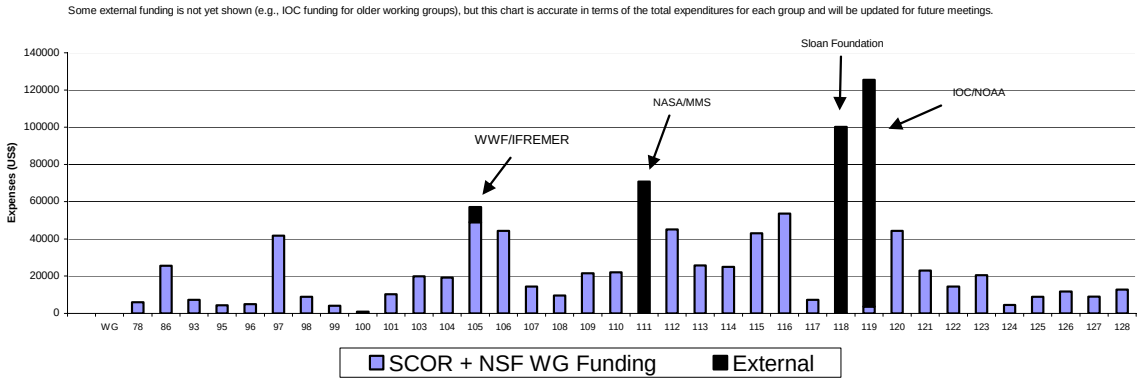
2.0 WORKING GROUPS REPORTS

Expenditures by SCOR Working Groups (1995-2006)



These figures only account for funds that were spent through SCOR. Several working groups, such as WGs 105, 109, and 119, had additional funding that was spent directly by cooperating organizations or funding agencies.

2.1 Disbanded Working Groups

2.1.1 WG 78--Photosynthetic Pigments in Oceanography

SCOR contributed funding for a scoping meeting for a Volume 2 of the SCOR book from WG 78, entitled *Phytoplankton Pigments in Oceanography*. The report of the scoping meeting follows. So far, promises of contributions have been made from the International Atomic Energy Agency (US$2000), the University of Quebec ($1000), and possibly the U.S. National Aeronautics and Space Administration.

REPORT of a WORKSHOP On a Follow-Up Volume of the Book

"PHYTOPLANKTON PIGMENTS IN OCEANOGRAPHY"

Held in MONACO

7-12 April 2006

Submitted to

SCOR – UNESCO

By

Suzanne Roy
Einar Skarstad Egeland
Geir Johnsen
Carole Llewellyn
Simon Wright

15 May 2006

I. PREAMBLE

In 1997 a comprehensive pigment monograph was published by UNESCO: "*Phytoplankton Pigments in Oceanography – guidelines to modern methods*" which resulted from the activities of SCOR Working Group 78. It was edited by Drs. S.W. Jeffrey, R.F.C. Mantoura and S.W. Wright, and contained details of classic and modern pigment techniques, preparation of pigment standards, extracting and storing pigments and comparisons of spectrophotometric, fluorometric and chromatographic techniques. A unique set of pigment data, useful for identifying 47 key phytoplankton pigments, was also included.

This book has been highly successful and is widely used as a reference across the many aspects of pigment applications. These applications are growing, particularly with regard to pigment remote sensing and to environmental monitoring. The ability to readily convert pigment concentrations into class abundance has widened application further. However, it is recognised by the user community that, since 1997, there have been many advances in the field both in terms of basic pigment chemistry and methodology but also in technical and field applications. These advances need to be brought together into a readily accessible volume. Following discussions with the editors of the 1997 volume and SCOR, a new supplementary volume on updates since 1997 was suggested. SCOR therefore funded a workshop in April 2006, in which experts from most scientific areas of phytoplankton pigments were brought together to discuss advances since 1997 and the structure and contents of a potential new volume. At the meeting, following the request of two former editors, Dr. Shirley Jeffrey and Dr Fauzi Mantoura, to withdraw from lead roles in the new volume because of other commitments, a team of new editors to take this new volume forward were discussed and chosen.

In this report, following the comments from the previous editors (Section III), the new editors summarise the workshop and present a proposed structure for the new volume resulting from the delegate discussions at the workshop. The new editorial panel is looking forward to the challenge of putting together a SCOR Phytoplankton Pigments in Oceanography Volume 2 that will meet the requirements of the user community. Pigment specialists that attended the workshop truly hope that SCOR will support this initiative, particularly after the great success of the first Volume and the clear need for an update.

We sincerely thank SCOR for its financial support of the meeting, and Dr. Fauzi Mantoura and IAEA for hosting this workshop in Monaco. Our greatest thanks extend also to Drs. Shirley Jeffrey, Fauzi Mantoura and Simon Wright for initiating discussions with SCOR about this second volume, and preparing the background for the workshop.

The new Editorial Board for Volume 2: Suzanne Roy, Einar Skarstad Egeland, Geir Johnsen, Carole Llewellyn, and Simon Wright

Monaco, April 12, 2006

II. SUMMARY OF NEW DEVELOPMENTS

High-performance liquid chromatography (HPLC) analysis of pigments has now become the recommended protocol for monitoring phytoplankton in large-scale international programs (e.g., JGOFS: Joint Global Ocean Flux Studies and SOLAS: Surface Ocean – Lower Atmosphere Study). Additionally, HPLC pigment measurements are recognized as essential in ground-truthing and developing algorithms to estimate biomass from ocean colour remote-sensing satellite techniques (Ocean Optics Protocols). In the near future, remote-sensing hyperspectral instrumentation will require detailed pigment analysis from the surface layer of the ocean. This has potential in identifying particular algal groups of importance in a biogeochemical context (e.g., diatoms, coccolithophores) or that impact human activities such as aquaculture (e.g., toxic algal blooms).

Since the publication of the first volume there have been many important developments that have improved our basic understanding of phytoplankton. Several new algal groups have emerged, including pinguiophyceans, pelagophyceans and bolidophyceans. New pigments, in particular chlorophyll c-type pigments and fucoxanthin derivatives, have also been discovered. This has been aided by advances in separation and identification. The development of liquid chromatography – mass spectrometry (LC-MS) methods has helped the identification of these compounds and LC-MS is rapidly becoming an important tool for laboratories interested in pigment analysis.

In the last decade, routine pigment analysis to interpret phytoplankton abundance and distribution has become more widely accessible. The commercial availability of pigment standards (DHI Water & Environment, Denmark and Carotenature, Switzerland) and the computer programme CHEMTAX that enables conversion of pigment concentrations into quantitative class estimates, have aided this accessibility. The time is now right, and it is important that these new advances are brought together in one volume and made available to as many users as possible.

III. COMMENTS FROM THE PREVIOUS EDITORS

In October 2004 UNESCO advised the Editors of the 1997 volume "*Phytoplankton Pigments in Oceanography – guidelines to modern methods*" that this widely used Monograph was out of print. A survey of key oceanographic pigment experts carried out by the Editors recommended that an immediate reprint was essential to the field, and that a second edition incorporating new advances should be considered.

In May 2005, the SCOR Secretariat (Dr. Ed Urban) invited the Editors to provide a proposal, with detailed costing, for a second edition, which could be discussed at the next SCOR Secretariat meeting in Cairns, Australia in August 2005.

The Editors agreed that to keep the issues simple and costs down, a new stand-alone supplementary volume might be the answer. The 1997 Monograph is still valid and widely used (see above).

New chapters would include new advances in:

- Pigment analytical methods
- Pigment chemistry
- Pigment chemotaxonomy
- Theories of algal chloroplast endosymbiotic relationships
- Computational methods for interpreting field data (e.g., CHEMTAX)

Appendices would be upgraded where necessary. A new editorial group could take over preparation of the supplementary second edition, with the original editors helping with various aspects as requested.

A CD of the first edition could be included in the sleeve of the second edition to allow researchers access to the full first edition material.

The proposal was accepted by the SCOR Secretariat meeting in Cairns (2005), and US$15,000 was provided to cover costs of holding a small international Workshop in Monaco to look at the issues.

The following report summarizes the findings of the workshop, and submits a positive new proposal to SCOR to take the project to the next stage.

We, the previous Editors, thank SCOR at all times for the support received, and we wish the new editorial panel every success.

S.W. Jeffrey
R.F.C. Mantoura
S.W. Wright

Monaco, April 12, 2006

IV. WORKSHOP OVERVIEW: OBJECTIVES, PROGRAM, SCIENTIFIC PRESENTATIONS AND LIST OF PARTICIPANTS

A - WORKSHOP OBJECTIVES

- To review recent progress in phytoplankton pigments in oceanography
- To select critical updates for a Second Volume of the SCOR/UNESCO Monograph "Phytoplankton Pigments in Oceanography"
- To agree and draft chapter summaries, contents, and production timelines
- To propose chapter authors and editors
- To complete Workshop Report to SCOR and IOC/UNESCO

B - WORKSHOP PROGRAM

Friday, April 7	Arrival of delegates in Monaco
Saturday, April 8	Presentations of new advances by colleagues
Sunday, April 9	Presentations of new advances by colleagues
Monday, April 10 & Tuesday, April 11	Detailed discussion of new scientific advances: identify new chapters, authors, topics within chapters, editorial panel, timelines, milestones, SCOR requirements, UNESCO requirements, detailed costing of expenses for supplementary volume
Wednesday, April 12	Draft Report to SCOR. Close meeting at noon.

C - SCIENTIFIC PRESENTATIONS

A total of 20 talks and 5 posters were presented over the first two days of the meeting, covering various new developments in the field of phytoplankton pigments and applications in oceanography. The titles of these presentations are given below.

TALKS:

1. **Airs, R**. - Approaches to Pigment Analysis by LC/MS/MS: Novel Structures
2. **Brunet, C**. - Sun And The Sea : The Xanthophyll Cycle in Marine Algae
3. **Claustre, H**., **Uitz, J., Morel, A., Hooker, S. and Ras, J.** - Towards a Global Assesment of Oceanic Phytoplankton Community Composition Based on Surface Chlorophyll *a*

4. **Egeland, E.S**. - New Algal Carotenoids
5. **Garrido, J.L., Zapata, M. and Rodríguez, F**. - New Methods Unveil "New" Pigments in "Old" Species
6. **Garrido, J.L., Zapata, M. and Rodríguez, F**. - Mass Spectrometry Study of New Pigments in *Karenia* and *Tetraselmis* Species
7. **Hooker, S.** - An Overview of the SeaWiFS HPLC Analysis Round-Robin Experiment (SEAHARRE) Activity
8. **Jeffrey, S.W**. - Recent Advances in Chlorophyll *c* Pigments, Mycosporine Amino Acids (MAAs), and Phytoplankton Pigment Taxonomy
9. **Johnsen, G., Volent, Z., Fell, F., Tangen, K. and Sakshaug, E**. - Monitoring of Phytoplankton Blooms in Coastal Areas
10. **Latasa, M.** - Improving Estimations of Phytoplankton Class Abundances Using CHEMTAX
11. **Llewellyn, C.** - MAAs : Method Developments and Field Studies
12. **Neveux, J., Tenório, M.M.B. and Dupouy, C**. - Phycoerythrins and Diazotroph Abundance in Tropical Waters
13. **Pinckney, J.L.** - Current Perspectives on Gyroxanthin and *Karenia brevis*
14. **Platt, T.** - Ocean Biogeochemical Provinces
15. **Rodríguez, F., Zapata, M. and Garrido, J.L**. - Chlorophylls - Not Only Carotenoids - As Markers of Phytoplankton Groups in Field Studies
16. **Roy, S**. - Advances in the Analysis of Mycosporine-Like Amino Acids
17. **Sathyendranath, S. and Platt, T.** - Pigments from Space
18. **Schlüter, L**. - Aspects of Methodology (HPLC/Cell Counts)
19. **Van Heukelem, L**. - HPLC Quality Assurance Monitoring : Recognizing a Need
20. **Wright, S., Higgins, H. and Boucher, C**. - Chemtax Analysis of Pigment Data : New Developments

POSTERS:

1. **Barlow, R., Clementson, L., Stuart, V., Sessions, H., Sathyendranath, S., Lutz, V., Kyewalyanga, M., Fukasawa, M., and Watanabe, S**. - Pigment Patterns in the Surface Phytoplankton of the Subtropical Southern Hemisphere
2. **Neveux, J.** - Spectrofluorometry for Chlorophyll Analysis
3. **Ras, J. and Claustre, H**. - HPLC Analysis of Phytoplankton Pigments: Improving Sensitivity for Hyper-Oligotrophic Conditions
4. **Thomas, C.S. and Van Heukelem, L**. - Vitamin E Acetate as an Internal Standard for Use with Pigment Analysis by High Performance Liquid Chromatography
5. **Van Heukelem, L., Hooker, S.B. and Thomas, C.S**. - Evaluating and Reducing Uncertainties in HPLC Pigment Analyses

D - LIST OF PARTICIPANTS

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V. STRUCTURE OF PROPOSED VOLUME 2

The presentations on scientific advances in phytoplankton pigments since 1997 provided the Workshop with the basis for a two-day roundtable discussion, in which all delegates participated, to identify the major scientific advances that should be covered in a new volume. These discussions were focussed on updates required on Chapters in Volume 1 and requirements for new stand-alone chapters. Following discussion with the new editors, it was concluded that the most useful structure of Volume 2 for the user would be as follows:

- PART 1 New pigments
- PART 2 New methods
- PART 3 Selected applications in oceanography
- PART 4 Complete set of revised and new data sheets
- PART 5 Appendices including updates on Volume 1

Access to Volume 1:
It was suggested by the former editors and supported by the workshop delegates (if financially viable) that a CD of the first Volume, could be included in the sleeve of Volume 2. This way readers would have easy access to Volume 1.

PART 4:
Most users have expressed great satisfaction with the pigment data sheets of Volume 1. Delegates concluded that all data sheets should be available from a single source and that data sheets on pigments included in Volume 1 should be revised with newest HPLC traces for each pigment, and printed together with new data sheets on the new pigments.

Detailed contents for each of PART 1 to PART 5 are provided in the next section.

VI. CONTENTS OF PROPOSED VOLUME 2

PHYTOPLANKTON PIGMENTS IN OCEANOGRAPHY – VOL. 2
Table of Contents

PART 2 – NEW METHODS FOR PIGMENT ANALYSIS

2.1 New *in vitro* Spectroscopic Methods (Spectrophotometry, Spectrofluorimetry) (JN, GJ, Robert Porra?)

- 2.1.1 Spectrophotometric methods in extracts from phytoplankton communities
- 2.1.2 Spectrofluorimetric methods for chlorophylls and phycobilins
- 2.1.3 Method comparisons
- 2.1.4 Other passive fluorescence methods

2.2 New HPLC Separation Techniques (JG, MZ, RG, JP, LVH, RA, SW, ESE)

- 2.2.1 Review of separation principles
- 2.2.2 New methods
  - 2.2.2.1 Analysis of pelagic phytoplankton communities
  - 2.2.2.2 Analysis of microphytobenthic communities
  - 2.2.2.3 Analysis of bacteriochlorophylls
  - 2.2.2.4 Analysis of degradation products
- 2.2.3 Methods comparison

2.3 Quality Assurance for Quantitative LC Pigment Analysis (LVH, SH, ESE)

- 2.3.1 Method validation approach
  - 2.3.1.1 The use of internal standards
- 2.3.2 QC measurements based on the variables used for calculations
- 2.3.3 Sampling considerations
- 2.3.4 Reporting practices
- 2.3.5 Improvements to accuracy for field sample analyses and recommendations

2.4 Liquid Chromatography - Mass Spectrometric Methods for Pigment Analysis (RA, JG, RG, ESE)

- 2.4.1 Overview of classical mass spectrometry techniques.
- 2.4.2 Coupling of LC to MS
- 2.4.3 Instrumentation: ionization sources and detectors
- 2.4.4 Multistage mass spectrometry
- 2.4.5 Ionization and characteristic fragmentation pathways
  - 2.4.5.1 Chlorophylls, bacteriochlorophylls and their derivatives
  - 2.4.5.2 Carotenoids
- 2.4.6 Future outlook: LC/NMR

2.5 Quantitative Chemotaxonomy (SW, Harry Higgins, RG, ML, LS, JP, FR, CL)

- 2.5.1 Update of ChemTax method
- 2.5.2 Multiple regression methods
- 2.5.3 Variability of Marker Pigment: Chl *a* and Chl *a*:C ratios
- 2.5.4 Confirmation from microscopic, flow cytometric and flow-cam measurements
- 2.5.5 Community structure

PART 3 – SELECTED PIGMENT APPLICATIONS IN OCEANOGRAPHY

3.1 Pigment Remote Sensing and Biogeography (TP, SS, HC, GJ)

3.1.1 Global Chlorophyll *a* as an integrative measurement of biogeochemical variables and processes on a large scale

3.1.1.1 Biogeochemical Provinces

3.1.1.2 Applications to biogeochemical fluxes and models

3.2 Monitoring of Phytoplankton Blooms and Other Local Scale Features (GJ, JP, MZ, SS)

3.2.1 Common and unique pigments in HAB species

3.2.2 Absorption-based approaches to HAB detection

3.2.3 Pigment signature as an aid for remote- and *in situ* monitoring of phytoplankton blooms

3.3 *In vivo* and *in situ* Biooptics Including Pigment Proteins (GJ, SS, HC, Norman Nelson, Barbara Prézelin, Nick Welschmeyer?)

3.3.1 *In situ* fluorescence profiles and their relation to pigments

3.3.2 Biooptical properties of whole cells

3.3.2.1 Absorption and scattering characteristics

3.3.2.2 Photosystems and light harvesting complexes

3.4 Pigments and Photoacclimation Processes (CB, GJ, SR, Miguel Olaizola?)

3.4.1 Photoacclimation in seawater from information on photoprotective pigments

3.4.2 Photoacclimation and fluorescence

3.4.3 Photoacclimation and UV radiation

3.5. Pigment-based Rate Measurements (RG, JN, ML)

3.5.1 Pigment radiolabelling methods for rate measurements

3.5.2 Stable isotope methods

3.5.3 Dilution technique

PART 4 – NEW COMBINED DATA SHEETS (JG, ESE, RA, RG, SW, MZ)

Update of Part IV of Volume 1. All data sheets are kept together, for user convenience

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PART 5 – APPENDICES

Appendix A. Pigment Abbreviations (MZ, JG, ESE, CL, SR)
Abbreviations for new pigments
Abbreviations for mycosporine-like amino acids

Appendix B. Extinction Coefficients (ESE, LS, LVH, SH, JN)
Extinction coefficients available for new pigments and pigments not covered in Vol. 1
Extinction coefficients used by DHI

Appendix C. New Reference Microalgal Cultures and Revised HPLC Chromatograms for SCOR Reference Cultures (MZ, LVH, SW, RA?)
Reference microalgal cultures proposed for new algal classes and prochlorophytes
Revised HPLC chromatograms for SCOR reference cultures
Chromatograms for harmful algal species

Appendix D. Update on Standard Preparation, Filtration, Storage, Extraction Solvents (RG, SJ, ESE)
Micropreparation and purification of pigment standards

Appendix E. Update on Filtration, Storage and Extraction Solvents (LVH, SH, JP, FR, ML, ESE, JN)
Size-fractionation : filters and procedures
Recommendations for sampling and extracting microphytobenthos
Reappraisal of extraction solvents

Appendix F. Instrumentation Update : Autosamplers and Detectors (SW, LVH, JG)
New autosamplers and LC detectors

Appendix G. Minimum Criteria for Identifying Phytoplankton Pigments (ESE, CL)
Criteria for routine identification from seawater samples
Criteria for identification of new unknown pigments (LC-MS)

Appendix H. Commercial Suppliers of Pigments (CL, ESE, LS)
Update information from Vol. 1

Appendix I. Suppliers of SCOR Reference Algal Cultures (CL, SR, SW)
Update information from Vol. 1

Appendix J. Names and Affiliations of Participants (SR)

VII. EDITORIAL PANEL FOR VOLUME 2

The new editorial panel of Volume 2 is composed of five researchers, listed below in alphabetical order. Dr. Suzanne Roy will act as lead editor and coordinator of the team. The former editors of Volume 1 have agreed to act as consultants whenever requested.

Dr. **Einar Skarstad Egeland**, from Bodø University College, Norway, is a carotenoid chemist, specializing in the analysis of carotenoids from natural sources (mostly prasinophyte algae, but also other algae). He is now mainly involved in cross-disciplinary research within aquaculture and seafood quality.

Dr. **Geir Johnsen**, from Dept. of Biology, Norwegian University of Science and Technology, is a marine biologist using bio-optical methods and pigment information in photosynthetic research, biodiversity studies, photosynthetic endosymbionts in marine invertebrates, remote- and in situ sensing of phytoplankton blooms/coastal management and time-series measurements to elucidate the effect of change in key environmental variables on plankton speciation and biomass.

Dr. **Carole Llewellyn**, from Plymouth Marine Laboratory, UK, is a marine biogeochemist with over 20 years experience in phytoplankton pigments. Her research interests are focused on understanding the role of phytoplankton in the ocean and more specifically on microbial and food web dynamics, microbial biodiversity, community composition and photophysiology. At an applied level, her research contributes to eutrophication and pollution studies and links with remote-sensing satellite and bio-optics studies.

Dr. **Suzanne Roy**, from Institut des Sciences de la Mer, Université du Québec à Rimouski, is a biological oceanographer who has used pigments to follow the fate of phytoplankton in carbon flux programs such as JGOFS and NOW (Arctic Polynya) and is also working on the influence of UV radiation on phytoplankton, particularly with respect to photoprotection.

Dr. **Simon Wright**, from the Australian Antarctic Division, is a biochemist who has developed HPLC systems for analysis of phytoplankton pigments and applied them to analysis of phytoplankton populations of the Southern Ocean. He also collaborated in the development of CHEMTAX software for interpretation of oceanographic pigment data, and was a co-editor of volume 1.

VIII. SCHEDULE OF ACTIVITIES AND TIMELINES FOR PRODUCTION OF VOLUME 2

First drafts of the chapters are expected by the end of December 2006 (pending approval from SCOR before the end of June 2006). The chapters will be sent to two external referees and one referee from the team of editors. Revised chapters are expected by August 2007. Production of the book could start in November 2007.

IX. PROJECTED PRODUCTION COSTS

The overall cost of the proposed Volume is estimated at 24600 Euros (~29800 US$), based on the following items:

- Book production
  Based on an average of 14 pages per chapter x 14 chapters, 4 pages for the Preface, 130 pages for the revised + new data sheets and 40 pages for the Appendices, the book should have approximately 370 pages. UNESCO Press had estimated the cost for a 300 pages book at *ca* 14000 euros for 2000 copies.
  Estimated cost for a 370-page book = 17300 euros (to be confirmed by UNESCO Press).

- Book cover
  This cost should be relatively modest, since we intend to keep the same book cover design, but add more colours (to represent new pigments) as well as a LC-MS trace and perhaps a colour remote-sensing figure. **Estimated cost = 300 ?? euros**

- Colour plates
  At maximum, four colour plates could be included, mostly for illustrations of remote-sensing results. **Estimated cost = 3000 ?? euros**

- Production of a CD from Volume 1
  This involves scanning of Volume 1 and copying on a CD (one CD per book).
  Estimated cost = 2000 ?? euros

- Professional fees
  The English language editor who worked on the first volume, Dr. Vivienne Mawson (Australia), has agreed to do the editing for Volume 2. **Estimated cost = 2000 euros**

Several participants suggested that training workshops in pigment analysis by advanced chromatographic methods should be held on a regular basis. We would like to initiate discussion with SCOR and UNESCO about this.

2.2 Current Working Groups

2.2.1 WG 111: Coupling of Winds, Waves and Currents in Coastal Models (1996)

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.

Co-Chairs:

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Kristofer Döös	SWEDEN	Satish Shetye	INDIA
Roger Flather	UK	Yeli Yuan	CHINA-Beijing
Vladimir Gryanick	RUSSIA		

Associate Members:

John Allen	USA	I.A. Maiza	EGYPT
Michael Banner	AUSTRALIA	Eloi Melo	BRAZIL
Jurjen Battjes	NETHERLANDS	Yoshiaki Toba	JAPAN
Carlos Garcia	BRAZIL		

Executive Committee Reporter: Ilana Wainer

Date: Sun, 30 Jul 2006 22:35:02 -0400
From: "Christopher N. K. Mooers" <cmooers@rsmas.miami.edu>
Subject: SCOR WG111 Annual Report
To: Ed Urban <scor@jhu.edu>
Cc: wainer@usp.br, Norden Huang <norden@neptune.gsfc.nasa.gov>

Dear Ed - The Annual Report for SCOR WG111 (Coupling Waves, Currents, and Winds in Coastal Models) is very simple. We have not held any meetings and are not planning anymore. Our only outstanding activity is the preparation of a book to be published by Cambridge University Press. We have excellent working relations with our CUP liaison, Dr. Susan Francis, who is anxiously awaiting receipt of our ms. We hope to submit our book ms to her within a few months. - Cheers, Chris

Professor Christopher N. K. Mooers, Director
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2.2.2 WG 115: Standards for the Survey and Analysis of Plankton (1999)

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

- To review the present methods of collection, analysis and curation of plankton samples by agencies involved with time-series measurements and the uses which are made of the data.
- To overview the different instrumental approaches to measuring plankton, identify improvements that can be made to sampling strategies and make recommendations on how instruments can be improved and integrated with direct plankton sampling systems for calibration.
- To establish a strict methodology for inter-comparison/calibration of different sampling systems.
- To recommend a standard package of additional measurements that should be taken in association with plankton surveys to enhance the resulting products and assess logistical requirements, identify improvements that could be made in existing instrumentation for use in or attached to towed bodies for plankton survey.
- To encourage the use of the products of long-established surveys and the application of new strategies for large-scale and long-term sampling of zooplankton by organising an international symposium. Publish the products of reviews by members of the working group, selected presented papers and workshop reports in an internationally recognised, peer-reviewed journal or SCOR-sponsored book.

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K.K.C Nair	INDIA	Hans Verheye	SOUTH AFRICA
P. Christopher Reid	UK		

Associate Members:

Erika Head	CANADA	Juha Flinkman	FINLAND

Executive Committee Reporter: Annelies Pierrot-Bults

SCOR WG 115: Standards for the Survey and Analysis of Plankton

Report of the third meeting and mini-symposium held at the Sir Alister Hardy Foundation of Ocean Science, Plymouth, United Kingdom

19-20 May 2006

Participants:

International Scientific Committee:

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AKIRA TANAGUCHI, Tokyo University of Agriculture, Japan

Background

This third and final meeting of SCOR Working Group 115 took the form of a mini-symposium held in the Learning Resources Centre within the Marine Laboratory, Plymouth. The meeting followed two earlier meetings, the first in Honolulu in February 2002. The second was an expanded meeting held at the University of Concepción Oceanographic Laboratory, Dichato, Chile to enhance the development of standards for survey and analysis of plankton, technology transfer and networking for the region of South America.

Form of the mini-symposium

The mini-symposium followed the programme shown in Annex I. Seventeen talks were presented by Full and Associate Members of the Working Group and participants from Norway, Sweden, Canada and the United Kingdom over the first day and one-half of the meeting. These talks covered the following themes for ocean-scale plankton surveys:

- Plankton surveys: past and present
- Factors affecting the distribution of plankton
- Sampling strategies and methodologies
- Intercomparison of sampling surveys
- Databases and archives
- Capacity building for surveys
- Plankton analysis
- Instruments and new technologies.

After each session there was twenty minutes of discussion. The PowerPoint presentations of all of the talks have been placed on the SAHFOS website, www.sahfos.org under SCOR WG 115. It is expected that the talks will appear as peer-reviewed scientific papers in a special issue of the *Journal of the Marine Biological Association of the United Kingdom.* The first paper has been submitted with a deadline for others by the end of this year.

The final session of the mini-symposium consisted of the participants splitting into two groups to consider the presentations and formulate recommendations for SCOR relating to the Terms of Reference of Working Group 115.

Given below is a brief outline of the contents of the presentations.

Plankton surveys: past, present and future

Philip C. Reid and Hans Verheye provided an overview of the history of plankton surveys from their first initiation at the end of the 19th century to present where there are now some 28 time series extending over more than 10 years in different areas of the world. They noted that only two surveys have extensive spatial coverage at monthly sampling intervals, the Continuous Plankton Recorder (CPR) survey in the North Atlantic and the California Cooperative Oceanic

Fisheries Investigations (CALCOFI) in the North East Pacific. As a result, it is presently impossible to evaluate rates of change in pelagic ecosystems for large areas of the world's oceans.

Hans Verheye described the establishment of a regular CPR survey in the Benguela Current Large Marine Ecosystem and some early results from a "Proof-of-Concept" CPR tow. This trial tow, which took place in October/November 2005, has shown that it is feasible to use a CPR to sample plankton in the surface waters of the Benguela region and confirmed its potential use in regular surveys in the future. The distribution, abundance and diversity of plankton collected indicates that the CPR has sampled different water masses in the region and could provide valuable information to help manage the ecosystem.

Factors affecting the distribution of plankton

Svein Sundby *et al.* used data from the CPR surveys in the North Sea which demonstrated the long-term decrease of *Calanus finmarchicus* abundance. These changes were related to field observations and modelled fluxes of water mass exchange in the region and the winter hibernation *C. finmarchicus*. The importance of the results for the general failure of cod recruitment in the North Sea was discussed.

Another example of how the distribution and abundance of *C. finmarchicus* and *C .hyperboreus* have been affected by environmental conditions throughout the spring and summer in the Norwegian Sea was given by Cecilie Årnes et al. The results of a statistical analysis was discussed in terms of adaptations of the two *Calanus* species to their physical environment, prey availability and predator risk.

Sampling strategies and methodologies

Graham Hosie described the development of a suite of likely sampling systems and methodologies to be used to sample plankton as part of the Census of Antarctic Marine Life. The CPR is expected to play a significant rôle and be deployed from all participating vessels in a circum-Antarctic survey and the data collected will serve as a common reference in the plankton studies.

The methods used to sample the gelatinous species *Mnemiopsis leidyi* which has invaded the Caspian Sea, were described by Tamara Shiganova et al. This presentation had particular significance as it dealt with an important group of plankton, which are frequently overlooked because of their fragility and yet can have major influence in the functioning of marine ecosystems.

Intercomparison of sampling surveys

Sonia Batten considered the difficult problem of establishing a strict methodology for comparing data obtained from different plankton samplers. As the whole plankton community is so diverse in size only mesoplankton were considered, but even then no one sampler can adequately sample

the four dimensions which this assemblage occupies. The difficulties involved in comparison of data between samplers were illuminated and the need for knowledge of filtering and flow characteristics of samplers for quantitative comparisons was emphasised. An example of an alternative approach for intercomparisons was given using 'data products' to integrate data.

A comparison of two sampling devices for zooplankton, the CPR (SAHFOS) and a new generation of computer controlled undulating sampler (U-Tow, EnviroTech Inc, U.S.) deployed in the Gulf of Finland was given by Juha Flinkman. The results showed that the CPR collected at least an order of magnitude lower abundances of plankters, depending upon types of animals, than the U-Tow. The main problems

in making comparisons was determining appropriate mesh size and actual volumes filtered.

Databases and sample curation

The wide range of issues involved with databases were discussed by Darren Stevens and Philip C. Reid. These included access to data, complexities in comparing different sampling methods (e.g. nets, pumps, video and acoustic systems), frequency of sampling, depth and time of sampling, consistency of taxonomy, deficiencies in knowledge of life histories of plankton. Developments in information technology were given and the need for databases to be interoperable and for organisations to start to work with fixed standards stated.

Capacity building for surveys

Carmen Morales considered capacity building in the context of ocean monitoring and research. She defined the capacity building components which are essential for existing large scientific programmes such as GOOS, GLOBEC, IMBER, CoML, Euro-Oceans etc. These components include: a) training of students, technicians and scientists, b)availability of platforms and instrumentation for sampling and analyses and c)access to information systems and networking for the exchange of data and information. How these components could be translated into specific actions or have already been done so were exemplified for the Latin American region.

Instruments and new technologies

Philip C. Reid and Hans Verheye presented an overview of the different instrumental approaches measuring plankton from bacteria and phytoplankton to zooplankton (see separate report). Traditional and simple net sampling is still the most frequently used device for zooplankton sampling. However, a large diversity of plankton sampling equipment has been developed over the recent decades and is becoming increasingly used in standard surveys, particularly various kinds of multinets (e.g. Aries, Gulf V, Hydrobios, BIONESS and MOCNESS). Another group of instruments are the Towed Undulating Oceanographic Recorders (TUOR) such as Batfish, Seasoar II, Scanfish, Aquashuttle, U-tow, NuShuttle, Triaxus, HytovAcrobat, Biofish and Minibat. These are equipment which can be deployed with a diversity of sensors and to varying extent requires skilled experts to operate and maintain. This is also needed for the Autonomous

Underwater Vehicles (AUV). Various kinds of pumps are used to profile plankton either vertically or horizontally such as the Continuous Underway Fish Egg Sampler (CUFES). Optical Plankton Recorders (OPC) and Laser Optical Plankton Recorders (LOPC) are instruments increasingly used for counting zooplankton from the mesoscale and up, while Coulter Counters and flow cytometers can be used for smaller particles. Sun Song and Ivan Heaney presented an overview of the methods for plankton analysis from the traditional method of identifying and counting plankton samples using microscopy, which is labour and cost demanding, to the OPC method, Coulter Counter and DNA barcoding.

In addition, several more-specific presentations on new approaches within plankton research ware made. Phil Culverhouse presented the initiative Research on Automated Plankton IDentification (RAPID) and gave an interesting overview of the challenges in particle recognition. The initiative has been developed from a recently held SPACC/GLOBEC Workshop in San Sebastian. Tor Knutsen presented a new towed underwater vehicle (MESSOR) developed at the Institute of Marine Research, Bergen. The vehicle is equipped with multi-frequency acoustic sensors from 38 to 710 kHz, OPC/LOPC, CTD, fluorometer and a 5-net Multinet. Webjørn Melle presented a new macroplankton trawl, which is used in combination with a multiple cod end (MULTISAMPLER) trawl for larger fish. Bengt Karlson gave an overview of new equipment for phytoplankton sampling evaluated at an ICES/IOC workshop in Sweden in August 2005. Peter Burkill showed how inexpensive flow cytometers can be used to measure viruses, bacteria and phytoplankton.

Recommendations of the meeting

TOR 1: "*To review the present methods of collection, analysis and curation of plankton samples by agencies involved with time-series measurements and the uses that are made of these data"*

Collection of samples

1. At present, on a basin scale, the most cost effective sampling strategy is the Continuous Plankton Recorder, acknowledging its limitations. However, spot stations and smaller regional areas (e.g., Longhurst areas) should also be sampled frequently (monthly) using nets/water bottles as simpler methods.

2. Existing time series should not change the way that they sample. New technology could be used to add value to these time series. For example, an Optical Plankton Sampler could be used to give a quick indication of plankton present or more frequent data.

3. It is recognised that gelatinous zooplankton are poorly monitored. Net sampling with immediate analysis and video recorders may be methods for recording them.

Analysis of samples

1. In recent years computer-aided image recognition has made significant progress in counting plankton samples within broad groups (e.g., ZooScan). Categorising taxa is the next step and the

development of systems with this capability is now required to analyse large sample numbers produced by time-series surveys. It is recommended that a SCOR Working Group be established on automated image recognition of plankton. The timeliness of establishing such a Working Group arises because of the decline in taxonomists and the rapid increase in technological capabilities in this field.

2. Taxonomy and training of taxonomists must be funded as they will be essential in the development and calibration of automated analysis systems for the foreseeable future.

Curation of samples

1. The essential need for curation of samples from surveys at the institution level was recognised. This should include:

- barcoding to track samples and encode supplementary information
- the curation of original samples and a voucher (including an e-voucher) collection. Voucher collections are essential for DNA-based programmes (e.g., CoML barcode of life) and teaching. They will also be required for an original source of reference material so that machine-based recognition will have a physical sample to refer to.
- Databases and metadatabases with citation systems to reference source material and track data use.

TOR 2: *"To overview the different instrumental approaches to measuring plankton, identify improvements that can be made to sampling strategies and make recommendations on how instruments can be improved and integrated with direct sampling systems for calibration"*

Sampling systems and instrumentation

1. For plankton surveys there should be a clear distinction between well-tested equipment and more experimental instruments used by one or a few institutions. Equipment for sampling ichthyoplankton, for example, CUFES, was not presented during the meeting but forms part of the Working Group's responsibility.

2. Not withstanding the limited depth of sampling of the Continuous Plankton Recorder, it is proposed that the depth range for monitoring zooplankton should be down to 200 m as a minimum range. However, it should be emphasized that in arctic and arcto-boreal ecosystem copepods (e.g., *Calanus finmarchicus*) have a life cycle where much larger depths are occupied as they overwinter down to depths deeper than 200m.

Quantitative sampling

1. A great challenge is to control and measure the volume flux of water through plankton sampling equipment and better instruments for volume flux measurements can improve the quantitative aspects of plankton surveys to a substantial extent. Mechanical flow devices with

propellers are not satisfactory because small changes in the angle of the propeller, or its position in the sampler's mouth opening or intake, might affect the flow measurements. Therefore, it is recommended that electromagnetic and acoustic methods are developed for the measurement of flow through plankton sampling equipment.

Instrument certification and calibration

1. The certification of plankton sampling equipment should include flume tank tests so that the hydrodynamics of the instruments can be fully described for various speeds and angles/orientations. Such testing requires qualified engineering expertise and specially equipped laboratories. In addition, *in situ* intercalibration between the various instruments is recommended, particularly intercalibration between net samplers and Optical Plankton Counters.

Improvements to instrumentation

1. Fluorometers should be used which reduce the problem of scattering (pulse fluorometers) and which can discriminate between taxa such as cyanobacteria and phytoplankton groups (multi-frequency instruments).

2. The full size range of plankton should be covered in a single instrument package to include both chlorophyll measurements and plankton particles.

TOR 3: *"To establish a strict methodology for the inter-comparison/calibration of different sampling systems"*

1. New technologies must be able to be compared to existing instruments in the field to establish functionality and limitations.

TOR 4: *"To recommend a standard package of additional measurements that should be taken in association with plankton surveys to enhance the resulting products and assess logistical requirements, identify improvements that could be made in existing instrumentation for use in or attached to towed bodies for plankton surveys"*

Additional measurements and sensors

1. There are different demands on additional equipment with respect to ships of opportunity, research vessels and buoys. In addition to the need for measuring the volume flux through the plankton sampling equipment and for the improved measurement of fluorescence (see TOR 2), it is recommended that temperature, oxygen, salinity, and pressure (depth) sensors should be included in a standard package. However, the sensors must be prioritised depending on cost. It is particularly recommended to make shipboard measurements of wind speed and light because these are the two variables which to the largest extent determine the vertical distribution of zooplankton. Light influences the vertical migration behaviour of zooplankton and wind (through wind mixed turbulence) affects behavioural responses and vertical physical forcing (see

separate report by Svein Sundby in the report of the second meeting of SCOR Working Group 115).

2. Although pH sensors were considered as additional equipment for plankton sampling, it was concluded that these are not appropriate at present as the natural variability of pH in oceans is small compared to the sensitivity of the instruments.

Improvements for sampling strategies for monitoring programmes

1. In addition to well-established time-series plankton surveys often employing the Continuous Plankton Recorder, it is recommended that there should be fixed stations where monitoring should be conducted to 200 m depth. There is a world-wide need for establishing surveys but the focus should be placed on
several selected ecosystems:

- High-latitude regions
- Enclosed seas such as the Baltic and Mediterranean Seas, the Black Sea, the Japan Sea and the Yellow Sea
- "hot spots" like the Arabian Sea, the Chile-Peruvian upwelling region and the Benguela upwelling region.

All these regions are considered to be important regions with respect to productivity in relation to climate change.

2. In any specific ecosystem, single-survey transects with monthly-to-weekly sampling frequency should be applied to resolve seasonal signals while more comprehensive spatial sampling should be conducted once or twice each year. New technology should be adopted once it is proven to be robust. Data should be fully available and compliant with the requirements of GOOS.

3. Links should be developed between national monitoring programmes, or preferably, an international network should be developed that helps support the programmes (e.g., national GOOS programmes). International organisations such as ICES, PICES and CAMLR should be consulted when monitoring programmes are established.

4. Remote sensing and ecosystem modelling (i.e., phytoplankton modelling) should be more actively used to help decide where to establish monitoring programmes.

5. Working Group 115 recommends that SCOR WG 125 be given an additional term of reference, that is, to evaluate how zooplankton monitoring is proceeding globally and that WG 125 should prepare an annual report on progress made.

Chairman's concluding remarks
The mini-symposium contained a great amount of information on plankton surveys, past, present and looking towards the future. The presentations were all of excellent quality and content.

Helped by its limited size, the symposium engendered a lot of discussion, interaction and interest between the participants. That this was so was the result of the efforts of the Working Group members throughout the life of WG 115. Although the presentations are already available in their PowerPoint form, their full publication as a special edition of *The Journal of The Marine Biological Association of the UK* should conclude the efforts of this Working Group.

There was a feeling from the Working Group members and those of the other attendees at the final meeting that, although much had been achieved there was yet more to do. This opinion is reflected in the recommendations above. Immediately after the mini-symposium and as result of discussions at it, a proposal has been made to SCOR by Philip Culverhouse for a Working Group to be set up on automated image analysis of plankton. This proposal has my full support. I believe that much progress has been made in recent years in this subject by researchers in several groups and organisations. A SCOR Working Group would enable this important area to develop quickly and powerfully. There is a real need to have faster and more powerful analytical methods for plankton sample analyses as the number of surveys expands and the number of trained taxonomists declines. This does not mean that the need for taxonomy is reduced; the need for capacity building in this area remains.

The formation of SCOR WG 125 has taken forward the needs of ocean-scale plankton research and it is recommended that its terms of reference should be extended to ensure that progress on plankton surveys and monitoring should remain an interest and concern of the SCOR community. I would also endorse this suggestion. A knowledge of quantitative and qualitative changes in the plankton in the world's oceans and seas is fundamental for understanding the effects of climate change and responses to fisheries, pollution, enrichment and other influences yet unknown.

.**Acknowledgements**

The Working Group wishes to thank SCOR for supporting the mini-symposium and for all the help, advice and guidance so willingly provided by Ed Urban. Special thanks are due to the Marine Biological Association for the use of the Learning Resources Centre at the Marine Laboratory, Plymouth and to the staff of SAHFOS for the local organisation and ensuring that the meeting went smoothly. I am particularly grateful to all the members of the Working Group and Associate Members for their willing support at all times.

S. I. Heaney
23 July

2-28

Date: Sat, 12 Aug 2006 21:41:36 -0700
From: MackasD@pac.dfo-mpo.gc.ca
Subject: RE: WG125 annual report to SCOR
To: ed.urban@jhu.edu

I support this addition. It is quite timely. There is currently increased interest and activity re expanding zooplankton monitoring and also the use of zooplankton time series data. I will be attending two planning workshops in the next few months (one US and one in Japan), so there will certainly be new info to report on.

2.2.3 WG 116: Sediment Trap and ^{234}Th methods for Particulate Organic Carbon Export in the Upper Ocean (1999)

Terms of Reference:

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

CHAIR:

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2-30

Date: Tue, 08 Aug 2006 17:31:57 -0400
From: Ken Buesseler <kbuesseler@whoi.edu>
Subject: Re: WG 116 Publication
To: Ed Urban <ed.urban@jhu.edu>

SCOR WG #116 activities

During this past year SCOR WG #116 has been focused on completing and submitting a paper by Buesseler, K.O., A.N. Antia, M. Chen, S.W. Fowler, W.D. Gardner, Ö. Gustaffson, K. Harada, A.F. Michaels, M. Rutgers van der Loeff, M. Sarin, D.K. Steinberg and T. Trull (2006). Estimating upper ocean particle fluxes with sediment traps. <http://www.whoi.edu/science/MCG/cafethorium/website/publications/JMR_submitted_Mar_06_Buesseler_et_al_text_and_figs.pdf> Submitted to /Journal of Marine Research /in May 2006 (full copy can be found at http://www.whoi.edu/science/MCG/cafethorium/website/about/index.html#). To reach this point, a subset of the WG met in Honolulu at the Ocean Sciences meeting to finalize changes from an earlier draft of this paper (Fowler, Trull, Steinberg, Gardner and Buesseler). As of July 2006, the paper is still in review at JMR. We expect that revisions of this paper will be completed this year, and no further meetings will be needed to complete this activity. We are requesting SCOR assistance to pay for the color graphics and reprints which we will distribute. We have been told four color figures will cost about $1000 and 100 reprints will cost around $250. We also have a draft *EOS* article in hand that we plan to submit once we have final news that our publication will be accepted.

This short piece includes discussion of WG #116 goals and activities, and points the non-specialist to this upcoming JMR paper and summarizes recommendations we make concerning upper ocean trapping. We think that the combination of a detailed review of sediment trapping issues in JMR and the short EOS piece to the non-specialist will provide a great resource for this field. It should also be noted that the entire volume of papers on the application of ^{234}Th that appeared in *Marine Chemistry* Vol. 100 that were in part sponsored by this same SCOR WG activity appeared earlier in 2006, and copies can be found also at the Cafe Thorium Web site noted above. As such, we are pleased to be ending this WG activity with a variety of important publications in the open literature that address directly the initial terms of reference for our group, and we thank the SCOR office for supporting these activities.

Ken

2.2.4 WG 119: Quantitative Indicators of Marine Ecosystem Change Induced By Fisheries
Joint with IOC (2000)

Terms of Reference:

- To review the current state of knowledge in different marine and terrestrial disciplines relevant to the development of indicators for marine ecosystems (environmental, ecological and fisheries).
- To review theories (hierarchy, cascade…) and indicators that have been developed in terrestrial ecology and to assess their utility for marine ecosystems.
- To develop new indicators to study the functional role of species in ecosystems, exploitation and environment using output of multi-species models or available time series (e.g., fish catch statistics….), and using satellites, GIS (Geographic Information System).
- To apply these indicators in a comparative way to characterize ecosystem states, changes and functioning.
- To assess the utility of these indicators for management purposes and for the sustainable utilization of renewable resources**.**

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(Continued on next page)

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Executive Committee Reporter: Akira Taniguchi

2.2.5 WG 120: Marine Phytoplankton and Global Climate Regulation: The *Phaeocystis spp.* Cluster as a Model (2000)

Terms of Reference:

- Establish a website to facilitate coordination of ongoing research worldwide, and to create cohesion of efforts
- Make an inventory of aspects that relate to cycling of biogeochemically relevant elements. These aspects are:
  - Factors regulating bloom inception
  - The grazing issue: bottom-up or top-down control
  - Cellular response to environmental factors
  - Distribution patterns: molecular-biological approaches
  - Genetics: pathways of distribution and biodiversity in the cluster
  - Emission of climate-relevant biogenic gases, and relevance for climate regulation
  - Cloud inception and characterisation of condensation nuclei over blooms
  - Sensitivity of climate models for presence of plankton, *in casu* the *Phaeocystis* cluster
- Meet once a year to discuss progress, and divide tasks to arrive at a series of chapters produced under the responsibility of members of the Working Group.
- In the last year writing of a series of reviews covering the subjects mentioned under 2, which will be the chapters of a book that will be produced as the product of the Working Group. At least 2 of the WG members are responsible for each chapter.

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Ronald Kiene	USA	Maria Vernet	USA
M. Madhupratap	INDIA	Ingrid Zondervan	GERMANY

Executive Committee Reporter: Julie Hall

2.2.6 WG 121: Ocean Mixing (with IAPSO) (2002)

Terms of Reference:

- Summarize past results, including analyses of historical field data, concerning the sources for, and geographical distribution of, mixing in the deep-ocean basins. In light of recent results, tidally driven mixing mechanisms will be emphasized.
- Assess, within the established observational and theoretical context, those difficulties involved with parameterization of mixing in numerical ocean GCMs.
- Assess what more should be done by further observational programs or improved observational techniques to fill gaps in understanding essential to provide useful information for modeling the effects of deep-ocean mixing, including the potential to detect deep-ocean mixing through remote sensing and tracer techniques.
- Produce a comprehensive, published final report incorporating appropriate results from the above topics.

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Executive Committee Reporter: Victor Akulichev

IAPSO/SCOR WG 121 on Ocean Mixing
Progress as of 31 July 2006

This working group was formally approved by SCOR in October 2002. The present working group membership reflects interim changes, following recommendations made to SCOR by the original members, to the associate memberships. The group is currently at full strength as follows:

Full Members	**Associate Members**
Hans Burchard (Germany)	*Sybren Drijfhout* (Netherlands)
Chris Garrett (Canada)	*Ann Gargett* (USA)
Toshiyuki Hibiya (Japan)	*Theo Gerkema* (Netherlands)
Peter Killworth (UK)	*Sonya Legg* (USA)
Trevor J. McDougall (Australia)	*Jennifer Mackinnon* (USA)
Eugene Morozov (Russia)	*Mark Merrifield* (USA)
Robin Muench, Chair (USA)	*Rob Pinkel* (USA)
David Salas de Leon (Mexico)	*Fangli Qiao* (China)
Louis St. Laurent (USA)	*Barry Ruddick* (Canada)
Anders Stigebrandt (Sweden)	*Anne Marie Treguier* (France)

The group has focused, per its terms of reference, on assessing the role of turbulent mixing in the large-scale ocean circulation. The scientific concensus needed to accomplish this task has relied on networking, through conferences and email communications, of specialists in field and theoretical studies of turbulent mixing and of those seeking to incorporate mixing into large-scale ocean circulation models. Toward this end, one highly successful dedicated conference and several dedicated sessions at other conferences have been convened. A tentative set of recommendations for ongoing and future action has been published, along with a number of pertinent papers, in the open literature. Details are provided below.

1. Working Group Meetings

The most recent meeting was held during October 2004 in conjunction with the IAPSO/SCOR Ocean Mixing Conference in Victoria, Canada. This meeting focused on reaching a consensus of the scientific recommendations made during the course of the conference, on publication of the conference proceedings, and on the issue of a legacy from the working group that would continue beyond the time of the group's dissolution.

There has been no compelling need for a meeting since October 2004. The membership has been involved in pursuing goals identified at that meeting and has communicated as needed via email and through informal smaller gatherings of group members at the international conferences noted below.

2. Requests to SCOR concerning membership or terms of reference

The working group has no requests concerning membership or terms of reference.

3. Activities between working group meetings

Activities completed over the past year:

● Publication in early 2006 of the proceedings volume from the October 2004 IAPSO/SCOR Conference on Ocean Mixing, held in Victoria, Canada, as a special "Ocean Mixing" issue of *Deep-Sea Research II* (Volume 53, Numbers 1-2, 2006, ISSN 0967-0645).

● Organization of a symposium on ocean mixing during the IAPSO Assembly that took place in Cairns, Australia during summer 2005. More than 25 abstracts were received for presentation at this symposium.

● Organization of a session on ocean mixing at the February 2006 American Geophysical Union (AGU) Ocean Sciences Meeting in Honolulu, Hawaii. More than 120 papers were presented in this session, making it the third largest session at this very well attended meeting (~3000 attendees). Abstracts of presentations are available on the conference CD, available from the AGU.

● Preliminary preparations have been made toward proposing an ongoing series of Gordon Research Conferences focused on ocean mixing. More discussion follows below under "Future plans".

Ongoing activities:

● Organization continues of a session on ocean mixing that has been approved for the Fall 2006 AGU meeting in San Francisco, USA. Information on the meeting and a description of session OS15, Ocean Mixing, can be found on the AGU meeting Web site at http://www.agu.org/meetings/fm06/.

● Organization continues of an international symposium on ocean mixing approved for the XXIV General Assembly of the International Union of Geodesy and Geophysics (IUGG) in Perugia, Italy during July 2007. Information on the General Assembly, along with a description of the ocean mixing symposium, can be found on the IUGG Web site at http://www.iugg2007perugia.it/.

Future plans:

● Submission of a proposal to the Gordon Research Conferences for an ongoing sequence of conferences that will address ocean mixing. The inaugural conference, assuming a successful proposal, is anticipated to be held in early 2009. (Originally planned for early 2008, conflicts

with other scheduled meetings have dictated postponement to early 2009.) Initial inquiries to the Gordon Research Conferences have been well received, and a mechanism is now in place for submission in 2007 of a conference proposal. A continuing series of these conferences, which are typically popular and provide an excellent venue for exchange and discussion of new concepts, is intended as a legacy of the working group. General information on the Gordon Research Conferences can be found at http://www.grc.org/.

4. Next working group meeting

The next and final meeting will take place in conjunction with the IAPSO Ocean Mixing symposium at the IUGG General Assembly in Perugia, Italy during July 2007. Discussion will focus on how well the group has met its goals, will revisit the recommendations published in the proceedings volume from the 2004 Ocean Mixing Conference, will discuss plans for a series of Gordon Research Conferences on ocean mixing, and will address any other issues that might be seen as bearing on the group's goals or legacy. A primary goal of this final meeting will be to discuss and outline a brief final report to be submitted for publication in a suitable journal such as *EOS*, *Oceanography* magazine, or the *Bulletin of the American Meteorological Society*. Estimated costs for member travel to Perugia are US$4,500.

5. Assessment of progress

The group is ahead of schedule, having hosted a major conference and published the proceedings volume, both major steps toward the primary working group goals. The proceedings volume will comprise the bulk of the group's work to fulfill its terms of reference. Remaining goals include final preparations for those meetings listed above, preparation of a brief final report that will reassess the earlier published group recommendations, and steps toward establishment of a group legacy in the form of a Gordon Research Conference series on ocean mixing.

Robin Muench
Chair, IAPSO/SCOR Working Group 121

2.2.7 WG 122: Estuarine Sediment Dynamics (with LOICZ and IAPSO) (2003)

Terms of Reference:

- Collect and analyze global data on sediment retention in estuaries versus export to the coastal ocean, based on climate, hydrologic, physical, geological, chemical, and biological, and human processes, and including estuarine systems of different types, from tropical to subpolar.
- Evaluate available models of estuarine sediment retention.
- Identify research, observation (including standard measurement procedures), and modeling activities needed to improve predictions of sediment retention in estuaries.
- Conduct the above three TORs through WG meetings and an international workshop of interested scientists.
- Document the work of the WG and the workshop through a Web-based database of river/estuary sediment characteristics and trapping efficiencies, a special issue of a peer-reviewed journal, and a short article written for research managers and policymakers.

Co-Chairs:

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Susana Vinzon	BRAZIL
Eric Wolanski	AUSTRALIA

Associate Members

Mario Cáceres	USA
Ray Cranston	CANADA
Pedro Depetris	ARGENTINA
Steve Kuehl	USA
John Milliman	USA
Pedro Walfir M. Souza Filho	BRAZIL
Colin Woodroffe	AUSTRALIA
Marek Zajaczkowski	POLAND

Executive Committee Reporter: Laurent Labeyrie

2.2.8 WG 123: Reconstruction of Past Ocean Circulation (PACE) (with IMAGES) (2003)

Terms of Reference:

- Assess the existing paleoceanographic methods for reconstructing the history of ocean circulation over the past 120,000 years. Are the existing methods sufficient for a robust reconstruction of past ocean circulation? Are existing chronological tools sufficient to reconstruct distinct ocean circulation states? If not, what developments are necessary?
- Assess the available paleoceanographic data for reconstructing the history of ocean circulation over the past 120,000 years. Can robust conclusions on past ocean circulation be drawn from existing data? For what time periods and locations?
- Develop recommendations for future approaches to quantitatively assess the hypothesised changes in ocean circulation over the same time scale.
- Identify a minimum array of global locations and data types that would help to constrain uncertainties concerning changes in ocean circulation linked to major climate changes, bearing in mind the potential for collecting appropriate geological material as well as the size of the expected circulation signal relative to uncertainties in the methods. Through international co-operation within the IMAGES and ODP, existing cores would be identified and plans for new coring to meet these objectives would be discussed.

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Olivier Marchal	USA
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Ein-Fen Yu	CHINA-Taipei
Rainer Zahn	SPAIN

Associate Members

Jess Adkins	USA
Eduard Bard	FRANCE
Thierry Fichefet	BELGIUM
Jerry McManus	USA
Ulysses Ninneman	NORWAY
Andrew Weaver	CANADA

Executive Committee Reporter: Laurent Labeyrie

SCOR Working Group 123
SCOR/IMAGES Working Group on Past Ocean Circulation
Annual Report
July 31, 2006

Submitted by Jean Lynch-Stieglitz and Catherine Kissel (co-chairs)

The SCOR/IMAGES Working Group on Past Ocean Circulation was formed in order to assess the tools and data currently being brought to bear on the reconstruction of past ocean circulation and to develop recommendations for future quantitative assessment of past ocean circulation. During the first two years, this group organized and held a workshop on this subject which took place from March 20 to March 23 at the Georgia Institute of Technology in Atlanta. The aim of this workshop was to (1) Assess the potential of existing paleoceanographic proxies—to what extent can they constrain scenarios of past ocean circulation if widely applied, (2) Assess the sufficiency of existing data coverage, and (3) Determine whether a large-scale coordinated program is warranted, and what it might look like, based on the above. The workshop was well attended by a diverse segment of the paleoceanographic community working on past ocean circulation.

The main objective in our third year of the PACE working group was to compile a document summarizing the findings of the working group. The working group members wrote summaries of the workshop findings on points (1) and (2) above in advance of our final working group meeting, which was held at the Société Géologique de France in Paris in April 2006. These summaries form the first portion of our final working group document, which is currently in draft form and in the process of being edited. At the working group meeting we discussed our recommendations for future research efforts in reconstructing past ocean circulation on the basis of this summary of the data and methods (see attached agenda). At this meeting we also wrote a draft of our recommendations for future PACE efforts, forming the final portion of the working group document. The group recommends both a full compilation and analysis of existing data, which can be used to constrain deep ocean circulation during the Last Glacial Maximum (most likely as part of the MARGO effort), as well as the development of a field and modeling program (PACE) to reconstruct ocean circulation on millennial timescales over the past 25,000 years. We anticipate a final edited version of the PACE Working Group document will be available by Jan 1, 2007.

We initiated a theme (special issue) on Past Ocean Circulation for the AGU publication, *Geochemistry, Geophysics, Geosystems (G-cubed)* to publish the papers that were presented at the 2005 workshop as well as related papers on the subject. Working group members Jean Lynch-Stieglitz, Olivier Marchal and Catherine Kissell serve as guest editors for the theme. The theme is now closed for new submissions, and most of the papers are in the review process and should appear in 2006.

We have also written a review paper on the meridional overturning circulation in the Atlantic Ocean during the LGM, which will be submitted to *Science* as soon as the cited papers in the *G-cubed* theme are accepted for publication as per *Science* policy on citing unpublished work.

Budget: We received a commitment of $45,000 ($22,500 from SCOR and $22,500 from IMAGES) for the working group activities. In addition the NSF Mesh Office provided $10,000 and IMAGES provided an additional $6400 (5000 Euros) for travel support for young scientists to attend the workshop in 2005. We spent $8000 for travel and other expenses related to the final working group meeting in April 2006. At this point in the final year of our group, we have spent all but $2000 of the money committed from SCOR, and $3500 of the funds from IMAGES. Some of these funds will be used to fund a final trip (Paris-Atlanta) for one of the co-chairs so they can work on the final editing of the Working Group document and other working group products. The remaining funds will either be returned for other uses, or, with the approval of SCOR and IMAGES be carried forward for the two activities recommended by the group.

AGENDA
April 1, 2006 SCOR/IMAGES Working Group 123 (PACE) Meeting
Société Géologique de France, Paris, France

Attending: C. Kissel, J. McManus, J. Hirschi, O. Marchal, S. Mulitza, I. Hall, J. Lynch-Stieglitz, E. Ivanova, U. Ninnemann, J.C. Herguera, R. Zahn

1. (9:00 – 10:30) Are the existing methods sufficient for a robust reconstruction of past ocean circulation? If not, what developments are necessary?

2. (10:30 – 11:30) Are existing chronological tools sufficient to reconstruct distinct ocean circulation states? If not, what developments are necessary?

3. (11:30 – 12:30 LUNCH 1:30-2) Can robust conclusions on past ocean circulation be drawn from existing data? For what time periods and locations?

4. Update on G-cubed special issue, Science Review, WG Document

5. (2:00-4:00 pm) Present two possibilities and discuss merits

6. (4:30 – 6:30) Agree on plan

2.2.9 WG 124: Analyzing the Links Between Present Oceanic Processes and Paleo-Records (LINKS) (with IMAGES) (2003)

Terms of Reference:

- Use the new insights gained from contemporary ocean biogeochemical studies to identify or refine our understanding of key oceanic processes and develop or improve proxies for these processes for subsequent use in paleoceanographic studies.
- Refine established proxies, provide mechanistic understanding and foster the development of new proxies within integrated multidisciplinary process studies in the modern ocean.
- Use proxy evidence from the sedimentary records to test hypotheses of the oceanic response to climate change.

Co-Chairs:
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Raja S. Ganeshram	UK
Alan Kemp	UK
Carina Lange	CHILE
Renate Scharek	SPAIN
Dieter Wolf-Gladrow	GERMANY
Ein-Fen Yu	CHINA-Taipei

Associate Members

Fatima Abrantes	PORTUGAL
Robert Anderson	USA
Tim Baumgartner	MEXICO
Jelle Bijma	GERMANY
Marcia Caruso Bicego	BRAZIL
Christina De La Rocha	UK
Jacques Giraudeau	FRANCE
Corrine Lequéré	GERMANY
Ulysses S. Ninnemann	NORWAY
Frederic Partensky	FRANCE
Carles Pedros-Alio	SPAIN
Aldo Shemesh	ISRAEL
Alexander A. Vetrov	RUSSIA
Richard Zeebe	GERMANY

Executive Committee Reporter: Ilana Wainer

Third Report on the SCOR/IMAGES Working Group **LINKS**

"Analysing the links between present oceanic processes and paleorecords"

2005-2006

The aim of the LINKS working group is to publish review papers that address the links between the formation of particulate material in the surface waters by biological processes and the sediment record. This is aimed to develop a better understanding of past ecosystem functions and also to identify major gaps in our understanding.

Meetings:

The first meeting of the LINKS group in September 2004 during ICP-8 in Biarritz, France, served to bring together for the first time all LINKS members and to develop an outline of the planned publications.

The second LINKS meeting took place at the AGU Conference in San Francisco, USA, 5-6 December 2005. A separate meeting of the LINKS group was held during this conference and the plans for the publication were further discussed and modified as it had become clear that the first outline was not focussed enough (see below).

In addition to this separate meeting, LINKS organised a special oral session at the AGU Conference under the LINKS title. Eight selected papers were presented (see Appendix 1) During the discussions in the special session new aspects for the planned review papers were addressed and some of the participants expressed interest in contributing to LINKS.

The third LINKS meeting will take place in the Hanse Wissenschaftskolleg (HWK) in Delmenhorst (near Bremen), Germany, 21 – 24 November 2006. The application to hold this workshop at the Wissenschaftskolleg including some additional funds for the workshop has been approved in June 06. The main goal of this meeting is to discuss the five manuscripts that are prepared in advance and finalise them. 25 Participants are invited to join this meeting and to contribute to the discussions (see Appendix 2): 10 LINKS members, ca. 5 associate members, ca. 5 participants representing SOLAS, IMBER, LOICZ, IMAGES and GEOTRACES, 5 interested scientists from the AGU conference and participants from local research institutes with relevant research interests.

Planned Publication:

We suggest publishing a series of focussed papers in *Global Biogeochemical Cycles* or a similar journal (see below). The aim is to produce short and challenging papers that address a current topical aspect. The final discussion about the choice of the publishing journal will be taken at the

workshop. For each manuscript two LINKS authors will take the lead and are responsible for the progress of the paper. They can include additional authors, as necessary, for the paper.

The focussed topics will address an issue of general importance or a current hypothesis for controls of ocean productivity and export. It will be approached from the 'present ocean' and the 'paleo ocean' point of view by the two authors. As before, the main questions for each topic are: How well do we understand the present day processes that control export? How good is our reconstruction of past ecosystems? What are the major gaps in our understanding and can we suggest a strategy for the development of new proxies for specific processes?

The following topics were chosen for the 5 papers (tentative titles and outline):

Ballast and Rain Ratios

- What are the main functional groups in the carbonaceous and siliceous plankton and how do they shape the ecosystem?
- How do changes in the rain ratio affect export?
- Is there evidence from the past that ballasting increases export?
- How can the functional groups be included in models, how many groups do we need for modelling?

Authors: Roger Francois, Dieter Wolf-Gladrow

Role of dust-borne trace metals (Fe) on stimulation of PP and nitrogen fixation

- N:P:Fe and their significance for N_2 fixation.
- Fe limitation and its effect of Si uptake.
- Changes in the elemental composition of phytoplankton at different Fe supply - consequences for export and nutrient regimes.
- Large diatoms benefit mainly from iron fertilisation experiments->consequences for export.
- What do we know from paleo-records in respect to the effects of Fe on the plankton (shifts in phytoplankton assemblage, nitrogen fixation….)?

Authors: Frank Dehairs et al.

What generates most export in key areas?

- Upwelling areas, SO fronts, and blooms; how important is the deep chl maximum for export?
- The most productive species may not be the best exporters and may not be best recorded in the sediments
- Which are the most important species for export (compare evidence from plankton, traps and sediment)?
- Importance of large diatoms (also from deep chl. max.) and of species with endosymbionts

Authors: **Alan Kemp, Carina Lange, Renate Scharek**

The effects of changes in hypoxic zones on large-scale nutrient cycles

- Factors leading to reduced O_2 concentrations (reduced ventilation, biological consumption)
- Role of anammox vs. denitrification
- What are the effects of low oxygen on N/P and N/Fe ratios and how does the plankton respond to such changes in respect to species composition?
- What is the effect on N_2 fixation?
- Paleo-evidence of changes in the N- and P-cycle.

Authors: Raja Ganeshram, Karin Lochte

"Windows of opportunity" for paleorecords

- How can we identify most 'reliable' proxies that are less subject to alterations?
- Which environmental conditions are conducive to preservation of which proxies?
- Which chances are provided by biomarkers, stable isotopes, molecular techniques for reconstruction of paleoecosystems?

Authors: Marie-A. Sicre, Ein-Fen Yu?

Sunset Activities of LINKS:

After the workshop at the Hanse Kolleg, the manuscripts will be revised and perhaps additional comments from colleagues will be invited. It is planned to finalise the manuscripts in January and to submit them. Publication is planned for 2007 and LINKS will then be disbanded.

Financial Requests:

Financial support from SCOR and IMAGES is required for the meeting in Delmenhorst in November (see Appendix 3). This will comprise travel costs for the regular members.
We also ask additional funds to cover the travel costs for the anticipated 5 Associate Members. Since in the previous meetings the LINKS working group did not use all funds potentially available and covered the travel costs of the members to some extent from other sources, we hope that SCOR and IMAGES will be able to help with additional funds for this meeting.
We will ask the Global Change programmes to fund the travel costs for their representatives.

Accommodation, meals and transport between airport Bremen and Delmenhorst for 30 persons are covered by the grant from the Hanse Wissenschaftskolleg.

The total request for funds from IMAGES and SCOR is: 17,760 US$
(see detailed list in Appendix 3)

Appendix 1:

Ocean Sciences [OS] Session at AGU

OS34A MCC:3012 Wednesday

Analyzing the Links Between Present Oceanic Processes and Paleo Records I

Presiding: K. Lochte, Leibniz Institute for Marine Sciences at the University of Kiel; M.A. Sicre, Laboratoire des Sciences du Climat et de l'Environnement

Biogenic Opal Deposition in the Eastern Equatorial Pacific Over the Last 300 Kyrs: Silica Leakage Revisited - Kienast, S.S., Kienast, M., Francois, R., Calvert, S.E., and Brzezinski, M.

Plankton Functional Group Variability and Global Change: The Eastern Equatorial Pacific on the Glacial-Interglacial Timescale - Loubere, P.

The Role of Diatoms in Export Flux - Kemp, A.E., Pike, J., Pearce, R.B., and Davies, A.

Nitrogen Fixation in Summertime Surface Waters of the Guaymas Basin, Gulf of California - Prahl, F.G., Popp, B.N., and Valdez-Holguin, J.E.

Pacific dominance of oceanic N_2 fixation diagnosed from nutrient distributions - Deutsch, C., Gruber, N., Sarmiento, J.L., and Sigman, D.M.

Modeling Deep Sea Delta Calcite in the Eastern Equatorial Pacific Over the Last 25,000 Years: Normalizing Sedimentation Rate with Excess 230-Thorium Activity, or Not? - Mekik, F.A.

Controls on Carbon Isotope Fractionation in Alkenone-Producing Algae: Field Evidence - Popp, B.N., Wallsgrove, R., and Prahl, F.G.

Temporal and Depth Trends in Phosphorus and Carbon Forms in Ocean Particulates from Monterey Bay, California - Cade-Menun, B.J., and Paytan, A.

Appendix 2:

3rd LINKS meeting

Hanse Wissenschaftskolleg, Delmenhorst (near Bremen), Germany,
21 – 24 November 2006

List of Participants (preliminary)

Links members:

1. Karin Lochte, Kiel, Germany (co-chair), klochte@ifm-geomar.de
2. Marie-Alexandrine Sicre, Gif-sur-Yvette, France (co-chair), sicre@lsce.cnrs-gif.fr
3. Dieter Wolf-Gladrow, Bremerhaven, Germany (applicant), dwolf@awi-bremerhaven.de
4. Frank Dehairs, Bruxelle, Belgium, fdehairs@pop.vub.ac.be
5. Roger Francois, Canada, rfrancois@eos.ubc.ca
6. Raja.Ganeshram, United Kingdom, Raja.Ganeshram@glg.ed.ac.uk
7. Allan Kemp, Southampton, United Kingdom, aesk@mercury.soc.soton.ac.uk
8. Carina Lange, Chile, clange@udec.cl
9. Renate Scharek, Spain, rscharek@gi.ieo.es
10. Ein-Fen Yu, Taiwan, efyu@ntnu.edu.tw

Associate Members: (it is expected that not all of the listed 9 associated members will be able to participate, we anticipate 5 assoc. members to join the meeting)

11. Fatima Abrantes (Portugal), *Expertise*: paleoceanography, micropaleontology, diatoms. (fatima.abrantes@igm.pt)
12. **Jelle Bijma, (Bremerhaven), *Expertise*: carbonate system, foraminifera, oxygen and carbon isotopes. (jbijma@awi-bremerhaven.de)**
13. **Marcia Caruso Bicego (San Paolo), *Expertise:* Organic geochemist, pollutants, biomarkers, proxies. (marcia@io.ups.br)**
14. **Jacques Giraudeau (EPOC, Bordeaux, France) *Expertise*: coccolithophorids, micropaleonthology, paleoceanogrpahy, paleoproductivity. (giraudeau@epoc.u-bordeaux1.fr)**
15. **Ulysses S. Ninnemann (Univ. Bergen, Norway) *Expertise:* Paleoceanography, stable isotopes in foraminifera, carbon cycling and past ocean dynamics. (ulysses.ninnemann@geol.uib.no)**
16. Frederic Partensky (CNRS Roscoff & Univ. Paris, France) *Expertise:* genomics, molecular ecology, pico-phytoplankton, phytoplancton physiology. (partensky@sb-roscoff.fr)
17. *Carles Pedros-Alio (Spain),* Expertise*: molecular biology. cpedros@icm.csic.es*
18. **Christina De La Rocha (AWI) *Expertise*: isotopic composition of biogenic silica, diatoms physiology. crocha@awi-bremerhaven.de**
19. Richard Zeebe (USA) Expertise: Mechanistic models of biological processes and isotope pathways. zeebe@soest.hawaii.edu

Members of Global Change Programmes:

16. *Tim Baumgartner (CICESE, Mexico), GLOBEC, trbaumgartner@ucsd.edu*
17. Ilana Wainer (San Paolo, Brazil), SOLAS, Wainer@usp.br

18. Ralph Schneider (Kiel), PAGES / IMAGES
19. Kay Christian Emeis (Hamburg) IMBER
20. LOICZ to be determined

Other participants:

21. Christine Klaas, (AWI Bremerhaven)
22. Avan Antia (IFM-GEOMAR, Kiel)
23. Hans Brumsack (ICBM, Oldenburg)
24. participant from AGU session
25. participant from AGU session

Programme of the meeting:

The main goal of the meeting is to write and discuss a series of papers on 5 topics relevant to the LINKS project and prepared in advance of the meeting. In addition to the 10 LINKS members we will invite up to 15 colleagues to discuss the draft manuscripts or contribute as co-authors.

21 November 2006

11:00–12:00 *Welcome, Introduction, outline of workshops plan (Karin Lochte)*
Practical information (*Dieter Wolf-Gladrow*)

12:00–13:00 Lunch

Presentation of the groups

13:00–13:45 "Ballast and Rain Ratios", *Suggested authors: Roger Francois, Christine Klaas, Dieter Wolf-Gladrow (group 1)*

13:45–14:30 "Role of dust-born trace metals (Fe) on stimulation of primary production and nitrogen fixation" *Suggested author: Frank Dehairs (group 2)*

14:30–15:15 "What generates most export in key areas", *Suggested authors: Alan Kemp, Renate Scharek (Group 3)*

15:15 -15:45 *Coffee break*

15:45–16:30 "Effects of changes in hypoxic zones on large-scale nutrient cycles", *Suggested authors: Raja Ganeshram, Karin Lochte* (Group 4)

16:30–17:15 "Windows of opportunity" for paleorecords", *Suggested authors: Marie-Alexandrine Sicre, Carina Lange, Ein-Fen Yu (Group 5)*

17:15-17:5 Proposals for Free Round Tables to discuss upcoming topics

22 November 2006

9:00-12:00	Meeting of Groups 1 & 2
12:00–13:00	*coffee break*
11:15–13:15	Meeting of Groups 3 & 4
13:15–14:30	*Lunch*
14:30–15:30	Meeting of Group 5 & Free Round Table
15:30–16:00	*Coffee break*
16:00–17:30	Plenary discussion: Interaction with international programs (IMBER, GLOBEC, SOLAS, LOICZ, GEOTRACES)

23 November 2006

9:00–10:30	Group Report and discussion (Groups 1 & 2)
10:30–11:00	*Coffee break*
11:00–12:30	Group Report and discussion (Groups 3 & 4*)*
12:30–13:30	*Lunch*
13:30–15:00	Group Report and discussion (Group 5 & Free Round Table)
15:30–16:00	*Coffee break*
16:00–17:30	Finalising discussions on the manuscripts

24 November 2006

9:00–12:00	Plenary discussion: Conclusions from the meeting How to proceed within the writing groups Choice of journal Deadlines and responsibilities
Ca. 12:30	Closure of the meeting.

Appendix 3

Estimated Costs for the 3rd LINKS Workshop

Item	Cost per person (€)	Total Costs (€)	Source
Travel for regular Members			SCOR & IMAGES
3 x Overseas	2 000	6 000	
5 x Europe	600	3 000	
2 x Germany	200	400	
		sum: 9 400 €	*= 11 280 US$*
Travel for associated Members			SCOR & IMAGES
2 x Overseas	2 000	4 000	
2 x Europe	600	1 200	
1 x Germany	200	200	
		sum: 5 400 €	*= 6 480 US$*
Travel for Representatives of	ca. 1 000	5 000	Global Change Progr.
Global Change Programmes		*sum: 5 000 €*	*= 6 000 US$*
Additional Participants	ca. 500	2 500	Home Institutes
		sum: 2 500	*= 3 000 US$*
Accommodation and meals			HWK
25 x Accommodation at the HWK		6 627	
all Meals and Coffes		3 522	
Transport airport - HWK		210	
1x Student Helper		930	
Consumables for Office		300	
		sum: 10 153 €	*= 12 184 US$*

2.2.10 WG 125: Global Comparisons of Zooplankton Time Series (2004)

Terms of Reference:

- Identify and consolidate a globally representative set of "long zooplankton time series" (selected from the data sets listed in Table 1, plus perhaps from additional regions for which time series can be pieced together from a sequence of shorter programs).
- Facilitate migration of individual data sets to a permanent and secure electronic archive.
- Develop and share protocols for within-region and within-time period data summarization (e.g., spatial, seasonal and annual averaging, summation within taxonomic and age categories).
- Based on the above, develop priorities and recommendations for future monitoring efforts and for more detailed re-analysis of existing sample archives.
- Carry out a global comparison of zooplankton time series using (in parallel) a diverse suite of numerical methods, examining

    1. Synchronies in timing of major fluctuations, of whatever form.
    2. Correlation structure (scale and spatial pattern) for particular modes of zooplankton variability (e.g., changes in total biomass, replacement of crustacean by gelatinous taxa, alongshore or cross-shore displacements of zoogeographic distribution boundaries).
    3. Amplitude of variability, both for total biomass and for individual taxa, and comparison to the amplitude of population fluctuations of predator species (fishes, seabirds, marine mammals). Is there amplification at higher levels of the food web?
    4. Likely causal mechanisms and consequences for the zooplankton variability, based on spatial and temporal coherence with environmental and fishery time series.
    5. Sensitivity and specificity of data-analysis tools.

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Young-Shil Kang	KOREA		
Todd O'Brien	USA	Harold Bachelder	USA – Sponsored by PICES
Mark Ohman	USA	Juha Flinkman	FINLAND
Chris Reason	SOUTH	A. Lopez-Urrutia	SPAIN
Anthony	AFRICA	Welbjørn Melle	NORWAY – Sponsored by
Richardson	AUSTRALIA		ICES
Andy Solow	USA	Luis Valdes	SPAIN

Executive Committee Reporter: Annelies Pierrot-Bults

SCOR Working Group 125
"Global Comparisons of Zooplankton Time Series"
July 2006 Status Report

Initial WG125 meeting
Most members attended the first WG 125 meeting, held 7-9 November 2005 at the U.S. NOAA facility in Silver Springs MD. Overall, it was a congenial and productive session. Special thanks go to Todd O'Brien for local logistics arrangements, and to Hal Batchelder for preparing detailed minutes of the meeting. In terms of content, the first day and one-half were spent getting everyone better acquainted with the available zooplankton time series. For each of the major data sets, we reviewed:

- Meta-data characteristics (time-series duration; sampling location and frequency; sampling/data reduction methods and zooplankton taxonomic/stage resolution; present format; availability of other supporting data).
- Ongoing sample reprocessing and other forms of data mining
- Numerical analysis methods used to date (e.g., raw time series, anomalies referenced to local average, multivariate resemblance/ordination/clustering, change point detection, meta-analyses)
- Highlights of local results and interpretations (amplitude of variability, dominant time scales, date intervals containing large changes, environmental and fishery covariance,....).

We spent the remainder of the meeting discussing choices, priorities and schedules for "what to do next" (decisions and subsequent actions described below).

Planned/completed intersessional work & progress toward WG Terms of Reference
The December 2005 meeting planned the following work for 2006:

- Pooling data in a single archive. The first step (now nearly complete) is to transfer our simplest and most-comparable time series (total biomass, and biomass & abundance of dominant calanoid copepods) into the NOAA/NMFS database.
- Development and sharing of numerical tools for data display, and extracting average seasonal cycles. Dr. Lopez-Urrutia has developed scripts for several of these tasks, written in "R", a free-ware statistical programming environment.
- Development/evaluation of statistical tools for comparing years and regions, and testing for synchronies. O'Brien and Solow met in Woods Hole in spring 2006 (with part-time phone participation by Mackas) to identify and resolve statistical issues regarding data characteristics and their effects on various analysis methods. Recommendations will be explained and implemented at the next WG meeting.
- Bringing in additional data sets. Top priorities are better representation of the Southern Ocean, European marginal seas, the south Pacific and Indian Oceans, and various Russian data sets. The group agreed to seek a Russian Associate Member, and external funding to support his/her travel. Both are now in place (see below).

- Setting up a Web site. Thanks to Todd O'Brien, an initial version is now up and running (http://scor.e-plankton.net), snapshot shown in Fig. 1. It includes both a "public" section (describing the WG, its mandate, and graphical examples of completed analyses) and a password-protected "data workshop" containing archives of raw and processed data, electronic library of relevant scientific papers, commentaries on advantages and pitfalls of various analysis methods

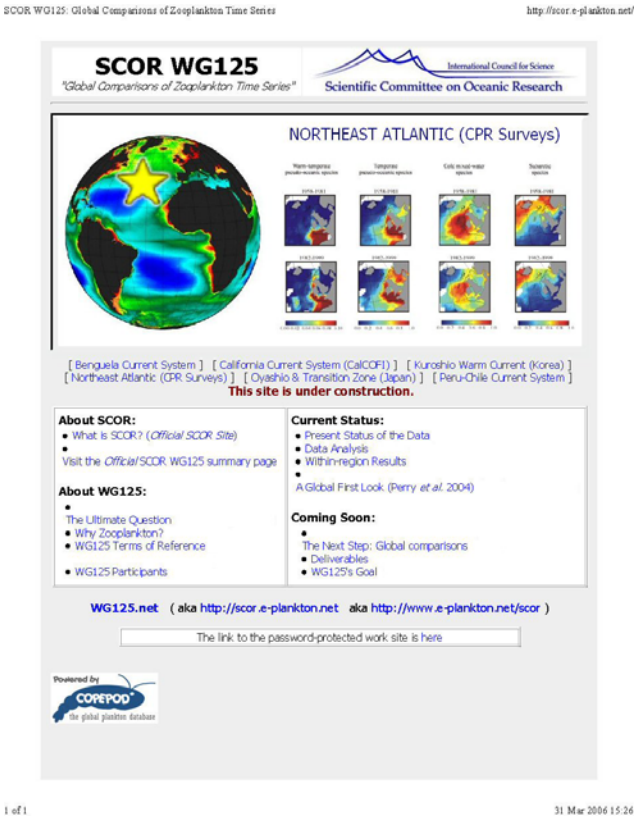

Fig. 1. Front page screen capture from the WG125 web site

Changes in WG membership

- By mutual request, Dr. Juha Flinkman is replacing Dr. M. Viitasalo as the Associate Member providing expertise on data from the Baltic Sea.
- Dr. Alyona Arashkevich (Russia) has very recently been invited to join as an Associate Member providing expertise on Black Sea time series, plus other Russian data holdings.
- NOAA has agreed to provide additional WG funding to facilitate access to additional data sets. Part of this funding will cover Dr. Arashkevich's travel to WG meetings.

Next WG meeting

- The next WG meeting will be in early December 2006 (Lima Peru, immediately following the Humboldt Current Symposium). Patricia Ayon has volunteered to manage the local arrangements. The intent is for this to an intensive hands-on data analysis workshop.

Subsequent conference/publication schedules:

- The May 2007 "4th International Zooplankton Production Symposium" (Hiroshima, Japan) will include a half-day topic session on "Global comparisons of zooplankton time series" (convenors Mackas and Valdes).
- WG members agreed that the tasks of the Working Group would not be completed in time for the May 2007 meeting to be our final presentation/publication product. We are instead targeting a spring 2008 "global ocean change" conference that is being organized by Luis Valdes.
- WG members Mackas and Ohman (plus colleagues W. Peterson (USA) and B. Lavaniegos recently completed a comparative analysis of recent zooplankton time-series data from the California Current system. This has been submitted to *Geophysical Research Letters*, as part of a series of papers on 2005 ecosystem anomalies in the northern CCS. It is also scheduled for oral presentation at the October 2006 PICES conference.
- Mackas and G. Beaugrand are co-authoring a review paper on "Global Comparison of Zooplankton Time Series" for a September 2006 GLOBEC workshop being organized by Juergen Alheit. Following the workshop, a revised and updated version will subsequently be submitted for publication in *Journal of Marine Systems*.

Table 1. SCOR WG 125: Terms of Reference and present membership

Terms of Reference (summary)	**WG Membership (regional & topic expertise)**	
1. Gather a globally representative set of "long zooplankton time series"	"Full" = SCOR-sponsored	"Associate"
2. Facilitate data transfer to a secure electronic archive	D. Mackas (Co-chair, NE Pacific)	H. Batchelder (PICES, NE Pacific)
3. Develop, test, and share protocols for data summarization and statistical analysis	H. Verheye (Co-chair, SE Atlantic and Benguela Current)	D. Checkley (GLOBEC, fisheries data sets)
4. Compare zooplankton time series using a suite of numerical methods to examine:	P. Ayón (Humboldt Current)	A. Lopez-Urrutia (Spain, data visualization)
• Correlation structure (time & space scales)	S. Chiba (NW Pacific & Project ODATE)	W. Melle (ICES, Norwegian & Barents Seas)
• Synchronies in timing		
• Causal mechanisms & consequences	Y.-S. Kang (Asian Marginal Seas)	L. Valdes (ICES, NE Atlantic & Mediterranean)
• Sensitivity & specificity of data-analysis tools		
5. Develop priorities & recommendations for:	T. O'Brien (Database management)	J. Flinkman (Finland, Baltic)

• Future monitoring • Additional processing of existing samples	M. Ohman (CalCOFI & California Current) C. Reason (Climatology & physical oceanography) A. Richardson (Continuous Plankton Recorder) A. Solow (Statistical methods)	

2.2.11 WG 126: Role of Viruses in Marine Ecosystems (2004)

Terms of Reference:

- Summarize past results on virus-meditated mortality of algae and prokaryotes and the impact on oceanic carbon and nutrient cycling.
- Coordinate data collection to assess the role of viruses in different water masses.
- Assess the methodological limitations of the techniques available for quantifying the virus-mediated mortality of microorganisms (eukaryotes and prokaryotes) and their impact on carbon and nutrient cycling, and make recommendations for the best available approaches to study viruses and viral processes in the sea.
- Establish and maintain a Web site as forum that can be used by the "viral community" for exchange of data and ideas and future plans.
- Convene an International Symposium that could include a published proceeding such as a special issue of *Limnology and Oceanography* or *Deep-Sea Research*.
- Write a "definitive" textbook on Methods in Marine Virology.

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Keizo Nagasaki	JAPAN
Curtis Suttle	CANADA
Willie Wilson	UK
Eric Wommack	USA

Associate Members

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Jed Fuhrman	USA
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Télesphore Sime-Ngando	FRANCE
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Declan Schroeder	UK
Grieg Steward	USA
Dolors Vaqué	SPAIN

Executive Committee Reporter: Julie Hall

Scientific Committee on Oceanic Research Annual report of Working Group 126 – *The role of viruses in marine systems*

Co-chairs
Markus G. Weinbauer (France)
Steven W. Wilhelm (United States)

Outcome of the most recent working group meeting, particularly in relation to fulfilling the groups terms of reference.

The first open meeting of the group was held in Vancouver, British Columbia, Canada, June 1 – 3, 2006 and organized by Curtis Suttle and Amy Chan. More than 40 attendees spent two days discussing the charge of this group and presenting information of their research into marine virus ecology. Fifteen lectures by leaders in the field of were complimented by 20 posters from other researchers, including graduate students and postdoctoral fellows. A highlight of the meeting was attendance by 2 top researchers from outside the marine virus ecology arena, Drs. Roger Hendrix and Robert Edwards, who spoke, respectively, on phage genomics and the metagenomic analysis of virus communities. An outline of the conference as well as a list of abstract are appended to this document.

The event concluded with discussions concerning one of the proposed outcomes of this working group: the development of a definitive manual on methods in marine virus ecology. As reported last year, the plan is to publish an electronic version and make it freely available to people who are interested though the *American Society for Limnology and Oceanography's* Web site for their journal *Limnology and Oceanography: Methods*. A draft outline of the proposed chapters is circulating amongst the core members and it is anticipated that authors will be approached in July 2006.

Another outcome arising from the first working group meeting was the reaffirmation of a commitment from the investigators to work towards having a "virus-centric" research project, where investigators from all labs are invited to participate and compare methods. Locations for this program, to most likely be carried out in 2008, are still being discussed as is the potential funding.

Plans for the next working group meeting.

Currently we are planning to hold a meeting in 2007, most likely somewhere central to most of the members. We have already had members in Europe as well as the United States volunteer to host this meeting. We are still planning for a final meeting in 2008 in France (to be locally hosted and organized by Markus Weinbauer).

Overall progress of working group in completing its terms of reference, in reference to the initial time schedule for the group.

In general the group is making significant progress in all of its goals. We anticipate that charges to authors for our publication will be made in August, with a submission date of sometime in early 2007. We hope to have drafts of the manuscripts completely ready for review by the core members at the 2007 meeting, with late 2007 representing a target publication date.

SCOR WG126 members were also involved in the *"Practical workshop on virus ecology methods"*, organized by Full Member W.H. Wilson. Held at the Marine Biological Association labs in Plymouth, UK, in July 2006, the workshop involved eight SCOR WG 126 members who acted as instructors, local graduate students who acted as demonstration "assistants" and 31 students from around the globe who spent the week discussing various aspects of methods, participating in hands on demonstrations of cutting-edge techniques, and developing connections with the course "experts". Information on this course is available at (http://viruses.bluemicrobe.com/workshoponvirusecologyme.htm) - the course practical manual is also included in this report (appended after the Vancouver meeting synopsis).

APPENDIX I: Outline of publication being produced by WG 126
METHODS IN AQUATIC VIRUS ECOLOGY

Editor: **Paul F. Kemp**
Organizing editors: **Curtis A. Suttle, Markus G. Weinbauer and Steven W. Wilhelm**
To be published by the American Society for Limnology and Oceanography

Section I. Introduction
Section II. Sampling:
1. Traditional methods for concentrating viruses from water
2. Concentration of viruses from water samples by tangential flow
3. Separation of virus particles from sediments in aquatic systems

Section III. Enumeration:
4. Direct counts of viruses by epifluorescence microscopy
5. Determining virus abundance by flow cytometry
6. Estimation of infectious virus titre by plaque assay or MPN assay

Section IV. Characterization:
7. Transmission electron microscopy of viruses and viral communities
8. Characterization of virus lytic cycles.

Section V. Virus production:
9. Estimating virus production rates
10. Estimating the abundance of lysogens
11. Virus-induced mortality and geochemical implications

Section VI. Isolation and purification of viruses:
12. Isolation of viruses infecting photosynthetic and non-photosynthetic protists
13. Isolation of viruses infecting cyanobacteria
14. Isolation of viruses infecting aquatic heterotrophic bacteria
15. Purification of virus particles with centrifugal gradients
16. Preparation and application of fluorescently labeled virus particles

Section VII. Molecular methods:
17. Isolation of nucleic acids from virus particles and communities
18. PCR primers, probes, and the construction of gene libraries
19. Fingerprinting virus communities by DGGE
20. Fingerprinting virus communities by PFGE
21. Construction of microarrays and applications to virus analysis
22. The challenges of metagenomics with virus communities

Section VIII. Whole community experiments:
23. Mesocosm experiments with virus communities
24. Field studies over spatial and temporal scales

APPENDIX II: Program and abstracts from June 2006 meeting of WG126

THE SCIENTIFIC COMMITTEE FOR OCEANOGRAPHIC RESEARCH

WORKING GROUP ON MARINE VIRUSES – WG 126

Virus Ecology in Marine Systems: a workshop on methods

JUNE 1 – 3, 2006, THE UNIVERSITY OF BRITISH COLUMBIA, VANCOUVER, BC

MEETING SCHEDULE

Thursday 1 June

Location: Peter Wall Institute for Advanced Studies, University Centre, 6331 Crescent Rd., UBC

1630 to 1900 ***REGISTRATION AND MIXER***

Friday 2 June

Location: Michael Smith Lab, Auditorium, Rm 102, 2185 East Mall, UBC

INTRODUCTORY REMARKS

0800 POSTER SET-UP AND LOADING OF TALKS

0900 A BRIEF WELCOME AND MEETING LOGISTICS **- CURTIS A. SUTTLE**

0910 OVERVIEW OF WG 126 GOALS- CHALLENGES, ROADBLOCKS AND PITFALLS
MARKUS G, WEINBAUER & STEVEN W. WILHELM

I. ACCURATE ESTIMATES OF VIRUS ABUNDANCE AND PRODUCTION

0925 COLLECTION, PROCESSING AND PRESERVATION FOR DIRECT COUNTS AND FLOW CYTOMETRY - **CORINA P.D. BRUSSAARD** – Royal Netherlands Institute of Sea Research, Netherlands

1000 WORKING WITH VIRUSES IN MARINE SEDIMENTS **–**
JANICE E. LAWRENCE – University of New Brunswick, Canada

1035 Coffee Break

1055 DETERMINING VIRUS-MEDIATED MORTALITY IN MARINE SYSTEMS –
MARKUS G. WEINBAUER- CNRS Oceanographic Laboratory – Villefranche sur Mer, France

1130 ISOLATION AND CHARACTERIZATION OF NEW VIRUS – HOST SYSTEMS –
KEIZO NAGASAKI – Fisheries Research Agency – Hiroshima, Japan

1205 ***Lunch Break (on your own)***

II. GENE-BASED ESTIMATES OF VIRUS DIVERSITY

1400 COMMUNITY PROFILING WITH DGGE AND SEQUENCING - **STEVEN M. SHORT**– University of Denver, USA

1435 CHARACTERIZATION OF CONSERVED GENES FOR VIRUS GROUP - **FENG CHEN-** University of Maryland, USA

1510 POSTER SESSION

1730 ***Adjourn for day***

1900 BANQUET – Peter Wall Institute for Advance Studies, University Centre, 6331 Crescent Rd., UBC

Saturday 3 June

Location: Michael Smith Lab, Auditorium, Rm 102, 2185 East Mall, UBC

III. GENOMICS, GENOME ANALYSIS and METAGENOMICS

0900 ***Meeting Logistics*** **- CURTIS A. SUTTLE**

0905 APPLICATION OF MICROARRAYS IN THE CHARACTERIZATION OF VIRUS GENOMES - **WILLIAM H. WILSON** – Plymouth Marine Labs, UK

0940 THE GENOMICS OF PHAGE - **ROGER W. HENDRIX** – University of Pittsburgh, USA

1015 Coffee Break

1035 METAGEMOMICS AND THE MARINE VIRUS COMMUNITY – **K. ERIC WOMMACK**– University of Delaware, USA

1110 THE GLOBAL MARINE VIRIOME - **ROBERT A. EDWARDS**– San Diego State University, USA

1145 ***Lunch Break (on your own)***

1400 METAGENOMICS WITH RNA VIRUSES - **CURTIS A. SUTTLE**– University of British Columbia, Canada

IV. GLOBAL IMPLICATIONS FOR MARINE VIRUSES

1435 THE SYNERGY BETWEEN VIRUSES IN NUTRIENT CYCLES AND SYSTEM GEOCHEMISTRY - **STEVEN W. WILHELM** – University of Tennessee, USA

1510 Coffee Break

1530 THE GLOBAL ROLE OF VIRUSES IN BLOOM TERMINATION, BIODIVERSITY AND MARINE ECOLOGY - **GUNNAR BRATBAK** – University of Bergen, Norway

1605 IMPLICATIONS ON GLOBAL SCALES - THE DEVELOPMENT OF MODELS FOR VIRUS ACTIVITY - **MATHIAS MIDDELBOE** - University of Copenhagen, Denmark

1640 MEETING WRAP-UP – SUMMARY

1730 Meeting Adjourns

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2.2.12 SCOR/IAPSO WG 127: Thermodynamics and Equation of State of Seawater (2005)

Terms of Reference:

- To examine the results of recent research in ocean thermodynamics with a view to recommending a change to the internationally recommended algorithms for evaluating density and related quantities (including enthalpy, entropy and potential temperature). Such recommendations would take into account the reformulation of the International Temperature Scale (ITS-90).
- To examine the most accurate recent knowledge of the freezing temperature of seawater, the calculation of dissolved oxygen, and the behaviour of seawater at high salinity.
- To examine the feasibility of using simple functions of three-dimensional space to take account of the spatially varying concentrations of alkalinity, total carbon dioxide, calcium and silica place on the determination of density in the ocean.
- To extend these concepts to a wider range of physical/chemical issues of relevance to the internal working of the ocean and of its interaction with the atmosphere and to present and potential future observational techniques.
- To write a set of related recommendations on the above topics in the form of a report to SCOR/IAPSO and a review or series of reviews to be published in the scientific literature.

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Valentina Gramm-Osipova	RUSSIA	Petra Spitzer	GERMANY
David Jackett	AUSTRALIA	Dan Wright	CANADA
Brian King	UK		

Executive Committee Reporter: Shiro Imawaki

SCOR/IAPSO WG 127 on the Thermodynamics and Equation of State of Sea water

Progress as at 31 July 2006

This working group was approved in 2005 and had its first meeting in May 2006, hosted by Dr Rainer Feistel at the Leibniz-Institut fuer Ostseeforschung, Warnemünde, Germany. The present membership is as follows

Full Members

Trevor J. McDougall, Chair (Australia)
Rainer Feistel (Germany)
Chen-Tung Arthur Chen (Taiwan)
Valentina N. Gramm-Osipova (Russia)
David R. Jackett (Australia)
Brian A. King (UK)
Giles M. Marion (USA)
Frank J. Millero (USA)
Petra Spitzer (Germany)
Dan Wright (Canada)

The first meeting in May 2006 was attended by all members except Valentina Gramm-Osipova (who was ill) and David Jackett and Petra Spitzer who were both added to the membership after the meeting.

1. Working Group Meetings

At the first meeting in May 2006 at Warnemünde we spent four days working through an agenda that closely resembled the 21 issues listed in our Terms of Reference. We had in front of us a set of position papers that had been prepared previously by several members of the working group. Progress was made on each item, with milestones constructed for work to be completed by a series of dates leading up to our next meeting in May 2007. We agreed on some important basic features of a new description of seawater thermodynamics, for example,

- That the primary standard for fresh water will be that defined by the International Association for the Properties of Water and Steam (IAPWS) and known officially as the "Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use", briefly "IAPWS-95" (Wagner and Pruß, 2002, *Journal of Physical and Chemical Reference Data*, **31**, 387-535). The properties of seawater will be defined relative to those of fresh water described by IAPWS-95. This new description of seawater will be in form of a single thermodynamic potential function (Gibbs function) as a primary standard, rather than by a set of equations like the current EOS-80 formulation. From this primary standard, practical approximate equations for specific quantities or purposes will be derived, for

example, equations that are valid in restricted parameter ranges or are designed for improved computational speed.

- All new algorithms will be in terms of the 1990 international temperature scale. We are still discussing how this will actually be achieved.
- We outlined a hierarchy of procedures by which we will check that the Gibbs function of Feistel (2003, *Progress in Oceanography*, **58**, 43-114) does indeed represent the raw data of the original published papers of the various thermodynamics quantities from which it was derived. This work is being carried out by several subcommittees of WG127 and will include the checking of various computer algorithms (in Fortran and Matlab) that produce the thermodynamic quantities of interest from the Gibbs function of seawater.
- We hope to be able to extend the Gibbs function of Feistel (2003) to improve its accuracy (especially freezing temperature, enthalpy and specific heat capacity) for very salty water (from approximately 50 to 110 g/kg) for temperatures up to 40°C and pressures up to 100 MPa = 10,000 dbar.
- We are actively considering defining a new salinity variable, called "reference salinity" S_R, which is quantitatively identical with "absolute salinity" S_A within practically reasonable limits. The reason for this formal distinction is that the exact chemical composition of real sea salt is unknown (and will be unknown in the foreseeable future), but the stoichiometry of the reference sea salt can suitably be specified, based upon the latest standard atomic weights, for use in theoretical and chemical models, or experiments with artificial seawater. We do not advocate phasing out the use of practical salinity S. There are three main reasons for introducing an extra salinity variable. First, freshwater content of seawater is $(1 - 0.001S_A)$ not $(1 - 0.001S)$, and S_A and S are known to differ by about 0.5%. There seems no good reason for continuing to ignore this known difference in ocean models. Second, salinity expressed in the PSS-78 scale is outside the system of SI units. Reference salinity is expressed in units of g/kg, as absolute salinity. This approach could terminate the ongoing controversies in the oceanographic literature about the use of "psu" or "pss" and makes research papers readable to the outside scientific community. Third, the next largest improvement in the equation of state of seawater (with respect to that derived from Feistel (2003)) will come from incorporating the variation in the composition of seawater. It is known that the ratio of various constituents of seawater vary throughout the world ocean. This variation impacts (i) the determination of S_A from measurements of conductivity ratio, and (ii) the dependence of density on both S and on S_A. We are investigating methods of estimating the difference between these two types of salinity so that measurements of conductivity ratio (and hence of Practical Salinity) plus additional information (such as nutrient measurements) can be used to estimate S_A. We are also investigating whether the various thermodynamic properties of interest can then be determined to sufficient accuracy from knowledge of S_A alone (that is, without having to know the concentrations of all the individual constituents).
- Through a sister relationship with the International Association for the Properties of Water and Steam we are advocating further measurements on the properties of seawater and the development of more accurate and more robust refractive index sensors from which absolute salinity could be calculated.

2. Requests to SCOR concerning membership or terms of reference

The membership has been increased by two since the first working group meeting, and there are no further requests for changes in membership at this time.

3. Activities between working group meetings

Many of the issues on our agenda are being pursued by individual members, and by subcommittees of WG127, and we expect substantial progress on these issues by the time of our second meeting in May 2007.

4. Next Working Group Meeting

The next meeting of the working group is planned for the week of 7-11 May 2007 at the University of Messina in southern Italy where colleagues of Professor Frank Millero have offered to host the meeting. Since our working group needs to meet for many days of concentrated discussion, there is no particular advantage in holding our meeting in conjunction with an existing scientific conference.

5. Assessment of Progress

The working group has begun with a burst of enthusiasm and much inter-sessional activity in the few months since May 2006. We are pleased with the progress made at the first meeting and have achieved some of our milestones since May. We will push forward with the other issues on our 2006-2007 action list so that we can review progress in May 2007 and assess how far we are then from our end goal of a redefined Gibbs function and redefined salinity for seawater.

Trevor J McDougall
Chair, SCOR/IAPSO Working Group 127

2.2.13 WG 128: Natural and Human-Induced Hypoxia and Consequences for Coastal Areas (2005)

Terms of Reference:

- Synthesize the state of the science for the following aspects of coastal hypoxia:
    - prevalence and spatio-temporal variability,
    - natural and human causes,
    - effects on the biogeochemistry and ecology, and
    - resistance, resilience and recovery of ecosystems.
- Identify gaps in our understanding of hypoxia and make recommendations for future research;
- Determine the requirements for observing and modeling hypoxia and its impacts in coastal systems; and
- Document the work of the group in a special issue of a peer-reviewed international journal or a book by a major world publisher.

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Temel Oguz	TURKEY
Nancy Rabalais	USA
Osvaldo Ulloa	CHILE

Associate Members:

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Werner Ekau	GERMANY
Ragnar Elmgren	SWEDEN
Elva Escobar	MEXICO
Andy Gooday	UK
Mike Kemp	USA
Silvio Pantoja	CHILE
Mary Scranton	USA
Anja van der Plas	NAMIBIA

Executive Committee Reporter: Robert Duce

Natural and Human-Induced Hypoxia and Consequences for Coastal Areas: Current Status
Annual Report – 2005/2006

1. Introduction

WG 128 was officially approved in August 2005, when SCOR had its annual meeting in Australia. Following the feedback received from the SCOR annual meeting, the original proposal was thoroughly revised and re-submitted to SCOR in October 2005. This group of experts will collect and synthesize the available data on coastal hypoxia and produce a state-of-the-science report that (1) documents the prevalence and variability of coastal hypoxia and its ecological and biogeochemical consequences, (2) identifies the gaps in our understanding, and (3) evaluates the requirements for observing and modeling hypoxia events and their impacts.

2. Activities since August, 2005

WG 128 is a multidisciplinary group of experts with 10 full members and 9 associate members. After the formation of WG #128, several activities have been undertaken, and some are still going on, including revision of the proposal and refinement of the terms of reference, preparation of a list of synthesis papers, etc. Contacts with IMBER, GLOBEC and LOICZ have been made to establish collaborations with this WG on the study and synthesis of coastal hypoxia and its consequences.

With regard to the organization of our first face-to-face meeting, we adopted the idea and suggestion from SCOR to hold it as part of an international conference. The co-chairs of WG 128 successfully proposed a session on "Natural and human-induced hypoxia in the ocean" (BG3.02) for the EGU annual Assembly in April 2006.

3. Vienna Meeting (April 6-7, 2006)

The Vienna Meeting of this WG was organized in three parts, which were well cross-linked. In day one (April 06, 2006), the EGU special session on coastal hypoxia took place. Altogether, 15 posters were displayed in the poster room for the entire day, covering a variety of aspects of hypoxia with wide geographic coverage (Annex 1). There was also an oral presentation program for this session, and six 15-minute lectures were presented, among which 5 lectures were given by the members of WG#128 with an audience of approximately 50 in the late afternoon (Annex 2).

Day 2 of the Vienna Meeting was reserved for the business meeting of WG # 128, with 13 WG members attending together with three other participants of the EGU Meeting. The April 7 meeting was focused on the revision of terms of reference (TORs) and planning for the activities of this WG in its lifetime, for example, to clarify the final products of this WG and to determine who will do what between meetings (Annex 3).

For the purpose of comparison, we list below the previous Terms of Reference in our proposal to SCOR dated October 31, 2005.

The working group will conduct its work by pursuing the following terms of reference:

1). Synthesize the state of the science for the following topics:

- *prevalence and spatio-temporal variability of natural and human-induced coastal hypoxia, particularly intermittent hypoxic events,*
- *retrospective examination of the effects of hypoxia on the biogeochemistry and ecology of coastal marine systems, particularly the role of daily to inter-decadal variability, and*
- *non-linearity (e.g., asymmetric influence) in effects of the formation of, and recovery of coastal ecosystems from, hypoxic events;*

2). Identify gaps in our understanding of hypoxia and make recommendations for future research;
3). Determine the requirements for observing hypoxic events and their impacts in coastal systems, and for modeling coastal hypoxia and its impacts;
4). Document the work of the group in a special issue of a peer-reviewed international journal or a book by a major world publisher.

As compared with the previous defined TOR for this Working Group#128, the revised form has become more condensed. For instance, the non-linearity effect in the proposal is removed, because we believe "non-linearity" is too vague and in fact non-linearity exists in many aspects of coastal oceanography. Rather we now put the emphasis on the effect of coastal hypoxia on biogeochemistry and ecology, and should pay attention to the resistance, resilience and recovery of ecosystems.

It was suggested that an economics expert with an awareness of coastal hypoxia-related issues be invited to join the WG Membership. LOICZ and SCOR will be approached for suggestions of an economics expert to be involved in the activities of this WG.

As far as the final products of this WG are concerned, fourteen titles were tentatively proposed at the Vienna Meeting:

- Natural and human forcing/causes of hypoxia;
- Geographical coverage of hypoxia occurrence;
- Bibliography – breaking into papers/reports/books and reviews categories;
- Paleorecords of hypoxia;
- Future research avenues and knowledge gaps (including genomics, economics, model inter-comparisons);
- Worldwide oxygen trend patterns;
- Recovery following remediation efforts (including unanticipated side effects);
- Designing observation systems for studying coastal hypoxia;
- Hypoxia effects on the benthic-pelagic coupling – biogeochemical and ecological perspective – integrated view of organic matter fluxes, bioturbation, nutrient cycling within the sediments;
- Crossing the disciplinary boundaries of ocean physics and biogeochemistry (e.g., Benguela upwelling, Humbolt, GoM, Cariaco, etc.) – differences and commonalities;
- Consequences of hypoxic events on neighbouring coastal areas and open ocean;

- Hypoxia/anoxia as a source of greenhouse gases (N_20 and CH_4);
- Changes in hypoxia frequency and intensity with global warming;
- Overall SUMMARY.

The list of papers is currently being circulated among WG members to require revision and contributions. New topics may be proposed and/or some of above-mentioned titles will be changed in the mean time.

The consensus view at the Vienna Meeting was to recommend publication of our work in an international peer-reviewed journal, for example, an EGU open-access journal such as *Biogeosciences.* However, the final decision will depend on the funding availability to cover the publication cost, for which the possibility of obtaining extra funding should be explored.

At Vienna, participants discussed when and where to have the second meeting of WG#128. It was suggested that a mid-2007 or late-2007 meeting date appeared preferable to most people. People would present their draft synthesis papers at this second meeting, as a mechanism of sharing ideas with the broader scientific community and getting criticism. Organization of the meeting in early 2008 was discarded as being too late, with a danger of losing the WG's momentum. Following is a list of potential opportunities for holding the second meeting of this WG:

- IMBER - LOICZ Continental Margins Open Science Conference in 2007, suggested venue Shanghai. This concept is endorsed by both IMBER and LOICZ.
- Lima in 2007 - Second El Niño conference.
- AGU in San Francisco in December 2007.
- Large Marine Ecosystems in China in 2007.
- ASLO - Montreal August 2007.
- Estuarine Research Federation (ERF) in Providence, Rhode Island, USA on Nov. 4-8, 2007. Good Conference Center, 1400 people. Special session proposals are due June 30, 2006.
- Stockholm 3-day meeting for 40-50 people on coastal hypoxia with special funds, followed by SCOR WG128 meeting immediately afterwards. This has to be a one-time effort.
- NATO ARW grant for special workshop. Eutrophication might fit in. Might need to give half of the funds to eastern European countries (e.g., Black Sea countries).

Based on the feedback from IMBER and LOICZ, we assume that the second meeting of this WG will be held in Shanghai in late 2007, jointly with the LOICZ/IMBER continental margin open science conference (cf. attached letter from IMBER and LOICZ).

4. Links with other international programs

Communication of our activities to other scientific groups should be maintained to help move forward the study of coastal hypoxia and to establish partnerships with SCOR WG 128:

IMBER (Jing, Jack, Wajih)	GEOHAB (Pedro)
LOICZ (Nancy)	SCOPE (Venu)
GLOBEC (Werner, Anja)	Argo (Denis, Osvaldo)
SOLAS (Osvaldo)	GEOTRACES (Silvio)

Additional international program links may include:

Census of Marine Life - COMARGE/CHESS (Lisa) - link to OMZ;
International programs - umbrella programs – But it was felt that perhaps we should limit our linkages to ICSU-sponsored programs;
Argo would thus fall under the GOOS or CLIVAR program.

5. Individual tasks between Vienna meeting and second WG meeting

- April 15 - Denis – send list of proposed papers WITHOUT author names, so that everyone feels comfortable proposing his/her name for any paper. Ask WG members whether we have missed important topics at the Vienna meeting. Ask everyone to indicate which papers they would like to participate in as co-authors.
- April 15 – Denis and Jing - send the list of papers and minutes to group (Note: completed).
- May 05 - Temel – check if NATO absolutely requires a book in order to sponsor a workshop (Note: completed).
- May 05 - Werner – verify if someone at his lab (i.e., ZMT) is available to maintain private and public SCOR WG 128 Web site (Note: ZMT is unable to help, should think about another solution).
- May 05 – Everyone - send Nancy citations for bibliography on hypoxia around the world (Note: in progress).
- May 15 – Everyone – point out missing paper topics (Note: in progress).
- May 15 – Nancy - find out if LOICZ is willing to produce a SCOR coastal hypoxia private and public website. May have funds at her lab for an IT person who would design and maintain SCOR WG 128 website (Status: the delay of getting a data management system started at LOICZ until October or November indicates that an alternate site would be suitable. Nancy will check with her IT department for this help and the potential for a password-protected WG Web site for exchange of comments and documents).
- May 15 - Ragnar – examine the possibility of obtaining Swedish funding for a hypoxia workshop
- May 15 - Jack and Jing – ask Ed Urban about ways to support associate member travel expenses (Note: completed).
- May 20 – Nancy and Ragnar – propose name (s) of economics expert who could be added to WG membership.
- May 30 – Everyone - finalize authors' commitments to papers.
- June 15, 2006 – Jing and Denis – send annual report of WG activities to Ed Urban for SCOR.
- June 30 - Nancy - Propose a special coastal hypoxia session for Estuarine Research Foundation meeting in Providence, Rhode Island (Status: based on the desire for a Continental Margins Open Science Conference in Shanghai, this will not be submitted).

- August 31, 2006 – Leading authors provide outlines of their papers.
- June 15, 2007 – Jing and Denis – send annual report of WG activities to Ed Urban
- Mid-2007 or late 2007 - Hypoxia workshop with draft papers ready.
- 2008 – Submit papers for special issue of *Biogeosciences*, or other suitable journals.

6. Preliminary ideas on the second meeting of this WG

We are recently informed that IMBER and LOICZ will organize a Joint Continental Margins Open Science Meeting in the second part of 2007, and people have proposed to have this meeting at Shanghai. We are proposing to have our second WG meeting at the same time as for the IMBER/LOICZ OSM, which will allow us to get contributions from external people working on the science of continental margins, the main focus area of our work on hypoxia. Moreover, IMBER and LOICZ are also two of the SCOR and/or IGBP projects we are currently maintaining strong cross links with.

We have only a rough idea on the budget requirement, that is, international travel to Shanghai for nine full members (JZ is a local person based at Shanghai), a meeting for two days and three nights at Shanghai plus per diem.

Annex 1.
Coastal hypoxia **POSTER** session

Author in Attendance:	**Thursday, 6 April 2006 15:30 - 17:00**
Display Time:	Thursday, 6 April 2006 08:00 - Thursday, 6 April 2006 19:30
Chairperson:	LEVIN, L.

A0001 EGU06-A-00643; BG3.02-1TH4P-0001
Ivanova, E.; Sergeeva, N.
Small-scale patches of hypoxic sediments: a comparison of diversity of patch-associated and background meiofauna

A0002 EGU06-A-01169; BG3.02-1TH4P-0002
Gilbert, D; Sundby, B; Gobeil, C; Mucci, A; Tremblay, G.-H.
Linking northwest Atlantic physical oceanographic processes to the oxygen regime of the St. Lawrence Estuary

A0003 EGU06-A-01754; BG3.02-1TH4P-0003
Naik, H.S.
Sedimentary Nitrogen Cycling Over the Western Continental Shelf of India

A0004 EGU06-A-02105; BG3.02-1TH4P-0004
Ekau, W.
Large Scale Low Oxygen controlling Distribution Patterns of Early Life Stages of Fish in the Northern Benguela and Southern Angola Currents. (solicited)

A0005 EGU06-A-02483; BG3.02-1TH4P-0005
Zhang, J.; Zhang, G.L.; Wu, Y.; Ren, J.L.; Liu, S.M.
Seasonal hypoxia and its impact on the coastal ecosystems off the large rivers in China

A0006 EGU06-A-10641; BG3.02-1TH4P-0006
Katsev, S; Sundby, B; Mucci, A
Predicting the geochemical response of sediments affected by hypoxia in the Lower St. Lawrence Estuary

A0007 EGU06-A-10643; BG3.02-1TH4P-0007
Chabot, D.; Couturier, C.; Dutil, J.-D.; Claireaux, G.
Non-lethal hypoxia reduces growth rate in fish due to a narrowing of their metabolic scope: demonstration with Atlantic cod, common wolffish and sole

A0008 EGU06-A-10937; BG3.02-1TH4P-0008
Lavik, G.; Stuehrmann, T.; Fuchs, B.; Bruechert, V.; Amann, R.; Lass, U.; Kuypers, M.
Anaerobic oxidation of hydrogen sulfide coupled to nitrate reduction in Namibian Coastal waters

A0009 EGU06-A-10938; BG3.02-1TH4P-0009
Yin, K.
Lack of seasonal hypoxia in spite of high nitrogen enrichment in the Pearl River estuary and adjacent coastal waters

A0010 EGU06-A-04829; BG3.02-1TH4P-0010
Oguz, T.
Hypoxia and Anoxia in the Black Sea (solicited) (Poster)

A0011 EGU06-A-01751; BG3.02-1TH4P-0011
Falina, A.; Volkov, I.
Thermohaline and hydrochemical structure of the deep waters in the eastern basin of the Black Sea observed in 1997-2005. (Poster)

A0012 EGU06-A-01737; BG3.02-1TH4P-0012
Dewitte, B.; Pizarro, O.; Echevin, V.; duPenhoat, Y.
The seasonal cycle of the oxygene minimum zone and the extra-tropical Rossby wave in the South Eastern Pacific (solicited) (Poster)

A0013 EGU06-A-08561; BG3.02-1TH4P-0013
Machain-Castillo, M.L.; Diego-Casimiro, G.; Ruiz-Fernández, A.C.; Cuesta-Castillo, L.B.
Living (rose bengal stained) benthic foraminifera from the oxygen minimum zone in the Gulf of Tehuantepec, Mexican Pacific. (Poster)

A0014 EGU06-A-03710; BG3.02-1TH4P-0014
Szajdak, L.; Zyczynska-Baloniak, I.; Szczepanski, M.
Function of small pond as biogeochemical barrier for the decrease of different kinds of nitrogen in agricultural landscape (Poster)

A0015 EGU06-A-04673; BG3.02-1TH4P-0015
Gilbert, D; Freeland, H; Tran, A
Oxygen measurements on Argo floats (Poster)

Annex 2.
Coastal hypoxia **ORAL** session

Thursday, 6 April 2006, 17 :30-19 :00

Lecture Room: Lecture Room 19

Chairperson: OGUZ, T.

17:30 EGU06-A-01720; BG3.02-1TH5O-001
- **Naqvi, W.**; Naik, H.; Jayakumar, A.; Shailaja, M.; Pratihary, A.; Narvekar, P.
17:45 Seasonal oxygen deficiency over the western continental shelf of India (solicited)

17:45 EGU06-A-01353; BG3.02-1TH5O-002
- **Rabalais, N**
18:00 Hypoxia in the Gulf of Mexico (solicited)

18:00 EGU06-A-01793; BG3.02-1TH5O-003
- **Levin, L.**; Cowie, G.; Woulds, C.; Lamont, P.; Whitcraft, C.
18:15 Oxygen minimum zone influence on benthos: boundary effects, thresholds and bioturbation. (solicited)

18:15 EGU06-A-02014; BG3.02-1TH5O-004
- **Gooday, A.J.**; Larkin, K.E.
18:30 The ecological role of benthic foraminifera in low-oxygen environments and their use as indicators of hypoxia in the historical and geological records (solicited)

18:30 EGU06-A-06887; BG3.02-1TH5O-005
- **Bruechert, V**; Zitzmann, S; Stief, P; Julies, E; Currie, B; Peard, K; Van der Plas, A;
18:45 Endler, R
Biogeochemistry of hydrogen sulfide and methane in sediments of the Namibian upwelling system and their relationship to water column anoxia and nutrient levels (NAMIBGAS)

18:45 EGU06-A-01717; BG3.02-1TH5O-006
- **Monteiro, P.**; Florenchie, P.; Queiroz, T.; van der Plas, A.
19:00 The nature and dynamics of oceanic forcing of seasonal and interannual variability of coastal hypoxia in the Benguela upwelling system (solicited)

19:00 END OF SESSION

Annex 3.
Plan for the First WG Meeting at Vienna (April 7, 2006)
1) Objectives
1. To refine the terms of reference for SCOR WG 128.
2. To clarify the final products of this SCOR WG.
3. To determine who will do what with relevant schedule for the lifetime of this WG.
4. Design a detailed plan of activities between the Vienna meeting and our second WG meeting.

2) Introduction
WG Members take about 5 minutes each to describe their research activities and results. What do you personally expect this WG to achieve? What contributions do you think you can make with respect to the terms of reference? Which tasks do you want to assume leadership for?

3) Terms of Reference
The working group will conduct its work by pursuing the following terms of reference:

1. Synthesize the state of the science for the following aspects of coastal hypoxia:

- prevalence and spatio-temporal variability
- natural and human causes
- effects on the biogeochemistry and ecology
- resistance, resilience and recovery of ecosystems;

2. Identify gaps in our understanding of hypoxia and make recommendations for future research;
3. Determine the requirements for observing and modeling hypoxia and its impacts in coastal systems;
4. Document the work of the group in a special issue of a peer-reviewed international journal or a book by a major world publisher.

Question 1: Who will do what before our second WG meeting?

Question 2: Is there any expertise missing on WG to allow it to achieve its terms of reference? Geographical expertise? Disciplinary expertise? …… LUNCHTIME

4) Final products
We should decide whether we need a workshop on coastal hypoxia. It will be less expensive and easier to do the WG's work without a workshop, but the group may want to reach out to a larger community of interested individuals. The group may need to find outside funds if we want to do a workshop.

- Original research papers OR reviews/synthesis papers? Is there enough new material to justify writing new syntheses papers? Is it the right time?
- Monograph (book) or special journal issue?
- Paper on forcing/causes of hypoxia

- Paper on future research avenues and knowledge gaps?
- Paper on worldwide oxygen trend patterns (and temporal variability)
- Paper on designing coastal hypoxia observation systems?
  - What observations techniques do we require?
  - Automated versus ship-based observation systems
  - Sustainability of the observation system: long-term monitoring versus short-lived research program?
- Paper on models -designing data assimilation and prediction systems?
  - What kinds of models are required? Should we promote model intercomparisons?

5) Subgroups - white paper writing teams (Lisa's email)

(a) forcing/causes of hypoxia - including complex interactions and variability
(b) susceptibilities to hypoxia - ecosystems, settings, geographic regions, organisms
(c) consequences of hypoxia - system responses: biogeochemistry, ecology, anthropogenic and socio-economic issues. Cascading effects; Benthic-pelagic interaction
(d) remediation/ resilience/recovery of physical, chemical features, biological structure and function
(e) historical patterns/ temporal variability

6) Links with other international programs

Communication of our activities to other scientific groups: to what extent do we need to publicize our work, and how do we do it?

IMBER (Jing, Jack, Wajih)	GEOHAB (Pedro)
LOICZ (Nancy)	SCOPE (Venu)
GLOBEC (Werner, Anja)	Argo (Denis, Osvaldo)
SOLAS (Osvaldo)	GEOTRACES (Silvio) Others?

7) Other issues of discussion

- Next meeting – when, where, proposed activities
- Timeline for the WG's activities, particularly what will be done between meetings. Who will do what?
- Missing expertise on WG?
- Network – do we need a website ? Any volunteers for site maintenance?
- Draft report of our 2005-2006 WG activities to be sent to SCOR by mid –June.

8) WG members at the Vienna Meeting: Boris Dewitte (France), Werner Ekau (Germany), Ragnar Elmgren (Sweden), Denis Gilbert (Canada), Andy Gooday (UK), Lisa Levin (USA), Jack Middelburg (The Netherlands), Pedro Monteiro (South Africa), Temel Oguz (Turkey), Nancy Rabalais (USA), Mary Scranton (USA), Anja van der Plas (Namibia), and Jing Zhang (China-Beijing).

2.3 Working Group Proposals

2.3.1 Working Group on Deep Ocean Exchanges with the Shelf

Proposal for a Joint IAPSO/SCOR Working Group on Deep Ocean Exchanges with the Shelf

Background

As part of its strategy for the 21st century, the International Association for the Physical Sciences of the Oceans (IAPSO) has proposed a new scientific focus area on Deep Ocean Exchanges with the Shelf (DOES). The primary goal of DOES is to understand the physical and chemical interactions taking place at the shelf break between the deep ocean circulation and the shelf currents, and their impact on marine life and biogeochemical cycles. SCOR has identified interdisciplinary work focussed on the shelf break as a priority area for new working groups. IAPSO is thus proposing this joint working group.

The joint WG will consist of a mixture of physical, chemical and biological oceanographers, including both theoretical and observational experts. Although much of the work of the group will be concerned with planning better physical models of the shelf break region, an important aim is to include the requirements of chemical and biological oceanographers for output from such models. The involvement of scientists from developing countries will help to meet the capacity-building goals of both organisations.

The support of IAPSO and SCOR will enable the members of the working group to hold a first meeting to push forward the research required on this topic, to arrange a DOES workshop for all interested scientists, and to hold a final meeting to complete the final publication of the working group. Although much preliminary work can be conducted by email, it is vital to have face-to-face meetings to make significant progress.

Rationale - Deep Ocean Exchanges with the Shelf

The shelf break is a region of steep slopes, strong narrow currents, internal tides, shelf waves and significant vertical motion. With the advent of much finer resolution in ocean models, it is a good time to address the links between the shelf circulation and the deep ocean circulation at the shelf break. Improved understanding of the exchanges between the shelf and the deep ocean will be useful for more realistic models for studying climate, the carbon cycle, sedimentation and marine ecosystems. The increased detail in the improved models often leads to prediction of features that have not yet been observed. This can lead observational oceanographers to include fieldwork in their cruise plans that will either establish the existence of these new features or test the validity of the models.

Even as ocean models become more realistic by having much finer resolution in space and time, there are still significant problems in resolving the high variability that occurs around the shelf

break between the deep ocean and continental shelves. Modellers have often regarded the shelf break as the nominal seaward boundary of shelf models or the coastal boundary of deep ocean models. Even with the finest resolutions in ocean general circulation models, the shelf region is poorly resolved with only a few grid points. Ocean observers have had difficulty in securing measurements at the edge of the shelf due to the narrowness of the currents and steep slopes. However, new technologies are now enabling measurements in such challenging environments. For example, swath bathymetry gives accurate bottom topography, the ship's dynamic positioning allows precise placing of moorings and acoustic Doppler current profilers allow measurements throughout the water column even in strong currents. At the same time, fine-scale (1km or less) coastal models such as the Regional Ocean Model System (ROMS) with multiple depth layers are now being used to model the movement of water, chemical species and sediments on the shelf, and are being connected to biogeochemical models of the local ecosystem. Meshing these models into larger-scale deep ocean models offers the chance to resolve some of the unknowns.

The exchanges and fluxes that occur near the shelf break are important parts of the global ocean circulation. These fluxes include sediments and biomass as well as seawater. Coupled ocean-atmosphere general circulation models require, for example, the input of freshwater outflow from rivers. These inputs are generally added at the location of the river. But, in reality the fresher water flows along the shelf, sometimes for considerable distances, before it crosses the shelf break and enters the deep ocean (for example, along the Oregon coast, as has been modelled by Baptista et al. (2005)). Similarly, the formation of Antarctic Bottom Water and other dense water masses often occur over continental shelves before they flow offshore. An example of a biological flux is the movement of patches of krill on and off the Antarctic shelf, as described by Murphy et al. (2004).

Strong tidal mixing at the shelf break and over variable topography is an important feature in the energy balance of the Earth's oceans (see, for example, Jayne and St.Laurent (2001), Wunsch and Ferrari (2004)). Internal and surface tides are built into shelf models but are usually absent from deep ocean general circulation models. Strong mixing associated with significant topography is an important component in the theories of the global thermohaline circulation. Coastal models often use terrain-following coordinate systems (sometimes called sigma coordinates). Although this method deals better with the changes in shelf slopes compared with models using standard grid boxes, they introduce significant problems due to pressure gradient force error as described in Berntsen and Furnes (2005).

A new generation of high-resolution models is under development including, for example, (i) the Nucleus for European Modelling of the Ocean (NEMO) begun in France but now forming the basis of a wider European project and using interactive nesting (see www.lodyc.jussieu.fr/NEMO/); (ii) the next generation of the Hamburg Shelf Ocean Model (HAMSOM), called the Vector Ocean-Model (VOM), including biological and physical coupling on an unstructured adaptive grid (see Harms et al. (2003)); (iii) the Imperial College Ocean Model (ICOM) using an unstructured mesh (see Gorman et al. (2006)); and (iv) the Hybrid Coordinate Ocean Model (HYCOM) a data-assimilative hybrid isopycnal-sigma-pressure coordinate ocean model (see Chassignet et al. (2006)). The WG will monitor the progress of

these new models, and encourage the use of such models for looking at the details of processes near the shelf edge and for the inclusion of biogeochemical fields. The WG will also encourage further observations in regions that can validate and enhance the understanding of the model output.

With the advent of the new observational technologies and the new generation of ocean models, this is an appropriate time to set up this working group. Improved models and observations leading to a better understanding of the processes that occur between the shelf and the deep ocean will be of benefit in maintaining fish stocks and dealing with threats of pollution from oil and gas wells, and for studying river runoff and sedimentation. Coastal areas are often regions of enhanced primary production due to coastal upwelling. Understanding the carbon cycle in such ecosystems is relevant to climate studies.

Interaction with other programmes

Two existing SCOR WGs have links with this proposed WG. The published output from WG 111 on Coupling Waves, Currents, and Winds in Coastal Models will form part of the current knowledge of shelf oceanography. The ongoing IAPSO/SCOR WG 121 on Ocean Mixing will provide useful input about deep ocean mixing to the proposed WG.

The ongoing international Antarctic Zone (iAnZone) project (an affiliated programme of SCOR) is concerned with modelling and observations in the Southern Ocean, including strategies to understand climate variability in the Antarctic Zone. It includes the Synoptic Antarctic Shelf-Slope Interactions Study (SASSI); a programme of observations over the Antarctic shelf and slope as part of the International Polar Year (see http//roughy.tamu.edu/sassi/sassi.html).

The carbon cycle in the shelf and upwelling zones is an important ingredient for the modelling by the Climate Variability and Predictability (CLIVAR) programme. The discussion of applications on chemical and biological fluxes needs to be in collaboration with projects such as the International Geosphere-Biosphere Programme (IGBP) Land-Ocean Interactions in the Coastal Zone (LOICZ) project and the SCOR/IGBP Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) project. IMBER is particularly concerned with how long-term global change (including changes to the deep ocean/shelf fluxes) will affect biochemical cycles and ecosystems. Members of the WG would interact with scientists involved in these programmes to determine the mutual benefit that can be derived from collaboration and to avoid unnecessary duplication.

Other important collaborators are to (i) the Surface-Ocean-Lower Atmosphere Study (SOLAS) for their interest in biogeochemical interactions and feedbacks between ocean and atmosphere, and (ii) GEOTRACES, the international study of global marine biogeochemical cycles of trace elements and their isotopes, where the proposed WG can help with the understanding of the processes in the ocean that affect the concentrations of these tracers. Links between the proposed working group and SOLAS and GEOTRACES will be straightforward as members of their steering and planning committees work in the same building as the proposed chairman of the proposed WG.

Statement of Work / Terms of reference
IAPSO proposes the formation of an international joint working group with SCOR to advance modelling and observations of deep ocean exchanges with continental shelves. IAPSO wishes to foster research work on the links between shelf and deep-sea oceanography by using the working group to generate ideas and encouragement for future research by the wider oceanographic community with funding from national and international bodies.

The working group will complete the following tasks, over a period of four years:

1. Establish the current state of knowledge and make recommendations for future research related to the following topics:

- processes due to shelf waves, internal tides, shelf-break upwelling;
- river and estuary input of sediment and fresh water into shelf seas;
- dissipation of tidal motion along the continental margins;
- chemical and biological flux exchanges between the deep ocean and coastal ecosystems;
- the influence of ocean physics and chemistry around the shelf break on fisheries and climate; and
- coupled physical-chemical-biological numerical models that have a more realistic description of the exchanges at the shelf edge.

2. Determine where further observational programmes (using improved technology) are needed to improve understanding of shelf-break processes and to provide help with the formulation of more realistic models of the fluxes between the shelf and the deep ocean;
3. Serve as an international forum for oceanographers to discuss current research on the interaction between the coastal zone and the deep ocean, by using the services and membership database provided by IAPSO.
4. Foster collaboration between developed and developing countries that have interest in the shelf zone; limited-area models are required to help scientists in countries that do not have access to large computers, and
5. Produce a comprehensive, published final report incorporating the latest results on the above topics. This report will be in a form of a special issue of a peer-reviewed journal or a book by a major publisher.

Timetable: If approved by SCOR, the following three working group meetings will be held:

4. The proposed first formal meeting of the WG will take place in July 2007 in association with the International Union of Geodesy and Geophysics meeting in Perugia, Italy. Preliminary work prior to this meeting (conducted by email) will lead to identification of additional Associate WG members, and the creation of an agenda for the meeting.
5. The second meeting will occur at the time of the proposed Workshop on Deep Ocean Exchange with the Shelf to involve a wider group of experts from many countries. To support delegates from developing countries, other sources of funding will be sought

(including ONR, the EU and SCOR). A venue in 2008 in a developing country would be ideal, for example Cape Town, South Africa.

6. The third and final meeting will be held in July 2009 in association with the IAPSO/IAMAS Joint Assembly to be held in Montreal, Canada. This meeting will be for final discussions to input into the final report of the working group.

Membership

Working group membership is proposed to consist of scientists from various countries with expertise in both modelling and observations of the oceans and in biological, chemical and physical oceanography. If approved, there are 10 proposed Full Members and 2 Associate Members whose travel will be funded by IAPSO. Further Associate Members may be identified to widen the WG expertise.

Full Members:

John Johnson (UK), Chair	Ocean models, particularly shelf. Limited area models.
Piers Chapman (USA), Vice-Chair	Marine chemistry. Nutrients and tracers in the ocean circulation.
Isabel Ambar (Portugal)	Ocean observations, particularly off Iberia. Meddies.
Jan Backhaus (Germany)	Shelf / ocean exchange. Slope convection. Biological models.
Hu Dunxin (China)	West Pacific Physical oceanography and marine sedimentation.
Wajih Naqvi (India)	Marine chemistry. IMBER Scientific Steering Committee. Marginal seas.
Alex Orsi (USA)	Cross-shelf exchanges. iAnZone co-chair. Convection and fronts.
Gordon Swaters (Canada)	Ocean models. Process studies.
Olga Trusenkova (Russia)	Bathymetric effects in the Japan Sea.
Takeshi Matsuno (Japan)	Water exchanges to/from Kuroshio. Biological production.

Associate Members (funded by IAPSO):

If this working group is approved, IAPSO will fund the travel costs for

Pedro Monteiro (South Africa)	Marine Chemistry. Benguela coast (ocean-shelf-river).
John Middleton (Australia)	Ocean circulation over continental shelves. Coastal trapped waves.

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2.3.2 Working Group on Automatic Plankton Visual Identification

Proposal for a SCOR Working Group on Automatic Visual Plankton Identification

Background and Rationale

One of the main problems confronting plankton research is low sampling resolution, both spatial and temporal. Although it is widely recognized that the relevant scales for plankton are much smaller than those usually sampled, the work involved in plankton sample analysis has made it impossible to sample at very high resolution in most programs. To some extent the lack of sampling capability has been resolved using simplified measurements such as Chl a, total biovolume, biomass (wet or dry weight) or more sophisticated systems providing size and number of particles (e.g., OPC). However, these methods lack the ability to distinguish between different functional groups of plankton known to have very different roles in the ecosystem (e.g., diatoms vs flagellates, marine snow, or copepods vs. appendicularians).

In recent years several *in situ* and laboratory imaging systems have been developed. These systems are capable of obtaining relatively good-resolution images at high sampling rates that would, in theory, allow quantification of the abundance of taxonomically well-resolved groups in the appropriate spatial and temporal scales (Wiebe & Benfield 2003). Development of these systems has presented a new problem: the manual analysis of images from such systems is impractical; due to the huge amount of information and quantities of images they produce. New image analysis systems offer a potentially advantageous solution compared to manual methods of counting and sizing. With the aid of image analysis and classification software and hardware, the images can be identified to at least major groups. Many sophisticated automatic recognition algorithms exist, and research in this area is very active. There is a very real potential of using image analysis techniques to obtain more refined taxonomic classification in the near term.

In the future, if marine science is to achieve any progress in addressing biological diversity of plankton in the ocean then it needs to sponsor development of new technology to image and identify specimens in plankton samples, acting as an adjunct to existing (and increasingly scarce) taxonomists and marine ecologists (Culverhouse et al. 2006). We propose to focus on the automation of identification. Drawing from recent progress in object recognition in the wider machine vision community marine scientists and engineers have had some significant successes in demonstrating automated recognition of plankton taxa.

A training set of objects is used to establish the pool of features and their prior distributions. Statistical and other pattern-classification methods are then used to cluster the feature occurrences in test specimens and hence derive identification. Thus, in the Automatic Diatom Identification and Classification (ADIAC) system (DuBuf and Bayer, 2000) a large set of morphological measurements (for example, specimen length, width, aspect ratio) is made of each specimen placed under the microscope. Some of these measurements are similar to those made by taxonomic experts and is similar to ZooSCAN (Grosjean et al., 2004), used for zooplankton

recognition and counting where a “forest” of classifiers is used. DiCANN (Dinoflagellate Identification by Artificial Neural Network; Culverhouse et al., 1996), a tool for dinoflagellate phytoplankton species recognition, analyses low-resolution shape, texture, and size characteristics, but uses the machine to discover how these features correlate with object classes through Support Vector Machine (SVM) clustering. Recently SIPPER (Shadow Image Particle Profiling Evaluation Recorder; Samson et al., 2001; Remsen et al. 2004) has employed SVM categorisers fed from shape moments, granulometric and domain-specific features to recognise five classes of plankton. The Video Plankton Recorder (VPR), developed at Woods Hole Oceanographic Institution, has been used as a test bed for a number of analysis protocols (Tang et al., 1998; Hu and Davis, 2005). The most recent VPR system demonstrated recognition through texture analysis and categorisation.

Using automation to assist experts in visual plankton identification is relatively new. Engineers and scientists developing these instruments usually assess machine performance through cycles of training and testing. Most systems in development at the moment rely on images of plankton collected from the field or from culture samples. The experimenter labels each specimen image, which is then processed by the machine. The machine-given label is then compared to the human-given label to assess machine performance. Once performance is at an acceptable level the machine is ‘released’ for more routine application. An important step in the evaluation, and subsequent widespread scientific use, of these identification machines is the validation of their labelling abilities. It must also be recognised that people are biased and can make mistakes whilst labelling specimens. These errors must be removed from reference data sets used for training machines (Culverhouse et al 2003). A factor governing the widespread adoption of these new machines is the level of confidence the community has in their performance, and the quality of their results. Existing manual methods are, in a sense, rigorously quality controlled. The same must be established for automatic methods.

A recent GLOBEC/SPACC-sponsored workshop held at San Sebastian, Spain, in November 2005, concluded that it was imperative to co-operate and not compete in the development of machine vision solutions for automatic labelling of plankton. The RAPID (Research into Automatic Plankton Identification) group arose from this, formed initially by members of the workshop. This group is ideally placed to support the development of standards and foster the spirit of co-operation. A team from the organising members of RAPID has liaised with SCOR WG115 on Standards for the Survey and Analysis of Plankton and produced this proposal for a new working group.

GLOBEC, IMBER, Census of Marine Life, and Census of Marine Zooplankton are some of the global initiatives that will benefit from the outputs of this working group. This is reason enough for an international approach to this work. However, it is also important from several other perspectives: plankton identification is an international problem, and a global approach will increase the visibility of local solutions to identification and perhaps also adoption of solutions from outside marine science. A common platform will make it quicker to integrate new software into applications that are immediately useable by marine scientists.

Relevance to Other SCOR Activities
This working group would be highly relevant to the future of the Continuous Plankton Recorder (CPR) and other time-series biological surveys as significant increases in throughput could be achieved by automation supporting manual analysis of samples. Automatic identification of common taxa will free taxonomists to focus on the more difficult identifications and deeper questions. This could also encourage 'new blood' into taxonomy and systematics.

The outcome of the proposed group could make collection of future data for worldwide comparisons of zooplankton populations easier (WG 125). The proposed group will consult regularly with the SCOR Panel for New Technologies for Observing Marine Life (two associate members of the proposed WG are members of the Panel—Gaby Gorsky and Sun Song), particularly on collaborative workshops.

An order-of-magnitude increase in existing analysis throughput is required to address the needs of global monitoring and research programmes such as GOOS, GLOBEC, and IMBER. Automation will help achieve this increase and the new working group would assist through the following terms of reference.

Terms of Reference
The RAPID group has identified an urgent need for a common software toolbox for plankton image classification, which is robust and flexible, allows data post-processing for ecology modelling and other applications and is fast for *in situ* real-time processing. It is accepted that open-source software, supported by a community, is a reliable way of generating robust code that is tailored to the needs of the community. These terms of reference are designed to foster and grow that community for automated visual identification of marine plankton, together with reviewing practices and establishing the necessary standards to ensure widespread uptake of these new technologies across biological oceanography. The working group will attempt to foster a confidence in marine scientists, who may feel threatened by the adoption of this technology. It will define standards for image data validation for use in training machines and people.

The proposed terms of reference are

- *To encourage the international co-operation of software developers and marine scientists to use and enhance the open-source development platform, so that a common toolset can be built up over time that is of value to the community.*

  Rationale: the RAPID community, as the basis of its toolset, has adopted the Zooimage common software platform. To be of value to the wider scientific community, this open-source toolset needs strong support from a critical mass of end-users and developers. This SCOR Working Group could achieve support through both dissemination activities and through the review of function and leading the debate of developer and end-user issues. The opportunity of an open-source platform for specimen identification is extremely important, as it gives all developers and users an easy way of extending and enhancing function with a low cost of effort. This is particularly important in developing nations where large repositories of taxonomic expertise exist but financial resources for acquisition of commercial software and

hardware are frequently limiting. This activity will best be addressed through a working group meeting to discuss dissemination and then through the Internet and academic/conference papers.

- *To review existing practices and establish standards in the use of reference image data used for training automation machines and in training people.*

  Rationale: A global database of specimens and images is needed for training machines and also for training experts. A pilot Web site to address this aim is being set up at both Plymouth University and Louisiana State University. However, the exact nature and function of the database should be defined by the biodiversity, ecology and taxonomy communities as well as the software developers. This working group would be well placed to stimulate discussion and establish international operational standards for the reference system, through the Internet, working group meetings and academic/conference papers.

- *To establish a methodology for inter-comparison/calibration of different visual analysis systems*.

  Rationale: wide availability of computer-based plankton recognition systems will cause difficulty for potential customers, as systems performances are compared. A common set of benchmark measurements will simplify the comparisons and strengthen both the developer community and the end-user confidence in these systems. Such benchmarks are commonplace in the computing industry. They need to be created for this new domain.

- *Encourage the adoption of the open-source ZOOIMAGE to the marine ecology, taxonomy and systems developers. Publish the products of reviews by members of the Working Group, selected presented papers and workshop reports in an internationally recognised, peer-reviewed journal or a book by a major publisher.*

The proposed working group will extend the dissemination activities to special sessions at existing international conferences, to raise the profile of progress and solutions. Funding for these activities will be sought from other agencies and foundations.

Sponsorship by SCOR would focus the international community on the working group's terms of reference, which will facilitate global debate and hopefully mark rapid progress in automatic plankton identification.

Working Group Composition (with plankton recognition systems in [...])
The working group will have two co-chairs, Mark Benfield (USA) and Phil Culverhouse (UK). Benfield is a marine scientist, but has worked on plankton recognition software for some years. Culverhouse is an electronics engineer with a background in biology and experimental psychology; he has been developing plankton identification techniques since 1989.

Full Members

Elena Arashkevich (Russia)	Zooplankton taxonomist
Mark Benfield (USA)	Zooplankton ecologist and machine vision software developer/user [VPR, ZOOVIS] **and co-chair of group**
Phil Culverhouse (UK)	Cognition, AI and machine vision engineer [HAB Buoy] **and co-chair of group**
Philippe Grosjean (Belguim) [Zooimage]	Statistician and machine vision software engineer
Maria Grazia Mazzocchi (Italy)	Zooplankton Taxonomist
Rubens Lopes (Brasil)	Zooplankton ecologist and machine vision user [Zooscan]
Angel Lopez-Urrutia (Spain)	Zooplankton ecologist and machine vision software developer [R-package]
Josué Alvarez-Borrego (Mexico)	Phytoplankton ecologist and machine vision developer
Mike Sieracki (USA)	Phytoplankton ecologist and machine vision software user [Flowcam]
Hans Verheye (South Africa)	Zooplankton taxonomist

Associate Members

Hans DuBuf (Portugal)	Engineer and machine vision developer for diatom ecology [ADIAC]
Gaby Gorsky (France)	Zooplankton ecologist and machine vision software developer/user [Zooscan, UVP]
Carin Ashjian (USA)	Zooplankton ecologist and machine vision software developer/user [VPR]
Xabier Irigoien (Spain)	Zooplankton ecologist and machine vision software user
Sun Sung (China)	Zooplankton ecologist and machine vision software developer/user
Bob Williams (UK)	Zooplankton ecologist and machine vision software developer/user [HAB Buoy]
Norm McLeod (UK)	Morphometrician morphometrics method developer, micropalaeontologist, with interest in machine vision software; also, as Keeper of Palaeontology at Natural History Museum, user/ link to terrestrial and paleontological systematics groups

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2.3.3 Working Group to coordinate the availability of a world register of marine species (WoRMS)

Proposal for a SCOR Working Group to coordinate the availability of a world register of marine species (WoRMS)

Background and rationale

An authoritative checklist of all marine species is urgently required to facilitate biological data exchange, marine biological data management, integration of biological with other ocean data, and to allow taxonomists to focus on describing new species instead of overlooking recently described species and correcting past nomenclatural confusion (Costello et al. 2006). The production of such a list has added benefits in fostering collaboration between experts at a global scale. Easy access to the list allows ecologists and local experts to correct their use of taxonomic names, and encourages submissions of overlooked species to the list. In turn, this stimulates biogeographic and evolutionary research.

Local and regional species checklists are also in demand for conservation and fisheries management, ecological surveys, and training in marine ecology and environmental management. However, these lists are inevitably compromised by either not being updated by experts, inheriting past misuse of names, using the same name for different species in different locations, using different names for the same species in different regions, or combinations of these problems. The solution is a single world checklist easily accessible on the World Wide Web, and updated by experts.

The absence of such a world list reflects the local and regional focus of marine biology in the past. Now, biodiversity informatics enables collaboration and data management to be fast at low cost (Costello and Vanden Berghe 2006). It is critical that the list is authoritative, freely accessible on the World Wide Web, and easily maintained and updated. However, there is no obvious existing coordinating body for such a world checklist.

This proposal is for establishment of a SCOR Working Group to develop a sustainable world register of marine species (WoRMS), including (a) a board of taxonomic editors who will maintain it, (b) a central data portal, and (c) a funding and management plan beyond the life of the working group.

The role of the Census of Marine Life (CoML), the International Association of Biological Oceanography (IABO), the Ocean Biogeographic Information System (OBIS), Catalogue of Life (and its partners Species 2000 and the Integrated Taxonomic Information System), Global Biodiversity Information Facility (GBIF), and other organisations and initiatives in providing a long-term structure for the management of WoRMS will be explored. At present, these initiatives have different or broader goals, not focused on producing a checklist of marine species. We are confident that we can coordinate and obtain funding for the creation of WoRMS during the tenure of this SCOR WG, and thereby ensure that a key component of marine data

management is available to the scientific community and other end users. Without the focus of a SCOR WG, it is unlikely that this will happen within the next few years. The results of this working group would contribute to other SCOR WGs, including those on plankton (WGs 115 and 125) and new technologies (WG 115). Progress will be reported to SCOR as required, and presented at the SCOR-supported conference on Ocean Biodiversity Informatics (OBI 2007) in Halifax, Canada, November 2007.

The WoRMS portal will be interoperable with existing Global Species Databases (GSD) containing marine species, including FishBase, Hexacorallians of the World, AlgaeBase, CephBase, UNESCO Register of Marine Species (URMO, contains list of several smaller marine phyla extracted from the literature), and others. We estimate that at least half of the estimated 200,000 described marine species are not included in existing registers of marine species and GSD. WoRMS will contribute to the Catalogue of Life, presently including almost 50% of all world species, and used by OBIS (www.iobis.org) and GBIF (www.gbif.org) as their master lists of species names. Rather than duplicate existing efforts, WoRMS would build on existing databases and focus on facilitating the filling of gaps by supporting funding applications.

WG members will directly apply for funding to create the authoritative lists and support their data management. Such proposals are planned for 2006 and will be assisted by the support of a SCOR WG. Potential funding sources include foundations, CoML, OBIS, the European Commission, the U.S. National Science Foundation, and national agencies. Proposed members have experience in marine biological data management, the coordination of the creation of European Register of Marine Species (ERMS) and its subsequent development, and expertise in particular taxonomic groups.

Terms of reference

The primary term of reference of this SCOR Working Group would be to develop a sustainable world register of marine species (WoRMS). The subsidiary tasks would be to create:

(a) a board of taxonomic editors who will maintain it,
(b) a central data portal, and
(c) a funding and management plan.

The results of the SCOR WG will be freely accessible on the Internet. This may be through an existing initiative or as a stand-alone portal, depending on the best strategy agreed by the WG. The timetable will include review of gaps in global registers of marine species, funding applications, online drafts, and plans for WoRMS sustainability (see Table 1).

The SCOR WG will meet annually at venues that are cost and time effective for participants. For example, one meeting may be in association with OBI 2007. Group work would start by email as soon as SCOR approval was received.

Table 1. Timetable for the WG.

Year	2006	2007				2008				2009		
Quarter	4	1	2	3	4	1	2	3	4	1	2	3
Review sources, identify gaps		x										
Funding for gaps	x	x	x									
Agree data exchange with existing sources			x									
Start filling gaps				x								
First draft of WoRMS online					x							
Draft strategy for WoRMS maintenance							x					
Second draft of WoRMS									x			
Mechanisms for WoRMS maintenance implemented											x	
WoRMS completed												x

Proposed Members
The proposed WG Members have expertise in

- international coordination of registers of marine species for Europe (Costello, Vanden Berghe) and southern Africa (Griffiths),
- data management (Vanden Berghe, Patterson, Palomares), and
- taxa which are highly rich in species, but lack global lists. The Crustacea (Lowry, Poore, Boxshall) and Mollusca (Rosenberg, Bouchet) comprise at least half of all marine species, but no global lists exist, except for smaller sub-groups such as Cumacea, Isopoda, Mysidacea, Euphausacea, and Aplacophora. The protists (Patterson) are a complex group of unicellular animals and plants whose classification is being rapidly re-organised with new molecular data.

A major parallel activity aims to create Web pages for all marine species through a synergy of several projects, including FishBase, SeaLifeBase, AllFish, AlgaeBase, Hexacorallians of the world, and one proposed member (Palomares) is directly involved with the first three. WoRMS will use biodiversity informatics tools to automate interactions with such projects. Full WG Members will use their existing involvement in related initiatives to maximise synergy of effort, for example,

- Costello for OBIS, CoML, GBIF, ERMS, IABO;
- Vanden Berghe for IODE, IOC, OceanTeacher; and
- Lowry for Crustacea.Net.

Associate Members will work largely by correspondence and will include custodians of existing registers of marine taxa at global and regional scales. Potential contributors to the working group, beyond the Full Members, are available upon request. Some of these individuals will be identified by the working group later as potential Associate Members, contingent upon approval by SCOR, based on (1) their relevant scientific expertise, (2) global and developing country balance in the WG, (3) gender balance in the WG, and (4) their availability to participate.

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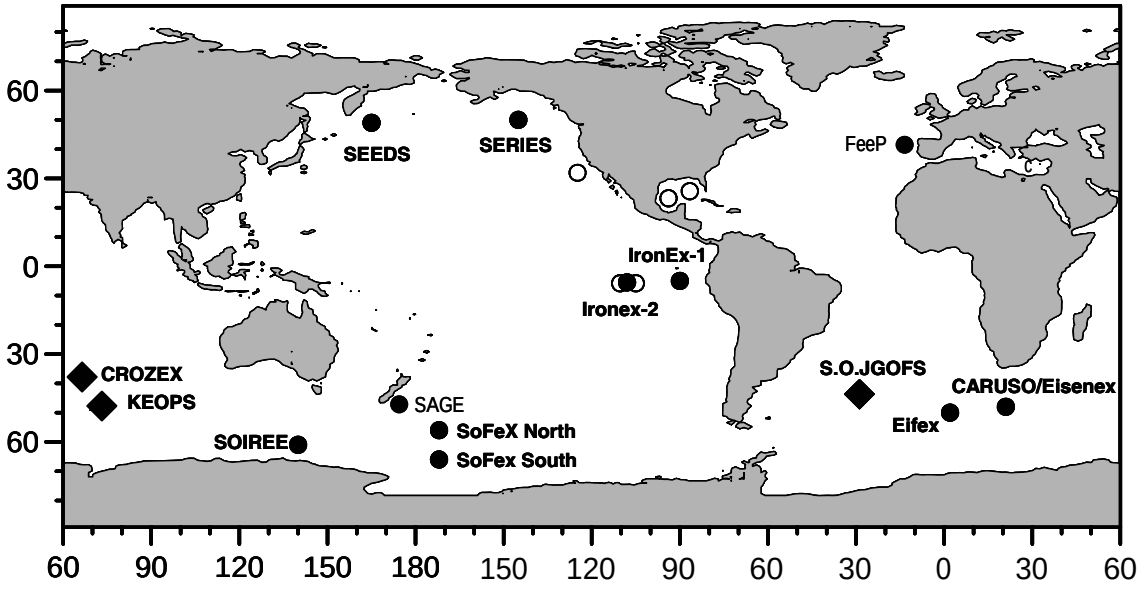
2.3.4 Working Group on The Legacy of in situ Iron Enrichments: Data Compilation and Modelling

Proposal for a SCOR Working Group
The Legacy of *in situ* Iron Enrichments: Data Compilation and Modeling

Introduction

From 1993 onward there have been 10 *in situ* iron fertilization experiments, from Ironex-1 (1993) to SEEDS-2 (2004), as well as 3 natural fertilization studies (1992 Southern Ocean JGOFS, 2004-2005 Crozex, 2005 KEOPS). Primary results of individual experiments have been reported in *Nature* and *Science* as well as in oceanography journals, sometimes in special issues of journals like *Deep-Sea Research II* and *Progress in Oceanography*. For the most recent experiments (e.g. Eifex 2004, SEEDS-2, CROZEX, KEOPS) primary results are now being processed into manuscripts.

Synthesis of the combined experiments has only just now started with one first semi-quantitative effort by multiple authors (*de Baar et al., 2005*) focusing on only the most basic variables (i.e., primary production, major nutrients, CO_2 system variables). This is seen as the modest first step toward more rigorous quantitative assessment by ecosystem simulation modeling of these unique time-series experiments. Nevertheless, several remarkable trends are becoming apparent from the combination of experiments. For example, light limitation due to depth of the wind-mixed layer was highly significant, and the major floristic response was always by larger size class diatoms, with almost universal flourishing of *Pseudonitzschia* sp. Unfortunately, during this first synthesis effort it was found that integrated datasets of even the earlier single experiments of the 1993-2000 period hardly existed, with one laudable exception (SOIREE, data CD in 2001 *DSR-II* special issue). At most, the individual scientists had their own data files which were kindly and generously made available. Sometimes fundamental data (e.g., hydrography, incoming sunlight or PAR) could hardly be traced; some other data of interest could not be located in time vis-à-vis the publication time frame of the synthesis article.



The *in situ* fertilization experiments (filled dots) and natural fertilization studies (filled diamonds) thus far: SO. JGOFS (1992), IronEx-1 (1993), IronEx-2 (1995), SOIREE (1999), CARUSO/EisenEx (2000), SEEDS-1 (2001), SOFeX-North (2002), SOFeX-South (2002), SERIES (2002), EIFEX (2004), SEEDS-2 (2004), SAGE (2004), FEEP (2004), CROZEX (2004/2005), KEOPS (2005). Cyclops (C in East Mediterranean) P fertilization, FeCycle (not shown) and various pilot experiments (open circles) are beyond scope of this WG proposal (map after *deBaar et al., 2005*)

In addition to this synthesis of basic variables of the then-available 8 experiments, there have been some recent articles combining 2-3 experiments for specific topics, that is, CO_2 budgeting (*Bakker et al. 2005*) and DMS(P) processes (*Turner et al., 2004*).

A special synthesis workshop (FeAX) was held in Wellington (New Zealand) in November 2005 under the aegis of SOLAS. Currently, the insights gained during that workshop are being written into another, mostly descriptive, multi-authored manuscript (*Boyd et al., in preparation*). At this meeting it was furthermore unanimously agreed by all participants that a special effort should be developed toward establishing a common open-access database of the *in situ* iron enrichment experiments. From this unanimous agreement follows this proposal for a SCOR WG. Success of this group could provide a model for data synthesis within SOLAS, IMBER, and other projects.

Rationale

The iron enrichment experiments have been done at great expenditure of scientists' time, research vessel time, and other costs. Thus overall, taxpayers of various nations worldwide have invested heavily in these experiments. Yet apart from the typical first round of articles on any single experiment, this investment has not led to an international resource or heritage. The already collected but thus far widely scattered data, once brought together, would be extremely valuable for various reasons:

- the ocean science community needs to fully exploit the results of preceding *in situ* experiments before proposing and implementing the next generation of experiments. In other words, there is no credibility to continue asking taxpayers to subsidize one experiment after another in the future, unless the ocean science community first fully exploits the investments of the past decade. Full use of existing data may yield insights to help design future experiments.

- properly compiled datasets of both natural and *in situ* iron fertilizations, which will allow the application of 'generic' simulation modeling, will yield insights and model robustness far beyond what is feasible by simulating just one experiment. Simulation modeling can include physical mixing, phytoplankton productivity, overall ecosystem functioning, iron chemistry, CO_2 budgeting, DMS(P) processes, and combinations of these variables and processes.

- the value of the experiments is far beyond the 'iron issue'. For example, the experiences and findings of labeling (SF_6 and sometimes ^3H as well) and following a patch of water are most valuable for designing future 'lagrangian' experiments for a wide variety of purposes well beyond the iron issue. If nothing else the simulation modeling of dispersion of the added

tracer(s) is a learning tool for quantifying lateral and vertical mixing in the surface oceans. Moreover, the practical ability to follow a surface water mass or 'patch' over periods of weeks to months allows a wide range of topical biogeochemistry studies.

Objectives

The objectives of the proposed working group are twofold:

1. Data compilation. Assembling a common open-access database of the *in situ* iron experiments, beginning with the first period (1993-2001; Ironex-1, Ironex-2, SOIREE, EisenEx, SEEDS-1) where primary articles have already been published, to be followed by the 2002 experiments where primary articles are now in progress (2002; SOFeX and SERIES), to be followed by the most recent experiments (2004; EIFEX, SEEDS-2). Similarly for the natural fertilizations S.O.JGOFS (1992), CROZEX (2004/2005) and KEOPS (2005).

2. Modeling. Simulation by 'generic' modeling of two or more (2-10) such experiments for various topics such as oceanic mixing processes, plankton ecology, carbon budgeting, and DMS(P) processes.

1. Data compilation
An international Working Group under the aegis of SCOR and with full endorsements by SOLAS and other international bodies is deemed essential for success in compiling all the appropriate databases. At the planning stages of each experiment, mutual access of data is commonly agreed and most funding agencies require the data to enter the public domain within 24-36 months after completion of the granted project. Nevertheless, in practice, compilations beyond individual investigators rarely occur, for a variety of reasons:

- Projects tend to be under-funded, often subject to budget cuts before granting, and the originally intended data management often is quietly sacrificed.
- At the level of the individual scientist only the most essential data are rapidly picked out for publication of articles, and an individual dataset often is not even compiled.
- Some types of data can be produced relatively rapidly, sometimes already available at the end of the cruise, while other types of data require much painstaking labor afterwards in the home laboratory. Physical oceanography data tend to become available for the community at large within 2-3 months, but marine chemists and biologists seem to be far slower in data dissemination.

In summary, our marine science community at the onset of each new project has been intending data management and eventual open access, yet for various reasons in the end this has rarely been accomplished. This proposal aims to remedy this situation for the *in situ* iron enrichment experiments, which may also serve to improve data practice of other future ocean experiments.

An international Working Group will be able to set the example (i) for readily making available data, first to colleagues of the given experiment and next to the open access database, (ii) for proper recognition of the original scientist, (iii) for enhancing the slow culture of one discipline to meet the faster data dissemination practices of another discipline, and (iv) for re-assuring hesitant scientists about protection of their interests as original data producer.

2. Modeling

Simulation models pivoting around phytoplankton ecology have thus far been performed independently for SOIREE (Hannon et al., 2001), IronEx (Chai et al., 2002), SEEDS-1 (Yoshie et al., 2005), SERIES (Takeda et al., 2005; Denman et al., in press), and comparison of Ironex-SOIREE-SEEDS (Fujii et al., 2005; Fujii and Chai, submitted). Moreover, there exists a refined simulation model on DMS(P) of SERIES (LeClainche et al., 2006). For physical mixing versus dispersion of SF_6 tracer, efforts are being made by Goldson, Law and others. Implications for Ocean Biogeochemical Climate Models (OBCMs) including full ocean circulation and cycling of trace element iron are being pursued by Follows, Sarmiento and others. In general within each class of models, that is, plankton models, mixing models, OBCMs, the individual models vary widely in design and objectives, and much can be learned by comparison between such models.

The Working Group will in a suite of 2-3 workshops bring together these modelers as well as key experimentalists to compare models, define common standard scenarios for validation and, in general, make available the compiled datasets (objective 1) to the evolving community of modelers.

Terms of Reference

Within the proposed 4-year period of existence, the WG plans to achieve the following objectives:

1. Compilation of a database for open access (via the Internet) of the following experiments in three steps:

1.1. the 1999-2001 era (IronEx-1, IronEx-2, SOIREE, EisenEx, SEEDS-1), plus 1992 S.O.JGOFS
1.2. the 2002 experiments (SOFeX-North, SOFeX-South, SERIES)
1.3. the 2004 experiments (Eifex, SEEDS-2, SAGE, FeeP), plus natural fertilizations CROZEX, KEOPS

This effort will include a commonly agreed data policy for users to best acknowledge the original data producers (e.g., by offering co-authorship and perhaps assignment of digital object identifiers for individual data sets). Obviously, a practical description of methods used, calibration etc. (so-called metadata) will also be included. This crucial first objective does not, in itself, require costly traveling to workshops. In essence the members are committed to send their data files to the common data centre, and advise their colleagues in any given experiment to do the same. Finally, an official data publication or publication(s) will be realized in a suitable venue, for example, an article in the special issue overall product of the WG (see item 4 below) and in *Eos* (Transactions Am. Geophys. Union). The database and experiences gained will provide an example for future next-generation *in situ* experiments.

2. Organization of 2-3 workshops where simulation modelers and key scientists of the experiments will meet. These workshops will be publicized in advance (SCOR website, other websites and newsletters) to allow colleagues beyond the actual WG membership to express interest in participation. This may serve as a mechanism to involve additional colleagues from developing nations.

3. Organization of 2-3 special sessions of presentations at international marine science conferences, to encourage presentations from colleagues not yet involved in the activity.

4. Final publication of a suite of simulation modeling articles, as well as the common database (i.e., its brief description), and new synthesis papers based on data comparison, in a special issue of an oceanographic journal, as well as a multi-authored paper with recommendations for the next generation of *in situ* experiments.

Optional. Beyond the above four terms of reference to be accomplished, the WG may finally organize a training and education activity, for example, a summer school.

Data Management

The EUR-OCEANS Network of Excellence comprises a Data Integration and Networked Database task force with major objectives: (1) to rescue relevant historical datasets, (2) to organise long-term archiving of scientific information, and (3) to develop an electronic portal for online access and dissemination. Dr. Nicolas Dittert as head of this task force will also be Full Member of the proposed SCOR WG. The WG will rely on the permanent data centres World Data Centre-MARE (Bremen) and PANGAEA (AWI, Bremerhaven) for implementation of above Terms of Reference number 1. The WDC-MARE is within the WDC Network linked with the relevant data centres in North America (e.g., CDIAC at Oak Ridge), Asia and other regions. The World Data Centres will also ensure long-term data storage.

Working Group Membership

Full membership and associate membership will aim for a good mix of junior and senior scientists in both categories, where senior colleagues are urged to pursue own funds for workshop participation, thus allowing optimal allocation of the WG budget to participation of junior scientists.

Membership will include a mixture of pivotal leaders of the various experiments, as well as various disciplines, as well as various modelers. In accordance with SCOR experiences, the Working Group will consist of 10 Full Members. These will be accompanied by a quite extensive group of Associate Members in order to ensure the necessary additional excellent expertise as well as involvements in the various *in situ* experiments, natural experiments, and simulation modeling. Both for Full Members and Associate Members, appropriate representation of both gender and developing country scientists will be achieved. Several more excellent scientists are envisioned to contribute datasets and/or modeling expertise via liaison with the Full and Associate Members, and workshops will be open to permit involvement of others. As a result of enthusiastic responses so far, please find below a suite of names of Liaison Scientists where more names will be added in due course.

Name	Major Relevant Expertise	Experiment(s)	Nation
Co-chairs:			
Prof. Christiane Lancelot	plankton ecosystem modeling	SOIREE	Belgium
Dr. Philip Boyd	plankton ecology	SOIREE, SERIES	New Zealand
Full Members:			
Dr. Dorothee Bakker	CO_2 system	SO JGOFS, SOIREE, EisenEx, CROZEX	UK
Prof. Uli Bathmann	polar mesozooplankton	SO JGOFS, EisenEx, Eifex	Germany
Dr. Kenneth Coale	iron-biota experiments	Ironex-1&2, SOFeX	USA
Prof. Hein De Baar,	iron and CO_2	GEOTRACES, SO JGOFS, EisenEx	Netherlands
Dr. Nicolas Dittert		data management EUR-OCEANS and WDC-MARE	European Union
Dr. Minhan Dai	ocean cycling of carbon and metals	GEOTRACES	China-Beijing
Prof. Maurice Levasseur	DMS(P) and plankton	SEEDS-2, SERIES	Canada
Prof. Shigenobu Takeda	iron chemistry & biology	SEEDS-1&2, SERIES	Japan
Associate Members:			
Dr. Philip Assmy	diatom responses	EisenEx, Eifex	Germany
Prof. Stephane Blain	iron biogeochemistry	KEOPS	France
Dr. Ken Buesseler	export production	IronEx, SOFeX	USA
Dr. Peter Croot	iron chemistry	Eisenex, SOFeX, Eifex	Germany
Prof. Ken Denman	modeling	SERIES	Canada
Dr. Laura Goldson	tracer dispersion & mixing	EisenEx, SOFeX	UK
Dr. Mick Follows	various modeling including OBCMs		USA
Dr. Masahiko Fujii	simulation modeling	SEEDS-1&2, SERIES	Japan
Prof. Huasheng Hong	ocean biogeochemistry	JGOFS	China-Beijing
Dr. Alex Kozyr		ocean CO_2 data management at CDIAC	USA
Dr. Cliff Law	tracer dispersion & mixing	SOIREE, SERIES	New Zealand
Dr. Adrian Marchetti	diatom responses	SERIES	Canada
Dr. Pedro Mayer Branco	plankton ecosystem modeling	Eisenex	Portugal

Dr. Jun Nishioka	iron physical chemistry	EisenEx, SEEDS-1&2, SERIES	Japan
Dr. Micha Rijkenberg	iron photoredox chemistry	SOIREE, EisenEx	UK
Dr. Michiel Rutgers Van Der Loeff	export production	GEOTRACES, SO JGOFS, EisenEx	Germany
Dr. Veronique Schoemann	iron-phytoplankton, *Phaeocystis*		Belgium
Dr. Volker Strass	polar physical oceanography	EisenEx, Eifex	Germany
Prof. Atsushi Tsuda	zooplankton ecology	SEEDS-1&2, SERIES	Japan
Prof. Yuan-HoTung	marine chemistry and ecology		China-Taipei
Dr. Sue Turner	DMS(P) cycles	IronEx, SOIREE, EisenEx	UK
Dr. Klaas Timmermans	iron-diatom interactions	EisenEx, KEOPS	Netherlands
Prof. Benjamin Twining	intracellular iron	SOFeX	USA
Prof. Andy Watson	CO_2 system, tracer dispersion	SOIREE, EisenEx	UK
Prof. O. Wingenter	rarely studied trace gases	SOFeX	USA
Prof. Wen-Xiong Wang	trace elements uptake and transfer in phyto-zooplankton		China-Beijing
Dr. Shaojun Zhong		GEOTRACES Standards and Intercalibration task team	China - Beijing
Liaison Scientist: (*Liaison Scientists will be informed about and invited in all activities, they will submit datasets and/or are involved as simulation modeling experts. The below names merely are the beginning of a growing list of enthusiastic colleagues, each with excellent scientific credentials)*			
Gnanadesikan, Dr. Anand	ocean modeling including OBCMs, iron cycle		USA
Le Clainche, Dr. Yvonnick	ecosystem DMS(P) modeling	SERIES	Canada
Nightingale, Dr. Philip	tracer dispersion, air/sea	IronEx, EisenEx	UK
Rivkin, Prof. Richard	bacterial responses	SERIES	Canada
Sanders, Dr. Richard	carbon export	CROZEX	UK

Sarmiento, Prof. Jorge		ocean modeling including OBCMs, iron cycle	USA
Savoye, Dr. Nicolas	export production	Eifex	France
Vezina, Dr. Alain	ecosystem inverse modeling, DMS(P)		Canada

Co-sponsorship(s) and Financial Support and Budget

The endorsement by the international organizations and projects SCOR, SCAR, SCOR-IGBP-SOLAS, SCOR-IGBP-IMBER, SCOR-GEOTRACES is deemed of primary importance for fostering the constructive, collaborative spirit essential to meet the terms of reference. The SOLAS SSC in its annual meeting, Amsterdam, May 2006, has fully endorsed this WG initiative. Moreover, in July 2006, the Executive of the IMBER SSC has expressed support. The proposal is also supported with great enthusiasm by the two co-chairs Dr. Bob Anderson and Prof. Gideon Henderson of GEOTRACES and will be listed on the agenda of the next GEOTRACES SSC to be held at end of year 2006.

Nevertheless, SCOR is envisioned to take primary responsibility and accountability for the working group. Co-sponsoring by SCOR and SCAR jointly is envisioned. Informally, the SCAR leadership and international office has been very positive thus far. This proposal is submitted to the Joint SCAR/SCOR Expert Group in Oceanography for its advice and endorsement at its second meeting at 10-11 July 2006 at Hobart, Australia. This endorsement would support the submitted request to SCAR for co-sponsorship, to be discussed and decided at the XXIX SCAR Delegates Meeting, 17-19 July 2006 at Hobart, Australia.

The proposed co-chairs and full members now also are making efforts to realize significant if not major co-sponsorship by other agencies. Briefly, the EUROCEANS Network of Excellence of the European Union has, in keeping with its major mission, agreed in principle to consider co-sponsorship for support of workshops as well as data management tasks. In practice the current proposal has been submitted to EUROCEANS for their existing schemes of subsidizing workshops and data management respectively. Similarly, the U.S. NSF has been approached for support. Finally, the scientists among above membership from leading nations of iron enrichment experiments, notably Canada, New Zealand, Japan, Germany, United Kingdom, will be asked to pursue some support of their respective national agencies. Last, but not least, the above scientists of smaller nations, including Belgium and The Netherlands, will be asked for a similar effort.

The standard budget for a SCOR WG would allow organization of 3 workshops for 10-12 Full Members at a cost of US $ 15000 per workshop, that is, in the order of US $ 45000 in total. The various above initiatives most likely would allow realization of this budget. Additional finances may well be realized towards supporting Associate members, as well as financing other costs such as data management expenses or publication costs.

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References of overview articles each containing many more references

Boyd, Jickells, Law, Blain, Boyle, Buesseler, Coale, Cullen, de Baar, Follows, Harvey, Lancelot, Levasseur, Pollard, Rivkin, Sarmiento, Schoemann, Smetacek, Takeda, Tsuda, Turner, and Watson (in prep) A synthesis of mesoscale iron-enrichment experiments 1993-2005: key findings and implications for ocean biogeochemistry, to be submitted to *Science*

De Baar, H.J.W., P.W. Boyd, Kenneth H. Coale, Michael R. Landry, Atsuhsi Tsuda, Philip Assmy, D.C.E. Bakker, Y. Bozec, R.T. Barber, M.A. Brzezinski, K.O. Buesseler, M. Boyé, P. L. Croot, F. Gervais, M.Y. Gorbunov, P. J. Harrison, W.T. Hiscock, P. Laan, C. Lancelot, C. Law, M. Levasseur, A. Marchetti, F. J. Millero, J. Nishioka, Y. Nojiri, T. van Oijen, U. Riebesell, M.J.A. Rijkenberg, H. Saito, S. Takeda, K.R. Timmermans, M. J.W. Veldhuis, A. Waite and C.S. Wong (2005) Synthesis of Iron Fertilization Experiments: From the Iron Age in the Age of Enlightenment. In: Orr, J. C., S. Pantoja, and H.-O. Pörtner (eds.) The Oceans in High CO_2 World, Special Issue of *J. Geophys. Res. (Oceans)*, *110*, C09S16, doi:10.1029/2004JC002601, pp 1-24.

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Jickells, T.D., Z.S. An, K.K. Andersen, A.R. Baker, G. Bergametti, N. Brooks, J.J. Cao, P.W. Boyd, R.A. Duce, K.A. Hunter, H. Kawahata, N. Kubilay, J. laRoche, P.S. Liss, N. Mahowald, J.M. Prospero, A.J. Ridgwell, I. Tegen, and R. Torres (2005) Global Iron Connections Between Desert Dust, Ocean Biogeochemistry, and Climate, *Science*, 308, 67-71.

2.3.5 Working Group on Ocean Time Series: Coordination and Integration of Science Objectives, Methods, Databases and Capacity-Building Efforts

SCOR Working Group on Ocean Time Series: Coordination and Integration of Science Objectives, Methods, Databases and Capacity Building Efforts

Abstract

A SCOR Working Group (WG) on Ocean Time Series is an effective and visible mechanism to bring together similar but uncoordinated observing programs dispersed around the world. This WG is timely because of initiatives such as OceanSITES, ANTARES and POGO, which seek to link scientists conducting time-series efforts. The SCOR WG will complement these initiatives and define a framework for addressing new scientific questions of global and climate change scope that require time series of comprehensive, physical and biogeochemical oceanographic observations, as well as ensuring analytical integrity in the collection of biogeochemical variables. The WG and framework will help link and coordinate international oceanographic time-series programs, compare and unify methods, and provide a common philosophy and protocols for sharing information among time-series programs and with the public. The WG will explore the utility of time-series programs for international capacity building, and assist new time-series programs to facilitate their success. The effort will contribute to a better international research infrastructure focused on understanding the link between regional and global oceanographic processes.

Rationale and Scientific Background

Frequent and repeated measurements collected over a long time are necessary to understand phenomena in the ocean that change irregularly and at different time rates in ways that are impossible to document from a single field expedition (GCOS, 1997). Time series are also required to differentiate long-term trends from events or changes occurring over months and seasons. Unfortunately, most ship-occupied ocean time series have focused on a few parameters, such as temperature and salinity, some biogeochemical variables, and few exceed several years. Yet, a small number of these sites exist around the world where the temporal variability of both physical and biogeochemical ocean properties has been observed simultaneously for periods of time of the order of a decade.

A truly global observatory requires coordination of the international community, trained scientific and technical personnel, compatible methodologies and robust partnerships. In the past, the significant efforts required to maintain each comprehensive time series have precluded efforts to link programs scientifically and logistically. These time series struggle with management and funding constraints, and, in order to sustain the basis for scientific observations of the program, outreach to the community and to the public are frequently limited. SCOR provides a unique umbrella to hold an international dialogue on how to coordinate these programs to address larger-scale science questions, ensuring the data generated from the ship-occupied time-series locations are comparable and for addressing conceptual and human capacity problems that hinder global and climate-scale research. These are dimensions for which the proposed SCOR WG would complement scientific initiatives like

OceanSITES (http://kela.soest.hawaii.edu/OceanSITES/), ANTARES (http://www.antares.ws), and POGO (http://ocean-partners.org/). The SCOR WGs, by its very nature, is not a research program but it can help focus research questions and activities for the future. Therefore, the SCOR WG and these initiatives are not in any type of direct competition and rather they would all benefit from each other.

The following are considered model time-series observing programs:

BATS: The oldest time series, dating back to 1954. Monthly measurements continue to be taken at and near the original Hydrostation S, located some 28 km southeast of Bermuda. BATS data show a clear link between biogeochemical cycles in the Sargasso Sea, El Niño-Southern Oscillation (ENSO), and the North Atlantic Oscillation (NAO) (Lomas and Bates, 2004) (http://www.bbsr.edu/cintoo/bats/bats.html).

HOT: HOT has conducted near-monthly cruises since 1988 to station ALOHA, approximately 100 km north of Oahu, Hawaii. Their findings show tight links between biogeochemical processes, including primary production, and seasonal variations and to the ENSO (http://hahana.soest.hawaii.edu/hot/intro.html).

CARIACO: A continental margin time series started in 1995 in the anoxic Cariaco Basin, Venezuela, to help interpret the paleoclimate record stored in its sediments. One of the major findings of CARIACO has been identifying this upwelling location as a source of carbon dioxide (Muller-Karger et al., 2004). (http://www.imars.usf.edu/CAR/index.html).

ESTOC: This European series was initiated in 1994 aproximately100 km north of the Canary Islands, Spain. ESTOC has documented Meddies (Mediterranean salt lenses), and the influence of African upwelling and Saharan dust on regional oceanography (http://www.noc.soton.ac.uk/animate/data/estoc/estocdescription.php).

Terms of Reference

We propose to establish a SCOR Working Group on Ocean Time Series which visit their study locations regularly by ship and that undertake both physical and biogeochemical measurements. The Working Group would define a framework for collaboration, coordination, methods assessment, capacity building, data exchange and future funding opportunities. The vision is to address ocean science questions of global- and climate-scale scope. The product will be a plan for coordinating such programs and for linking oceanographic time series with land and atmosphere time-dependent data collection efforts. This Working Group will complement the efforts of POGO to integrate the continental-scale ANTARES time series group into the Group on Earth Observations (as a contribution to GOOS), and provide a means to address methods standardization, maintenance of analytical integrity and capacity building, something necessary in these projects that experience considerable personnel turnover. It will also help communication between these separate programs; enhance communication between researchers with common interests, and between researchers and the broader public. The Working Group will help define the important and continuing role of SCOR in advancing ocean sciences through time-series efforts.

Specifically, the objectives are to:

- Identify scientific questions that require coordination among the time series and link all major established efforts, as well as emerging and planned ocean time-series efforts.
- Review current oceanographic time-series sampling methods, and, to the extent required, define standard methods and strategies to use time-series programs to build technical human capacity.
- Identify logistical problems and provide solutions. Define funding issues and outline a coordinated strategy for sustainable funding, including identifying new sources of funding.
- Coordinate a major publication encompassing time-series work done in the past decades and their major findings. Also, generate several layman publications to educate the general public on time series.
- Link this Working Group with the currently funded SCOR WG115 ("Standards for the survey and analysis of plankton") and integrate their relevant findings.

Working Group Membership

The working group will have ten Full Members and five Associate Members. Full Members are recruited from key ship-occupied time-series stations, including the ANTARES network. Associate members incorporate emerging or potential time-series programs and ensure better global representation. Proposed members are listed below.

Full Members	Time Series/Program
Frank Muller-Karger (University of South Florida, USA) – Proposed WG Chair	CARIACO (Carbon Retention in a Colored Ocean)
David Antoine (Laboratoire D'Océanographie de Villefranche, France)	BOUSSOLE (Boueé pour l'acquisition de Séries Optiques à Long Terme)
Eduardo Klein (Universidad Simón Bolívar, Venezuela)	CARIACO
Ruben Escribano (Universidad de Concepción, Chile)	COPAS Time Series
Mike Lomas (Bermuda Biological Station for Research, Bermuda)	BATS (Bermuda Atlantic Time-Series Program)
David Karl (University of Hawaii, USA)	HOT (Hawaii Ocean Time-series)
Julio Morell (University of Puerto Rico Mayaguez, Puerto Rico)	CaTS (Caribbean Time-Series Station)
Doug Wallace (IFM-GEOMAR , Germany)	CV (Cape Verde Time Series Site)

Marimar G. Villagarcia (Instituto Canario de Ciencias Marinas, Spain)	ESTOC (Estación Europea de Series Temporales del Océano)
Salvador A. Gaeta (Instituto Oceanográfico, Universidad de São Paulo, Brazil)	OPISS (IOUSP)

Associate Members	**Time Series/Program**
Scott Nodder (New Zealand)	NIWA (National Institute for Water and Atmospheric Research)
Ruben Negri (Argentina)	INIDEP (Instituto Nacional de Investigación y Desarrollo Pesquero)
Susumu Honjo (Woods Hole Oceanographic Institution, representing Japan)	J-PAC (Joint North Pacific Research Center)
Shuba Sathyendranath (Canada)	POGO (Partnership for Observation of the Global Oceans)

Working Group Activities

This SCOR WG will perform the following activities over a period of three years to accomplish the Terms of Reference. The WG will conduct its business through one formal meeting per year and a minimum of two annual team-wide teleconferences; additional teleconference meetings will address specific issues in subcommittee structure. Virtual meetings will use sophisticated Internet video-conferencing freeware including Skype (http://www.skype.com) and VRVS (http://www.vrvs.org).

The first joint teleconference will be held in January 2007. During this conference, the working group will review the terms of reference and membership, and refine a strategy to address each objective. The timing and potential locations for face-to-face meetings will be discussed. Definition of subcommittees to meet the Terms of Reference, creation of an agenda and logistics for the first face-to-face meeting will be discussed during the first joint teleconference and in subsequent communications with WG members.

The first formal meeting of the WG will be in May 2007, in conjunction with the CARIACO Time-Series annual meeting, in Venezuela. The expected outcome of the first formal meeting will be to review each time series, an implementation plan to achieve the terms of reference, and define tasks for each working group member or subcommittees.

The year 2 formal meeting will be held in conjunction with a CARIACO-BATS meeting during August 2008, likely in Bermuda. An outline of the major publication will be completed, as well as identification of potential layman publications.

A final physical WG meeting will be planned to summarize the major outcome of the SCOR WG. At this time, the drafts of the final publication will be reviewed and final assignments made. We will

consider holding this final meeting to coincide with an AGU conference or other major science meeting, to ensure effective participation and exposure of findings at low cost.

Separate funding from POGO will be sought to cover general expenses and additional participant support in annual meetings, especially international students who would be tasked with helping organize the logistics of each meeting, reporting during the meeting, and collating the outcome. This will help expose a new generation to time-series programs and science leaders.

References

GCOS Report No. 41. 1997. Joint GCOS GOOS WCRP Ocean Observations Panel for Climate (OOPC). UNESCO. 18-20 March. Baltimore, Maryland, USA.

Lomas, M. and N.R. Bates. 2004. Potential controls on the interannual partitioning of organic carbon during the winter/spring phytoplankton bloom at BATS. Deep-Sea Res. II 51: 1619-1636.

Muller-Karger, F.E., R. Varela, R. Thunell, Y. Astor, H. Zhang, and C. Hu. 2004. Processes of Coastal Upwelling and Carbon Flux in the Cariaco Basin. Deep-Sea Research II. Special Issue: Views of Ocean Processes from the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) Mission: Volume 2 - Edited by D.A. Siegel, A.C. Thomas and J. Marra. Vol. 51/10-11 pp 927-943.

2.3.6 Working Group on Tsunamis: Examination, Modeling and Risk Estimation (2007-2010)

Proposal for a new SCOR Working Group: "Tsunamis"

Background and Rationale

The destructive tsunami generated by the 26 December 2004 $M_w = 9.3$ megathrust earthquake off the coast of Sumatra and Andaman Islands in the Indian Ocean killed more than 226,000 people and left millions more displaced and homeless. Damage is estimated in the billions of dollars. As a result of international tourism, countries far removed from the major disaster areas felt the global reach of the Sumatra tsunami, which triggered the largest international relief effort in history. The highly destructive waves generated by the 1-10 m vertical displacements of the crust elevated our awareness of tsunami hazards to a new level. The extensive damage and loss of life from this event have forever changed our view of tsunamis as relatively infrequent, marginally significant, local consequences of earthquakes. Tsunamis are now considered one of the most dangerous global catastrophes.

To learn from this tragedy, the tsunami research community has responded with an unprecedented effort to collect and interpret the vast amount of tsunami-related data. There is historical evidence of tsunamis in the Pacific Ocean that have traveled across the ocean causing destruction thousands of kilometers from the source. However, the Sumatra tsunami of December 26 was the first global tsunami to occur during the "instrumental era". It provided high-quality tsunami measurements on a worldwide basis. The tsunami was clearly recorded by a large number of tide gauges throughout the worlds' oceans, including those in the North Pacific and North Atlantic. Global tsunami propagation models (cf. Titov et al., 2005) demonstrated that the mid-ocean ridges served as wave guides to the 2004 event. They efficiently transmitted tsunami energy from the source area to far-field regions of the Pacific and the Atlantic coast of North America. The 2004 Sumatra tsunami is now recognized as the most globally distributed and accurately measured tsunami in recorded history. More than 200 digital records of this tsunami are available and years after the event, tsunami measurements are still being collected and archived.

An unprecedented number of international survey teams working in the impacted coastal areas of the Indian Ocean collected a tremendous amount of data on maximum tsunami wave heights along the coasts (vertical and horizontal tsunami run-ups). The Sumatra tsunami was the first major tsunami that was clearly recorded by satellite altimetry (Topex-Poseidon, Jason and Envisat satellites). Signals from the earthquake and tsunami were also recorded by a wide variety of other geophysical instruments, including GPS, hydrophones, seismometers and infrasound stations. This huge volume of observational data has prompted scientists to revise previously held conceptions regarding tsunami propagation and transformation. It also generated many questions initiated by public interest and incomplete scientific understanding. These data provide us, the scientific community, with a unique opportunity to better understand the physics of tsunami generation, propagation and dissipation. Collection, careful examination and interpretation of these data, requires broad international cooperation and *a SCOR Working Group on Tsunamis* could play a key role in this process.

A question of particular importance is numerical modeling of tsunami waves: their generation, propagation and inundation of the coast. The 2004 Sumatra tsunami was the first tsunami when numerical model simulations of global tsunami propagation could be coupled with global water level records. This has shed light on the evolution of tsunami wave properties during inter-ocean spread. As a consequence, this event has exposed several problems in tsunami modeling. First is the availability of globally accurate and reliable bathymetry and coastal topography (for potentially floodable regions). Second are nonlinear 3-dimensional effects in coastal zones. These remain a serious problem for tsunami modelers and could be effectively considered under the *SCOR Working Group guidance*.

The 2004 Sumatra tsunami strongly affected the coasts of the entire Indian Ocean, killing citizens from more than 60 countries. This resulted in significant scientific and public interest in the problem of tsunami warning and mitigation. Many new scientists and specialists have become involved in this problem. Many countries have begun work on elaboration of their national tsunami warning systems. A *SCOR Working Group on Tsunamis* could provide valuable guidance, assistance and scientific understanding to these individuals and countries.

This working group would be an efficient international team of leading scientists from various geographical regions, representing countries both with a long history of tsunami research (e.g., Japan, USA and Russia) and those that are beginning to work in this area (e.g., Guadeloupe, Thailand and Malaysia). Most of the potential members of the group have a record of successful cooperation, working on joint projects.

The rationale behind the proposal to create the *SCOR Working Group on Tsunamis* is summarized as the following. The devastating tsunami of the 26 December 2004 in the Indian Ocean (and some other catastrophic tsunamis in recent time) has piqued the interest of the public, governments and scientists in the problem of tsunamis. There is a vast quantity of data that now exists on major tsunami events of the past two years. This demands and deserves detailed analysis and interpretation to better understand the phenomenon. However, this goal cannot be achieved by a few individuals working in isolation. A well-coordinated international effort to collect, process and interpret the available data will derive significantly more valuable outcomes in a shorter time frame. The international nature of the group will also facilitate the translation of the scientific results to the practical world of warning and mitigation.

As a response to the tragic events, several regional and international organizations and groups have been created or significantly reconstructed. These include the Intergovernmental Coordination Groups on the Pacific and Indian Ocean Tsunami Warning Systems (ICG/PTWS and ICG/IOTWS, respectively) working under the umbrella of the Intergovernmental Oceanographic Commission (IOC/UNESCO). The main purposes of these organizations and groups are *applied research and development*. They are directed to providing effective tsunami warning and mitigation of the catastrophic consequences of tsunami events. The main purpose of the *SCOR Working Group on Tsunami* would be to promote *scientific research*. It would solve specific scientific problems, enhance the scientific knowledge of tsunami physics and provide this scientific information for practical use. This working group would work in close cooperation with IOC, providing scientific background for the IOC applied organizations and projects. This co-operation would be achieved, in part, through the

members of the SCOR Working Group, who are also members of the various Intergovernmental Coordination Groups. Taking into account the scientific and practical importance of the tsunami study, we expect the foundation support of this working group to come from national and international funds.

Terms of Reference

Based on discussions between the prospective members of the SCOR Working Group on Tsunamis, the following three primary themes of the group's activity have been specified:

(1) Analysis of tide gauge tsunami data
(2) Numerical modeling of tsunami waves
(3) Estimation of tsunami risk for the coastal regions

These three themes have high scientific significance and practical importance. The detail regarding each is of these themes is give below.

(1) ***Analysis of tide gauge tsunami data***

The working group would collect and analyze coastal and open ocean tsunami records from all over the World Ocean. The main attention will be paid to the records of the Sumatra tsunami of 26 December 2004 (this tsunami was recorded by approximately 200 tide gauges), but other major tsunami events with well-documented records also would be examined carefully (e.g., Chile, 1960; Alaska, 1964; Shikotan, 1994; Peru, 2001; Tonga, 2006). There are four major problems to work on in respect to these data:

- Separation of the source and topography effects in the tsunami records. From this, estimate their relative influence for different sites and the distance from the source distance.
- Reconstruction of the tsunami source.
- Comparison of near-field (near-source) and far-field tsunami records to investigate the evolution of a tsunami with distance.
- Intercomparison of the major tsunamis (e.g., the global 1960 Chile and 2004 Sumatra tsunamis) and examination of the source physics and wave field characteristics of the corresponding tsunamis.

All these problems are of key importance for tsunami understanding and prediction.

(2) ***Numerical modeling of tsunami waves (generation, propagation and runup)***

There are three main directions of tsunami modeling:

- Numerical modeling of *historical events.* This is important for better understanding of the physical mechanisms of these events, and to verify the models by comparison with the existing observational data.
- Numerical modeling of the plausible *worst-case scenarios* for future tsunami events to estimate tsunami risk for specific regions of the World Ocean.

- *Real-time* numerical modeling of tsunami propagation in the case of a major earthquake; this is a crucial problem for efficient tsunami warning.

The main purpose of the group is to outline the effective ways to do these three types of modeling. The concrete problems to consider are:

- Collecting and utilizing accurate bottom bathymetry and coastal topography
- Example modeling studies to support developing Tsunami Warning Systems (in particular, for the Indian Ocean, Caribbean, and Mediterranean).
- Estimation of various tsunami sources (rupture and possible landslide characteristics) for selected study regions (or for some countries); determination of domain dimensions for modeling with respect to sources, vulnerable coastal regions, and buoy locations; and determination of several scenarios for the modeling.
- Determine the best format of the database to develop the outputs of each scenario from modeling so that model results can be used immediately after the tsunami event for decision-making and warning issues.
- Development of numerical tools for computation of wave structure interaction and wave characteristics in inundation zone

Solving these problems may have important practical outcomes.

(3) *Estimation of tsunami risk for the coastal regions*

The problem of long-term tsunami forecast, that is, estimation of tsunami risk for specific geographical regions and local areas, is the problem of the highest priority, especially for the regions where studies have never been provided in the past (e.g., the coasts of the Indian Ocean). There are two main directions of the group activity in the frame of this theme:

- Development of effective new methods to estimate tsunami risk based on the methods of extreme statistics and numerical modeling.
- Estimation of tsunami risk for specific geographical regions first of all for the coasts of the Indian Ocean and Caribbean.

The main scientific product of the Working Group's activity would be a book (collection of scientific papers) summarizing the main scientific results of the group. Also the group will regularly present individual scientific articles in refereed journals.

Working Group meetings

The meetings of the SCOR Working Group on Tsunamis (WGT) are planned to be on an annual basis, that is, three meetings during the four-year period, 2007-2010. One of these meetings (in 2007) will be combined with the IUGG International Tsunami symposiums and two (2008 and 2010) will be independent. The exact places of these meeting will be defined later. One of the main criterions that will be taken into account is the minimizing travel expense for the WGT members.

2007: WGT Meeting 1 Perugia, Italy (July, 2007**)**
(combined with the 23rd International Tsunami Symposium, XXIV IUGG General Assembly)

2008: WGT Meeting 2 **??**

2010: WGT Meeting 3 **??**

Beyond the SCOR-sponsored meetings, some additional informal Working Group meetings are possible combined with some other tsunami meetings.

Preliminary Time Table

Year	Theme		
	Tsunami analysis	**Numerical modeling**	**Tsunami risk**
2007	- Collecting the tide gauge data from the 2004 Sumatra tsunami and other major tsunami events. - Overview of the 2004 Sumatra tide gauge measurements in the Indian, Pacific and Atlantic oceans.	- Collecting and utilizing the bottom bathymetry and coastal topography. - Example modeling studies for Indian Ocean and Caribbean (to support developing Tsunami Warning Systems)	- Preliminary estimation of tsunami risk for the Indian Ocean (based on historical earthquake and tsunami data). - Preparation of the corresponding paper
	Meeting of the SCOR Tsunami Working Group (23rd IUGG Tsunami Symposium), Perugia, Italy, July 2007		
2008	- Statistical analysis of the 2004 Sumatra tsunami records and other major historical tsunami events. - Parameterization of tsunami events, comparative analysis of wave structure.	- Development of the tsunami scenario for the Indian Ocean, Mediterranean, and Caribbean. - Numerical modeling of global historical tsunami events.	- Development of new methods to estimate tsunami risk (based on of extreme statistics and numerical modeling) - Preliminary estimation of tsunami risk for the Caribbean region.

	Second Meeting of the SCOR Tsunami Working Group Preparation of peer-reviewed papers.		
2009	- Separation of the source and topography effects for the 2004 Sumatra tsunami. Reconstruction of the tsunami source - Intercomparison of near-field and far-field tsunami characteristics	Development of numerical tools for computation of wave structure interaction and wave characteristics in inundation zone	- Estimation of tsunami risk for the Indian Ocean, Mediterranean and Caribbean regions
2010	Preparation of the special volume (paper collection) summarizing the results and findings of the SCOR Tsunami Working Group		
	Final Meeting of the SCOR Tsunami Working Group		

Proposed Members of the Group

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Expertise: tsunami waves, applied mathematics, numerical modeling, nonlinear waves (one of the authors of MOST code), tsunamis field survey, tsunami risk, ocean dynamics.

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2.3.7 Working Group on the Role of Lanternfish in the Ocean

Proposal for a SCOR Working Group on Lanternfishes in the Ocean

(Revision: 31 May 2006)

EXECUTIVE SUMMARY

Lanternfishes (family Myctophidae) are small but abundant fishes found in the midwaters of the entire world ocean. Due to their ubiquity, abundance and vertical migratory behavior, they undoubtedly play major roles in the oceanic food web. Not only are lanternfishes major predators on zooplankton, but they comprise a significant portion of the diet of pinnipeds, penguins and other marine birds.

It is proposed that a SCOR Working Group (WG) be convened to investigate the role of lanternfish in the ocean. The WG goals will be:

1) Summarize the state of knowledge of methods and techniques employed for determining myctophid population dynamics, and to summarize the state of knowledge about myctophid biology, especially as it pertains to an understanding of the role of lanternfishes in the world ocean ecosystem.
2) Assess ongoing research effort required in these areas, including and emphasizing the utilization of modeling techniques and approaches.
3) Target those myctophid species and those geographic areas in the world ocean that could benefit from a focus of these and other innovative research approaches in terms of biomass turnover rate.
4) Establish and maintain a web site for the exchange of information and ideas between mesopelagic fish specialists, marine biologists and physical oceanographers, as well as other interested groups such as fisheries scientists.
5) Produce a comprehensive report incorporating the results from the above activities for which we would seek appropriate publication, whether in a peer-reviewed journal or as a book.

The WG will bring together a group of scientists, including young investigators and senior scientists, from a variety of countries and subdisciplines. Over a four-year period the WG would have three meetings and sponsor an international conference of myctophid specialists, fishery biologists and related marine scientists. The final report of the WG will identify the critical knowledge gaps as well as suggest ways that those gaps might be addressed.

RATIONALE

The mesopelagic region of the world's ocean comprises 1.4×10^9 km^3 of the total ocean volume (Herring 2002:249) and mesopelagic fishes are the largest component of its biomass. These are

small fishes, usually 2 to 10 cm in length and usually found at depths from 100 to 1000 meters below the surface. The family Myctophidae, commonly known as lanternfish, makes up about 65% of all mesopelagic fishes and has a global biomass estimated at 660 million tons (Hulley in Paxton & Eschmeyer 1995).

Most fish population dynamics studies have been directed toward more economically important fishery groups (such as sardines, rockfishes, cod or herring) or large species (such as tunas), or toward marine mammals (such as whales and dolphins). Preliminary research indicates that myctophids play a significant role in the marine food web, acting as both predator and prey. As predators, myctophids primarily feed on copepods, ostracods and euphausiids. In turn, lanternfishes are reported as prey of numerous fishes, sea birds and pinnipeds. While much data has been obtained, the details of various food chains involving myctophids need to be worked out.

The proposed Working Group will focus international attention on the most logical way to explore the dual problem of the lack of knowledge of the population dynamics and biology of these lanternfishes, together with a lack of understanding of the domino effect on the ecosystem due to changes in relative abundances of the various myctophid species. While the kind of research that must be conducted is basic research, it is clearly of practical importance to a more complete understanding of the marine ecosystem and role of myctophids.

Most lanternfishes are broadly tropical in distribution (Hulley, pers. comm.), and are influenced by changes in environmental factors as readily as nearshore fishes, such as being entrained by fronts or transported by currents (Backus et al., 1969; Backus & Craddock, 1982; Bekker, 1985; Brandt, 1981; Craddock et al., 1992; Figueroa et al., 1998; Gorbunova et al., 1985; Hulley, 1992; John et al., 2000; Konstantinova et al., 1994; Koubbi et al., 2003; Rodriguez-Graña & Castro, 2003; Rogachev et al., 1996; Rojas et al., 2002; Sameoto, 1981; The Ring Group, 1981; Zelck & Klein, 1995). This is further complicated by the vertical diurnal migration deep-sea fishes undertake. For example, Linkowski (1996), in looking at the myctophid genus *Hygophum*, determined three types of species-specific migratory patterns in relation to lunar cycles. Proximity to coastal areas also affects vertical distribution. Ropke (1993) found the larvae of four species of myctophids occurred on the average about 20 m deeper in the central oceanic region compared to the coastal areas off Oman and Pakistan. The structure and ecology of the deep-sea community and its relationship to epipelagic and nearshore communities is still largely unknown (Parin, 1986).

With the hope of gaining a more detailed ecological understanding of mesopelagic fishes, the lanternfishes are an ideal study organism. The Myctophidae includes at least 250 species. It is the most speciose family of deepsea fishes, comprising at least 20% of the oceanic ichthyofauna (McGinnis, 1974). They are considered the dominant fishes in most midwater samples and the most abundant. Gjøsaeter and Kawaguchi (1980) estimated the biomass of all mesopelagic fish in the ocean to be at least 9.5×10^8 tons. Nair et al. (1999) estimated the biomass of mesopelagic fishes, mainly myctophids, in the Arabian Sea to be about 100 million tons, and

Beamish et al. (1999) estimate the biomass of just the myctophid *Stenobrachius leucopsarus* in the Subarctic Pacific (including the Bering Sea and Sea of Okhotsk) to be approximately 21 million tons. Predation by this large biomass has an affect on the structure of the food web in the amount zooplankton biomass removed. Hopkins and Gartner (1992) estimated a nightly removal of 2% of the zooplankton biomass in the Gulf of Mexico by lanternfish. These fishes can also be the most speciose family present in a midwater collection. Klepadlo (pers. comm.) has typically found 20-40 myctophid species in midwater trawl samples in temperate to tropical Pacific waters. Hopkins and Gartner (1992) indicate some trawl collections could have over 50 myctophid species and suggest niche separation as a means to reduce competition. Lanternfish species interactions need to be better understood and more clearly defined.

The oceanic food web, as on land, is driven by the energy passed through the web (Longhurst & Harrison, 1988; Tanimata et al., 2005) as the organic matter of prey organisms passes to the predators. The meso- and bathypelagic zones of the deep sea are generally regarded as those of low energy and productivity due to lower food availability at greater depth (Childress et al., 1980). However, migratory mesopelagic fishes are a key to the active transport of food energy to depth. Myctophids undergo diurnal migrations, feeding in the epipelagic (0-200 m) and upper mesopelagic (200-500 m) zones (Balanov et al., 1994), and bringing both nutrients and carbon dioxide to deeper layers (500-1000 m) in or near the oxygen minimum layer (Nair et al., 1999; Butler et al., 2001). The large biomass of myctophids is also a large forage mass for other predators, that is, fishes, birds, mammals (see Appendix). The caloric content of lipid-rich myctophids has been shown to be a significant energy source for marine predators (e.g., Phleger et al., 1997; Lea et al., 2002). It has been found that during the breeding season for various sea birds and pinnipeds, myctophids can comprise up to 90% of their diets (Cherel et al., 2002; Croxall et al., 1988; Croxall & Lishman, 1987; Croxall & North, 1988; Guinet et al., 1996; Ridoux, 1994; Woehler & Green, 1992).

Mesopelagic fishes, particularly the lanternfishes, have an important and possibly critical role in rapid turnover and replacement of their prey populations (Haedrich, 1997). Hopkins and Gartner (1992) estimated that myctophids remove at least one-third of the daily production of zooplankton from the epipelagic zone in the eastern Gulf of Mexico. While feeding primarily on copepods and euphausiids, lanternfishes have been found to switch to phytoplankton when the availability of zooplankton is limited (Robison, 1984; Ishihara and Kubota, 1997; Sutton et al., 1998). Watanabe et al. (2002) examined three species of myctophid in the Kuroshio waters and found that the trophic competition is reduced by specializing in different food organisms. However, Watanabe and Kawaguchi (2003) have shown that *Myctophum nitidulum* seemed to change their diet composition according to changes in the composition of prey species in its habitat. It is unknown if other species of lanternfishes are specialist or generalist feeders in relation to their prey composition.

As in any marine organism, changes in oceanographic conditions affect the habitat of myctophid adults and larvae and play a role in the distribution, and survivorship and recruitment success (Field et al., 2006; Shannon et al., 2003). Herring (2002:253) pointed out that “Natural

disturbance of deep-sea populations has not yet been identified, nor has it been attempted experimentally." For example, in a species with very wide distribution, Zelck and Klein (1995) found that the salinity characteristics of lower surface waters correlated better with distribution of *Ceratoscopelus maderensis* than did temperature. On the other hand, Rojas et al. (2002) determined that upwelling and cold plume dynamics were important factors affecting the survivorship of *Diogenichthys atlanticus* and *D. laternatus*. Nonaka et al. (2000) found significant seasonal variation for *Myctophum affine* larvae off eastern Brazil, and Tsarin (1985) found that *Myctophum asperum* substituted for *Myctophum lunatum* during the winter monsoon period in the western Indian Ocean. The response of the myctophid community structure to postulated climatic changes affecting the oceans may significantly alter the marine food web. How the biodiversity of lanternfishes affects the ecosystem as a whole warrants further investigation and new study methods to predict the consequences of various types of disturbances.

STATEMENT OF WORK/TERMS OF REFERENCE

It will be the goal of this Working Group to:

1) Summarize the state of knowledge of methods and techniques employed for determining myctophid population dynamics, and to summarize the state of knowledge about myctophid biology, especially as it pertains to an understanding of the role of lanternfishes in the world ocean ecosystem.
2) Assess ongoing research effort required in these areas, including and emphasizing the utilization of modeling techniques and approaches.
3) Target those myctophid species and those geographic areas in the world ocean that could benefit from a focus of these and other innovative research approaches in terms of biomass turnover rate.
4) Establish and maintain a web site for the exchange of information and ideas between mesopelagic fish specialists, marine biologists and physical oceanographers, as well as other interested groups such as fisheries scientists.
5) Produce a comprehensive report incorporating the results from the above activities for which we would seek appropriate publication, whether in a peer-reviewed journal or as a book. If the group decides to produce a book, it will also produce a summary article for a peer-reviewed journal.

MEETINGS

The WG will have a duration of 4 years with three meetings of the members over that period. The first WG meeting would take place within three to six months after the availability of funds. The primary task of the first meeting would be to develop a plan to achieve the terms of reference. The primary discussion would focus on how to produce the final report. This would include setting time frames and allocating tasks to members most logically by their geographic areas of interest, in order to bring together the information for past and ongoing efforts. The

secondary task of the first meeting will be determining the steps for the establishment of a web site for the exchange of information among myctophid specialists, and biological and physical oceanographers. Because the interests of this working group with those of IMBER will potentially intersect, we have been in contact with Julie Hall, IMBER Chair, to determine how best to interact in order to benefit both organizations.

It is clear that a working group of ten Full Members, plus an indeterminate number of Associate Members, will have difficulty bringing together all the necessary knowledge of ongoing efforts, let alone addressing potential future efforts. Therefore, one of the activities at the first WG meeting will be the planning for an international conference of myctophid specialists and related marine scientists including fishery biologists in order to specifically spell out the state of our knowledge of all aspects of myctophid biology. It is expected that such a conference would occur 18-24 months after the first WG meeting and would bring together some 40-50 specialists from all parts of the world. Support for such a conference would be sought from various agencies and private foundations. The incorporation of results of a successful international myctophid conference will greatly enhance the Working Group's final report by making it more comprehensive and inclusive.

The second WG meeting would be held immediately after the international conference. The agenda will include a discussion of how to incorporate the results from the conference into the WG final report, that is, those actions and activities that will need to be undertaken by the WG members in order to have the results ready for incorporation into the final report. This will result in an initial draft that would be circulated electronically to the members who would be free to solicit comments and inputs from other specialists. The contributions from the various WG members will be brought together into a revised draft. This draft will be discussed and finalized at the third and last WG meeting, to be held approximately 12 months after the second WG meeting.

Such a timetable is reasonable. It allows for some slippage of the dates and times, but will still permit completion of the WG activities and the final report within the planned 4-year period.

Time 0 -- Availability of funds
3-6 months later – WG Meeting One
18-24 months later – International Myctophid Conference
1 day – 1 month later – WG Meeting Two
12 months later – WG Meeting Three
3 months later – Final report ready for publication

WORKING GROUP MEMBERSHIP

The Working Group membership will consist of 10 members from a variety of countries including both developed and developing countries. It will include both myctophid specialists,

and biological and physical oceanographers already involved in, or with an interest in, mesopelagic fishes.

Potential Working Group Participants:

Bernard J. Zahuranec, Co-Chair; Myctophid systematics and biogeography
Smithsonian Institution, Division of Fishes, Washington, D.C., USA

M. M. Rabbani, Co-Chair; Director General of NIO, Biology of marine invertebrates
National Institute of Oceanography, Karachi, Pakistan

Cynthia Klepadlo; Assistant Curator, Taxonomy of deep-sea fishes worldwide
Scripps Institution of Oceanography, Marine Vertebrates Collection, Calif., USA

Samina Kidwai; Associate Research Scientist, Biology of marine invertebrates
National Institute of Oceanography, Karachi, Pakistan

John Paxton; Taxonomy, anatomy, biology, and relationships of myctophids;
Australia and Indo-PacificAustralian Museum, Sydney, N.S.W., Australia

P. Alexander Hulley; Systematics and biogeography of myctophid on worldwide basis
South African Museum, Cape Town, Republic of South Africa

S. A. Tsarin; Biology, systematics and life history of deep-sea fish, especially western Indian Ocean Institute of Biology of the Southern Seas, Sebastopol, Ukraine

Padmini Dalpadado; Life history and biology arctic fishes; extensive life history work on a single myctophid species (*Benthosema pterotum*)
Institute of Marine Fisheries, University of Bergen, Norway

Chiuki Sassa; Ecology of mesopelagic fish, East China Sea and West Pacific
Seikai National Fisheries Research Institute, Nagasaki, Japan

Donald Olson; Physical oceanographer, interaction of marine fishes and physical and environmental variables
Department of Physical Oceanography, Rosensteil School of Marine and Atmospheric Sciences, University of Miami, Florida, USA

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Appendix

Taxon	Scientific name	Common name	Reference
Piscean	*Apogonops anomalus*		Blaber & Bulman 1987
Piscean	*Apristurus microps*		Ebert 1996
Piscean	*Apristurus saldanha*		Ebert 1996
Piscean	*Auxis* sp.	bullet mackerel	Sanchez-Velasco et al. 1999
Piscean	*Bathyraja maculata*		Orlov 1998
Piscean	*Bathyraja matsubarai*		Orlov 1998
Piscean	*Bathyraja minispinosa*		Orlov 1998
Piscean	*Bathyraja papilionifera*		Orlov 1998
Piscean	*Bathyraja papilionifera*		Stehmann & Schulze 1996
Piscean	*Brama brama*		Blaber & Bulman 1987
Piscean	*Champsocephalus gunnari*	mackerel icefish	Lee et al. 2002b
Piscean	*Decapterus russelli*	mackerel scad	Raje 1997
Piscean	*Dissostichus eleginoides*	Patagonian toothfish	de la Rosa et al. 1997
Piscean	*Epigonus denticulatus*		Matallanas 1982/83
Piscean	*Etmopterus spinax*	velvet-belly lanternshark	Relini Orsi & Wurtz 1976
Piscean	*Etmopterus spinax*	velvet-belly lanternshark	Wurtz & Vacchi 1981
Piscean	*Eumegistus* sp.		Parin & Prutko 1985
Piscean	*Euthynnus lineatus*	black skipjack	Sanchez-Velasco et al. 1999
Piscean	*Galeus polli*		Ebert 1996
Piscean	*Gymnodraco acuticeps*	Antarctic dragonfish	Pakhomov 1998
Piscean	*Helicolenus dactylopterus*	jacopever	Weilbach et al. 1998
Piscean	*Hexanchus griseus*	sixgill shark	Ebert 1994
Piscean	*Holohalaelurus regani*		Ebert 1996
Piscean	*Hoplostethus atlanticus*	orange roughy	Rosecchi et al. 1988
Piscean	*Hoplostethus mediterraneus*	silver roughy	Kerstan 1989
Piscean	*Iago omanensis*	bigeye houndshark	Waller & Baranes 1994
Piscean	*Katsuwonus pelamis*	Japanese skipjack tuna	Kikawa 1977
Piscean	*Lepidopus caudatus*		Blaber & Bulman 1987
Piscean	*Macrourus holotrachys*	South Atlantic grenadier	Dudochkin 1988
Piscean	*Macruronus magellanicus*	long-tailed hake	Bezzi 1984
Piscean	*Macruronus novaezelandiae*	hoki	Blaber & Bulman 1987
Piscean	*Macruronus novaezelandiae*	hoki	Bulman & Blaber 1986
Piscean	*Macruronus novaezelandiae*	hoki	Jay 1993
Piscean	*Macrurus rupestris*	round-nose grenadier	Savvatimskij 1985
Piscean	*Merluccius albidus*	offshore hake	Rohr & Gutherz 1977
Piscean	*Merluccius capensis*	shallow-water Cape hake	Chlapowski 1977
Piscean	*Merluccius capensis*	shallow-water Cape hake	Pillar & Wilkinson 1995
Piscean	*Merluccius capensis*	shallow-water Cape hake	Prenski 1986
Piscean	*Merluccius capensis*	shallow-water Cape hake	Roel & McPherson 1988

Piscean	*Merluccius gayi peruanus*	Peruvian hake	Alamo & Espinoza 1997
Piscean	*Merluccius paradoxus*	deep-water Cape hake	Chlapowski 1977
Piscean	*Merluccius paradoxus*	deep-water Cape hake	Roel & McPherson 1988
Piscean	*Merluccius polli*	Benguela hake	Kilongo 1998
Piscean	*Merluccius polli*	Benguela hake	Kilongo & Mehl 1998
Piscean	*Merluccius productus*	Pacific hake	Outram & Haegele 1972
Piscean	*Micromesistius australis*	polaca	Otero 1977
Piscean	*Micromesistius australis*	polaca	Perrotta 1982
Piscean	*Micromesistius poutassou*	blue whiting	Miller 1966
Piscean	*Notolepis annulata*	ringed barracudina	Skora & Balushkin 1994
Piscean	*Oncorhynchus* spp.	Pacific salmon	French et al. 1971
Piscean	*Oncorhynchus* spp.	Pacific salmon	Nagasawa et al. 1997
Piscean	*Paradiplospinus antarcticus*		Solyanik 1964
Piscean	*Promethichthys* sp.		Parin & Prutko 1985
Piscean	*Reinhardtius hipplglossoides*	Greenland halibut	Yang & Livingston 1988
Piscean	*Salmo salar*	Atlantic salmon	Hansen & Pethon 1985
Piscean	*Salmo salar*	Atlantic salmon	Hislop & Youngson 1984
Piscean	*Salmo salar*	Atlantic salmon	Jacobsen & Hansen 1997
Piscean	*Salmo salar*	Atlantic salmon	Jacobsen & Hansen 2001
Piscean	*Salmo salar*	Atlantic salmon	Thurow 1973
Piscean	*Scomber japonicus peruanus*		Alamo et al. 1996
Piscean	*Scomber scombrus*	mackerel	Walker & Nichols 1993
Piscean	*Scopelosaurus adleri*		Balanov 2001
Piscean	*Scopelosaurus harryi*		Balanov 2001
Piscean	*Sebastes* spp.	rockfishes	Dower & Perry 2001
Piscean	*Sebastes borealis*	short-raker rockfish	Orlov & Abramov 2001
Piscean	*Sebastes marinus*		Gorchinski & Kiseleva 1992
Piscean	*Sebastes marinus*		Gorelova & Borodulina 1997
Piscean	*Sebastes mentella*		Gonzalez et al. 2000
Piscean	*Sebastes mentella*		Gorelova & Borodulina 1997
Piscean	*Sebastes mentella*		Shibanov et al. 1994
Piscean	*Sebastes paucispinis*	bocaccio	Phillips 1960
Piscean	*Squalus sucklii*		Hubbs 1917
Piscean	*Theragra chalcogramma*	walleye pollock	Yamamura et al. 2002
Piscean	*Theragra chalcogramma*	walleye pollock	Yoshida 1994
Piscean	*Thunnus alalunga*	albacore	Iverson 1971
Piscean	*Thunnus alalunga*	albacore	Kim et al. 1997
Piscean	*Thunnus alalunga*	albacore	Nihira 1988
Piscean	*Thunnus albacares*	yellowfin tuna	Bard & Pezennec 1991
Piscean	*Thunnus albacares*	yellowfin tuna	McPherson 1991

Piscean	*Thunnus obesus*	bigeye tuna	Kim et al. 1997
Piscean	*Thunnus obesus*	bigeye tuna	McPherson 1991
Piscean	*Thyrsites atun*	snoek	Negpen 1979
Piscean	*Trachurus* spp.	horse mackerel	Acevedo & Fives 2001
Piscean	*Trachurus declivis*		Blaber & Bulman 1987
Piscean	*Trachurus picturatus murphyi*		Alamo et al. 1996
Avian	*Aptenodytes forsteri*	emperor penguin	Kirkwood & Robertson 1997
Avian	*Aptenodytes patagonicus*	king penguin	Charrassin et al. 1998
Avian	*Aptenodytes patagonicus*	king penguin	Hindell 1988a
Avian	*Aptenodytes patagonicus*	king penguin	Jouventin et al. 1994
Avian	*Aptenodytes patagonicus*	king penguin	Klages & Bester 1998
Avian	*Aptenodytes patagonicus*	king penguin	Olsson & North 1997
Avian	*Aptenodytes patagonicus*	king penguin	Perissinotto & McQuaid 1992
Avian	*Aptenodytes patagonicus*	king penguin	Putz et al. 1998
Avian	*Aptenodytes patagonicus*	king penguin	Wilson et al. 1993
Avian	*Catharacta antarctica lonnbergi*	Antarctic skua	Reinhardt 1997
Avian	*Catharacta maccormicki*	South Polar skua	Montalti et al. 1997
Avian	*Catharacta maccormicki*	South Polar skua	Reinhardt 1997
Avian	*Diomedea chrysostoma*	grey-headed albatross	Reid et al. 1996
Avian	*Diomedea melanophris*	black-browed albatross	Reid et al. 1996
Avian	*Eudyptes chrysolophus*	macaroni penguin	Green et al. 1998
Avian	*Fratercula arctica*	Atlantic puffin	Falk et al. 1992
Avian	*Halobaena caerulea*	blue petrel	Cherel et al. 2002a
Avian	*Hydrobates pelagicus*	British storm petrel	D'Elbee & Hemery 1998
Avian	*Larus argentatus atlanticus*	yellow-legged herring gull	Hamer et al. 1994
Avian	*Larus novaehollandiae hartlaubi*	Hartlaub's gull	Morant 1987
Avian	*Larus novaehollandiae hartlaubi*	Hartlaub's gull	Walter 1985
Avian	*Oceanodroma furcata*	forked-tail storm-petrel	Vermeer & DeVito 1988
Avian	*Oceanodroma leucorhoa*	Leach's storm-petrel	Vermeer & DeVito 1988
Avian	*Pagophila eburnea*	ivory gull	Orr & Parsons 1982
Avian	*Phalacrocorax capensis*	Cape cormorant	Walter 1985
Avian	*Phoebetria palpebrata*	light-mantled sooty albatross	Thomas 1982
Avian	*Procellaria aequinoctialis*	white-chinned petrel	Croxall et al. 1995
Avian	*Procellaria aequinoctialis*	white-chinned petrel	Jackson 1985
Avian	*Puffinus griseus*	sooty shearwater	Jackson 1985
Avian	*Puffinus tenuirostris*	short-tailed shearwater	Gould et al. 2000
Avian	*Pygoscelis antarctica*	chinstrap penguin	Jansen et al. 1998
Avian	*Pygoscelis papua*	gentoo penguin	Leseroel et al. 2004
Avian	*Rissa brevirostris*	red-legged kittiwake	Lance & Roby 1998
Avian	*Rissa tridactyla*	black-legged kittiwake	Lance & Roby 1998
Avian	*Sterna dougallii*	roseate tern	Ramos et al. 1998

Avian	*Sterna fuscata*	sooty tern	Surman & Wooller 2003
Avian	*Sterna hirundo*	common tern	Granadeiro et al. 2002
Mammalian	*Arctocephalus forsteri*	New Zealand fur seal	Fea et al. 1999
Mammalian	*Arctocephalus gazella*	Antarctic fur seal	Daneri 1996
Mammalian	*Arctocephalus gazella*	Antarctic fur seal	Daneri & Carlini 1999
Mammalian	*Arctocephalus gazella*	Antarctic fur seal	Daneri & Coria 1993
Mammalian	*Arctocephalus gazella*	Antarctic fur seal	Green et al. 1989
Mammalian	*Arctocephalus gazella*	Antarctic fur seal	Klages & Bester 1998
Mammalian	*Arctocephalus gazella*	Antarctic fur seal	Lee et al. 2002a
Mammalian	*Arctocephalus gazella*	Antarctic fur seal	North et al. 1983
Mammalian	*Arctocephalus philippii*	Juan Fernandez fur seal	Acuna & Francis 1995
Mammalian	*Arctocephalus pusillus*	Cape fur seal	Bester et al. 2002
Mammalian	*Arctocephalus tropicalis*	Subantarctic fur seal	Klages & Bester 1998
Mammalian	*Balaenoptera edeni*	Bryde's whale	Gallardo & Pastene 1983
Mammalian	*Balaenoptera edeni*	Bryde's whale	Kawaguchi & Kawamura 1981
Mammalian	*Delphinus delphis*		Chou et al. 1995
Mammalian	*Globicephala melas*	long-fined pilot whale	Gannon et al. 1997
Mammalian	*Lagoenorhynchus obscurus*	dusky dolphin	Wuersig et al. 1997
Mammalian	*Lissodelphis borealis*		Chou et al. 1995
Mammalian	*Stenella attenuata*	pantropical spotted dolphin	Robertson & Chivers 1997
Molluscan	*Dosidicus gigas*	jumbo squid	Markaida & Sosa-Nishizaki 200
Molluscan	*Dosidicus gigas*	jumbo squid	Nigmatullin et al. 2001
Molluscan	*Illex argentinus*	short-finned squid	Santos & Haimovici 1997
Molluscan	*Moroteuthis ingens*	deepwater squid	Jackson et al. 1998
Molluscan	*Moroteuthis ingens*	deepwater squid	Phillips et al. 2001
Molluscan	*Moroteuthis ingens*	deepwater squid	Phillips et al. 2003
Molluscan	*Ommastrephes bartramii*	neon flying squid	Araya 1983
Molluscan	*Ommastrephes bartramii*	neon flying squid	Lipinski & Linkowski 1988
Molluscan	*Ommastrephes bartramii*	neon flying squid	Watanabe et al. 2004
Molluscan	*Pterygioteuthis gemmata*		Nesis 1993
Molluscan	*Pyroteuthis margaritifera*		Nesis 1993
Molluscan	*Sthenoteuthis oualaniensis*		Shchetinnikov 1992
Molluscan	*Sthenoteuthis oualaniensis*		Tsarin & Chesalin 1983
Molluscan	*Sthenoteuthis oualaniensis*		Zuyev et al. 2002
Crustacean	*Acanthephyra pelagica*	oplophorid shrimp	Cartes 1993
Crustacean	*Plesionika* spp.	pandalid shrimp	Cartes & Fanelli 2004
Crustacean	decapods		Cartes et al. 1994
Crustacean	euphausids		Cartes et al. 1994
Crustacean	mysids		Frank et al. 1984

SCOR SCIENTIFIC SUBSIDIARY BODIES - as of September 7, 2006

		CHAIR / CO-CHAIR	***REPORTER***
WORKING GROUPS			
WG 111	Coupling Waves, Currents and Winds in Coastal Models	Huang/Mooers	Wainer
WG 115	Standards for the Survey and Analysis of Plankton	Heaney	Pierrot-Bults
WG 116	Sediment Trap and ^{234}Th Methods for Carbon Export Flux Determination	Buesseler	Labeyrie
WG 119	Quantitative Ecosystem Indicators for Fisheries Management	Cury/Christensen	Taniguchi
WG 120	Marine Phytoplankton and Global Climate Regulation: The *Phaeocystis spp.* Cluster as a Model	Gieskes/Belviso	Hall
WG 121	Ocean Mixing	Muench	Akulichev
WG 122	Mechanisms of Sediment Retention in Estuaries	Kjerfve/Perillo	Labeyrie
WG 123	Reconstruction of Past Ocean Circulation (PACE)	Lynch-Stieglitz/Kissel	Labeyrie
WG 124	Analyzing the Links Between Present Oceanic Processes and Paleo-records (LINKS)	Lochte/Sicre	Wainer
WG 125	Global Comparisons of Zooplankton Time Series	Mackas/Verheye	Pierrot-Bults
WG 126	Role of Viruses in Marine Ecosystems	Weinbauer/ Wilhelm	Hall
WG 127	Thermodynamics and Equation of State of Seawater	McDougall	Imawaki
WG 128	Natural and Human-Induced Hypoxia and Consequences for Coastal Areas	Zhang/Gilbert	Duce
SCIENTIFIC STEERING COMMITTEES, PANELS, etc			
GLOBEC	Global Ocean Ecosystem Dynamics SSC	Werner	Taniguchi
GEOHAB	Global Ecology and Oceanography of Harmful Algal Blooms SSC	Pitcher/Babin	Hall
SOLAS	Surface Ocean - Lower Atmosphere Study SSC	Liss/Matrai	Labeyrie
IMBER	Integrated Marine Biogeochemistry and Ecosystem Research TT/SSC	Hall/Hansell/ Monfray	Duce
LOICZ	Land-Ocean Interactions in the Coastal Zone SSC	McManus	Hall
	GEOTRACES	Anderson/ Henderson	Duce
	The Ocean in a High-CO_2 World Symposia	Cicerone/Orr	Duce
IOCCP	International Ocean Carbon Coordination Project	Sabine	Sundby
	Panel on New Technologies for Observing Marine Life	Elgar Desa	Pierrot-Bults

	SOLAS/INI Review of Anthropogenic Nitrogen Impacts on the Open Ocean	Duce/La Roche	MacCracken
	IGBP/SCOR Fast-Track Initiative on Atmospheric CO_2 and Ocean Biogeochemistry: Modern Observations and	Elderfield/ Caldeira/ Kleypas/	Hall
PACKMEDS	Physics and Chemistry as the Key to Marine Ecosystem Dynamics and Structure	Mellilo/Rizzoli	Sundby

AFFILIATED PROGRAMS

CoML	Census of Marine Life	Grassle	Taniguchi
iAnZone	International Antarctic Zone	Heywood	Wainer
IMAGES	International Marine Global Changes	Rohling	Labeyrie
InterRIDGE	International RIDGE Studies	Devey	Labeyrie
IOCCG	International Ocean Colour Coordinating Group	Yoder	Hall
	InterMARGINS	Whitmarsh	Labeyrie

PARTNER ORGANIZATIONS

IGBP	International Geosphere-Biosphere Programme	Brasseur	Sundby
POGO	Partnership for Observation of the Global Oceans	de Leeuw	Hall
SCAR	Scientific Committee on Antarctic Research	Thiede	Hall/Labeyrie
SCOPE	Scientific Committee on Problems of the Environment	Sala	Pierrot-Bults
IOC	Intergovernmental Oceanographic Commission	Pugh	Sundby
WCRP	World Climate Research Programme	Lemke	MacCracken
PICES	North Pacific Marine Sciences Organization	Alexander	Akulichev

ACTIVITIES UNDER DEVELOPMENT/MISC.

RGSO	Regional Graduate Schools of Oceanography and Marine Environmental Sciences	Wainer