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**OF THE**

**SCIENTIFIC COMMITTEE ON OCEANIC RESEARCH**

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# REPORT OF THE XXIII GENERAL MEETING OF SCOR

Southampton Oceanography Centre

Empress Dock, Southampton, UK

Monday, Tuesday, September 16 & 17, and Friday, September 20, 1996

## 1.0 INTRODUCTION

### 1.1 Opening Remarks and Administrative Arrangements

The XXIII General Meeting of the Scientific Committee on Oceanic Research (SCOR) took place at the Southampton Oceanography Centre on September 16, 17 and 20, 1996. A two-day scientific symposium on "Mid-Ocean Ridges: their Biology, Physics and Geology" was jointly organized by SCOR WG 99 ("Linked Mass and Energy Fluxes at Ridge Crests") and the British RIDGE research community, and this took place on September 18 and 19.

The list of participants in the SCOR General Meeting is given in Annex 1; the program of the mid-ocean ridge symposium may be found in Annex 2, and a symposium publication is forthcoming from the Southampton Oceanography Centre.

The General Meeting was chaired by Professor I.N. McCave, the President of SCOR, who welcomed the participants for this, his final meeting as President. Professor John Shepherd, Director of the Southampton Oceanography Centre, also welcomed everyone to this major new institution which combines the former Institute of Oceanographic Sciences (Wormley) with the Departments of Oceanography and Geology of Southampton University, as well as the office for research vessel services which was previously separated from IOS Wormley.

### 1.2 Approval of the Agenda

The Agenda for the meeting was adopted without change and this report follows the format of the agenda as adopted. An explanation of all acronyms and abbreviations used in this report appears in Annex 12 on the last page.

### 1.3 Report of the President of SCOR

Professor McCave reviewed the highlights of his four year term as President of SCOR which would end at this meeting. He noted especially the various new working groups which were established during this period and that they have a fairly equitable disciplinary balance among their various topics. There was also a new emphasis on coastal science as recommended in the report of the ICSU Panel which reviewed SCOR in 1992. The development of the Joint Global Ocean Flux Study (JGOFS) and the program on Global Ocean Ecosystem Dynamics (GLOBEC) as SCOR's contributions to the International Geosphere-Biosphere Program (IGBP) should be a matter of pride for SCOR. SCOR's scientific competence is recognized in the Memorandum of Understanding among the sponsors (IOC, ICSU, WMO) of the Joint Scientific and Technical Committee for the Global Ocean Observing System (JGOOS) and SCOR is being called upon to contribute its expertise in the GOOS planning process.

During his tenure, two countries have joined SCOR; Ireland and the Philippines. The new mechanism of Affiliated Programs now permits SCOR to consider sponsoring activities which may extend beyond the scientific scope or normal lifetime of a single SCOR working group, and for which a substantial commitment of funds or staff support is not required from SCOR (as it has been in the cases of JGOFS and GLOBEC). Two of these activities, the program on Acoustic Thermometry of Ocean Climate (ATOC) and International Marine Aspects of Global Change (IMAGES) arose from SCOR working groups. The agenda for the General Meeting included discussions of these and two other programs originating outside SCOR, all of which sought Affiliated Program status (see Agenda item 2.5).

Professor McCave noted that good links have now been developed with the International Union of Pure and Applied Chemistry (IUPAC) and that the General Meeting would consider the first proposal for a joint

SCOR-IUPAC activity (see Agenda item 5.).

In conclusion, the President expressed his hope that SCOR will continue to play a strong role to enhance the depth and breadth of international activities in all branches of the marine sciences.

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

In accordance with the SCOR Constitution, the General Meeting appointed an *ad hoc* Finance Committee to review the administration of SCOR finances during the previous fiscal year (1995) and the current year. It also drafted a budget for 1997 activities based on the decisions taken during the meeting and was charged to make any other recommendations relating to SCOR's finances which it felt to be appropriate. The Committee was chaired by M. Whitfield (UK), included I. Jones (Australia), B. Sundby (Canada) and K. Taira (Japan) and presented its report to the General Meeting under agenda item 3.3.

## **2.0 SUBSIDIARY BODIES**

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

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

The Chair of former WG 78, R.F.C. Mantoura, reported that, while his group had been established a rather long time ago, this coincided with the development of new techniques for pigment determination, such as high performance liquid chromatography and remote sensing, and with the emergence of large-scale programs such as JGOFS. The WG organized three laboratory workshops and, as a result of these, the scope of its planned monograph of pigment methods was greatly expanded to include other types of pigments in addition to chlorophyll, and simpler methods for use at sea. The monograph arising from these workshops will replace a much earlier version prepared by SCOR WG 17 and published by UNESCO in 1966. Entitled "Phytoplankton pigments in oceanography: guidelines to modern methods", the lengthy manuscript was edited by S.W. Jeffrey, R.F.C. Mantoura and S.W. Wright, and is in the final stages of preparation for publication by UNESCO in its series *Monographs in Oceanographic Methodology* in early 1997.

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

M. Whitfield, the Chair of former WG 80, reported that he is working to update the various papers submitted by members of the WG some time ago. He is exploring the possibility of expanding the report of WG 80 in collaboration with IUPAC.

### **2.2 Current Working Groups**

As the President introduced this portion of the agenda, he reminded participants that the SCOR Constitution and the Objectives and Procedures for SCOR Working Groups specify that the tenure of SCOR subsidiary bodies automatically expires at each General Meeting. Their reports must demonstrate adequate justification for their reinstatement for an additional two years. The Executive Committee Reporters for each working group were called upon to present the relevant reports and to make recommendations to the General Meeting on the actions to be taken.

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

J. Strömberg reported that WG 86 held a meeting in Prague, Czech Republic (May 24-25, 1996) to discuss the organization of the approved Gordon Research Conference on Sea Ice Ecology to be held in Ventura California, 2-7 March 1997. This conference will be the final activity of WG 86. The science program was drafted at the meeting (see Annex 3) and has been widely distributed.

This will be the first in a series of Gordon Research Conferences on the Polar Marine Sciences which was established in response to the initial approach of WG 86 for funds to support its planned conference.

A committee was established to organize a book on Sea Ice Ecology, consisting of R. Horner, (Chair), S.F. Ackley and Richard Rivkin. This effort will proceed in parallel with, but distinct from the Gordon Conference, since the conferences have a prohibition on the publication of proceedings. The Gordon Conference will provide an opportunity to complete the organization of the book, as most potential chapter authors will be in attendance, and poster papers presented by conference participants will allow new results to be included, and other authors to be identified at the meeting.

Members of WG 86 have participated in the writing of a science plan for the Antarctic Sea Ice Processes Ecosystems and Climate (ASPECT) which is part of the SCAR Global Change in Antarctica Program. More information on ASPECT and the links between it and other SCAR activities and those of SCOR is available from the SCOR Secretariat.

The General Meeting noted the report of WG 86 with satisfaction.

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

I.N. McCave reported that completion of the final report of WG 89 was expected by the end of 1996. The report from the Chair, Paul Komar, stated that it is the intention of the WG to submit the product to a publisher, together with a list of additional contributions to be made by invited authors. The purpose of these invited papers is to fill gaps or to provide more details than covered by the SCOR-report chapters. The final product will provide a comprehensive examination of sea-level variations and coastal responses, ranging from a storm surge lasting a day to the large-scale changes in sea levels that occurred during the millions of years of the Quaternary ice ages. Much of the report is directed toward a review of techniques that are used to analyse beach-erosion responses to elevated water levels as during a storm surge, and shoreline recession due to the long-term progressive rise in sea level. The final two chapters consider the applications of the analysis techniques in coastal-zone management, and recommendations offered by WG 89.

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

The Chairperson of WG 93, Annalies Pierrot-Bults, gave a brief scientific review of the status of the field of pelagic biogeography and recent advances in using models to define biogeographic provinces. In relation to WG 93, she reported most of its earlier work had been published in *Progress in Oceanography* (33(4):1994). Since then, the work on a Glossary of Biogeographic Terms has been nearly finalized in English. It was decided to translate the terms in Spanish, Russian, Japanese, and German while the descriptions will be only in English. The Glossary will be made available on floppy disk; publication on paper or other electronic media is still undecided. The group has also ensured that a list of pelagic species will be part of the ETI (Expert Center for Taxonomic Identifications, Amsterdam) IOC/UNESCO Register for Marine Species.

The main task still to be completed by WG 93 is the publication of the Proceedings of the International Conference on Pelagic Biogeography which it sponsored in Amsterdam in July 1995. UNESCO has agreed to publish this volume which contains fifty-one articles and a workshop report with recommendations for future work.

These recommendations may form the basis for a future proposal to SCOR for a new working group. In formulating this proposal, the WG should take account of the activities of GLOBEC and the Living Marine Resources Module of GOOS.

The General Meeting agreed that the work of WG 93 should be completed in correspondence and that it could be disbanded pending the completion of the two remaining publications.

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

S. Krishnaswami reported that WG 95 has finalized work on a special issue of the *Journal of Marine Systems*. The issue was expected to appear by early 1997 and will include a preface by the chair of the working group, Gerhard Graf, and a SCOR logo on the front page.

The final point of the terms of reference for WG 95 was to organize or contribute to an international symposium. The WG had planned a special session during the symposium on "Computerized Modelling of Sedimentary Systems" being held at Güstrow, Germany, October 8 to 11, 1996. More than 120 scientists were expected to participate in this meeting, and SCOR funds were being used to facilitate invitations to additional scientists from developing countries.

The final report of WG 95 was planned to be completed during the Güstrow meeting. The Chair sought advice from SCOR on an appropriate publication venue for this report, which will consist of a short summary of the above-mentioned special journal issue, the catalogue of remaining scientific questions, and a comment on this catalogue. The General Meeting agreed that further information on the length of this report was required in order to make this decision.

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

Vere Shannon presented two documents on behalf of WG 96; a report to SCOR including the report of the final meeting of the WG which took place in Hobart in March 1996, and a request to SCOR for transition of the Working Group to the status of a SCOR Affiliated Program.

The WG submitted a detailed report to SCOR in 1995 and this is awaiting publication at IOC as a SCOR scientific contribution to the Global Ocean Observing System. At its 1995 and 1996 meetings, the WG on Acoustic Monitoring became more involved in the international planning of components of the international program known as Acoustic Thermometry of Ocean Climate (ATOC). In the period since its 1995 meeting, an important step forward had been taken in the implementation of an acoustic monitoring program in several regions, following a two year delay due to marine mammal issues.

The 1995 meeting of the SCOR Executive had approved a mechanism which would allow for a longer term arrangement through which international collaboration in ocean science could proceed under SCOR sponsorship. At its Hobart meeting, Working Group 96 considered the criteria for this longer-term arrangement. Thus the motivations for the final meeting in 1996 were two-fold: to review progress and future plans following the initiation of transmissions for the Pacific acoustic tomography array and to prepare for a longer term association with SCOR.

Brief summaries of the activities and accomplishments of WG 96 and of the technical presentations on ATOC progress are given in Annex 4.

In presenting the request for ATOC to become an Affiliated Program of SCOR, Shannon felt that all of the criteria for this status (see *SCOR Proceedings*, Vol. 31, pg. 17) had been met. The statement from the group was accepted by the General Meeting. In requesting the international endorsement of the ATOC program by SCOR, the group noted:

"The initial inspiration and scientific impetus for acoustic monitoring of the global ocean found expression in the US ATOC program, which has implemented the acoustic monitoring in the Pacific and runs the program office. However it is clear both from our final report to the SCOR Executive following the 1994 meeting and from the brief account of the 1996 meeting presented below that support has developed rapidly within the international community with significant financial and research contributions being made by several countries. To summarize, what began as a US funded and motivated program is now evolving into a truly international undertaking with independent proposals being put forward by several countries for the development of a global program. This success owes much to SCOR sponsorship, especially its sponsorship of participants from developing countries, and to the recognition of international participation provided by the fact that the meetings are held under the auspices of SCOR. It must be emphasized that the goal of monitoring the ocean acoustically cannot be undertaken without international collaboration. Moreover the goal is ambitious and will take time to implement. The benefit of the SCOR connection is vital to achieving this long term goal and motivates the Working Group's application to the Executive for transition to the longer term arrangement."



The former WG 96, with expanded membership, will form an international steering committee for the ATOC program with the following "science goals". They represent a transition from the original WG 96 terms of reference, reflecting the more focussed demands of the longer term scientific ambitions of the ATOC program. These science goals become the new terms of reference for the ATOC group:

- To develop international projects for the installation and long term operation of acoustic systems in the world ocean for monitoring changes in ocean properties over scales of 1000-10,000km and over time scales from seasonal to decadal and longer.
- To develop improved acoustic technology and improve data interpretation approaches for long range acoustic monitoring of the ocean.
- To develop integrated ocean climate studies involving remote sensing, especially satellite altimetry, acoustic monitoring and ocean modeling.

The initial program is presently underway in the Pacific Ocean. An active acoustic monitoring program is being carried out in the Mediterranean. A feasibility test of an acoustic monitoring program was carried out in the Arctic. The plan is to build on these initial successes and implement programs in other oceans such as the Indian Ocean and North Atlantic over the next decade.

In accordance with SCOR criteria, the membership of the group is international and will rotate (including the Chairperson) on a routine basis. The initial membership is: Victor A. Akulichev, Institute of Marine Technology Problems, Vladivostok, Russia; Arthur Baggeroer, Massachusetts, USA; Leif Bjorno, Technical University of Denmark; Gary Bold, University of Auckland, New Zealand; Geoffrey Brundrit, University of Cape Town, South Africa; Chris Clark, Cornell Laboratory of Ornithology, New York, USA; Dan Costa, University of California, USA; Yves Desaubies, IFREMER, France; Nikolai Dubrovsky, NN. Andreev Acoustics Institute, Russia; David Farmer, Institute of Ocean Sciences, Sidney, BC, Canada; Andrew Forbes, CSIRO Division of Oceanography, Tasmania, Australia; Bruce Howe, University of Washington, Seattle, Washington, USA; Harley Hurlburt, Stennis Space Centre, MS, USA; William Kuperman, Scripps Institution of Oceanography, California, USA; Martin Lawrence, Naval Scientific Advisor, Australia; Dimitris Menemenlis, Massachusetts Institute of Technology, Massachusetts, USA; Jim Mercer, University of Washington, Seattle, Washington, USA; Peter Mikhalevsky, Science Application International Corp, Virginia, USA; Walter Munk, Scripps Institution of Oceanography, California, USA; C.S. Murty, National Institute of Oceanography, India; Iwao Nakano, Japan Marine Science & Technology Centre, Japan; John Penrose, Centre for Marine Science & Technology, Perth, Western Australia; Robert Spindel, University of Washington, Seattle, Washington, USA; Peter Worcester, Scripps Institute of Oceanography, California, USA; Carl Wunsch, MIT, Massachusetts, USA; and Renhe Zhang, Chinese Academy of Sciences, National Laboratory of Acoustics, China.

The General Meeting encouraged the ATOC steering group to develop close links to the WCRP and GOOS scientific planning efforts. It approved the status of Affiliated Program for ATOC and formally disbanded WG 96 with thanks to its Chair, Dr. David Farmer, and to all of its members.

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

The final meeting of WG 97 was in the form of a major technical workshop. The Working Group successfully obtained funding from NATO for an Advanced Study Institute on the Physiological Ecology of Harmful Algal Blooms. This workshop was held from May 27 -June 6, 1996 at the Bermuda Biological Station for Research; support was obtained from NATO for this meeting, which was supplemented by funds from SCOR and the IOC. A total of 87 participants from 29 countries met for 10 days in a combination of lectures, poster sessions, and discussion groups. In addition, participants benefited from highly technical demonstrations that were offered. These demonstrations were on topics such as: molecular probes for harmful algal bloom species, neuroreceptor assays, rheology and small-scale physical processes, remote sensing and ocean optics, mixotrophy, modern cyst techniques, and cytotoxicity.

One of the responsibilities of the Working Group was to prepare a report on the status of knowledge on the Physiological Ecology of Harmful Algal Blooms. This will be accomplished through the publication of a book or proceedings from the NATO/ASI. Over 30 chapters are already planned, and many of these are in the hands of the editors (D. M. Anderson, A. E. Cembella, and G. M. Hallegraeff). The book will be published by Springer-Verlag with funds from NATO. Plans are to have final copies of the manuscripts in the publishers hands by November, with publication in early 1997. This book will be an important resource to the field, with state-of-the-art reviews on all of the major toxic organisms and the physiological processes involved in their growth and toxin production.

A report submitted to the General Meeting addressed the other term of reference for the working group, namely to identify key areas where research is needed on a priority basis. In all, thirteen themes for future action were identified (see Annex 5). Agreeing that WG 97 should now be disbanded, the General Meeting requested its Chair, Don Anderson, to set some priorities among these topics identified by the WG and to formulate a proposal for a new SCOR WG in the general field of harmful algal blooms.

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

No meeting was held during the last year, but some progress was made in the collection of data relating to sardine and anchovy populations and how they have changed over many years. A comprehensive report concerning the first meeting of SCOR WG 98 has been placed on the Internet (<http://www.cibnor.conacyt.mx/externo/fluc/scor/scorwg98.html>). As the Reporter for WG 98, Brian Rothschild, noted, the driving scientific question for the group is the dynamic interrelationships between co-occurring populations of sardines and anchovies in various regions. These two fish species alone comprise 40 to 50% of global fish catches.

As one step in meeting its terms of reference, a sub-group of WG 98 planned to hold a workshop in 1996 (this was already approved by SCOR in 1995); this meeting was now expected to take place late in the year. This would be followed by a final meeting of the working group in late 1997. Following that, it may be appropriate to incorporate the working group into the GLOBEC effort on Small Pelagic Fishes and Climate Change. Many WG 98 members have already become active in SPACC. Laurent Labeyrie noted that the history of climate change as recorded by the fish scales and otoliths found in marine sediments is important for the IMAGES program; he will make contact with the WG98/SPACC groups.

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

I.N. McCave reminded the participants in the General Meeting that the Symposium on Mid-Ocean Ridges - Their Biology, Geology and Chemistry to take place over the next two days was organized as the final activity of WG 99 in cooperation with the RIDGE research group at Southampton. It included a series of presentations by members of the WG providing reviews, and perspectives on future research directions, in a number of key areas of mid-ocean ridge science ranging from upper mantle dynamics to biological productivity. The Symposium emphasized both the impact of ridge-related fluxes on the global ocean environment, and the intimate links between physical, chemical and biological processes and earth structure at a range of scales and depths, which between them necessitate scientific approaches that cut across the traditional disciplinary boundaries of the natural sciences. The proceedings of this event will be published by the Southampton Oceanography Centre, with some support from SCOR. See Annex 2 for the program of talks presented during the symposium.

In addition to this, WG 99 has undertaken to produce a "booklet" on ridge research, written for the informed lay person or funding agency representatives. A draft of the booklet and a set of figures - both monochrome and color - has been prepared, but will require further editing prior to publication. Completion and distribution of the booklet will be the WG's next major task after the Symposium.

The report of WG 99 briefly reviewed the current scientific progress and opportunities in the field of ridge research:

"The past year has seen considerable progress in ridge related research internationally. Probably the largest single activity has been the field programme, carried out during 1996, for the MELT experiment, run primarily by the US RIDGE programme but involving significant international collaboration. In this experiment, an unprecedented array of ocean bottom seismic and electromagnetic observing stations has been deployed across the southern East Pacific Rise to study the dynamics of magma generation and transport and mantle flow beneath the ridge. In summer 1996 Iceland has been the venue for three major, international scientific meetings, all either partly or wholly devoted to ridge science. Research programmes on mid-ocean ridges have continued in many countries, and India seems set to become the next country to launch a major mid-ocean ridge research initiative, designated InRidge.

The study of biological processes at hydrothermal vents has, this year, been given renewed topicality by two other events: the announcement that a meteorite believed to be derived from the surface of Mars may contain evidence for the presence of life on that planet 3.5 Ga ago; and speculation that Jupiter's moon Europa may have an ocean of liquid water beneath the thick crust of ice that forms its outer layers. Both of these intriguing possibilities serve to underline the importance of hydrothermal vents at ridges as natural laboratories for the study of the evolution of life on Earth."

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

The Executive Director of the IMAGES program, Laurent Labeyrie, made a brief scientific presentation on the accomplishments of WG 100 and discussed various types of records of climate change. Investigators linked to WG 100 have found a wealth of information in sediment cores and closely spaced samples within cores can now be analysed to reveal remarkably fine detail. For example, the effects of periodic "surges" of ice into the North Atlantic and their influence on the global thermohaline circulation (the so-called global conveyor belt) can be detected.

Two years ago, WG 100 proposed an international study of the marine aspects of past global change (IMAGES) to study the record of past climatic events such as these interruptions in the processes of deep water formation, which occurred on time scales of decades to centuries. The evidence of more than twenty such events can be seen in sediment records from areas from the North Atlantic, such as the Indian Ocean and the East China Sea. IMAGES proposes to collect cores in target areas for studies of past patterns of vertical circulation, heat transport and productivity. The program is cosponsored by SCOR and by the PAGES (Past Global Changes) program of IGBP.

At the time of the General Meeting, one cruise in the North Atlantic on the French vessel, *Marion Dufresne*, had successfully demonstrated the feasibility of international cooperation in this effort with 17 scientists from 13 countries participating. Plans for two more cruises, in the South African - Benguela region and a transect from New Zealand to Taiwan, were already well advanced.

The Science Plan for IMAGES was published in 1995 and the General Meeting agreed that WG 100 should now be disbanded. At the same time, it is appropriate for the IMAGES program to become an Affiliated Program of SCOR. The steering committee had met a requirement of the SCOR Executive Committee that there should be a nominal membership fee for participating nations in the IMAGES program so as to facilitate the involvement of developing countries.

The international planning activities and some of the secretariat costs for IMAGES are covered by the membership fees of participating countries. They are required to give free access to IMAGES core collections and to share data freely. But, the appearance of a two-tier system in which some countries making larger contributions to the international IMAGES budget had more influence in the program planning process, was felt to be counter to SCOR and IGBP procedures. This led to considerable discussion at the General Meeting, and between the SCOR Officers and representatives of IMAGES. It was agreed that the IMAGES program should become an Affiliated

Program of SCOR, providing that the IMAGES membership structure is brought into conformity with SCOR and IGBP conventions on the rights of scientists from all member countries to participate in the planning process on an equal basis. This will be resolved in discussions between SCOR Officers and representatives of IMAGES and IGBP in the near future.

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

The Chair, Ian Jones, reviewed the history of the working group which was established in 1992 to examine the question of the influence of sea state (and other variables) on the wind stress over the ocean. The working group met, formally and informally, five times, and held two workshops to develop the text of a monograph, which is to be published by Cambridge University Press. As well, the workshops encouraged the research community to investigate a number of unresolved issues in momentum transfer at the sea surface.

The working group's final meeting was held in St Petersburg in September 1996 and as the draft of the monograph was approved at that meeting, the working group recommended that it be disbanded, having satisfied its terms of reference. Jones expected that the monograph would be published in 1997. The General Meeting accepted the recommendation that WG 101 be disbanded and that a final review of the manuscript for the monograph should be the responsibility of Henry Charnock, Southampton Oceanography Centre, a Corresponding Member of the WG.

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

The Reporter for WG 102, Vere Shannon, reminded the General Meeting that he and Allyn Clarke had been charged by the Executive Committee meeting in late 1995 to arrange for an independent review of the paper produced by the working group. This was underway under the leadership of Nick Fofonoff of Woods Hole Oceanographic Institution. The review was expected to be in SCOR's hands by the end of 1996 and IOC has agreed to publish the paper as the last volume in the series, *UNESCO Technical Papers in Marine Science* since this is where all of the closely-related publications by the former Joint Panel on Oceanographic Tables and Standards appeared. WG 102 was not disbanded in case there was a need for a small amount of additional work on the paper following the receipt of the review.

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

Allyn Clarke reported that at its first formal meeting in 1995, WG 103 conducted a detailed, critical discussion of its draft document which was prepared in correspondence. This meeting produced a stimulating evolution of ideas and viewpoints that has resulted in a more mature version of the document. While it was agreed to try to complete the report as early as possible, at the meeting it was noted that several fundamental studies related to wave breaking were in progress that may well impact on its substance and recommendations and that there may be some advantage in awaiting the outcomes of such studies before completion of the WG's report.

The WG 103 Chair, Michael Banner, in his report to the General Meeting, stated that this has indeed proven to be the case. For example, his own collaboration with colleagues has now led to the resolution of several very fundamental issues associated with microscale breaking waves. These findings are likely to have a very significant impact on our understanding of air-sea interaction fluxes. On a larger scale, using a computational approach, other studies have just established wave field parameters whose universal threshold allows the reliable prediction of the onset of breaking in nonlinear modulating gravity surface wave trains. Various cases have been examined including unforced and wind forced situations, and the influence of a vertical shear current. These two contributions resolve very long-standing problems associated with wave breaking and should certainly be included in the report.

Accordingly, plans are being made for a second formal meeting of WG 103 in 1997 in order to review and finalize the report for submission to SCOR by the end of 1997. Banner also noted the Executive Committee's strong recommendation for an open literature publication in addition to the report to SCOR and he will highlight this to the WG members as a key issue to be addressed. Cambridge University Press requested Banner to prepare a proposal to publish an adaptation of the report as a companion volume to the successful monograph that arose from WG 83 and the current effort towards this goal by WG 101. Another option is to reshape it into a critical review article to be submitted to an appropriate oceanographic journal. The General Meeting felt that this is a realistic goal given the

scope of the draft report, especially with the inclusion of the recent research developments.

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

Terry Healy introduced the report received from the Chair of WG 104, Robert Buddemeier. The group met in conjunction with the 8th International Coral Reef Symposium in Panama in June 1996.

Both coral reef issues (e.g., the International Year of the Reef, the International Coral Reef Initiative) and climate/environmental issues (e.g., the debate surrounding the IPCC reports) are currently high-profile issues in the areas of marine and environmental science. Plenary presentations at the Symposium stressed the strong and growing reliance of the paleoclimate community on coral-based records, and also pointed out the uncertainties and range of scientific issues involved in coral taxonomy and responses to environmental factors. These developments have produced considerable interest in, and application of the findings of, the Working Group.

An open scientific workshop, chaired by R. Buddemeier, was held during the symposium in Panama. Its major objective was to obtain input from the wider scientific community to SCOR Working Group 104. The participants agreed on a clarification of the fact that the term "adaptation" in the title of the WG included the subject of acclimation as well, and they held a structured brainstorming session to identify issues, questions, and sources of information. Discussions were spirited, wide-ranging, and there was an evident high level of interest in the topics.

Following the workshop and Symposium, the first formal meeting of the Working Group was convened. It first focussed on the issues of definition of reef communities, assemblages, and organisms as a critical basis for undertaking a multidisciplinary assessment. It then discussed issues of scale, and the interactions of the "paleo," the biological, and the climatological specialties. Based on these discussions and the outcomes of the preceding workshop, plans were made for initial development, circulation, and review of outlines or drafts of papers directed toward aspects of the WG 104 product. Although further refinements and additional contributions will be developed, an initial list of topics and contributors was assembled, along with suggestions for possible collaborators outside of the Working Group. A substantial amount of review and publication in the area of community metabolism, and CO<sub>2</sub> and carbonate saturation state effects has already been carried out by Gattuso, Smith, Hatcher, and Opdyke; this material is available for integration with the overall results of the proposed new reviews and syntheses on the following topics: Symbiosis Ecology; Biogeography and Population Genetics; Quaternary Rates of Environmental Change; Ecology and Community Issues; Reproduction, Calcification and Bleaching in Marginal (High Latitude) Environments; Physiological Responses in Stable and Variable Environments; Quaternary Community Change and Relevance to Modern Communities, Case Study Comparison of Brazilian with Caribbean Reef Systems; Models and Integration; and Climate Change Scenarios and Effects.

An informal drafting workshop may be held in 1997, possibly in association with the LOICZ Open Science Meeting in The Netherlands in October, to ensure that rapid progress is made with this publication. In addition, WG 104 is planning for a "centerpiece" session in a symposium at the Society for Integrative and Comparative Biology (SICB -- formerly the American Society of Zoologists, or ASZ) annual meeting to be held in Boston in January of 1998. The proceedings of that session would be published in the *American Zoologist*. This symposium has the potential to provide substantial visibility to the Working Group and to SCOR.

The General Meeting approved of these plans and noted the speed with which WG 104 is addressing its terms of reference. It allocated a single budgetary amount which could be used as needed for the two meetings discussed above. It also accepted, with pleasure, the offer of the Land-Ocean Interactions in the Coastal Zone (LOICZ) Core Project of IGBP to cosponsor WG 104, noting that LOICZ will provide some financial support for its activities and that the LOICZ Report Series may be an appropriate venue for the eventual publication arising from the group's activities.

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

The following membership of the SCOR Working Group was confirmed in the spring of 1996.

G. Bianchi	Norway	D. Pauly	Canada
H. Gislason	Denmark	R. Quinones	Chile
S. Hall	Australia	C. Reid	United Kingdom
J. McManus	Phillipines	K. Sainsbury	Australia
S. Murawski	USA	M. Sinclair	Canada (Chairperson)

In addition, several corresponding members have been added. They are:

J. Caddy	Italy (FAO)	T. Baumgartner	USA
H. Lindeboom	Holland	J. Rice	Canada*
J. Christensen	Phillipines	G. Jameison	Canada*
T. Platt	Canada*	K. Zwanenburg	Canada*
D. Gordon	Canada*	W. Wooster	USA (PICES)

\* - some of these Canadian Corresponding Members were invited specifically to participate in the Halifax meeting (see below).

The general issue for WG 105 is the impact of various fishing methods on marine ecosystems. Several of the members have been active in a parallel working group within ICES that has addressed this topic within a North Atlantic context (Gislason, Lindeboom, Rice). A corresponding member will be added to represent PICES. In the interim, Warren Wooster is listed above. The first meeting of the Working Group was planned to take place in Halifax, Nova Scotia, Canada on November 5-7.

The members have been requested to prepare overview presentations on their areas of expertise relative to the issue of ecosystem effects of fishing. These were to be presented to an open meeting, followed by a smaller working group meeting. The topics of these presentations provide an overview of the issues to be developed by the group:

Murawski/Rice	Conceptual approaches to the evaluation of ecosystem effects of fishing.
Pauly/Christensen:	Carrying capacity of the world's oceans from a trophic dynamic perspective.
Platt/Sathyendranath:	Update on estimates of global primary production from satellite radiometer data, in relation to fish production from different biogeographic zones.
Reid:	Summary of evidence of temporal and spatial changes in zooplankton community structure in the North Atlantic (from CPR data) in relation to patterns of fishing effort.
Quinones:	Summary of evidence of zooplankton community structure changes in eastern boundary currents (including CALCOFI data) in relation to environmental and fishing changes.
Hall:	Impacts of fishing on benthos, the European experience.
Gordon/Schwinghamer:	Impacts of trawling on benthos, the Grand Banks experiment.
McManus:	Impacts of fishing on coral reef communities.
Gislason:	Impacts of environmental variability and fishing on fish community structure, the European experience.
Zwanenburg/Howell:	Impacts of environmental variability and fishing on fish community structure in the Northwest Atlantic (Cape Hatteras to Cape Chidley).
Sainsbury:	Impacts of environmental variability and fishing on fish community structure in Australia and New Zealand.
Bianchi:	Evidence for changes in groundfish community structure in tropical waters due to fishing practices.
Lindeboom:	The use of closed areas for the evaluation of the ecosystem effects of fishing.
Caddy:	Have marine fisheries resulted in loss of biodiversity at the species level?
Sinclair:	Have marine fisheries resulted in a loss of biodiversity at the population level?
Jameison:	Specific issues associated with invertebrate fisheries.

The representative of SCAR requested that the activities of WG 105 be brought to the attention of the Committee for the Conservation of Antarctic Living Marine Resources.

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

The WG 106 Reporter, Terry Healy, noted that in late 1995, the Executive Committee had approved funds for a meeting of WG 106 in 1996, provided that sufficient progress had been made with the preparation of chapters for its publication to warrant a meeting which was primarily for editorial purposes. Healy reviewed the status of the draft chapters and it now appeared unlikely that such a meeting would take place before early 1997. The General Meeting agreed that funds allocated for the 1996 meeting could be carried forward.

As a second activity in 1997, the WG plans an International Conference on Muddy Coasts to be held at the Senckenberg Institute in Germany in October. The proposed title of the Conference is "Hydrology, Sedimentology, Geochemistry and Ecology of Muddy Coasts".

### 2.2.16 *WG 107 Improved Global Bathymetry*

WG 107 was established by the SCOR Executive Committee in late 1995, with the following terms of reference:

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

The following individuals have accepted invitations to join WG 107:

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

#### Corresponding Members:

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

The first meeting of WG 107 was planned to take place in Southampton in November 1996. Members will address the following topics:

- Terms of Reference and Objectives of WG 107
- Needs of the physical oceanography/ modeling community for improved bathymetry
- Needs of marine geology and bathymetric capability
- Implementation Plan for WG 107: Future Actions, Experiments, Model Sensitivity Runs, Meetings, Reports

To aid discussion, speakers are preparing for circulation in advance of the meeting a written text setting out the state of the art in their field, and identifying limitations, in terms of the three key items. The Chair has proposed that these papers be published in the *UNESCO Technical Papers in Marine Science*, along with the conclusions and recommendations of the WG, however the recent discontinuation of this series means that an alternative publication venue will have to be found.

The General Meeting approved the request by Summerhayes to reconvene the group after one year to review progress, finalize recommendations, and draft the final paper for publication (a) in an appropriate peer-reviewed international journal (e.g. *Deep Sea Research*), (b) as the concluding section to the *Technical Paper*,

and possibly (c) in an appropriate hydrographic journal. It was proposed that this second meeting be held at Johns Hopkins University in November 1997.

### 2.2.17 *WG 108 Double Diffusion*

The Chair of the newly-established WG 108, Yuli Chashechkin personally presented the first report of the group to SCOR. Active research by theoreticians and laboratory experimentalists has clarified some important features of convective structures and related phenomena. While much of the basic physics is understood completely enough, theoretical description of the processes and their parameterization needs considerable updating. The dependence of structure, geometrical parameters and fluxes upon external characteristics are to be established. The role of double diffusive convection in the transfers of heat and mass needs to be clarified.

Chashechkin noted that the final membership list of WG 108 is as follows:

#### Co-Chairs:

Yuli D. Chashechkin	Russia	Joe H.S. Fernando	USA
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#### Members:

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

#### Corresponding Members:

Hendrick Dijkstra	The Netherlands	Lev Karlin	Russia
Rostislav Ozvidov	Russia	Emin Ozsoy	Turkey
R. Pasquetti	France	Arcady Tsinober	Israel

The group received approval from the General Meeting to hold its first meeting in conjunction with the May 1997 Liège Colloquium on Hydrodynamics, which will be cosponsored by SCOR. The topic of the 1997 Colloquium is "Marine Turbulence Revisited".

## 2.3 Committees and Panels

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

The Ocean Modelling Newsletter continues to be produced on behalf of SCOR by a panel which is chaired by Peter Killworth (UK). European Community funding has ensured the continued viability of the Newsletter and the most recent issue to be published was No. 110.

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

The report from JGOFS was presented by the Chair of the SSC, John Field, and is given in Annex 6. He highlighted the major scientific achievements of JGOFS during the past year; these are described in Annex 6. Field reminded the General Meeting that during 1995, JGOFS had been subject to an evaluation by its sponsors, in particular as part of a larger overall evaluation of IGBP conducted by ICSU and IGFA. The relevant section of the report of the IGBP evaluation which dealt with JGOFS may be found in *SCOR Proceedings*, Volume 31, Annex 5. At its meeting in April 1996, the JGOFS SSC reviewed the recommendations of the Evaluation Panel in detail and is taking them into account in its current actions. For example, in response to the suggestion that JGOFS was not adequately addressing the issue of fluxes below the upper layer, and between the ocean and the sediments, a new Task Team on Deep Ocean Fluxes has been established.

The synthesis volume arising from the JGOFS Scientific Symposium (May 1995) is expected to be published in the new Cambridge University Press global change series and editorial work should be complete by mid-1997.



Early in 1996, the new JGOFS International Project Office began operations at the University of Bergen, Norway. It is now fully staffed with an Executive Officer (Roger Hanson) an Assistant Executive Officer with special responsibilities for data management issues (Beatriz Balino) and an Administrative Assistant (Judith Stokke). These staff positions, and some of the operating costs of the JGOFS IPO are supported with funds from the University of Bergen and the Norwegian Research Council.

Much of the JGOFS report focussed on the results of the 11th meeting of the JGOFS SSC which took place in Bad Munstereifel, Germany in conjunction with the IGBP Congress. This event provided a venue in which, for the first time, all the SSCs for the IGBP program elements met in the same place. There were many opportunities for inter-project discussions such as, in the case of JGOFS, a joint meeting with the LOICZ SSC in order to further develop the plans for the Continental Margins Study. The accomplishments of the various regional Planning Groups (North Atlantic, Equatorial Pacific, Southern Ocean and Indian Ocean) and scientific Task Teams (Synthesis and Modelling, Continental Margins, Photosynthesis Measurements, Remote Sensing, etc) were reviewed at the SSC meeting and are recorded in Annex 6.

In response to a suggestion from the IGBP directed to all of its program elements, the JGOFS SSC gave consideration to a restructuring plan which seemed to be better suited to the needs of the program as it moves towards the important phase of analysis, synthesis and integration once the field activities are completed in 1998 or 1999. The current SSC has 17 members; the suggestion of the IGBP was that all SSCs should move towards a membership of not more than 15 and that these should include the Chairs of important subsidiary activities. Accordingly, JGOFS proposed to the General Meeting a scheme in which the SSC would consist of 6 "at large" members, who would serve 3 year terms on the SSC, plus the Task Team and Planning Group Chairs. The SSC would nominate the Chair and the Vice-Chair from among the "at large" members, for approval and appointment by SCOR and IGBP. The Chairs of the Task Teams and Planning Groups would be nominated by the groups themselves and appointed by the SSC. They would also serve rotating terms of office.

Field proposed that JGOFS move towards this new SSC structure through a process of attrition which would take two to three years to complete as existing SSC members completed their terms on the committee. He noted that Hall, Krishnaswami, McCarthy, Merlivat, Moore and Sakshaug were due to rotate off the SSC at the end of 1996, but that under the new scheme, Hall and Sakshaug would remain on the committee in their capacities as Chairs of Task Teams. He proposed that the other positions be filled by one new appointment, and nominated Toshiro Saino (Japan) for consideration by SCOR and IGBP. The implications of the proposed restructuring plan can be seen in Table 1 in Annex 6.

Finally, Field reported that he had been asked by the JGOFS Executive to remain as Chair of the SSC for an additional year while the search for a new Chair continues. Hugh Ducklow has agreed to assist him as Vice-Chair.

Jarl Strömberg, speaking as Executive Committee Reporter for JGOFS, expressed the thanks of SCOR to Norway for its generous support of the project office, and noted that the program seems to be successfully moving towards its later stages of interpretation and integration of results.

The restructuring plan gave rise to some discussion, the consensus being that it is appropriate for the steering committees of mature programs to be smaller. The proposed plan would give rise to a larger JGOFS SSC for one year, while the new structure is put into place, but it would decrease in size as a result of attrition after that. The "at large" members could be selected to represent the modelling and data management communities which will have a greater role to play as the program moves into a synthesis mode.

The representative of IGBP, Neil Swanberg, cautioned that the suggestion that SSCs consider a restructuring had not yet been formally endorsed by IGBP itself. The General Meeting approved in principle the scheme as proposed by Field, recognizing that the final decisions would have to be taken by the IGBP and SCOR Officers. The nomination of Saino and the re-appointment of Field as Chair for one year were approved for transmission to IGBP.

Readers are referred to Annex 6 for more detailed information on JGOFS activities in 1996 and to the new Home Page (<http://ads.smr.uib.no/jgoofs/jgoofs.htm>) for the most up-to-date information.

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

Shortly before the SCOR Executive Committee meeting in 1995, GLOBEC was adopted as a new program element of the IGBP. Thus the program now has three international sponsors, namely SCOR, the IOC and IGBP. Since that time the GLOBEC SSC has been reconstituted under the leadership of the incoming Chair, Roger Harris (UK). The composition of the new GLOBEC SSC strives for balanced disciplinary and international representation while at the same time maintaining important continuity with the membership of the original SCOR/IOC committee. Steps are being taken to further broaden the membership, particularly in the southern hemisphere. The membership of the new SSC, as approved by the Officers of SCOR and IGBP following discussions at the IGBP Congress in Bad Munstereifel (April 1996) is:

Dag Aksnes	(Dept. of Fisheries and Marine Biology, Univ. Bergen)	Norway
Jürgen Alheit	(Baltic Sea Research Institute, University of Rostock)	Germany
Tommy Dickey	(University of California, Santa Barbara)	USA
Roger Harris	(Plymouth Marine Laboratory)	UK Chair
Eileen Hofmann	(Old Dominion University)	USA
Tsutomu Ikeda	(Faculty of Fisheries, Hokkaido University)	Japan
Ian Perry	(Pacific Biological Station, DFO, Nanaimo)	Canada
Brian Rothschild	(University of Massachusetts, Dartmouth)	USA
Jarl-Ove Strömberg	(Kristineberg Marine Research Station)	Sweden
Svein Sundby	(Institute for Marine Research, Bergen)	Norway
Qisheng Tang	(Yellow Sea Fisheries Research Institute, Changde)	China

Roger Harris briefly described the scientific rationale for GLOBEC to the General Meeting in a report which supplemented the written report to be found in Annex 7. He noted that large-scale shifts in marine populations are a natural phenomenon and that there is evidence of them having occurred through the available historical information on fisheries which spans a period of more than 1,700 years. We now have accurate time series data on regime shifts in various stocks of sardines around the Pacific basin which occur simultaneously and seem to be driven by climatic variability. The conclusion that there are naturally occurring, long-term fluctuations in abundances in marine populations is not underpinned by adequate understanding of the processes that cause these fluctuations or of the impact that patterns of global climate change may have on them.

GLOBEC will address these challenges through its integrated core program which includes several cross-cutting topics and four major field study components. The cross-cutting activities include: GLOBEC retrospective data analysis to take advantage of the many fisheries-related data bases and time series which are available for additional study; the development of GLOBEC process studies required to obtain a better understanding of processes such as zooplankton mortality, predation and so on; numerical modelling; and technology development for GLOBEC. The latter two activities are currently being addressed by GLOBEC working groups, while the first two require further development by the new SSC at its first meeting in November 1996.

The period since the approval of GLOBEC as a Core Project of the IGBP saw a reduction of activity in international GLOBEC as the SSC was being reconstituted and arrangements made for its first meeting. However, plans for several of the field programs, particularly the Small Pelagics and Climate Change, the ICES/GLOBEC Cod and Climate Change, and the PICES/GLOBEC Climate Change and Carrying Capacity efforts have been advanced during this time. Summary information on each of these is given in Annex 7. Planning for the Southern Ocean GLOBEC program will be resumed at the SSC meeting.

Finally, Harris reported that much of his time during 1996 had been devoted to editing a completion of the GLOBEC Science Plan in response to comments from the IGBP. He anticipated that the final version would be approved by the SSC at its meeting and that the plan could then be forwarded to the IGBP Secretariat for publication in late 1996.

The General Meeting thanked Roger Harris for his report and for agreeing to assume the leadership of the GLOBEC program. It also expressed sincere appreciation to Brian Rothschild for his leadership of the program since its inception in 1991 to the point where it is now approved as one of the internationally endorsed global change research programs.

#### **2.3.4 SCOR/IGBP Task Force for the Surface Ocean Lower Atmosphere Study (formerly GOEZO)**

Neil Swanberg, Deputy Executive Director of the IGBP, presented a brief report on the gradual planning process for a "second generation" oceanic global change research program which will build upon the results of JGOFS. The importance of marine biogeochemical processes to the interacting Earth system is now firmly established. JGOFS has provided major insights into the role of the oceans in the global carbon cycle; the fieldwork phase of JGOFS is due to end in 1998/99. Yet JGOFS' sponsors, SCOR and IGBP, recognize that many key questions concerning the ocean-atmosphere interface cannot be adequately investigated within that timescale, nor will they be addressed within other existing projects, as currently defined.

Recognizing that new approaches need to be developed, SCOR and IGBP agreed to set up a Task Force to define the main scientific questions concerning the upper ocean/lower atmosphere, and their interactions, that are central to global change processes - and that will remain unanswered after the completion of existing marine and atmospheric projects around the turn of the century. A preliminary assessment of how research in this area should proceed was carried out by a panel led by Ken Denman of Canada, as the joint Working Group for the Global Ocean Euphotic Zone Study (GOEZO). That group's 1994 report recommended that GOEZO should be re-formulated, re-focussed and re-named; furthermore, detailed planning should begin in 1996, to benefit from the 2nd IPCC Scientific Assessment. Denman suggested Surface Ocean - Lower Atmosphere Study (SOLAS) as the name for the new project, and that has been adopted as its working title. [This name is under reconsideration to avoid confusion with the international convention on the Safety of Life at Sea.]

The following draft Terms of Reference for the SOLAS Task Force were agreed by the Officers of SCOR and IGBP in June 1996:

- To review the Intergovernmental Panel on Climate Change Working Group I (IPCC-WGI) 1995 Scientific Assessment to identify the critical problems where progress is limited by our knowledge of how the upper ocean functions and how it controls atmosphere-ocean transfers.
- To consider, and if necessary refine, the following question as the basis for a project that will help to fulfil the marine and atmospheric scientific goals of IGBP and SCOR: "How will the coupled physics, biology and chemistry in the upper ocean respond to projected climate and environmental change over the next 50-100 years, and with what feedback implications?"
- To review the projected scientific advances of the ongoing global marine and atmospheric programs, and identify gaps in what they are likely to achieve relative to the above question.
- To report by early 1997 to the sponsors, with a recommendation for the form that further progress on SOLAS should take. If the Task Force recommends further development of SOLAS, then this should include a simple draft plan of action and timetable for the development of SOLAS over the next 2-3 years.

Andrew Watson (University of East Anglia, UK) was subsequently appointed Chair of the SOLAS Task Force, and the following individuals have also agreed to serve: Wallace S Broecker (Lamont Doherty/Columbia University, USA); Martin Heimann (Max Planck Institute, Hamburg, Germany); M Dileep Kumar (NIO, Goa, India); James J McCarthy (Harvard University, USA).

A three-day meeting of the SOLAS Task Force has been provisionally scheduled for 13-15 November 1996, at the University of East Anglia. [This subsequently took place in January 1997 at the CIBA Foundation in London.] The costs of this meeting will be shared by SCOR and IGBP.

Swanberg informed the General Meeting that IGBP viewed the small group referred to above as the participants for the London workshop, rather than as the membership for a continuing group. The results of the workshop and recommendations for future action will be discussed at the IGBP Officers meeting in February 1997. The General Meeting agreed that planning for SOLAS was not an urgent matter and should proceed at a slow, but steady pace in close cooperation with the synthesis phase of JGOFS, GLOBEC modelling activities, the International Global Atmospheric Chemistry (IGAC) project of IGBP and with appropriate physical oceanographic components of the WCRP, especially CLIVAR. Robert Duce accepted the responsibility to serve as Executive Committee Reporter for SOLAS.

## 2.4 Proposals for New Working Groups

The following proposals were circulated to all national committees for comments before the General Meeting.

### 2.4.1 *Marine Biogeochemistry of Iron*

This proposal was submitted and presented to the General Meeting by David Turner (IUPAC) and Michael Whitfield (SCOR). It arose from discussions between the International Union of Pure and Applied Chemistry and SCOR during the past two years in which areas of mutual interest were identified for possible joint activities.

The proposal that a lack of iron can limit phytoplankton growth in the oceans was first put forward in the 1930s, but it was not until the 1980s that developments in clean sampling and analysis techniques had advanced sufficiently to allow accurate measurements of iron at trace levels. *In vitro* incubation experiments showed that addition of iron stimulated enhanced phytoplankton growth in HNLC (High Nutrient Low Chlorophyll) surface ocean waters. The observations led to the formulation of the hypothesis that phytoplankton growth in these waters is limited by iron. This hypothesis has been strengthened by the results from the IRONEX iron fertilization experiments in the equatorial Pacific, where addition of iron to open ocean HNLC water was shown to stimulate increased primary production. Further support comes from the observation that the plume of enhanced chlorophyll concentrations downstream of the Galapagos Islands is associated with enhanced iron concentrations, together with observation of a similar iron-chlorophyll correlation in the Polar Front north of the Weddell Sea. The result has been an upsurge of research interest in all aspects the marine biogeochemistry of iron, which has resulted in a substantial body of published research.

The field has now advanced to the stage where a critical analysis of progress to date and the identification of future research priorities can be of considerable benefit to the research community as a whole. Whitfield and Turner proposed that SCOR and IUPAC establish a joint Working Group on the marine biogeochemistry of iron, with Commission VI.1 (Fundamental Environmental Chemistry) as the collaborating component of IUPAC. The aim would be to prepare for publication a critical review on the subject drawing on the expertise of SCOR and IUPAC in marine science and chemistry respectively. The review should not only assess the progress achieved to date, but should propose priorities for future work.

Six major subject areas were identified in the proposal for consideration by the Working Group during its initial phase. The IUPAC contribution would be to review developments in iron chemistry, to assess their relevance to marine biogeochemistry, and to assist as "informed outsiders" in the review of developments within the marine field. It is envisaged that IUPAC will contribute mainly, but not exclusively, to the first four of the areas outlined below:

- The state of knowledge of iron speciation in seawater (complexation, redox, dissolved/colloidal/particulate distributions); to what extent can these distributions be modelled accurately?
- Analytical methods for the measurement of total iron and iron speciation in seawater
- Iron transformations in seawater (photochemical reduction, leaching from particles, redox kinetics, gut solubilisation)
- Bioavailability of iron in seawater (uptake mechanisms, relation to speciation, siderophore release); iron requirements of different plankton groups
- Sources, sinks and distributions of iron in the ocean (including atmospheric and hydrothermal inputs); ice-core

ice-core evidence for past temporal variations?

- Evidence for iron limitation in HNLC areas (Pacific, Antarctic, including IRONEX)

Several participants remarked on the timeliness of this topic; in particular, Duce stressed its importance for the atmospheric sciences due to the links between atmospheric chemistry and the bioavailability of iron as it enters the ocean. The lack of any consideration of horizontal transport of iron was referred to the proponents of this topic for possible incorporation into the terms of reference, as was the need for expertise on the physiology and fluxes of iron within cells. Such comments made it clear that the topic was probably too complex for a single working group and it was agreed to focus more narrowly on the processes occurring in the water column as outlined above. The group should adopt a "black box" approach to biological processes and should not attempt to address the historical record of iron variations in ice cores. To reflect this, the title of the proposed group was changed to *Biogeochemistry of Iron in Seawater*. Field noted that JGOFS strongly endorsed this proposal.

IUPAC's mode of operation for working groups is somewhat different than SCOR's and concentrates on the production of a major publication. It was agreed that some discussion with the IUPAC Officers may be necessary, but that the group should work in correspondence, without financial support, for the first year, in preparation for an authors' meeting at a later date. The possibility of publishing the working group's report in the IUPAC Series on Analytical and Physical Chemistry of Environmental Systems was raised.

The establishment of this working group was approved in principle. It will be chaired by David Turner (Sweden) and Keith Hunter (New Zealand) who will revise the terms of reference to reflect the discussion at the General Meeting, and finalize the membership list in consultation with SCOR and IUPAC, taking into account the many nominations received from national committees.

#### 2.4.2 *Marine Oil Spill Bioremediation*

Submitted by the Canadian SCOR Committee, this proposal addressed a very specific topic of applied science. Bioremediation, a proven treatment for the removal of organic contaminants in terrestrial environments, is one of the emerging countermeasure technologies being proposed for the treatment of marine oil spills. While marine oil spill bioremediation has been demonstrated to be effective in laboratory studies and some field trials (including the experimental clean-up of oiled cobble beaches impacted by *Exxon Valdez* spill), its potential effectiveness relative to other techniques has not been quantitatively measured in detail. Furthermore, recent field trials have also shown that some marine shoreline environments have a naturally high biodegradation capacity where the addition of bioremediation agents or nutrients offer little or no benefit, given the physical effort and financial costs required. To fully understand the causes of these differences in the experimental results obtained under natural environmental conditions, scientific studies are needed to identify the factors which control or limit the efficacy of marine oil spill bioremediation strategies. The proponents felt that this topic would benefit from a coordinated international effort to support the comparison of experimental results obtained under various environmental conditions. It was recognized as a priority area that merits further attention during the 2nd International Oil Spill Research and Development Forum, organized by the International Maritime Organization (IMO), London, 1995; an informal group was formed during the meeting with the task to foster scientific studies on the aspects which control or limit the natural rates of oil degradation in the marine environment, and alternative means for its enhancement by bioremediation. A SCOR Working Group was felt by the proponents to be the ideal mechanism to formalize the aims of this group to highlight the shortcomings of existing knowledge of marine oil spill bioremediation, and to identify and develop priority research needs and opportunities.

The General Meeting felt that this topic did not fall within SCOR's main area of expertise and that other organizations, such as IMO, UNEP or IOC should take the lead in this field. If SCOR were to be involved in such an activity, the scientific issues should be more clearly articulated. In conclusion, the Canadian SCOR Committee was urged to direct this proposal to other, more appropriate, organizations. It could then be developed in partnership with SCOR if that were felt to be desirable.

### **2.4.3 Intercomparison and Validation of Ocean-Atmosphere Energy Flux Fields**

This proposal from the Russian SCOR Committee was presented by Yuli Chashechkin. He said that it was intended to bring together scientists from different fields and institutions in order to devise an effective strategy of intercomparison and validation of energy fluxes on the sea-air interface. During the last three decades a number of comprehensive climatologies of sea-air interaction have been produced, but, being based on different data sets and different parameterizations, they indicate a very wide range of estimates of the ocean heat budget and meridional heat transport. At present there is little agreement between the flux producers and the flux users on the "best estimate" of the energy fluxes and it is not clear what criteria should be used to achieve that agreement.

Chashechkin noted that surface flux information is available from *in situ* platforms (ships, buoys etc.), satellites and numerical weather forecast models and he briefly reviewed the present position with regard to each of these data sources.

Detailed studies undertaken over the last years indicate that there are still significant random and systematic errors and uncertainties in sea-air interface climatologies based on voluntary observing ship (VOS) data, available from the Comprehensive Ocean-Atmosphere Data Set (COADS) collection of marine meteorological reports. In addition to voluntary observing data and the data from special field experiments, for the last 2 decades we have observations (especially wind observations) from meteorological buoys. These buoys are usually treated as absolute truth in modelling activities and in calibration and validation of satellite sensors. However, there are important inhomogeneities associated with the buoy data as well, which need to be taken into account given their importance.

Over the last 15 years, great progress has been archived in the construction of remotely sensed data sets over the ocean. Forcing fields available from satellites have at present global scale coverage in space and the duration of about several years. These data sets from various satellites need to be inter-compared and compared to in-situ measurements.

In summary, the decades of 1980s and 1990s are unique in providing an overlap of: voluntary observing ship data; subsistent studies for VOS observations; meteorological buoys data; remotely sensed forcing fields; model reanalyses; oceanographical reverse estimates; and high quality sea-air flux arrays from field experiments. This gives us an exceptional opportunity to develop links between the different methods and data through cross-validation and intercomparison. The aim will be to devise an effective strategy of the creation of an unbiased climatology of sea-air interface which will be accepted by flux producers and flux users (modelers). This will ensure that we are prepared for the future when ocean surface forcing fields will be available from the data assimilation systems.

Chashechkin proposed a Working Group to examine the different sources of flux estimates and the different approaches available to evaluate the accuracy of those estimates. One function of this Group would be to serve as a panel for the presentation of the results of intercomparisons and validations of different flux products. The primary scientific objective of the Working Group would be to understand the weak and strong points of the different sources of flux estimates and to make sound recommendations for the improvement of parameterization schemes, objective analysis techniques and data processing. The advantage of such a body would be in creating a dialogue between measurement providers, flux producers, modelers and remote sensing specialists. This would ensure that any recommendations and suggestions will be comprehensively discussed and analysed from each of the different viewpoints.

Recent meetings, especially the WCRP Workshop on Air-Sea Flux Fields for Forcing Ocean Models and Validating GCMs, have stressed the need for international cooperation in this area. This activity will contribute successfully to CLIVAR, WOCE, GEWEX as well as to other programs which have a demand for the "best estimates" of sea-air fluxes on different temporal and spatial scales. It should also make a considerable contribution to the GCOS (Global Climate Observing System), which considers sea-air exchange to be of a very high priority.

Raymond Pollard and Peter Taylor, representing the WCRP, strongly supported the Russian proposal, but noted that the Joint Scientific Committee for the WCRP had recently approved a similar activity. Readers are referred to Annex 11 (WCRP report) for additional information on WCRP's activities in this field. They proposed that a joint

SCOR/WCRP effort be initiated and much of the ensuing discussion focussed on an examination of the terms of reference and membership suggested for both the WCRP group and this proposed SCOR WG.

A small group refined the terms of reference and reported back to the General Meeting, recommending the SCOR establish a working group jointly with the WCRP, to be Co-Chaired by Sergei Gulev (Russia) and Peter Taylor (UK and Chair of the JSC group). The General Meeting accepted this recommendation and the terms of reference for the new WG:

- to review the requirements of different scientific disciplines for air-sea flux data sets;
- to compile a catalogue of available surface flux data and flux-related data sets, including those becoming available from the various reanalysis projects, and to review, in consultation with users and producers, the strengths and weaknesses of these data sets;
- to inform the scientific community of the work of the group by the use of the World Wide Web, by publication of the final catalogue, and by convening, at a suitable time, a scientific workshop;
- to keep the JSC and SCOR informed of progress in the area and present recommendations for action as necessary

The final membership of the group was to be determined by the Co-Chairs in consultation with the SCOR Executive Committee Reporter.

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

The 32nd Executive Committee meeting (1995) originally considered this proposal which was revised to make the terms of reference more narrowly focussed. The revised proposal was presented by Ian Jones who noted that the topic arises, in part, from the deliberations of the Working Group on the Influence of Sea State on the Atmospheric Drag Coefficient (WG 101) which he chairs.

Jones noted that past research efforts in ocean dynamics in general, and coastal dynamics in particular, have tended to focus on different aspects of the physical processes separately: meteorology, currents, or wave generation. Coupled models were limited through the parameterization of one process or the other. But the dynamics of all the phenomena are coupled; they must be treated explicitly and comprehensively. The proposal called upon SCOR to establish a Working Group to examine the critical issues involved in the coupling between wind forcing, surface waves and currents in the coastal ocean; and to review the existing observational data to define the future needs for understanding the coastal region as a whole. Due to the proximity of the coastal waters to land, observational data are easy to obtain for the verification of the models. Because coastal waters provide a substantial portion of heat exchange between the atmosphere and the ocean, the group could also estimate the impact of the coastal waters in global ocean dynamics and climate studies.

The complete proposal for this working group appears in Annex 8. Briefly, as stated above, its primary scientific objective of this Working Group would be to understand the coupling among surface waves, currents and forcing winds in the coastal ocean. Some initial questions to be addressed include:

- What processes govern the generation and propagation of waves across the shelf?
- In particular, what is the partition of energy and momentum fluxes into waves and currents and how does this partition change with time and cross-shelf position in different wind forcing regimes?
- How do the changes in surface mixed layer structure due to wave effects influence the wind-driven current response?
- What are the effects of waves on the magnitude and directional characteristics of the surface wind stress?
- How significant are wave refraction, associated breaking and wave-current interaction in controlling the wind-generated current response, and how does this influence the further evolution of the wave and wind fields?
- How does the coupled model differ from the uncoupled models?
-

- What is the role of the coastal waters as sources in global heat exchange between the atmosphere and the oceans, and as a boundary condition for global climate studies?

The Working Group should lead to a renewed effort to develop a coupled coastal wind-wave-circulation model based on state-of-the-art field measurements of the surface wind and wind stress fields, the surface wave and current fields, and the water column current and density response. The focus of the Working Group will be on special issues related to the development of a coupled coastal wind-wave-circulation model for assessing the health of the coastal environment and estimating the role of the coastal waters in global ocean dynamics. Final results for the Working Group will be communicated to other appropriate research efforts, for example, LOICZ, the Land-Ocean Interactions in the Coastal Zone, and GLOBEC, the Global Ocean Ecosystems Dynamics program.

The General Meeting agreed to establish this working group, accepting some revisions of the terms of reference developed after the discussion; these are reflected in Annex 8. The final membership will be agreed by Norden Huang (USA), Chair of the group and Ian Jones, Executive Committee Reporter.

## 2.5 Affiliated Programs

As a result of several requests for SCOR sponsorship of international programs, at the 32nd Executive Committee meeting, a new category of Affiliated Programs was created to allow a means of providing SCOR sponsorship to activities which are of a long-term nature and are therefore not suitable for a SCOR Working Group. Certain criteria were established for these programs (see item 2.5, *SCOR Proceedings*, vol. 31) and SCOR sponsorship was granted to four Affiliated Programs. The status of each of these was reviewed by the General Meeting.

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

This program was fully discussed under Agenda item 2.2.5. (WG 96 - Acoustic Monitoring of the World Ocean). The period since the 32nd Executive Committee Meeting was one of transition in which the working group became an international steering group for the ATOC experiment. The WG was officially disbanded by the General Meeting.

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

Similarly, the transition of SCOR WG 100 to the Scientific Committee for this program was discussed under Agenda item 2.2.9 and the working group was formally discharged by the General Meeting.

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

The Chair of InterRidge, Roger Searle, gave a presentation on this program which was seeking SCOR Affiliated Program status. It is an international initiative concerned with all aspects of ridge research. It supports and develops programs that have major scientific interest, and which will benefit from international discussion, planning and implementation. InterRidge aims to develop scientific, technical and logistical cooperation among nations involved in mid-ocean ridge research activities and to strengthen the international potential for innovative research into the next century.

In order to meet these goals, InterRidge will:

- facilitate the exchange of ideas and plans, e.g. by convening international workshops
- provide current information about research activities, especially sea-going operations
- help to improve procedures for data management, exchange, synthesis and preservation
- create an information data base (e.g. track lines, sample locations, geochemical analyses, etc)
- assist in defining and coordinating field programs and experiments
- encourage participation of smaller oceanographic countries and individual scientists from non-sea-going countries.



InterRidge is developed around three main scientific themes: Global Ridge Systematics; Meso-scale Investigations; and Observing and Quantifying Active Ridge Processes. The program is guided by an international Steering Committee which includes representatives of participating nations. There are standing working groups which develop specific projects and advise the Steering Committee. There is a fully-funded and staffed InterRidge office. InterRidge membership is open to all nations engaged in ridge research and there are three levels of membership payments, including no payment at all for Corresponding Members. The membership of the Steering Committee also includes *ad hoc* members (up to a maximum of 4 or one third of the total membership) who are appointed to provide balance or links to other programs.

The involvement of SCOR in InterRidge membership decisions was agreed to be of an advisory nature, primarily to assist InterRidge in maintaining appropriate international balance on the Steering Committee. Since the InterRidge activity has no formal international sponsor, the affiliation with SCOR would give it an international imprimatur. At the same time, it will provide an important link between SCOR and the marine geological community which has been lost with the disbanding of the Commission for Marine Geology. The affiliation of InterRidge to SCOR was approved by the General Meeting.

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

This request for Affiliated Program Status which was first considered in 1995, was resubmitted to the SCOR General Meeting on the grounds that the information presented to the 1995 Executive Committee meeting was incomplete, especially with respect to the membership of the group and some of its objectives. The Executive Committee requested more information, particularly in relation to the established criteria for Affiliated Programs. [See *SCOR Proceedings* Volume 31, page 19 for a record of the earlier discussion of iAnZone.] A revised document was presented to participants in the General Meeting by Vere Shannon.

iAnZone has as its primary goal to advance our quantitative knowledge and modelling capability of the seasonal cycle and interannual variability of the ocean and its sea ice cover, with emphasis on climate-relevant fluxes which couple the Antarctic zone to the global ocean. The first internationally coordinated iAnZone activity was the US-Russian Ice Station Weddell in 1992, directed at the exploration of the environmental conditions along the western margin of the Weddell Sea and the formation and spreading of Antarctic Bottom Water. The second activity was the Antarctic Flux Zone (AnzFlux) experiment in 1994 in which heat fluxes within the winter mixed layer, sea ice and atmospheric boundary layer were precisely measured. A third activity, to be coordinated by iAnZone will take place in 1997-98 is called Deep Ocean Ventilation Through Antarctic Intermediate Layers (DOVETAIL). Building upon the earlier programs, this effort should produce a better definition and understanding of the export of cold water produced within the Weddell Gyre into the global ocean and climate system.

Shannon felt that this heretofore informal group now has a proven record in bringing internationally coordinated scientific projects to fruition, particularly in a field which is not being addressed in detail by any other international program. The group has addressed the issues regarding membership which were of concern to SCOR and Shannon recommended that iAnZone be granted the status of Affiliated Program.

This was agreed by the General Meeting, provided that small revisions were made to the terms of reference for iAnZone. These were subsequently accepted by iAnZone as follows:

- to identify, develop and coordinate research projects meeting the iAnZone goal
- to provide a forum for the exchange of iAnZone research plans, results and data
- to promote the coordination between iAnZone and global climate research programs, and with other Southern Ocean programs as appropriate
- to advise SCOR on the development of appropriate observing systems (e.g. for GOOS, GCOS), data sets and modelling strategies needed to understand the scales and mechanisms of climate variability within the Antarctic Zone.

SCOR agreed that the appropriate function for iAnZone is to “promote and provide advice” within its area of expertise to SCOR and to the relevant WCRP and IGBP programs.

### 3.0 ORGANIZATION AND FINANCE

#### 3.1 Membership

The Membership Officer, S. Krishnaswami, and the Executive Director presented the following information on changes in SCOR membership since November 1995:

##### *Nominated Members.*

- Canada Dr. Bjorn Sundby has been appointed to serve as a nominated member for SCOR replacing Dr. Mark Donelan.
- France Dr. P. Buat-Menard will succeed Dr. P. Lassere as France's third nominated member.
- Germany The three nominated members to SCOR from Germany are Professor W. Fennel, Professor Gerhard Graf and Dr. Gerold Wefer.
- Indonesia Dr. Anugerah Nontji has been appointed to serve as Indonesia's second nominated member replacing Dr. Aprilani Soegiarto.
- South Africa Dr. J.R.E. Lutjeharms will step down as South Africa's second nominated member and his successor has not been named as of this date.

##### *Representative Members:*

- CMG The Commission for Marine Geology has been disbanded by IUGS, meaning that Professor Yves Lancelot (France) and Professor R. Kidd (UK) are no longer *ex-officio* members of SCOR.

##### *Other Membership Issues:*

Dr. Eric Odada, Chair of the National Oceanographic Committee of Kenya has authorized the release of the information that he expects Kenya to become a member of SCOR in the near future.

#### 3.2 Publications Arising from SCOR Activities

The Publications Officer, Terry Healy, and the Executive Director presented a report on publications arising from SCOR activities since the 32nd Executive Committee meeting.

##### *GLOBEC Publications*

Small Pelagic Fishes and Climate Change Program: Report of the First Planning Meeting. GLOBEC Report No. 8. February 1996.

Rothschild, Brian (1995). Future Directions of the IGBP: Global Ocean Ecosystem Dynamics. *Global Change Newsletter* No. 24: 12-13.

##### *JGOFS Publications*

Protocols for the Joint Global Ocean Flux Study (JGOFS) Core Measurements. JGOFS Report No. 19. (A Reprint of IOC Manuals and Guides No. 29). June 1996.

Remote Sensing in the JGOFS program. JGOFS report No. 20. September 1996

##### *Publications Arising from SCOR Working Groups*

Phytoplankton Pigments in Oceanography: Guidelines to Modern Methods. Shirley Jeffrey, R.F.C. Mantoura and

Simon Wright (eds). The final product of WG 78 is in press at UNESCO for publication in the series *UNESCO Monographs in Oceanographic Methodology*.

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

Watson, Andrew (1995). Future Directions of IGBP: Marine Biogeochemistry - After JGOFS, SOLAS? *Global Change Newsletter* No. 24: 14.

Gross, Elizabeth and Terry Healy, 1995. SCOR: What is it and What Does It Do? *Oceanography* 8(3): 114-115

Healy, Terry, 1996. SCOR: What is it and What Does It Do? *Ocean News*. No. 5: 2-3.

Gross, Elizabeth, 1996. News from SCOR on International Science Activities. *Oceanography* 9(1). (In press).

SCOR Proceedings No. 31. Report of the 32nd Executive Committee Meeting of SCOR. Cape Town, South Africa. November 14-16 1996.

Ocean Modelling Newsletter - The most recent issue received in the SCOR Secretariat is No. 110.

Proceedings of the International Scientific Conference on the Tropical Ocean Global Atmosphere (TOGA) Programme. This Conference was co-sponsored by SCOR and took place in Melbourne, Australia, 2-7 April 1995. WCRP-91, WMO/TD No 717. Two volumes.

Healy proposed that one of the SCOR Officers should assume responsibility for the dissemination of SCOR news on a regular basis. One venue for this would be the "Ocean News" published by Elsevier. [This task has subsequently been assumed by the SCOR Secretary, Bjorn Sundby.]

The Executive Director informed the meeting that a SCOR Home Page had just become operational; its address is <http://www.jhu.edu/~scor>.

### 3.3 Finance

The Chair of the *ad hoc* Finance Committee, Michael Whitfield, presented the report from his group which had met twice during the General Meeting and had worked with the Executive Director on a review of the state of SCOR finances for the past (1995) and current (1996) fiscal years. The budget and final financial statement for 1995 are given in Annex 9.

Whitfield noted that a healthy cash balance had been carried forward from 1994 into 1995 and again into the 1996 financial year. In general there was a good match between the budget predictions and actual income or expense amounts as seen in the 1995 final statements. In reviewing the status of the current year's finances, the Finance Committee found that where there had been reductions in income, these involved "earmarked" funds so that a corresponding expense item had also been reduced or eliminated. The Executive Director proposed a number of revisions to the budget for 1996 to take account of these fluctuations and the *ad hoc* Finance Committee recommended acceptance of her proposals.

The collection of arrears in membership dues has continued, with success, and arrears represented a very small portion of the membership income. Whitfield and his committee recommended that the 1991 membership contribution from Bangladesh be waived in order to allow this national committee to retain its SCOR membership. This step was taken in recognition of the economic status of Bangladesh and the fact that this country is likely to be more seriously affected than most by such global phenomena as climate change and sea level rise. It was suggested that SCOR should sponsor the participation of a representative of the Bangladesh SCOR committee to the General Meeting in 1998.

The Finance Committee report included a draft budget for the 1997 fiscal year which took into account the requests of working groups for meetings as well as other demands on SCOR funds. The predicted income is

approximately \$550,000, not including the cash balance to be carried forward from 1996. Of this amount, \$366,000 would be spent directly on scientific activities, including a small allocation for meetings of one or two of the newly-established working groups should they be ready in time to meet in 1997. This budget for 1997 predicted a carry over of only \$47,000 to 1998; this was felt to be the absolute minimum amount with which SCOR should be prepared to begin its activities in a new year.

Finally, looking forward to 1998, the *ad hoc* Finance Committee recommended that membership contributions should be increased by 3%, effective January 1, 1998, in order to provide SCOR with a slight buffer against the effects of inflation.

The General Meeting accepted the report of the *ad hoc* Finance Committee.

The Finance Committee also raised the issue of an internal Strategic Review of SCOR which was recommended by the XXII General Meeting (*SCOR Proceedings*, Vol. 30, item 3.5), but which had not yet taken place. Noting that SCOR has little flexible income and, thus, limited ability to start new activities and to influence the directions of ocean science, Whitfield stressed the importance of conducting this review.

The President responded that he had invited Arthur Nowell (USA), Su Jilan (China), Michael Whitfield (UK) and Julia Marton-Lefèvre (Executive Director, ICSU) to participate in a review meeting which he will convene during the next six months. The review will examine the mode of operations of SCOR in the light of changes in the international style of ocean science; how does SCOR set its priorities for new activities; should SCOR do more in relation to policy issues; can the links between SCOR and its national committees and the oceanography community at large be improved? Allyn Clarke suggested that both former and new members of the SCOR Executive Committee should be involved in the review process. Other participants proposed that input should be sought from SCOR members and associated organizations and programs. The review meeting should also consider ways in which the funding base of SCOR can be broadened. In this regard, it was noted that more support should be sought from the cosponsors of SCOR activities, in particular the IGBP.

#### **3.4 Addition to the SCOR Constitution**

The Executive Director informed the General Meeting that she had written to all national committees to inform them that in accordance with the United States tax code for tax-exempt organizations, it was necessary to add the following clause to the SCOR Constitution:

“In the event of the dissolution of SCOR, its assets shall be ceded to one or more charitable organizations, to be utilized in conformity with the aims of SCOR and ICSU.”

A similar clause appears in the ICSU Statutes. No objections to this change were received from national committees and General Meeting approved this addition to the SCOR Constitution. In accordance with ICSU rules of procedure, it will be sent to ICSU for approval.

#### **3.5 Election of SCOR Officers**

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

The Nominations Committee established by the 1995 Executive Committee meeting was chaired by the Past-President, Jarl Strömberg, and included Colin Summerhayes (UK) and Su Jilan (China). Strömberg presented the report of the Committee, reviewing past practice in SCOR elections and the various nomination which had been received. In all, seven nominations were received for the three vacancies. The Nominations Committee

recommended a slate of officers for approval: President - John Field (South Africa); Secretary - Bjorn Sundby (Canada); Vice-President - Sergei Lappo (Russia). This recommendation was based on the need for an appropriate geographical and disciplinary balance on the Executive Committee as well as a timely rotation of its members in accordance with the recommendations of the last ICSU review of SCOR. After a break to allow for informal discussion of this proposal, the slate as recommended by the Nominations Committee was elected by acclamation.

A discussion ensued in which the need for more formal procedures for SCOR elections was stressed. The Constitution does not provide any guidance in this matter. While it is a reflection of the reputation of SCOR that so many good nominations were received, this also makes the election process more complex. Terry Healy suggested that there should be a deadline established for the receipt of nominations, possibly three months before a General Meeting and that the Nominations Committee should announce its recommended slate about a month before the meeting. Nominees who are not part of this slate could still be proposed for election at the General Meeting; in this case a formal ballot would be required. Candidates should be asked to certify their willingness to be nominated and should be given an opportunity to speak at the General Meeting. Finally, these formal procedures should be sent to all national committees with the request for nominations.

Thanking Terry Healy for these useful proposals, McCave suggested that a small group be established to consider them in detail and to propose revisions to the SCOR Constitution for a set of procedures for elections. This group will be chaired by Ian Jones (Australia) and will include the President (Field), Secretary (Sundby), Past-President (McCave) and one Vice-President (Krishnaswami).

### 3.6 Other Organizational Issues

#### 3.6.1 *Review of Agenda 21, Chapter 17*

As agreed at the 32nd Executive Committee meeting, the SCOR Secretary, Brian Rothschild, convened a small *ad hoc* group to review this document which arose from the Rio Conference (United Nations Conference on Environment and Development - UNCED - June 1992), and to consider its implications for SCOR and the contributions which SCOR could make to "Rio follow-up".

Rothschild presented the recommendations of this review group which included Terry Healy (New Zealand), Colin Summerhayes (UK), S. Krishnaswami (India) and Ezekiel Okemwa (IOC, Kenya). Agenda 21 is a "blue print for action for global sustainable development into the 21st century." Chapter 17 of Agenda 21 is of most concern to SCOR. It is directed at the "protection of the oceans, all kinds of seas, including enclosed and semi-enclosed seas, and coastal areas and the protection, rational use and development of their living resources." Chapter 17 calls for new approaches to management and development taken at national, regional and global levels. It suggests that these new approaches should be "integrative in context and anticipating in ambit". Taking these goals into consideration, Chapter 17 outlines a program that covers: integrated management and sustainable development; marine environmental protection; sustainable use and conservation of living resources in zones of national jurisdiction and on the high seas; a focus on critical uncertainties for management of the marine environment and climate change and strengthening international and regional cooperation and coordination; and the special problems of small islands. Key elements in each component of the program include data and information management, development of scientific and technological capacities, human resource development and capacity building.

The General Meeting agreed that SCOR should take account of the content of Agenda 21, Chapter 17 in developing its own program and in selecting topics for its working groups, continuing, however, to maintain scientific excellence as the primary guiding principle. Rothschild proposed that broader involvement in SCOR working groups could be achieved by partitioning some problems into regional considerations. The critical elements of capacity building and the development of scientific expertise are topics on which SCOR should interact to a greater degree with IOC. At all times, however, the primary objective of SCOR as a scientific organization, must be clear.

## 4.0 RELATIONS WITH INTERGOVERNMENTAL ORGANIZATIONS

### 4.1 Intergovernmental Oceanographic Commission

The representative of IOC, David Pugh, presented a report on the current activities of the Commission. He noted that the primary purpose of the IOC is "to promote scientific investigation with a view to learning more about the nature and resources of the oceans through the concerted actions of its members." While the intergovernmental nature of IOC does make it less flexible than organizations like SCOR, IOC has more positive concern for the direct application of its scientific activities, and for development issues. Pugh recalled that SCOR is the primary scientific advisor to the IOC and thus, indirectly, to its 124 Member States.

Pugh reviewed the major components of the IOC program, citing examples of SCOR activities which are complementary to many IOC efforts. The SCOR working groups on Sea Level Rise and Erosion of the World's Coastlines and on Sea Level and Muddy Coasts are relevant to the IOC program on a Global Sea Level Observing System. The new working group on Improved Global Bathymetry has strong links to the Expert Group on the General Bathymetric Chart of the Ocean (GEBCO). Once this SCOR group has completed its scientific tasks, the IOC could play a very strong role in persuading governments to make the recommended bathymetric measurements.

The IOC is also endeavouring to carry out certain assessments concerning the oceans and the conditions of the marine environment. These are aimed at synthesizing results of IOC actions mainly at the regional levels. The IOC may well wish to seek the advice of SCOR regarding these matters. It is, of course, recognized that overall ocean assessments are being pursued within the ICSU-SCOPE framework and through the Independent World Commission on the Oceans.

The IOC cooperates with SCOR in several IGBP projects, including JGOFS and GLOBEC. The JGOFS Advisory Panel on CO<sub>2</sub> provides for an interaction between IOC and SCOR on this important matter. The first International Symposium on Ocean CO<sub>2</sub> took place in January 1996 and was cosponsored by both IOC and SCOR. The IOC wishes to maintain its cosponsorship of GLOBEC and cooperation with SCOR in this program as part of the activities related to the IOC program on Ocean Science and Living Resources. Through its financial support to SCOR, the IOC provides limited financial support to GLOBEC and normally attends the relevant meetings.

Other areas related to the coastal zone also involve cooperation between IOC and SCOR. IOC is most interested in the SCOR Working Groups studying sedimentary properties of coastal zones. Coastal zone observations are high on the priority list and cooperation with SCOR is being sought. The new SCOR Working Group on Ocean Bathymetry is seeking cooperation and interaction with the IOC Ocean Mapping Program, also cosponsored by WHO. It appears essential that this dialogue be maintained for mutual benefit and avoidance of duplication. Ocean bathymetry is an important factor in relation to GOOS.

Cooperation with SCOR is also being sought in relation to the IOC Training and Education Program development. It would be very desirable if SCOR-associated laboratories could offer provision of experts for advanced training and education. This matter should be further pursued. The regional subsidiary bodies of the IOC are essential mechanisms of IOC as regards specification of regional programs and identification of related capacity building requirements based on national and regional needs and interests. This mechanism is used in discussions with potential donors and could also be used in relation to joint training and education and possibly other actions with SCOR. McCave referred this matter to Izabel Gurgel (Brazilian SCOR) for consideration in her capacity as Chair of the TEMA Strategy Subcommittee.

With respect to the development of GOOS, SCOR is involved indirectly through the co-sponsorship of GOOS by ICSU. The Joint Scientific and Technical Committee for GOOS (J-GOOS) requested SCOR to convene a workshop to begin preliminary planning for the Living Marine Resources module of GOOS; this was done in March 1996 under the leadership of John Shepherd (UK) and Brian Rothschild (USA). The report of this workshop was prepared for presentation to J-GOOS at its meeting in April 1996. Allyn Clarke, who is the ICSU/SCOR representative to J-GOOS, noted that this committee is advancing well with scientific planning for GOOS, although

the complex issues of the Coastal module had not yet been addressed. He expressed the hope that coordination and communication between J-GOOS and the Intergovernmental Panel for GOOS - the implementation planning side - would improve once the new GOOS Support Office Director has been appointed.

In the brief discussion which followed the IOC report, the similarities and differences of the two organizations were noted. While IOC is more complex, the political framework within which it must operate is necessary for many activities which must involve governments. A strong desire to see the cooperation between SCOR and IOC continue and to be strengthened was expressed by several participants.

#### **4.2 World Meteorological Organization**

A written report summarized briefly the recent activities undertaken within WMO which may be of interest to SCOR.

The work of the Data Buoy Co-operation Panel (DBCP) continues to be effected largely by its technical co-ordinator, Mr. Etienne Charpentier, who co-ordinates directly with both operational and research deployers of drifting and moored buoys. In July 1996, reports from around 849 buoys (over 54 % of the total deployed) were inserted onto the GTS for global distribution. Four action groups of the Panel, the European Group on Ocean Stations, the International Arctic Buoy Programme, the International Programme for Antarctic Buoys and the International South Atlantic Buoy Programme are fully operational and expected to continue for the foreseeable future. A fifth action group, the International Buoy Programme for the Indian Ocean, was established in September 1996.

The DBCP has been increasingly involved in efforts to persuade meteorologists and oceanographers to collaborate on combined meteorological and oceanographic drifting buoys. The low cost Lagrangian drifter equipped with barometer-port developed by the Scripps Institution of Oceanography has proved to be a success with substantial deployments during the past year.

Integrated Global Ocean Service System (IGOSS) has responded to the termination of the TOGA and WOCE research programmes (TOGA December 1994, WOCE field phase 1997) with the formalization of an operational ship-of-opportunity (SOO) programme, the initial objective of which is to maintain a base network corresponding to the low density TOGA/WOCE network in support of global climate studies and operational applications, as recommended in the OOSDP report and supported by GOOS and GCOS. The programme was initiated in 1996 and is coordinated through a SOOP Management Committee and a SOOP Implementation Panel, with scientific guidance and oversight being provided by the GOOS/GCOS/WCRP Ocean Observing Panel for Climate and the CLIVAR Upper Ocean Panel.

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>

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

Brian Rothschild, as representative of ICES, noted that the ICES Annual Science Conference and Statutory Meeting would take place in Iceland immediately after the SCOR General Meeting. SCOR cosponsored a theme session on "The North Atlantic Components of Global Programs: Lessons to ICES-GLOBEC from WOCE and JGOFS".

The main item of business with respect to ICES was a request for SCOR co-sponsorship of a "Symposium on the Role of Physical and Biological Processes in the Recruitment Dynamics of Marine Populations" to be held in conjunction with the 1997 Annual Science Conference and Statutory Meetings of ICES in Baltimore in September 1997. The General Meeting was pleased to approve this request and noted the direct relevance of this topic to the GLOBEC program and the proximity of the ICES meetings to the SCOR Secretariat.

ICES has established an office in Copenhagen to provide coordination for the ICES North Atlantic components of the GLOBEC program, especially the Cod and Climate Change program. The Director of this office is Keith Brander.

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

The written report from PICES focussed on its contribution to the GLOBEC program, namely the PICES/GLOBEC Carrying Capacity and Climate Change Program (CCCC). At the 1995 PICES annual meeting, the Implementation Plan for CCCC was finalized and has been published along with the Science Plan from the previous year in PICES Scientific Report No. 4. The PICES Science Board recommended that the CCCC program organize a Workshop on Conceptual/Theoretical Studies and Model Development, and establish three task teams; MODEL - to advance the development of conceptual/theoretical and model studies; BASS - development of basin scale studies and REX - development of the intercomparison of regional scale studies.

The Workshop was held in June 1996. Its objectives were to review the state-of-the-art, and gaps in knowledge of, coupled physical-biological and ecosystem models in member countries, and in on-going international programs, and to develop the model related requirements of the CCCC Implementation; to identify scientific, technical and methodological issues and identify requirements for model and theoretical approaches to guide the process and observation studies, and to integrate the results of the CCCC program.

There was strong support for a distributed modelling effort instead of a centralized modelling activity, with PICES playing a key coordinating and communication role. Other recommendations include the integration of the vertical mixed layer models into the general circulation models for development of coupled physics-plankton production models; standardization of models for lower trophic level processes such as nutrient uptake and grazing, and prediction; and comparison of fish bioenergetics, movement, and bottom-up and top-down multispecies rhododynamic models.

The BASS task team met during the workshop and recommended retrospective comparison of lower trophic level dynamics between eastern and western subarctic gyres, standardization of zooplankton sampling methods and time series measurements of primary productivity and zooplankton in order to compare changes in plankton populations with changes in the physical environment.

The REX task team met and recommended development of monitoring program at key cross-shelf locations in as many regional seas as possible. The transects should be complemented with measurements from moorings, especially if placed in "pulses point" which may represent locations of strong system variability control

Other PICES activities of interest to SCOR include the publication of the Proceedings of the Workshop on the Okhotsk Sea and Adjacent Areas, held in June 1995, in the PICES Scientific Report Series No. 6. Finally, PICES has setup three new Working Groups: WG 10 on Circulation and Ventilation in the Japan(East) Sea; WG 11 on Consumption of Marine Resources by Marine Birds and Mammals; and WG 12 on Crabs and Shrimps.

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

A report was received from:

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

Julian Priddle (UK) introduced the report from CCAMLR, the first received in several years. Links between CCAMLR and SCOR are being developed due to the interest of the Commission in the Southern Ocean GLOBEC program.

CCAMLR continues to be very active in the field of Antarctic ecosystem research and resource management. There are currently three major fisheries in the CCAMLR Convention Area, for krill (between 70 000 and 100 000 tonnes taken annually mainly from the South Atlantic), toothfish (about 8 000 tonnes taken annually from around South Georgia and Kerguelen Islands) and icefish (about 4 000 tonnes taken from Kerguelen in 1995). The fishery for toothfish currently takes its allowable catch, but the krill fisheries take less than 10% of their allowable catch.



All fisheries are subject to management measures (CCAMLR Conservation Measures) such as catch limitations, and provision is made for the controlled development of new fisheries alongside the acquisition of data with which they can be assessed. Developments in assessment methodology over the last few years have seen the introduction of precautionary mechanisms for dealing with uncertainty and ecosystem interactions. This means that, under conditions of increased uncertainty and/or greater risk of adverse impact on the ecosystem (for instance, reduced food supply to dependent predators), the assessment models will generally calculate a reduced allowable catch.

CCAMLR has had an Ecosystem Monitoring Program in place since 1987 which monitors reproductive parameters of selected predators and complements CCAMLR's more traditional assessment approaches. The aim of this program is to detect changes in the Antarctic ecosystem and identify those which are due to fishing and those which are due to natural environmental causes. The program has generated an extensive data set, with time series of over 15 years for some parameters, which is now yielding highly valuable information on interactions within the Antarctic ecosystem, and which will act as the basis for advice on the management of the harvested components of the ecosystem.

CCAMLR has a Scheme of International Scientific Observation and a System of Inspection which monitor its fisheries. The Scheme of Observation establishes a mechanism for the placing of observers on vessels to collect scientific data from fisheries, and is currently mandatory for all vessels in the South Atlantic toothfish fishery. The System of Inspection provides a mechanism for international inspection of compliance of vessels with CCAMLR Conservation Measures.

Both systems have been in successful operation for a number of years. Data obtained by observers has been particularly useful in addressing the incidental seabird mortality problem, which occurs in longline fisheries where birds are accidentally caught on sinking hooks and drown. Observations in 1995 demonstrated that the measures put in place by CCAMLR for reducing seabird mortality, particularly the requirement for night time setting, appear to be reducing the number of albatross killed, but not petrels. CCAMLR is currently producing an information booklet entitled 'Fish the Sea not the Sky' to further inform fishermen worldwide about its mitigation measures.

### *Independent World Commission on the Oceans*

In response to requests received by the SCOR secretariat, the President presented information about a new intergovernmental organization, the Independent World Commission on the Oceans (IWCO). This body was established, partly in response to the ratification and implementation of the Law of the Sea. It is analogous to a long series of Independent Commissions, such as Willy Brandt's Commission on North-South relations, and Gro Brundtland's Commission on Environment and Development.

The IWCO's mandate covers a three year period during which it will:

- seek to develop world consciousness of the unique role of the oceans for planetary survival and of the critical importance of rational management of ocean space and resources, including their interaction with rivers and land-based activities, and for this purpose.
- draw the attention of world leaders - including political, business, environmental, scientific and academic leaders - and the public at large to emerging issues relating to ocean development and the direct or indirect impact of human activity on ocean resources.
- encourage the further development of the ocean regime emerging from the United Nations Convention on the Law of the Sea in the light of changing scientific perceptions and discoveries, with particular attention to the problems and needs of developing countries;
- study the interactions between the Law of the Sea Convention, Agenda 21 (in particular, Chapter 17 which deals with the Seas and Oceans), the Biodiversity Convention, the Climate Change Convention and other recent Treaties, Agreements and Programmes, and explore ways of utilizing overlaps for enhancing the implementation of each;
- examine the economic potential of the oceans, including fisheries and the future developments in aquaculture and in mariculture; desalination for agricultural and domestic purposes; mineral and energy

- production; sea-borne trade and ocean-dependent tourism; marine scientific research and technology development; as well as the equitable distribution of these goods and services;
- analyse the requirements of integrated coastal management and the impact of the conclusions of the World Conference on Population, the World Conference on Habitat, the Agreement on Straddling Fish Stocks and Highly Migratory Stocks, the World Conference on Small Island Developing States as well as of trade and coastal tourism on integrated coastal and ocean management;
- explore new forms of North-South and South-South cooperation in joint technology development;
- study the dangers threatening the seas and oceans and the viability of their living resources and of marine biodiversity; the potential implications of sea-level rise and global warming and its social and economic impacts;
- endeavour to define modalities for strengthening the Institutional framework for ocean governance at various levels;
- contribute to the interpretation and development of the concepts of the peaceful uses of the oceans and the reservation of the oceans for peaceful purposes as well as the potential contributions of ocean governance to the implementation of the United Nations secretary-General's Agenda for Peace.

In the fulfilment of its tasks, the Commission will encourage the ratification and implementation of the UN Convention on the Law of the Sea and the Implementation of Agenda 21 (in particular, its Chapter 17). It will work with the United Nations Secretariat, UNESCO, other Agencies and Programmes of the UN system competent in ocean affairs, and with other intergovernmental as well as non-governmental organizations, at the national, regional, and global levels.

The Commission is large to reflect the various disciplines and the various regions involved in ocean affairs. It presently has a total of 40 members, coming from all regions of the world, from industrialized and developing countries. The Commission's Chairman is H.E. Dr. Mário Soares, President of the Republic of Portugal. Information about the complete membership of the IWCO is available from the SCOR Secretariat.

The Commission held its First Session in late 1995. Five more sessions are planned up to a Final Plenary Session to be held within the framework of the International Year of the Oceans, 1998, and in conjunction with EXPO '98 'The Oceans: A Heritage for the Future'. It will include a Conference on 'Oceans and Society on the Threshold of the Third Millennium' and the adoption of the 'Declaration of Lisbon'.

The General Meeting welcomed the creation of the Independent World Commission and expressed the hope that it would successfully fulfill its mission of raising public awareness of the oceans.

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

### **5.1 International Council of Scientific Unions**

The General Meeting expressed regret that a direct conflict between the dates of the ICSU General Assembly and the IOC Executive Council meeting, both immediately after the SCOR meeting, meant that SCOR would not be represented at the ICSU General Assembly. The Executive Director informed the General Meeting that SCOR would once again be due for a review by ICSU in 1997. During the past year, SCOR has responded to ICSU requests for input on topics such as Food Security. Other items related to ICSU had been dealt with under specific items in the Agenda for the General Meeting.

### **5.2 ICSU Unions and Committees**

Reports were received from the following ICSU organizations.

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

A general report received from SCOPE appears as Annex 10 to this report. It described the structure of SCOPE and its current activities.

Allyn Clarke represented SCOR at a preliminary meeting convened by SCOPE to discuss a proposed project entitled "Solving Environmental Problems of the Oceans", an assessment of the status of ocean science in response to societal needs as defined in Chapter 17 of Agenda 21. This would be somewhat analogous to the assessment of climate conducted by the IPCC.

The project proposed by SCOPE will be part of a coordinated effort by several intergovernmental and non-governmental organizations to provide a comprehensive assessment of environmental problems of the oceans, building upon currently available knowledge from a wealth of sources. This scientific basis will provide practitioners and policy-makers with the tools to ensure best practices for the use, development and protection of the natural resources of the world's oceans.

To this end, SCOPE, together with SCOR and in close consultation with the International Oceanographic Commission (IOC), the Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP), the United Nations Environment Program (UNEP), and other international organizations dealing with problems of the oceans, proposes:

- to assemble scientific and technical information currently available, in order
- to evaluate current knowledge about environmental problems of the oceans, in order
- to provide an integrated assessment of best practice and limits to progress, in order
- to identify a range of options for action to ensure best use and protection of resources.

Clarke noted that SCOPE is taking the lead in this effort and that the search for funds to support it is underway. He urged SCOR to remain involved and to ensure that it is well represented on any steering committee established for the ocean assessment.

#### *Scientific Committee on Antarctic Research (SCAR)*

The SCAR representative, Julian Priddle (UK), reported that at its recent meeting, SCAR had taken several decisions of direct relevance to SCOR. Firstly, it was agreed that the SCAR Global Change Program Office in Hobart should be the point of contact with SCOR and that the SCAR Global Change Program Coordinator, Ian Goodwin, should work closely with the SCOR Executive Director and the Chairs of relevant SCOR sponsored programs and working groups for coordination with related SCAR programs. Goodwin is also charged to investigate the need for a joint SCAR-SCOR working group on oceanography; a proposal will be prepared for the next SCAR and SCOR meetings. The SCAR meeting approved a draft science plan for a new program entitled Antarctic Sea Ice Processes and Climate (ASPECT). This program has close links to SCOR WG 86 on Sea Ice Ecology and to the iAnZone program.

The SCAR report included annexes on other SCAR activities with oceanic components. In addition to ASPECT, these include the program on Ecology of the Sea Ice Zone (EASIZ) and a new initiative on Late Quaternary Antarctic Sedimentary Record of Ice Margin Evolution (ANTIME). ANTIME will begin with a workshop in July 1997 which will assess the status of knowledge in the following key topics:

- The extent, timing and regional differences of the Last Glacial Maximum in Antarctica.
- What rapid or episodic events occurred during the Late Quaternary?
- What are the key forcings and feedbacks that influence the retreat and readvance of the Antarctic ice sheet?
- What changes have occurred to the ice shelves and outlet glaciers during the Holocene?
- Technology coordination; and,
- Correlation of Late Quaternary Antarctic environmental history and deep ocean sedimentary records.

The Chair of the SCAR Group of Specialists for Global Change and the Antarctic (GLOCHANT) contacted the Executive Director of SCOR shortly before the General Meeting, requesting assistance in naming representatives of SCOR programs to the newly-reconstituted GLOCHANT group. It was agreed that these positions should be filled by Julian Priddle, Chair of the JGOFS Southern Ocean Planning Group, and Eileen Hofmann, Chair of the GLOBEC Southern Ocean Working Group.

The General Meeting welcomed these developments which seemed likely to result in much closer ties between SCOR and the relevant oceanic activities in SCAR.

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

David Turner (Sweden) and Michael Whitfield (UK) presented information on IUPAC. SCOR has been developing closer links to this organization during the past two years and this has resulted in the creation of a joint working group (see item 2.4.1). The bulk of IUPAC's activities takes place within its 37 Commissions, which are organized into seven Divisions.

There are presently three IUPAC Commissions with projects in marine chemistry:

Commission on Equilibrium Data (V.6) - A review "Specific Problems in the Measurement and Interpretation of Equilibrium Data in Sea Water" by Prof. Robert Byrne (USA) is in press in *Pure and Applied Chemistry*. A project entitled "Influence of Pressure on Chemical Equilibria in Aqueous Solutions, with Particular Reference to Sea Water" aims to assess the magnitude of the influence of pressure on chemical speciation in the oceans. The main focus is on the effect of pressure on key equilibria (e.g. those involving carbonate, hydroxide, phosphate and chloride), particularly at low temperature. The project is expected to be completed by the end of 1996, and the report will be submitted for publication following internal review within the Commission. The results are expected to be particularly relevant to analysis and modeling of data from deep-sea projects such as InterRidge.

Commission on Solubility Data (V.8) - This Commission sought the support of SCOR for a project on the Solubility of Oceanic Salts. The General Meeting agreed that, while the group involved wanted financial support from SCOR, there did not seem to be any possibility of substantial SCOR involvement in the project. The Chair of the project (Jack Lorimer, Canada) should be asked to submit a more formal proposal to SCOR, setting out the scientific justification for it, the total budget and the amount sought from SCOR, a time schedule, plans for reporting progress to SCOR and publication plans, including details of how SCOR's sponsorship would be acknowledged.

Commission on Fundamental Environmental Chemistry (VI.1) - This Commission has participated in the preparation of a proposal for a joint SCOR/IUPAC Working Group on "The Marine Biogeochemistry of Iron".

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

A letter from the Secretary-General of IUPAP stated that while his organization does not currently have any activities relevant to oceanography, he did hope that joint activities would be possible in the future.

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

Steve Thorpe (UK), the representative of IUTAM in SCOR, drew several meetings to the attention of the General Meeting. These include IUTAM Symposia in 1997 on:

Simulation and Identification of Organized Structures in Flows. Lyngby, Denmark, 28-29 May  
Material Instabilities in Solids. Delft, The Netherlands, 9-13 June  
Rheology and Computation. Sydney, Australia, 20-25 July  
New Applications of Nonlinear and Chaotic Dynamics in Mechanics. Ithaca, NY, USA. 27 July - 1 August  
Computational Methods for Unbounded Domains. Boulder, USA 3-7 August  
Dynamics of Slender Vortices. Aachen, Germany. 31 August - 3 September  
Rheology of Bodies with Defects. Beijing, China. 2-6 September

***Union Radio Scientifique Internationale (URSI)***

A report from the URSI representative, Dag Gjessing (Norway), gave complete information on the current membership of URSI. He noted that over some time, URSI has been directing some attention to the sea surface, particularly through its Commission F on Remote Sensing. Such topics as wave propagation and remote sensing, remote sensing of precipitation and clouds, SAR polarimetry and interferometry, microwave remote sensing for ecological applications, and so on are being addressed by the Commission. At least 12 of its sessions at the 1996

URSI General Assembly reflected these interests. These included sessions on topics such as "Higher Order Statistics for Scattering Calculations from a Wind Roughened Ocean Surface", "Scatterometer Measurements of Ocean Surface Stress Magnitude and Direction from Aircraft and from ERS-1", And "Quantitative Estimates of Surface Current Features and Near Surface Wind Speeds in ERS-1, 2, and SAR Images".

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

The Deputy Executive Director of IGBP, Neil Swanberg, reported that all issues of importance relating to IGBP had been dealt with under the discussions of JGOFS, GLOBEC and SOLAS.

### 5.2.2 *World Climate Research Program*

A extensive report from the WCRP office provided information on the major oceanographic components of the WCRP. It was introduced by Allyn Clarke and appears in Annex 11.

Clarke noted that the World Ocean Circulation Experiment (WOCE) has entered a period of transition from field work to Analysis, Interpretation, Modeling and Synthesis (AIMS), 1997 being the last year of dedicated field work in WOCE. During AIMS, the task of producing a global view of the oceans depends on assembling all the sub-sets into composite global data sets. A WOCE distributed data management system has been set up with a number of WOCE Data Assembly Centers and Special Analysis Centers located at research institutions in several participating WOCE countries. Many WOCE data sets and products are already on line and, as final data sets are completed, they will be passed to the World Data Centers for permanent archiving. Keeping track of WOCE data collection, processing and archiving is a Data Information Unit, located at the University of Delaware, USA.

A fully comprehensive view of the overall success and scientific legacy of WOCE will only emerge as the AIMS phase advances. Nevertheless, several important results stemming from WOCE research have been reported recently. Notably, extensive tracer measurements (tritium/helium and CFCs) collected during WOCE sections are offering novel insights into the circulation rates and paths of water masses, as well as into the process of thermocline ventilation. The abundance and accuracy of drifter and float data are providing a new description of the ocean circulation at the surface and at 1000m, particularly in remote regions rarely surveyed by ships, and the coverage of ALACE data in the Pacific is now becoming sufficient to permit a comprehensive velocity field to be mapped. The development of measurement techniques using Acoustic Doppler Current Profilers is giving the basis for a refined view of the relationship between directly measured currents and those computed from geostrophy. WOCE measures of temperature and salinity have shown substantial changes since previous surveys in the 1960s and 1980s, providing a perspective on the spatial structure of decadal climate changes in the ocean. Regarding ocean model development, intercomparisons with data (particularly measurements) are showing the rapidly increasing realism of models, but are also highlighting features where further refinements are needed.

The Science Plan for the program on Climate Variability and Predictability (CLIVAR) was published in 1995. The major program elements of CLIVAR are CLIVAR-GOALS aiming to determine the variability and predictability of the Global Ocean Atmosphere Land System on seasonal-to-interannual times-scales (building on the successes of TOGA), CLIVAR-DecCen aiming to determine the mechanisms of variability and predictability of climate fluctuations on decadal-to-centennial time scales with special emphasis on the role of the oceans in the global coupled climate system, and CLIVAR-ACC examining Anthropogenic Climate Change. Of these, planning for GOALS is the most advanced. Detailed information about the development of these components of CLIVAR is given in Annex 11. Overall, the CLIVAR program is moving towards the development of a detailed Implementation Plan for presentation to an international CLIVAR scientific and implementation conference in the first half of 1998.

In the meantime, a smooth transition from WOCE to CLIVAR is being planned to reflect the reorganization of WOCE as it enters the AIMS phase and the establishment of GCOS and GOOS. Moreover, the TOGA/WOCE data assembly and analysis infrastructure is being reassessed, taking into account CLIVAR, GCOS and GOOS data management plans. CLIVAR is working actively with WOCE to encourage nations who are currently funding TOGA and WOCE data centers to continue to support these activities. The WOCE/CLIVAR liaison group has developed a list of long-term ocean observations which should be continued under CLIVAR.

The Arctic Climate System Study (ACSYS) has produced data revealing a significant warm temperature anomaly in the Arctic Ocean of as much as 10°C. Arctic Ocean dynamics are turning out to be considerably more complex than anticipated and marked shifts in the Beaufort Sea gyre have been detected on seasonal and longer time scales.

Finally, the General Meeting noted that a WCRP "mid-term" conference will take place in Geneva in 1997. It will consider WCRP priorities in the light of the 1995 IPCC Second Assessment Report and taking into account the changing interests of policy-makers and governments in the issue of climate change.

### **5.3 Affiliated Organizations**

Reports were received from the following organizations and were supplemented by their Presidents. The General Meeting noted with regret the decision of the International Union of Geological Sciences to disband the Commission on Marine Geology which had been an Affiliated Organization of SCOR.

#### **5.3.1 *International Association for Biological Oceanography***

The President of IABO, Fred Grassle, presented a verbal report from his organization. He had just come from the joint meeting of the Estuarine and Coastal Sciences Association and the Estuarine Research Foundation where he had participated in a meeting on the Biodiversitas initiative. Grassle requested SCOR's involvement in a meeting on marine biodiversity to be convened by IABO in one year's time.

The mechanisms for communication within IABO have been brought up to date and 28 National Correspondents have been confirmed. The IABO Executive considers that representation is now sufficiently wide for activities to recommence and steps towards the revitalization of IABO are well underway. Responses already received confirm that support for the marine component of the DIVERSITAS Program should continue to have top scientific priority. When sufficient responses have been received, they will be analyzed with a view to determining other scientific activities which IABO would support, as well as identifying meetings which it would be appropriate for IABO to sponsor.

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

Robert Duce, President of IAMAS, reported that much of the effort in IAMAS within the past year has been related to the planning for the Joint Assembly of IAMAS and IAPSO to be held in Melbourne, Australia from 1-9 July 1997. The overall theme of this conference is Earth-Ocean-Atmosphere, Forces for Change, which reflects the present challenge facing the world's scientific community to respond to the pressure to provide relevant knowledge and solutions to a public that is increasingly concerned about changes to the natural environment. Duce noted that a joint IAMAS/IAPSO Assembly provides an excellent opportunity for special symposia that emphasize the interactions between the ocean and atmosphere that are so central to many fundamental geophysical processes. Particular emphasis in a number of symposia will be given to the southern hemisphere.

The IAMAS President and Secretary General participated in an informal meeting of the Executive Committee of the International Union of Geodesy and Geophysics (IUGG) in June 1996. At that meeting IAMAS presented a preliminary proposal to IUGG to begin consideration of the formation of an ALLIANCE of National Meteorological and Hydrological Services (NMHSs), the University community, and the IUGG, with the following objectives:

- To provide close links between operations and research;
- To facilitate interactive research between developing and developed countries;
- To facilitate application of newly developed scientific insights and technologies;
- To provide and exchange software for data processing and synthesis;
- To develop new approaches to education and training; and
- To create international "Help" Bulletin Boards

The early concept is that the ALLIANCE would consist of a loose and flexible framework of organizations and individuals that would make full use of the Internet; currently available Internet Web sites relating to meteorology, hydrology, and oceanography (primarily through IAMAS, IAPSO, the International Association of Hydrological Sciences (IAHS), and the International Association of Geomagnetism and Aeronomy (IAGA) of IUGG); and the availability of a large pool of dedicated scientists, many of whom are retired and eager to contribute. It is expected that the financial requirements for such an ALLIANCE would be minimal. The IUGG and its associations gave general approval to this process and charged IAMAS as follows:

To pursue the ALLIANCE in discussions with other IUGG bodies, such as IAPSO, IAHS, and IAGA; the University Corporation for Atmospheric Research (UCAR); and the World Meteorological Organization (WMO);

To flesh out the proposal and plans;

To initiate general agreements with WMO and UCAR;

To proceed in close cooperation with the IUGG President and Bureau; and

To periodically report to the IUGG bodies.

This process and discussions are now underway and will be the subject of a special session at the IAMAS/IAPSO General Assembly in Melbourne and further discussion at the SCOR meeting in '97.

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

The President of IAPSO, Vere Shannon, also reported that his organization is deeply involved in planning for the IAMAS/ IAPSO Joint Assembly. The Joint Assembly will have 15 IAPSO Symposia and 2 IAPSO workshops.

An IAPSO Homepage on the World Wide Web (WWW) is now available at <http://www.olympus.net/IAPSO/>. This is on a high-performance, commercial file server with a direct connection to the WWW to provide quick access to the homepage. The homepage provides information on IAPSO; links to university, institute, or laboratory departments and programs dealing with physical sciences of the oceans; links to other sources of information on oceanography and geophysical sciences; and other WWW links of interest. Links to the IAPSO Homepage have been established on some other oceanography related homepages, and that effort is continuing.

Shannon and the Secretary General of IAPSO, Fred Camfield, participated in a meeting with other association Presidents and Secretaries General and the IUGG Bureau to discuss Union business and preliminary plans for the upcoming IUGG General Assembly in Birmingham England in July 1999. IAPSO expects to co-sponsor a number of joint symposia with other IUGG Associations and/or other components of the International Council of Scientific Unions at this General Assembly. There were preliminary discussions of obtaining funding to partially support attendance of scientists from countries-in-need.

There have been some preliminary considerations of an IAPSO Assembly in 2001, and possible joint symposia at Assemblies of other Associations in 2001.

## **5.4 Corresponding Organizations**

Reports were received from the following organizations:

### **5.4.1 *Arctic Ocean Sciences Board***

Larry Clark reminded the General Meeting that the AOSB was established in the early eighties to facilitate Arctic Ocean research through the support of multinational and multidisciplinary natural science and engineering programs. The Board consists of representatives from about 14 countries with active involvement or interest in the Arctic. The Board has no budget for funding projects *per se*; however the members represent substantive programs within their respective countries. Through the collective collaboration of these programs, the Board can undertake interdisciplinary projects that would normally be outside the capability of an individual institution. For example, a major multinational multi year program in the Greenland Sea concluded with a Symposium in Hamburg, March

1995, and resulted in about 30 refereed scientific papers. The Board acts as a forum for the exchange of information on national and international arctic science initiatives and discussions on subjects of mutual priority and interest. It collaborates with other arctic science organizations.

Current AOSB activities include a project on Arctic Paleo-River Discharge (APARD) for which a workshop was planned in Germany in late 1996. The Board has also agreed to organize an International Symposium on Arctic Freshwater Balance. This topic is timely as the significance of freshwater input from the Arctic to the sub-arctic Atlantic Ocean in controlling thermohaline circulation within the global ocean is now becoming apparent. The Executive Director reported that SCOR has been invited to participate in the organization of this event at a very early stage and that it is expected to take place in early 1998 in Finland. The US National Science Foundation has already committed funds for the preliminary planning process for this meeting and requested the SCOR Secretariat to administer its funds for the AOSB. NATO support is also being sought for the symposium. The NATO Science Committee was approached to enquire whether the Symposium could be a potential candidate for a NATO Advanced Study Institute (ASI) and the response was encouraging. The Chair of AOSB, Geoff Holland, has agreed that SCOR should have a high profile as a sponsor of this meeting. The General Meeting endorsed these plans.

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

A brief report from ECOR informed SCOR of a planned ECOR General Assembly for October 16-19 1996 to be held at the NRC Marine Board in Washington DC, USA. The Executive Director of SCOR was invited to attend this meeting to give a presentation on SCOR's structure and mode of operation. ECOR is still undergoing a process of regeneration and revitalization which includes a review of membership and the form of its membership. An ECOR journal has been set up jointly with the Ocean Engineering Research Center at Memorial University. This is entitled *Oceanic Engineering International* and the first issue is due out in early 1997. It includes some ECOR news as well as technical papers and reviews. Activity in working groups has been undergoing a similar process to that of ECOR itself. A report from the working group on autonomous underwater vehicles has been published and a second report is due shortly. An internal report from the working group on Marine Pollution has been drafted. A working group on Wave Energy Conversion is being formed with funding from Japan. A working group on Marine Mining is being formed and this will concentrate on the environmental effects of marine mining. There is interest in working groups on Tanker Safety and CO<sub>2</sub> disposal in the Oceans. Finally, ECOR has been accepted as a Scientific Associate of ICSU.

#### ***Scientific Committee of the Confédération des Activités Subaquatiques***

Nic Flemming provided information on the CMAS Scientific Committee on behalf of its new President. Experimental work by divers is getting more attention in academic journals and "even made the color cover of *Nature* last year". The European Commission has allocated a budget line for the support of scientific diving in its Marine Science and Technology Program. The CMAS-UNESCO Code of Practice for Scientific Diving has been completely revised and re-published by UNESCO. CMAS has acted as an advocate for scientific divers in many countries where legislation tends to include them in the same classification as construction workers or oilfield divers. Some success has been achieved in persuading legislators to develop different codes for scientific diving.

### **5.5 Other Organizations**

#### ***The Oceanography Society***

Robert Duce, President of The Oceanography Society (TOS) reported that TOS, in cooperation with WCRP, IGBP, HDP and SCOR, held its first European meeting in Amsterdam, in July 1996. The unique format of TOS meetings and the meeting theme, "The Role of the Ocean in Global Change Research Highlighting the Oceanographic Aspects and Importance of the Global Change Research of WCRP, IGBP and HDP" attracted 225 scientists and students from 23 countries. SCOR provided invaluable logistical and financial support for the meeting by making available travel funds for four needy scientists.

The next TOS Scientific Meeting is scheduled for April 1-4, 1997 in Seattle, Washington. The overall theme of the meeting is "Ocean Interfaces", and the program was being developed at the time of the General



Meeting. SCOR accepted the invitation from TOS to a co-sponsor of this meeting.

New officers of TOS for 1996 to 1998 were installed at the Amsterdam meeting. Robert Duce of Texas A&M University is the new President, Kenneth Brink of Woods Hole Oceanographic Institution is the President-Elect, and Margaret Leinen of the University of Rhode Island is the Past-President. New members of the TOS Council include Tony Knap of the Bermuda Biological Station and Larry Mayer of the University of New Brunswick, Canada.

Duce also reported that in order to maintain the momentum generated by its first European meeting and to further foster individual and organizational relationships outside North America, TOS plans to hold its second European meeting in 1998. "Coastal and Marginal Seas" will be the general meeting theme, and he expressed the hope that SCOR would also co-sponsor that meeting.

The Oceanography Society very much values its ongoing relationship with SCOR. TOS continues to extend its invitation to SCOR for materials with an international perspective for publication in "Oceanography" magazine. Approximately 25-30% of the society's membership is now international.

## **6.0 FUTURE MEETINGS**

### **6.1 Future meetings of SCOR**

The representatives of the Brazilian SCOR Committee, Izabel Gurgel and Marilia de Albuquerque, reaffirmed the invitation of their country to SCOR to hold its Thirty-third Executive Committee Meeting of SCOR in Brazil in September or October 1997. They suggested the venue of Angra dos Reis, a coastal resort town south of Rio de Janeiro. [This was later changed to Rio itself in order to allow some joint sessions with other ICSU bodies that will be meeting there at the same time.] A one week schedule for the meeting was discussed, allowing two to three days for the Executive Committee meeting itself, a day of presentations from the Brazilian oceanographic community and an appropriate field trip. A special effort will be made to encourage participation in this meeting from the countries in the region, including those such as Peru, Uruguay and Venezuela which are not yet members of SCOR. The General Meeting accepted this invitation with gratitude.

Winifried Gieskes of The Netherlands SCOR Committee put forward a formal invitation for the XXIV General Meeting to be held in his country in September/October 1998, on the island of Texel in connection with the Netherlands Institute for Sea Research. This invitation was also accepted with pleasure.

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

The Executive Director presented a list of international meetings of interest to SCOR during the next two years, in addition to those which had been discussed under earlier agenda items.

SCOR co-sponsorship was granted to the following meeting by the Executive Committee meeting in 1995:

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

The General Meeting approved requests for SCOR co-sponsorship of the following meetings. In most cases, SCOR's financial involvement is limited to the provision of a small amount of support to facilitate the participation of oceanographers from developing countries and from the countries of the former Soviet Union.

- Ocean Data Symposium. March 12-15 1997. Dublin, Ireland.
- The Oceanography Society - Scientific Meeting. April 1-4 1997. Seattle, USA.
- 29th International Liège Colloquium on Ocean Hydrodynamics. Marine Turbulence Revisited. May 5-9 1997. Liège, Belgium.
- Stability and Instabilities of Stratified and/or Rotating Flows. June 24-26 1997, Moscow.
- VIII International Conference on Harmful Algae. June 25-29 1997. Vigo, Spain.
- Joint IAMAS-IAPSO Assembly: Earth - Ocean - Atmosphere - Forces for Change. July 1-9 1997. Melbourne,

- VIII International Conference on Harmful Algae. June 25-29 1997. Vigo, Spain.
- Joint IAMAS-IAPSO Assembly: Earth - Ocean - Atmosphere - Forces for Change. July 1-9 1997. Melbourne, Australia.
- The Role of Physical and Biological Processes in the Recruitment Dynamics of Marine Populations. A Symposium to be held in conjunction with the 1997 ICES Annual Science Conference, September 1997. Baltimore.
- Oceanic Fronts and Related Phenomena. The Konstantin Fedorov Memorial Symposium. May 18-22 1998, Saint Petersburg, Russia.
- Ocean Circulation and Climate. The World Ocean Circulation Experiment Conference. May 24-29 1998, Halifax, Canada.
- The Oceanography Society - Scientific Meeting. June 1998. Paris. This will be the second TOS European meeting. The theme is "Coastal and Marginal Seas".

The following meeting was discussed in more detail since it will require a greater involvement on SCOR's part:

David Halpern presented information to the General Meeting on the International Conference on Satellites, Oceanography and Society (ICSOS) which he is planning as part of the celebrations associated with the International Year of the Ocean in 1998. The meeting will take place in August 1998 in Lisbon as part of the world's fair, Expo '98. The theme of Expo '98 is the "Heritage of the Oceans" and it marks the 500th anniversary of Vasco de Gama's voyage of exploration.

ICSOS celebrates the twentieth anniversary of the launch of the Seasat and Nimbus-7 satellites, which together demonstrated the engineering and scientific accomplishments of measuring sea surface temperature, sea surface height, surface wind velocity, sea ice, and near-surface phytoplankton abundances. The theme of ICSOS is to examine how satellite observations are contributing to the advancement of marine science for benefits to society. The goal of ICSOS is to establish how satellite measurements can lead to new and valuable marine services to society, unachievable with conventional methods. Topics to be considered include improved daily and extended weather and sea ice forecasts, accurate seasonal-to-interannual climate predictions, and better management of living resources.

The products of the conference will be a high quality book and an innovative explanatory brochure to be issued just before the meeting showing the "State of the Global Ocean" based on near real-time satellite images. The organizers of Expo '98 want to make this available to all visitors to the world's fair which may entail the production of several million copies.

Halpern was also seeking the cosponsorship of various space agencies and other international organizations such as IGBP, IOC, NASA, ESA and WCRP. He specifically requested SCOR to provide administrative support for the scientific organizing committee and to act as a repository for the funds committed to the conference. The organizing committee will be established in consultation with the co-sponsors. The General Meeting agreed that this was an opportunity for SCOR to have a high level of visibility at a large meeting and endorsed the plans as presented by Halpern. The Executive Director will work with him, particularly in the financial administration required for the conference.

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

- International Symposium on Ocean Disposal of Carbon Dioxide. October 31 - 1 November 1996. Tokyo, Japan.
- ICES Symposium: Seabirds in the Marine Environment. November 22-24 1996. Glasgow, Scotland.
- The Temporal Variability of Plankton and Their Physico-Chemical Environment. March 19-21 1997. Kiel, Germany.
- JGOFS Symposium on Synthesis and Modelling. May 20-26 1997. Oban, Scotland.
- Symposium on the Antarctic and Global Change. July 14-18 1997. Hobart Tasmania.

- Fifth International Carbon Dioxide Conference. September 8-20 1997. Cairns Australia.
- International Symposia on Environmental Biogeochemistry: Matter and Energy Fluxes in the Anthropocentric Environment. September 21-27 1997. Monopoli, Italy.

## 7.0 OTHER BUSINESS AND CLOSING

Terry Healy proposed that, in order to increase the involvement of scientists from developing countries in SCOR activities, one of the SCOR officers should be assigned the responsibility for getting appropriate nominations for new working groups as they are proposed and established by SCOR. He also urged SCOR to ensure that female scientists are adequately represented in all activities. Finally, he requested that the possibility of closer ties to UNEP be explored since that organization has many activities in the coastal ocean, especially in its Regional Seas Program.

\* \* \* \* \*

In closing the meeting, the outgoing President, I.N. McCave, expressed the deep appreciation of SCOR to Jarl Strömberg, the Past-President, for whom this was his last meeting as a member of the SCOR Executive Committee. He particularly noted the support he had personally received from Strömberg in his own early days as President of SCOR. Thanks were also extended to other members of the SCOR Executive who were completing their terms of office: Brian Rothshchild, who as Secretary had "pumped ideas into SCOR in a vigorous way"; Terry Healy, Vice-President and Publications Officer who had done a great deal to raise the international profile of SCOR; and Allyn Clarke whose advice on climate issues had been invaluable on many occasions.

The incoming President, John Field, thanked McCave on behalf of all SCOR members for his service as President and appealed for his continuing involvement and support as an active Past-President of SCOR. Field looked forward to an exciting four years as President of SCOR, including the International Year of the Ocean in 1998.

**ANNEX 1 - List of Participants**

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XXIII GENERAL MEETING  
SOUTHAMPTON OCEANOGRAPHY CENTER, SEPTEMBER 16, 17 & 20, 1996**

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**ANNEX 2 - Program of Symposium on Mid-Ocean Ridges**

**SCOR Working Group 99 and BRIDGE Research Results  
2-Day Science Meeting, Southampton Oceanography Centre, UK  
18th and 19th September 1996.**

**Day 1 - Wednesday 18th September, 1996 - SCOR WG 99 Symposium  
"Linked Mass and Energy Fluxes at Ridge Crests"**

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**Introduction and Welcome**

**John Shepherd (Director, Southampton Oceanography Centre)  
Martin Sinha (Cambridge Bullard Laboratories, Chair WG 99)**

**Presentation 1**

**David Needham (IFREMER, France)  
Background: The Global Ridge System**

**Presentation 2**

**Martin Sinha (Cambridge Bullard Laboratories, Chair WG 99)  
Crustal Accretion and Lithospheric Construction**

**Presentation 3**

**Charlie Langmuir (Lamont-Doherty Earth Observatory)  
Melt Generation and Mantle Flow**

**Presentation 4**

**Henri Bougault (IFREMER, France)  
Hydrothermal Processes: Exchange, Concentration and Dispersal**

**Presentation 5**

**Kim Juniper (University of Quebec, Canada)  
Biological Productivity Associated with Hydrothermalism**

**Presentation 6**

**Nils Holm (University of Stockholm, Sweden)  
Abiotic Organic Synthesis in Hydrothermal Systems**

**Video Presentation**

**Hiroimi Fujimoto (Ocean Research Institute, Tokyo, Japan)**

**Poster Session**

Day 2 - Thursday 19th September, 1996  
BRIDGE Research Results: An Overview

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Introduction and Welcome

Lindsay Parson (MOR Processes Group, Southampton Oceanography Centre)

Presentation 1

Christine Pierce (Durham University), M. Sinha, S. Constable, D. Navin, L. McGregor, A. White, G. Heinson, and M. Inglis.

Geophysical Evidence for a Magma Chamber beneath the Slow-spreading Reykjanes Ridge, N. Atlantic

Presentation 2

Rex Taylor (Southampton Oceanography Centre)

Petrogenesis of Extrusives at the Reykjanes Ridge Section of the Mid-Atlantic Ridge

Presentation 3

Chris German (Southampton Oceanography Centre)

Controls on High Temperature Hydrothermal Activity: Latest BRIDGE Collaborative Research South of the Azores

BRIDGE Research Results: An Overview, Part 2  
(Martin Sinha (Cambridge University Bullard Laboratories))

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Presentation 4

Ian Rouse (Southampton Oceanography Centre)

BRIDGE Technology: the Present and the Future

Presentation 5

Adam Schultz (Institute of Theoretical Geophysics, Cambridge University)

Diffuse Hydrothermal Flow at Slow-spreading Mid-Ocean Ridges

Presentation 6

Gerald Ernst, Chris German, Martin Palmer, John Davis and Steven Sparks (Bristol University)

Sedimentation from Hydrothermal Plumes in Cross-currents

Presentation 7

Peter Herring et al. (Southampton Oceanography Centre)

Larval Dispersal between Hydrothermal Vents

Presentation 8

David Dixon and Linda Dixon (Plymouth Marine Laboratory)

Blind Vent Shrimp has Eyes After All

### ANNEX 3 - Ecology of Sea Ice - (WG 86)

The Working Group held a meeting in Prague, Czech Republic (May 24-25, 1996) to discuss the organization of the approved Gordon Research Conference on Sea Ice Ecology to be held in Ventura California, 2-7 March 1997. Arrangements for the scientific program were drafted there and have been completed via correspondence since the May meeting. The science program (attached) has been sent in for publication in Science and placement on the Gordon Research Conference Web site. All Speakers and Discussion Leaders were formally invited and have responded indicating their willingness to participate. The first circular of the Gordon Conference was mailed and posted, the positive responses received to date, together with the attendance of Speakers, Discussion Leaders and Working Group members suggests that the maximum attendance allowed (135 participants) will be achieved. Future activities include the posting of future circulars and the formalizing of commitments for travel support received to date from NSF, ONR and SCOR, acceptance of applications for attendance, leading up to the the conference week (2-7 March 1997).

A committee was established to organize a book on Sea Ice Ecology, consisting of R. Horner, (Chair), S.F. Ackley and Richard Rivkin. This effort will proceed in parallel with, but distinct from the Gordon Conference, since the conferences have a prohibition on the publication of proceedings. The Gordon Conference will provide an opportunity to complete the organization of the book, as most potential chapter authors will be in attendance, and poster papers presented by conference participants will allow new results to be included, and other authors to be commissioned onsite.

We participated in the writing of a science plan for the Antarctic Sea Ice Processes Ecosystems and Climate (ASPECT). (S.F. Ackley and G.S. Dieckmann). As part of the SCAR Global Change in Antarctica Program, this plan was presented to the SCAR Delegates at their meeting in Cambridge in August 1996. As reported at the last SCOR meeting, the ASPECT program and the ongoing CS-EASIZ (Coastal Zone-Ecology of Antarctic Sea Ice Zone) are looked on as the Antarctic implementation in their sea ice ecosystem research of the concepts and activities developed in our Working Group on Sea Ice Ecology. This past year, the development of the ASPECT program was closely coordinated with activities of other Southern Ocean programs, including those of SCOR (JGOFS, GLOBEC), the informal association of Antarctic Zone (ANZONE), and WCRP (International Antarctic Data Buoy Program and the International Antarctic Ice Thickness Monitoring Program) and emerging activities in CLIVAR. Based on these developments, ASPECT was framed to complement but not overlap with these activities, by carrying programs into the sea ice zone that are not otherwise being undertaken, as well as the specific sea ice studies that bear on climate and ecosystem issues that are not covered at all in these other programs.

#### Science Activities of Working Group 86

Most recently, the science activity consisted of identifying the topics, speakers and titles of presentations at the Gordon Conference. A copy of the program is attached. Publications and Abstracts of Scientific Papers published under WG86 activities are also enclosed.

#### Publications

Ecology of Sea Ice Biota 1. Habitat, terminology and methodology, 1992 (R. Horner, et al, the members of SCOR Working Group 86), *Polar Biology*, v. 12 p. 417-27

Summary. Polar regions are covered by extensive sea ice that is inhabited by a variety of plants and animals. The environments where the organisms live vary depending on the structure and age of the ice. Many terms have been used to describe the habitats and the organisms. We here characterize the habitats and communities and suggest some standard terms for them. We also suggest routine sampling methods and reporting units for measurements of biological and chemical variables.

Ecology of Sea Ice Biota 2. Global Significance, 1992, (L. Legendre, et al, the members of SCOR Working Group 86), *Polar Biology*, v. 12, 429-44

**Summary.** The sea ice does not only determine the ecology of ice biota, but it also influences the pelagic systems under the ice cover and at ice edges. In this paper, new estimates of Arctic and Antarctic production of biogenic carbon are derived, and differences as well as similarities between the two oceans are examined. In ice-covered seas, high algal concentrations (blooms) occur in association with several types of conditions. Blooms often lead to high sedimentation of intact cells and faecal pellets. In addition to ice-related blooms, there is progressive accumulation of organic matter in Arctic multi-year ice, whose fate may potentially be similar to that of blooms. A fraction of the carbon fixed by microalgae that grow in sea ice or in relation to it is exported out of the production zone. This includes particulate material sinking out of the euphotic zone, and also material passed on to the food web. Pathways through which ice algal production does reach various components of the pelagic and benthic food webs, and through them such top predators as marine mammals and birds, are discussed. Concerning global climate change and biogeochemical fluxes of carbon, not all export pathways from the euphotic zone result in the sequestration of carbon for periods of hundreds of years or more. This is because various processes, that take place in both the ice and the water column, contribute to mineralize organic carbon into CO<sub>2</sub> before it becomes sequestered. Processes that favour the production and accumulation of biogenic carbon as well as its export to deep waters and sequestration are discussed, together with those that influence mineralization in the upper ice-covered ocean.

Physical controls on the development and characteristics of Antarctic sea ice biological communities--a review and synthesis, 1994, (S.F. Ackley and C.W. Sullivan, present and past Chairmen of WG 86), *Deep-Sea Research* 1. v. 41, p. 1583-1604

**Abstract.** Ice structures found in Antarctic sea ice and related morphological processes are summarized, including: frazil ice growth; the flooded snow layer; pressure ridge induced flooding; thermally driven brine drainage; and platelet-ice formation. The associated colonization, physiological adaptation, and growth of sea ice biota within these structures, to the levels presently identifiable, are also reviewed. A strong interactions exists between the physical processes that form, evolve and deteriorate sea ice, and the biological communities located within sea ice. Variability of ice structure and associated biological communities over small spatial scales necessitated analysis of the biological component in combination with physical and chemical properties of the sea ice. The ice microstructure provides indication of the growth and evolution of the ice properties and initially defines how ice biota colonize the ice. The light, temperature, space and nutrient fields within which ice biota subsequently adapt and grow, are the other key determinants of the biology. While the ice microstructure shapes the localized biological response, relatively large regions of pack ice have characteristic microstructures. Regional patterns of biomass and biological productivity within the Antarctic sea ice zone may therefore be predictable as a result of these physical- biological associations. Examples from the drifting pack ice and fast ice zones of the Weddell and Ross Seas are given.

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**GORDON RESEARCH CONFERENCE ON SEA ICE ECOLOGY  
2-7 March 1997, Ventura, CA, USA**

S.F. Ackley, Chairman; L.Legendre, Vice-Chairman

**Scientific Program**

**Session 1. (Sunday Evening 7:30-9:30)**

**Setting The Scene--Sea Ice Response to Atmospheric and Oceanic Forcing**

**Wilford F. Weeks, Discussion Leader**

**Peter Lemke--Variability in Arctic and Antarctic Sea Ice**

**Hajo Eicken--Growth and Metamorphism of Sea Ice related to Sea Ice Ecology**

**Session 2. (Monday Morning 9-12:30)**

**Energy and Mass Exchanges in Sea Ice Systems**

**Manfred Lange, Discussion Leader--Review of Ice Physical Properties**

**Donald Perovich--Optical Processes in Sea Ice Related to Sea Ice Ecology**

**Victoria Lytle--Convective and Diffusive Heat and Mass Exchange in Sea Ice**

**Vernon Squire--Marginal Ice Zone and Polynya Processes Impacting the Biological Environment**

**Monday Afternoon (4:30-6). SEA ICE ECOLOGY I POSTER SESSION**

**(I. Melnikov, Discussion Leader)**

**Session 3. (Monday Evening 7:30-9:30)**

**Ice Edge Ecology**

**Paul Treguer, Discussion Leader--Review of Current Knowledge on Ice Edge Ecology**

**C. Lancelot--Mechanisms of Food-web Export at Ice Edges**

**Harvey Marchant--Mechanisms of Deep Export at Ice Edges**

**Session 4. (Tuesday Morning 9-12:30)**

**Ice-related Primary Production**

**Satoru Taguchi, Discussion Leader--Review of Ice Related Primary Production**

**Egil Sakshaug--Ice-Related Photosynthetic Processes**

**Walker O. Smith--Revisiting Estimates of Ice-related Primary Production in the Southern Ocean Michel**

**Gosselin--Revisiting Estimates of Ice-related Primary Production in the Arctic Ocean Igor Melnikov--(Poster Session I Report and Discussion)**

**Session 5. (Tuesday Evening 7:30-9:30)**

**Abiotic factors controlling structure and function of sea ice communities**

**Gerhard Dieckmann, Discussion Leader**

**Marcus Gleitz--The Role of Ice Biota in Modifying the Geochemical Properties of Sea Ice Christian Fritsen--Coupled Physical-Biological Modeling of Surface and Bottom Sea Ice Communities**

**Session 6. (Wednesday Morning 9-12:30)**

**Internal Sea Ice Communities and their Trophic Structures**

**M. Spindler, Discussion Leader--Review of Knowledge on Internal Sea-ice Communities**

R. Rivkin-- Bacterial Dynamics--Production and Dissolved Organic Carbon  
S. Grossmann--Seasonal Dynamics of Microbial Food Webs in Sea Ice--Fate of Ice-related Primary Production  
R. Gradinger-- Auto- and Heterotrophic Flagellates and Other Algae  
D. Garrison-- Higher Trophic Levels Within the Sea Ice

Wednesday Afternoon (4:30-6) SEA ICE ECOLOGY II POSTER SESSION  
(M. Fukuchi, Discussion Leader)

Session 7. (Wednesday Evening 7:30-9:30)  
Pelagic Organisms Associated With Sea Ice  
Bjoern Gullicksen, Discussion Leader--Review of Pelagic Organisms Associated with Sea Ice

Louis Fortier--Effects of Ice-related Primary Production on Zooplankton, Fish Larvae and Juveniles  
Vassily Spiridonov--Antarctic krill: Diverse Effects of Sea Ice on Life History and Distribution

Session 8. (Thursday Morning 9-12:30)  
Sea-ice Related Carbon Flux  
Sus Horjo, Discussion Leader-- Current Knowledge of Sea-ice Related Carbon Flux

L. Codispoti--Biogeochemical Constraints of the Sea-ice Related Carbon Flux  
K. Takahashi--Carbon and Related Biogenic Particle Fluxes in the Bering Sea and Adjacent Regions  
C. Michel-- Downward Carbon Export from Sea Ice  
M. Fukuchi--Poster Session II Report and Discussion

Thursday Afternoon (5-6pm) BUSINESS SESSION

Session 9. (Thursday Evening, 7:30-9:30)  
Ice-related Apex Predators  
Ole Jorgen Lonne, Discussion Leader--Review of Ice-related Apex Predators

H. Hop--Polar Cod and its Relation to Sea Ice Ecology  
W. Trivelpiece--Penguin Populations In Antarctica, Relationships to Sea Ice: Breeding, Feeding, Predation

Friday Morning. Conference Closed. Depart after Breakfast.



**ANNEX 4 - Physiological Ecology of Harmful Algal Blooms (WG 97)**  
**Key Issues and Suggested Research Priorities**

**1. MIXOTROPHY BY HAB SPECIES**

**Justification:**

It is now clear that many Harmful Algal Bloom species have the potential for mixotrophic nutrition. The ability to utilize both photosynthetic and heterotrophic pathways may give species of mixotrophic HAB a competitive advantage over strictly autotrophic members of the phytoplankton. Thus, we cannot understand bloom dynamics, the effects of eutrophication on plankton communities, or life cycle dynamics of key HAB taxa without thoroughly understanding the forces driving mixotrophy and the extent to which autotrophic processes are supplemented by heterotrophy.

**Research Priorities:**

- Develop reliable methods to detect and quantify mixotrophic nutrition
- Determine the mixotrophic potential of key HAB species
- Identify factors that induce or enhance phagotrophy in photosynthetic organisms
- Investigate the effects of natural and anthropogenic eutrophication on HAB mixotrophy
- Evaluate the effects of mixotrophic nutrition on toxicity of HAB species
- Assess the significance of mixotrophic HAB on the structure and function of marine food webs

**2. THIN LAYERS AND MICROPHYSICS OF THE PYCNOCLINE**

**Justification:**

Different strategies lead some species, amongst which a large proportion of the harmful species, to accumulate into thin layers (some tens of centimeters) associated with the pycnocline for long periods of time. Spatial scales in these features have not yet been investigated but there is evidence that they can extend, at least, to the 10 km scale.

For different species, greater knowledge of behavioral responses responsible for such accumulations or confinement would allow better understanding of HAB dynamics. Detailed studies of a few target species might lay the basis for typifying functional groups of species. Such detailed studies would thus also provide insights into biomodification of the physico-chemical environment.

Although all the detailed processes leading to and maintaining these thin layers are not yet understood or even described, the displacement and maintenance of these layers are of paramount importance to the prediction of harmful events. The behavior of these boundary layers has not yet been sufficiently investigated by physicists (for example in cross-shelf and along-shore transport).

**Recommendations:**

Studies of the microphysics at the appropriate scales, involving physicists, should be encouraged in order to:

- Characterize the microphysics and chemistry at the viscous and intermediate sub-ranges in order to quantify the various processes influencing the development of HABs.
- Characterize the processes leading to the formation and the erosion of thin-layers.
- Develop an understanding and modeling of mesoscale advection in thin layers in relation to cyclic forcing, weather events and biologically mediated reduction of turbulent viscosity (through turbulence suppression, e.g. by differential solar heating of phytoplankton layers, and/or by viscoelastic polymer secretion).
- In order to understand 3D-movements of these features, development of appropriate instruments is necessary (density-adjusting floats, fine-scale profilers, particle analyzers, video systems, in situ rheometers).

### 3. MACRONUTRIENTS

#### Justification:

There has been an increase in anthropogenic nutrient inputs to many coastal areas. Correlative evidence indicates that HABs have increased in response to elevated nutrient loading in localized regions (e.g., North Sea, Baltic Sea, Seto Inland Sea, Tolo Harbor). Some HABs have also been related to natural nutrient dynamics (e.g., upwellings) in coastal areas. The relationship between macronutrients and mechanisms of HAB formation/maintenance remain to be determined. In particular, it is unknown whether HAB species have unique nutrient utilization capabilities and strategies which allow them to out compete other species, or whether, in the presence of high nutrient availability, the occurrence of HABs is controlled by grazing pressure. Other unresolved issues include the role of nutrient supply ratios in selecting for HAB species, and the importance of DOM either directly, as a nutrient source, or as an indirect promoter of HABs.

#### Research Priorities:

- Determine the nutrient utilization capabilities and strategies of selected HAB species in comparison with co-occurring phytoplankton. Interactive field and laboratory studies are essential. Field studies may require the development of new technologies for focusing on individual species in conjunction with more traditional approaches.
- Determine how nutrient concentration, composition, ratios, and cycling influence the occurrence of HABs. Retrospective analysis of long-term data available in some regions or evidence preserved in cores can provide information about the past occurrence of HAB in areas where nutrient inputs have increased. Process-oriented field studies of current HABs, especially recurrent, predictable HABs where all phases of the bloom dynamics can be studied, are essential.
- Evaluate the role of DOM as either a direct source of nutrients which HAB species can utilize or as an indirect stimulant of HABs through interaction with bacteria and the microbial loop.
- Investigate the relative importance of top-down control in regulating species composition of HABs.

### 4. POPULATION GENETICS/BIOGEOGRAPHY

#### Justification:

Morphological features and life histories are the primary criteria used to distinguish phytoplankton species. However, a single group of organisms defined in this way a species may include multiple genetic variants or strains. Definition of species and their associated infraspecific variants is critical for understanding the basis of biodiversity, toxin production, physiological optima and tolerances and origins of HABs on local and global scales. The presence of genetic variation even within populations of apparently unspecific blooms creates serious problems for studies based on clonal cultures because it is unclear how representative these cultures are of natural populations. There is an urgent need to expand the study of genetic variation in HAB species with particular reference to the roles of biogeography, genetic isolation and long-term changes in genetic diversity.

#### Research Priorities:

- Molecular tools are particularly useful for these studies. Currently available techniques are limited and progress is slow because of the small number of investigators in this area. More technology needs to be developed, particularly those techniques that bridge the critical gap between lab investigations and natural populations. More training opportunities need to be provided for phytoplankton ecologists to learn these tools.
- The requirement of morphotaxonomy to provide a platform for species identification and genetic comparisons necessitates a renewed effort in this area. The impending loss of expertise in morphotaxonomy creates a need for training new people in traditional as well as advanced methods of recognition of morphospecies.
- Support for culture collections is declining. However, a primary requirement for the study of genetic variation among HAB organisms is the availability of multiple isolates of the same species from different geographic areas. Recognition of the importance of culture collections is required and more

- financial support is needed to maintain and expand them.
- Physiological studies should recognize the potential for variability for such parameters as environmental optima and tolerance ranges, quantity of toxins and toxin profiles because the patterns of variation may yield useful insights into the relative importance of adaptive factors controlling the distribution of organisms. More technology, such as automated counting methods, need to be developed that facilitates the examination of larger sample sizes.
  - Multidisciplinary approaches to the study of genetic variation can yield critical insights. Support for multidisciplinary investigations that examine HAB species from both morphological and subcellular perspectives should be encouraged.
  - There is provocative evidence that anthropogenic dispersal of HAB species has occurred. The introduction of harmful organisms may be accompanied by the introduction of harmful genes that may be incorporated into native populations. Further assessment of the extent of role of human-assisted dispersals and their occurrence in the past needs to be conducted.

## 5. FRESHWATER/STRATIFICATION

### Justification:

Some degree of vertical stability is essential for the development of phytoplankton blooms. Such stability can be provided by density gradients caused by heat or by low salinity inputs. Examples of the latter include estuaries and buoyant coastal currents. However, freshwater input also brings with it a supply of poorly characterized, land-derived nutrients: macronutrients, such as nitrogen and phosphorous from agricultural and industrial/domestic sources; micronutrients including metals and vitamins; and, dissolved and particulate organic materials. The latter may serve as growth promoters (e.g. chelators) or directly as nutrients.

The linkage between HABs and freshwater input has been established in many areas (e.g. *Phaeocystis* blooms associated with Rhine River discharge, *Heterosigma* blooms in the Strait of Georgia, *Alexandrium* blooms in the southwestern Gulf of Maine coastal current, and *Pyrodinium* blooms along river plume fronts). Research is needed to understand the mechanisms underlying this linkage and to elucidate the relative importance of the many factors which may be operating.

### Research priorities:

- Determination of in situ algal species growth rates and physiological status within and outside areas of freshwater influence as they relate to the chemical constituents of the water;
- Determination of the relative importance of physical effects and algal behavior vs. direct growth stimulation;
- Elucidation of the mechanisms underlying blooms occurring within low salinity water masses vs. those occurring at the boundaries of water masses;
- Develop an understanding of the influence of the timing of freshwater inputs and stratification to bloom dynamics

## 6. SMALL SCALE PHYSICS, BEHAVIOR, AND PHOTOSYNTHESIS

### Justification:

We have a conceptual model, often termed the Margalef mandala, that provides a framework for describing how physiology, behavior and hydrography interact to promote or maintain algal blooms. We also have good descriptions of algal blooms in several well-studied regions. However, we are not yet able to couple sufficiently detailed information on algal physiology and behavior into realistic hydrodynamic models to describe single species bloom events in natural water columns. Consequently, our present numerical models are not robust in the real world.

**Research Priorities:**

- Incorporate physics into all HAB initiatives to provide information on the environmental conditions that support bloom development, maintenance and decline.
- Develop effective methods to characterize how organisms behave under the influence of variable environmental factors.
- Develop appropriate methods to characterize photosynthesis and nutrition under relevant, natural hydrodynamic variability. Conventional culture techniques are not sufficient.
- Improve coordination among physiological/behavioral characterizations, biological-physical modeling, and quantitative descriptions of hydrography and natural communities.

**7. ECOPHYSIOLOGY OF TOXIN PRODUCTION IN HAB SPECIES****Justification:**

Toxic secondary metabolites associated with harmful blooms in aquatic ecosystems are produced by several groups of photosynthetic eukaryotic and prokaryotic microorganisms, including non-photosynthetic bacteria. To date, research on these compounds has focussed on structural elucidation, detection methods and mechanisms of action. The next major research efforts required for understanding the physiological function of toxin production are rigorous investigations of their biosynthetic pathways and genetic regulation. Some data are available on these topics but we have only begun to understand these processes. The effect of environmental factors on production of marine and freshwater biotoxins (known as phycotoxins when derived from algal sources) has not been investigated in sufficient detail for any of the toxin groups, but some information is available for a limited number of strains of toxigenic species. For example, production of toxins associated with PSP (paralytic shellfish poisoning) has been studied in *Alexandrium* spp., *Pyrodinium bahamense*, and *Gymnodinium catenatum*, and there have been several investigations on the production of NSP (neurotoxic shellfish poisoning) toxins by *G. breve*, DSP (diarrhetic shellfish poisoning) toxins in *Prorocentrum* spp., anatoxin in *Anabaena* spp., and domoic acid, the toxin which causes ASP (amnesic shellfish poisoning), by *Pseudo-nitzschia* spp.

Biosynthetic schemes for certain PSP toxins (saxitoxin and neosaxitoxin) have been proposed and the structures of many analogues have been elucidated, yet the details of the synthetic pathway(s) and genetic regulation among the different toxin-producing organisms remain largely unknown or hypothetical. In contrast, the structure of ASP toxin (domoic acid) is known and its biosynthesis is well described - we can now ask probing questions concerning its regulation and physiological importance. A total understanding of the function of these toxins will only be achieved when we determine their structure, biosynthesis, genetic regulation and ecophysiology. Emphasis should be placed on the functional roles of toxins in the primary source organisms, e.g. do these toxins serve an intrinsic or an extrinsic function? Understanding the genetic basis for toxin production will also provide valuable insights into their ecophysiological role in bloom dynamics.

**Research Priorities:**

- Determine the kinetics of growth, toxin biosynthesis, and interconversions.
- Identify the cellular location of the toxins and the timing of their production in the cell cycle.
- Characterize the components of the toxin biosynthetic pathways.
- Determine if toxins are directly involved in predator-prey interactions.
- Determine if toxins serve an allelopathic function against other algae, bacteria or fungi, including the role of other compounds in stimulating or inhibiting the effect of the toxins.
- Determine the critical interactions between extrinsic environmental factors and the genome in regulating toxin biosynthesis, catabolism and sequestration (phenotypic vs. genotypic variation in HAB species).
- Model the production of toxins for extrapolation to natural populations. Determine the evolutionary origin of the toxin biosynthetic genes.
- Develop and maintain international sources for toxin standards and reference materials.

## 8. BACTERIAL-ALGAL INTERACTIONS IN HAB POPULATION DYNAMICS, CELLULAR GROWTH, AND TOXICITY.

### Justification:

Co-existing with algal communities containing HAB species are microbial assemblages which, like the algae, undergo changes in species composition, exhibit nutrient competition, and produce bio-active compounds, including toxins. These and other microbial processes are influenced by the algal community and, in turn, can potentially influence the population dynamics, cellular growth, and toxin characteristics of the algae. It is now clear that bacteria can produce both intracellular and extracellular compounds with algicidal as well as growth inhibiting or stimulating effects. Moreover, available evidence demonstrates that bacteria not only can modify the toxicity of algal cells, but can themselves synthesize certain 'algal' toxins.

### Research Priorities:

We must now characterize natural bacterial assemblages associated with HABs, and establish whether production of growth/toxicity modifying substances and/or toxins occurs on temporal and spatial scales permitting them to influence algal bloom dynamics, cellular growth, and toxicity. It is also essential to determine whether bacteria constitute an important source of 'algal' toxins in the context of trophic transfer and seafood safety issues. Suggested approaches to achieve these objectives include:

- Apply classical and molecular approaches to characterize the temporal/spatial association of bacterial assemblages with HABs, and define the systematic as well as functional relationships between bacteria and these algae.
- Isolate and characterize bacterial and algal bio-active metabolites, and determine their respective effects on bacterial and algal growth and/or toxicity, including elucidation of the mechanisms involved and the patterns of synthesis in natural communities.
- Evaluate the role of toxigenic bacteria as a point of entry for the transfer of 'algal' toxins between trophic compartments in aquatic food webs, and assess the contribution of these microbes to the toxification of fisheries resources.
- Determine the distribution of toxin genes among bacteria and extrachromosomal elements (e.g., plasmids, viruses) as a means of explaining the phylogenetic diversity of organisms capable of synthesizing certain 'algal' toxins, and identifying potential mechanisms for the lateral transfer of these genes.

## 9. TRACE METALS AND CHELATOR INTERACTIONS

### Justification

Trace metals including iron, manganese, cobalt and selenium have been hypothesized to limit the production of harmful algal blooms. Examples include limitation of *Alexandrium tamarense* (Gulf of Maine), *Aureococcus anophagefferens* (Peconic Bay), *Heterosigma sp.* (Osaka Bay) and *Chattonella antiqua* (Seto Inland Sea) by iron, the limitation of *Chrysochromidina sp.* (Kattegat) by cobalt and the inhibition of *A. tamarense*, and *C. antiqua* by copper. In most cases, the importance of a single trace metal was determined when the addition of that particular metal stimulated the growth of a HAB organism in culture.

In recent years, the importance of chemical speciation and organic complexation in the open ocean has revolutionized our view of how trace metal chemistry affects phytoplankton growth dynamics. Current data on trace metal concentrations in coastal waters, along with information on chemical speciation and biological interactions indicate that it is plausible that trace metals influence the growth and species composition of coastal phytoplankton communities. This new information on trace metal availability now needs to be applied to the development, density and frequency of harmful algal blooms.

## **Research Priorities**

- Obtain more detailed information on trace metal concentrations and speciation in coastal waters.
- Determine techniques to estimate their bioavailability to harmful algal bloom species.
- Examine the mechanisms of uptake.
- Examine the effects of multiple nutrient limitation.
- Determine the minimum cell quotas for trace metals.
- Examine the effects of trace metal limitation on cellular biochemistry including toxin biosynthesis.
- Examine the importance of bacteria trace metal interactions.

## **10. LIFE CYCLES**

### **Justification**

Knowledge of life cycles and cell cycles is fundamental to the understanding of formation, maintenance, and decline of harmful algal blooms. The water column or benthic origins of bloom inocula, cell growth, bloom termination and long-term species are mediated by poorly understood or largely unknown life cycle event. Most HAB species have benthic phases, which are believed to be important in species survival and persistence, but control on interactions between planktonic and benthic phases remain to be elucidated.

### **Research Priorities**

- Full elucidation of life histories for all HAB species;
- Development of rapid and reliable molecular/immunological probes for detection of life cycle stages, leading to improved and/or automated recognition;
- Description of cell cycle morphologies (for example, division stages) facilitating calculation of in situ growth rates;
- Determination of endogenous cell cycles, for example, the gating of cell division on a diurnal basis and annual cycle of excystment;
- Identification of the specific nutritional and environmental triggers as well as genetic controls involved in stage transformation, and the conditions required for successful transformation;
- Determination of the survival and metabolic activity of benthic stages;
- Understanding the physics of warm column - sediment transport and subsurface sediment mixing and burial in deep sediment and their influence on life history.

## **11. EMERGING TECHNIQUES AND TECHNOLOGY**

### **Justification:**

An understanding of HAB phenomena requires the detection of causative species and their toxins. Analogous problems exist in biomedical diagnostics, and many techniques and technologies used for those purposes are applicable to HAB research. For example flow cytometry, antibody and DNA probes, and receptor binding assays have been transferred and used successfully in the laboratory and, to varying degrees, in field studies. The interfaces between traditional disciplines have often yielded scientific breakthroughs, thus interdisciplinary collaborations should be fostered to solve the difficult issues relevant to understanding HAB phenomena. Programs should be developed that foster cross-training and collaborations between biomedical and HAB researchers.

### **Research priorities:**

Inexpensive, simple, efficient, and accessible methods for identification and detection of all HAB species and toxins must be developed. Methodologies and tools should be made widely available to the field as a whole as they are developed. Confirmation of the efficacy and utility of new techniques in the field requires multi-disciplinary investigations that could include: taxonomy, physical oceanography, ecology, and biochemistry.

- **Probes for species identification.** DNA and antibody probes have been developed and tested in the laboratory for a limited number of HAB species. These probes must now be tested in the field.
- **Toxin detection.** Receptor assays for toxins in HAB species have been demonstrated in the laboratory.

These assays now need to be tested for utility in natural populations..

- **Measurement of in-situ growth rates.** Methods for determining in situ growth rates are needed to understand the mechanisms driving HABs. Flow and imaging cytometric methods are useful in the field and show promise for HAB species.
- **Probes for physiological status.** Many fluorescent probes for measuring intracellular conditions have been developed for mammalian systems. Application of these tools to algal physiology may yield new understanding of the regulation of phytoplankton population dynamics. Since the choice of reference taxa is critical due to potential genetic variability, culture repositories should be supported and expanded internationally.

## ANNEX 5 - Acoustic Monitoring of Ocean Climate (WG 96/ATOC)

### Review of WG 96's activities since its establishment

The working group has met five times: informally in Vienna (1991), in La Jolla (1992), in Brest (1993), in Mauna Kea (1994) and in Hobart (1996). The working group meetings have been open to any interested scientists and participants came from many different countries including Australia, Britain, Canada, China, Denmark, France, Germany, India, Japan, New Zealand, Norway, Russia, South Africa and the United States. To assist the executive in assessing the group's activities, a brief summary of the last meeting is appended to this submission. .

Briefly, we identify the achievements of the working group for each of the terms of reference:

1. The essential concept of acoustic monitoring involved measurement of acoustic travel time. In the late 1980's, there was a transition in the application of acoustic tomography from technical achievement to science. For example, precise heat content measurements were made out to ranges of 1000km. An important project relating to long range acoustic monitoring was the Heard Island Feasibility Test carried out in 1991. The transition to measurements over ranges of hundreds of several thousand kilometers required the development of new techniques and approaches. However, the tested concepts and analytical techniques of acoustic tomography provided a basis for discussion of propagation measurements over greater distances and have continued to do so through the life of the working group. It is apparent that the basic concept of measurements over ocean basins unavoidably entails international collaboration. It is not possible to plan a study of, for example the Atlantic Ocean, and not see the necessity of involving the participation of at least two or three coastal nations. Since useful spatial resolution of tomographic arrays improves markedly with the number of nodes, it is clearly desirable to include as many geographically dispersed participants as possible. Thus the essential idea of acoustic monitoring over long ranges requires a high degree of international collaboration.
2. The working group has evaluated several routes for international collaboration. These include deployment of hydrophone systems, including autonomous and towed arrays to detect controlled sources. An important form of international collaboration has been the use of cruises to establish the acoustic propagation environment. WG 96 has encouraged several subgroups to form, for example covering international collaboration in the Arctic, the Western Pacific and the Indian Ocean. These subgroups have in some cases been very active. For example the Trans-Arctic Propagation experiment was an outgrowth of an important collaboration between Russia and the U.S. China and Russia have planned collaborative work in the Western Pacific and India, Australia and South Africa have collaborated in the design of propagation studies and related activities in the Indian Ocean. In the 1996 European Acoustics meeting in Crete there were three full time sessions devoted to the discussion of acoustic tomography, particularly in the Mediterranean, with active involvement of France, Germany and Greece. It is apparent that international collaboration in acoustic tomography is active and increasing.
3. The challenge of successfully implementing long range acoustic propagation measurements of ocean properties has motivated many new ideas and approaches during the life of the working group. Moreover the seminal results of the Heard Island Feasibility Test have challenged existing theories and concepts of acoustic measurement. For example, there were some unexpected features of the long range transmission through sharp fronts and past topography, including mode stripping and transfer of energy between modes, which have motivated several new theoretical analyses. Each meeting of the working group has introduced novel and interesting concepts for monitoring the ocean acoustically. For example, in the Hobart meeting, there was a presentation of the idea of using acoustic transmissions by whales as tomographic sources of opportunity. There has been an experiment in the Strait of Gibraltar to explore the use of horizontal advection of the acoustic pulse by water currents, contributing to a change in horizontal angle-of-arrival. The use of low frequencies (~28Hz) has been investigated as a means of overcoming internal wave scattering of the signal. It must be emphasized that the direction in which we are moving is towards an integration of tomography, satellite altimetry and modeling and data assimilation. The working group addresses all of these evolving topics.



## Hobart Meeting 27-29 March, 1996

Twenty scientists from fourteen countries met in Hobart to review progress on, and plans for ocean acoustic monitoring of the ocean.

Following our previous meeting in Hawaii, a final report on the results of SCOR WG 96 activities was submitted to the SCOR Executive and is now awaiting publication. Since that meeting, an important step forward had been taken in the implementation of an acoustic monitoring program, following a two year delay due to marine mammal issues. Transmissions have now begun at Pioneer Sea Mount and signals are being acquired at many sites around the Pacific Ocean. In the interim, a smaller scale study, the Thetis experiment had begun in the Mediterranean; it includes all of the essential components of satellite altimetry and tomography. Moreover the SCOR Executive had also paved the way for a longer term arrangement through which international collaboration in ocean science could proceed under SCOR sponsorship. It appeared appropriate that Working Group 96 consider the conditions for entering a longer term agreement and ensure that it fulfills the necessary requirements. Thus the motivations for our meeting were two-fold: to review progress and future plans following the initiation of transmissions for the Pacific acoustic tomography array and to prepare for a longer term association with SCOR.

### Summary of Presentations

In reviewing the accomplishments of ATOC over the past few years, Walter Munk identified the results of the Heard Island Feasibility Test in which acoustic propagation over many thousands of kilometers was resolved with great precision, sufficient to track the relative motion of the source and detector. Nevertheless the arrival structures differed from computer predictions in various ways posing a challenge to the modellers. Kuperman showed how oceanographic features tend to remove lower order modes, a result consistent with Baggeroer's observations of the Heard Island transmissions in which only 8 modes contributed. Scattering from internal waves is probably more important and Flatt's calculation including internal wave scattering was able to explain some of the differences. Munk pointed out the large basin scale temperature changes within the North Atlantic that have taken place in recent times. Temperature trends at 1000m of order  $10\text{m}^{\circ}\text{C}/\text{year}$  would have produced a very measurable signal with long range acoustic propagation.

Spindel presented results of an ATOC engineering test which demonstrated a high level of performance for transmissions made from the research platform FLIP over ranges up to 1800km. Of particular interest to the working group, however, were preliminary results of the first ATOC transmissions from the Pioneer source off the California coast. For one particular long distance station, acoustic travel time showed a distinct cooling. While advective effects most likely contributed to the effect, it is consistent with what we would expect in the North Pacific at this time of year and thus provides a tantalizing indication of what is yet to come. The measurements clearly revealed the influence of tidal currents, which were in close agreement with predicted results.

Peter Mikalevsky described the new program of Arctic Climate Observations using Underwater Sound (ACOUS) to detect climate change trends and distinguish short term from long term variability. The Trans Arctic Acoustic Propagation experiment (TAP) was conducted in 1994 using a Russian sound source [19.6Hz, 250W] deployed at 60m depth with listening arrays (US / Canada in the Lincoln and Beaufort Seas). A surprising result was an increase of  $0.4^{\circ}\text{C}$  relative to historical data corresponding to a decrease in travel time of 2s. This result is consistent with circulation of warmer Atlantic water entering the Arctic. A recent experiment in which 68 submarine launched expendable conductivity-temperature-depth probes were released between the Beaufort Sea and Franz Josef Land produced results that were generally consistent with the acoustical measurements of TAP. Future plans include year round monitoring of the Arctic basins (1998) with a battery powered autonomous source at a depth of 100m in water 500m deep. A second source is planned in the central basin. Receivers will be linked by fibre optic cable; one system has already been installed in the Lincoln Sea. A second one near Barrow/Prudoe still awaits permits.

Zhang Renhe described the Sino-Russian joint Pacific program. This was originally designed to listen to ATOC sources, but the delay in ATOC transmission due to marine mammal issues forced them to change their objectives. Instead they used their resources to test a prototype autonomous source, to study long range propagation, to search

for suitable receiver locations and to study effects of shadowing by sea mounts.

Viktor Akulich discussed Russian acoustic and oceanographic activities. He expressed the opinion that although a naval receiving station was available in Kamchatka it would be preferable to install a new station in the Kurile Islands. The Russians are also considering installing a receiver on a sea-mount at a depth of 300-400m at a range of 300-400km. Russia seeks collaboration in the western Pacific, is presently organizing collaborative work with China and is establishing research links with Korea.

Activities in New Zealand were described by Gary Bold. These included measurements with a drifting array during the ATOC engineering tests which acquired 18 receptions on November 19-20 1994. Unambiguous measurements of the transmission from Pioneer Seamount constitute the largest ATOC path achieved to date (~10,000km). The results show an earlier arrival than implied by preliminary modelling which has led to some debate about the possible cause. New Zealand has now deployed a single hydrophone at a depth of 1800m in water of depth 1800m and has successfully detected the Pioneer transmissions. This deployment surely represents an exceptional effort to detect the ATOC signal at maximum range with minimum resources!

Due to the unprecedented and adverse attention given the US acoustic program by marine mammal enthusiasts, it has become necessary to divert a significant fraction of available resources (14% of the US program) to marine mammal research. It has taken approximately 21 months to turn this problem around. Andrew Forbes described the present status of the permitting process and of the research program being carried out by Chris Clark and Dan Costa. The basic questions being addressed relate to the species involved and the depth of their habitat. A number of experiments were conducted to see what sort of acoustic signals marine animals respond to. In one experiment with whales, various signals were transmitted to determine whether the normal routines of the animals were altered by the man-made signals. Except for a momentary pause in response to transmission of David Bowie music, the whales apparently ignored all the transmissions. One of the sources has been installed on Pioneer Seamount off San Francisco in 1000m of water. After the initial transmissions a major hiatus developed because 3 whales were found dead in the vicinity. After 3 weeks of concerted effort it was determined by the US authorities that the harm could not possibly have arisen from the acoustic thermometry transmissions and the program was restarted. The analysis to date has indicated no measurable effect on marine mammals, with tagged elephant seals showing no inclination to alter their migration path near the Pioneer site and other marine mammals, which are plentiful, showing no signs of wanting to leave. However there have been observed reactions to vessel noise.

Despite the great cost incurred by the marine mammal issue, it has to be said that the very extensive environmental study being carried out in the US has made it easier for future acoustic monitoring projects. This point was made at the recent European acoustics meeting in Crete.

Nikolai Dubrovskii reported on studies of potential effects of acoustic transmissions on marine mammals in the Arctic. During winter months much of the Arctic is free of marine mammals because of the ice cover. In May and June there is a rapid increase in marine life of all kinds at the ice edge as it moves forward. The Barents Sea is a major source of fish for Russia and adjacent countries. Thus the extent of penetration of ATOC sound transmissions into the Barents Sea is a matter of some interest. However calculations show that the shallow depth and the land barrier (Franz Josef Land) prevent sound penetration. Monitoring of marine mammals in the Franz Josef Land area showed the number to be very small. It is recognized that the Arctic is particularly sensitive to human intervention.

A novel viewpoint was explored by Bill Kuperman who discussed the localization of whales using their acoustic signals and the potential application of these signals to tomographic measurement. Working with the Fin whale spectrogram he showed that various modes are consistent with classical dispersion of modes traveling with different group velocities. He computed synthetic spectrograms for different ranges and bottom characteristics and matched results with the observed spectra by trial and error, yielding an estimate of bottom speed and range. He also discussed use of matched field processing for analysis of Blue whale calls. A study from the research platform FLIP is to be carried out later in the year.

Dimitris Menemenlis discussed the assimilation of data into climate models. His talk covered estimation processes, the global acoustic thermometry program and the Mediterranean study. Using the Global Circulation Model developed by John Marshall he compared the modelled surface elevation with satellite altimetry. He commented on the outstanding improvement in models over the past few years. In the Mediterranean study he used both tomographic and satellite altimetry, together with the Marshall Global Circulation Model. Model results and satellite measurements differ however, so further work on this is needed. Experience has shown however that the circulation model with altimetry can be used for predicting and matching the temperature field.

John Penrose, C.S. Murty and Geoff Brundrit each discussed the potential of acoustic thermometry in the Indian Ocean. C.S. Murty described Indian activities. In particular acoustic tomography experiments have been carried out in the Bay of Bengal and Arabian Sea. In the East Arabian Sea significant temperature variations were found over a 300km range and a 10 day period. Important experience is being gained in the techniques that will be needed for basin scale thermometry. John Penrose considered the implications of possible source locations at Leuwin, Cocos Island and Christmas Island. Based on 150 years of American whaling data it is apparent that the west coast of Australia is important to humpbacks, so this may not be an optimum source location. Geoff Brundrit described the results of acoustic shots transmitted from Cape Town and received off Tasmania. He pointed out the potential for exploiting minimum sound speed areas in the Indian Ocean.

Iwao Nakano described a 200Hz system consisting of 5 pressure compensated transceivers which were successfully tested over a 1000km range south of Japan. Mooring motion was monitored and shown to be related to tides. JAMSTEC has also developed a 75Hz receiving system for listening to ATOC sources.

New technical issues were also discussed by Nikolai Dubrovski who considered the problem of designing a free flooding source. He analyzed the behaviour of the Helmholtz resonator, a half-wave tube with rigid and elastic walls, a  $\frac{1}{4}$  wave tube and other designs.

An important new possibility for detecting thermometry signals was introduced by Martin Lawrence, who presented plans for acoustic monitoring of the Comprehensive Test Ban Treaty. Hydroacoustic monitoring has some significant advantages over seismic measurement, since it is easier to separate "false alarms". Time series and spectra of underwater explosions are very different to those of earthquakes. Six single-hydrophone stations are proposed. Signals will be detected in the 1Hz - 100Hz band. Island stations will have hydrophones on each side with only 20Hz bandwidth as higher frequencies are greatly attenuated by bottom interaction.

Bob Spindel also presented the first results of the Pioneer transmissions. The signal was detected on several SOSUS receivers around the Pacific. Temperature changes were greatest near the surface, as expected. A significant correlation existed with the tidal signal.

There was extensive discussion of the best direction for future work. Attention focussed on the Indian Ocean. The climatic signal is much greater than in the Pacific and with India, Australia and South Africa (and possibly France) expressing interest, the time seems right for such an initiative. It is also worth noting that 1998 has been identified as the Vasco de Gama year in which nations around the Indian Ocean are emphasizing their common interests. Thus acoustic monitoring of the Indian Ocean would be propitious at this time and may focus support on ocean and climate research in the area.

A primary challenge will be economic. If battery powered sources were practical an acoustic monitoring program would be more readily accomplished. However under existing configuration such sources would only last 6 months. A possible reduction in duty cycle to 1% may overcome this obstacle. Bob Spindel pointed out that 6 autonomous vertical arrays are available. An acoustic issue is that dispersion is less in the Indian Ocean than the Pacific, necessitating longer path length for a given resolution. However this is offset to some extent by the much bigger signals.

Bob Spindel also presented the first results of the Pioneer transmissions. The signal was detected on several SOSUS receivers around the Pacific. Temperature changes were greatest near the surface, as expected. A

significant correlation existed with the tidal signal.

In the Pacific program the delegates from Russia and China voiced strong opposition to discontinuing the Kauai transmissions at the end of the prescribed experimental period.

The Kauai source has not yet been installed, but the permit for its installation has been granted. Indeed there was very strong international support from all delegates for continuing the program. The situation is particularly acute for the western Pacific nations which have been building up a program to study ocean climatology once the source is in place. It would be a serious blow to the thermometry programs of these nations if the Kauai source was discontinued before a useful scientific program had been carried out in this area. The chief difficulty is that the permit for the source is of limited duration. SCOR WG 96 urges the US program to investigate ways of extending the permit to allow transmission for a significantly longer period.

#### Our next meeting:

It will be recalled that we also discussed possible locations for our next meeting. Various participants kindly proposed hosting this meeting, including Victor Akulich (Vladivostok) and Geoff Brundrit (Cape Town). Following this meeting we received a further invitation from Dr. Desa of NIO, Goa. All of these locations have important attractions and there is every reason to arrange meeting at each in the future. Walter Munk and I considered the alternatives and decided that, given the importance of emphasising new activities in the Indian Ocean, it would be most appropriate to hold our next meeting at NIO, Goa. We are presently communicating with Dr. Desa and Dr. Murty about optimum dates which will be communicated to you shortly.

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## ANNEX 6 - Joint Global Ocean Flux Study (JGOFS)

Contributed by:

Roger B. Hanson, JGOFS CPO Executive Officer

John G. Field, JGOFS SSC Chairman

The JGOFS Scientific Steering Committee completed its 11<sup>th</sup> meeting in Bad Munstereifel, Germany, April 1996. Many national JGOFS programs are presently approaching their projected lifetime and their active ocean field programs will be gradually phased out by 1999-2000. From now and until 2005, JGOFS plans are to shift its focus and emphasis towards data synthesis, data archiving and merging biogeochemical-ocean models with global ocean models. In this report, we will review JGOFS scientific activities since the 1995 Annual Progress Report.

### *Scientific Highlights*

JGOFS Time-Series Stations. Time-Series Stations off Bermuda and Hawaii, in particular, have provided a valuable time series of ocean observations, which will proved to be invaluable for calibrating ocean models. These observations have shown that a large part of the carbon transport out of the photic zone is by seasonal mixing of refractory dissolved organic carbon down into the deep ocean. The seasonal to interannual variability in mixing seems related to the ENSO cycle and the dynamics of spring blooms in response to physical forcing. The balance of all of the possible carbon fluxes in and out of the euphotic zone yields a loss of dissolved inorganic carbon that is a fraction of the temporal changes in the stocks of all forms of carbon. Similar anomalies occur with the inorganic nitrogen stocks, which suggest the importance of nitrogen fixation in the overlying waters. Decade-scale variations in the dust deposition to the oceans may provide both a regulation of the carbon and nitrogen cycles and a possible biotic feedback to climate. A partial summary of the results obtained at the two U.S. JGOFS-WOCE time-series stations have been recently published (Deep-Sea Research, Vol. 43 (2.3), 1996).

Arabian Sea Experiment. Preliminary analyses of ARABESQUE (UK Arabian Sea Process Study) suggests that during the late SW Monsoon to Inter-monsoon period, the fate of a significant proportion of the primary production cannot yet be accounted for. Budgeting algal carbon growth as production against its degradation through processes of grazing and particulate sedimentation leaves a large theoretical surplus of organic carbon. As the phytoplankton population is not growing, the carbon must be lost through other mechanisms. The most likely explanation is via the dissolved organic carbon pool. This would imply that the bacterial population respond with elevated growth and activity producing elevated pCO<sub>2</sub> in surface waters. Yet, preliminary results suggests neither high bacterial production nor a significant change in surface water pCO<sub>2</sub>. Once data analysis is complete and analyzed, attempts will be made to resolve the fate of the missing organic production by biogeochemical modelling and to show once more the importance of DOC in yet another marine environment.

Southern Ocean Experiment. Recent JGOFS studies in the Southern Ocean have highlighted the role of zooplankton in the cycling and export of phytoplankton carbon. Repeat surveys over several years have shown substantial variation in zooplankton grazing, which may have important implications for the food web and carbon flux. Around South Georgia, dense phytoplankton blooms form in years where krill populations are low, and carbon export from the blooms may be high in some regions. In contrast, in years where krill abundance is high, phytoplankton concentrations are reduced, and carbon export from the bloom may be low. Now, reports have shown that in the austral summer 1994-5, there were far fewer krill than expected where large swarms of gelatinous zooplankton occur. These conclusions may have important ecosystem implication for the longer term if the balance between different classes of grazers in the Southern Ocean is changing as a result of large-scale environmental change.

Iron Enrichment Experiment II. The first experiment in the Equatorial Pacific was only partly successful in that the enriched patch of water was subducted under another water body, and the apparently enhanced phytoplankton removed from the photic zone. No CO<sub>2</sub> draw down was observed. In the second experiment, reported verbally at the IGBP-symposium in Bad Munstereifel by Andy Watson and Peter Liss, both enhanced primary production and CO<sub>2</sub> draw down were observed, supporting the iron-limitation hypothesis for that part of the ocean.

### *Scientific Steering Committee*

At the 11<sup>th</sup> Annual Meeting of the SSC in Bad Munstereifel, the Scientific Committee of IGBP requested that each Scientific Steering Committee, which is well advanced in its implementation Plan, consider a restructuring to match its evolving tasks by including the Chairs of the Planning Groups and Task Teams on the SSC. The goals of the restructuring are aimed at reducing the membership of the SSC, retaining key expertise, and focusing on funding support in a manner most supportive of the science.

The JGOFS SSC supported the reduction in size but expressed several concerns including discipline balance, gender diversity and international representation. The SSC Chairman suggested that restructuring might be considered along with the 1997-1998 rotations of Committee members with the aim of reducing the size of the SSC (Table 1, JGOFS Scientific Steering Committee Membership/Appointment Timelines/Chairs of Planning Groups and Task Teams).

New members of the Scientific Steering Committee who began their 3-year term on the SSC, 1 January 1996, are: Alexander Bychkov (Russia), Hugh Ducklow (USA), James Murray (USA), Bronte Tilbrook (Australia), and Jurgen Willebrand (2nd 3-year term).

The SSC Chairman will complete his term of office this year but will remain on the SSC for one additional year as Past-Chair, according to our past procedures. This September, the JGOFS Executive Committee will recommend a nominee for JGOFS Chairperson to the General Meeting of SCOR and to the SC-IGBP for approval.

SSC members who are scheduled to rotate off the Committee on December 31 this year are: Swami Krishnaswami (India), Liliane Merlivat (France), Egil Sakshaug (Norway), Julie Hall (NZ), and Robert Moore (Canada). The Chairman felt that restructuring might be achieved through attrition over the next 2-3 years. During this process the SSC might retain the current SSC members who are also leaders (chairs) of the Planning Groups and Task Teams on the Committee or until disbanded.

The JGOFS Executives will develop a specific plan for restructuring the SSC at its annual meeting in Bergen just prior to the SCOR General Meeting. The JGOFS Chairman will then present the plan for restructuring the JGOFS SSC and nominations for new members to the SCOR General Meeting and the SC-IGBP for consideration

### *Planning Group Reports*

Many of the JGOFS Planning Groups have approached the completion of their Terms of Reference. The Chairs have asked the Committee for guidance on how the Groups should proceed.

North Atlantic Planning Group (Chair: Michael Fasham). National funding for a North Atlantic Ocean Process Study in 1997-99 is doubtful. Funding agencies in several countries are redirecting resources to other JGOFS programs and national priorities. The SSC felt that with this shift in National funding priorities, the NAPG is still needed and should be retained. They recommended that the NAPG shift its focus to North Atlantic coordination, synthesis, and modelling studies. The North Atlantic Ocean Synthesis must be a major task for the NAPG, and it plans to liaise with IGBP Global Analysis, Interpretation and Modelling (GAIM) and JGOFS Synthesis and Modelling Task Team (SMTT). NAPG plans to meet in late May 1997 to discuss their new focus and emphasis.

Indian Ocean Planning Group (Chair: Peter Burkill). The current field program of the Indian Ocean Process Study has been completed (August 1996). Since its conception, this Study has reached several milestones: coordination of 6 countries and funding agencies, publication of cruise reports and research papers, archiving data sets on CD-ROMs in The Netherlands, United Kingdom and Germany, and contribution to capacity building and training programs in the region. In the future, the IOPG will be restructured to focus on data merging and integration, as well as synthesis and modelling. They plan to organize an Indian Ocean synthesis meeting in 1997.

Equatorial Pacific Planning Group (Chair: James Murray). The field program of the Equatorial Pacific Process Study has been completed. The Study confirms the importance of the ENSO in affecting rates of primary production and CO<sub>2</sub> flux in the Equatorial Pacific. They also confirm the Bermuda findings of DOC being an

important component of carbon flux out of the photic zone. In addition, the first mesoscale iron fertilization experiment off the Galapagos Islands showed enhanced primary production and CO<sub>2</sub> declined slightly in a HNLC ocean region. It is unclear how this group will proceed; the SSC needs a progress report from this Planning Group in 1997.

Southern Ocean Planning Group (Chair: Julian Priddle). A report by the SOPG on the JGOFS Southern Ocean Process Study identified present strengths, as well as research gaps in the Study and recommended areas where development and coordination with other international programs, such as SCAR, would strengthen the Southern Ocean Process Study. Despite a number of cruises over several years, the factors controlling primary productions in the Southern Ocean remain an enigma. Synthesis and modelling activities are underway in many National JGOFS programs and with GLOBEC Southern Ocean modelling activities. The SOPG Chair recommended that the group remains as formed until the completion of its Terms of Reference. The SSC approved the recommendation.

### ***Task Team Reports***

Several JGOFS Task Teams have completed their Terms of Reference and have disbanded, while others are either in the process of nominating Task Team Members or beginning their Terms of Reference.

Synthesis and Modelling Task Team (Chair: Trevor Piatt). This Task Team is actively planning modelling symposia, workshops and training courses with other IGBP activities over the next 3 years. The SSC approved the Task Team's plans to arrange the proposed activities. At present, the Oban Modelling Symposium Committee has organized a Modelling Symposium in Scotland (20-26 May 1997). This activity and others of the Tasks Team are important to JGOFS legacy, visibility, data synthesis/modelling, and discipline and capacity building within the non-industrialized countries. The Chair reported that the Toulouse Modelling Workshop Report has been drafted. The JGOFS Executive Officer estimates a JGOFS Report around December 1996.

Continental Margin Task Team (Co-Chairs: Julie Hall and Stephen Smith of LOICZ). In April 1996, the joint JGOFS and LOICZ Scientific Steering Committees approved the CMTT Report and its recommendation to organize its first joint JGOFS & LOICZ Coastal Margin Workshop in Lagos, Nigeria (14-18 October 1996). A Joint JGOFS-LOICZ CMTT Report will be published by LOICZ Core Project Office (September 1996). The Nigerian workshop will also link with other African programs of IGBP START. Workshop participants will focus on developing budgets of material fluxes between the continental margins and the open ocean at four specific key sites. A follow up workshop will be planned for synthesis and held in conjunction with the LOICZ Open Science Meeting in Texel, The Netherlands (April 1997). In the future, the CMTT will consider the implementation and designation of JGOFS-LOICZ projects for continental margin process studies.

Photosynthesis Measurement Task Team (Chair: Egil Sakshaug). A report, *Measurement of the Parameters of Photosynthesis: Light Absorption and Quantum Yield of Photosynthesis Derived from P vs E Determinations*, has been revised and will be published as a JGOFS Report this Fall. The SSC approved the Task Team's plans to organize a "mini-symposium" to address several remaining tasks. The proposed site is Svalbard, Norway (August 1997).

Data Management Task Team (Chair: Roy Lowry). JGOFS Data Management issues are major concerns of the Committee. Several achievements have occurred since the Villefranche Symposium. Most notably is the production of CD-ROMS with JGOFS Process Study data sets from the North Atlantic, the French EUMELLI study sites, and the Indian Ocean. With the appointment of a JGOFS database manager (Assistant Executive Officer) at the Core Project Office, many other issues can now be addressed and dealt with shortly, for example, an inventory of all JGOFS cruises and its availability electronically on the Internet, and the construction and documentation of JGOFS databases along with metadata. The EO and AEO plans to meet with the DMTT Chair to discuss priorities of JGOFS data management, IGBP-Data and Information System (DIS), and many other Task Team issues at BODC (16-19 September 1996).

Deep Ocean Flux Task Team (Co-Chairs: Graham Shimmield and Karin Lochte). At its April Meeting, the SSC noted the concern in the Evaluators Report that not enough attention was being paid to deep ocean fluxes.



Accordingly, the SSC instituted a new Task Team to replace the disbanded Benthic Flux Task Team. The DOFTT will focus on interfacing with PAGES/IMAGES and in addressing JGOFS deep ocean issues. No meetings are presently planned.

Biogeochemical Ocean & Atmosphere Transport Task Team (Co-Chair: Bronte Tilbrook and Barry Huebert of IGAC). The SSC appointed Bronte Tilbrook to liaise with IGAC on behalf of JGOFS. It was recommended that no formal BOATTT be reconstituted, since no meetings are presently planned.

Remote Sensing Task Team (Chair: James Yoder). A report, *Remote Sensing in the JGOFS Program*, is being published as a JGOFS Report No. 20 (in press). On behalf of JGOFS, the Chair will represent JGOFS concerns at the European JGOFS Marine Remote Sensing Co-ordinating Office (ERSCO). ERSCO plans to support European JGOFS Remote Sensing Projects needs in high resolution Ocean Color and Temperature Scanner (OCTS), data processing and archiving. No meetings are presently known.

North Pacific Task Team (Acting Chair: Alexander Bychkov). In April, the SSC approved the recommendation that the North Pacific Group form a task team and approved the name, North Pacific Task Team. Because of the proposed lifeline for JGOFS (1989-1999), national funding and etc., the SSC decided that the North Pacific Group would have more of a coordinating than a planning role and approved the group as a Task Team. The Terms of Reference for the Task Team have been drafted and members nominated for JGOFS Executive Committee approval. This Task Team will assist the coordination of ongoing biogeochemical ocean studies in the North Pacific and support the region's National JGOFS Committees.

JGOFS IOC-CO<sub>2</sub> Panel (Chair: Andy Watson). The Panel met in Puerto Rico last January 1996. It will continue to oversee JGOFS interests and cooperation with WOCE cruises contributing to the JGOFS Global Survey. At the Bad Munstereifel meeting, the SSC expressed concerns over the completion of the North Atlantic JGOFS-WOCE CO<sub>2</sub> Survey. U.S. Department of Energy funding for the final cruise remains questionable.

Time Series Task Team (Chair: Gerold Wefer). The 1995 JGOFS SSC disbanded this team. The SSC believes that at this point in JGOFS's life and international interests in ocean time-series stations, JGOFS interests can be best served by sending JGOFS representatives to time-series station workshops and meetings. This strategy is cost effective and productive in having JGOFS interests taken into account at planning and networking workshops. This Fall 1996, JGOFS plans to support 2 JGOFS representatives at the IAI US-Canada-Chile Time-Series Station Workshop in Chile (October 1996). In March 1997, JGOFS plans to contribute to the support of the GOOS-OOPC Time Series Workshop (Baltimore, Maryland). The JGOFS Chairman and 4 other JGOFS representatives are expected to participate.-

Many of the activities listed above illustrate the efforts of the JGOFS SSC, JGOFS Representatives, Chairs of the Task Teams and Planning Groups in integrating JGOFS activities with those of other IGBP Programme Elements (and Framework Activities) and with other programmes, such as WCRP. A Special Session on Oceans at the IGBP Congress in Germany exemplifies JGOFS efforts in the integration of its programs with IGBP marine programs and across relevant science areas.

#### ***JGOFS Core Project Office***

JGOFS has completed its relocation of the Core Project Office from Kiel, Germany, to Bergen, Norway. The SSC accepted the offer of Norway to host the Core Project Office at the University of Bergen, after Professor Ulf Lie and Associate Professor Truls Johannessen successfully secured government funds and University facilities. The Norwegian commitment now ensures continuous operation at a substantially higher level of activity until 31 December 1999. The Office was established in the Center for Studies of Environment and Resources at the University of Bergen (1 January 1996).-

Administrative Business. The JGOFS Core Project Office is completely staffed with 3 full-time positions. The new Executive Officer has appointed an Assistant Executive Officer (AEO), Beatriz Balino, to manage JGOFS data assembly, distribution and inventory, and an Administrative Assistant, Judith R. Stokke, to manage JGOFS Core

Project Office administrative business. The AEO expects to receive her Doctorate Degree from the University of Bergen, December 1996.

Financial support for the Core Project Office comes from the Norwegian Research Council (staff salaries), the University of Bergen (capital equipment and University infrastructure), and the Center for Studies of the Environment and Resources at the Bergen High Technology Center (Computer Facilities and Offices). Additional program funds come from the International Geosphere and Biosphere Programme (IGBP) and the Scientific Committee on Oceanic Research (SCOR) to support the framework activities of JGOFS Scientific Steering and Executive Committees.

Data Management and Information System. The Core Project Office is concerned with facilitating data assembly, data distribution, and data archiving by the National JGOFS Programs. In this endeavor, an International JGOFS Home Page (<http://ads.smr.uib.no/jgofs/jgofs.htm>) has been constructed. It now lists and is linked to Home Pages of the IGBP Secretariat, IOC, IGBP Programme Elements, National JGOFS Project Offices, relevant International Programs, and popular Internet browsers. The JGOFS Home Page lists the Core Project Office responsibilities and provides information on the History of JGOFS, Goals and Objectives, Research Strategy, Planning Groups and Task Teams Activities (under construction), Scientific Highlights (developing), JGOFS Data Inventory (under construction), Organization and Structure, Core Project Office, Calendar of Activities, Web Sites and Liaisons, Participant Addresses, and Publications.

JGOFS data assembly (documentation) is the responsibility of the individual Nations and their JGOFS Programs, unlike the WOCE data system, which has a central archive for all WOCE data sets at the World Data Center. Therefore, the Core Project Office will assist National JGOFS Programs in assembling, archiving and distributing JGOFS oceanographic data sets. Many National JGOFS Programs have active JGOFS Data Centers and/or central archives in National Ocean Data Centers (e.g., USA, Canada, UK, Germany, and France) for database assembly, distribution and archiving. For other JGOFS National Programs, the Core Project Office is contacting Data Managers and National Chairs to locate JGOFS oceanographic data sets and to inventory their National JGOFS projects, cruises, and scientists. This information will be available on the Internet and archived on CD-ROMs for future use.

Reports and Publications. JGOFS Reports are now available directly from the Core Project Office or via the JGOFS Home Page. A reprinting (100 copies) of the *Protocols for the Joint Global Ocean Flux Study (JGOFS) Core Measurements* (originally published as IOC Manuals and Guides No. 29 and now reprinted as JGOFS Report No. 19) has been completed. It was announced to the JGOFS National Program Offices and its community on the JGOFS Home Page. Following the announcement, there has been an enthusiastic request for copies of the JGOFS Protocols. Multiple copies (10) were sent to the IOC and SCOR initially. The Office has since limited one copy of the reprint per individual request and supplies are nearly exhausted. The JGOFS SSC may recommend a second reprint of the JGOFS Protocols.

The Core Project Office also plans to publish several JGOFS Reports before the end of this year. The report on *Remote Sensing in the JGOFS Program* (JGOFS Report No. 20) will be available September 1996. It was submitted by JGOFS Remote Sensing Task Team, Chair James Yoder. Two other JGOFS Reports are in preparation: Photosynthesis Measurements by Chair Egil Sakshaug, and Toulouse Modelling Workshop Report by Geoff Evans.

***Public Relations:***

Press Releases. The Office has supported special interest papers, articles, and reports for the University of Bergen paper *Pa Hoyden* and the Bergen newspaper *Bergen Tidende*. It has also contributed international articles to newsletters and handbooks (IGBP Global Change Newsletter, U.S. JGOFS News, and IGBP Handbook).

Oceanographic Society. The Office plans to construct a general International JGOFS Poster for JGOFS Scientific Steering Committee for their use at any National and International symposia, workshops, or meetings. The poster will have information on JGOFS Research, Recent and Past Research Highlights, and Data Management. The

Office has also offered to help host the 2<sup>nd</sup> European Meeting of The Oceanography Society in Bergen (1998). Information on Bergen convention facilities were submitted to TOS Meeting Committee for consideration (August 1996).

TABLE 1  
JGOFS Scientific Steering Committee (SSC) and  
JGOFS Planning Groups and Task Teams (Chairs)

<u>NAME</u>	<u>COUNTRY</u>	<u>Committee</u>	<u>Chairs</u>	<u>1996</u>	<u>1997</u>	<u>1998</u>
		<u>Members</u>				
Burkill, Peter	UK		<sup>3</sup> IOPG	Chair	Chair	
Bychkov, Alex	Russia	SSC	<sup>2</sup> NPTT	SSC	SSC	SSC
Ducklow, Hugh	USA	SSC		SSC	SSC	SSC
Fasham, Michael	UK		<sup>3</sup> NAPG	Chair	Chair	
Field, John (Chair)	S. Africa	<sup>1,4</sup> SSC		SSC	<sup>5</sup> SSC	
Hall, Julie	NZ	<sup>4</sup> SSC	<sup>2</sup> CMTT	SSC	Chair	
Krishnaswami, S.	India	<sup>4</sup> SSC		SSC		
Liu, KK	China-TW	SSC		SSC	SSC	
Lochte, Karin	Germany	SSC		SSC	SSC	
Lowry, Roy	UK		<sup>2</sup> DMTT	Chair	Chair	
McCarthy, James (E)	USA	<sup>1</sup> SSC		SSC	SSC	
Merlivat, Liliane (VC)	France	<sup>1,4</sup> SSC	IOC-CO2	SSC		
Moore, Robert	Canada	<sup>4</sup> SSC		SSC		
Morel, Andre	France	SSC		SSC	SSC	
Murray, James	USA	SSC	<sup>3</sup> EqPAC	SSC	SSC	SSC
Platt, Trevor	Canada		<sup>2</sup> SMTT	Chair	Chair	
Priddle, Jullan	UK		<sup>3</sup> SOPG	Chair	Chair	
Sakshaug, Egil (E)	Norway	<sup>1,4</sup> SSC	<sup>2</sup> PSTT	SSC	Chair	
Shimmield, Graham	UK	SSC	<sup>2</sup> DOFTT	SSC	SSC	
Takahashi, Taro	USA	SSC		SSC	SSC	
Tilbrook, Bronte	Australia	SSC		SSC	SSC	SSC
Willebrand, Jurgen	Germany	SSC		SSC	SSC	SSC
Yoder, James	USA		<sup>2</sup> RSTT	Chair	Chair	

(1) The JGOFS Executive Committee consists of the Chair and Vice-Chair, and two at-large SSC Members, as Executive Members.

(2) Task Teams (TT): NPTT-North Pacific, PSTT-Photosynthesis, CMTT-Continental Margin, DOFTT-Deep Ocean Flux, RSTT-Remote Sensing, DMTT-Data Management, and SMTT-Synthesis and Modelling

(3) Planning Groups (PG): IOPG-Indian Ocean, EqPAC-Equatorial Pacific, NAPG-North Atlantic, SOPG-Southern Ocean.

(4) Members scheduled to complete 3-year term on the JGOFS Committee in 1996.

(5) Past JGOFS Committee Chair

## ANNEX 7 - Global Ocean Ecosystem Dynamics (GLOBEC)

### GLOBEC adopted by IGBP as Core Project

During the IGBP meeting held in Beijing in October 1995, the GLOBEC Science Plan was presented to and approved by the SC-IGBP. GLOBEC is thus accepted as a new IGBP Core Project, with co-sponsorship by the Scientific Committee on Oceanic Research (SCOR) and the Intergovernmental Oceanographic Commission (IOC).

The adoption of GLOBEC as a Core Project of the International-Geosphere Biosphere Program is a significant land-mark in the development of the international program. The achievement by GLOBEC of IGBP Core Project status has been a direct consequence of the hard work of Professor Brian Rothschild and the original SSC team over a number of years. GLOBEC has come a long way since the first international GLOBEC planning meeting in Ravello in 1992. This strong foundation places the project in a good position to move to the implementation phase, and to develop an effective Implementation Plan. This will be one of the critical issues facing the members of the new GLOBEC SSC.

GLOBEC was represented at the first IGBP Congress held Bad Münstereifel in Germany from 17 to 23 April. This was the first time in the ten year history of the IGBP that all the Program Elements had met together. A full day was devoted to presentations from the Chairs of the of the eleven IGBP Program Elements (including GLOBEC) in which recent successes and future plans were reviewed. A particular question after the GLOBEC presentation concerned the perceived northern hemisphere focus of the project; clearly developing GLOBEC in the southern hemisphere is an important issue which needs addressing.

A specific session at the Congress addressed the topic of "IGBP Oceans Research", and a challenge for the GLOBEC community will be to establish effective integration and links with the other two marine Program Elements (JGOFS and LOICZ). However, an even more stimulating challenge will be to view GLOBEC research in the wider context of the IGBP, and to look to developing good interactions with relevant terrestrial projects, making comparisons between terrestrial and marine ecosystems. For example there is potential for linking, through possible theoretical and modeling work, with the initiative of GCTE on "Global Change and Ecological Complexity". The wider IGBP context also challenges GLOBEC to bear in mind the human dimension, for example aspects of food supply (the significance of fisheries), and training and capacity building.

### Scientific Steering Committee

Completion of the Science Plan and the adoption of GLOBEC by IGBP have provided the opportunity make some changes in the composition of the SSC. Both SCOR and IGBP rules call for a rotation of the Chairs and members of their committees every three years; this mechanism ensures that there is an opportunity for new people to become involved. The composition of the GLOBEC SSC strives for balanced disciplinary and international representation while at the same time maintaining important continuity with the membership of the original committee.

The membership of the GLOBEC SSC is:

Prof Dag Aksnes	(Dept. of Fisheries and Marine Biology, Univ. Bergen)	Norway
Dr Jürgen Alheit	(Baltic Sea Research Institute, University of Rostock)	Germany
Prof Tommy Dickey	(University of California, Santa Barbara)	USA
Dr Roger Harris	(Plymouth Marine Laboratory)	UK Chairman
Prof Eileen Hofmann	(Old Dominion University)	USA
Dr Tsutomu Ikeda	(Faculty of Fisheries, Hokkaido University)	Japan
Dr Ian Perry	(Pacific Biological Station, DFO, Nanaimo)	Canada
Prof Brian Rothschild	(University of Massachusetts, Dartmouth)	USA
Prof Jarl-Ove Stromberg	(Kristineberg Marine Research Station)	Sweden
Dr Svein Sundby	(Institute for Marine Research, Bergen)	Norway
Dr Qisheng Tang	(Yellow Sea Fisheries Research Institute, Qingdao)	China

The SSC will have the responsibility of overseeing the development and implementation of the GLOBEC program in accordance with the published Science Plan; the SSC will develop a detailed Implementation Plan for GLOBEC for presentation to the sponsoring organizations and the larger scientific community; the SSC will recommend to the sponsoring organizations the necessary action to be taken in accordance with the GLOBEC Science and Implementation Plans and to coordinate and manage the resulting activities; the Steering Committee will collaborate, as appropriate with other global change programs and planning activities, such as JGOFS, LOICZ, WCRP, the IOC/FAO program on Ocean Science and Living Resources, and the emerging Global Ocean Observing System, GOOS; they will establish appropriate data management policies to ensure sharing and preservation of the GLOBEC data set; and finally, the SSC will report regularly to SCOR, IGBP and IOC and to other bodies such as WCRP, ICES and PICES, on the state of planning and accomplishment of GLOBEC.

The new GLOBEC-SC will hold its first meeting at Johns Hopkins University 11-13 November, 1996. At that meeting the date and venue for the 1996 SC meeting will be decided.

#### **The Science Plan**

The GLOBEC Science Plan has benefited from the careful drafting by the SCOR/IGBP Core Project Planning Committee. It has been based on a draft plan written by the SCOR/IOC SSC for GLOBEC in 1994. That plan was itself based on a number of scientific reports generated by the successful series GLOBEC working groups, and on discussions at the GLOBEC Strategic Planning Conference (Paris, July 1994). The members of the SCOR/IGBP CPPC were Prof Brian Rothschild (Chair), Dr Robert Muensch (Chief Editor), Prof John Field, Dr Berrien Moore, Dr John Steele, Prof Jarl-Ove Stromberg and Dr Takashige Sugimoto. Steps are now in hand to publish the approved GLOBEC Science Plan as a matter of priority, having incorporated a number of suggestions made by members of the IGBP-SC in Beijing.

#### **The Major Components of GLOBEC**

The GLOBEC Core Program consists of a series of activities, planned under the aegis of the GLOBEC SSC. Much of the foundation has been laid at a series of planning meetings, in particular the 1993 GLOBEC Working Group on Population Dynamics and Physical Variability (GLOBEC Report No, 2) ; other working groups are directing GLOBEC efforts in, for example Numerical Modeling (GLOBEC Report No, 6, and also see below) and Sampling and Observation Systems (GLOBEC Report No, 3).

In addition the GLOBEC Core Program has a major field study component. The four largest field research programs are briefly described below.

**GLOBEC Southern Ocean Program (SO-GLOBEC):** The SO-GLOBEC program is focussed on understanding how physical forces influence population dynamics and predator-prey interactions between key species. Special efforts will be made to study the little-known overwintering strategies of zooplankton and top predators. The knowledge gained will significantly advance our understanding of Southern Ocean marine ecosystems and will enable us to adequately monitor and predict the impact of climate change.

Planning for a Southern Ocean GLOBEC program has been developed at a number of meetings and working groups (GLOBEC Reports Nos, 5 & 7), and issues of implementation are now being considered as a matter of urgency by the new SSC. A new Southern Ocean Working Group is being constituted under the Chairmanship of Professor Eileen Hofmann.

**Small Pelagic Fishes and Climate Change (SPACC):** SPACC aims to identify linkages between the physical forces that control growth of small pelagic fish populations (sardines, anchovies, scads, herrings, mackerels, sprat, menhadens and others). The long-range goal is to forecast how changes in the patterns and intensity of these forces, caused by elevated greenhouse gases and global warming, will alter the productivity of small pelagic fish populations.

SPACC planning has already involved a major workshop in Mexico (GLOBEC Report No, 8). A subsequent meeting was held in Swakopmund, Namibia, 4-8 December 1995, to consider the SPACC Implementation Plan, and

further consideration of implementation will be made at a meeting in Mexico City , 19-23 August 1996. Drs John Hunter (Southwest Fisheries Science Center, La Jolla) and Jürgen Alheit (Baltic Sea Research Institute, Warnemuende) have played a central and active role in the development of SPACC.

**ICES - GLOBEC Cod and Climate Change Program (CCC or "3Cs"):** The International Council for the Exploration of the Sea (ICES) and GLOBEC have joined together to develop an innovative program to advance the understanding and prediction of variability in fish stock recruitment, both in the short term (annual forecasts) and in the long term ("climate effects"). Cod was chosen as the candidate species for this exercise because its biology is well-known and supported by ample data bases. It has a pan-Atlantic distribution, and its abundance and distribution have been shown to be sensitive to specific past examples of climate variability. These considerations provide Cod and Climate Change (CCC) with the possibility of developing new capabilities in predicting fish recruitment from a better understanding of the interaction of physical processes and population dynamics. A report of planning for Cod and Climate Change is given in GLOBEC Report No, 4.

ICES, in association with GLOBEC, have recently appointed Dr Keith Brander, from the Fisheries Laboratory, Lowestoft, UK, as the co-ordinator of the North Atlantic Regional Office of GLOBEC. This position will provide a strong basis for advancing North Atlantic GLOBEC research such as the Cod and Climate Change program. A first meeting to consider the role of the GLOBEC North Atlantic co-ordinator was held at ICES headquarters, Copenhagen 6-7 June; Professor Jarl-Ove Stromberg and Dr Juergen Alheit represented the GLOBEC-SC at this meeting.

**PICES-GLOBEC Climate Change and Carrying Capacity (CCCC or "4Cs"):** The North Pacific Marine Sciences Organization (PICES) and GLOBEC are jointly organizing a program on Climate Change and Carrying Capacity (CCCC) in the temperate and subarctic regions of the North Pacific Ocean. The general scope of the CCCC Program has a strong emphasis on coupling between atmospheric and oceanographic processes, their impact on the production of major marine living resources and how they respond to climate change on time scales of decades to centuries. Particular emphasis is being placed on regime shifts, and on the biology of salmonid stocks.

PICES held a recent modeling workshop at Nemuro, Japan (June 23), and the October PICES Annual Meeting to be held in Nanaimo, British Columbia (11-20, October), will consider further aspects of the implementation of CCCC.

#### **National and Regional Programs; GLOBEC modeling initiatives**

A major future priority of the SSC is to work closely with National GLOBEC committees and emerging regional programs to ensure effective co-ordination and integration, and to realize the full research potential of these regional initiatives. Many such GLOBEC activities are well established and ongoing, for example the US George's Bank Program. It is a strength of the international program that there is already so much GLOBEC research momentum.

GLOBEC has an active Numerical Modeling Working Group, under the Chairmanship of Professor Allan Robinson, Harvard. The group met in Nantes, France, 17-20 July 1995, and a draft report on "Interdisciplinary Model Formulation and Parameterization" summarizes the outcome of the meeting. GLOBEC has also co-sponsored a meeting on "Modeling the Role of Zooplankton in the Marine Food Chain" held at the Isaac Newton Institute for Mathematical Sciences, University of Cambridge, 12-16 August 1996.

#### **GLOBEC reports**

One report has been published in the last year: GLOBEC Report No.8., Report of the first planning meeting on Small Pelagic Fishes and Climate Change Program. La Paz, Mexico, June 20-24, 1994

## ANNEX 8 - Coupling Wind, Waves and Currents in Coastal Models

### 1. Preamble:

Past research efforts in ocean dynamics in general, and coastal dynamics in particular, have tended to focus on different aspects of the physical processes separately: meteorology, currents, or wave generation. Coupled models were limited through the parameterization of one process or the other. But the dynamics of all the phenomena are coupled; they must be treated explicitly and comprehensively. In the recent SCOR Working Group 101 deliberations, we found that the wind stresses could not be parameterized without specific knowledge of underlying waves, involving their amplitude, frequency and direction. Then in Working Group 103, it was found that breaking waves can influence the surface stress as well as the dynamics of the whole water column. Consequently, a complete coastal model will have to include a coupled wave component.

SCOR is requested to establish a Working Group to examine the critical issues involved in the coupling between wind forcing, surface waves and currents in the coastal ocean; and to review the existing observational data to define the future needs for understanding the coastal region as a whole. Due to the proximity of the coastal waters to land, observational data are easy to obtain for the verification of the models. Because coastal waters provide a substantial portion of heat exchange between the atmosphere and the ocean, we also want to estimate the impact of the coastal waters in global ocean dynamics and climate studies.

Relative to the open ocean, the coastal region has received far less attention than it deserves. Based both on scientific and societal considerations, actions must be taken to redress the situation. From the scientific point of view, the coastal waters serve as the transitional zone between the lands and the ocean, where large temperature contrasts often exist. A substantial portion of the global heat exchange between the atmosphere and the oceans takes place in this region. Furthermore, the coastal waters also provide the boundary condition for the open ocean in a truly coupled land-ocean-atmospheric model for climate studies.

From a societal point of view, 50% of the world's population lives within five miles of the sea today; 16 of the world's 20 largest cities are also in this region, according to the World Resource Report for 1995 (World Resource Institute, Oxford University Press). Moreover, the population in the coastal zone is increasing; by 2030 it is estimated that over 60% of the world's population will live there. The advantages of living in the coastal region are obvious. Yet accompanying these advantages there are also problems; storm surges, hurricanes, flooding and beach erosion could all inflict severe damage to this sensitive region. An understanding of coastal processes is the first step towards effective countermeasures to assure the effective use and health of this environment.

The dynamics of the coastal region are at the same time both simpler and more complex than those of the open ocean. They are simpler because the dominating dynamic phenomena, such as tides, are linear in the coastal region. The region is limited in size compared to the open ocean, and the coastline offers a definite boundary which no energy and momentum fluxes can cross. It is more complex because the coastline geometry and bottom topography are additional variables to be considered. Finally, the decidedly inhomogeneous environment makes the region far more complicated. Consider an alongshore wind. The waves will be refracted by the uneven topographic features and propagated in different directions, even if the wind speed and direction are uniform. They will extract energy and momentum from the wind and modify the air-sea fluxes, which will change the effective momentum flux into currents. As the coastal currents develop, they begin to influence the amplitude and direction of the surface wave field, which in turn modifies the surface wind and atmospheric forcing. In the case of a cross-shelf wind, as it starts to blow offshore over the coastal water, it starts to generate small-scale wind waves. They also extract momentum and energy from the wind. Limited by the relatively small coastal domain, the small-scale wave field never becomes uniform, so that the atmospheric forcing also remains spatially inhomogeneous. This interaction between wind and waves alters the air-sea momentum and energy fluxes, which results in altering not only the coastal circulation pattern, but also the coastal atmospheric dynamics. Strong coupling among the surface waves, currents and winds is a unique characteristic of the coastal ocean.

As stated above, the primary scientific objective of this Working Group is to understand the coupling among surface waves, currents and forcing winds in the coastal ocean. Some initial questions to be addressed include:

- What processes govern the generation and propagation of waves across the shelf?
- In particular, what is the partition of energy and momentum fluxes into waves and currents and how does this partition change with time and cross-shelf position in different wind forcing regimes?
- How do the changes in surface mixed layer structure due to wave effects influence the wind-driven current response?
- What are the effects of waves on the magnitude and directional characteristics of the surface wind stress?
- How significant are wave refraction, associated breaking and wave-current interaction in controlling the wind-generated current response, and how does this influence the further evolution of the wave and wind fields?
- How does the coupled model differ from the uncoupled models?
- What is the role of the coastal waters as sources in global heat exchange between the atmosphere and the oceans, and as a boundary condition for global climate studies?

The Working Group should lead to a renewed effort to develop a coupled coastal wind-wave-circulation model based on state-of-the-art field measurements of the surface wind and wind stress fields, the surface wave and current fields, and the water column current and density response. The focus of the Working Group will be on special issues related to the development of a coupled coastal wind-wave-circulation model for assessing the health of the coastal environment and estimating the role of the coastal waters in global ocean dynamics. Final results for the Working Group will be communicated to other appropriate research efforts, for example, LOICZ, the Land-Ocean Interactions in the Coastal Zone, and GLOBEC, the Global Ocean Ecosystems Dynamics program.

## 2. Terms of Reference

- To review the present status of our knowledge on each component of coastal dynamics: coastal wave models, coastal circulation models, and the coastal atmospheric boundary layer models.
- To examine the existing coastal circulation and wave data from both conventional and remotely-sensed sources to detect possible weaknesses of uncoupled models, and to address the issues of a coupled model.
- To build and strengthen a collaborative research effort on a coupled coastal dynamics model, between wave, circulation and coastal meteorology modelers, both among the members of the Working Group and with other existing groups.
- To estimate the contribution of coastal waters in heat exchange between the atmosphere and the ocean, which has importance for global modeling and climate studies.
- To prepare a final report summarizing the present status of our knowledge, recommending future research and observational studies of the coastal regions.

## 3. Membership

### Chair:

Norden E. Huang

NASA Goddard Space Flight Center, MC 971, Greenbelt, MD 20771, USA  
Temporary e-mail address: norden@cco.caltech.edu

### Members:

Yeli Yuan

First Institute of Oceanography

China

John Hutchnane

Proudman Oceanographic Laboratory

UK

Peter Craig

CSIRO Marine Labs, Hobart

Australia

Wolfgang Rosenthal

GKSS Research Institute

Germany

Vladimir Graynick

Institute of Atmospheric Physics

Russia

S. Shetye

National Institute of Oceanography

India

### Associate Members:

Christopher N. Mooers

University of Miami

USA

Henry Chamock

Southampton University

UK

Mike Banner

University of New South Wales

Australia

Yoshiaki Toba

EORC, NASDA

Japan

Jurgen Battjes

Delft University

The Netherlands

I. A. Maiza

Institute of Oceanography

Egypt

Carlos Garcia

Universidade do Rio Grande

Brazil



**ANNEX 9 - Budget and Final Financial Statement for 1995**

**STARTING CASH BALANCE AND INCOME**

	Budget Revised & Approved by EC-32	December 31 1995 Actual Income
<b>BALANCE 1/1/95</b>	<b>68,425.73</b>	<b>68,426.00</b>
<b>Funds Held in JGOFS Special Fund</b>	<b><u>18,702.91</u></b>	<b><u>0.00</u></b>
<b>Total Cash plus Income</b>	<b>87,128.64</b>	<b>68,426.00</b>
<b>INCOME:</b>		
Membership	180,000.00	205,185.00
ICSU Grant / JGOFS	23,950.00	23,950.00
ICSU Grant / GLOBEC	23,950.00	23,950.00
IGBP Grant / JGOFS	40,500.00	40,500.00
Use of JGOFS Special Fund	0.00	18,703.00
Other grants to JGOFS:		
ONR	25,000.00	25,000.00
COSTED	1,000.00	1,000.00
START	5,000.00	5,000.00
UNESCO/ROSTAS	2,050.00	2,050.00
IOC Contracts	30,500.00	25,000.00
NSF Grant / Travel Awards	90,000.00	81,181.00
NSF Grant / Geosciences	<u>195,000.00</u>	<u>123,734.00</u>
<b>Total Income</b>	<b>616,950.00</b>	<b>575,253.00</b>
<b>TOTAL CASH PLUS INCOME</b>	<b><u>704,078.64</u></b>	<b><u>643,679.00</u></b>

## EXPENSES AND YEAR END CASH BALANCE

	Budget Revised & Approved by EC.-32	December 31 1995 Actual Expense
<b>SCIENTIFIC EXPENSES:</b>		
WG 78 (for publication)	6,000.00	6,000.00
ex WG 92 Reville Symposium	5,000.00	0.00
WG 93	8,000.00	7,308.00
WG 97	10,000.00	11,681.00
WG 100	8,000.00	930.00
WG 101	1,000.00	1,000.00
WG 103	10,000.00	6,620.00
New WG's	12,000.00	12,981.00
JGOFS	172,500.00	169,946.00
GLOBEC	<u>90,000.00</u>	<u>79,700.00</u>
Total Subsidiary Bodies	322,500.00	296,166.00
Publications	19,000.00	18,927.00
Travel Awards	90,000.00	81,059.00
COASTS Publication	2,500.00	2,500.00
Executive Committee meeting	25,000.00	27,494.00
Representation	<u>4,000.00</u>	<u>1,826.00</u>
	<u>140,500.00</u>	<u>131,806.00</u>
<b>TOTAL SCIENTIFIC EXPENSES</b>	<b>463,000.00</b>	<b>427,972.00</b>
<b>ADMINISTRATIVE EXPENSES</b>		
Salaries plus benefits	88,600.00	60,160.00
Communication	7,000.00	7,666.00
Audit	6,000.00	5,000.00
Office Equipment	1,500.00	1,217.00
J.H.U. overhead charges	17,100.00	17,087.00
Bank charges, (gain) on exchange	200.00	(625.00)
Miscellaneous	<u>2,500.00</u>	<u>2,660.00</u>
Total SCOR Administration	122,900.00	93,165.00
<b>TOTAL EXPENSES</b>	<b>585,900.00</b>	<b>521,137.00</b>
BALANCE 31/12/95	99,475.64	122,542.00
Plus JGOFS Special Fund	<u>18,703.00</u>	<u>0.00</u>
<b>TOTAL CASH PLUS EXPENSES</b>	<b><u>704,078.64</u></b>	<b><u>643,679.00</u></b>

## **ANNEX 10 - Scientific Committee on Problems of the Environment (SCOPE)**

### **INTRODUCTION**

On its establishment as a scientific committee by ICSU in 1969, SCOPE received the mandate to advance knowledge of the influence of humans on their environment, as well as the effects of these environmental changes upon people, their health and their welfare, with particular attention to those influences and effects which are either global or shared by several nations. Its task is also to serve as a non-governmental, interdisciplinary and international council of scientists and as a source of advice for the benefit of governments and international bodies with respect to environmental problems. SCOPE functions as an interface between environmental science and the decision-making sphere by concentrating on scientific problems of major global significance, with the objective to critically examine and synthesise available knowledge on a given issue. It aims to focus attention on controversial questions, stimulate new approaches, identify research needs and encourage the adoption of sound environmental practices.

### **MEMBERSHIP**

Current SCOPE membership consists of thirty-eight science academies and research councils, and twenty-two international ICSU scientific unions, committees and associates. Contacts with the Republic of Korea led to the application for membership presented by the Korean Academy of Science and Technology. This was accepted by the Executive Committee in February 1996. The Republic of Korea thus becomes the 38th national member of SCOPE.

### **1995 ACTIVITIES of the SCIENTIFIC PROGRAMME**

#### **Interaction with other ICSU unions and scientific committees:**

In October 1995 the Executive Board of ICSU requested that SCOPE undertake an integrated assessment of environmental problems of the oceans, to evaluate current knowledge about these problems and identify a range of possible options to address them.

Diversitas, the successful collaborative study of SCOPE-IUBS-UNESCO, has developed into a full-grown programme, which will soon function under its own secretariat, and ICSU, IUMS and IGBP have joined the partnership for the second phase.

The complementary role of IGBP (research) and SCOPE (review and assessment) is mutually beneficial, and ties to this fellow ICSU organisation are extremely close. The ecosystem function of biodiversity and the new earth-system services, below-ground biodiversity, and behaviour of large scale ecosystems projects are excellent examples of this cross-fertilization.

Joint projects involving SCOPE and other ICSU organisations include:

- the above-mentioned Diversitas programme, with IUBS
- earth surface processes, a joint project with IUGS (also involving IGU)
- mercury and RADTEST, with IUPAC

Intergovernmental agencies and organisations also contribute support and input to the programme:

The United Nations Environment Programme is SCOPE's foremost partner and has contributed to a majority of our projects in 1995 (sustainable land management, groundwater contamination, environment and economics, indicators for sustainable development and mercury cycling). The ecosystem function of biodiversity project has benefited from UNEP input and support, and key project individuals have prepared sections 6 and 7 of UNEP's Global Biodiversity Assessment, the follow-up to the Biodiversity Convention established at the Rio Conference. The Indicators project is contributing to the work plan of the UN Commission on Sustainable Development.

The European Commission continues to strongly support SCOPE and its programme, principally through the indicators for sustainable development, biodiversity, RADTEST, and SGOMSEC projects. The World Health Organisation, through its International Programme on Chemical Safety (in which UNEP and ILO participate) continues to co-sponsor SGOMSEC. The North Atlantic Treaty Organisation sponsored also the Novosibirsk workshop of the mercury cycling project.

IUCN was involved in the planning meeting held in Geneva in January 1996 for the invasive species project and may become a full-fledged partner of SCOPE in this study. It has also requested assistance from SCOPE to identify experts for its newly constituted Commission on Environmental Management.

#### The scientific programme:

The IX General Assembly reviewed the progress of projects and approved implementation of new studies. The following projects were terminated in 1995, and members of the respective SACs thanked for their efforts: Particle Flux In The Ocean, Phosphorus Cycles, Effects Of Increased UV-B Radiation, Ecotones In A Changing Environment and Organic Matter Budgets. Since its establishment in 1969, SCOPE has maintained a watching brief on environment and development fronts through studies integrating pure science and policy concerns. The present scientific programme continues to address such issues through multidisciplinary efforts, with the underlying objective to promote sustainability. At the end of 1995, ongoing projects were re-organised in a 3-cluster structure.

#### I Practices & Policies

- The Sustainable Biosphere Project (SBP) aims to understand the biophysical, social, and economic determinants of sustainable ecological systems and to stimulate the implementation of practices and policies which will lead to a sustainable biosphere. The SBP focuses on seven different regions of the world: Amazonia, the Baltic Sea, the Great Lakes and Mediterranean Basins, the Hindu-Kush/Himalayan system, the Southern African savannas, and Oceania. Each region presents a known, definable set of interactions among ecological, social, and economic conditions, and an adequate data base from which to propose management options. The Amazonia and Baltic Basin case studies became operative in 1995, convening planning meetings and securing funding.
- The Latin American regional workshop of the Sustainable Land Management in Semi-Arid and Sub-Humid Regions project was held in Mexico in February 1995. Proceedings of the meeting, as well as recommendations for policy planners are expected outputs of this component of the project. The proceedings volume of the regional African workshop on semi-arid and subhumid regions (Dakar, Senegal, 1993) was published by CIRAD, SCOPE and UNEP in 1995.
- An integrated approach to understanding and managing relations between natural- and human-dominated ecosystems is needed to achieve sustainability. The workshop of the Environment and Economics project was held in the Pantanal region of Brazil in November 1995 to review computational questions, integrating ecological and economic theory and models, time and space scale issues, and interaction among the different stakeholders. These factors were developed in case studies at different spatial and temporal scales, analyzing both technical and stakeholder interactions.
- The Indicators for Sustainable Development project, launched in 1994, aims to produce specific recommendations on aggregated indicators of national performance, and to foster international dialogue on this issue, particularly between users and data producers. A first workshop, sponsored by the governments of Belgium and Costa Rica, UNEP and SCOPE, was organised in January 1995 (Ghent, Belgium) to identify and assess the needs of indicator users. Results were submitted to the CSD which supported the continuing work on these issues and specifically requested the scientific community and SCOPE to further develop highly-aggregated indicators, identifying and assessing the linkages among the economic, social, institutional and environmental elements of sustainable development. The focus of the

second workshop (Wuppertal, Germany, November 1995) moved from users' needs to the scientific and academic issues underlying sustainable development indicators.

- Ecological engineering is dedicated to the design and construction of sustainable ecosystems that provide a balance of natural and human values. The project on Ecological Engineering And Ecosystem Restoration was designed around three themes: a synthesis of past accomplishments and future potential of ecological engineering; the formalization of conceptual and technical linkages among diverse aspects of the field with special focus on management applications and institutional needs; and the development of a vision of the field and its future, for scientists, planners and managers involved in the application of the principles of ecological engineering. The first meeting was held in Estonia in November 1995. The workshop which focussed on "Remediation of Ecosystems Damaged by Environmental Contamination" emphasized not only types of approaches likely to be successful but considered the short and long-term costs of alternative approaches.
- The IX General Assembly decided to launch a new project, A Global Strategy on Invasive Species which aims to develop a global strategy for dealing with alien invasive species, thus helping to preserve Earth's biological diversity. In its first phase this project will review our current knowledge base on invasives, develop new tools and approaches to deal with the invasives problem globally, and help implement the international Convention on Biological Diversity which has the sweeping requirements for preventing and eradicating alien species that threaten ecosystems, habitats or species. Partners, co-players and stakeholders in this project are scientists, conservationists, managers, policy-makers and intergovernmental and governmental experts.
- Earth-system Services and Human Population is another newly approved project that will link recent progress in understanding the function of the earth-system, at the global scale, with perspectives on the present and future demands human activities impose on those functions. This project will link biosphere and earth-system function with questions of human impacts and demands to provide short- and long-term perspectives on the ability of the earth-system to satisfy a suite of critical services. In the first phase, four earth-system functions (freshwater resources; air quality; soil fertility; and products of photosynthesis for food, fuel, and fiber) will provide the foci for separate international, interdisciplinary workshops.

## II Ecosystems Processes & Biodiversity

- The Groundwater Contamination project has sought to provide tools for the evaluation of aquifer vulnerability to contamination and to assess the capacity of aquifers eventually to detoxify pollutants. Training seminars directed at decision-makers, engineers and technicians were an integral component of the various regional workshops organized to date. In August 1995 a regional workshop and training session in Beijing focussed on "Groundwater contamination in China and surrounding countries". UNEP provides support for this project.
- The joint SCOPE-IUGS (International Union of Geological Sciences) study, Earth Surface Processes, Materials Use and Urban Development: understanding the human contribution to global geomorphological change, launched in March 1995, aims to quantify and describe the magnitude of direct and indirect human-driven changes on the surface of the earth; to evaluate their influence on the work of geomorphological processes; and to assess their consequences for the environment and people. Three themes have been identified for review: extractive activities, urban development, and fluvial and coastal systems. Meetings in Spain in March 1995 developed the agenda and a handbook for the project, and the first regional Asian workshop was convened in Singapore in June 1995.
- The study on Biodiversity and Ecosystem Functioning was designed to synthesize knowledge of the role of biodiversity in ecosystem functioning and focussed on specific biotic regions of the world. The following problem areas were identified as priority topics for future research efforts: below-ground

biodiversity; estuaries, coastal zones and mangrove ecosystems; the nature of keystone species and our capacity to predict their presence and potential effects of their loss; and systemics and taxonomy studies. The synthesis volume entitled "Functional Roles of Biodiversity: A Global Perspective" (in press) will include explicit research priorities and recommendations. A popular book is due to be published in early 1997 and will be targeted to advisers, decision-makers, teachers and the educated lay public. This project is linked to two major international efforts: the Global Biodiversity Assessment/GBA, coordinated by UNEP as a follow-up to the UN Conference on Environment and Development (1992) and a contribution to the implementation of the International Convention on Biodiversity, and DIVERSITAS, the joint programme launched in 1990 by SCOPE, IUBS, and UNESCO, and now expanded to include ICSU, IGBP, and IUMS.

- Biodiversity in Soils and Sediments, a project approved in June 1995, will continue to explore the role biodiversity plays in the functioning of ecosystems, evaluating and assessing the current state of knowledge of the relationships of soil and sediment organisms to critical ecosystem processes. The biota and chemical and physical properties of soils and sediments are interlocking components of fundamental importance for the existence of terrestrial, freshwater and marine ecosystems. This study will provide input to core element 1 (biodiversity of ecosystem functioning) and special target research area 6 (soil and sediment biodiversity) of DIVERSITAS.
- A new project on Behaviour of Large-scale Ecosystems looks at the "synapse" that exists between the available body of small-scale fundamental environmental knowledge and large-scale policy questions that need answers. It aims to create ways to measure the resilience of large-scale ecosystems to a range of specific stressors (changes in climate, land use and resource exploitation) and to demonstrate the application of these methods in several systems. Six target ecosystems/landscapes have been identified (Baltic Sea, northern lakes, wet savannas, dry savannas, grasslands, boreal forests, tropical forests, coral reefs, mangroves).

### III Health & Environment

- The Scientific Group on Methodologies for the Safety Evaluation of Chemicals, SGOMSEC, was established in 1980 under the aegis of SCOPE and IPCS (International Program on Chemical Safety), itself a joint undertaking of WHO, ILO and UNEP. Its basic objective is to assess current and new methodologies for the safety evaluation of chemicals with respect to human health and to ecosystems and the biosphere as a whole. Ten SGOMSEC studies have been completed as of 1996. Studies in 1995 included:
  - SGOMSEC 11 - Methods on Risk Assessment for Neurobehavioural Toxicity. focussed on constructing a suitable risk assessment framework for neurobehavioural toxicity, to examine current methodology and to determine how such test results could be used in assessing the risks associated with exposure to chemicals. Results will be published in 1996 in Environmental Health Perspectives.
  - SGOMSEC 12 - the workshop on Methods for Assessing Susceptibility to Environmental Hazards aimed to provide a didactic guide to methods involved in the identification of susceptible populations to environmental hazards by investigating biological markers of genetic susceptibility; biological markers of exposure; other biomarkers of susceptibility; susceptible populations in ecosystems; and ethical, social and legal issues surrounding studies of susceptible populations and individuals.
- RADTEST (Radioactivity from Nuclear Test Explosions) is an international collaborative study to examine radioactivity from nuclear test explosions which have been conducted at various test sites around the world for peaceful and military purposes. Radionuclides produced by these tests comprise by far the largest source of man-made radioactivity released into the Earth's environment to date. RADTEST has provided the opportunity for scientists who were directly or indirectly involved with these tests to share

previously restricted work involving data, models and knowledge about the fate of the release of radionuclides and their possible human health effects. An international workshop focusing on methodologies of dose transfer, epidemiology and subsurface transport was held in March 1995 in Liege, Belgium.

- Over the past century, anthropogenic emissions have tripled the concentrations of mercury in the atmosphere and in the surface oceans. The Mercury Cycling in Ecosystems project focuses on the sources and geographic distribution of Hg contamination, its ecology in temperate and tropical areas, the methylation of Hg in temperate and tropical areas and its demethylation in organisms, environmental factors influencing the cycling of mercury, food web accumulation processes and the biological effects of metallic, inorganic and organic mercury. The workshop held in Novosibirsk, Siberia in July 1995 was co-sponsored by NATO as an Advanced Research Workshop. A fact-finding mission traveled to Zimbabwe in November 1995.

#### **PUBLICATIONS**

SCOPE series reports, synthesis monographs resulting from individual projects, are circulated free of charge to SCOPE members and are also available commercially. Two volumes in the SCOPE series were published by Wiley, UK in 1995:

SCOPE 53 - Methods to Assess the Effects of Chemicals on Ecosystems (IPCS Joint Activity 23 - SGOMSEC 10)

SCOPE 54 - Phosphorus in the Global Environment - Transfers, Cycles and Management

Project outputs take diversified forms, with executive summaries, special reports, articles in scientific journals, or special issues of such journals.

A sustained effort is also being made to reach audiences beyond the scientific community *stricto sensu*, with outputs targeted to decision-makers, practitioners and/or the general public. Some recent examples of such publications are listed below.

The proceedings of the Eastern and Central European regional workshop on Groundwater Contamination and training course in Trebon, South Bohemia, Czech Republic, in June 1994 were published by Kluwer this year and distributed commercially and free of charge via the SCOPE and UNEP networks.

"Indicators of Sustainable Development for Decision-Making", the report of the Ghent ISD workshop, was published by the Federal Planning Office of Belgium and submitted to the CSD.

"Understanding and Managing Ecotones", the proceedings of an international SCOPE/UNEP workshop in Ecology International, 22, 1995; "The Status of the Science Examining Ecotones", in BioScience, vol. 45, n. 5, 1995.

"Global Land Use Change - a perspective from the Colombian Encounter", with edited papers and presentations of the scientific symposium organised by the Spanish Committee for SCOPE, was published by the CSIC in Madrid.

"Impact sur l'Environnement d'une Guerre Nucleaire : Effets Ecologiques et Agricoles" was published by the Belgian SCOPE Committee in collaboration with IUR. This is a French-language popular presentation of ENUWAR findings.

"Soil Remediation", published by the Belgian SCOPE Committee, presents the proceedings of a symposium that focussed on contaminated sites (terrestrial and aquatic).

The Japan SCOPE Committee provides a translation of the SCOPE Newsletter for its members and the China/CAST Committee regularly publishes a Newsletter reporting on activities of its members at national and

international level. The SCOPE Unit based at Essex University issues a RADTEST Newsletter on a regular basis.

The SCOPE Newsletter is distributed free of charge through the Paris Secretariat and SCOPE committees in member countries. The SCOPE Bulletin, a brief review of projects and activities, is circulated six times a year to representatives of Committees and Unions for rapid exchange of information among members of the SCOPE community. Again this year, SCOPE offered selected titles from its series to institutions in developing and reorganizing countries, free of charge.



## ANNEX 11 - Report from the World Climate Research Program (WCRP)

### 1. INTRODUCTION

This report summarizes the main developments and events relevant to SCOR since the SCOR Exec-32 meeting. Updates are provided on the three WCRP programmes with the most significant oceanographic components: WOCE, CLIVAR and ACSYS. Some cross-cutting issues are also addressed, namely air-sea fluxes and general matters related to coordination and management of the WCRP.

### 2. WORLD OCEAN CIRCULATION EXPERIMENT (WOCE)

A separate report, entitled "Project Status 1996; Future AIMS" will be submitted. The paragraphs below outline progress in the completion of the WOCE observational programme and the status of the Analysis, Interpretation, Modelling and Synthesis (AIMS) phase, as presented to the Joint Scientific Committee for the WCRP (JSC) at their seventeenth session in March 1996.

#### 2.1 WOCE Observational Programme

##### *Satellites*

The satellites of prime importance to WOCE continue to operate successfully. The French-US TOPEX/POSEIDON mission is expected to provide good data until beyond the end of WOCE observational phase in 1997. TOPEX/POSEIDON altimeter data have far exceeded expectations of their accuracy (now ~3 cm rms.), and, with the development of improved global tide models, have enabled ocean circulation signals to be studied in detail. Much new information on ocean eddy variability, seasonal and interannual changes, and the dynamic topography of the ocean has been inferred from altimeter data.

Following prolonged discussions and lobbying from the WOCE Scientific Steering Group and many other concerned scientists, agreement has been reached to provide a follow-on TOPEX/POSEIDON sensor as part of the Earth Observing System although a launch date has not yet been confirmed. This decision is of major importance in the light of the reliance that WOCE has come to place on high quality altimetric data and will also be of great benefit to CLIVAR. However, the determination of absolute currents from altimetry requires the geoid to be known with high precision on horizontal scales smaller than those presently available to the civilian community. This requires a dedicated gravity satellite mission (see also section 4.2.1).

ERS-1 has now collected data for a total of 5 years. Its altimeter, scatterometer and ATSR sensors continue to operate satisfactorily but the PRARE tracking system, needed for precise orbit determination, remains inoperative as it has from the start of the mission in 1991. ERS-1 was joined by ERS-2 (an essentially identical satellite in 1995). PRARE tracking is operative on ERS-2 and initial problems with the ERS-2 scatterometer have now been solved. Unfortunately, the ATSR-2 sea surface temperature sensor failed but recent attempts to re-activate it appear to have succeeded. Both ERS-1 and ERS-2 continue to provide valuable scatterometer wind vector data. The ERS-1 and -2 satellites are presently operating a tandem mission of a 35 day repeat orbit with a 30-minute offset between the two satellites (equivalent to a ground track separation of 1 day).

##### *Hydrography*

By the end of 1997, approximately 90% of the global one-time hydrographic survey will have been completed. The plans for repeat hydrography were ambitious and it is expected that only a somewhat lower percentage (~70%) of repeat stations will be completed. Similarly, time-series stations have remained under-committed but six locations in the Atlantic and Pacific are being occupied regularly. A detailed resurvey of the North Atlantic will be carried out in 1996-97 and among other things will document the pre-and post-winter states of the ocean.

In all, WOCE will have occupied a total of about 20000 hydrographic stations by the conclusion of the field phase. This may be compared with a global archive of approximately the same number of stations to depths of 3000m previously occupied this century. The WOCE data set however has major advantages, including

quasi-synopticity when compared with the historical archive, uniform high data standards and comprehensive measurements of transient tracers.

#### *Floats*

The ALACE (Autonomous Lagrangian Circulation Explorer) float that was developed specifically for WOCE has been deployed in large numbers (mostly from WOCE Hydrographic Programme cruises), and these deployments will continue to the end of the observational phase. The ALACE drifts at a preset level (in WOCE around 1000m) and, typically every 3-4 weeks, surfaces to transmit position, temperature and pressure data to the Argos satellite system. Since the ALACE float has an operational design life of up to 5 years, data from floats launched during WOCE will continue to become available for several years after 1997. Efforts are continuing to improve the lifetime of the floats and to reduce their cost. Some floats have completed over 100 10-day cycles. Of the first major deployment in 1991, 36% are still operational after over 60 cycles and four and a half years.

ALACE floats offer considerable potential for data collection in remote areas. Versions of floats measuring temperature profiles between their operating depth and the surface have already been deployed in substantial numbers and salinity profiles are also now becoming available.

#### *Drifters*

The joint TOGA/WOCE Surface Velocity Programme (now in the process of transition to a CLIVAR activity) has been extremely effective in promoting the development of surface drifters with improved durability (now standing at a mean lifetime of 400 days) and reduced slip, furnishing useful surface velocity data and other information to WOCE. All drifters measure sea surface temperature many have atmospheric pressure sensors and some provide observations of salinity.

#### *Upper ocean thermal observations*

The deployment of expendable bathythermographs (XBT) is from merchant vessels, and thus the coverage of data from the joint TOGA/WOCE XBT programme is largely confined to major areas of commercial shipping activity. In particular, the number of observations from the southern hemisphere is inadequate. Data availability overall has declined in the past year mainly as a result of cutbacks in USA programmes in the North Pacific. Furthermore, funding for many lines was provided as a contribution to TOGA, and several countries are finding it difficult to identify resources to continue XBT sampling after 1996. Another major concern is that only a small percentage (for some years as low as 20%) of XBT data transmitted in real time on the GTS ever becomes available for the detailed delayed-mode reanalysis being undertaken by WOCE. The development of ALACE floats (see above) holds the prospect of obtaining temperature (and salinity) profiles in remote regions with little shipping activity, and plans for seeding and populating such regions with floats are being drawn up.

#### *Current meters*

Most current meter arrays have now been deployed and many are still in the water. The main purpose of these arrays has been to determine transports in boundary currents on the eastern and western ends of zonal hydrographic heat flux lines and to measure the flows through channels between deep ocean basins and choke points between oceans. During WOCE, the ability to make current measurements using Acoustic Doppler Current Profilers (ADCPs) of various types improved greatly. Shipborne profilers have benefited from improvements in Global Positioning System (GPS) navigation and now routinely use differential GPS positions (to a few metres) and ship heading information (to 0.1 degree). Lowered ADCP sensors on CTD packages produce full-depth current profiles and moored ADCPs are in use in the strongest boundary current regions where conventional moorings would be inadequate.

#### *Sea level*

The high quality of altimeter data has greatly advanced understanding of spatial patterns of sea level change, and helped remove the problems of interpreting gauge data from a relatively small number of offshore and island sites and the uncertainties in relating coastal values to open ocean conditions. Nevertheless, the network of WOCE sea level gauges (a subset of the GLOSS network) is being maintained and must be continued in order to

provide ground truth data for altimeters, as well as to infer geostrophic currents through key choke points and flow through straits. It is also important to maintain records at several stations having long time series (more than 100 years) as a basis for monitoring long-term trends and variability. At present, nearly 100 stations provide data in real time and 60 additional stations data in delayed mode.

## **2.2 Assembly of WOCE Data Sets**

Individual principal investigators and scientists have the responsibility for collecting WOCE data sub-sets (e.g. from a particular WOCE hydrographic section, moored array). The task of producing a global view of the oceans depends on assembling all the sub-sets into composite global data sets. The success of this process depends on many factors, including the willingness of principal investigators to pool their data, agreement to uniform data standards and formats, acceptable rules of confidentiality and data exchange, and achieving a consensus on useful data products. A WOCE distributed data management system has been set up with a number of WOCE Data Assembly Centres and Special Analysis Centres located at research institutions in several participating WOCE countries. Encouraging the assembly of WOCE data sets, ensuring their availability in suitable formats and overseeing the whole system are the responsibility of the WOCE Data Products Committee. Many WOCE data sets and products are already on line and, as final data sets are completed, they will be passed to the World Data Centres for permanent archiving.

While the data system is coping reasonably well at present, almost all elements of the system are inadequately funded and resources are not sufficient to be able actively to search out data and to provide the "added-value" to data sets that would make them more accessible and user-friendly to researchers. The funding commitments to most components of the system are relatively short-term, with few guarantees even up to 2000, at which time data will still be flowing through the system. It has been estimated that, over the programme lifetime, funding agencies will have allocated no more than 2% of the WOCE budget to data management, reflecting the unwillingness to divert resources from observations and analysis. It was emphasized that CLIVAR should give early attention to the need for substantial funding of its data system.

Keeping track of WOCE data collection, processing and archiving is a Data Information Unit, located at the University of Delaware, USA. The unit interacts closely with the WOCE International Project Office which is responsible for the overall co-ordination of the complete experiment.

## **2.3 Data Assimilation and Synthesis**

The challenge of synthesising the multiplicity of WOCE observational data sets into a complete, dynamically consistent view of the global ocean circulation in the 1990s is no less daunting than that of implementing the 7-year global survey. This step involves the development of models of the global ocean and individual basins, together with significant advances in the capability of merging data sets of diverse characteristics and their assimilation into models. The WOCE Synthesis and Modelling Working Group has the substantial task of the detailed planning for the AIMS phase of WOCE, reviewing progress and making recommendations on the most promising lines of research, fostering efforts to acquire the necessary scientific skills, and assessing the resources needed.

The AIMS phase is indeed essential in capitalising on the enormous investment in the WOCE observational component and the collection of a global oceanographic data set. The comprehensive analysis of WOCE data will provide a significant improvement in our understanding of the role of the ocean in the climate system. However, to carry out AIMS requires a comparable commitment to that for the WOCE field phase, and this needs to be supported through existing national funding mechanisms. In particular, the quantum advance required in ocean modelling to support the assimilation and analysis of WOCE data as well for climate prediction depends on major commitments of staff and computing resources (including significant amounts of super-computer time). These resources cannot be provided by the small research groups typically located at universities or oceanographic institutions, but must come from large organizations such as the United Kingdom Meteorological Office, the Max Planck Institute for Meteorology in Hamburg or large USA facilities (e.g. GFDL, JPL, NCAR).

## 2.4 Model Development

With the increasing availability of powerful parallel processing machines, several groups worldwide are now running "eddy permitting" global models. The term "eddy permitting" implies that the models' horizontal resolution (typically 25km) allows mesoscale eddies (characteristically of diameter 100-200km) to be represented but not fully resolved. Many other groups have models covering entire ocean basins. All these activities contribute to the development of improved ocean models for climate research.

In climate prediction, coupled ocean-atmosphere models are being used, but the resolution of the ocean component so far is very coarse and many features of the resulting representation of the ocean are far from realistic. Progress is dependent on:

- (I) computers large and fast enough to explore the incorporation of "eddy permitting" ocean components in coupled ocean-atmosphere models;
- (ii) developing model formulations that allow the processes of ventilation and water mass modification at high latitudes to be better described;
- (iii) better representation of bottom topography so that abyssal flows, and in particular exchanges between ocean basins, can be improved;
- (iv) reduction of climate drift, systematic errors and the use of large flux-correction terms in coupled models;
- (v) improved data sets for model initialization.

## 2.5 Recent WOCE Findings

A fully comprehensive view of the overall success and scientific legacy of WOCE will only emerge as the AIMS phase advances. Nevertheless, several important results stemming from WOCE research have been reported recently. Notably, extensive tracer measurements (tritium/helium and CFCs) collected during WOCE sections are offering novel insights into the circulation rates and paths of water masses, as well as into the process of thermocline ventilation. The abundance and accuracy of drifter and float data are providing a new description of the ocean circulation at the surface and at 1000m, particularly in remote regions rarely surveyed by ships, and the coverage of ALACE data in the Pacific is now becoming sufficient to permit a comprehensive velocity field to be mapped. The development of measurement techniques using Acoustic Doppler Current Profilers (shipborne, lowered or moored, benefitting also from improved position and heading information made possible by exploiting the GPS) is giving the basis for a refined view of the relationship between directly measured currents and those computed from geostrophy. WOCE data are also being increasingly exploited for diagnostic studies. WOCE measures of temperature and salinity have shown substantial changes since previous surveys in the 1960s and 1980s, providing a perspective on the spatial structure of decadal climate changes in the ocean. It was noted at the sixteenth session of the JSC that heat and fresh water fluxes from oceanic sections were inconsistent with other air-sea exchange computations (either based on observations or inferred from models). In the past year, global flux estimates have been obtained using pre-WOCE data. The results continue to indicate the need for a reappraisal of air-sea exchange fields based on in-ocean measurements and on determinations from ships, buoys and satellites. In this respect, observations collected during WOCE will be superior to those pre-WOCE by virtue of the mass flux estimates based on direct current measurements.

Regarding ocean model development, intercomparisons with data (particularly measurements) are showing the rapidly increasing realism of models, but are also highlighting features where further refinements are needed. The strengths and weaknesses of model formulations with, on one hand, depth as a vertical co-ordinate, and, on the other hand, density are also being revealed.

## 2.6 WOCE Organizational Aspects

The third session of the Intergovernmental WOCE Panel took place in June 1995. The view was expressed that the scope of the panel's work should be broadened to consider issues relevant to the ocean components of WCRP programmes (WOCE, CLIVAR, ACSYS) since there were many questions in common. (This would require an appropriate reconstitution of the panel). The Director of the WCRP will take up discussion of this matter with IOC.

In respect of the functioning of the revised WOCE committee structure put in place in 1995 to reflect the changing emphasis in WOCE to modelling and data analysis, it was noted that the Synthesis and Modelling Working Group had a heavy burden in elaborating the detailed plans required, and was therefore not able to review wider WOCE science issues as had been originally expected. Consequently, it was now thought necessary to identify new members to reinforce the strength and breadth of the WOCE Scientific Steering Group (reversing the slimming down of the group agreed at the sixteenth session of the JSC). For the future, WOCE will look to CLIVAR to carry forward several of the key observational systems initiated by WOCE and to build up a picture of ocean variability on decadal and longer timescales. A WOCE/CLIVAR liaison group has been established which will oversee WOCE input to the CLIVAR implementation plan.

The WOCE International Project Office has moved to premises within the new UK Southampton Oceanography Centre. The quarterly WOCE International Newsletter, edited and compiled by the project office, now has a circulation of about 1000 with very complimentary feedback being received. An on-line bibliography of over 1400 references is maintained.

During the AIMS phase, WOCE will need to make known its achievements through a range of meetings and publications. Since the WOCE observational component generally proceeded on a basin-by-basin basis (with data sets for some basins already nearing completion), specific basin workshops will be arranged. Observationalists and modellers will, in the perspective of the overall synthesis of WOCE data, examine not just individual sections and data sets, but how they relate to one another, what they reveal about the outstanding scientific problems, and how model results compare with data. The first workshop on the Pacific Ocean was held in August 1996, to be followed by South Atlantic and Southern Ocean workshops in 1997, Indian Ocean and North Atlantic in respectively 1998 and 1999. To mark the completion of WOCE observations in 1997, a major conference is being planned in 1998 in Canada, bringing together those who have contributed to WOCE and the many others interested in the results. The conference would consider the major challenges to be addressed before the final conclusion of WOCE in 2002.

### **3. CLIMATE VARIABILITY AND PREDICTABILITY (CLIVAR)**

#### **3.1 CLIVAR Scientific Planning**

The CLIVAR Science Plan was published in August 1995 (WCRP-89, WMO/TD-No. 690), the culmination of almost two years of drafting, redrafting, reviews, and revisions by the international scientific community. The major programme elements of CLIVAR are CLIVAR-GOALS aiming to determine the variability and predictability of the Global Ocean Atmosphere Land System on seasonal-to-interannual times-scales (building on the successes of TOGA), CLIVAR-DecCen aiming to determine the mechanisms of variability and predictability of climate fluctuations on decadal-to-centennial time scales with special emphasis on the role of the oceans in the global coupled climate system, and CLIVAR-ACC examining Anthropogenic Climate Change.

The science plan has generated widespread interest and almost 4000 copies have been distributed. It is gratifying that there appears to have been relatively little post-publication criticism of the document, perhaps because it was so widely aired prior to preparation of the final version. Following in the footsteps of TOGA and WOCE, CLIVAR is becoming a focal point for research planning in many countries.

Attention is now being given to fostering the activities required at an international level for the implementation of CLIVAR. Overall, planning for CLIVAR-GOALS is at the most advanced stage, with several national programmes (most notably the USA) being organized around the GOALS concept. Also, the implementation of GOALS can build on the structures developed in TOGA. Following TOGA, a series of review papers summarizing TOGA achievements and highlighting issues for the future is being prepared and should provide additional foci for GOALS. Another development of particular relevance to GOALS is the launching of the International Research Institute by the International Forum on forecasting El Niño held in November 1995. The International Research Institute is expected to constitute an important multi-national contribution to CLIVAR,

in particular GOALS. In respect to the important monsoon component of GOALS, which has the objective of understanding the large-scale structure of the monsoon and its relationship to global climate, various modelling activities are being promoted and an observational and diagnostic strategy is being planned.

The DecCen component of CLIVAR requires further basic scientific discussion to develop specific implementation thrusts. Two themes have been given priority, namely large-scale atmosphere-ocean mechanisms playing a part in climate variability on decadal to centennial timescales, and the identification and observation of ocean climate variability; two workshops are being planned to gather input on these topics. A workshop is being organized in Vancouver, Canada (September 1996) to look at the mechanisms forcing decadal to centennial climate variations, and in particular their induction by large-scale atmosphere ocean interactions. The predictability of climate on these time-scales depends on the precise nature of these interactions. Various possibilities are random variability in the atmosphere inducing low frequency variability in the ocean (the null hypothesis), coupled atmosphere-ocean modes of very low frequency, and feedback between the ocean-atmosphere and ice. The workshop will review these and other possible mechanisms and consider the observational and modelling programme needed to investigate the situation more thoroughly. A second workshop will be held in Villefranche-sur-Mer, France, October 1996, focusing on the nature and role of physical oceanographic processes contributing to climate variability on decadal to centennial timescales, and aiming to formulate the ocean programme required to support CLIVAR-DecCen. Topics to be considered will include the role of the ocean in governing the global climate system, key ocean regions in climate, the long-term measurements needed to observe climate-related ocean variability, ocean process studies required, and modelling investigations. This workshop will also be sponsored by EUROCLIVAR.

The initial development of CLIVAR-ACC will be based on experimentation with and results from global coupled ocean-atmosphere models. Particular attention will be given to numerical experimentation/data analysis required for refining the detection and attribution of anthropogenic climate change.

Above all in the implementation of CLIVAR, despite the differences in emphasis of the three major programme elements, mutually supportive and cross-cutting projects will be constructed wherever possible. Any single activity is likely to contribute to more than one of the programme components, since these are closely related and dealing with different aspects of an interconnected global climate system with no clear break in the spectrum of climate variability between seasonal-to-annual and decadal timescales. Thus as CLIVAR develops, the distinction between the programme elements defined initially may be expected to fade, and the implementation of CLIVAR will increasingly be centred round cross-cutting observing, analysis and modelling projects. Already, numerical experimentation and ocean observations and studies are recognized as central cross-cutting themes in CLIVAR.

### **3.2 Numerical Experimentation Activities in Support of CLIVAR**

Two CLIVAR Numerical Experimentation Groups have been formed, the first (NEG-1) in support of CLIVAR-GOALS, the second (NEG-2) in support of CLIVAR-DecCen and CLIVAR-ACC. The models used in studying climate variability at different timescales are becoming increasingly similar, but there is nevertheless at present a fundamental difference in the work of the two groups in that CLIVAR NEG-1 is essentially dealing with the question of prediction and predictability, CLIVAR NEG-2 with long-term climate simulations, the response of the climate system to anthropogenic forcing and the representation of long-term climate variability. The continued development of atmospheric component of the coupled models of varying types employed on CLIVAR is naturally also of basic concern. CLIVAR therefore follows closely the activities related to atmospheric climate modelling undertaken by WGNE. In particular, the reanalysis projects are of fundamental interest to all three CLIVAR programme elements, and CLIVAR will participate fully in the WCRP conference on reanalysis being organized in 1997.

CLIVAR NEG-1 is undertaking several studies that will underpin the implementation of many important aspects of CLIVAR as well as carrying forward the activities of its predecessor groups, the TOGA Numerical Experimentation Group and the joint WGNE/TOGA Monsoon Numerical Experimentation Group, including

intercomparison of ENSO simulations in coupled models, assessment of dynamical predictability at seasonal timescales, simulation of monsoon variability and predictability, initializations and analyses for climate forecasts, and intercomparison of ocean models forced by wind stress products from reanalyses.

In addition to considering questions related to the detection and attribution of climatic change, CLIVAR NEG-2 agreed to extend and build on initiatives undertaken by its predecessor, the Steering Group on Global Climate Modelling, in particular the intercomparison of the control climates of coupled models. CLIVAR NEG-2 also recognized the importance of co-ordination of planning large climate change numerical experimentation projects with IPCC. Furthermore, it would be timely to give special attention to the development of the ocean component of coupled models now that WOCE was moving into its analysis and synthesis phase. The foci of initial CLIVAR NEG-2 efforts can be grouped under the following headings: intercomparison of coupled models, standardized forcing scenarios, refinement of the ocean component of climate models, idealized sensitivity experiments, detection of climate change, and development of comprehensive models of the full climate system.

### 3.3 CLIVAR Upper Ocean Panel

The primary objective of the CLIVAR Upper Ocean Panel is to consider the implementation strategy for a sustained measurement programme in the upper ocean in support of CLIVAR predictability studies, monitoring and basic research. The responsibility of the panel extends well beyond the upper (tropical) ocean observational requirements for GOALS- or ENSO-type prediction and includes measurements around the globe needed to identify and understand other predictable components of the climate system. In particular, consideration will be given to obtaining global observations of redistribution of heat and mass in the upper ocean required for studying variations on decadal and longer timescales.

The first major task is the evaluation of the effectiveness of existing observing systems and to develop the means to assess the appropriate mix of measurement and observing systems that would provide the full suite of upper ocean variables required for CLIVAR. Special attention will be paid to the possibilities offered by new technologies. Other national and international activities are also concerned with planning upper ocean observing systems, and there will be close co-ordination with these activities. An excellent starting point for the work of the CLIVAR Upper Ocean Panel is in fact provided by the report of the Ocean Observing System Development Panel, although the scope of this document is considerably wider than CLIVAR requirements. Based on this and other input, the following near-term activities will be undertaken:

- (i) Improvement of sea surface temperature information by instituting refined quality control of voluntary observing ship measurements and assessing the impact of ATSR for reducing large-scale biases and extending coverage;
- (ii) Review of sampling strategy for salinity measurements, based on guidance from the WOCE Synthesis and Modelling Working Group on the specific areas where information is critical in monitoring deep and intermediate water mass formation and stability changes;
- (iii) Assessment of the impact of various tropical wind stress products in climate prediction systems (in conjunction with CLIVAR NEG-1);
- (iv) In collaboration with CLIVAR NEG-1, use of sets of ocean-atmosphere fluxes (as inferred from operational meteorological analyses and from satellites) to estimate flux divergence in the ocean and for modelling seasonal and interannual variability;
- (v) Initializations and analyses for climate forecasts: as well as studies of the optimal blend of observing systems to provide analyzed initial states for model predictions and verification, the possibility of extending a baseline observing system (in situ surface winds and upper ocean thermal data) to the global tropics will be examined;
- (vi) Formulation of proposals for maintaining specific global upper ocean observing systems implemented under TOGA and WOCE for monitoring decadal variability worldwide (taking into account the results of several meetings in the coming months, including the CLIVAR Large-Scale Air-Sea Interaction workshop, and the workshop on the CLIVAR Ocean Programme in support of DecCen). The Upper Ocean Panel has already emphasized the importance of sustaining a level of upper ocean thermal

sampling in the North Pacific equivalent to that achieved in the last twenty years under TRANSPAC and related programmes and, in particular, continuing long-time series lines in preference to starting new lines or extending those with shorter histories.

A series of workshops is being planned in support of these activities; the first to be held in conjunction with the second session of the Panel, 21-24 October 1996. Consideration will also be given to the promotion of technology development where needed, proposing indices and integrating measurements to monitor important climate signals in the upper ocean and validation studies for satellite-derived measurements, as well as reviewing efforts by individual scientists or small groups that would contribute to a global CLIVAR observing system. The appropriate liaison will be established with the joint GCOS/GOOS/WCRP Ocean Observing Panel for Climate (OOOPC).

### **3.4 Palaeoclimatology**

Proxy records of climate variability provide the only means of reconstructing past climate histories beyond the range of instrumental records and are therefore of potentially great value for model validation. Much work is needed to retrieve and interpret palaeoclimatic records in ways that would be useful for CLIVAR studies.

A joint workshop with the IGBP Core Project on Past Global Changes (PAGES) (Venice, Italy, December 1994) identified many areas of potential collaboration and it was proposed that a joint PAGES/CLIVAR Working Group be formed to formulate and promote a programme of palaeoclimatic reconstruction which would provide long-term records of palaeodata of direct relevance to both programmes. Particular emphasis would be placed on collecting, analysing and interpreting the data in such a way as to reveal evidence of the patterns of global climate variability on the time scales of interest to CLIVAR. Membership of the working group would include experts in various palaeodata fields, such as ice cores, tree rings, corals and deep sea sediments as well as strong representation from the climate modelling community.

### **3.5 Asian-Australian Monsoon**

A CLIVAR Workshop on Asian-Australian Monsoon Meteorology and Oceanography (Melbourne, Australia, April 1995) affirmed its belief in the hypothesis that Asian-Australian monsoons are predictable. In order to assess the limits of monsoon predictability, to foster model development, and to provide the necessary observations to carry out actual predictions, the workshop proposed:

- a series of process studies aimed at improving and validating model parameterizations and simulations of key processes;
- diagnostic and modelling research to assess whether useful predictability for Asian-Australian monsoons is attainable;
- long-term observations of key ocean, atmosphere and land variables for diagnostic and hindcast studies of predictability, and for initialization and verification of predictions.

It was especially recommended that the relationship between the interannual variability of monsoonal circulations and the tropical biennial oscillation, the phase of ENSO, and decadal time-scale variability be investigated. It was noted that critical gaps existed in the present observational system in the Indian Ocean and adjacent land areas.

As noted, CLIVAR NEG-1 is taking up the issue of model simulation of monsoon variability and predictability. Additionally, a CLIVAR Monsoon Panel has been established with the overall responsibility of developing a strategy to investigate climate variability and predictability of the coupled ocean-atmosphere-land system in the Asian-Australian-African region. The panel should also consider the monitoring needed for the Indian Ocean, Western Pacific and surrounding marginal seas and land regions to examine the structure and variability of the monsoon, and process studies that might be required. The Monsoon Panel would promote the interactions between meteorologists, oceanographers and hydrologists from interested nations necessary for comprehensive monsoon studies, and establish co-operation with other relevant existing and planned regional and



multi-national programmes. Special efforts will be devoted to considering the role of the ocean in the monsoon cycle and whether experiments to explore the sensitivity of the Asian-Australian monsoon to conditions in different ocean basins and the relationship between Indonesian throughflow, ENSO and monsoon variability are needed. The development of research thrusts in these areas by CLIVAR would be a natural complement to the land-atmosphere interactions being emphasized in the GEWEX Asian Monsoon Experiment (GAME).

### **3.6 Implementation Issues**

#### *Preparation of implementation plan*

The principal task of the CLIVAR Scientific Steering Group and the International CLIVAR Project Office is now in the preparation of a comprehensive initial CLIVAR implementation plan and to move CLIVAR forward from the planning to implementations stage. This plan will build on the various CLIVAR planning workshops and meetings which have already been held or were being arranged for later in 1996. The plan will draw extensively on the TOGA review papers and the results of the final TOGA conference. WOCE input will be obtained through the WOCE/CLIVAR liaison group (see section 8.6) and full account will be taken of the conclusions of the IPCC Second Assessment Report. Programme activities and requirements for the Antarctic will be considered in conjunction with ACSYS and by establishing the appropriate links and liaison with SCAR.

The implementation plan is evidently a document that will steadily evolve and updates will be issued as needed as ideas for taking the full range of CLIVAR scientific questions are further elaborated. A first draft of a CLIVAR implementation plan should be produced for review at the eighteenth session of the JSC in March 1997.

#### *International CLIVAR conference*

The CLIVAR Scientific Steering Group proposed that the initial implementation plan should be presented as an international (intergovernmental) CLIVAR scientific and implementation conference in the first half of 1998. The conference would be intended to garner national commitments for the implementation of CLIVAR.

#### *WOCE/CLIVAR transition*

The old TOGA/WOCE programme planning committees first evolved into CLIVAR/WOCE committees and are now being reconstituted to reflect the reorganization of WOCE and the establishment of GCOS and GOOS. Moreover, the TOGA/WOCE data assembly and analysis infrastructure is being reassessed, taking into account CLIVAR, GCOS and GOOS data management plans. CLIVAR is working actively with WOCE to encourage nations who are currently funding TOGA and WOCE data centres to continue to support these activities. The WOCE/CLIVAR liaison group has developed a list of long-term ocean observations which should be continued under CLIVAR (which will be fully considered in the preparation of the CLIVAR implementation plan).

#### *CLIVAR/GCOS/GOOS liaison*

The steps towards CLIVAR implementation are taking place at the same time as similar stages of planning and implementation of GCOS and GOOS. It is CLIVAR's intention that as much as possible of its activity should take advantage of GCOS/GOOS structures. CLIVAR bodies will only be established after ensuring that they would not duplicate GCOS/GOOS bodies (e.g., the CLIVAR Upper Ocean Panel has a very different role from the Ocean Observing Panel for Climate). The TAO implementation panel has been constituted as a joint CLIVAR/GCOS activity.

### **3.7 The International CLIVAR Project Office**

The International CLIVAR Project Office began functioning in July 1995 under the Directorship of Dr. M. Coughlan. The Office has already taken a number of steps to increase awareness of CLIVAR in the scientific community and to stimulate interest in the programme. These included the initiation of an International CLIVAR Project Office report series and establishment of a CLIVAR home page (<http://www.dkrz.de/clivar/hp.html>) containing current information on CLIVAR panels, working groups, summaries of workshop and meeting results, research opportunities, and a calendar of CLIVAR-related meetings. Three editions of a newsletter "Exchanges" has been completed and distributed to nearly 4000 people on the CLIVAR mailing list.

## **4. ARCTIC CLIMATE SYSTEM STUDY (ACSYS)**

### **4.1 Progress in Arctic Studies**

Interesting new data have been collected in ACSYS, revealing a notable warm anomaly in the Arctic Ocean with increases of temperature as much as 10C at various depths. Arctic Ocean dynamics are turning out to be considerably more complex than anticipated and marked shifts in the Beaufort Sea gyre have been detected on seasonal and longer time scales.

### **4.2 Ice draft**

Fifteen upward-looking sonars (ULS) are now operational in the Arctic Ocean. The four-year (1990-1994) monthly mean ice draft series from the Fram Strait show a non-systematic seasonal cycle of ice draft with an average month-to-month variation of 0.7 m. The average minimum of ice draft is in September (1.77 m) and the maximum in July (2.75 m). The ice volume exported through the Fram Strait has been estimated to be about  $2.6 \times 10^3$  km<sup>3</sup> per year. This amount may be interpreted as the mean annual net production of Arctic Ocean sea ice. The ice flux estimation in the strait is used as an effective constraint on model simulations of Arctic climate.

### **4.3 Modelling**

An ACSYS sea-ice/ocean modelling workshop took place in September 1995 at the Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany. The workshop reviewed the status of sea-ice modelling at the main modelling centres and concluded that only 5 out of 20 global climate models used realistic sea-ice models. Most sea-ice modules in coupled models are too sensitive to atmospheric temperature change due to CO<sub>2</sub> increase and they do not realistically represent the oceanic surface buoyancy fluxes. As dynamic-thermodynamic sea-ice models show less high latitude warming than pure thermodynamic models and also provide more realistic fresh water/salt fluxes associated with the ice motion, the "optimal" dynamic-thermodynamic sea-ice model needs to be developed for coupled climate models using the validation data sets from ACSYS.

### **4.4 Workshops**

A WCRP workshop on sea-ice thickness measurements and data analysis combined with the fourth session of the ACSYS sea-ice/ocean modelling panel is planned to be held from 7-11 April 1997 at Monterey, California, USA. The workshop will:

- (i) summarize the present observationally-based understanding of ice thickness in both polar regions;
- (ii) identify outstanding scientific questions regarding ice thickness;
- (iii) review the role of ULS and submarine ice draft data;
- (iv) develop an ice thickness monitoring strategy for 1998-2003; and
- (v) recommend special purpose observational programmes.

An ACSYS solid precipitation climatology project workshop was held in September 1995 in Reston, Virginia, USA, to consider an optimal strategy for estimating precipitation and run-off of fresh water to the Arctic Ocean. The principal conclusions of the workshop were:

- (i) correction for gauge biases developed by national agencies and WMO need to be evaluated to establish a procedure to provide consistent Arctic-wide precipitation data at the Global Precipitation Climatology Centre, Offenbach-am-Main, Germany;
- (ii) algorithms for the estimation of snow/water equivalent from passive microwave data require regional/seasonal corrections and uncertainty estimates should also be added;
- (iii) hydrometric stations provide reliable data for about 75% of the mean fresh water inflow to the Arctic Ocean, the remaining fraction needs to be estimated.

An ACSYS/IASC/EPB workshop on Arctic regional climate models will be organized on 4-6 November

1996 at the Hadley Centre, Bracknell, UK.

#### 4.5 Antarctic Projects

##### *Sea-ice thickness measurements*

ACSYS is also engaged in monitoring sea-ice thickness and motion in the Antarctic and the modelling of Antarctic sea ice and ice-ocean interaction in the Antarctic Sea-ice Zone (ANSIZ). Unique sea-ice draft data collected under a WCRP Antarctic Ice Thickness Project in seven different locations in the ANSIZ are now available to the international science community for four different periods (1990-1992; 1992-1993; 1993-1994; 1994-1995). Nine ULS systems continue sea-ice draft measurements in the ANSIZ.

##### *Drifting buoy observations*

A WCRP International Programme for Antarctic Buoys (IPAB) was launched in 1994. It builds upon co-operation among agencies and institutions in different countries with Antarctic interests. Some 15 organizations from 8 countries participate in the implementation of the IPAB. The IPAB aims to have sufficient buoy deployments to achieve and maintain a network of drifting platforms with observational points spaced at about 500 km over the ANSIZ. Position, air pressure and (for those buoys which are in water) sea-surface temperature are collected under the IPAB as basic data. Some drifting buoy systems are equipped to additionally measure other parameters such as air temperature, ice and/or snow temperature, wind speed and direction, snow and sea-ice properties and oceanographic variables. Drifting platforms are located and data are collected via CLS Service Argos. A uniform, quality-controlled data base for ice motion and surface meteorology and oceanography, as required by the Antarctic research community, has been established at the Antarctic Co-operative Research Centre (Hobart, Australia), where a co-ordinating office of the IPAB is situated.

Nearly 20 buoys contributed data to the IPAB during 1995. Buoy losses in the Antarctic are high since most ice buoys used so far do not survive in open water for a very long time. Since there is a generally northward divergent component to the pack-ice drift in the Antarctic, many buoys deployed at high southern latitudes eventually move north of the ice edge and out of the main region of IPAB interest.

##### *Plans For Future*

The need for internationally co-ordinated Antarctic climate research is now under discussion within WCRP. It is anticipated that ACSYS/CLIVAR workshops will be organized in the course of the next two years in order to develop proposals for an internationally co-ordinated study of the Antarctic climate system. WCRP will establish (via ACSYS and CLIVAR) appropriate connections with SCAR GLOCHANT (in particular ASPECT) and iAnZone.

Joint ACSYS/CLIVAR projects for studying of high latitude-global climate variability and interaction will be the subject of discussion at upcoming CLIVAR workshops (see section on CLIVAR) and at the next ACSYS SSG meeting (October 1996).

Co-ordinated planning for climate research in the Antarctic amongst the many groups already involved would seem highly desirable. Should iAnZone be accepted by SCOR-XXIII as a SCOR affiliated programme (agenda item 2.5.4), a joint SCOR/SCAR/WCRP study of the Antarctic climate system may become feasible.

## 5. GENERAL ISSUES

### 5.1 Air-sea Fluxes

The question of determining global fields of ocean-atmosphere fluxes is one that cuts across all components of the WCRP. The JSC at its fourteenth session in March 1993 therefore asked a few leading experts to undertake appropriate interdisciplinary consultations in this area and, in particular, to organize periodic workshops or symposia bringing together representatives of interested scientific groups. The objective would be to review estimates of fluxes inferred by various means (i.e. from operational meteorological analyses, climate simulations, observations) and to characterize perceived deficiencies in data sets. Such a workshop was held in

October 1995 at ECMWF, Reading and nearly 50 scientists from various interested communities (atmospheric and ocean modellers, experts in relevant in situ atmospheric and oceanographic measurements as well as in remotely-sensed data) participated. Topics covered included: the needs of ocean models for adequate surface forcing fields; estimates of fluxes from different observational sources (remotely-sensed data, ocean surface (buoy) observations, ship measurements, from specialised data sets e.g. the Comprehensive Ocean Atmosphere Data Sets (COADS), from field programmes such as TOGA-COARE); model-derived flux fields (in particular from operational meteorological analyses and reanalysis projects); use of atmospheric and ocean energy/moisture budgets as a constraint on surface fluxes; and verification of fluxes using wave and ocean models. The full report of the workshop, including copies of extended abstracts and the detailed conclusions, is being published in the WCRP report series (WCRP-95, in press). Appendix I to this report contains a summary of the principal findings and recommendations of the workshop.

The JSC at its seventeenth session in March 1996, noted that the workshop had strikingly illustrated the different approach and interests of different elements of the scientific community in questions relating to air-sea fluxes and their use and application. Nevertheless, the workshop had been important in encouraging the interaction and dialogue between the data assimilation community, atmospheric and oceanic modellers, oceanographers, and satellite meteorologists on the subject of air-sea fluxes which had hitherto been limited.

The JSC considered that inter-disciplinary consultations in this area should be fostered, and therefore agreed to set up, as recommended by the workshop, a limited-life task group to carry forward the needed activities. It was reiterated that the determination of global fields of air-sea fluxes was one that was important for many components of the WCRP. The task group would therefore report to the JSC and not be linked directly to a specific WCRP component. The principal responsibility of the task group, as well as developing inter-disciplinary action and dialogue, would be to catalogue and evaluate available flux-related data sets on the lines described above. The terms of reference suggested for the task group were as follows:

- (i) To review requirements of different scientific disciplines for air-sea flux data sets;
- (ii) To compile a catalogue of available surface flux and flux-related data sets, including those becoming available from the various reanalysis projects, and to review, in consultation with users and producers, the strengths and weaknesses of these data sets;
- (iii) To inform the scientific community of the final catalogue, and by convening, at a suitable time, a scientific workshop;
- (vi) To keep the JSC informed of progress in this area and present recommendations for action to the JSC if necessary.

The following membership was proposed:

It was agreed that Dr. P.K. Taylor (Southampton Oceanography Centre, U.K.) should be invited to lead the task group. The membership of the groups would be completed by experts in the areas of flux-field data sets (e.g., COADS), model-derived fluxes, and relevant observations techniques and remote-sensing methods. A member with responsibility to fluxes over ice-covered seas would also be included (with appropriate advice also being sought from ACSYS on how to approach this issue).

The task group should take advantage of relevant activities (e.g., an intercomparison of flux data sets at PCMDI). The JSC noted that WGNE was planning a co-ordinated intercomparison of air-sea fluxes from the reanalysis projects, and would probably be able to assist in an intercomparison of atmospheric boundary layer parameterizations using the single-column model approach now being explored. The JSC looked forward to a further workshop on this subject, with, if possible, a wider participation than achieved at the workshop at ECMWF in October 1995 where several scientific groups and countries with a known interest in this subject had not been represented. It was noted that NCEP has expressed its willingness to host such a workshop in Washington, DC, probably in the second half of 1998.

Since JSC-XVII, a proposal has been submitted to SCOR to establish a similar group on air-sea fluxes. Discussions are currently underway about the merits of co-sponsoring such a group.

### 5.2 Overall Co-ordination of the World Climate Programme (WCP)

The Intergovernmental Meeting on the WCP in Geneva in 1993 recommended that an integrated plan for the whole WCP and related activities including IGBP, IHDP, the Global Climate/Ocean/Terrestrial Observing Systems (GCOS, GOOS, GTOS) and the Intergovernmental Panel on Climate Change (IPCC) should be prepared for presentation to governments.

The integrated plan, titled "The Climate Agenda: A Proposal for an Integrating Framework for International Climate-related Programmes", has been completed. The plan proposes that activities should be developed along four main thrusts:

- new frontiers in climate science and prediction;
- climate services for sustainable development;
- studies of climate impact assessments and response strategies to reduce vulnerabilities;
- dedicated observations of the climate system.

With respect to the overall implementation mechanism for the proposal, the plan recommends that an "Interagency Committee on the Climate Agenda" (IACCA) should assume a truly inter-organizational co-ordinating function and be formally constituted through a joint decision of the international organizations carrying out major climate-related programmes. The Climate Agenda has been endorsed in principle by WMO Congress, the Governing Council of UNEP, the General Committee of ICSU, and the IOC Assembly, and would be considered by the FAO Council in October 1996.

### 5.3 WCRP "Mid-term" Scientific Conference

An important recommendation contained in the scientific review and assessment of the WCRP undertaken by ICSU in 1994 was to organize a "mid-term" scientific conference to consider WCRP priorities in the light of the 1995 IPCC Second Assessment Report and taking into account the changing interests of policy-makers and governments in the issue of climate change. At its sixteenth session, the JSC had accepted this recommendation and proposed that the conference be held in 1997.

The conference is being organized to attract the attention of managers of national climate/global change research programmes, key senior scientists and government scientific advisers, senior government administrators, and "policy-makers". Reviews will be given of WCRP accomplishments, the challenges lying ahead, and the prospects offered by continuing progress in the programme. A number of invited lecturers, including representatives of the sponsoring agencies, IPCC, IGBP, GCOS, etc., and of developing countries will be asked to summarise their expectations of the WCRP, and the priority issues to be taken up. The conference should also agree on a statement setting out the main themes, priorities and objectives for the WCRP for the next ten to fifteen years. The conference will be held in Geneva the week of 25 to 29 August 1997. The organizing committee is being led by Dr. J.P. Bruce (Canada).

## APPENDIX I

**Summary: WCRP Workshop on Air-Sea Flux Fields for Forcing Ocean Models and Validating GCMs (Reading, UK, October 1995)**

### Status of Flux Estimates

The workshop reviewed the overall status of flux estimates. It is difficult to identify which are the "best" surface fluxes since it is not known what the true values of the fields are. Basic knowledge is limited by lack of high quality observations over much of the earth, and inherently since the fluxes themselves are not directly observed but derived from observed variables using various parameterizations. Estimation of surface radiative

fluxes is particularly hampered by the uncertainties in the distribution and optical properties of clouds, especially at low levels, and by inaccuracies in measurements of atmospheric humidity. The estimates of surface fluxes from different sources each have their own strengths and weaknesses, and the choice of which to use may depend on the application (i.e. whether for global or regional purposes and the timescale). Fluxes derived from ship observations have the longest temporal record, but observations are sparse over most of the oceans outside northern hemisphere mid-latitudes and are subject to certain biases. Fluxes inferred from remotely-sensed data have the advantage of providing global coverage, but elaborate (sometimes highly empiricized) parameterizations are needed to deduce fluxes from the radiances actually observed by satellites. Fluxes obtained as a by-product of atmospheric analyses also cover the complete globe and benefit from consistent and controlled assimilation of several different types of observations. The realism of these flux fields has increased significantly in the last few years, but the scarcity of surface observations over many ocean areas often results in discrepancies between flux estimates from different assimilation systems in these regions. The fluxes are also highly dependent on the physical parameterizations employed in the assimilation model, and are very much subject to model changes whose effects can be larger than interannual variability. Fluxes from reanalyses will at least not suffer from this problem. The most accurate estimates of air-sea fluxes are probably produced in certain field experiments, but usually measurements are only available at a few specific points for limited periods in time. The differences in time and space scales between point observations and values from analyses or as inferred from satellite measurements can seriously complicate comparisons.

The need for satisfactory surface flux information, especially the surface stress or momentum flux, to drive ocean models was repeatedly emphasized. Although independent surface flux estimates are not required in the integration of a coupled model, comparison with values diagnosed from the integration is important in assessing errors in the whole system and in the separate component models. The horizontal resolution needed for global climatologically averaged fields appeared to be about  $1^\circ \times 1^\circ$  for most applications. When used in forcing models, the time resolution of fields required is not yet clear. With monthly forcing, the seasonal cycle is included, with daily the effects of synoptic weather systems, and with hourly the diurnal cycle. For ocean models, use of high frequency forcing (daily or higher) appears to produce a significant impact. It may be noted that a comparable uncertainty exists in how frequently atmosphere and ocean should interact in coupled models.

#### **Catalogue and Evaluation of Flux Estimates**

One of the principal recommendations to emerge from the workshop was that the range of all available flux estimates and near surface ocean observations from 1979 to the present should be catalogued and carefully evaluated. As well as indicating the accessibility of the data sets, strengths and weaknesses should be identified, especially in regard to their use in ocean modelling applications. Particular data sets could be recommended as "state-of-the-art" and the developments of "a best current estimate" of near-surface variables and surface fluxes for use in ocean and coupled models should be encouraged. Since 1979, several different independent data sets of individual parameters and fluxes are available including COADS, observations from specific field experiments such as TOGA-COARE and SEMAPHORE, WOCE research vessel data, VSOP-NA, remotely-sensed data, and fluxes from the various reanalysis projects (which would not be subject to changes in data assimilation systems). The variety of these data sets, especially over the North Atlantic, offers the possibility of new insights. For instance, heat fluxes calculated from WOCE cross-sections can be used in evaluating meridional heat transports inferred from the net surface heat fluxes from the reanalyses, COADS or other sources. These types of approach should give firmer indications of the reliability of the different flux climatologies and may suggest the means for an optimal merging of in situ measurements, satellite observations and reanalysed fields. Moreover, using WOCE oceanographic data in conjunction with the various meteorological data sets offers the opportunity for CAGE-type studies at least in certain regions of the North Atlantic. Overall, the intercomparison of flux estimates is expected to reveal the main regions of uncertainty, which might then be targeted in future field studies as well as suggesting what additional variables need to be measured in field experiments and to what accuracy.

#### **Observing System Aspects**

With respect to observing systems, the workshop pointed out the need to optimize the mix of satellite data, in situ measurements and fields obtained from models. For the first of these categories, multi-frequency (visible, infrared

and microwave) multi-satellite coverage (to ensure adequate sampling) employing sounders, imagers and active sensors would be required. With regard to ship observations, efforts to improve inferred flux estimates should be continued by attempting to reduce measurement biases further. Such work is under way at the Southampton Oceanography Centre. Information on corrections to ship observations may also be useful in data assimilation quality control. In situ observations of various parameters in the atmospheric surface layer and upper ocean would be needed in key locations in addition to those provided by the voluntary observing fleet. Good examples are the data from the TOGA-TAO array, and from operational buoys (such as the NOAA directional wave buoy system along the coasts of the USA, in the Gulf of Alaska and the Gulf of Mexico). Efforts should be made to obtain similar observations in polar regions and marginal ice zones. It was also noted that measurement techniques (i.e. low cost automatic radar and acoustic systems) are now or soon will be available offering the possibility of routine sampling of the vertical structure of the marine atmosphere. This would advance the understanding of sub-grid scale processes within the entire boundary layer required to be better able to model and compute air-sea fluxes. Providing volunteer ships with ceilometers would enable quantitative information on cloud base height and the depth of the boundary layer to be obtained. Exploiting these parameters in data assimilation systems could lead to substantial improvements in the representation of stratus and stratocumulus clouds, potentially a key step in refining surface flux estimates.

#### **Intercomparisons of Flux Fields from Different Sources**

The workshop made a number of recommendations concerning specific intercomparisons of flux fields from different sources. Highest priority was attached to the comparison of surface fluxes from the various reanalysis projects with other estimates, in particular with the revised climatology of surface marine fluxes based on COADS prepared by da Silva et al. Comparisons with the satellite-based GEWEX Surface Radiation Budget data set (in which the surface shortwave radiation estimate is probably the best available) and with SSMI and scatterometer surface winds (not used in the reanalyses and hence an independent data set) as well as with *in situ* data from field experiments and the FSU tropical wind product should also be made. Moreover, it was recommended that the intercomparison and evaluation of fluxes from operational data assimilation systems, as undertaken by WGNE, should be continued, and extended to include near-surface meteorological variables such as humidity, temperature and winds. The need for operational centres to monitor the fluxes produced by their operational systems and to examine the effects on surface fluxes of changes in their systems was emphasized.

#### **Flux Parameterization Schemes**

Regarding the significant differences in flux estimates from various sources, the workshop saw that these were linked to differences in the source data (satellite, *in situ* or model), in the temporal or spatial scale of the estimate, and in the actual parameterizations employed in computing the fluxes. Basic research into certain air-sea flux questions was definitely needed such as changes in exchange coefficients in high and low wind situations, the role of spray, the role of the sea state and effects of waves. The apparent weakness of winds and stresses in the equatorial Pacific inferred from operational systems also needed to be investigated.

## ANNEX 12 - Acronyms and Abbreviations

ACC	Anthropogenic Climate Change
ACSYS	Arctic Climate System Study
ANTIME	Antarctic Ice Margin Evolution
AOSB	Arctic Ocean Science Board
ASI	Advanced Study Institute
ASPECT	Antarctic Sea Ice Processes, Ecosystems and Climate
ATOC	Acoustic Thermometry of Ocean Climate
BASS	Basin Scale Studies
CALCOFI	California Cooperative Fisheries Investigation
CCAMLR	Commission on the Conservation of Antarctic Marine Living Resources
CCC	Cod and Climate Change Program
CCCC	Climate Change and Carrying Capacity
CFC	Chlorofluorocarbon
CLIVAR	Climate Variability and Predictability
CMAS	Confédération des Activités Subaquatiques
COADS	Comprehensive Ocean-Atmosphere Data Set
DOVETAIL	Deep Ocean Ventilation Through Antarctic Intermediate Layers
EASIZ	Ecology of the Antarctic Sea Ice Zone
ECOR	Engineering Committee on Oceanic Resources
ERS	Earth Remote Sensing (satellite)
ESA	European Space Agency
GCOS	Global Climate Observing System
GEBCO	General Bathymetric Chart of the Ocean
GEWEX	Global Exchange of Water Experiment
GLOBEC	Global Ocean Ecosystem Dynamics
GLOCHANT	Global Change in Antarctica
GOEZS	Global Ocean Euphotic Zone Study
GOOS	Global Ocean Observing System
HNLC	High Nutrient - Low Chlorophyll
IABO	International Association of Biological Oceanography
IAMAS	International Association of Meteorology and Atmospheric Sciences
iAnZone	International Antarctic Zone
IAPSO	International Association for the Physical Sciences of the Ocean
ICES	International Council for the Exploration of the Sea
ICSOS	International Conference on Satellites, Oceanography and Society
ICSU	International Council of Scientific Unions
IGAC	International Global Atmospheric Chemistry program
IGBP	International Geosphere-Biosphere Program
IGFA	International Group of Funding Agencies for Global Change Research
IHO	International Hydrographic Organization
IMAGES	International Marine Aspects of Global Change program
IMO	International Maritime Organization
InterRidge	International RIDGE studies
IOC	Intergovernmental Oceanographic Commission
IPCC	Intergovernmental Panel on Climate Change
IRONEX	Iron Fertilization Experiment
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



IWCO	Independent World Commission on the Oceans
J-GOOS	Joint Scientific and Technical Committee for GOOS
JGOFS	Joint Global Ocean Flux Study
LOICZ	Land-Ocean Interactions in the Coastal Zone
NASA	National Aeronautic and Space Agency
NATO	North Atlantic Treaty Organization
OOSDP	Ocean Observation System Development Panel
PAGES	Past Global Changes
PICES	North Pacific Marine Sciences Organization
REX	Regional Experiments
RIDGE	Mid-Ocean Ridge Interdisciplinary Studies
SCAR	Scientific Committee on Antarctic Research
SCOPE	Scientific Committee on Problems of the Environment
SCOR	Scientific Committee on Oceanic Research
SOLAS	Surface Ocean - Lower Atmosphere Study
SOOP	Ship of Opportunity Program
SPACC	Small Pelagic Fishes and Climate Change
SSC	Scientific Steering Committee
TEMA	Training, Education and Mutual Assistance
TOGA	Tropical Ocean - Global Atmosphere
TOS	The Oceanography Society
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
URSI	Union Radio Scientifique Internationale
VOS	Voluntary Observing Ship
WCRP	World Climate Research Program
WG	Working Group
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment
WWW	World Wide Web