTEE MEMBERS (1999)

Fasham, Michael	UK	SSC Chair
Anderson, Robert	USA	
Bathmann, Ulrich	Germany	SOSG Chair
Burkill, Peter	UK	IOSG Chair
Bychkov, Alex	Russia	NPTT co-Chair
Falkowski, Paul	USA	
Garcon, Veronique	France	NASG Chair
Hall, Julie	New Zealand	CMTT co-Chair
Hong, Huasheng	China	
LeBorgne, Robert	France	EPSG Chair
Liu, KK	China-Taipei	SSC Vice-Chair, CMTT co-Chair
Lochte, Karin	Germany	DOFTT co-Chair
Lowry, Roy	UK	DMTT Chair
Monfray, Patrick	France	OCMIP Representative
Platt, Trevor	Canada	IOCCG Representative
Quifiones, Renato	Chile	
Saino, Toshiro	Japan	NPTT co-Chair
Sakshaug, Egil	Norway	PMTT Chair
Shimmield, Graham	UK	DOFTT co-Chair
Tilbrook, Bronte	Australia	
Wallace, Douglas	Germany	
Watson, Andrew	UK	CO <sub>2</sub> Panel Chair

## JGOFS APPENDIX II: LIST OF MEETINGS

### Meetings planned for 2000

8-10 February 2000, Nagoya, Japan - The 5th Meeting of the North Pacific Task Team and North Pacific Synthesis Workshop, Contact Toshiro Saino, Institute for Hydrospheric-Atmospheric Science, Nagoya University, Furo-cho, Chigusa-Ku, Nagoya 464-01, JAPAN, E-mail: [tsaino@ihas.nagoya-u.ac.jp](mailto:tsaino@ihas.nagoya-u.ac.jp)

Spring, 2000, Kiel, Germany - Data Management Task Team Meeting. Contacts: Roy Lowry (Chair), British Oceanographic Data Centre, Bidston Observatory, Birkenhead, Wirral, Merseyside L43 7RA, UNITED KINGDOM, or Margarita Conkright Gregg, NOAA/NODC, E/OC5, Silver Spring, MD, E-mail: [mconkright@nodc.noaa.gov](mailto:mconkright@nodc.noaa.gov)

13-17 April, Bergen, Norway - 2nd JGOFS Open Science Conference, Contact: Roger Hanson, JGOFS International Project Office, Center for Studies of Environment and Resources, Bergen High-Technology Centre, University of Bergen, Norway. Tel: (+47-555) 84244, Fax: (+47-555) 89687, Email: [Roger.Hanson@jgofs.uib.no](mailto:Roger.Hanson@jgofs.uib.no)

11-12 April, Bergen, Norway - The 15th meeting of the JGOFS Scientific Steering Committee, Contact: Roger Hanson, JGOFS International Project Office, Center for Studies of Environment and Resources, Bergen High-Technology Centre, University of Bergen, Norway. Tel: (+47-555) 84244, Fax: (+47-555) 89687, Email: [Roger.Hanson@jgofs.uib.no](mailto:Roger.Hanson@jgofs.uib.no)

9-13 July, Brest-France - The Southern Ocean: climatic changes and the cycle of carbon. An international JGOFS symposium, Contact: Paul Treguer, UMR CNRS 6539, Institut Universitaire Europeen de la Mer, Technopole Brest-Iroise, Place Copernic, 29280 PLOUZANE, France, Tel: (+ 33 2) 98 49 86 64, Fax: (+ 33) 2 98 49 86 45, Email: Paul.Treguer@univ-brest.fr

#### **Meetings held in 1999**

18-22 January, Tsukuba, Japan - JGOFS/IOC CO<sub>2</sub> Advisory Panel Meeting. Second International Symposium on CO<sub>2</sub> in the Oceans, Contact: Shizuo Tsunogai, Marine & Atmospheric Geochemistry Lab, Division of Oceanic & Atmospheric Sciences, Graduate School of Environmental Earth Science, Hokkaido University, Sapporo 060-0810, Japan. Tel: (+81 11) 706 2368; Fax: (+81 11) 706 2247, Email: mag-hu@ees.hokudai.ac.jp

18-20 January, Bangalore, India - International Scientific Symposium: Biogeochemistry of the Arabian Sea, Synthesis and Modelling, Contact: Roger Hanson, JGOFS International Project Office, Center for Studies of Environment and Resources, Bergen High-Technology Centre, University of Bergen, Norway. Tel: (+47-555) 84244, Fax: (+47-555) 89687, Email: Roger.Hanson@jgofs.uib.no

18-20 January, Bangalore, India - 1st Meeting of the Indian Ocean Synthesis Group, Contact: Peter Burkill, Plymouth Marine Laboratory, Prospect Place, West Hoe, Plymouth, PL 1 3DH, United Kingdom, Tel: (+44-1752) 633 422, Fax: (+44-1752) 633 101, Email: p.burkill@pml.ac.uk

21-29 January, Bangalore, India - Training Course on Biogeochemical Modelling of the Ocean, Contact: Roger Hanson, JGOFS International Project Office, Center for Studies of Environment and Resources, Bergen High-Technology Centre, University of Bergen, Norway. Tel: (+47-555) 84244, Fax: (+47-555) 89687, Email: Roger.Hanson@jgofs.uib.no

16-19 March, Taipei - 4th Meeting of North Pacific Task Team, Contact: Alexander Bychkov, Institute of Ocean Sciences, P.O. Box 6000, Sidney, British Columbia, B.C. Canada V8L 4B2. Tel: 1-250-363-6364, Fax: 1-250-363-6827, Email: bychkov@ccs.ios.bc.ca

7-13 May, Yokohama, Japan - 14th Meeting of JGOFS SSC (2nd IGBP Congress), Contact: Roger Hanson, JGOFS International Project Office, Center for Studies of Environment and Resources, Bergen High-Technology Centre, University of Bergen, Norway. Tel: (+47-555) 84244, Fax: (+47-555) 89687, Email: Roger.Hanson@jgofs.uib.no

24-26 August, Baltimore, MD, USA - JGOFS Executive Meeting, Contact: Roger Hanson, JGOFS International Project Office, Center for Studies of Environment and Resources, Bergen High-Technology Centre, University of Bergen, Norway. Tel: (+47-555) 84244, Fax: (+47-555) 89687, Email: Roger.Hanson@jgofs.uib.no

20-22 September, Toulouse, France - 2nd Meeting of the JGOFS North Atlantic Synthesis Group, Contact: Veronique Garcon, Cent. Nat. de la Recherche Scientifique, GRGS, 18 av Edouard Belin, F. 31055 Toulouse Cedex, France, Email: veronique.garcon@cnes.fr

**ANNEX 8 - GLOBEC: Global Ocean Ecosystem Dynamics**  
**Report of the SCOR/IOC/IGBP Scientific Steering Committee for 1999**  
Contributed by Roger Harris, Chairman GLOBEC SSC  
Plymouth Marine Laboratory, UK

**Summary of main achievements**

- Publication of the Implementation Plan
- Appointment of the IPO Executive Officer
- Publication of the GLOBEC Open Science Meeting Special Issue of *Fisheries Oceanography*
- Bologna Data Assimilation Workshop
- Establishment of a new combined Modeling and Sampling Group
- Establishment of new Retrospective Studies, and Process Studies Working Groups
- Full participation in the IGBP Congress

**Development of the GLOBEC Implementation Plan**

After final revision, SCOR and IOC approved the Implementation Plan, during the autumn of 1998. Formal approval was then given by IGBP at the SC-IGBP meeting in Estoril, Portugal in February 1999. There have been a number of technical problems with the final editing, and the IGBP staff member responsible left the Secretariat in the spring, so there was delay over the summer in printing the Plan in Stockholm. It was particularly unfortunate that it was not possible to publish the Plan in time for the IGBP Congress. The GLOBEC Implementation Plan was finally published in September, 1999, as IGBP Report No. 47, GLOBEC Report No. 13.

With the completion of the Implementation Plan the major issue confronting the Scientific Steering Committee at their fourth meeting in Japan was that of how to implement the programme of research laid out in the Plan. The SSC are responsible for taking charge and making sure that what is in the plan is done. To achieve this aim, the headings from the new Implementation Plan formed the major Agenda items for the 1999 SSC meeting. It was not possible to cover all aspects (Activities and Tasks) in detail during the meeting, nor can all be activated at once; the budget will not support this. The aim was to agree key actions and set priorities, for example Working Groups and workshops, for the coming year.

**Retrospective analyses and time series studies**

Although retrospective work is a central element in the Implementation Plan, no mechanism has yet been created to promote and guide these activities. At the Shonan Village Meeting A general consensus emerged that implementation of Focus 1 activities would require clear oversight and planning beyond what is now offered in the national and regional programs. This would require developing an agenda for implementation of prioritised activities and the organisational structure to achieve the goals set out.

A small Focus 1 Working Group is being established under the leadership of Ian Perry. The group will comprise a small subset of the GLOBEC SSC and others to implement approaches to address particular Focus 1 topics. This working group will catalyse activities through organisation of study groups, symposia and meetings to initialise the implementations. Proposed topics for the new WG were outlined as:

**Priority 1: Identify and evaluate ongoing time series research programs (Activity 1.1.1) for developing plans to support and co-ordinate sampling activities. This would be co-ordinated with the IOC initiative on time series program inventories. Time frame - completion by end of 2000**

**Priority 2: Identify possible locations for developing new, retrospective paleo data sets (Activity 1.3.1) This will be done in collaboration with compatible activities that are currently planned by PAGES-IMAGES (e.g. N. Atlantic survey in 1999; E. Pacific, 2001) and will be designed to advance the specific agendas of both GLOBEC and PAGES. The first step will be undertaken with a planning workshop to identify and develop the site-specific information as well as the necessary sampling protocols of GLOBEC requirements and to assign responsibilities for implementation. Time frame - completion by end of 2000**

**Priority 2: Identify and develop statistical approaches needed (Activity 1.2.1) to deal with the particular problems of biological time series. This will include identification of relevant data in need of "rescuing" (Activity 1.1.3).**

**Priority 3: Apply GLOBEC findings to support new time series activities (Activity 1.4.1) e.g. Liaison with IOC-GOOS (see below).**

### **Process studies**

International GLOBEC has not fostered activity in this area since the Cambridge meeting, in 1993, on "Population Dynamics and Physical Variability". Implementation strategy was discussed by the SSC, and a Focus working group under the leadership of Serge Poulet was agreed. This working group will 1) define specific tasks to address, in the study of the variability of rates in relation to physical variability; the target should be to define and inter-compare standard approaches and methodologies, 2) organise a meeting to review the achievements of process studies within the Regional and National Programmes and to identify gaps between what has been achieved and the goals laid out in the Implementation Plan.

The expected date for the first meeting will be defined as soon as possible, and will be before May 2000. The location for the first meeting was proposed as the Roscoff Marine Station.

The following initial activities were proposed for the WG:

- Defining core parameters for key process measurements, and core methods, filling the gap between the present state of the art and future needs for GLOBEC within the scope of the process studies identified in the Implementation Plan, and following zooplankton and fisheries modelling requirements.
- Organising a meeting to review the achievements of Process Studies within the Regional and National GLOBEC Programmes and to identify gaps between what has been achieved and the goals laid out in the Implementation Plan

### **Predictive and modelling capabilities**

At the Paris SSC meeting it had been agreed that potential Chairmen be approached for a newly constituted Sampling and Modelling Group. This new group would be configured to best meet the developing needs of the programme, and would have new Terms of Reference, chairmanship and membership. A list of potential members for the new group had been made through consultation within the SSC and outside, with a particular emphasis on including representatives from the regional field programmes. However, the two potential Chairmen nominated had both declined. Subsequently Professor Francisco Werner of the Department of Marine Sciences, University of North Carolina, Chapel Hill, accepted the SSC's invitation to lead the new group. The group will bring new focus,

direction and impetus to the GLOBEC modelling effort. Membership is currently being considered with a view to a first meeting in early 2000.

At the IGBP Congress, a joint session was organised by GLOBEC and JGOFS on, "Marine Ecosystem Models: Exploiting the JGOFS legacy". JGOFS is moving to its synthesis and modelling phase and there have been major achievements by JGOFS in relation to carbon flux modelling, modelling primary production, and coupling biology to GCMs. This legacy of JGOFS provides a solid foundation for GLOBEC modelling efforts at higher trophic levels, and for developing coupled physical-biological models. These are developed in Focus 3 of the GLOBEC Implementation Plan.

The aim of this discussion session was to explore ways to evaluate how far ecosystem modelling has progressed in addressing JGOFS and GLOBEC questions, and to nourish its progress further. In addition, the session discussed with other core projects how they could best share their experiences with other marine research agendas. Coupled physical and biogeochemical models in marine ecosystems constitute powerful research tools to test ecosystem functioning scenarios derived from in situ or satellite observation analysis. They are also the unique routes towards predicting the marine environment's response to natural and/or anthropogenic perturbations. Particular issues addressed were:

- Which aspects of ocean physics and dynamics are of the most direct concern for marine ecosystems?
- Are there significant structural differences in marine ecosystems and how do such differences affect the biological pump? Do the data give us enough information to choose among the candidate models and degree of complexity?
- How do we evaluate the fit of models and the constraining power of data? How do we extrapolate from local studies to the global scale?
- How "well" does the present generation of coupled biogeochemical and physical models predict the seasonal cycle of total and export production, distributions of phytoplankton chlorophyll, etc.?

A GLOBEC workshop on "The assimilation of biological data in coupled physical/ ecosystem models" was held in Bologna, Italy, from June 28-30 1999 involving biological data assimilation practitioners and advisors from physical oceanographic data assimilation, biological dynamics and modelling, biological observations and experiments. The organising committee included; Tommy Dickey, Eileen Hofmann, Michio Kishi, Nadia Pinardi, and Allan Robinson, chairman.

The goal of the Bologna workshop was to overview and assess the prospectus for the potential use of biological data assimilation together with the assimilation of compatible physical and chemical data, and to consider the utility and /or necessity of simultaneous assimilation of acoustical and optical data

Specific topics discussed included:

- The applicability and role of various methods of data assimilation (estimation, control and inverse methods, etc.)
- The structure of coupled models to accommodate and facilitate data assimilation
- Parameter estimation

- Process studies and simulations
- Development of predictive capability
- Dual use of data for validation and assimilation
- Feedback between models and observational strategies and implications for measurement technologies.

This was the final workshop in the successful series organised by the Numerical Modelling Working Group.

#### **Feedback from Changes in Marine Ecosystem Structure**

This is recognised as perhaps the most challenging of the GLOBEC Research Foci, and one for which other sessions at the IGBP Congress proved particularly valuable

To advance Activity 4.1 establishment of a small group of experts to discuss and develop the concepts of "atmospheric centres of action" and their roles in the variability of fish populations is recommended. This would link with the activities of the Focus 1 Working Group. Stronger contacts with the meteorological community are being sought and it is planned to explore opportunities to make GLOBEC presentations at CLIVAR meetings. Under Activity 4.2 it is planned to build on GLOBEC - LOICZ interactions, as a contribution. If specific geographic regions can be identified for GLOBEC - LOICZ studies, then other IGBP core programs (and other programs in general) with interests in the same geographic region might be invited to participate to build a large integrated regional study. Ramiro Sanchez will participate for GLOBEC in the LOICZ upcoming Open Science Meeting in Argentina

#### **Framework Activities**

These are the "cross-cutting" activities that demand attention from all components of international GLOBEC. These efforts will truly demonstrate the "value added" of the co-ordinated international programme. The list of activities in the draft Implementation Plan was reviewed by the SSC at their fourth meeting, and it was recognised that this would require prioritisation. Sampling and Modelling is largely the mandate of the new WG and the SSC will look to this group for recommendations. Data Management is at present seen to be largely an IPO function. Some scientific networking activities will also be done by the IPO, some are the responsibility of Foci, for example, interactions with climate programs

At the IGBP Congress, capacity building in SPACC was discussed both in the GLOBEC Steering Committee and in a joint meeting with START. The START experience is that mentoring is one of the most successful capacity building techniques; in this approach scientists from developing and developed countries work jointly on a particular research project relevant to the developing country. The START experience is that workshops, general academic training, or short training courses were much less successful. The success of SPACC workshops may be greater than other programs because of the practical nature of fishery work. If the technique is useful in fisheries there is a good chance it will be used. The costs of mentoring and student fellowships are substantial and SPACC will need help in soliciting funds from foundations to support such projects. With the establishment of the International Project Office it may be able to help out in seeking support for capacity building. The SSC also considered that GLOBEC might promote an educational and graduate research program that was certified by GLOBEC/SPACC. The program could have the following characteristics:

1. Certification that the research project is relevant to the client country.
2. Commitment of the donor academic institution to support the program.
3. Certification that the curricula provides practical benefits to the client country.
4. Commitment from the client country that the infra-structure and other kinds of support will exist when the student graduates and returns to the home country.

5. Some financial commitment of the client country to the project.

#### **Southern Ocean GLOBEC (SO-GLOBEC)**

In September 1998 a workshop was held at the U.S. National Science Foundation (NSF) with the objective of providing advice to the NSF Office of Polar Programs that could be used in the development of an Announcement of Opportunity (AO) for SO GLOBEC field activities. The report from this workshop is available via the U.S. GLOBEC web site and was also published in the U.S. GLOBEC newsletter in early 1999. Following this workshop, the NSF Office of Polar Programs released an AO for SO GLOBEC in mid-March 1999. Proposals in response to this AO are due 15 June 1999 and results of the proposal review will be available in late December 1999.

Aspects of the U.S. SO GLOBEC program that are important for other efforts in the Southern Ocean are that the study region includes the entire west Antarctic Peninsula continental shelf region, and that there are two field seasons, with the first in winter 2001 and the second in winter 2002. Within each field season, there will be two cruise periods, with the first in April-May and the second in July-August. During the 2001 field season the U.S. field effort will involve two ships, the RVIB Palmer (an icebreaker) and the RV Gould. The second year will involve only a single ship, the RV Gould.

In March 1999 the International Whaling Commission Working Group on Climate Effects on Cetaceans met in Edinburgh, Scotland with the intent of designing a collaborative field study with SO GLOBEC. The recommendations from this workshop will be presented to the IWC at the annual meeting in May 1999. Following the acceptance of these recommendations, more detailed planning will be needed to co-ordinate SO GLOBEC and IWC field activities in the Southern Ocean. It is anticipated that the IWC effort will be in the austral summer of 2001 and will include two IWC vessels. The region in which these vessels will operate is to be determined at future planning meetings.

At the meeting of the SO GLOBEC planning group in Paris in March 1998, a tentative ship schedule was drafted that would provide year round coverage in the Antarctic Peninsula region. The draft schedule involved participation by the U.S., Germany and the United Kingdom. Since that time, changes have occurred which have moved the German SO-GLOBEC effort to May 2001. Presently, there is no obvious mechanism to provide SO GLOBEC studies in the Antarctic Peninsula region during austral summer 2001 and 2002. However, CCAMLR cruises in this region, which are typically sometime in the January to March period, may be able to provide some bridging observations for the SO GLOBEC studies that will occur at other times of the year. The lack of coverage in the Antarctic Peninsula region during the austral summer will affect planning of IWC field activities.

Since the GLOBEC SSC meeting in Paris, names for membership of SO GLOBEC working groups on modelling and data management have been finalised. The working group membership and general objectives of the two working groups were published in the most recent International GLOBEC newsletter. Plans are now being made for the working groups to meet and begin their activities. A meeting of the SO GLOBEC planning group took place in August 1999. It was not possible to get all planning group members to the same venue, so part of the group met in Cambridge, England during the Southern Ocean Interannual Variability Workshop that took place at the British Antarctic Survey in early August. The remainder of the group met at the Krill Symposium that took place in Santa Cruz, CA in late August. The planning group members who attended both meetings will provide continuity.

#### **Small Pelagic Fishes and Climate Change (SPACC)**

Recent multinational activities of SPACC include, in the Americas projects on Spawning Habitat Dynamics (US, Mexico, Chile, and Chile), IMECOCAL (Mexico, US), and Sardine Trophodynamics (Brazil and US), and a

recently approved IAI proposal forming an eastern Pacific consortium (Peru, Chile, Mexico, US, Canada, Costa Rica, Columbia, and Ecuador). In southern Africa (South Africa, Namibia, and Angola) SPACC affiliated programmes include BENEFIT (Angola, Namibia, South Africa, Norway, Germany, VIBES (South Africa, and France), and ENVIFISH (Angola, Namibia, South Africa, Italy, Germany, Norway, and UK) and a SPACC project on physical forcing and pelagic fish production supported by a German aid mission and the research vessel METEOR. In addition, a SPACC programme exists in the Baltic Sea which involves Denmark Sweden, Finland, Estonia, Latvia, Poland, Russia and Germany; the project has been recently described in the last GLOBEC newsletter.

The Spawning Habitat Mapping (SPACC working group 8) carried out using the continuous underway egg sampler (CUFES) is developing well. The work is currently underway, in Mexico, USA, South Africa, and Spain, with new starts in Peru and Chile before the close of 1999. Purchase of CUFES, and training, for the Americas were financed by the IAI. The IMECOCAL program is also highlighted, which links with the CalCOFI program in the USA. IMECOCAL extends the CalCOFI survey pattern along nearly the full length of the Baja California peninsula (Mexico). Using the data from these linked surveys, Mexican and US scientists will write joint papers on the changes in ocean climate and fish distributions that have occurred over the last 50 years.

Future needs for education, training and workshops for SPACC were discussed at the SSC meeting. A workshop in early 2000 is needed for working group 8, as are implementation meetings for the SPACC working groups on genetics, and ocean climate and resource availability. A workshop on retrospective work was also considered important once the report of SCOR working group 98 is distributed and evaluated.

#### **ICES-GLOBEC Cod and Climate Change Programme (CCC)**

The plan for work in the Cod and Climate Change programme over the period 1999-2004 is contained in the Implementation Plan and is being actively followed through. A workshop on retrospective analysis of changes in the fisheries and plankton of the North Sea took place in March 1999 concentrating particularly on the "gadoid outburst" during the 1960's and 70's. Preparations have begun for a workshop on cod growth, which is planned for May 1999.

A symposium on the Trans Atlantic Study of Calanus (TASC) took place in August 1999 and there will be a mini-symposium and three GLOBEC related theme sessions at the ICES Annual Science Conference in September 1999. Full details of these are in the International GLOBEC Newsletter, the ICES/GLOBEC Newsletter and on the ICES web site ([www.ices.dk](http://www.ices.dk)). As a follow-up to the TASC symposium, there is a proposal to hold a theme session in 2000 on linkages between the dynamics of zooplankton and cod. ICES/GLOBEC Newsletter 4 (March 1999) contains information about GLOBEC related activities in fifteen ICES countries.

The ICES Working Group on Zooplankton Ecology will shortly be publishing a Zooplankton Methodology Manual and intends to carry out further analysis and publication of results from a sea-going workshop on inter-comparison of sampling gears over the next year. A joint meeting between this group and colleagues from PICES is proposed for next year in order to address issues of common interest, including methodology, standardisation, operational uses for monitoring activities and environmental indices and a review and comparison of zooplankton ecology of the North Atlantic and North Pacific.

The ICES/GLOBEC Co-ordinator post has been funded for a further two-year period (to July 2000) by Canada, US, Iceland and UK. Further extension of the post is being actively considered, since the level of GLOBEC related activity is likely to remain high for several years.

The EuroGLOBEC Science Plan provides a basis for GLOBEC related projects to organise around in applying for European funding. It also identifies the need for co-ordination and working linkages with programmes outside Europe.

#### **PICES-GLOBEC Climate Change and Carrying Capacity Programme (CCCC)**

The activities and plans of the PICES-GLOBEC, Climate Change and Carrying Capacity (CCCC) Programme, involve four Task Teams (TT) currently: Basin Study (BASS) in the central gyre, Regional Experiment (REX) along the coastal areas of Asia and North America, Model (MODEL), and Monitoring (MONITORING).

The BASS TT completed a review of the papers from the BASS Symposium 1997 entitled "Ecosystem dynamics in the eastern and western gyres of the sub-arctic Pacific". The proceedings have been published in *Progress in Oceanography* in summer 1999. This information can be used for identifying research questions and opportunities with respect to the physical structure and ecosystem dynamics of the gyres.

The REX TT published PICES Scientific Report Series No. 9, "PICES CCCC Workshop on development of cooperative research in coastal regions of the North Pacific". This will be a basis for a long-term work plan in the region. Also, the title of the REX Topic Session during the PICES VII in Fairbanks, Alaska in 1998 was "CCCC of the North Pacific: recent findings of GLOBEC and GLOBEC-like program in the North Pacific". Members agreed to continue the same Topic Session in the PICES meeting for next several years. The 1998 REX Workshop on "Climate effects on small pelagic species" will be published in the PICES Scientific Report Series in 1999. REX plans to hold a workshop on "Comparative dynamics of herring and euphausiids" in 1999.

The monitoring TT held a workshop in 1998, and reviewed the existing activities among member countries. Members also identified monitoring needs and inter-calibration experiments. The results of the Workshop will be published in the PICES Scientific Report Series in 1999. They will construct a table of present shipboard monitoring in the subarctic North Pacific by time and space. The future CPR operation across the North Pacific, and zooplankton sampling gears will be discussed in 1999.

The Model TT dealt with lower trophic level model comparison issues in the 1998 Workshop, and gathered information for a nutrient data base. Also, they built a directory of existing circulation models which will later be expanded to include biological models. The results of the Workshop will be published in the PICES Scientific Report Series in 1999. They plan to include the nutrient data base directory, and make a prototype lower trophic level model with 15 compartments available on the WWW in 1999.

#### **Developing Relations with GOOS-LMR**

GOOS-LMR is mentioned at many places in the Implementation Plan. Dr Ned Cyr, from IOC, attended the SSC meeting, and this provided a good opportunity for a first-hand report on the status of GOOS-LMR planning, and how it might link with GLOBEC implementation. The recent activities of the Living Marine Resources module of the Global Ocean Observing System (LMR GOOS) were considered.

LMR GOOS is in the process of defining a strategic design, and has compiled a draft table of generic monitoring products which will be considered for inclusion in the final model. In addition, LMR GOOS, has begun to designate ongoing observing projects as components of GOOS Digital Observing System (DOS) and to develop concepts for pilot projects. One recommended pilot project is the initiative of LMR GOOS observing activities in conjunction with ongoing regional GLOBEC projects. This approach could be mutually beneficial, with GLOBEC field studies helping to define an effective suite of general monitoring products for LMR GOOS, and LMR GOOS ultimately ensuring that the time series observations begun by GLOBEC become operational. It was recommended that an informal GLOBEC-LMR GOOS working group be established to pursue further collaboration on pilot

projects, and to provide a means for GLOBEC input on selection of generic LMR GOOS. Roger Harris represented GLOBEC at the LMR-GOOS Panel meeting held in Montpellier, March 22-24, 1999.

**Scientific Steering Committee**

The GLOBEC SSC met once during the year, at the IGBP Congress, Shonan Village, Japan, 7-13<sup>th</sup> May 1999. Agenda items discussed are covered in this report. The full Minutes of the SSC meetings are available from the GLOBEC Web-Site (<http://www1.npm.ac.uk/globec/>), or on request from the Plymouth Office. The current membership of the GLOBEC SSC is shown in the Table below.

		1999	2000	2001
Dr Jürgen Alheit	Germany			
Dr Tim Baumgartner	Mexico			
Dr Francois Carlotti	France			
Dr Tommy Dickey	USA			
Dr Roger Harris*	UK			
Prof Eileen Hofmann	USA			
Dr Tsutomu Ikeda	Japan			
Dr Suam Kim	Korea			
Dr Celia Marrase	Spain			
Dr Ian Perry	Canada			
Dr Serge Poulet	France			
Dr Nadia Pinaridi	Italy			
Dr Sergey Piontkovski	Ukraine			
Dr Ramiro Sanchez	Argentina			
Dr Frank Shillington	South Africa			
* Chairman				

Nominations have been made to the co-sponsors to fill the seven seats on the SSC which become vacant at the end of the year.

**International Project Office**

After an initial unsuccessful selection process during 1998, a re-advertisement for the Executive Officer position was placed in January 1999, a short-list of candidates was interviewed, and Dr Manuel Barange, currently at the Sea Fisheries Research Institute in Capetown, accepted the position. Manuel Barange was awarded his PhD in 1991 on the ecology of euphausiids in the Benguela upwelling system. Following a post-doctoral project on the acoustic assessment of Antarctic krill he joined the fisheries acoustics team of the SFRI in 1993, and became head of its Surveys Division in 1996. He has conducted research on euphausiid ecology, zooplankton and fish aggregative behaviour, vertical migration and trophic ecology of fish, survey design and acoustic assessment of pelagic and semi-demersal fish populations. He has also participated actively in the administrative and scientific management of the SFRI (now Marine and Coastal Management), particularly in regional and international initiatives on the dynamics of fisheries resources and their physical environment in the Benguela. Manuel Barange will start in October 1999. The SSC at their meeting in Japan expressed widespread approval of this outcome, and they look forward to working with Dr Barange, and to the renewed impetus that his appointment will bring to GLOBEC. Recruitment of a Deputy Executive Officer is currently underway. Andrea Watson, Media Co-ordinator, completes the IPO team in Plymouth.

## **ANNEX 9 - SCOR Affiliated Group on Acoustic Monitoring of the Global Ocean (ATOC)**

Prior to a meeting of the SCOR AG on Acoustic Monitoring of the Global Ocean at JAMSTEC on February 10, a symposium was held at the Hotel Kaiyo, Tokyo, on February 8-9. This symposium, sponsored by JAMSTEC and supported by the Japanese Science & Technology Agency, the Nippon Foundation, the Oceanographic Society of Japan and the Marine Acoustics Society of Japan, served to establish the current status of acoustic thermometry and acoustic tomography internationally. Thirty two papers were presented over two days in five sessions:

- Progress in acoustic tomography (observations, techniques, modeling)
- Results of Acoustic Thermometry of Ocean Climate in the Pacific
- Application of acoustic tomography and thermometry to other ocean basins
- Linking ocean acoustic data with general circulation (and other) models
- Developments in acoustic sources, simple receivers, signal processing

Proceedings of this Symposium, compiled by JAMSTEC are in press and will be available shortly. The emphasis was on new and intriguing technologies, methods and models, which are fully reported in the Proceedings. A theme that emerged from many of the speakers was that international collaboration has been vital to their recent developments and advances. This theme was carried forward to the SCOR AG meeting at JAMSTEC, which immediately followed the Symposium.

The declared theme of the meeting was, "Progressing plans for proliferating acoustic thermometry". Discussion centred on four possible objectives that would help achieve this goal:

- Establishing an Indian Ocean acoustic thermometry network
- Augmenting the Pacific network
- Developing inexpensive receivers
- Calibrating the acoustic thermometer with CTDs

### **Augmenting the Pacific network**

This item was discussed first, with Peter Worcester (Scripps) taking the lead in describing the prospects of either continuing or augmenting the Pacific ATOC network. The source on Pioneer Seamount is due to be recovered very soon, after two years of intermittent operation. One of the conditions of the Marine Mammal Permit that permitted its limited use for marine mammal research was that it and its cable would be removed after two years of operation. The ATOC source off Kauai will cease transmission in October this year unless an extension for its operation is gained. There was general consensus that a high priority be given to continuing the time series at Kauai.

Reports from the extensive marine mammal research program are that they have not found any measurable effects of biological significance of the ATOC sound transmissions on marine mammals in the vicinity of either source. This result may support a successful application to operate the Kauai source for climate research, without the need for an accompanying marine mammal research program.

Peter Worcester reported that a billboard array, formed by a VLA deployed in conjunction with the Point Sur HLA, is operating with support from ONR and is likely to continue if a low frequency source continues to operate in the North Pacific.

### **Developing inexpensive receivers**

At the preceding symposium, Thierry Terre (IFREMER) and Bruce Howe (APL/UW) described their efforts to develop autonomous, inexpensive receivers that would enable acoustic thermometry networks to be established in ocean basins or regions not covered by existing military receivers. The main obstacle to building low cost receivers is the need for high precision clocks. Present clock technology (rubidium oscillator periodically "on") is not characterised as low cost, nor particularly low power. The availability of GPS timing signals to terrestrial and sea surface receivers has slowed the development of low cost, low power clocks for undersea use. Increasing battery capacity is the present design solution.

Autonomous low frequency sources capable of multi-year deployment are still not a reality, and cabling sources, while relatively reliable, is a costly exercise. Iwao Nakano (JAMSTEC) described their progress in designing and fabricating higher efficiency sources, but battery capacity is still a constraint. Bruce Howe described a developing program, the Deep Earth Observing System (DEOS) which is envisaged to install 30 to 40 ocean bottom seismometers powered by cables to shore. It is conceivable that provision could be made in such a network to also power an ATOC-like source.

### **Establishing an Indian Ocean acoustic thermometry network**

The Chair, Andrew Forbes, took the lead in proposing the establishment of an acoustic thermometry network in the Indian Ocean. Several critical elements are required to make this a reality:

- a low frequency source
- cable to power the source
- a suitable source site
- receivers

Consistent with the identified theme of international collaboration, Peter Worcester (Scripps) and Bob Spindel (APL/UW) expressed strong support for the redeployment of one of the Pacific ATOC sources to the Indian Ocean. CSIRO Australia has successfully negotiated with Telstra (Telecommunication Australia) for the supply of the required length of suitable cable, currently stored in Singapore. Andrew Forbes has identified Cocos Island as a suitable source site, based on its location, bathymetry and sovereignty (as an Australian territory). A site survey will be conducted in October this year using a CSIRO research ship, in conjunction with Bruce Howe (APL/UW) and Matt Dzieciuch (Scripps). Preliminary propagation analysis shows that a source placed at sound axial depth at Cocos should ensonify 75% of the Indian Ocean. Fabianne Gaillard (IFREMER) has, since the SCOR meeting, offered to contribute one of their new generation of autonomous receivers off Madagascar, to be installed by IFRTTP's Marion Dufresne. Martin Lawrence (CTBTO) has indicated that data from a network of three Test-Ban Treaty hydroacoustic stations soon to be installed in the Indian Ocean, should be available for "dual use". These elements all add up to a very real prospect that an Indian Ocean acoustic thermometry network will become a reality over the next couple of years.

There was overwhelming consensus expressed by the SCOR AG that this initiative be pursued vigorously.

In a more general discussion about the next step for acoustic thermometry, several points were made:

- The European Space Agency was faced with similar problems, some years ago, of relying on government agencies to fund its expansion. The solution was found in engaging the active support of industry. This could prove a successful model to follow.
- A greater effort could be made to become a key contributor to CLIVAR, GOOS, EUROGOOS, instead of an independent program.

- An expended, updated programmatic document needs to be written that builds on the successful Pacific demonstration of ATOC, and clearly maps out a plausible global network. This integrated approach has more chance of success than a sequential, piecemeal approach.

## **Participants**

**Andrew Forbes, Chair**

**Victor Akilicheb**

**John Colosi**

**Bruce Cornuelle**

**Warren Denner**

**Yves Desaubies**

**Brian Dushaw**

**Fabienne Gaillard**

**Kevin Heaney**

**Bruce Howe**

**Ola Johannessen**

**Leon Krige**

**Bill Kuperman**

**Martin Lawrence**

**Dimitris Memmenlis**

**Peter Mikhalevsky**

**C.S. Murty**

**Jungxul Na**

**Iwao Nakano**

**Uwe Send**

**EC Shang**

**Bob Spindel**

**Thierry Terre**

**Peter Worcester**

**L Xiao**

**Renhe Zhang**

**ANNEX 10 - International Antarctic Zone (iAnZone )**  
**Report of Activities for Period Ending September 1999**

*iAnZone* has had a highly productive past year. In concert with its primary goal of providing a vehicle for coordination and integration of Antarctic oceanographic research programs that emphasize climate interactions, the past year's efforts came to a focus at the biannual meeting held in Mar del Plata, Argentina during May 1999. The South American meeting site represented a deliberate attempt to facilitate attendance by southern hemisphere participants. This meeting was attended by 22 oceanographers. Seven countries, including Australia, the United States and some in western Europe and South America, were represented. Also represented were the US National Science Foundation and the WCRP program of the WMO.

Each of the several activities being addressed by *iAnZone* was discussed at the biannual meeting. A detailed set of minutes from the meeting is currently in preparation and will be provided to SCOR when available. A brief summary of the meeting provides an effective summary of *iAnZone* progress over the past year.

Brief synopses were presented of US, Argentine, German, Spanish and Brazilian research in the region of the Weddell-Scotia Confluence. This research has included both field and modeling studies. *iAnZone* was instrumental in developing an international program called *DOVETAIL* (Deep Ocean Ventilation Through Antarctic Intermediate Layers), which is focused on this region, and is playing an active role in integration of the results from recent field work, ongoing modeling work, the new multi-year field program planned to be undertaken by Brazil, and long-term current measurements planned by the US. Through these several efforts, the possibility now exists that we may obtain an unprecedented decade-long time series documenting interannual variability of oceanographic conditions in the region and, in so doing, gain valuable new insight into Southern Ocean climate change. An international scientific workshop that will address integration and coordination of ongoing *DOVETAIL* research has been scheduled to take place in Barcelona during May 2000, directly following the EGS Assembly in Nice.

Research on polynyas, shelf and slope circulation is being carried out at a number of sites. Work by Australian researchers along the Adèlie Land coast was discussed, and tentative results were addressed at some length within the context of shelf-slope convection and bottom water formation. Brief descriptions were presented of work planned to take place from 1999 through 2003, allowing ample opportunity for future input and possibly participation on the part of other researchers. This topic of polynyas and bottom water formation is being addressed in the southwest Weddell Sea by *FRISP* (the Filchner-Ross Ice Shelf Project), a joint UK, Norwegian and US program. The possibility of field work in 2001 and 2003 was discussed, providing an opportunity for planning of collaborative efforts. Underway and planned Italian work addressing polynya fluxes in Terra Nova Bay and slope frontal processes in the Ross Sea was presented and discussed. This work included both physical and biological oceanographic components, and provided needed input for the early planning stages of an international program, discussed briefly below, that is being planned to address shelf-slope water mass modification processes.

Brief presentations were made of ongoing and projected work under the *WOCE*, *SO GLOBEC* and *LTER* programs, and ways were discussed in which these might be integrated with *DOVETAIL* program interests. Possible approaches included consideration of variability in the Circumpolar Current using model results

The topic of bottom water formation and modification through shelf-slope density flow and deep ocean convection processes provides current primary foci for *iAnZone* new program planning. *iAnZone* has to date been responsible for development of three programs in the Weddell Sea. The first dealt with northward boundary transport, the second with heat flux and water formation processes, and the third with efflux of deep and bottom water from the Weddell Sea. Plans are now underway for a fourth set of experiments that will address water mass

formation mechanisms. One experiment is perceived as an open ocean convection study, is based heavily upon winter field work in the eastern Weddell Sea, and is primarily a German program with some Finnish participation also possible. Additionally, a group of US researchers has voiced interest in the open ocean convection problem and plan to coordinate with the European work. A second experiment will address deep water formation associated with shelf break fronts and density flows, and will probably be based on a field experiment in the Ross Sea. This second experiment is planned to be heavily international. Preliminary planning for a US component was carried out at a workshop during February 1999 and was presented and discussed briefly at the Mar del Plata meeting. Planning for the international program will take place at a workshop that is scheduled for late September 1999.

Concern was voiced about the lack of an "umbrella" program for meteorological and ice observations in the Southern Ocean, the intended emphases being on climate studies. The Antarctic drift buoy program has decreased in size since its inception, and is now in danger of folding. The importance of a long sequence of buoy-derived records for understanding climate change was emphasized. These studies would be encompassed, along with development of sea ice models, under a newly proposed WCRP program on Climate and Cryosphere" (*CLIC*). The *iAnZone* group recommended full support of CLIC, inasmuch as the Southern Ocean is felt to be both important to global climate and badly undersampled. This topic is being pursued through WCRP representatives.

There was some discussion of newly developed methodology and instrumentation relevant to high latitude Southern Ocean work. Use of ice-toughened PALAS floats to improve our understanding of Weddell Gyre circulation was suggested. Formation of an international program of volunteers to launch floats as part of a large-scale program was suggested and is being pursued informally. The lack of reliable ice data was mentioned, and a standardized method for reporting ice conditions was described.

A number of administrative points were addressed at the Mar del Plata meeting. The matter of member rotation was broached. The two past co-chairmen, E. Fahrbach (Germany) and A. Gordon (US) stepped down at the end of the meeting and were replaced by H. Hellmer (Germany) and R. Muench (US) who will co-chair the group through the next biannual meeting. Concern was voiced that member terms be sufficiently long to maintain a "corporate memory", which suggests that terms encompassing two biannual meetings would be appropriate. Because of the small number of members in attendance (7), it was decided to defer specific decisions concerning member rotations until the next scheduled biannual meeting. At this time, a number of members is planned to be rotated out and new members added. This will provide an opportunity to broaden the geographical basis for membership by including those from other countries, such as Korea and China, that have newly-developed Antarctic oceanographic programs. The point was made that these members must be able to pay their own way to attend the biannual meetings. It was determined that future meetings need to be structured to provide more of a forum for scientific presentations, particularly within the context of national programs. It was recommended that more effort be put into obtaining proxy presentations from those countries not able to send representatives. It was noted that an *iAnZone* web site is maintained at LDEO, and meeting attendees were asked to submit material for this site.

The next *iAnZone* biannual meeting has been tentatively scheduled to take place on 8-13 October 2001 in Italy in conjunction with a Ross Sea conference. In the interim, the *iAnZone* goal of international coordination and integration of Antarctic ocean activities is being pursued through specific workshops, such as the planning workshop for the shelf-slope study, and via email as in the case of the planned Brazilian field work. The May 1999 meeting served as a highly effective focal point that allowed presentation and discussion of a broad range of programs at a single venue and thereby set the stage for these continuing international collaborations.

## ANNEX 11 - International Ocean Colour Coordinating Group

### Background

The International Ocean-Colour Coordinating Group (IOCCG) was established in 1996, under the auspices of the Intergovernmental Oceanographic Commission (IOC) of UNESCO, following a resolution endorsed by the Committee on Earth Observation Satellites (CEOS). In 1998 the group became an Affiliated Program of the Scientific Committee on Oceanic Research (SCOR) which subsequently provided infrastructure support and financial management for the group. In June 1999, the IOCCG applied for Associate status of CEOS, which will be discussed at the next CEOS Plenary (November, 1999).

### About the IOCCG

The IOCCG is a committee of experts in the field of satellite ocean colour, which acts as a liaison and communication channel between users, managers and agencies in the ocean-colour arena. Aims of the IOCCG include promoting strong international cooperation and coordination in the acquisition, calibration, validation, distribution and utilization of ocean-colour data as well as broadening the user community for ocean-colour data, particularly in developing countries, through advanced training courses.

In the past three years, five satellites carrying ocean-colour sensors have been launched by various nations (one of these has since ceased to function), with a further five satellites scheduled for launch by the end of 2000. Many of these missions have different technical and hardware requirements and not all provide global coverage. Clearly, there is a need for coordination of these satellites as well as for the acquisition, distribution and calibration of the data.

### Major Scientific Achievements:

Over the past year, the IOCCG has been involved in a wide range of activities. These include the formation of a number of specialized scientific working groups, provision of training opportunities in developing countries, as well as coordination with other relevant scientific programmes such as those of CEOS and JGOFS.

#### *Specialized working groups*

A major focus of the IOCCG has been the initiation of specialized working groups to investigate various aspects of ocean-colour technology and its applications. The end product of these working groups is the publication of a scientific report which can be used to provide appropriate advice to Space Agencies. Last year saw the publication of two IOCCG reports in this series: the first report entitled "Minimum Requirements for an Operational Ocean-Colour Sensor for the Open Ocean" (IOCCG Report Number 1) was published in November, 1998. This report explored the feasibility of including a minimum set of common spectral channels on all future ocean-colour sensors. The second report in the series entitled "Status and Plan for Satellite-Ocean-Colour Missions: Considerations for Complementary Missions" was published in May, 1999. This report dealt with the technical requirements for global-scale, operational, remote sensing of ocean colour in both Case 1 and Case 2 waters and also addressed the issues of complementarity that arise when more than one sensor with similar capabilities is in orbit at the same time. Both reports have been well received by the scientific community and will be used in discussions with CEOS for planning a strategy for ocean-colour remote sensing in the post-2005 era.

A third IOCCG working group recently met in Ispra, Italy (14-18 June, 1999) to discuss various aspects of remote sensing in Case 2 waters. It is well recognized that the standard algorithms in use today for chlorophyll retrieval from satellite data only work well in relatively simple Case 1 waters. The prospects of better algorithms for Case 2 waters have improved vastly with the advent of the new generation of ocean-colour sensors, which have superior spectral and radiometric resolution. At present, the working group is drafting the text for IOCCG Report Number 3, which will: (i) examine how various substances influence the colour of Case 2 waters (ii) review the progress to

date in remote sensing of Case 2 waters and identify residual problems (iii) summarise the potential applications and (iv) point out promising avenues for further action. It is hoped that this report will be published by the end of the year.

### *Training courses*

In January, 1999, the IOCCG coordinated and sponsored an advanced training course on Biogeochemical Modeling of the Ocean, in Bangalore, India, as a component of a broader JGOFS training course. More than forty students from twenty different industrialized and developing countries participated in the course. The course content included analytical methods, numerical simulation and the use of remotely-sensed data on ocean colour as a tool for extrapolation. In addition to the lectures there were also computer demonstrations of software, along with hands-on training. The feedback from the students at the end of the course indicated that it was very well received and many students were looking forward to applying the new skills they had acquired in their research programmes. The timeliness of the training course will be enhanced by the wealth of satellite data on ocean colour which is now available from the new-generation of ocean-colour sensors.

### *Coordination with other scientific programmes*

The IOCCG continues to support the CEOS initiative for an Integrated Global Observing Strategy (IGOS). Initially this support was directed through the Ocean Biology Pilot Project, which CEOS handed over to the IOCCG to implement. Recently, the focus of IGOS shifted from the Space Agencies to the "users", through the formation of an IGOS Partnership. In addition, the Ocean Biology Pilot Project was incorporated with GODAE into the new "Oceans Theme". This structure should provide a more coherent focus for the implementation of an IGOS. The IOCCG hopes to become a member of the IGOS Partnership once the application for CEOS Associate status has been approved.

The IOCCG has also been collaborating with NASA's SIMBIOS Project (Sensor Intercomparison and Merger for Biological and Interdisciplinary Oceanic Studies), through participation in the SIMBIOS Science Team Meetings as well as planning future working groups with SIMBIOS members to investigate the calibration of ocean colour sensors to common standards (see below).

### **Plans for the next year**

#### *Working groups*

The IOCCG has commissioned several new working groups to discuss various issues of relevance to remote sensing of ocean colour and to produce reports for the IOCCG Series of Reports. The following new working groups have been recently established:

- **Calibration of ocean-colour sensors to common standards:** Chaired by Dr. A. Neumann (DLR, Germany). This group will investigate the absolute calibration of ocean-colour instruments to a common standard as well as the radiometric intercalibration of sensors. The group includes representatives from major Space Agencies as well as SIMBIOS.
- **Establishment of a standard validation data set:** Chaired by Dr. J. Ishizaka (Nagasaki University, Japan). The aim of this working group is to establish a source of sea truth data for Space Agencies and users. The data would help to confirm the calibration of new sensors, ensure the accuracy of satellite data (validation), detect the bias of each sensor as well as detect regional biases.
- **Data merging – chaired by Dr. J. Campbell (University of New Hampshire, USA).** This group aims to implement a strategy to produce a merged long-term, global, chlorophyll data set, taking into account issues such as atmospheric correction. The group will collaborate with representatives from each of the three major agencies that provide ocean-colour data (ESA, NASDA and NASA) to examine these issues, and to prepare an IOCCG Report.

### *Training courses*

In November, 1999, the IOCCG will hold another advanced training course on remote sensing of ocean colour. This course entitled "Applications of Marine Remote Sensing" will take place at the Asian Institute of Technology, Bangkok, Thailand. The course is being organized and coordinated by the IOCCG and will be sponsored by NASDA, IOCCG and JRC. Participants will be drawn principally, but not exclusively, from the SE Asian region. Lectures will cover a range of topics from bio-optical fundamentals to the use of *in situ* data for retrieval of chl-*a* from Case 2 waters. Special emphasis will be placed on applications of ocean colour relevant to the South-East Asia region. Practical sessions will be held every afternoon including hands-on exercises and demonstrations. Over 80 applications have already been received indicating the high demand for this type of training course.

### **Current Membership of the IOCCG**

The IOCCG Committee is currently chaired by Dr. Trevor Platt (BIO, Canada) and consists of 20 members drawn from Space Agencies and ocean-colour communities, selected to reflect a balance of both providers and users of ocean-colour data as well as geographical location. There are two types of committee members:

- scientific members, appointed in their personal capacities, who fill the needs of the IOCCG for specific expertise, and
- members representing various Space Agencies and other organizations which have an interest in ocean-colour remote sensing and in providing support for the activities of the IOCCG.

The term of service is usually three years except where the members participation is governed by a Space Agency nomination. Rotation of members will be implemented according to a roster.

### **IOCCG Committee Members (1999)**

Aiken, James	-	Plymouth Marine Laboratory, United Kingdom
Campbell, Janet	-	University of New Hampshire, USA
Dantzler, Lee	-	NOAA/NESDIS, USA
Frouin, Robert	-	Scripps Institution of Oceanography, USA
Ishizaka, Joji	-	Nagasaki University, Japan
Kopelevich, Oleg	-	P.P. Shirshov Institute of Oceanography, Russia
Lifermann, Anne	-	CNES, France
Marra, John	-	NASA HQ, USA
Morel, André	-	Laboratoire de Physique et Chimie Marines, France
Navalgund, Rangnath	-	Indian Space Research Organization, India
Neumann, Andreas	-	German Aerospace Research Establishment, Germany
Parslow, John	-	CSIRO Division of Fisheries, Tasmania, Australia
Platt, Trevor (Chairman)	-	Bedford Institute of Oceanography, Nova Scotia, Canada
Rast, Michael	-	ESA/ESTEC, Netherlands
Schlittenhardt, Peter	-	Joint Research Center, Ispra, Italy
Shillington, Frank	-	University of Cape Town, South Africa
Tanaka, Tasuku	-	EORC/NASDA, Tokyo, Japan
Ulloa, Osvaldo	-	Universidad de Concepción, Chile
Yoder, James	-	University of Rhode Island, USA
Yoo, Sinjae	-	Korea Ocean Research and Development Institute

### **Benefits of the Affiliation to SCOR**

The IOCCG has greatly benefited from the efficient and professional manner in which its funds have been managed by SCOR. In addition, the IOCCG has been strengthened by having visible links with one of the major international and intergovernmental organizations in the marine sphere. The affiliation of the IOCCG with SCOR also ensures an efficient mechanism for coordination with other SCOR programs, such as JGOFS or GLOBEC, or with intergovernmental organizations such as the International Council for the Exploration of the Sea (ICES), as well as non-governmental organizations such as the International Geosphere-Biosphere Program (IGBP).

### **Relevance of Ocean Colour to Societal Needs**

Measurements of ocean colour from space allow oceanographers to view the global distribution and concentration of chlorophyll pigments (an index of phytoplankton biomass) in the oceans. There are three broad applications of this data. Firstly, since phytoplankton fix carbon dioxide during photosynthesis, ocean-colour data can be used to quantify the ocean-atmosphere fluxes of carbon and to help understand how it is controlled and why it varies from year to year. This is of major importance in climate change research. Secondly, ocean-colour data may be used in the general area of coastal zone management, including fisheries management. Ocean-colour maps of pigment distribution may be used directly to help predict the presence of fish shoals for operational fishing fleets, or they may be used to provide long-term data for analysis of decadal trends in exploited fish stocks. Ocean-colour data are useful for many other aspects of coastal-zone management, *e.g.* monitoring harmful algal or coastal pollution. Lastly, since phytoplankton control the optical turbidity in most parts of the ocean they also control the manner in which the mixed layer heats up under the influence of the sun. The transmissibility of visible light through the ocean is an important element in physical models that calculate the depth and temperature of the mixed layer, which is critical for weather forecasting in maritime areas.

**ANNEX 12 - 1998 Final Financial Statement and Budget Comparison**

	<b>BUDGET</b>	<b>ACTUAL</b>
<b>INCOME</b>		
Membership	210,000	229,610
less uncollectable dues		-2,540
ICSU Grant re JGOFS	17,500	17,500
ICSU Grant re GLOBEC	17,500	17,500
IGBP Support fror GLOBEC	10,000	7,250
IOC Contracts	29,000	29,000
Less IOC support to ICSOS		-10,000
Less IOC support to ICSOS		-9,000
NSF Grant re Travel Awards	62,000	57,612
NSF Grant re Science Activities	250,000	249,749
NASA Grant re Coastal Models WG	15,000	9,239
NATO Support for AOSB Symposium	24,100	24,109
NASA Grant re GEOHAB Workshop	15,000	15,000
NSF/NOAA Grant re GEOHAB	20,000	20,000
Nessling Foundationn re GEOHAB	7,800	7,807
IUPAC Support fro Fe Symposium	6,000	6,000
Miscellaneous Income	<u>607</u>	<u>608</u>
<b>SCOR INCOME</b>	<b>684,507</b>	<b>669,444</b>

***AFFILIATED ACTIVITIES (funds managed by SCOR Secretariat)***

<b>INCOME FOR ICSOS</b>	93,930
<b>INCOME FOR IOCCG</b>	111,991
<b>TOTAL INCOME</b>	<b>875,365</b>

**EXPENSES**

**SCIENTIFIC EXPENSES**

Sardine and Anchovy WG ('97 exp)	617	617
Coral Reefs WG - symposium	12,200	13,151
Fish Harvest Impacts WG	15,000	14,921
Iron Chemistry WG	16,000	15,451
Coastal Models WG	15,000	9,239
New WG - Groundwater	5,000	4,646
New WG - Asian Monsoons	10,000	9,738
JGOFS	100,000	83,236
GLOBEC	100,000	92,369
SOLAS	<u>4,000</u>	<u>3,763</u>
<b>Total SCOR Subsidiary Bodies</b>	<b>277,817</b>	<b>247,131</b>
<b>Other Scientific Activities</b>		

AOSB Symposium	55,000	53,682
GEOHAB Workshop	62,800	66,012
Graduate Education Initiative	600	567
Fedorov Memorial Symposium	5,000	5,000
TOS magazine sponsored issue	30,000	30,396
Fe Symposium	15,000	11,135
Misc. NSF funded activities	5,000	3,527
Travel Awards	<u>70,000</u>	<u>57,612</u>
<b>Total</b>	<b>243,400</b>	<b>227,931</b>
<b>TOTAL SCIENTIFIC EXPENSES</b>	<b>521,217</b>	<b>475,062</b>
<b>RELATED SCOR EXPENSES</b>		
Representation	7,500	6,981
Publications	27,000	23,625
General Meeting	<u>20,000</u>	<u>22,889</u>
<b>Total</b>	<b>54,500</b>	<b>53,495</b>
<b>TOTAL NON-ADMIN. EXPENSE</b>	<b>575,717</b>	<b>528,557</b>
<b>SCOR SECRETARIAT EXPENSES</b>		
Salaries and Benefits	125,000	123,927
less allocation to major programs		-33,500
part-time help / web page, etc	4,000	0
Communications*	6,000	2,864
Office Equipment	3,200	3,697
Audit and Accounting Services*	6,000	7,550
JHU overhead charges	19,000	18,593
Bank charges	200	185
Miscellaneous*	4,000	2,113
Loss on Foreign Exchange	0	<u>31</u>
<b>TOTAL SECRETARIAT EXPENSES</b>	<b><u>167,400</u></b>	<b><u>125,460</u></b>
<b>TOTAL SCOR EXPENSES</b>	<b>743,117</b>	<b>654,017</b>
<b>AFFILIATED ACTIVITIES (funds managed by SCOR Secretariat)</b>		
<b>EXPENSES FOR ICSOS</b>		<b>93,930</b>
<b>EXPENSES FOR IOCCG</b>		<b>111,991</b>
<b>TOTAL EXPENSES</b>		<b>859,938</b>
<b>SCOR BALANCE:</b>		
Accumulated Balance 12/31/97	121,944	121,944
Excess of Income over Expenses	<u>(23,610)</u>	<u>15,427</u>
Accumulated Balance 12/31/98	<b>98,334</b>	<b>137,371</b>

\* some costs in these budget lines were allocated to major activities (e.g. JGOFS, GLOBEC, ICSOS, IOCCG)

## ANNEX 13 - Report from World Meteorological Organization

The following paragraphs summarize briefly the activities undertaken within WMO during the past year which may be of interest to SCOR. This summary covers essentially the Marine Meteorology and Associated Oceanographic Activities Programme.

### **Buoys and other ODAS**

The Data Buoy Co-operation Panel (DBCP) held its fourteenth session in Marathon, Florida (USA) in October 1998 and its fifteenth session is scheduled for Wellington (New Zealand) in October 1999. The work of the panel continues to be effected largely by its technical coordinator, Mr Etienne Charpentier, who coordinates directly with both operational and research deployers of drifting and moored buoys. Approximately 1200 drifting buoys and 70 open ocean moored buoys worldwide operated by 25 countries are reporting basic marine meteorological, surface and sub-surface oceanographic variables onto the GTS. The total number of data reports from buoys distributed on the GTS in BUOY code has increased from less than 20,000 per month in mid-1987 to more than 220,000 per month in mid-1999.

Twelve countries and two data management centres submitted reports on their data buoy activities. These data are monitored and processed for long-term archival in at least four data management centres. At the operational level, the panel works through regional or programme Action Groups. At present time, there are seven such action groups, which are all essentially fully operational and likely to continue for the foreseeable future. These are the European Group on Ocean Stations, the International Arctic Buoy Programme, the International Programme for Antarctic Buoys, the International South Atlantic Buoy Programme, the International Buoy Programme for the Indian Ocean, the Global Drifter Programme and the TAO Implementation Panel. Statistics on data availability and reports from countries and data management centres are contained in the DBCP Annual Report for 1998, copies of which may be obtained from the technical coordinator. The panel also now convenes a scientific/technical workshop with its annual session, the proceedings of which are published in the panel's technical document series.

The panel's QC methods continue to be extremely effective in ensuring data quality is maintained at the highest level. Real time monitoring of the quality of buoy reports is undertaken by several major meteorological centres, which have formal WMO responsibilities for marine surface data. Quality control guidelines have been implemented by the technical coordinator and operate through a network of participating meteorological or oceanographic centres. QC guidelines have resulted in substantial improvements in quality since the introduction of the scheme, and now form a part of the WMO Guide to the Global Observing System. The DBCP home page is: <http://dbcp.nos.noaa.gov/dbcp/>

### **Integrated Global Ocean Service System (IGOSS)**

IGOSS has been directly involved in implementation of the common GOOS/GCOS ocean climate module, in particular through the Ship-of-opportunity Programme (SOOP). This programme is now being coordinated and monitored as an on-going, operational ocean observing system, and an operational SOOP implementation plan has been prepared. A complete and detailed survey of existing and projected SOOP resources was compiled. This resource survey is being used by the IGOSS Ship-of-opportunity Programme Implementation Panel (SOOPIP) and the Ocean Observations Panel for Climate (OOPC) as part of an ongoing dialogue to determine the most scientifically effective way of using the available resources to monitor upper ocean heat content in support of global climate studies. The SOOP Coordinator position was combined with the DBCP Technical Coordinator and has operated since April 1999. The new coordinator is regarded as the focal point for international coordination of all technical and management aspects of SOOP. The new SOOP home page is: <http://www.ifremer.fr/ird/soopip>

The IGOSS Products Bulletin (IPB) continues to compile and publish monthly IGOSS global and regional products as a service to the scientific and operational oceanographic community and international programmes.

The monthly electronic version of the IPB (EIPB) is available on line through World Wide Web (WWW) and can be accessed as follows: <http://rainbow.ideo.columbia.edu/productsbulletin>.

The EIPB is an important support not only to IGOSS, but to global observing systems such as GOOS and GCOS.

#### **Other activities**

In response to developing requirements for a more coordinated approach to operational ocean monitoring and services, and with support from the GCOS Steering Committee, the GOOS Steering Committee and the Joint Scientific Committee for the WCRP, the thirteenth WMO Congress (May, 1999) and the twentieth IOC Assembly (June/July, 1999) formally established a Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM). The JCOMM replaces the existing Commission for Marine Meteorology (CMM) and Joint IOC/WMO Committee for the Integrated Global Ocean Services System (IGOSS). The new body will be supported in equal measure by WMO and IOC, with responsibilities to include those of the existing CMM and IGOSS, as well as for coordinating and managing the implementation of an operational ocean observing system in support of GOOS and GCOS. The first transition planning meeting for the JCOMM took place in St.Petersburg (Russia) in July 1999. The meeting in particular addressed procedures for the transition from existing uncoordinated marine programme activities of WMO and IOC into a fully coherent and integrated approach to marine observing systems, data management and services envisioned under JCOMM. The first formal session of JCOMM is scheduled for 2001. The principal JCOMM science advisory body is OOPC.

Further information on all activities under the WMO Marine Programme (including DBCP and IGOSS) can be accessed through the WMO home page on the web: <http://www.wmo.ch/web/aom/marprog/marprog.html>.

## ANNEX 14 - ICES Report to SCOR - 1999

The 1998 ICES Annual Science Conference was held in Cascais, Portugal. It attracted more than 1,000 participants which was the highest number ever to participate in an ICES meeting. The Conference saw the full implementation of the new ICES Science Committee structure, viz Fisheries Technology, Oceanography, Resource Management, Living Resources, Mariculture, Living Resources, and Baltic Committees. The Committee's have an initial focus to develop the science components of an ICES Five-year Strategic plan, which will be unveiled shortly. They are also examining their current activities and developing new initiatives, based on the Strategic Plan, which are reflected in the names of various new working and study groups. Notable amongst these are new study groups on marine habitat mapping and marine biodiversity. In parallel with the re-organisation of the science structure of ICES, a thorough review of the ICES advisory structure is also currently underway. This is partly motivated by pressure from ICES partner organisations who increasingly need ecosystem-based advice.

Preparations are now well underway for the first of the ICES "Centenary" meetings. The 1999 Annual Science Conference will be a celebration of the Stockholm Conference of 1899 that paved the way for the formation of ICES in 1902. The Conference will include four special Centenary Lectures. These will be on "Otto Pettersson and the Birth of ICES" by Dr A Svansson, "ICES and Ocean Exploration" by Prof W Wooster, "ICES and the Overfishing Problem" by Prof. J Jakobsson and "ICES and Environmental Issues" by Prof A.D. McIntyre. The Conference has a broad programme reflecting the wide range of marine and fisheries issues of concern to ICES. These include "Plans for Major International Programmes in the North Atlantic Region over the Next Decade", "Nordic Seas Exchanges", "Application of Coupled Bio-physical Models in Studies of Zooplankton and Ichthyoplankton Advection and Dispersion", "Evaluation of Complete Fisheries Systems: Economic, Social, and Ecological Analyses" and "Ecosystem Management - Can We Make it Operational".

The ICES-SCOR Symposium on Ecosystem Effects of Fishing in March 1999 was, by all accounts, a tremendous success. ICES is grateful to SCOR for the major contribution it made to the planning and execution of this Symposium. The ICES Symposium on "Population Dynamics of *Calanus* in the North Atlantic: Results from the Trans-Atlantic Study of *Calanus finmarchicus*" was held very recently in Tromsø, Norway (24-27 August 1999). Most of the Symposium was based on the results of the EU MAST programme TASC. Amongst other things, the Symposium identified new research avenues, in particular in methodology relevant for zooplankton ecology. New technology platforms (e.g., OPC and VPR) are seen to have strong potential for future measurement of plankton on mesoscale and large scales, and to provide possibilities to estimate population dynamic processes at a new level. It was considered that the results presented to the Symposium represented a major contribution to the ICES scientific objective of understanding the physical, chemical, and biological functioning of marine ecosystems. The TASC programme in particular has demonstrated the value of interdisciplinary, international marine science projects in carrying out very large-scale research. A goal of studies such as this to provide ICES with the link to studies of fisheries dynamics through programmes such as GLOBEC.

Forthcoming ICES Symposia include:

ICES Symposium on "100 Years of Science under ICES": Helsinki, Finland, 1-3 August 2000. Convener: Dr E. D. Anderson (USA). Helsinki, Finland, 1-3 August 2000. Convener: Dr E. D. Anderson (USA).

ICES Symposium on "Capelin - What Are They Good For? Biology, Management and the Ecological Role of Capelin": Reykjavik, Iceland, Summer 2001: Co-Conveners: Dr H. Vilhjalmsson (Iceland) and Dr J. Carscadden (Canada).

ICES Symposium on "Hydrobiological Variability in the ICES Area, 1990-1999": Edinburgh, Scotland, UK, 8-10 August 2001. Co-Conveners: Dr R. R. Dickson (UK) and Professor J. Meincke (Germany).

ICES Symposium on "Acoustics in Fisheries and Aquatic Ecology": Montpellier, France, 10-14 June 2002 Co-Conveners: Dr F. Gerlotto (France) and Dr J. Massé (France).

Further details concerning these Symposia will be posted on [www.ices.dk/symposia](http://www.ices.dk/symposia).

The ICES/GLOBEC Regional Office continues to support and co-ordinate the activities of ICES in the ICES/GLOBEC programme on Cod and Climate Change. Dr K Brander remains in charge of the Office. The ICES/GLOBEC program has

produced a considerable body of work over the year (including Newsletters, Workshop and Working Group reports, Theme Sessions and the TASC Symposium). The Office has played a greater or lesser part in assisting with these, and has helped to ensure a flow of information across a wide geographic and scientific range of activity.

Progress in applying results from the programme to issues in fisheries management and environmental protection has proceeded steadily. The effects of environmental change (e.g. temperature effects on distribution, growth and recruitment) are becoming scientifically more credible, but there is some way to go in evaluating whether such effects are sufficiently large and predictable to treat them as explanatory variables rather than noise. Information about environmental change is considered to be more important at longer time scales and therefore in relation to management strategy, rather than short term tactics and year to year forecasting.

The ICES Working Group on Ecosystem Effects of Fishing has not yet held its 1999 meeting when its main activity will be to prepare a framework in which ICES evaluates and advises on ecosystem effects of fishing. It will review ecosystem effects of fishing activities in the Baltic Sea, and develop formats for providing structured information on quantities of fish discards and offal. It will also begin consideration of the development of integrated management objectives as a basis for an ecosystem approach to management, integrating fisheries and environmental aspects.

The ICES Advisory Committee on the Marine Environment (ACME) continues to work closely with those ICES Science Committees whose remits encompass environmental issues (Oceanography, Marine Habitat and Mariculture Committees). In 1999 ACME reported progress on a wide range of environmental issues based mainly on information prepared by a number of ICES working groups. These issues include the continuing development of monitoring guidelines and techniques, development of contaminant trend detection techniques, effect of extraction of marine sand and gravel, ballast water and sediment issues, effect of anthropogenic nutrients on the phytoplankton community, seabird diet and food supply, and environmental interactions of mariculture. ACME is the only ICES body responsible for preparing ecosystem advice, and in this respect it prepared advice at its 1999 meeting on the nature of interactions between sandeels and seabirds. The specific advice relates to whether the large quantities of sandeels being fished from the North Sea might adversely affect the sandeels' predators such as seabirds and marine mammals. ACME has also been encouraging the development of a web-based ICES Environmental Status Report, based on products from various working groups. This can be viewed at [www.ices.dk/status](http://www.ices.dk/status). Its contents currently consist of a report on the 1998/1999 Ocean Climate Status (product of the Working Group on Oceanic Hydrography), and the 1989-1998 phytotoxin status (product of the ICES-IOC Working Group on Harmful Algal Bloom Dynamics).

## ANNEX 15 - Status Report on the WCRP

Several important developments have taken place within the WCRP during this past year with respect to our involvement with SCOR activities. Besides a very active AIMS phase for WOCE and rapid programme development in CLIVAR (see below), a new WCRP programme has been initiated to address the role of the cryosphere in global climate, dubbed "Climate and Cryosphere (CLIC)". A CLIC science plan has been drafted and it is anticipated that the document will be formally endorsed by the Joint Scientific Committee for the WCRP (JSC) in March 2000. CLIC will involve strong cooperation with IanZone, amongst others.

The activities of the joint SCOR/WCRP WG on Intercomparison and Validation of Ocean-Atmosphere Flux Fields will be reported under item 2.2.7. The work of this Group is of paramount importance to virtually every WCRP project. A final report from the WG is expected early in 2000.

WCRP is a sponsor, through the CLIVAR UOP and OOPC, of the Ocean Observing System for Climate Conference in St. Raphael, France, 18-22 October 1999. It is expected that this meeting will go a long way towards establishing the framework for a truly integrated global ocean observing system to support climate and other research and operational needs. WCRP also strongly welcomes the formation of the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) through the merger of the WMO Commission for Marine Meteorology and IGOSS. JCOMM provides a means by which research observations can become part of the operational mainstream of measurements, thereby helping to ensure continuity and international coordination and cooperation.

### World Ocean Circulation Experiment

The past year has been one of consolidation for WOCE following the very successful WOCE Conference in Halifax in May 1998. The analysis and interpretation of WOCE data continues despite the fact that in many countries specific WOCE funding lines have ended. This is evidenced by the continued rapid growth of the WOCE bibliography. The Analysis Interpretation Modelling and Synthesis (AIMS) phase has as its focus a number of regional and subject-based workshops. These are listed below:

<u>Date</u>	<u>Subject</u>	<u>Venue</u>	<u>Co-sponsor</u>
Aug 1996	Pacific	Newport Beach USA	
Jun 1997	S Atlantic	Brest France	
Aug 1997	S Ocean	Hobart Australia	
Mar 1998	State estimation	Baltimore USA	GODAE
May 1998	WOCE Conference	Halifax Canada	
Aug 1998	Ocean modelling	Boulder USA	CLIVAR
Sep 1998	Indian Ocean	New Orleans USA	
Feb 1999	Tracer	Bremen Germany	
Aug 1999	N Atlantic	Kiel Germany	
Late 2000	Variability	Japan	CLIVAR
Summer 2001	Fluxes	Southampton UK	JGOFS
2003	WOCE Conference	Baltimore USA	

The oversight of WOCE activities continues through its SSG and Data Products Committee. This latter group is overseeing the planned 2000 production of the second version of the CD ROM data set. A cause of some concern is the need for continued funding of the WOCE Data Assembly Centres until such time as WOCE data assembly and quality control are complete. In this regard the development of a data strategy for CLIVAR which may be expected to endorse the continuing need for many (if not all) WOCE DACs is crucial. The CLIVAR data structure for ocean, atmosphere, model and paleo data is being formulated by the CLIVAR Data Task team.

A comprehensive summary of observations made during the WOCE period is being assembled and will be published in 2000. A further activity is the production and distribution of a WOCE Atlas (electronic and hard copy) of hydrographic measurements. The funding and distribution strategy will be discussed by the WOCE SSG in October 1999.

The project continues to be supported by the WOCE IPO in Southampton UK. The production of the WOCE Newsletter occupies one staff member virtually full time but a reader survey in 1999 showed that the NL was highly valued by WOCE researchers and it will therefore continue in its present form until such time as relevant new material ceases to be forthcoming.

A book based on papers presented at the 1998 WOCE Conference is being produced and will be published in 2000.

WOCE officially comes to an end as a WCRP project in 2002, and a final WOCE Conference is planned for 2003. An offer to host this in the USA has been accepted.

A major discussion point at the next WOCE SSG meeting will be the assessment of progress made towards the goals of WOCE and the identification of problems hindering progress.

### **Climate Variability (CLIVAR)**

CLIVAR held a major International Conference at UNESCO headquarters in Paris 2-4 December, 1998. The response and enthusiasm shown by the 250 delegates representing 63 countries was a very gratifying endorsement of interest in CLIVAR science. The Conference reviewed the International CLIVAR Implementation Plan (WCRP No. 103) and representatives from countries in attendance briefly presented their national plans. A volume of proceedings has been published (WCRP No. 108). As noted at the Conference, the challenge now is to harness the energy and enthusiasm of nations and individuals into a coherent and internationally coordinated effort to address CLIVAR objectives. Many nations have developed, or are developing national CLIVAR plans, often as a direct result of the Conference, and CLIVAR is providing the framework for international consultations and coordination.

Together with GODAE and others, CLIVAR is initiating ocean observing projects such as ARGO - a global array of profiling floats, Pirata (Pilot Research Moored Array in the Tropical Atlantic), and expansion of the TAO/TRITON array both in the Pacific and the Indian Ocean. A CLIVAR Atlantic Panel has been formed to coordinate implementation of observing systems in support of the many CLIVAR research thrusts concerned with the Atlantic, eg. Variability of the American Monsoon Systems (VAMOS), African Climate Variability, North Atlantic Oscillation, Tropical Atlantic Variability, and Atlantic Thermohaline Circulation. Workshops are being planned for the Pacific and Southern Oceans to consider observing system and other requirements in these sectors.

Ocean and coupled modeling activities in support of CLIVAR are being carried out by the Working Group on Seasonal to Interannual Prediction and the joint CLIVAR/JSC Working Group on Coupled Modeling. Data assimilation, and in particular ocean data assimilation, are areas of particular concern, as well as, of course, the treatment of air-sea fluxes (see item 2.2.7).

As mentioned above, CLIVAR is designing a data management structure to meet its requirements which will take into account existing WOCE and TOGA centers as well as developing GCOS and GOOS activities.

**ANNEX 16 - SCOR Scientific Subsidiary Bodies  
as of January 1, 2000**

GROUP	TITLE OF WORKING GROUPS	Chair/Co-Chair	Reporter
WG 103	The Role of Wave Breaking on Upper Ocean Dynamics	Banner	Fennel
WG 105	The Impact of World Fisheries Harvests on the Stability and Diversity of Marine Ecosystems	Sinclair	Field
WG 106	Relative Sea Level and Muddy Coasts of the World	Wang	McCave
WG 107	Improved Global Bathymetry	Summerhayes	Piccolo
WG 108	Double Diffusion	Chashechkin/ Fernando	Lappo
WG 109	Biogeochemistry of Iron in Seawater	Turner/Hunter	Tsunogai
WG 110	Intercomparison and Validation of Ocean-Atmosphere Flux Fields	Taylor/Gulev	Lappo
WG 111	Coupling Waves, Currents and Winds in Coastal Models	Huang/Mooers	Fennel
WG 112	Magnitude of Submarine Groundwater Discharge and its Influence on Coastal Oceanographic Processes	Burnett/Kontar	Sundby
WG 113	Evolution of the Asian Monsoon in Marine Records: Comparison Between Indian and East Indian Subsystems	Wang	McCave
WG 114	Transport and Reaction in Permeable Marine Sediments	Boudreau	Sundby
WG 115	Standards for the Survey and Analysis of Plankton	TBD	Burkill
WG 116	Sediment Trap and 234 <sup>Th</sup> Methods for Carbon Export Flux	Buesseler	McCave
WG 117	Synthesis of Decadal to Millennial Climate Records of the Past 80ky	Sarnthein/Kennett	McCave
WG 118	New Technologies for Observing Marine Life	Farmer	Burkill
<b>SCIENTIFIC STEERING COMMITTEES and other Program Planning Groups</b>			
JGOFS	Joint Global Ocean Flux Study SSC	Ducklow	Field
GLOBEC	Global Ocean Ecosystem Dynamics SSC	Harris	Burkill
GEOHAB	Global Ecology & Oceanography of Harmful Algal Blooms	Gentien/Fukuyo	Sundby
<b>AFFILIATED PROGRAMS</b>			
ATOC	Acoustic Thermometry of Ocean Climate	Forbes	Piccolo
IAnZone	International Antarctic Zone	Muench/Hellmer	Piccolo
IMAGES	International Marine Global Changes	Labeyrie	McCave
InterRIDGE	International RIDGE Studies	Cannat	McCave
IOCCG	International Ocean Color Coordinating Group	Platt	Field
<b>PROGRAMS UNDER DEVELOPMENT</b>			
SOLAS	Surface Ocean - Lower Atmosphere Study Task Team	Duce / Liss	Burkill

## ACRONYMS AND ABBREVIATIONS

AGU	American Geophysical Union
AIMS	Analysis, Interpretation and Modeling (phase of WOCE)
AOSB	Arctic Ocean Science Board
APL/UW	Applied Physics Laboratory, University of Washington
ASPECT	Antarctic Sea Ice Processes, Ecosystems and Climate (SCAR-GLOCHANT)
ATOC	Acoustic Thermometry of Ocean Climate
BASS	Basin Scale Studies (GLOBEC-CCCC)
C-GOOS	Coastal GOOS
CalCOFI	California Cooperative Fisheries Investigation
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CCC	Cod and Climate Change Program (ICES-GLOBEC)
CCCC	Climate Change and Carrying Capacity (PICES-GLOBEC)
CEOS	Committee on Earth Observing Satellites
CFC	Chlorofluorocarbon
CLIC	Climate and Cryosphere
CLIVAR	Climate Variability and Prediction program (WCRP)
CMM	Commission for Marine Meteorology (formerly of WMO)
CMIT	Continental Margins Task team (of JGOFS and LOICZ)
COASTS	Coastal Ocean Advanced Science and Technology Studies (of IOC)
CoML	Census of Marine Life
CPR	Continuous Plankton Recorder
CSIRO	Commonwealth Scientific and Industrial Research Organization (Australia)
CTD	Conductivity, Temperature, Depth (Profiler)
CUFES	Continuous Underway Fish gg Sampler
DBCPC	IOC/WMO Drifting Buoy Cooperation Panel
DMTT	Data Management Task Team (of JGOFS)
DOC	Dissolved Organic Carbon
DOFTT	Deep Ocean Fluxes Task Team (of JGOFS)
DOM	Dissolved Organic Matter
DON	Dissolved Organic Nitrogen
DOVETAIL	Deep Ocean Ventilation Through Antarctic Intermediate Layers (iAnZone)
EASIZ	Ecology of the Antarctic Sea Ice Zone (SCAR)
EC	Executive Committee (SCOR) or Executive Council (IOC)
ECOR	Engineering Committee on Oceanic Resources
EGS	European Geophysical Society
ENSO	El Niño-Southern Oscillation
EPSG	Equatorial Pacific Synthesis and Modeling Group (of JGOFS)
ESA	European Space Agency
FAO	Food and Agriculture Organization (UN)
FRISP	Fildner-Ross Ice Shelf Project
GAIM	Global Analysis, Interpretation and Modelling (IGBP)
GCM	Global Circulation Model
GCOS	Global Climate Observing System (WMO, IOC, ICSU, UNEP)

GEF	Global Environmental Facility
GEOHAB	Global Ecology and Oceanography of Harmful Algal Blooms (program of SCOR and IOC)
GESAMP	Group of Experts on the Scientific Aspects of Marine Environmental Protection
GLOBEC	Global Ocean Ecosystem Dynamics (SCOR, IGBP)
GLOCHANT	Group of Experts on Global Change in Antarctica (SCAR)
GODAE	Global Ocean Data Assimilation Experiment
GOOS	Global Ocean Observing System (IOC, WMO, UNEP, ICSU)
HAB	Harmful Algal Blooms
IABO	International Association of Biological Oceanography (IUBS)
IAI	Inter-American Institute for Global Change Research
IAMAS	International Association for Meteorology and Atmospheric Sciences (IUGG)
iAnZone	International Antarctic Zone
IAPSO	International Association for the Physical Sciences of the Ocean (IUGG)
IASC	International Arctic Sciences Council
ICES	International Council for the Exploration of the Sea
ICSOS	International Conference on Satellites, Oceanography and Society
ICSU	International Council for Science
IFREMER	Institut Francais de Recherche pour l'Exploitation de la Mer
IGAC	International Global Atmospheric Chemistry Programme (IGBP)
IGBP	International Geosphere-Biosphere Programme (ICSU)
IGO	an Intergovernmental Organization
IGOS	Integrated Global Observing Strategy
IGOSS	IOC/WMO Integrated Global Ocean Services System
IHP	International Hydrology Program (of UNESCO)
IMAGES	International Marine Aspects of Global Change program (IGBP/PAGES, SCOR)
INSA	Indian National Science Academy
InterRidge	International RIDGE studies
IOC	Intergovernmental Oceanographic Commission (of UNESCO)
IOCCG	International Ocean Colour Coordinating Group
IOSG	Indian Ocean Synthesis and Modeling Group (of JGOFS)
IPCC	Intergovernmental Panel on Climate Change
IPHAB	IOC Intergovernmental Panel on Harmful Algal Blooms
IPO	International Project Office
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 Mathematics
IWC	International Whaling Commission
JAMSTEC	Japanese Ministry of Science and Technology
JCOMM	Joint Commission on Oceanography and Marine Meteorology (of IOC and WMO)
JGOFS	Joint Global Ocean Flux Study (SCOR, IGBP)
JODC	Japan Oceanographic Data Center
JRC	Joint Research Centre (of the European Commission)
JSC	Joint Scientific Committee for the WCRP (ICSU, WMO)
LDEO	Lamont-Doherty Earth Observatory

LME	Large Marine Ecosystem
LMR	Living Marine Resources
LOICZ	Land Ocean Interactions in the Coastal Zone (IGBP)
MAST	Marine Science and Technology (EEC)
MBL	Marine Boundary Layer
NANSEN	North Atlantic - Norwegian Sea Exchange
NASA	National Aeronautics and Space Administration (USA)
NASDA	National Space Development Agency (Japan)
NASG	North Atlantic Ocean Synthesis and Modeling Group (of JGOFS)
NATO	North Atlantic Treaty Organization
NGO	a Non-governmental Organization
NIO	National Institute of Oceanography (India)
NFWAR	National Institute for Water Research (NZ)
NOAA	National Oceanic and Atmospheric Administration (USA)
NOPP	National Oceanographic Partnership Program (US)
NOW	Northwater polynya project
NPTT	North Pacific Task Team (of JGOFS)
NSF	National Science Foundation (USA)
NSFC	Natural Science Foundation of China
OCMIP	Ocean Carbon Model Intercomparison Project (of GAIM/
OOPC	Ocean Observations Panel for Climate (GCOS)
OOPC	Ocean Observations Panel for Climate
PACON	Pacific Science Congress on Marine Science and Technology
PAGES	Past Global Changes (IGBP)
pO <sub>2</sub>	partial pressure of CO <sub>2</sub>
PICES	North Pacific Marine Sciences Organization ("Pacific ICES")
PMTT	Photosynthetic Measurements Task Team (of JGOFS)
POC	Particulate Organic Carbon
POGO	Partnership for Observations of the Global Ocean
POM	Particulate Organic Matter
PON	Particulate Organic Nitrogen
PPJTT	Paleo-JGOF Task Team
REX	Regional Experiment
RSTT	Remote Sensing Task Team (of JGOFS)
SAHFOS	Sir Alister Hardy Foundation for Ocean Science (UK)
SC-IGBP	Scientific Committee of the IGBP (ICSU)
SCAR	Scientific Committee on Antarctic Research (ICSU)
SCOPE	Scientific Committee on Problems of the Environment (ICSU)
SCOR	Scientific Committee on Oceanic Research (ICSU)
SEAMONS	SCOR-IMAGES Evolution of the Asian Monsoon
SFRI	Sea Fisheries Research Institute (South Africa)
SIBEX	Second International BIOMASS Experiment
SIO	Scripps Institution of Oceanography
SO	Southern Ocean
SOIREE	Southern Ocean Iren Release Experiment

SOLAS	Surface Ocean - Lower Atmosphere Study (IGBP, SCOR)
SOOP	Ship of Opportunity Program
SOSG	Southern Ocean Synthesis and Modeling Group (of JGOFS)
SPACC	Small Pelagic Fishes and Climate Change (GLOBEC)
SSC	Scientific Steering Committee
SSG	Scientific Steering Group
SST	Sea Surface Temperature
START	Global Change System for Analysis, Research and Training (IGBP)
TAO	Tropical Atmosphere - Ocean
TASC	Trans-Atlantic Study of <i>Calanus</i>
TEMA	Training, Education and Mutual Assistance
TOS	The Oceanography Society
TT	Task Team
UCAR	University Corporation for Atmospheric Research
UN	United Nations
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific, and Cultural Organization
VAMOS	Variability of the American Monsoon Systems
WCRP	World Climate Research Programme (WMO, IOC, ICSU)
WDC	World Data Center
WESTPAC	IOC Regional Sub-Commission for the Western Pacific
WG	Working Group
WGASF	JSC-CCCO Working Group on Air-Sea Fluxes
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment (WCRP)
WWW	World Wide Web
XBT	Expendable Bathythermograph