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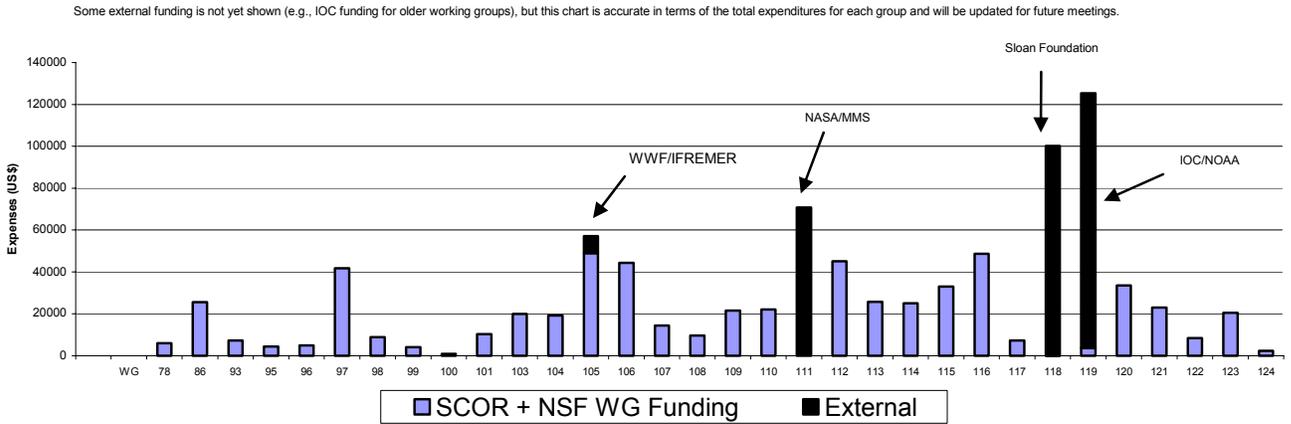
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Expenditures by SCOR Working Groups (1995-2005)



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.

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2.1 Disbanded Working Groups

2.1.1 WG 78--Determination of Photosynthetic Pigments in Seawater

Since the 2004 SCOR Executive Committee meeting, we became aware that the book *Phytoplankton Pigments in Oceanography*, which resulted from SCOR WG 78, is out of print. SCOR and IOC agreed to pay US\$3,000 each to reprint 500 copies, with a foreword added to explain some of the advances since the original book was published. Copies of the reprinted book will be sent to the libraries on the SCOR developing country library list.

The editors of the original book are preparing a proposal to SCOR and IOC for creation of a second edition of this popular book.

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.

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Carlos Garcia	BRAZIL		

Executive Committee Reporter: Ilana Wainer

SCOR WG 111 Progress Report June 2005

Background. WG111 is preparing a volume entitled “Coupled Coastal Wind-Wave-Current Dynamics” edited by Peter Craig/CSIRO (Marine, Hobart), Chris Mooers/RSMAS, University of Miami, and Norden Huang/GSFC, NASA. The editors have a contract with Cambridge University Press for the publication. The book is to have seven core chapters, each of which has a lead author who is coordinating the individual section authorship. There are about 40 authors in total.

The steps to publication are

1. chapter drafts are submitted to Peter Craig
2. they are edited for consistency of style and content
3. they are returned to the lead authors for modification
4. modified chapters are reformatted to CUP requirements by an editorial assistant
5. chapters are sent for review
6. reviewed chapters are returned to authors for modification
7. chapters are returned through the lead author, and the book is compiled.

Progress. At this stage, all chapters have reached draft form. Two require additional text before the stage-2 edit. Five have been through the full stage-2 edit, and have been now returned to lead authors, and one has been through the stage-4 formatting. Progress is good, and the product looks excellent, but the pace is (almost inevitably) slower than we had anticipated. Submission to CUP is planned for June 2006.

Financial. In August 2004, the remaining Aus\$9660 in the WG111 account was transferred to CSIRO to enable an editorial assistant to be employed to perform the stage-4 edit. To date, only one chapter has been ready for this edit. At 30 April 2005, Aus\$7469 remains to be spent on subsequent chapters.

This report prepared 27 May 2005 by

Dr. Peter Craig
Editor-in-Chief, WG 111
CSIRO Marine Research, Hobart, Australia

And it is submitted 29 May 2005 by

Prof. Christopher N. K. Mooers and Dr. Norden Huang, SCOR WG111 Co-Chairs

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 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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Executive Committee Reporter: Annelies Pierrot-Bults

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

Chairman: S I Heaney

Since the last meeting of WG 115 at The University of Concepción, Oceanographic Laboratory, Dichato, Chile on 14-16 November there has been limited progress. This has been due to personal difficulties in the circumstances of the Chairman. Nevertheless, WG members have undertaken commitments they made at the Chile meeting, including the near completion of a joint Argentinian-Chilean project for a Spanish manual on plankton methods. Other related activities undertaken by WG 115 members have involved planning the establishment of important new CPR routes and attending to the growing interest of the results of present surveys by various governments and scientific programmes.

It has been agreed with SCOR that the final meeting of WG 115 will be held at The Marine Laboratory (which incorporates the Sir Alister Hardy Foundation for Ocean Science) in Plymouth, England on 18 and 19 May 2006. A sub-group of members from Africa, Australia, Russia and Norway have agreed to act as organisers. The objective of the meeting will be to bring together the findings of the WG in relation to its Terms of Reference and to provide the greater scientific community with recommendations on standards for the surveys and analyses of plankton. The method of publication of the results of meeting has yet to be agreed between the WG and SCOR.

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, $\text{POC}/^{234}\text{Th}$ 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.

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Tom Trull	AUSTRALIA
Michiel Rutgers van der Loeff	GERMANY

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Executive Committee Reporter: Laurent Labeyrie

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Sediment Trap and ^{234}Th methods for Particulate Organic Carbon Export in the upper ocean: Current Status

Annual report- 2004/2005

Introduction

The past 12 months have been a very active time for WG #116. There were three main activities since our last report. As these reports are written in June of the calendar year, events in the past 12 months included: 1. participation in August 2004 workshop “Future Applications in the application of thorium-234 in Aquatic Systems” (FATE); 2. a short 2.5-day WG gathering immediately following FATE conference and 3. a final WG gathering on April 18-21, 2005 in Xiamen China. Each of these are discussed below.

1. FATE conference, August 16-19, 2004

(information from conference Web site and extracted from *EOS* article).

In August 2004, over 40 researchers from the United States, Europe, India, Australia, and China met at the Woods Hole Oceanographic Institution in Woods Hole, Massachusetts, USA to discuss the Future Applications of ^{234}Th in Aquatic Ecosystems (FATE). The purpose of the workshop was to bring together a number of international experts in the collection, analysis and interpretation of ^{234}Th in aquatic ecosystems with diverse opinions and backgrounds. The participants were asked to discuss and define current concepts in the use of ^{234}Th as well as a coherent strategy for future endeavors. Included in this group were several renowned radiochemists and geochemists not directly involved in ^{234}Th measurements, to provide outside perspective into the current status and future directions of ^{234}Th research. Invited talks focused on four main areas: (1) new methodologies and techniques, (2) the collection and application of POC/ ^{234}Th ratios, (3) modeling, and (4) ^{234}Th -speciation (program available online at: <http://www.geol.sc.edu/cbnelson/Thmeeting/Index.htm>).

SCOR helped support the funding of the meeting via partial travel assistance to several WG #116 members who attended, including Buesseler, Gustafsson, Fowler, Sarin, Trull, and Rutgers van der Loeff (who rejoined our WG in early 2005). As an outcome of the FATE meeting, there are several products that were produced or will be available that are directly relevant to the goals of WG #116:

- a. online bibliography of papers related to measurement and use of ^{234}Th
- b. online copies of the invited talks
- c. submittal and publication in *EOS* of meeting report--*EOS* Vol. 85, No. 45, 9 Nov. 2004, pg. 471-472- C. Benitez-Nelson and the ^{234}Th -Group
- d. organization of a submittal of a series of papers to *Marine Chemistry* for a special issue, including 4 major review articles (topic 1-4 above).

WG members played a major role in all of these activities, including being lead author on two of the invited talks and two of the 4 major review articles (Buesseler; Rutgers van der Loeff). These

manuscripts were submitted and have now returned after review. Revised manuscripts will be sent back to *Marine Chemistry* and guest editors in June 2005.

2. Woods Hole WG meeting, Aug. 19-21, 2004

WG members met immediately following the FATE conference to discuss the *Progress in Oceanography* manuscript “Estimating Upper Ocean Particle Fluxes with Sediment Traps: A progress report”. In addition to those WG members at the FATE conference, we were joined by Antia, Steinberg and Harada. The agenda followed the main sections or chapters in the manuscript, with copies for each having been distributed prior to our meeting. Comments and discussion continued throughout the meeting, with time taken to detail the tasks that remained, references, expertise to be consulted when needed, new figures to be drafted, and a schedule for finishing a completed manuscript. A plan was made to request a 4th and final WG meeting in spring 2005, which was later approved for funding by SCOR. Details on the now almost completed manuscript are discussed below in context of this spring meeting. It was decided to invite W. Gardner, an expert in hydrodynamics issues related to traps, to join our group in Xiamen as an Associate Member (an invitation which he accepted).

3. Xiamen, China WG meeting, April 18-21, 2005

A fourth and final WG meeting was held in Xiamen, China, hosted by Dr. Minhan Dai and his colleagues at the University of Xiamen. This meeting was a success from many perspectives, not least of which was progress made on the manuscript, all sections of which had been at least assembled in draft form prior to the meeting for distribution and discussion. Provided below is an outline of the agenda, a detail from the Contents of the manuscript (now at over 100 double spaced pages and over 20 figures, tables, not including appendixes). As in Woods Hole, each section was discussed in detail. There was more time built into the schedule in Xiamen for smaller groups and individuals to work on writing and editing tasks. WG members also participated over 2 afternoons in a series of general science talks to University of Xiamen staff and students. This was done to encourage interactions between scientists in Xiamen and WG members, and by all accounts the talks and the social program that brought us in contact with the staff were a big success.

As an update since the meeting, a new round of text, figures, tables, references and appendixes have been sent in May to Buesseler who is planning to submit the paper to *Progress in Oceanography* in June 2005. We have been in contact with an editor of the journal to discuss content, length and review issues. We are confident that this manuscript will be a major contribution to the field and a highlight of this SCOR WG process. Needless to say, we are all eager to reach completion and move on to the submittal stage soon. We anticipate that discussion of the reviewers’ comments and edits can be made without the need for another WG gathering.

Summary

We are reaching the end of SCOR WG #116 activities. This group has made exceptional progress in furthering our understanding of sediment trap and ²³⁴Th-based methods to quantify upper ocean fluxes, and is succeeding in organizing and passing on this knowledge to the ocean sciences and broader community. This progress has come as a result of the SCOR-sponsored gatherings and new

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associations we have made with each other, in addition to the continued progress being made as a result of individual science programs among the participants. The production of a series of Web products (talks, reference lists), a general-audience *EOS* article, and peer-reviewed publications (lead authors and co-author on 5 *Marine Chemistry* publications plus a major *Progress in Oceanography* review article) is significant in both the sheer quantity of work and quality of effort. As Chair, I am particularly pleased with the wide range of expertise we were able to bring together to this research area and the strength of the professional and personal relationships that have come out of this SCOR process. I encourage SCOR to continue these activities, maintain adequate financial support for WG participants, and add new WG initiatives as resources allow. The oceanographic community benefits in many ways from these efforts and thus SCOR staff, steering committee members and advisors, funding sources and importantly, all of the WG participants should be thanked for their contributions to this process.

Related items-

- I. Progress in Oceanography title, authors and Table of contents
- II. Xiamen agenda.

Estimating upper ocean particle fluxes with sediment traps: A progress report

Buesseler, K., Antia A., Chen, M., Fowler, S., Gardner, W., Gustafsson, O., Harada, K, Michaels, A., Rutgers van der Loeff, M., Sarin, M., Steinberg, D., Trull, T.

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1.1.2 *Nutrient cycling and particulate flux*

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1.1.4 *Remineralization and flux to the deep sea*

1.2. Measurement of Particle Fluxes using Sediment Traps

2. Hydrodynamics

2.1. The hydrodynamic issue

2.2. Progress in understanding the origin and scope of hydrodynamic biases

2.2.1 *Quantifying the role of fluid flow in particle collection*

2.2.2 *Determining particle sources to traps- "statistical funnels"*

2.3. Progress in avoiding the hydrodynamic problem

2.4. Progress in correcting for hydrodynamic biases

2.5 Hydrodynamics: summary

3. Zooplankton Swimmers

3.1. The swimmer issue

3.2. Progress in understanding scope of swimmer biases

3.3. Progress in avoiding the swimmers

3.3.1 *Avoiding swimmers*

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4. Solubilization

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4.4 Solubilization: summary

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6.1 Summary

6.2 Recommendations

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6.2.2. Further research to understand, avoid and correct for hydrodynamic biases

6.2.3. Trap designs and field protocols to reduce swimmer artifacts

6.2.4. Further research to understand, avoid and correct for swimmer artifacts

6.2.5. Solubilization

6.2.6. Experiments to “calibrate” traps using stable elements

6.2.7. Further research using radionuclides to “calibrate” traps

6.2.8. Summary of Recommendations

II. Xiamen agenda

April 17

- arrival and registration
- evening social and reception

April 18 (Day 1—all day for SCOR meeting)

- Discussion & presentation by lead authors of each section of *Progress in Oceanography* manuscript

April 19 (Day 2—half of the day for SCOR meeting, another for talks to Xiamen scientists)

- 08:30-12:00 Group discussion/work on summary section and recommendations
- 14:30-17:30 5 talks of 30 min each to Xiamen scientists
(tentative schedule- Buesseler, Steinberg, Antia, Michaels, Rutgers van der Loeff)
Those scientists not speaking use time for discussion/chapter revisions

April 20 (Day 3—half of the day for SCOR meeting, another for talks to Xiamen scientists)

- 08:30-12:00 Finalize *Progress in Oceanography* manuscript
- 14:30-17:30 5 talks of 30 min each to Xiamen scientists
(tentative schedule- Fowler, Trull, Sarin, Gardner, Harada)
Those scientists not speaking use this time for discussion/chapter revisions

April 21 (Day 4—half of the day for SCOR meeting)

- 08:30-12:00 Discussion of final publication schedule, SCOR bibliography, future experiments or workshops

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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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Executive Committee Reporter: Akira Taniguchi

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Proposal for a follow up of the SCOR-IOC WG 119 under the auspice of SCOR-IOC, Eur-Oceans, PICES?, GLOBEC?

Reconciling single fish stock management and ecosystem approach to fisheries? Purposes, issues and methods?

Philippe Cury

Worldwide, there is a tendency to advocate that using a proper single-stock fisheries management would lead to a reasonable ecosystem approach to fisheries, that is, to preserve the different components of the marine ecosystems and their dynamics. Indicators for both approaches have been developed, although few conceptual or practical bridges between them have been explored (*ICES Journal of Marine Science* volume on *Quantitative Ecosystem Indicators for Fisheries Management*) and a review of case studies is lacking.

In order to reconcile stock assessment and ecosystem approaches to fisheries through indicators, it appears important to examine, using a comparative approach, the indicators of both approaches and the resulting results in term of viability of the marine ecosystems. A conceptual framework could be derived from such a comparison and the respective contributions of single-stock fisheries indicators and those derived from ecosystem models to ecosystem approach to fisheries could be determined.

Such work (Shannon and Cury MS) has been initiated in the Benguela ecosystems considering long-term trajectories of ecosystems (contrasted trajectories between the northern and southern Benguela Current system during the last 40 years under different stock management), and respective ecosystem responses according to stocks management choices. It could be valuable for the international community to build on this experience and to generalize the approach using indicators; different stock assessment and ecosystem indicators can be evaluated knowing the trajectories of both fish stocks and other components of the ecosystem in marine ecosystems such as the North Sea, Bering Sea, Baltic Sea, Black Sea, Humboldt Current, Georges Bank, Newfoundland, South Catalan Sea. The purpose of this WG would be to use the same approach to strengthen the results in all ecosystems. A four-day WG meeting would be necessary to compare the experience and the indicators, and to write a review paper (we think of a paper in a very good journal if successful -*Science* possibly)

This review would be important to explore the respective inputs of both conceptual approaches. This is also a fundamental issue if we want to operationalize the implementation of the ecosystem approach to marine resources.

The European network of Excellence EUR-OCEANS would be keen on co-sponsoring this meeting and I recently discussed the concept with PICES and GLOBEC, who might want to participate also.

This is a topic has been generated by SCOR-IOC WG 119, and is clear in its objective and manageable. It can be organized early or mid-2006 and be a working group composed of about 10-15 scientists.

Funding: 10k€ (SCOR-IOC) + 10K€ (Other sources)

[Note from Ed Urban: Dr. Cury was notified that it was too late to submit a proposal for consideration of a SCOR working group and that the idea might not fit the working group model. There is still US\$11,239 left over from the WG 119 symposium, and this could be the SCOR-IOC contribution to the meeting, assuming that IOC agrees.]

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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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Executive Committee Reporter: Julie Hall

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Report of SCOR working group #120 activities

The end of this working group is near: a conference will be held in September 2005 for which the tentative programme has now been finalised thanks to additional personnel at the University of Groningen (The Netherlands), where the meeting will take place. The proceedings will be published early 2006 in *Biogeochemistry*. The conference programme follows.

Wednesday August 31, 2005

Chair: Véronique Schoemann

Taxonomy & distribution

09:00 Welcome & Opening by Winfried Gieskes

09:15 Linda Medlin: Taxonomy and distribution (preliminary title)

09:45 Winfried Gieskes: Variability in the contribution of *Phaeocystis* colonies to phytoplankton biomass in the North Sea and the North Atlantic between 1948 and 2005: Causes and consequences

10:15 coffee break

Life cycles

10:45 Véronique Rousseau: *Phaeocystis* life cycle phenomena

11:10 Laurent Seuront: Biologically induced viscosity and turbulence dampening at the ocean microscale during a *Phaeocystis globosa* spring bloom: phenomenology and consequences on zooplankton feeding and swimming behavior

11:35 Stuart Whipple: title coming

12:00 – 13:30 lunch

Physiological ecology

13:30 Véronique Schoemann: Physiological ecology of *Phaeocystis*

14:00 Maria van Leeuwe: The role of hexanoyloxyfucoxanthin in *Phaeocystis antarctica*

14:25 Walker Smith: Photosynthesis/irradiance responses of colonial and single-celled forms of *Phaeocystis antarctica* from the Ross Sea

15:50 Mike Lucas: Presence, productivity and response of *Phaeocystis* to Fe fertilisation in the Antarctic Polar Frontal Zone (Crozet Islands)

15:15 coffee & tea

15:45 Véronique Rousseau: Seasonal dynamics of phosphorus and microbial dominance in the Belgian coastal waters

16:10 Duncan Purdie: Environmental Regulation of *Phaeocystis* Blooms in Coastal Waters of the Western English Channel

16:35 Luis Felipe Artigas: Seasonal and inter-annual variability of *Phaeocystis globosa* outbursts in the

Eastern English Channel and associated phytoplankton dynamics

17:00 posters & drinks (posters will stay up during the conference)

18:00 conference dinner at the Hortus botanicus

Thursday September 1, 2005

Chair: Jens Nejtgaard

Toxicity & nuisance

09:15 Yu-zao Qi: Ecophysiological and Toxicological Studies of *Phaeocystis globosa* Scherffel

09:45 Marion van Rijssel: Haemolytic activity of living *Phaeocystis pouchetii* during mesocosm blooms

10:15 coffee break

Grazing & infochemicals

10:45 Jens Nejtgaard: Zooplankton grazing on *Phaeocystis*: a critical review and future challenges

11:15 Michael Steinke: Infochemistry of trace gases produced by *Phaeocystis* and other haptophytes: More than the biogeochemical cycling of climate-relevant elements

11:45 Elsa Breton: Feeding of *Noctiluca scintillans* during *Phaeocystis* spring blooms in the Belgian coastal waters

12:15 – 13:30 lunch

Vertical export

13:30 Paul Wassmann: Does *Phaeocystis* significantly contribute to the vertical export of biogenic matter?

14:00 **LUIS FELIPE ARTIGAS: PHYTOPLANKTON FATE THROUGH MICROBIAL LOOP PROCESSES AND TROPHIC TRANSFERS IN THE EASTERN ENGLISH CHANNEL, CHARACTERISED BY *PHAEOCYSTIS GLOBOSA* OUTBURSTS**

14:30 Anne-Carlijn Alderkamp: The carbohydrates of *Phaeocystis* and their fate in the microbial loop

15:00 coffee & tea

15:30 – 17:30 group discussions

18:00 dinner near Lake Paterswolde offered by the Research Institute CEES (Centre for Ecological and Evolutionary Studies)

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Friday September 2, 2005

Chair: Jacqueline Stefels

Viruses

09:00 Corina Brussaard: *Phaeocystis* and the role of viruses

09:30 Anne Claire Baudoux: Viruses as mortality agents for *Phaeocystis globosa* in the field

09:55 Gill Malin: Viral infection of DMSP-containing marine phytoplankton as a mechanism for DMS production

10:20 coffee break

DMS(P)

10:45 Jacqueline Stefels: An approach to ecosystem modeling of DMS(P)

11:15 Maurice Levasseur: title coming

11:40 Damodar Shenoy: DMSP production by *Skeletonema costatum*: Influence of sudden salinity changes

12:10 – 13:30 lunch

13:30 Louis Peperzak: Control of algal DMSP production by thiamin, the sulphur-containing vitamin B1

13:55 Ronald Kiene: title coming

14:20 Hyakubun Harada: title coming

14:45 coffee & tea

15:00 Dileep Kumar: Abundance and fluxes of Dimethyl sulphide in/from the North Indian Ocean

15:25 Jack DiTullio: Temporal evolution of the colonial *Phaeocystis antarctica* bloom in the Ross Sea during November 1998

16:00 social programme

Saturday September 3, 2005

Modeling

Chair: Christiane Lancelot

09:00 Christiane Lancelot: Modelling *Phaeocystis* blooms: Success, caveats and perspectives

09:30 Hans Los: Application of a multi-species phytoplankton model (BLOOM) to simulate *Phaeocystis* blooms

09:55 Anouk Blauw: Demonstration of an early warning system for *Phaeocystis* blooms in SW Netherlands

10:20 coffee break

10:45 Piet Ruardij: The role of colony formation by *Phaeocystis globosa* in the development and the decay of the bloom: a model study

11:30 Kevin Arrigo: Simulating *Phaeocystis* dynamics using a 3-D multi-taxa ecosystem model.

11:55 Elsa Breton: Hydroclimatic modulation of diatom/*Phaeocystis* blooms in the nutrient-enriched Belgian coastal waters (North Sea)

12:20 break

12:30 Véronique Rousseau: Adverse effects of *Phaeocystis globosa* blooms and their qualitative perception

12:45 Peter Verity: wrapping up

13:45 Winfried Gieskes: closing of the meeting

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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.
- Establish and maintain a Web site as a "virtual workshop" that can be used by the deep-ocean mixing community for exchange and discussion of ideas, results, and future planning.
- Produce a comprehensive, published final report incorporating appropriate results from the above topics.

Chair:

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Toshiyuki Hibiya	JAPAN
Peter Killworth	UK
Trevor J. MacDougall	AUSTRALIA
Eugene Morozov	RUSSIA
David Salas de Leon	MEXICO
Anders Stigebrandt	SWEDEN
Louis St. Laurent	USA

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Ann Gargett	USA
Theo Gerkema	NETHERLANDS
Sonya Legg	USA
Jennifer MacKinnon	USA
Mark Merrifield	USA
Rob Pinkel	USA
Fangli Qiao	CHINA-Beijing
Barry Ruddick	CANADA
Anne Marie Treguier	FRANCE

Executive Committee Reporter: Victor Akulichev

IAPSO/SCOR WG 121 on Ocean Mixing
Progress as of 31 May 2005

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

Full Members

Hans Burchard (Germany)
Chris Garrett (Canada)
Toshiyuki Hibiya (Japan)
Peter Killworth (UK)
Trevor J. McDougall (Australia)
Eugene Morozov (Russia)
Robin Muench, Chair (USA)
David Salas de Leon (Mexico)
Louis St. Laurent (USA)
Anders Stigebrandt (Sweden)

Associate Members

Sybren Drijfhout (Netherlands)
Ann Gargett (USA)
Theo Gerkema (Netherlands)
Sonya Legg (USA)
Jennifer Mackinnon (USA)
Mark Merrifield (USA)
Rob Pinkel (USA)
Fangli Qiao (China)
Barry Ruddick (Canada)
Anne Marie Treguier (France)

The primary activity of this working group since the inaugural meeting in 2003 has been organization of an international conference focused on evaluation of the state of ocean mixing research. This very well-received conference took place in Victoria, Canada during October 2004 and was attended by 120 experts in topical areas including large-scale ocean modeling, physics of turbulence and mixing, and field observations related to ocean mixing. A summary description of the conference is appended as Attachment 1.

The second formal meeting of Working Group 121 was held in Victoria, Canada in October 2004 directly following the close of the Conference on Ocean Mixing. Discussion during this brief meeting focused on information gained and recommendations made during the course of the conference, and on future possible actions for the group. A summary of this working group meeting is appended as Attachment 2.

The working group pursues, at present, the following:

- A special "Ocean Mixing" issue of *Deep-Sea Research 2* is currently under preparation and will consist of manuscripts submitted by attendees at the October 2004 conference. At this time 16 manuscripts have been submitted and are undergoing peer review. The special issue will present a robust, current evaluation of many facets of ocean mixing research. Publication is anticipated in about March 2006.
- The working group is contributing to organization of a symposium on ocean mixing during the IAPSO Assembly in Cairns, Australia during summer 2005. To date, 25 abstracts have been received for this symposium.

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- Working group members are contributing to planning a special “Ocean Mixing” session to take place at the February 2006 Ocean Sciences Meeting in Honolulu, Hawaii.

Future working group plans include the following:

- Organization of an ocean mixing symposium at the 2007 IUGG General Assembly.
- Preparation and submission of a proposal for an ongoing series of Gordon Conferences that will address ocean mixing. The suggested frequency of these conferences, assuming a successful proposal, will be every four years, with the first anticipated in early 2008.

The final meeting of this working group is planned to take place at the IUGG General Assembly in 2007.

Robin Muench
Chair, IAPSO/SCOR Working Group 121

ATTACHMENT 1

Summary Report
IAPSO/SCOR Conference on Ocean Mixing
Victoria, BC, Canada
11-14 October 2004

Motivations

The IAPSO/SCOR Conference on Ocean Mixing was the most recent of a very small number of open international conferences to focus on the issue of ocean mixing. Organized by SCOR Working Group 121 on Ocean Mixing, the conference was convened in response to community realization that our understanding of ocean mixing processes significantly lags our grasp of large-scale ocean circulation. A primary impact of this knowledge gap has been the inability of large-scale ocean and climate models to adequately incorporate these small-scale processes. This has, in turn, limited the ability of models to satisfactorily recreate the large-scale ocean circulation or to provide credible predictions of response to climate change scenarios.

Recent studies involving methods such as tracer release and utilizing newly developed instrumentation have narrowed the knowledge gap between the large-scale and the very small-scale ocean processes. We are consequently developing a quantitative understanding of the interactions that physically couple these processes and, concurrently, an improved ability to incorporate them into large-scale models. The conference was convened as a mechanism to aid the coordination of research efforts concerned with measurements of ocean mixing, understanding of the underlying dynamics and energy transfer mechanisms, and incorporation of these mechanisms into large-scale models.

Structure and Attendance

The conference was nominally structured around two presentation modes, each of equal importance, but the heart of the conference was the discussions that took place during the poster sessions and the ample free time that was provided. Each day, sets of invited, half-hour long oral presentations were made. These talks were intended to set the tone for discussion and to provide overview materials. The talks were followed by contributed posters that were available for viewing and discussion over coffee and lunch breaks and during dedicated afternoon poster sessions. Conferees were free to pursue these discussions into the evenings following the close of the venue each day.

There were 29 oral presentations, one of which took place at the conference banquet, each a half hour in length. Seventy-six presentations were made as posters, divided equally into two sessions each lasting for two days. The presentations were divided into four quite general subtopics; global concepts and large-scale models, observations, processes, and potential future activities. The more than 120 conferees represented institutions in Australia, Canada, China, France, Germany, Japan, Korea, Mexico, Netherlands, Norway, Russia, Sweden, UK, and the United States.

Conclusions and Recommendations

A large quantity of pertinent material was presented and discussed at the conference, and we (the Working Group 121 membership) mention here those issues distilled from the presentations that were felt to be of paramount importance.

The so-called “missing mixing” issue was discussed at some length. This issue stems from the need for small-scale mixing processes to resupply the deep ocean with potential energy that is lost to the meridional overturning circulation and to eddy formation processes. The mechanical energy budget for the deep ocean is in general poorly constrained; however, emerging evidence suggests that most mixing occurs near the bottom or side boundaries. The source for deep ocean mixing in the interior, and whether the associated energy budget can be closed using known sources, remain subjects of debate. Presentations at the conference suggested that sources for abyssal energy are greater than thought previously. Consequently, we have made progress toward achieving a deep ocean energy balance, and we can now better define the associated problems.

There was considerable discussion at the conference and the subsequent working group meeting concerning the pros and cons of various parameterizations, including addition of new physics rather than simply using parameters. We need physically based models that don't input diffusivities directly but, rather, compute it using the model code. We want non-dissipative, eddy-resolving models and need to specify our objectives without over-specifying the pathway by which we attain these goals. Ongoing efforts to develop high-accuracy, weakly/non-dissipative schemes such as compact finite difference and spectral element models, which are very amenable to parallel processing, should continue to be pursued as well as the “more conventional” models. Models need, in general, to be able to incorporate new breakthrough results without disrupting the original design performance. To quote an anonymous working group member, we need to “Allow for unpredicted brilliance to shine forth along the way.” These issues were generally unresolved and remain crucial.

New observational technology is becoming available, and the ocean community needs to move toward new and innovative measurement systems. Observationalists need to pursue the issue of collecting mixing-related data. While not a major issue at the conference, the working group feels that the technology issue deserves attention. Particular emphasis is needed on technology that we can use to observe the upper ocean through and beneath the surface mixed layer.

The working group endorses pursuit of the following:

- Continued efforts to document, through observations, and to physically understand mixing in and just beneath the upper mixed layer. We have a better basis for understanding of the deep abyss now than of the upper ocean.
- Continued emphasis on those studies currently focussed on overflow physics and the issues of entrainment and detrainment. These fall into the category of boundary processes whereby mass and energy are transported from the lateral boundaries to the ocean interior.
- Focussed studies of processes (transition layer, entrainment-detrainment, submesoscale) that

are proving particularly difficult within a modeling context. Eddy-related transports down through the submesoscale (<1 km) are of concern because they pose particularly egregious difficulties for models.

- Parameterization issues independent of models, for which we endorse the emergence of specialists (“parameterizers”) serving as interfaces between hard-core modelers and observational process people. Another way this need might be phrased is as independent process study people who are able to incorporate their results into models. This development could benefit, as well, from attempts to increase communications between oceanographers and those folk, often more engineering-oriented, who focus on basic fluid mechanics.
- As a corollary to the previous point, we need to replace those parameters used for “tuning” models with physically meaningful values or codes that can compute these values within the model. The idea is to move away from use of an eddy coefficient K , and particular attention is needed for the ocean interior rather than for the surface layer or boundaries. Increased reliance on high-accuracy, low-dissipation models such as compact finite difference and spectral element type models should be encouraged.
- More attention needs to be paid to momentum transfer and balancing energy budgets.
- Observational technology including, where possible, use of turnkey instruments allowing collection of mixing-related data by non-expert personnel. This focus includes technological development related to mixing observations (e.g., probes, acoustics, drifters, CTD, ADCP). Tracers are also proving useful in this context, and their use needs to be continued.

In addition to the foregoing, the following somewhat more specific issues were raised at the conference as being of particular significance or concern.

- How well do models deal with deep convection? It was suggested that current parameterizations are inadequate.
- How real is the “spectral gap” between internal wave and turbulent motions, is it a significant problem, and how might we deal with it?
- Models should focus on decadal variations, since we know this is significant time scale for variability.
- Surface waves should be related to mixed layer depth within an energy budget context.
- How do we define “the abyss”? Might it be defined as that part of the ocean where isopycnals outcrop neither at the surface nor at the seabed, and what are the possible ramifications of such a definition?
- How can we better integrate field experiments with the models that are likely to make use of both the field data and the physics learned from the data analyses?
- The role of double diffusion in large-scale ocean processes demands much greater representation in models than at present, especially in otherwise low energy parts of the central basins and the high latitude oceans where both energy and stratification are weak.
- How well do we really understand mixing in the equatorial regions?

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A final, overarching issue that surfaces through many of the above points is the need for models to better reproduce ocean physics. This must involve a greater collaboration between modelers and the students of mixing processes.

Planned follow-on activities

It is planned to publish a conference proceedings volume, to consist of topical and overview papers submitted by individual conferees in response to a pre-conference call for papers, in a special "Ocean Mixing" issue of *Deep-Sea Research Part 2*. Some 20 contribution titles were provided by prospective authors prior to and during the conference. The working group continues to solicit additional contributions in an attempt to provide a balance of papers that will sufficiently represent the issues discussed at the conference. All manuscripts will be fully peer reviewed per *Deep-Sea Research* publication criteria, with some members of the working group serving as guest editors. The target publication date of the proceedings volume will be in early to mid-2006.

The conferees were unanimously in favor of a follow-on conference, perhaps even a series of conferences, every 3-4 years starting with this conference. One possible approach is to hold a series of Gordon Conferences, after which this conference was structured, at appropriate intervals. The working group is considering this and will come up with a recommendation for further action.

The final post-conference action of the working group will be organization of a symposium on ocean mixing at the IUGG General Assembly that is scheduled to take place in Italy in 2007. The working group will meet at the time of the assembly and anticipates finalizing at that time plans for a second dedicated mixing conference for early 2008.

ATTACHMENT 2

Summary Minutes
SCOR Working Group 121 Meeting #2
15 October 2004
Victoria, BC Canada

Working Group Members present:

Hans Burchard	Robin Muench
Sybren Drijfhout	Rob Pinkel
Chris Garrett	Fangli Qiao
Toshi Hibiya	Barry Ruddick
Peter Killworth	Lou St. Laurent
Trevor McDougall	

The discussion focused primarily on topics raised during the Conference on Ocean Mixing, which had adjourned late on the previous day. Specific points were as follows:

- The conference format was very popular with participants and was quite successful in terms of generation and discussion of ideas and concepts. Future conferences should continue to use this format, which employs a small number of invited “keynote” speakers, a large number of posters, and a great deal of time for free discussion. A logical mechanism for organizing follow-on conferences would be a sequence of Gordon Conferences, which are structured similarly to the Conference on Ocean Mixing. The working group will pursue, through submission of a conference proposal to the Gordon Conferences, establishment of such a series starting in early 2008. Such a conference series could last for as long as there was a need, as demonstrated by attendance figures and positive evaluations by the conferees, and would provide a fitting legacy for the working group.
- There was some discussion of the makeup of the special Ocean Mixing issue of Deep-Sea Research 2. Concerns were expressed as to how a topical balance could be ensured, given that manuscript submission is voluntary. A possible approach will be to summarize otherwise neglected topics in the issue introduction that will be prepared by working group members.
- Recommendations were made for changes to the Associate Membership list of the working group. These recommendations reflected a desire to populate the group with experts likely to be highly active within the group as well in their own research.
- Technical issues were discussed that included energy sources for deep ocean mixing, the present rapid evolution of field observational technology, and parameterization of mixing process in models. These discussions led in turn to a feeling that we should endorse the emergence of specialists that serve to interface between modelers and observational process experts. Other scientific issues felt to require additional attention included field studies of submesoscale (< 1 km) processes, entrainment and detrainment. Technological development related to observation of ocean mixing needs to be strongly encouraged. These science and technical issues are also covered in the Conference Summary in Attachment 1, and so are not presented here in any detail.

A decision was finalized to hold the final Working Group 121 meeting in association with the IAPSO Assembly in 2007.

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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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James Syvitski	USA
Susana Vinzon	BRAZIL
Eric Wolanski	AUSTRALIA

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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

SCOR-LOICZ-IAPSO WG 122
MECHANISMS OF SEDIMENT RETENTION IN ESTUARIES
Annual Report
First year activities

WG 122 met for the first time, 12-16 September 2004, on the campus of Universidade do Algarve, Faro, Portugal. The meeting was hosted by Dr Alice Newton, a faculty of the university and a member of the Scientific Steering Committee of LOICZ. The meeting was cosponsored by SCOR, LOICZ, and the U.S. Office of Naval Research (ONR).

Participants

Co-chairs

Dr Gerardo M.E. Perillo and Dr Björn Kjerfve

Full Members

Dr Carl Amos

Dr Suh Gao

Dr Morten Pejrup

Dr Yoshiki Saito

Dr María Snoussi

Dr James Syvitski

Dr Susana Vinzon

Dr Eric Wolanski

Associate Members

Dr Pedro Depetris

Dr Marek Zajaczkowski

General WG Meeting Schedule

September 11 Arrival

September 12 Cruise to Ria de Formosa

September 13 Meeting day 1.

September 14 Meeting day 2 and presentations by local scientists

September 15 Meeting day 3.

September 16 Excursion to Sagres; departure

Scientific Program

September 13

0830-0900 Meeting inauguration

0900-1030 Gerardo M. E. Perillo: Introduction to sediment retention in estuaries and TOR
 Björn Kjerfve: Sediment issues in estuaries

1030-1045 Coffee break

1045-1230 Eric Wolanski: Siltation of macro-tidal tropical estuaries.

James Syvitski: Understanding of sediment sequestering within deltaic distributary channels.

Yoshiki Saito: Preservation potential and sediment facies of delta/estuary system.

Pedro Depetris: Revisiting the Paraná River biogeochemistry.

1230-1430 Lunch

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- 1430-1600 Susana Vinzon: Sediment Retention in Estuaries: Amazon case.
Marek Zajaczkowski: Transport and trapping of the sediment in the non-glacier contact fjord: The effect of tidal flats, Adventfjorde, Svalbard.
Maria Snoussi: River inputs to estuaries.
Shu Gao: River delta growth in relation to sediment retention.
- 1600-1615 Coffee break
- 1615-1800 Carl Amos: Effects of biology on benthic exchange processes.

September 14

- 0830-1030 Discussion on mechanics of and methods to determine sediment retention in estuaries.
- 1030-1045 Coffee break
- 1045-1230 Discussion on mechanics of and methods to determine sediment retention in estuaries.
- 1230-1430 Lunch
- 1430-1600 Presentations by scientists at Universidade do Algarve.
- 1600-1615 Coffee break
- 1615-1800 Discussion on available models of estuarine sediment retention.

September 15

- 0830-1030 General discussion and planning of future activities.
- 1030-1045 Coffee break
- 1045-1230 Discussion and assignment of responsibilities for the next meeting.
- 1230-1430 Lunch
- 1430-1600 Discussion and assignment of responsibilities for the next meeting.
- 1600-1615 Coffee break
- 1615-1800 Discussion of future schedule and conclusion of WG 122 meeting.

Discussion among the participants centered on the main terms of references: (i) mechanisms of sediment retention in estuaries, and (ii) modeling perspectives and methodologies to study retention. We discussed the basic parameters needed to establish adequate information for comparison of estuarine sediment retention globally. We developed a list of relevant parameters to be organized and circulated to the members of the WG122, for them to add values for estuaries for which data are available, either from published data or from studies and colleagues. A WG 122 Web site is being developed for WG members to and others to enter the data for as many estuaries as possible. This will then constitute the database on which to test models and make comparisons.

We discussed how best to model estuarine sediment retention, considering a spectrum of different modeling approaches from very simple box models to more sophisticated models. We also discussed how best to scale estuaries by development of non-dimensional parameters for comparisons of estuaries of different sizes from around the world. As a beginning, we will develop a simple analytical model, using an easy-to-calculate set of parameters as proxies for estimation of sediment retention. The model will be calibrated against more advanced models and direct available field observations to assess the reliability/degree of error of this simple approach.

We identified two important needs requiring further consideration: (i) the linkage between river sediment load and estuarine sediment dynamics; and (ii) sediment influx from the coastal ocean into estuaries. WG members were in agreement that this information is at best very poorly known and may only be available for a few estuaries from around the globe. In particular, little quantitative and observational information is available on sediment influx from the coastal ocean. River sediment input to estuaries may seem less complicated but, in reality, most river discharge and sediment load estimates are obtained for non-tidal locations far upstream (often one or more hundred kilometers) from the head of the estuaries. The estuarine reach between maximum salinity intrusion and the most seaward gauging station is unknown with respect to sediment dynamics. Thus, to prepare for the next meeting, we will attempt to gather all available and published information with respect to data, measurement methodology, and modeling procedures.

WG tasks

A series of tasks were agreed on and assigned to the WG members to be complete prior to the next meeting:

- A report on sediment input from rivers and their variability.
- A report assessing methodologies to study trapping mechanisms in estuaries and defining sediment budgets.
- A report on models applied to estimate estuarine sediment retention.
- Dynamic river-estuary sediment interaction.
- A spreadsheet with available data for a set of well-studied estuaries from around the world to allow comparisons and be used for model development.

Five reports were prepared by members of WG that are on display at the Web page of the WG. The titles and authors of the reports are

1. Gao, S. River delta growth in relation to sediment retention.
2. Lumborg, U. and Pejrup, M., Cohesive sediment transport modeling – application to the Lister Dyb tidal area in the Danish Wadden Sea.
3. Vinzon, S.B., Mechanisms of Fine Sediment Retention in Estuaries: reference to the Amazon Estuary.
4. Wolanski, E. Siltation of macro-tidal tropical estuaries.
5. Zajaczkowski, M. The changes of sediment transport pathway during the shift of glacier position from tidewater to land terminating. Case study: Kongsfjorden and Adventfjorden in Svalbard.

Second Meeting

A second meeting for the WG 122 is scheduled for the period 23-25 June 2005 in Texel, The Netherlands prior to the Open Science Meeting for LOICZ II to be held also in The Netherlands starting on June 27th. This meeting has only financial support from SCOR and LOICZ.

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Web Page

A web page has been developed and in continuous evolution and can be consulted at <http://www.criba.edu.ar/scorwg122>

Future Plans

The next steps of the WG regarding the accomplishment of the Terms of Reference and the organization of a final large meeting will be discussed in detail during the meeting in Texel.

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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Executive Committee Reporter: Laurent Labeyrie

SCOR Working Group 123
SCOR/IMAGES Working Group on Past Ocean Circulation
Annual Report
Submitted by Jean Lynch-Stieglitz and Catherine Kissell (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 assessments of past ocean circulation. This group organized a workshop on this subject which took place from March 20 to March 23 at the Georgia Institute of Technology in Atlanta. A total of 45 participants attended this workshop, among which were 10 members of the working group, 11 invited speakers, 10 students and post-docs and 11 other participants. Different scientific communities were represented in this group, with scientists involved in paleo-data acquisition, modeling and physical oceanography. The workshop was made possible through the support of SCOR and IMAGES to the Working Group, as well as supplementary travel funds from the U.S. NSF MESH Office and IMAGES to support the participation of young scientists.

The aims of this workshop were 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 organized first with oral presentations by invited speakers who presented overview presentations on the different available tools, their potential and limitations. This covered forward and inverse modeling, nutrient (carbon isotopes and trace metals) and radiogenic water mass tracers, physical properties of sediments (grain size and magnetic properties), radiocarbon in foraminifera and in deep-sea corals, salinity constraints from pore-water analyses and models, Pa/Th data and modeling, and paleo-geostrophic reconstructions based on benthic oxygen isotopes. A few presentations were also dedicated to modern ocean circulation and its monitoring. Each presentation (or group of presentations) was followed by 30 minutes general of discussions and questions (see the attached agenda). The presenters did a commendable job covering the breadth of existing efforts in their presentations, and the ensuing discussions were fruitful. The participants were left with a much deeper understanding of the potential, pitfalls, and complementarity of the various methods. These oral communications were supplemented by a number of posters showing new results from data investigations and modeling.

The second part of the workshop was dedicated to discussions about recommendations for future plans. First, we discussed the hypotheses and questions that we could address within the framework of a future organized effort for quantitative reconstruction of past ocean circulation (PACE). We then discussed the potential of existing methods for the success of two “strawman” goals for PACE. The first goal was to reconstruct the strength of the large-scale MOC in the Atlantic Ocean at millennial scales over the last 30 kyr with an estimate of the associated errors. The second goal was

to reconstruct large-scale water mass distribution and circulation for the global ocean during the last glacial maximum (about 19 to 23 kyr). For each of these goals we discussed the following questions:

1. What is the potential of the existing techniques and what is the existing coverage? This was discussed for each “family” of proxies for reconstructing ocean circulation, for chronological techniques which are a critical tool for the comparison of wide-spread time series, and also for the forward and inverse modeling techniques.
2. What advances are necessary in order to accomplish the strawman goals?

The PACE working group is in the process of producing a document assessing the existing techniques and compiling the extent of the available data before the next working group meeting in Spring 2006. At the 2006 Working group meeting we will formulate our recommendations for future research efforts in reconstructing past ocean circulation on the basis of this summary.

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. After the workshop, we have spent all but \$2000 of the money committed from SCOR for Years 1-3. The spring 2006 Working Group meeting will be held in Europe and will be supported with these remaining funds from SCOR, as well as the remaining \$7500 committed from IMAGES for Year 3.

SCOR/IMAGES Workshop on Paleocean Circulation
20-23 March 2005
School of Earth and Atmospheric Sciences
Georgia Institute of Technology
Atlanta, GA USA

Sunday March 20th

8:30 - 9:00 *Welcome And Workshop Goals*

9:00 - 9:45 Andrey Ganopolski *Forward Modelling Constraints On Past Ocean Circulation*

Nutrient water mass tracers

9:45 - 10:30 Andreas Mackensen *Water Mass Reconstruction From Carbon Isotopes*

10:30 - 10:45 *Break*

10:45 - 11:30 Tom Marchitto *Water Mass Reconstruction From Trace Metals*

11:30 - 12:00 *Discussion*

12:00 - 1:00 *Lunch*

Radiogenic Isotope water mass tracers

1:00 - 1:30 Sidney Hemming *Daughters Of Long-Half Life Radioactive Isotopes For Tracing Ocean Circulation*

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- 1:30-2:15 Alex Piotrowski *A millennial-scale record of watermass mixing from neodymium isotopes*
2:15 - 2:45 *Discussion*
2:45 - 3:00 *Break*

Physical properties of sediments

- 3:00 - 3:45 Gert Jan Weltje *Use And Limitations Of Sedimentary Grain Size In Flow Reconstruction*
3:45 - 4:15 Catherine Kissel *Bottom Water Sources From Magnetic Properties*
4:15 - 5:00 Kikki Kleiven *Bottom Water Flow From Sortable Silt Size*
5:00 - 5:30 *Discussion*

Monday March 21st

- 8:30 - 9:15 Carl Wunsch *Inverse Model Considerations In The Reconstruction Of Large Scale Ocean Circulation*

Radiocarbon

- 9:15 - 10:00 Lloyd Keigwin *Radiocarbon Measurements In Foraminifera*
10:00 - 10:45 Norbert Frank *Radiocarbon In Deep Sea Corals*
10:45 - 11:00 *Break*
11:00 - 11:45 Raimund Muscheler *Ocean Ventilation Changes From Atmospheric Radiocarbon*
11:45 - 12:15 *Discussion*
12:15 - 1:15 *Lunch*

Salinity Constraints

- 1:15 - 2:00 Jess Adkins *T-S-d18O Properties Of Past Water Masses From Porewaters*
2:00 - 2:45 Matthew Schmidt *Inter-Ocean Salinity Balance And Global Ocean Circulation*
2:45 - 3:15 *Discussion*
3:15 - 5:15 *Poster Session /Wine and Cheese Reception*

Tuesday March 22nd

Pa/Th

- 8:30 - 9:15 Roger Francois *Controls On The Distribution Of Pa And Th In Ocean Sediments*
9:15 - 10:00 Jerry McManus *Reconstructing Paleocirculation Using Stable Isotope And U-Series Disequilibria*
10:00 - 10:15 *Break*
10:15 - 11:00 Olivier Marchal *Modeling Pa/Th In Sediments*
11:00 - 11:30 *Discussion*

Geostrophic transport

- 11:30 - 12:15 Joel Hirschi *Monitoring Changes In Modern Atlantic MOC*
12:15 - 1:15 *Lunch*
1:15 - 1:45 Kevin Speer *Reconstructing Variability In Modern Atlantic MOC*

- 1:45 - 2:30 Jean Lynch-Stieglitz *Paleo-Geostrophic Calculations Using Oxygen Isotopes In Benthic Foraminifera*
- 2:30 - 3:00 *Discussion*
- 3:00 - 3:15 *Break*
- 3:15 - 4:15 *Breakout Groups 1*
- 4:15 - 5:15 *Report from Breakout Groups 1*
- 7:00 - 9:30 *Conference Dinner Mary Mac's Tearoom*

Wednesday March 23rd

- 8:30 - 9:00 TBA
- 9:00 - 10:00 *Breakout Groups 2*
- 10:00 - 11:00 *Report from Breakout Groups 2*
- 11:00 - 12:00 *Wrap-up/Discussion*
- 1:00 - 5:00 *Working Group 123 Meeting*

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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.

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Executive Committee Reporter: Ilana Wainer

Second Report on the SCOR/IMAGES Working Group LINKS
“Analysing the links between present oceanic processes and paleorecords”

2004-2005

The scientific focus of the working group LINKS is the export of material that links surface water processes with the sediment record. The central questions are: How well do we understand present-day ecosystem processes driving export and how well can we make a link from proxies to the past ecosystems? If proxies contradict each other, what is the cause and can we come to a mechanistic understanding? What are the major gaps in our understanding and can we suggest a strategy for the development of new proxies for specific processes?

During the first meeting of LINKS in conjunction with the 8th International Conference on Paleoceanography (ICP-8) in Biarritz, France on 10 September 2004, the group discussed the working plan and the products to be delivered. All full members and two associate members attended the one-day meeting (J. Bijma, F. Dehairs, R. Francois, R. Ganeshram, A. Gorgou, Kemp, C. Lange, K. Lochte, R. Scharek, M.-A. Sicre, Li Tiengan, D. Wolf-Gladrow, Ein Fen Yu).

LINKS plans to publish review papers structured according to the factors influencing export and addressing the above questions. It combines the expertise of ecologists and oceanographers who study the present-day ocean with paleoceanographers. The LINKS working group will restrict its work to summarizing existing knowledge in form of review papers and new research projects as part of LINKS are not planned. We envisage that the assessment of the current state of the art may help research projects to focus their research aims, improve their sampling strategy or to promote new collaboration. In particular, collaboration with GEOTRACES, CLIVAR, PAGES/IMAGES, LOICZ, SOLAS, GLOBEC and IMBER are considered.

The review papers will address

- Physical processes (including: stratification, upwelling, lateral transport) *R.Francois, Ein Fen Yu.*
- Nutrient ratios (including: N:P ratios, nitrogen fixation, denitirification, oxygen concentration) *R. Ganeshram, K. Lochte.*
- Nutrient utilization (including: trace elements, Si, dust) *F. Dehairs, D. Wolf-Gladrow.*
- Ecosystem structure (including: rain ratios, mode of export) *R. Scharek, A.Kemp.*
- Regeneration and transformation in the water column *F. Dehairs, R. Francois, M.-A. Sicre, A. Gogou*
- Burial and early diagenesis, *A. Kemp, C. Lange*

At present an outline has been drafted and will be discussed during the next meeting.

The next meeting of LINKS will take place in association with the AGU conference in San Francisco, 5-9 December 2005. A special session has been submitted for this meeting by the LINKS

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group. We plan to publicise the activities of LINKS in an article in *EOS* prior to the meeting in San Francisco.

Finances

US\$7500 have been attributed to WG124 LINKS by SCOR. The same amount will be provided from IMAGES. We have nothing to report on the financial aspect yet, since our next meeting will take place next December in San Francisco. We are planning to organize a Gordon Research Conference next year and still need to evaluate its overall cost.

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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Anthony Richardson (UK)

Andy Solow (USA)

Associate Members

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Harold Bachelder (USA) – Sponsored by PICES

Executive Committee Reporter: Annelies Pierrot-Bults

Brief report on status of
SCOR WG 125 on "Global Comparison of zooplankton time series":

The requested minor revisions of working group membership and terms of reference have now been completed and approved by the SCOR Executive Committee Reporter (Annelies Pierrot)

The majority of the 10 Full WG members (those whose travel is paid for by SCOR) were chosen based on their familiarity with and access to major long-term zooplankton time series located around the world. They include

- David Mackas (Co-chair, Canada) NE Pacific
- Hans M. Verheye (Co-chair, South Africa), SE Atlantic and Benguela Current
- Patricia Ayón (Peru), Peru-Chile Current
- Sanae Chiba (Japan), NW Pacific, and Project ODATE
- Young Shil Kang (Republic of Korea), Asian Marginal Seas
- Mark Ohman (USA), CalCOFI and California Current
- Anthony Richardson (Australia), NE Atlantic and Continuous Plankton Recorder

Three additional full members provide specialized technical expertise:

- Todd O'Brien (USA) database management
- Chris Reason (South Africa) climatology and physical oceanography
- Andy Solow (USA) statistical methods plus NW Atlantic

They will be joined by several Associate Members. The list of Associate Members is still being finalized. To date:

- PICES has agreed to sponsor Hal Batchelder (PICES CCCC + US GLOBEC)
- GLOBEC.INT has agreed to sponsor David Checkley (SPACC program – ‘Small Pelagics and Climate Change’).
- ICES WG on Zooplankton Ecology has nominated W. Melle to ICES

The first meeting of WG125 members will take place 7-9 November 2005 in Silver Spring, Maryland, USA at the NOAA National Marine Fisheries Service site. Agenda items for the first meeting include reports from all WG members on:

1. Regional data holdings (duration of time series, location, sampling method(s) and frequency, zooplankton taxonomic/stage resolution, supporting physical and biological data)
2. Ongoing sample reprocessing and other forms of data mining (what is being done, time frame for completion, ...)
3. Format and portability of data
4. Numerical analysis methods used to date (e.g., raw time series, anomalies referenced to local average, multivariate resemblance/ordination/clustering, change point detection and its

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hazards [CuSum, intervention analysis,.....])

5. Summary of local results (amplitude of variability, dominant time scales, date intervals containing large changes, environmental and fishery covariance,.....)

6. Comparisons with other regions where available.

Followed by group discussion of

7. Logistics for pooling/sharing our data

8. Priorities for analysis methods, and sharing of software tools

The second meeting is planned to coincide with the GLOBEC/PICES symposium on climate change and marine ecosystems, April 2006 in Honolulu, Hawaii.

A Web site will be hosted by the PICES organization and will include both “public” and “password-access” areas.

Dave Mackas
WG125 cochair

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

Terms of Reference:

- Summarize past results on virus-mediated 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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Executive Committee Reporter: Julie Hall

Progress of Working Group 126: Role of viruses in marine ecosystems

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 Declan Schroeder (UK)
 Grieg Steward (USA)
 Dolores Vaqué (Spain)

Activities (January 1, 2005 – July 1, 2005)

Several key events and activities have taken place that has positioned this group to move forward with its goals.

Expenses: The group has not yet expended any funds. Members met at their own cost in June 2005 (see below).

Meetings: A preliminary meeting of WG members, as well as interested marine virus researchers, was held in Santiago de Compostela, Spain, on Monday June 20, 2005. As this meeting was announced with short notice, not all members were able to attend. Chairs discussed the goals of the working group and collected feedback from members.

This meeting coincided with a special session at the ASLO conference (Viruses, Microbial Diversity and Ecosystem Function). Organized by co-chairs Wilhelm and Weinbauer as well as core member Suttle, the session included 17 oral presentations as well as 9 poster presentations. Attendance was surprisingly high, with as many as 200+ conference delegates in the room for some presentations.

A future meeting is currently being planned for Victoria, British Columbia. The meeting is tentatively scheduled for June 1-3, 2006. Dr Wilhelm will co-ordinate this meeting and is anticipated to begin planning in September or October of 2005. A meeting is also planned for Villefranche-sur-mer, France in 2008. We anticipate that a 2007 meeting may also be held, but this will be dependent on funds and necessity.

Production of a “definitive” textbook on methods in marine virology. Significant progress has been made in the development of the above resource. Led by core member CA Suttle, several decisions have been made about the nature of this book. The book will be wholly electronic and freely distributed to the global scientific community. Editorial management of this electronic resource will be carried out under the auspices of ASLO via their online journal *Limnology and Oceanography:Methods*. This activity has already been approved by the board of ASLO, and Dr Paul Kemp (editor of *L&O:Methods*) will act as the managing editor for this compilation. It will be necessary to extend the textbook to aquatic virology; this will increase the impact of the book.

In order to make this material freely available to the general community, all publication costs will need to be prepaid. A tentative agreement has been struck with the Gordon and Betty Moore Foundation’s program officer for Marine Microbiology (Dr Lita Proctor) to financially support this effort. Dr Suttle is currently constructing a proposal to the Moore Foundation and working with Dr Kemp to determine a budget. It is anticipated that this work will cost \$20,000 - \$30,000. Dr Proctor has agreed to entertain a proposal up to \$50,000.

Authors for chapters within the compendium have not been defined. However, as a stipulation we have stated that each chapter must be at the least co-authored by a senior person in the marine virology field. Details of the chapters will be worked out prior to the Victoria meeting, and it is anticipated that the lead author for each chapter will attend this working meeting and present an outline of the materials to the SCOR group. To ensure high quality, all WG members will have to approve the chapters. In addition, *L&O Methods* requires peer review, which was highly appreciated by the present WG members. *L&O Methods* also allows for adding comments electronically after publication. A workshop on methods in virology to be held in Plymouth in 2006 will be used to test the chapters prior to publishing, since students can comment on the usefulness and practicability of the protocols.

Development of International Collaborative Studies:

Members of SCOR WG126 are working together with other colleagues to firmly entrench virus ecology in the upcoming International Polar Year program of research. White papers from Canada (Suttle) and Norway (Bratbak) were submitted in early rounds, and currently core member Bratbak is leading the synthesis of a Microbial Cluster for the IPY which will include many of the SCOR working group members. It is anticipated that proposals for collaborative studies in marine virology will be submitted to funding agencies in multiple countries as part of the IPY: this includes a planned request for a large research vessel to the National Science Foundation (U.S.) to support a virocentric research effort in the Southern Ocean in 2007/2008.

2.3 Working Group Proposals

2.3.1 WG Proposal on Thermodynamics and Equation of State of Seawater

Proposal for a IAPSO/SCOR Working Group on the “Thermodynamics and Equation of State of Sea water” Background

Defining the equation of state of seawater is fundamental to many activities concerned with observing the physical state of the oceans and representing ocean processes in numerical models. The work of the Joint (IOC/SCOR) Panel on Oceanographic Tables and Standards (JPOTS) during the 1970s and 80s provided the world with a much-needed way to determine the salinity and density of seawater much more accurately than had been previously possible. The equation of state needed to do this is presently defined in algorithms published by Fofonoff and Millard (1983).

Since the mid-1980s there has been little formal study of these issues and yet there have been advances that point to a need to revisit the work initiated by JPOTS.

Timeliness and relevance

The International Equation of State is written in terms of the 1968 temperature scale. Virtually all new high precision ocean measurements are now made in the 1990 temperature scale. A growing group of scientists are unaware of the 1990 change, and may therefore wrongly employ the equation of state without taking into account the temperature conversion. In addition the 1990/1968 conversion is done with an approximate linear formula, deemed to be “adequate” for oceanographic purposes, but is not rigorously precise. Ocean modelling has made great advances driven by increased computing power, by improved physical understanding and by the need to better represent the oceans in climate models. Scientists who run global ocean models are keen to have an accurate equation of state and they need their equation of state to be expressed as a function of potential temperature rather than in terms of in situ temperature. Recent work by McDougall et al. (2003) and Jackett et al. (2005) has provided ocean modellers with such an algorithm based on Feistel and Hagen (1995) and Feistel (2003). In this way, the modern thermodynamic research of Feistel has made its way into ocean modelling, but this work has not yet been adopted by the observational oceanographic community.

The known thermodynamic quantities for which accurate measurements exist have now been incorporated into a Gibbs function for seawater (Feistel, 1993; Feistel and Hagen, 1995; and Feistel, 2003). The most recent study in this series, namely Feistel (2003), abbreviated below as F03, has carefully documented the known accuracy of each type of thermodynamic measurement. This work seems to represent the limit of accuracy that is available at this time to determine density and other properties of seawater. The relevance of this finding to the wider oceanographic community should be addressed.

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While the bulk of research has applied to the range of temperature and salinities typical of the open ocean, its relevance to areas of extreme high and low temperature and salinity as well as of nonstandard sea salt composition should be considered.

The case for SCOR sponsorship of the WG

SCOR has a long history of support of activities in this and related areas. Relevant past SCOR Working Groups that have studied related topics include:

- WG 4 Physical Properties of Sea Water
- WG 6 Chemical Oceanography
- WG 10 Oceanographic Tables and Standards (reconstituted as the Joint Panel on Oceanographic Tables and Standards (JPOTS))
- WG 49 Mathematical Modelling of Oceanic Processes
- WG 51 The acquisition, calibration, and analysis of CTD data
- WG 77 Laboratory Tests Related to Basic Physical Measurements at Sea
- WG 102 Comparative Salinity and Density of the Atlantic and Pacific Ocean Basins
- WG 121 Ocean Mixing

This working group would continue that long association. Its co-sponsorship by IAPSO and the support for the working group expressed by IOC provides a link to the foundation laid by the JPOTS panel.

Its subject matter matches the physical emphasis expressed in call for new WG proposals.

While the topics to be addressed by this WG may appear esoteric, they have applications and relevance to a wide range of modelling, observational and practical issues. (e.g., parameterisation of mixing in models, the calculation of density from temperature/salinity/pressure observations, the physics and chemistry of substances (such as liquefied CO₂) placed in the deep ocean).

In view of this wide relevance, the activities of the WG may be able to attract financial support other than that available from SCOR.

Terms of Reference

- (1) 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). (This work is elaborated in the priority 1 issues listed below)
- (2) 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.
- (3) 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.

- (4) 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.
- (5) 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.

Membership

Trevor McDougall (CSIRO, Hobart, Australia)

Ocean physics/thermodynamics specialist (proposed chair of this WG)

Brian King (SOC, Southampton, UK)

Observational physical oceanographer with interests in the precise measurement of temperature and salinity

Rainer Feistel (IOW, Warnemünde, Germany)

Sea water thermodynamics specialist

Dan Wright (Bedford Institute of Oceanography, Dartmouth, Canada)

Ocean modeller

Peter Brewer (MBARI, Monterey, USA)

Ocean chemist/CO₂ specialist

Frank Millero (RSMAS, Miami, USA)

Ocean composition and thermodynamics specialist (Past Chair SCOR WG 102)

Barak Herut (IOLR, Haifa, Israel)

High-salinity seawater specialist

Giles Marion (DRI, Reno, USA)

Ice and high-salinity chemistry specialist

Valentina Gramm-Osipova (Pacific Oceanological Institute , Vladivostok, Russia)

Ocean chemistry specialist

Vladimir Tchijov (UNAM, Mexico City, Mexico)

Specialist for ice physics.

Corresponding members

David Jackett (CSIRO, Hobart, Australia)

Mathematician and data specialist

Jim Swift (Scripps Institution of Oceanography, San Diego, USA)

Observational physical oceanographer/Data specialist

Detailed explanation of the proposed remit for the Working Group

The WG will produce new "official" thermodynamic quantities of seawater (including the equation of state), taking into account recent developments in ocean thermodynamics and the reformulation of the International Temperature Scale (ITS-90).

The working group's main thrust would be to evaluate the recent Gibbs function that has been published by Feistel (2003), to decide on the limits of its accuracy, to weigh up its accuracy vis-avis the presently used international equation of state, with a view to recommending a change to the

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internationally recommended algorithms for evaluating density and related quantities (including enthalpy, entropy and potential temperature).

The following is a more detailed list of issues that would fall within the Terms of Reference of the proposed working group and that would be the focus of the WG. These have been separated into priority groups indicating the order in which they might be addressed.

Items in the first two priority categories should be achievable by the proposed Working Group within a time frame of two years.

Priority 1 issues:

- 1.1 Adopt the recent IAPWS*-95 international scientific pure water standard (Wagner and Pruß, (2002)) as the freshwater reference system for modern seawater thermodynamics.
- 1.2 Update all oceanic algorithms so that they are written in terms of the ITS-90 temperature scale and provide practical conversion algorithms between old and new parameters.
- 1.3 Examine F03's Gibbs function and the quantities that are derived from it and establish error estimates for the maximum errors that might arise from its oceanographic use.
- 1.4 Consider recommendations for chemical potential, specific entropy, enthalpy, internal energy or free enthalpy (Gibbs energy) of seawater, which were not part of the JPOTS standards, including the arbitrary reference state definitions.
- 1.5 Examine the accuracy of potential temperature that is determined by equating entropy based on F03's Gibbs function.
- 1.6 Examine the benefits of using potential enthalpy (or conservative temperature) as an oceanographic variable to represent "heat content" in oceanography, in particular, the potential enthalpy that is found from F03's Gibbs function.
- 1.7 Recommend the most accurate algorithms for the freezing temperature of seawater for pressures up to 3000db.

* IAPWS - International Association for the Properties of Water and Steam (<http://www.iapws.org/>)

Priority 2 issues:

- 2.1 Recommend the most accurate algorithms for saturated vapour pressure over seawater.
- 2.2 Examine whether modern data warrant a new algorithm for calculation of oxygen.
- 2.3 Examine the impact of air saturation on seawater properties.
- 2.4 Examine whether it might be possible to further increase the accuracy of the determination of density and other thermodynamic properties by a focused effort at collecting a limited number of extra data sets (e.g., data on the temperature of maximum density or on density below 0°C (Caldwell 1978))
- 2.5 Reconsider the practically widespread use of "dbar/db", "ml/l" or "psu" as units and recommend definitions and formula symbols for density anomaly, specific entropy, specific Gibbs energy, specific internal energy, sound speed, isothermal and adiabatic compressibility, or isothermal and adiabatic haline contraction coefficient.
- 2.6 Examine the possibility of optical determination of spatial and temporal distributions of density anomalies by using a refractive index sensor attached to standard CTD probes.

- 2.7 Write a set of related recommendations in the form of a review to be published in the scientific literature.

In addition to these tasks, there is a further set of issues (listed below) that should be addressed in order to progress this field even further. It is not clear at this time whether these issues are amenable to neat algorithmic solutions, and so it seems appropriate that the Working Group be asked to report back to SCOR after 12 months whether these issues seem amenable to further study by a Working Group or whether these issues, while being worthy research questions, are not close to yielding recommendations for changing the practice of oceanographers.

Priority 3 issues:

- 3.1 Examine the limits that the varying concentrations of alkalinity, total carbon dioxide and silica place on the determination of density in the ocean, and to examine whether a simple function of three-dimensional space might be used as a correction for some of this effect for the present ocean (Brewer and Bradshaw, 1975; Millero, 2000).
- 3.2 Examine the present knowledge of the ratio of absolute salinity to practical salinity and to determine whether it might be possible to construct a simple function of three-dimensional space to provide an estimate of this ratio for the present ocean.
- 3.3 Issue a recommendation on how standard formulas should be applied to waters with known density anomalies like the Baltic Sea.
- 3.4 Examine the possibility of a recommendation for artificial standard seawater chemical composition as reference for future models, theoretical work, or alternative measurement technologies, including recommended IUPAC* values for fundamental physical constants and atomic weights.
- 3.5 Examine the need for extending all the existing formulas to higher salinities/temperatures as already done up to salinities of 50 for conductivity and density.
- 3.6 Examine the possibility of a unified thermodynamic treatment of cold high-salinity seawater, ice, and sea ice (Herut et al., 1990; Feistel and Hagen, 1998; Marion et al., 1999; Feistel and Wagner, 2005)
- 3.7 Write a set of related recommendations in the form of a review to be published in the scientific literature.

* IUPAC- International Union of Pure and Applied Chemistry <http://www.iupac.org/>

Mode of Operation of the Working Group

As reported above, the priority 1 and 2 tasks should be able to be achieved by the Working Group over a two-year period, with two face-to-face meetings, one in the early months of the group's formation, in early 2006, and one after twelve or fifteen months of existence.

It is envisaged that at the first of these meetings the specific issues listed as priority 1 should be discussed and work be assigned to individual members (in collaboration with other members and non-members) to be performed out of session. This work would be reported and discussed at the second session. At the second meeting the Working Group would be in a better position to see if some or all of the priority 2 and 3 tasks could be fruitfully tackled by this or another Working Group, and if so, on what timescale.

In general, the work of this group would involve a small group of specialist participants, with intersessional targeted work having to be performed at their home institutions. Progress reports would be written and sent out to other experts for comment.

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2.3.2 Proposal for WG to Investigate Mesopelagic Fish Populations as Potential Fishery Stocks

Summary

As the world's ocean fisheries have exploited more and more of the world's fishery stocks, there has been greater emphasis on finding new fish stocks. Among possible new stocks, the most abundant and widespread are the mesopelagic fishes of the world ocean. These are the small fishes that are widespread and common, usually found at depths from 100 to 1000 meters below the surface. Among the most abundant and considered typical of that fauna are the lanternfishes or myctophids of the family Myctophidae.

Suggestions and initial attempts have been made to begin fishing for lanternfish populations. Some of these are incredibly numerous in certain locations and at certain times, for example: the lanternfish *Benthoosema pterotum* in the Gulf of Oman and adjacent parts of the Arabian Sea. However, any kind of sustained fishery is dependent on regulating the fishery, based on an understanding of the biology and population dynamics of the exploited species and their predators. For virtually all species of mesopelagic fish, that knowledge is sorely lacking or nonexistent.

The proposed working group will focus on lanternfish as the most likely to be exploited in the future. Conducted over a period of four years, the working group will culminate in a final report that will (1) summarize past results on the state of understanding of myctophid biology and population dynamics; (2) assess ongoing efforts in these and related fields; and (3) assess what types of research efforts need to be carried out to increase understanding of myctophids as commercially exploited species. With the advent of new and powerful molecular tools in recent decades, the focus on biomolecular approaches give promise of new and faster ways of determining the population dynamics of mesopelagic species before any serious exploitation *even starts. The idea of using these and other advanced techniques will be central to the considerations and discussions of the proposed Working Group. The working group will also establish and maintain a Web site for the exchange of information between mesopelagic ichthyologists and fishery scientists. Such a Web site should help with planning for future research through the exchange of ideas and approaches.

Rationale

The commercial fisheries of the world ocean have become more and more efficient and capable in their exploitation of existing fish stocks. World population growth and economic development have put increasing pressure on finding and developing new fishery resources. As the possible exploitation of these potential new fishery stocks becomes more economically viable, there is no question that such development will take place, it is only a matter of when, where, and how. It is also clear that such exploitation must be done in a rational and sustainable fashion. However, sustainability is dependent upon knowledge of the population dynamics and biology of the

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exploitable species. Development of such a knowledge database depends on basic research into the population dynamics and biology of the exploitable species.

Among the largest such potential commercial fishery stocks are the vast numbers of mesopelagic fish that are found in the mid-layers of the world ocean, typically from 100 to 1000 meters below the surface. While there are many species from many families that constitute that fauna, the lanternfishes or myctophids of the family Myctophidae are perhaps the most widespread and ubiquitous. They have also been found to occur in enormous numbers and great abundance in particular times and places. A prime example of this is the lanternfish *Benthoosema pterotum* found in the Gulf of Oman and adjacent areas of the Arabian Sea.

The proposed SCOR Working Group would focus international attention on myctophid fish species. It is the most logical way to explore the dual problem of the lack of knowledge of the population dynamics and biology of these lanternfish together with a lack of understanding of what impact the wholesale removal of these fish might potentially mean to ocean ecosystems, particularly on the predators that prey on the myctophids. While the kind of research that must be conducted is basic research, it is clearly of practical importance to future fisheries development.

Furthermore, because the potentially exploitable fish populations are global in distribution, the basic research needed has global implications. It is timely to constitute such a working group at this time because large-scale exploitation of these fish has not yet expanded worldwide, but an exploratory commercial fishery effort for myctophids is being carried out by Iran in their part of the Gulf of Oman. The countries of Oman and Pakistan are also interested in investigating a potential mesopelagic fishery and other Indian Ocean countries may soon follow.

Scientific Background

The pelagic realm of the world's open ocean is the most extensive environment on the planet, arguably covering up to half of the Earth's surface. The surface portions of this realm, referred to as the epipelagic, have long supported important fisheries including tunas, swordfish, mahi mahi and various open ocean sharks. As the world's fisheries have become more extensive and intensive, pressure has grown to exploit new fish species. One area of potential investigation is in the pelagic, not the near surface, but the mesopelagic, the realm from approximately 100 to 1000 meters below the surface. This realm is inhabited by large populations of small fish, abundant and widely distributed. Among the most common and abundant are the lanternfishes of the family Myctophidae, the myctophids.

It has long been recognized that at some times and places myctophids can become extremely common and abundant. A prime example of this kind of extreme abundance is in the midwaters of the northwest Arabian Sea and adjacent Gulf of Oman where in the mid-1970s through 1983, Norwegian fishery scientists led by Dr. Jakob Gjosaeter of the University of Bergen conducted fisheries surveys. Those surveys were conducted aboard the fishery research vessel R/V *Dr. Fridtjof Nansen* belonging to the Norwegian Agency for International Development (NORAD) under the joint auspices of the UN Food and Agriculture Organization (FAO) and NORAD. He and

his colleagues reported that there was a large standing stock of these mesopelagic fishes, principally a few species of myctophids (Gjosaeter and Kawaguchi, 1980; Gjosaeter, 1981; Aglen et al., 1982; Gjosaeter, 1984). Using net sampling and based on acoustic returns using the ship's echosounders, they estimated a standing stock of some 100 million metric tons (Gjosaeter and Kawaguchi, 1980, Fig. 12.4, Table 12.4) for the entire region. Considering that the entire world's commercial fisheries catch is somewhere between 40 and 100 million tons annually, it means that if this estimate is accurate, it has the potential to be a very large fishery.

In the Gulf of Oman, the only myctophid present is *Benthoosema pterotum* and the Iranians have started a commercial fishery for myctophids in their part of the Gulf of Oman (pers. comm. Shahid Amjad, 2003). In the adjacent areas of the Arabian Sea outside the mouth of the Gulf, the main species reported in abundance is *B. pterotum* (Gjosaeter, 1981, Fig. 1, Table 1) and to a lesser extent further offshore, its close relative *B. fibulatum* (Nafpaktitis and Nafpaktitis, 1969, Fig. 11). Perhaps because of the abundance and potential commercial importance of *B. pterotum*, a surprisingly large amount of research has been conducted on this species and somewhat less on *B. fibulatum*. Scientists from a number of countries have contributed to this database. In Pakistan, Hussain and Ali-Khan (1987) studied the fecundity of both species. They found that *B. pterotum* females showed a fecundity of 200 - 1300 eggs while the larger *B. fibulatum* showed a fecundity of 400 - 5000 eggs. From Norway, Dalpadado (1988) studied the reproductive biology of *B. pterotum* and found indications that it spawns only once, but could not draw firm conclusions; Gjosaeter and Tilseth (1988) studied its spawning and larval development in the Gulf of Oman, finding that it spawns at night at depths from 100 - 300 meters below the surface and the slightly positively buoyant eggs drift upward and hatch in 10 hours in the 25 degree (C) water; and Dalpadado and Gjosaeter (1988) reported that most, if not all of the feeding took place at night in the epipelagic realm and was on zooplankton, primarily copepods. In Russia, Tsokur (1981, Fig. 2) illustrated the larvae of *B. pterotum* (as *Benthoosema pterota*) from the Arabian Sea. In India, K. Gopakumar et al. (1983) reported on the fatty acid composition liberated from the lipids of lanternfish (ibid., Table 4) and Lekshminair et al (1983) did a nutritional evaluation of the fish meal and fish hydrolysates from Gulf of Oman myctophids and found them to be of good quality, which could be used as a protein supplement in animal feeds. In Oman on 7 - 9 May 2001, a Workshop on Mesopelagic Fishes was held in Muscat under the auspices of FAO and an Information Paper, excerpted from Chapter 3.4 of Saetersdal et al. (1999) reviewed the R/V *Dr. Fridtjof Nansen* work in the Arabian Sea and reevaluated the estimated standing stock quantities of myctophids. The estimate for the entire region was reduced to some 47 million metric tons. Though this is about half of the original estimate of 100 million tons, it is still a huge standing stock.

The above discussion illustrates that while there is probably more known about the biology of *B. pterotum* and its congener, *B. fibulatum*, than any other myctophid species or species pair, little is known about the population dynamics (crucial information if a fishery for this species is to be a sustainable one), or of their role in the ecosystem as predator and as prey. Much less is known about virtually all of the remaining described species of myctophids in the world (probably more than 300) and this must be the focus of the Working Group's efforts.

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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 for determining the population dynamics of mesopelagic fish and the state of knowledge about myctophid biology, especially as it pertains to an understanding of the population dynamics of myctophid species and their role in marine ecosystems, including effects that removing the myctophids would have on the predator species that prey on them.
- 2) Assess ongoing research efforts on the above topics, especially including and emphasizing the utilization of modern molecular techniques and approaches.
- 3) Target which myctophid species and which geographic areas in the world ocean could most profitably benefit from a focus of these and other innovative research approaches.
- 4) Establish and maintain a Web site for the exchange of information and ideas between mesopelagic fish specialists and fishery specialists.
- 5) Produce a comprehensive report incorporating the results from the above activities for which we would seek publication as a peer-reviewed journal paper or special issue, or a book.

Meetings

It is proposed that the Working Group have duration of 4 years with three meetings of the members over that period. The first working group meeting would take place within three to six months after the availability of funds. The primary task of the first meeting will be the resolution of what procedures to use in order to come up with the best possible final report, including time lines and which working group members will be responsible to bring together the information for past and ongoing efforts on different topics, most logically by geographic areas. 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 and fishery specialists. It is clear that a working group of ten members plus an indeterminate number of associate members will have difficulty bringing in all the necessary knowledge of ongoing efforts, let alone potential future efforts.

Therefore, one of the activities at the first working group meeting will be the planning for an international conference of myctophid specialists and related marine scientists including fishery biologists. It is anticipated that this conference will build on the results of the 2001 FAO mesopelagic fish conference in Muscat but will differ in focusing: 1) heavily on myctophids and 2) on a world-wide basis rather than only emphasizing the Arabian Sea region. It is expected that such a conference would occur 18 - 24 months after the first working group meeting and would bring together some 40 - 50 specialists from all parts of the world. Support for such a conference would be sought from other agencies, private foundations and other sources. If such a conference were not held, it would not negate the importance of the Working Group's final report. However,

incorporating the results of a successful international myctophid conference would enhance the Working Group's final report by making it more comprehensive and inclusive.

The second working group meeting would be held after the international conference, ideally, immediately afterwards. On the agenda would be a discussion of how to incorporate the results from the conference into the final report, that is, what actions and activities would need to be carried out by the group members in order to have the results ready for incorporation into the final report. This would 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. These inputs from the members would be brought together electronically into a revised draft which would be discussed and finalized at the third and last working group meeting, to be held approximately 12 months after the second meeting.

This timetable is reasonable and allows for some slippage of dates and times which will still permit completion of the working group activities as well as the final report within the planned -year period.

Time 0 -- Availability of funds
 3 - 6 months later -- W.G. Meeting One
 18 - 24 months later -- International Myctophid Conference
 1 day - 1 month later -- W.G. Meeting Two
 12 months later -- W.G. 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 fishery specialists already involved in, or with an interest in, possible myctophid fisheries.

Because of the interest and potential importance of the known large populations of myctophids in the northwestern Arabian Sea, several members are from countries bordering that area, including one of the two co-chairs. Involvement of these individuals could be beneficial to SCOR by involving scientists from countries that have not been substantially involved in SCOR activities in the past (i.e., Pakistan, Iran, Oman, and Ukraine).

Full Members

Bernard Zahuranec, Co-Chair, USA -- An active and recognized researcher on the systematics and biogeography of myctophids. Career as a program officer at the US Office of Naval Research provided experience in setting up and running international conferences.

M.M. Rabbani, Co-Chair, Pakistan -- Director General of NIO (National Institute of Oceanography) in Karachi. As D.G., he is the *ex officio* marine scientist who will be the Pakistani collaborator for a US - Pakistan research project on Arabian Sea myctophid genomics proposed between University of California, Santa Cruz (UCSC) and NIO Karachi.

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Myctophid Fishery representative, Iran -- Past personal communications indicated that Iran has started an exploratory fishery for mesopelagic fish (*Benthoosema pterotum*) in their part of the Gulf of Oman so this position is for a knowledgeable member of that fishery organization but specific information about who that would be has been difficult to obtain. It is possible that the best place to start would be with Mr. Lotfollah Saeedi as Deputy Minister and first President of Iran Fisheries Organization.

Younis Al Akhzami, Oman -- As Director of the Fisheries Division of the Ministry of Agriculture and Fisheries, he is in the best position to represent Oman's interest in potential mesopelagic fisheries and their future plans for such fisheries.

Gopakumar Kumara, India -- As an active researcher early in his career, he and his colleagues published the most extensive and complete studies on the biochemistry and food value of *Benthoosema pterotum*, the extremely abundant mesopelagic myctophid in the Gulf of Oman and adjacent waters of the Arabian Sea. His final government position before retirement as Director of the Fisheries Division in the Ministry of Agriculture gives him a unique perspective and knowledge on the status of the marine fisheries of India.

Hiroya Sugisaki, Japan -- This young researcher (suggested by Dr. Akira Taniguchi) has, with colleagues listed below as possible Associate Members, been actively involved in conducting research into the potential for mesopelagic fisheries resources in the seas around Japan.

P. Alexander Hulley, South Africa -- Presently Assistant Director of the South African Museum in Cape Town, his administrative duties have not prevented him from continuing an active research program on the systematics and biogeography of myctophids. His efforts have particularly focused on the myctophids of the Atlantic and Indian Oceans.

John Paxton, Australia -- Presently retired from the Australian Museum in Sydney, he has nevertheless continued active research in ichthyology. His publications deal with the relationships of various species of myctophids and his past publication on the relationship of the many myctophid genera is a classic standard for the field.

Cynthia Klepadlo, USA -- As an assistant curator in the Fish Collection of the Scripps Institution of Oceanography, she has had extensive experience with mesopelagic fish, especially with Pacific species. This personal interest has prompted her to develop a comprehensive bibliography of myctophid publications, presently well in excess of a thousand entries, which she has offered to share with the other Working Group members.

Alexander Boltachev, Ukraine -- As an active marine ichthyologist, together with his colleague, Sergey Tsarin, in the Institute for Studies of the Biology of Southern Seas in Sevastopol, they have access to a huge collection of mesopelagic fish from all tropical seas, but with special emphasis in the Indian Ocean and southwest Pacific Ocean. This has given them unique insights and understanding of the systematics, biology and ecology of these fish.

Associate Members

Giacomo Bernardi, USA -- As an ichthyologist who employs molecular techniques, he is the Principal Investigator in the US - Pakistan cooperative project proposed to study the genomics of myctophids in the northwest Arabian Sea and adjacent Gulf of Oman discussed under Dr. M. M. Ribbani, above.

T.M.A. Khan, Pakistan -- Proposed by Dr. M. M. Rabbani, this young and energetic biological oceanographer has been included as a potential stand-in for Dr. Rabbani, should his duties as Director General of NIO Karachi prevent his participation in a Working Group meeting.

Masatoshi Moku, Japan -- A colleague of Dr. H. Sugisaki (listed above) included here for the same reasons as Dr. Sugisaki.

Chiyuki Sassa, Japan -- A colleague of Drs. Sugisaki and Moku, he has also provided material of several forms of *Benthosema* to Dr. Bernardi for comparative molecular genomic analyses.

Sergey Tsarin, Ukraine -- See discussion under Alexander Boltachev, above.

Padmini Dalpadado, Norway -- An active researcher at the Fisheries Institute of the University of Bergen whose PhD dissertation spelled out most of what is known about *Benthosema pterotum* in the Gulf of Oman, making it, arguably, the best understood myctophid in the world.

Frans Teutscher, FAO Rome -- As a participant in the 2001 Workshop on Mesopelagic Fishes supported by FAO in Muscat, Oman, he presented a paper entitled: "Options for utilization of lanternfish (*Benthosema pterotum*, Myctophidae) in the Gulf of Oman".

Wilfried Thiele, FAO Rome -- As another participant in the 2001 Muscat workshop, he coauthored a paper entitled: "Efficient capture and handling of lantern fish". The potential participation of Drs. Thiele and/or Teutscher (or perhaps other FAO scientists) would strengthen the output of the Working Group.

Eugene Fritz, USA -- Retired from National Marine Fisheries Service headquarters in Washington, DC, his knowledge of the fisheries of the world is encyclopedic and his approach to some of the problems has often been innovative and unorthodox, an approach that might prove especially welcome in dealing with the problems posed by potential mesopelagic fisheries.

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2.3.3 WG on Hydrodynamic and Sediment Transport Model Prediction Performance Criteria

1. Rationale

Hydrodynamic numerical simulation of wave and current processes, and sediment transport, is now a well established tool, and becoming ever more available. Model simulations are applied to a wide range of problems such as tidal currents in estuaries and inlets, longshore sediment transport, beach morphodynamics, sediment transport in and out of harbours, pollution dispersion, shelf currents, wave modelling, tsunamis, etc.

Several model suites are available internationally, including the well known HR Wallingford (UK), DHI (DK), Delft Hydraulics (NL), and 3DD (Dr Kerry Black; AU/NZ) models, which are used both for research purposes and applications in the international literature, as well as for commercial applications.

Elsewhere many new models have been, and are continuing to be, developed within research institutions. These models are applied in a wide range of coastal marine, oceanographic and engineering situations. Models have a variable performance, depending, *inter alia*, upon the skill of the modeller in setting the boundary conditions, and quality of the data for model calibration and verification.

However there is no standard test or parameter to judge performance of the models, and indeed, sometimes outrageous claims are made by the authors that the model has been “calibrated”. Such was the case in a manuscript submitted for an international journal presenting simulation of a tidal model with suspended sediment transport in which the author claimed the model was calibrated, but when one peruses the ‘calibration’ carefully it is clear that the ostensibly ‘calibrated model’ has up to 80 cm/s variation from the model predicted compared to the field measured result. Some parts of the “calibration” show current flow is 180 degrees out of phase with the model simulation! Is this acceptable within the scientific modelling community?

In the late 1980s GESAMP undertook a review of the suitability of various coastal models [GESAMP Report 43 Coastal Modelling, 1991]. At that time the GESAMP Working Group reviewed aspects of model suitability for simulating coastal processes but did not identify any quality performance tests for the models. Later, an IAHR Working Group issued guidelines aimed at standardising the *reporting* of validation tests of models, but did not make recommendations about standardising the evaluation procedures themselves. [International Association for Hydraulic Research, “Guidelines for Documenting the Validity of Computational Modelling Software”, 1994]. Recently, a European Thematic Network QNET-CFD [www.qnet-cfd.net] has addressed the question of specifying standard benchmark test cases for certain classes of flow model. They considered industrial and aeronautical, as well as environmental, Computational Fluid Dynamic models, and made recommendations about the most suitable classes of models as well as the need for validation tests.

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However, to date there is no internationally recognised set of criteria or scores that a researcher can use as a measure of the quality of their numerical simulation. In the late 1990s HR Wallingford, [under the leadership of R. Soulsby, in a project funded by EC MAST – the European COAST3D project] undertook detailed instrumentation and detailed data sets off Teignmouth and Egmond to use as a basis to compare various numerical model simulations.

In a paper resulting from that project, Dr J. Sutherland (2001) makes the statement:

“The question of how good a model is should be defined in a more quantitative manner than the usual ranking (poor, good, excellent) that is normally applied”,

and points out that HR Wallingford has worked on this issue. Sutherland identifies 4 model performance statistics including the Brier Skill Score, The Relative Mean Absolute Error (RMAE), The Scatter Index, and the Wilmott et al.’s Indices of Agreement that can be used for model performance assessment. In the same volume, Van Rijn used the concept of evaluating model performance based upon the Relative Mean Absolute Error (RMAE) and the Brier Skill Score.

However, these measures have evidently not gained wide international acceptance. Accordingly the purpose of this proposed SCOR Working Group is to review the available performance measures and recommend performance assessments, measures, or scores that marine hydrodynamic and sediment transport modellers can apply and quote concerning the quality of their predictions relative to measurements of distributions of quantities such as wave height, current velocity, suspended sediment concentration, pollutant concentration or bed morphology.

2. Terms of Reference

The purpose of this proposed Working Group is to bring together a group of experienced model users and model developers to:

- (i) review possible tests of various types (descriptive as well as statistical) that modellers might apply as a quality test of model performance;
- (ii) propose standard procedures and tests that model practitioners could/should apply to test the veracity of their model output; and
- (iii) assess whether it is possible to devise a “standard score” as a measure of model simulation performance.

3. Publication Output.

It is proposed to produce a paper to be published in a leading international journal, perhaps as a Special Issue, specifying the appropriate model performance measures for coastal oceanographic hydrodynamic and sediment transport simulations.

4. Proposed Membership

Chair - Prof Terry Healy (New Zealand)
 Co-Chair: Prof Richard Soulsby (Wallingford, UK)
 Dr Kerry Black (International model developer) (Australia/NZ)
 Dr Ida Broker (DHI model developer – Denmark)
 Dr Leo van Rijn or Dr Dirk-Jan Walstra (Delft Hydraulics, Netherlands)
 Gegar Presetya (Indonesia – tsunami modeller)
 Prof Shu Gao (Nanjing University, China)
 Dr Nick Kraus (USACE Waterways Experimental Station)
 ? A meteorologist : – weather forecast performance assessment
 ? A Time series statistician expert in marine field data analysis

5. Proposed Meeting Schedule

Meeting 1: 2006

Discussion and review. Refining of the terms of reference.

- Determine WG outputs: What can we achieve?
- Determination of publication outlet and type (Book? International Journal paper?/Special Issue?)
- Individual contributions
- Co-option of additional associate members
- Timetable and time-lines
- Communication methods
- Agenda for next meeting

Meeting 2: 2007

Review of contributions

? Workshop with various models testing

6. References

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Submitted jointly by Professors Terry Healy (NZ) and Richard Soulsby (UK) as a UK-NZ SCOR Working Group proposal.

Thursday, 28 April 2005

2.3.4 WG on Natural and Human-Induced Hypoxia and Consequences for Coastal Areas

Abstract

There is accumulating evidence and growing concern that low oxygen (i.e. hypoxic) conditions are proliferating in marine coastal environments worldwide. Coastal hypoxia has major ecological and biogeochemical consequences that are poorly understood and often studied in isolation from other conditions. The intensity, duration and frequency of coastal hypoxia are changing due to human-induced alteration of coastal ecosystems (e.g., enhanced delivery of nutrients and/or organic matter) and changes in oceanographic conditions potentially related to global warming, climate variability and ocean circulation patterns. Recent work suggests that hypoxia induces changes in ecology and biogeochemistry that are strongly coupled and linked with the adjacent land and open ocean. Hypoxia can be either intermittent or permanent, with different consequences for various organisms and key biogeochemical processes. The integration of existing knowledge on the biogeochemical and ecological processes related to intermittent hypoxia is central to this working group. This group will collect and synthesize the available data on coastal hypoxia and produce a state-of-the-science report that (1) summarizes the mechanisms governing coastal hypoxia, (2) documents the ecological and biogeochemical consequences, (3) identifies the gaps in our understanding and (4) evaluates the requirements for observing and predicting hypoxia events and their impacts.

Rationale

Events of low oxygen can cause serious problems in coastal areas of the world. These problems include changes in populations of marine organisms such as large-scale mortality, as well as changes in species distributions, changes in biodiversity, physiological stress, and other sublethal effects, such as reduced growth and reproduction (Service, 2004). Tourism can be negatively affected by dead organisms and unpleasant smells. Hypoxic events are increasing in intensity and frequency worldwide (Rabalais and Turner, 2001) and the public is becoming increasingly aware of the events and their impacts (Boesch, 2004; Ferber, 2004). Hypoxic events can not only be caused by nutrient and organic matter inputs from land areas, but also by natural intrusions of sub-surface oceanic low-oxygen waters (Grantham et al., 2004), or by stimulation from up-welled nutrients, such as in Benguela and California upwelling systems. It is important to synthesize existing knowledge about the causes and effects of hypoxia in coastal areas, and to recommend research, observation strategies, and modeling activities that can enable better understanding and prediction of hypoxic events to make adaptation and/or mitigation possible.

A SCOR working group is the best mechanism to ensure a coordinated international scientific effort on the issue of coastal hypoxia. The scientific rationale for this working group comes from the benefits that could be gained by bringing together biologists, chemists, and physicists to identify common features and differences in governing mechanisms among hypoxic systems in different coastal settings worldwide. The results of this working group would contribute to several SCOR and IGBP large-scale ocean research projects, and to national, regional, and international coastal observing systems.

Scientific Background

We do not provide a complete background on coastal hypoxia and consequences on biogeochemical cycles and marine ecology. Rather, we summarize those issues that have motivated the organization of the working group that is, increasing hypoxia problems in the coastal ocean, and their impacts on the functioning of ecosystems and biogeochemical cycles.

Hypoxia in coastal waters is governed by physical and biogeochemical processes. Enhanced delivery of nutrients and organic matter to coastal waters may generate hypoxia in certain settings (e.g., strong surface stratification and long water residence time). Upwelling of subsurface oceanic waters that have low oxygen content and subsequent warming may also cause zones of hypoxia. Upwelled nutrients along western boundaries result in enhanced productivity and subsequent accumulation of carbon and oxygen deficiency. The combined effect of natural upwelling of low oxygen oceanic water and enhanced availability of nutrients and organic matter may accelerate and intensify coastal hypoxia.

Hypoxia in a variety of coastal environments is now believed to be a major barrier to the sustainability of ecosystems (cf. Naqvi et al., 2000; Breitburg, 2002). There are several potential causes of hypoxia in the coastal ocean, including (1) increase in land-source input of organic materials and nutrients with limited circulation and vertical mixing, for example, off large river mouths and adjacent continental shelf areas; (2) climate-induced change (e.g., monsoon) in coastal oxygen depletion, and (3) intrusion of deep oxygen-depleted waters in near-coastal areas, through upwelling and changes in coastal circulation.

Although the occurrence of hypoxic events may not necessarily be induced by human activities, the existing knowledge indicates that anthropogenic perturbations can be an important factor in the occurrence of coastal hypoxia. Land-based human activities have been shown to greatly increase the riverine influx of nutrients world-wide and modify ratios between nutrient species, e.g., N/P and N/Si (Turner et al., 2003). Loading and composition of organic materials from terrestrial sources can also be modified by human activities in the watersheds. For instance, the construction of dams and/or reservoirs not only affects the fresh water discharge, and hence stratification of the receiving water bodies, but also dissolved silicate can be trapped resulting in highly modified N/Si and P/Si ratios. Deforestation and land erosion can have dramatic effects on coastal water quality. Other major pathways of nutrient inputs to the coastal environment include atmospheric deposition and discharge of groundwater. Another important influence of human activity is from marine aquaculture, which in some coastal regions (e.g., Asia) can have dramatic impact on the nutrient load in coastal waters.

A growing body of evidence suggests that interannual-to-interdecadal variability in ocean biology is linked to large scale fluctuations (e.g., El Niño/Southern Oscillation, Pacific Decadal Oscillation, North Atlantic Oscillation) through direct or indirect pathways of ocean circulation.

The net impacts of large-scale ocean current systems and associated biogeochemical conditions on the structure and dynamics of coastal ecosystems in general and coastal hypoxia in particular,

however, remain poorly resolved. Understanding the linkages between open ocean climate (Keeling and Garcia, 2002) and the frequency, duration and intensity of coastal hypoxia events is critical for open coastal regions since they support a major proportion of the world's fisheries and marine biodiversity, and are a focus of chemical transformations of globally important elements. For example, the intrusion of anomalously strong inflow of subarctic water into the California Current System led to unprecedented development of severe inner-shelf hypoxia and resultant mass mortality of fish and invertebrates in summer 2002 (Grantham et al., 2004). Gilbert et al. (2005) present evidence of a long-term decline of oxygen in the St. Lawrence Estuary (Canada) from intrusions of oxygen-poor oceanic water. How and to what extent the above mentioned mechanisms function in different climate and oceanographic settings have profound effects on the transition from oxygen-rich to hypoxic conditions and vice versa.

Low oxygen conditions have major consequences for biogeochemical cycles and the diversity and functioning of biological communities. Some hypoxic systems have been studied extensively, but an integrated view is lacking and there is limited understanding of the interactions between biogeochemical cycles and their dynamics. Hypoxia can alter the relative importance of nitrate removal pathways (e.g., denitrification, ammonium regeneration and anaerobic ammonium oxidation) and induce formation and emission of nitrous oxide, a radiatively active greenhouse gas. Oxygen conditions determine the retention and regeneration of phosphorus in sediments; regeneration increases under anoxic conditions and burial increases under oxic conditions. Many trace element cycles, including those of essential trace nutrients, are governed by oxygen availability. For example, iron regeneration is lowest under fully oxic and permanent anoxic conditions, and highest under low oxygen or alternating oxic-anoxic conditions. Iron released from coastal sediments becomes available for coastal plankton communities and, after cross-shelf transport, also for open ocean communities. Hypoxic conditions on shelf ecosystems could thus stimulate primary production in the adjacent open ocean by enhanced trace metal remobilization (e.g. through iron release) and along-isopycnal transfer.

The effect of hypoxia on marine benthic metazoans has been relatively well studied in terms of the number and biomass of animals (Levin, 2003) and the differential tolerance of benthic organisms towards low oxygen conditions. However, the consequences of these community changes on the interactions between metazoans and bacteria and functional diversity aspects as well as their impact on nutrient regeneration and cycling have been addressed only occasionally; there is a clear need for synthesizing the available data. Animals that are mobile can move away from hypoxic areas, but sessile organisms cannot relocate and experience physiological stress and may die, depending on the intensity, frequency, and duration of hypoxic events. If metazoans disappear from sediments, sulphide may reach the sediment-water interface (and even escape into the water column) and sulphide-intolerant organisms will not settle on or survive in the sediments. In extreme local cases, hydrogen sulphide has entered the water column and escaped to the atmosphere (e.g., Weeks et al., 2002). Within the shelf sediments of the Humboldt system, extended periods of hypoxia favor high biomass development in the form of mats of the giant sulphide bacterium *Thioploca* (Gallardo, 1977), which can link the benthos to modified water column food webs. Within the water column, low oxygen water causes changes in distribution of fish spawning (e.g., Black Sea anchovy), in the magnitude of recruitment (Baltic cod), and in available habitat of pelagic and demersal species,

increasing exposure to predation and other causes of mortality (e.g., Namibian hake). Extreme cases of hypoxia in surface waters can result from harmful algal blooms, resulting in mass mortality of water column (marine) organisms (e.g., Li et al., 2002).

Ecological and biogeochemical responses to decreasing oxygen concentrations can be fast, for example, die-off of seagrasses and benthic animals. The reverse is often not the case when oxic conditions return. The recovery of benthic communities may take years to decades. This differential response to decreasing and increasing oxygen (i.e., hysteresis) may result in alternative quasi-stable states or benthic regime shifts.

A number of observing systems are in the planning stages for coastal areas, as documented by the Coastal Ocean Observations Panel of the Global Ocean Observing System (GOOS), which has identified hypoxia as one of the issues of interest for coastal observations. There is a need for improved technology for observations, for example, through utilization of a range of sensors, not only for oxygen, but also sensors of nutrients and micro-nutrients important in generating hypoxia, as well as sensors of the biogeochemical and biological impacts of hypoxia. New technological developments have recently enabled scientists to routinely monitor oxygen concentrations remotely and transmit data in real-time (Körtzinger et al., 2004). These developments offer ample opportunities to begin the task of monitoring changes in the ocean's oxygen regime, as well as other measurements important for understanding the causes and consequences of hypoxia. It is timely to have a coordinated examination of the requirements for such systems, in terms of detecting and predicting hypoxic events and their consequences. The placement of sensors and their use in detection and prediction of hypoxic events is being carried out in various locations. Guidelines are needed for time and space scales for future placement and use of observing systems.

Model simulations are necessary to assess the sensitivity of oxygen budgets to variations in anthropogenic nutrient load from fresh water influx, water column properties and cross-shelf exchanges, variations in climate, etc and critical scales of forcing. The models designed to simulate temporal changes of oxygen in response to variations in climate and anthropogenic loading have involved various levels of complexity spanning from simple nutrient – oxygen models (e.g., Justic et al., 2003) to more sophisticated ones with various levels of food-web complexity (e.g., Park et al., 1996) and biogeochemical cycles (e.g., Oguz et al., 2000). An interdisciplinary modeling approach involving coupled physical and biogeochemical processes as well as local and open-ocean forcing is required for more accurate predictions of hypoxia events and for more deterministic understanding of their causes and effects. The latter issue is important in understanding global biogeochemical cycles, an active topic in oceanographic studies from tropical to high latitude.

Terms of Reference

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

1. Synthesize the state of the science and make recommendations for future research related to the following topics:
 - prevalence and variability (i.e., temporal and spatial) of human-induced coastal hypoxia,
 - influence of the open ocean on the occurrence of coastal hypoxia,

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- effects of hypoxia on the biogeochemistry and ecology of coastal marine systems, particularly the role of daily to intra-decadal variability, and
 - non-linearity (e.g., asymmetric influence) in effects of the formation of, and
 - recovery of coastal ecosystems from, hypoxic events;
2. Determine the requirements for observing hypoxic events and their impacts in coastal systems;
 3. Identify requirements for modeling coastal hypoxia and its impacts;
 4. Document the work of the group in a special issue of a peer-reviewed journal or a book by a major publisher.

Working Group Membership

The work proposed in this document would be carried out by a group of ten Full Members and 11 Associate Members (more Associate Members may be nominated at the first working group meeting). The proposed list of members provided below would ensure wide geographic coverage and includes expertise in biological, chemical, and physical oceanography, marine biology and fishery, and modeling. The Full Members listed below have agreed to serve on the working group, if it is approved.

Full Members

1. Jing Zhang (China) - Co-chair - Chemical oceanography
2. Denis Gilbert (Canada) - Co-chair - Physical oceanography
3. Jack Middelburg (The Netherlands) - Biogeochemistry and modeling
4. Nancy Rabalais (USA) - Biology
5. Wajih Naqvi (India) - Chemistry
6. Pedro Monteiro (South Africa) - Biogeochemistry
7. Temel Oguz (Turkey) - Physics and modeling
8. Lisa Levin (USA) - Benthic ecology
9. Osvaldo Ulloa (Chile) - Biology
10. Venu Ittekkot (Germany) - Biogeochemistry

Associate Members

1. Boris Dewitte (France) - Physics
2. Mike Kemp (USA) - Chemistry
3. Andy Gooday (UK) - Biology
4. Elva Escobar (Mexico) - Benthic biology
5. Ragnar Elmgren (Sweden) - Ecology
6. Mary Scranton (USA) - Microbial ecology
7. Werner Ekau (Germany) - Fishery
8. Howard Freeland (Canada) - Physical oceanography
9. Anja van der Plas (Namibia) - Chemical oceanography
10. Silvio Pantoja (Chile) - Biogeochemistry
11. Teruaki Suzuki (Japan) - Biology

Working Group Activities

If approved, the working group would organize its first meeting in early to mid-2006, potentially in conjunction with the Ocean Sciences Meeting (February) or the annual EGU meeting (late April). At its first meeting, working group members will make short presentations about their scientific activities, followed by (1) agreement on how they will fulfill their terms of reference (who will do what), (2) discussion of whether they will require a workshop to fulfill the terms of reference and produce their publication, (3) discussion of potential funding sources for a workshop, if needed, and (4) detailed planning related to the workshop and/or publication. If a workshop is planned, it will be held in late 2007 or early 2008, followed by the second meeting of the working group. The final meeting of the group will be held in 2009, to complete their publication.

The Scientific Committee on Problems of the Environment (SCOPE) will be approached about co-sponsoring the working group, as they have interest in this topic. The activities of this group could be useful for many global ocean research projects, including GEOHAB, GEOTRACES, GLOBEC, IMBER, LOICZ, and SOLAS. Therefore, the working group will ensure that mutually beneficial links are established with other global ocean projects.

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2.3.5 WG on Deep Ocean Exchanges with the Shelf

Background

As part of its strategy for improving its role in the 21st century, the International Association for the Physical Sciences of the Oceans (IAPSO) has established a new international programme 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. The shelf break is a region of steep slopes, strong narrow currents, internal tides, shelf waves and significant vertical motion. There will be a DOES symposium at the Joint Assembly in Cairns in August 2005 (convened by Dr. J. Johnson and Dr J. Middleton).

With the advent of much finer resolution to 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 fish stocks. Improved models can also assist observational oceanographers in planning their next cruises.

A joint working group (WG) between the Scientific Committee on Oceanic Research (SCOR) and IAPSO is proposed as, although the principal work of the working group will be in physical oceanography, the output from the working group will have interdisciplinary interest for chemists and biologists. It also aims to involve scientists from developing countries. The support of SCOR will enable the members of the working group to meet on three occasions to push forward the research required on this topic.

Rationale - Deep Ocean Exchanges with the Shelf

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 the 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 difficulty in securing measurements at the edge of the shelf due to the narrowness of the currents and steep slopes.

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. This is generally added at the location of the river. But, in reality the fresh water flows along the shelf, sometimes for considerable distances, before it crosses the shelf break and enters the deep ocean. 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.

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Strong tidal mixing at the shelf break is an important feature in the energy balance of the Earth's oceans. Internal and surface tides are built into shelf models but are absent from deep ocean general circulation models. Strong mixing associated with significant topography is an important component in the theories of the 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.

Improved models and a better understanding of the processes that occur between the shelf and the deep ocean will be of benefit in maintaining fish stocks, to 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 has consequences for climate studies.

Interaction with other programmes

Two SCOR WGs have links with this proposed WG. WG 111 on Coupling Waves, Currents, and Winds in Coastal Models is co-chaired by Christopher Mooers (who is one of the members of the proposed WG). Output from WG 111 will form part of the current knowledge of the shelf oceanography. The ongoing IAPSO/SCOR WG 121 on Ocean Mixing will provide useful input about deep ocean mixing to the proposed WG.

The carbon cycle in the shelf and upwelling zones is an important ingredient for the modeling by the Climate Variability and Predictability program (CLIVAR). 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.

Joint Working Group

IAPSO proposes formation of an international joint working group with SCOR to oversee the DOES programme. IAPSO wishes to foster research work on the links between shelf and deep-sea oceanography by using the DOES working group to generate ideas and encouragement for future research by the wider oceanographic community with funding from national and international bodies. The topics to be covered by the working group include:

- (1) Physical processes due to shelf waves, internal tides, shelf break upwelling;
- (2) River and estuary input of sediment and fresh water;
- (3) The influence of ocean physics around the shelf break on fisheries and climate;
- (4) Dissipation of tidal motion along the continental margins;
- (5) Flows over sills;
- (6) Chemical and biological flux exchanges between the deep ocean and coastal ecosystems;
- and
- (7) Coupled physical-chemical-biological numerical models that have a better description of the exchanges at the shelf edge.

Topic (2) will concentrate on the use of data from LOICZ and others in the boundary conditions of numerical models of the shelf and deep oceans. For topics (6) and (7) the DOES WG will collaborate with IMBER and LOICZ to complement their work and avoid unnecessary duplication. Improved models of the flows over the shelf break will be useful to the IMBER modelling project.

Terms of reference

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

- (1) Establish the current state of knowledge in the above topics and identify new research that should be encouraged;
- (2) Determine where further observations are needed to help with the formulation of better models;
- (3) Serve as an international forum for physical oceanographers to discuss current research on the interaction between the coastal zone and the deep ocean;
- (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) Set up a Web site that can be used by the DOES community for exchange and discussion of results and proposals for research and for dissemination to the wider community.

The working group will complete its work with a final report to SCOR and IAPSO and with the organisation of an international DOES symposium at the summer 2009 IAPSO Joint Assembly.

Timetable

Support is requested for three working group meetings (up to 10 persons per meeting):

1. February 2006 at the Ocean Sciences Meeting in Hawaii,
2. July 2007 in Perugia in association with the IUGG General Assembly;
3. Summer 2009 in association with the IAPSO Joint Assembly, location to be determined, for final discussion and input to the working group's report.

The first meeting of the WG will concentrate on summarising the present state of knowledge, and then topics will be assigned to members of the WG (and any co-opted associate members) for them to encourage new research proposals for the IAPSO community and to report and discuss at the second meeting.

Membership

Working group membership is proposed to consist of up to ten specialists from various countries with expertise in both modelling and observations of the oceans. Associate members may be co-opted to help with biogeochemical applications. The following group is proposed:

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John Johnson (chair, UK)	Ocean models, particularly shelf and shelf break. Limited area models.
Isabel Ambar (Portugal)	Ocean observations, particularly off Iberia. Meddies.
Jack Barth (USA)	Frontal instability processes. Coastal ocean dynamics (observations and models).
Hu Dunxin (China)	Physical oceanography and marine sedimentation. West Pacific boundary.
Christopher Mooers (USA)	Coastal ocean circulation dynamics. Shelf break processes. Regional circulation models.
John Middleton (Australia)	Ocean circulation over continental shelves. Coastal trapped waves.
Frank Shillington (South Africa)	Remote sensing of sea surface temperature and ocean colour.
Olga Trusenkova (Russia)	Bathymetric effects in the Japan Sea.
Takeshi Matsuno (Japan)	Water exchanges between the East China Sea and the Kuroshio. Biological production over the shelf.
Eric Wolanski (Australia)	Marine biology. Coral reefs.

11 April 2005

2.3.6 WG on Critical Bathymetric Studies

Executive Summary

A SCOR working group should be formed to evaluate and recommend bathymetric studies in critical regions of the world's oceans that are currently under-surveyed. These critical regions are those in which bathymetric surveys would provide highly valuable data. These data would apply to studies of currents, ocean mixing, tsunami propagation, and safe navigation as well as enhancing the accuracy of estimations of seafloor topography based on satellite altimetry. The working group would be charged with performing an independent, multi-dimensional analysis of the costs and benefits of these bathymetric studies and to identify regions where such studies would reap maximal societal and scientific return. This group would aim to offset the current trend of narrowly focused, proposal-driven, bathymetric studies that are funded solely for scientific purposes. While the SCOR working group would have no funding authority, the impetus generated by widely broadcasting their recommendations would bolster the chances of success of proposals to survey and study those regions identified by the working group. Their recommendations would include the collection of ancillary data (such as sidescan sonar images) to fulfill the promise of multi-disciplinary benefit to society and science.

Background

Currently, the coverage of the world's oceans by bathymetric mapping is highly heterogeneous, with very dense coverage in some areas, such as near busy coastal ports, and very sparse coverage in other areas, such as the South Pacific Ocean. This is clearly true for public domain data, but is likely to be true as well for the secret or proprietary data held by national military organizations and private industrial firms, respectively. To some degree, the oceans suffer the "Tragedy of the Commons" (Hardin, 1968), where the ocean is exploited by all, but under the stewardship of none. This is as true for exploration as much as it is for fisheries. Only areas of specific interest are mapped in detail, while vast areas are left unexplored.

While the accurate mapping of seafloor topography is in great demand, it remains woefully incomplete. The need for accurate bathymetry is demonstrated by its use in satellite altimetry estimations of seafloor topography, tsunami modeling, global circulation studies, oceanic mixing models, and even safety to navigation, as was demonstrated by the grounding of the US Navy nuclear submarine *San Francisco* in January 2005. From deep ocean circulation (Mercier and Speer, 1998) to ocean mixing (Polzin, *et al.*, 1997; Ledwell, *et al.*, 2000), bathymetry plays a significant role as a boundary or triggering condition. The contention has been made that we know the surface of the moon better than we know the solid surface of the Earth. Yet, the resource requirement for complete mapping of the seafloor is huge. An evaluation of the Global Ocean Mapping Project (GOMaP) estimated that 1,000 ship-years would be required for complete survey coverage, not considering transits and redundant coverage (Carron *et al.*, 2001). At current ship costs, this approximates US\$10 Billion (\$10₁₀), and hence has a very low probability of becoming a reality.

The new working group will complement, and naturally follow on from, the activities of SCOR WG 107 which last met in 1997 (Summerhayes *et al.*, 2001). WG 107 was charged with establishing the

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scientific needs for improved knowledge of ocean depths, with specifying the accuracy and resolution requirements and with recommending actions and priorities. The WG came up with six priority actions the fourth of which was to fill substantial gaps in the more remote or less often explored oceanic areas. Whereas many of the technical recommendations of WG 107 are now being addressed there has been a noticeable lack of advance in filling gaps in ocean bathymetry. The new working group is planned to build on WG 107 by providing strong arguments rooted in a broad spectrum of oceanographic research to convince scientists, hydrographers and, above all, funding agencies of the need for a new approach. The proposed membership of the new working group has very little overlap with that of WG 107.

Rationale

While complete mapping is unrealistic, carefully focused studies of limited extent (i.e. in critical regions selected to have the greatest impact on science and society) are a real possibility. These studies would maximize the advancement of knowledge across the full range of bathymetric applications, from enhancing satellite altimeter-based estimations of seafloor topography to safe navigation. These focused studies would differ from currently funded studies in that they would be optimized for the full spectrum of applications as opposed to evaluations based on a single discipline or geographic region, i.e. the data will be collected with more than one intended use. This will require a multi-disciplinary analysis of needs and sensitivity by an objective group of scientists, something that has not been done in the past. A SCOR working group is an ideal vehicle for such analysis.

The proposed working group would provide guidance and suggest priorities for bathymetric surveys that would complement the current bathymetric coverage, filling in blank or sparse regions in the context of multiple applications of bathymetry. The use of satellite altimetry to calculate free-air gravity anomalies, which are then correlated with bathymetric relief for estimating seafloor topography in regions otherwise unsurveyed, provides an important means of obtaining leverage from the limited, acoustic survey resources available. Thus, one of the evaluations would be of the impact of an acoustic bathymetric survey on the quality of the altimetric estimations within the region. Likewise, modeling of tsunami propagation is highly dependent on accurate bathymetry as tsunamis "feel" the influence of seafloor topography at all depths; their speed is depth-dependent and they are focused or scattered by depth variations in their path such as occur at seamounts. The tragedy of the Indian Ocean tsunami of December 2004 has made the public highly aware of the need for effective propagation modeling, threat analysis, and appropriate warning infrastructure. Bathymetry provides the critical foundation for the first two components.

The oceans, particularly currents and mixing, play a significant role in shaping and moderating our global climate. Recent research suggests that small variations in bathymetry and seafloor roughness can have major effects on current steering and deepwater mixing. For the global climate scientific community to gain an operative understanding of these processes, a knowledge of accurate seafloor topography and roughness are a required input to modeling efforts.

The proposed working group will be charged with evaluating the sensitivity of all of these efforts to improved bathymetry in critical areas. The working group will also evaluate the multi-dimensional

benefits of improved bathymetry to the entire spectrum of scientific research and understanding, as well as the benefits to society in terms of hazard response and mitigation. SCOR is a logical source for a broad spectrum, scientifically supportive, neutral party to evaluate the optimal use of resources to the benefit of all ocean sciences. They are best able to break the competitive, narrow interest log jam in specific, research-focused surveys and to identify critical areas of bathymetric research that will optimize the benefit to, and impact on, science and society.

Finally, the working group would issue guidelines and recommendations for the collection of ancillary geophysical data, in addition to bathymetry, that would enhance the utility and impact of the bathymetric data in other multi-disciplinary studies. It will also seek to ensure standards of stewardship, archiving, and distribution necessary to make the collected data available to the multiple studies to which they might apply and to ensure the long-term preservation of the data to their continued, effective, and wise use.

The SCOR Working Group on Critical Bathymetric Studies has the potential to significantly extend, and obtain leverage from, the investment of limited resources for describing the ocean's floor.

Terms of Reference

1. Identify and evaluate the most critical regions needing new bathymetry. Using multi-dimensional analysis and evaluation, rank the regions according to their impact on both science and society.
2. Provide both:
 - a) independent evaluations of the global advantage of studying the bathymetry of certain regions and
 - b) compelling arguments and recommendations for those studies.

Meetings

If the working group is approved, work would begin at an opportunistic meeting at the Fall 2005 American Geophysical Union (AGU) meetings in San Francisco, December 2005. (No funds would be requested from SCOR for this meeting). Interactions amongst the working group Members and the General Bathymetric Chart of the Oceans (GEBCO), the International Hydrographic Organization (IHO), the Intergovernmental Oceanographic Commission (IOC), the IOC's Consultative Group on Ocean Mapping (CGOM), the U.S. National Geophysical Data Center (NGDC) (as the World Data Centre for Marine Geology & Geophysics and the IHO's Data Centre for Digital Bathymetry) will determine whether to add Associate Members, as well as establishing communications infrastructure and protocols for the working group. The primary agenda for the first full working group meeting, in early 2006, would be to establish a work schedule, an electronic forum for meeting, interaction, and consultation, and a schedule of subsequent physical meetings.

A working period of four years is proposed for the working group to:

- i. assemble,
- ii. define the evaluation process,
- iii. acquire and define the requirements of science and society for bathymetry,

- iv. review extant data in the context of multi-disciplinary requirements for data,
- v. evaluate the relative value of bathymetric studies in various geographic regions, and
- vi. generate a working group report on the results of that final evaluation and publish summaries in peer-reviewed journals and elsewhere.

The final physical meeting would probably be at either GEBCO 2009 or Fall AGU 2009, and would highlight the public release of the working group report. A summary of the working rationale and results of the working group would be published in one or more peer-reviewed journals.

Working Group Members

1. Chairman, someone with broad experience in bathymetry and its diverse applications
 - a. *Suggestion: Dr. Walter H.F. Smith, Laboratory for Satellite Altimetry, NOAA, Silver Spring Maryland, USA. Chair, GEBCO Sub-Committee for Digital Bathymetry with research interests focused on reconnaissance of global deep-water bathymetry from space. Member SCOR WG107.*
2. Bathymetric data resource expert
 - a. *Suggestion: Dr. George F. Sharman, Director WDC Marine Geology and Geophysics, Boulder, USA*
 - b. *Suggestion: Dr. Christopher G. Fox, Director IHO Data Center for Digital Bathymetry, Boulder, USA*
3. Tsunami modeling expert
 - a. *Suggestion: Dr. Kenji Satake, Active Fault Research Center, National Institute of Advanced Industrial Science and Technology, Japan. Internationally recognized modeler.*
 - b. *Suggestion: Dr. Vasily Titov, Research Scientist, Tsunami Program, Ocean Environment Research Division, Pacific Marine Environmental Laboratory, USA*
4. Physical Oceanographer specializing in ocean circulation and climate.
 - a. *Suggestion: Dr. Sarah T. Gille, Assistant Professor, Scripps Institution of Oceanography and Department of Mechanical and Aerospace Engineering, University of California San Diego, USA. Research interests include Southern Ocean climate and dynamics, wind-forcing of the Southern Ocean and heat transport via the Antarctic Circumpolar Current, subgrid-scale parameterization for climate models, satellite oceanography from altimeter and scatterometer data, interpretation of ocean general circulation model output.*
5. Physical Oceanographer specializing in ocean tides and tsunamis.
 - a. *Suggestion: Dr. David J. Webb, National Oceanography Centre, Southampton, U.K. Research interests include large scale ocean circulation (both wind driven and thermohaline), ocean tides and tsunamis. Formerly Head of Ocean Circulation and Climate Advanced Modelling Project (OCCAM). Associate Member WG 107.*
6. Biological Oceanographer
 - a. *Suggestion: Dr. Alan Butler, Torres Strait and Northern Fisheries and Ecosystems, CSIRO Marine Research, Cleveland, Queensland, Australia. Research interest in the strategic development of 'optimal' techniques for the assessment of habitats and diversity, and characterization of ecosystems, using surrogate-based methods (e.g.*

classification of backscatter from acoustics) to predict underwater habitats SE of Australia and on the NW Shelf.

7. Bathymetrist with expertise in multi-dimensional analysis
 - a. *Suggestion: Dr. Martin Jakobsson, Department of Geology and Geochemistry, Stockholm University, **Sweden**. Research interests in Paleoceanography and seafloor processes of the Arctic Ocean, development of robust techniques for combining historical and contemporary bathymetric data sets, and the use of GIS and 3D visualization for handling and analyzing marine geological and geophysical data.*
8. General Bathymetric Chart of the Oceans (GEBCO) specialist
 - a. *Suggestion: Dr. Hans Werner Schenke, Alfred Wegener Institut, Bremerhaven, **Germany**. Chair, GEBCO Sub-Committee on Undersea Feature Names (SCUFN). GEBCO specialist in ocean bathymetry. Research interests in bathymetry of the Southern Ocean, especially the Weddell Sea. Member SCOR WG107*
 - b. *Suggestion: Dr. Jose Frias Salazar, INEGI, Aguascalientes, Mexico. GEBCO specialist in ocean bathymetry. Vice-President of the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico (IBCCA).*
9. General Bathymetric Chart of the Oceans (GEBCO) specialist
 - a. *Suggestion: Dr. Robin Falconer, Institute of Geological and Nuclear Sciences Ltd., **New Zealand**. Manager of the Natural Hazards Group of IGNS. Interest in strategic management, geological hazards, marine science, geographic information systems.*
 - b. *Suggestion: Dr. Vaughan Stagpoole, Institute of Geological and Nuclear Sciences Ltd., New Zealand.. Recently completed a new bathymetry compilation of the Ross Sea Sector South of 60°S. Senior person in all the UNCLOS work in New Zealand. Marine geophysicist with research interests in the crustal dynamics and thermal evolution of sedimentary basins.*
10. Bathymetrist and marine geophysicist
 - a. *Suggestion: Dr. Srinivas Karlapati, National Institute of Oceanography, Goa, **India**. Research interests in understanding the evolution of Arabian Sea. Graduate of the first Nippon Foundation/GEBCO training course in ocean bathymetry.*
 - b. *Mr. Cristian Rodrigo, Navy Hydrographic and Oceanographic Service (SHOA), Valparaiso, Chile. Works in National Oceanographic Data Centre (CENDOC). Experience of bathymetric mapping and setting up database systems. Practical marine geophysics experience on the Chilean hydrates program.*

References

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- Mercier, H and Speer, K.G. Transport of bottom water in the Romanche Fracture Zone and the Chain Fracture Zone, *J. Phys. Oceanogr.* 28 (1998) 779-790.

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Polzin, K.L., *et al.*, Spatial variability of turbulent mixing in the abyssal sea, *Science* 276 (1997) 93-96.

Summerhayes, C.P. *et al.*, *Improved Global Bathymetry*, Scientific Committee on Oceanic Research, Report of Working Group 107, (2001).

SCOR CHAIRS AND EXECUTIVE COMMITTEE REPORTERS/LIAISONS

		CHAIR / CO-CHAIR	REPORTER
<u>WORKING GROUPS</u>			
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 <i>Phaeocystis spp.</i> Cluster as a Model	Gieskes/Belviso	Hall
WG 121	Deep-Ocean Mixing	Muench	Akulichev
WG 122	Mechanisms of Sediment Retention in Estuaries	Kjerfve/Perillo	Labeyrie
WG 123	Reconstruction of Past Ocean Circulation (PACE)	Stieglitz/Kissel	Labeyrie
WG 124	Analyzing the Links Between Present Oceanic Processes and Paleo-Records	Lochte/Sicre	Wainer
WG 125	Global Comparisons of Zooplankton Time Series	Mackas/Verheye	Pierrot-Bults
WG 126	Role of Viruses in Marine Ecosystems	Weinhauer/Wilhelm	Hall
SCIENTIFIC STEERING COMMITTEES, PANELS, etc			
GLOBEC	Global Ocean Ecosystem Dynamics SSC	Werner	Taniguchi
GEOHAB	Global Ecology and Oceanography of Harmful Algal Blooms	Pitcher/Babin	Hall
SOLAS	Surface Ocean - Lower Atmosphere Study SSC	Liss/Matrai	Labeyrie
IOCCP	International Ocean Carbon Coordination Project	Sabine	Duce
IMBER	Integrated Marine Biogeochemistry and Ecosystem Research	Hall	Duce
LOICZ	Land-Ocean Interactions in the Coastal Zone	Talaue-McManus	Hall
	The Ocean in a High-CO ₂ World Symposium	Cicerone	Duce
	GEOTRACES	Anderson/ Henderson	Duce
	Panel on New Technologies for Observing Marine Life	De Sa	Pierrot-Bults

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	Platt	Sundby

PARTNER ORGANIZATIONS

IGBP	International Geosphere-Biosphere Programme
POGO	Partnership for Observation of the Global Oceans
SCAR	Scientific Committee on Antarctic Research
SCOPE	Scientific Committee on Problems of the Environment
PICES	North Pacific Marine Science Organization

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