2.0 WORKING GROUPS REPORTS

Expenditures by SCOR Working Groups (1996-2002), **p. 2-1**

2.1 Disbanded Working Groups, p. 2-2

2.2 Current Working Groups— The Executive Committee Reporter for each working group will present an update on working group activities and progress, and will make recommendations on actions to be taken. Working groups expire at each General Meeting, but can be renewed at the meeting and can be disbanded whenever appropriate.

2.2.1 WG 109—Biogeochemistry of Iron in Seawater, **p. 2-6** *Duce*
2.2.2 WG 111—Coupling Winds, Waves and Currents in Coastal Models, **p. 2-8** *Purini*
2.2.3 WG 112—Magnitude of Submarine Groundwater Discharge and its Influence on Coastal Oceanographic Processes, **p. 2-14** *Duce*
2.2.4 WG 113—Evolution of the Asian Monsoon in Marine Records: Comparison between Indian and East Asian Subsystems, **p. 2-18** *Labeyrie*
2.2.5 WG 114—Transport and Reaction in Permeable Marine Sediments, **p. 2-22** *Labeyrie*
2.2.6 WG 115—Standards for the Survey and Analysis of Plankton, **p. 2-25** *Pierrot-Bults*
2.2.7 WG 116—Sediment Traps and ^{234}Th Methods for Carbon Export Flux Determination, **p. 2-28** *Labeyrie*
2.2.8 WG 118—New Technologies for Observing Marine Life, **2-34** *Pierrot-Bults*
2.2.9 WG 119—Quantitative Ecosystems Indicators for Fisheries Management, **p. 2-64** *Field*
2.2.10 WG 120—Marine Phytoplankton and Global Climate Regulation: The *Phaeocystis spp.* Cluster As Model, **p. 2-69** *Hall*
2.2.11 WG 121—Deep-Ocean Mixing, **p. 2-72** *Purini*
2.2.12 WG 122—Estuarine Sediment Dynamics, **p. 2-76** *Labeyrie*

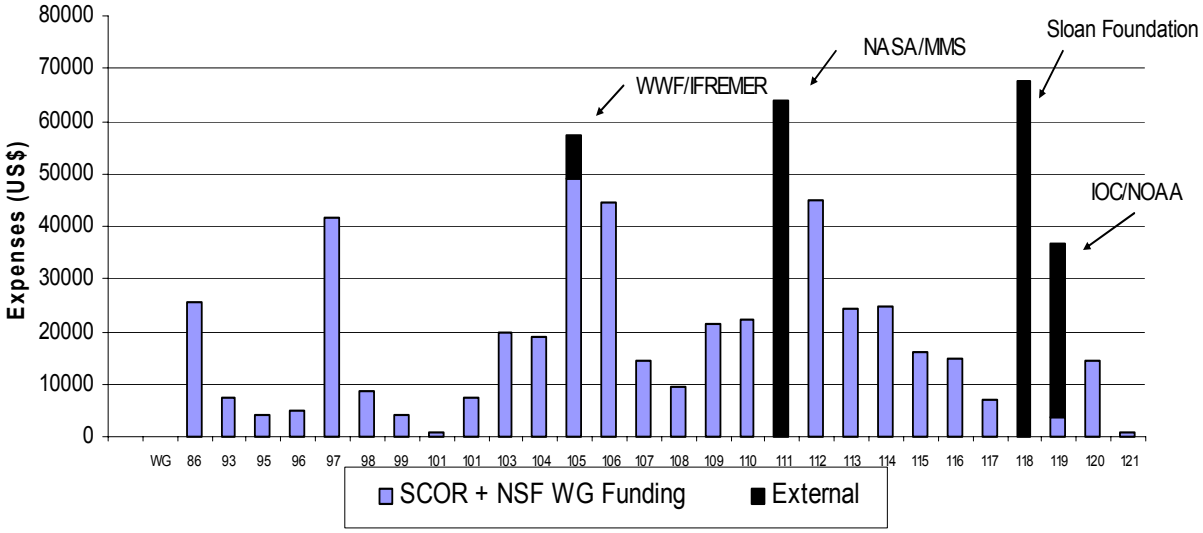
2.3 Working Group Proposals

2.3.1 Working Group to plan and implement GEOTRACES, a collaborative multi-national program to investigate the global marine biogeochemical cycles of trace elements and their isotopes, **p. 2-78** *Labeyrie*
2.3.2 SCOR/IMAGES Working Group to Investigate the Reconstruction of Past Ocean Circulation, **p. 2-85** *Zatsepin*
2.3.3 Working Group on Analysing the Links Between Present Oceanic Processes and Paleo-Records, **p. 2-92** *Wainer*
2.3.4 Working Group on the Physical and Biological Structure of Meso-scale Rings in World's Oceans, **p. 2-100** *Field*

2.4 SCOR Chairs and Executive Committee Reporters/Liaisons, p. 2-106

Expenditures by SCOR Working Groups (1995-2003)

Some external funding is not yet shown (e.g., IOC funding for older working groups), but this chart is accurate in terms of the total expe
for each group and will be updated for future meetings.



2.1 Disbanded Working Groups

2.1.1 WG 106: Relative Sea Level and Muddy Coasts of the World

Copy of EOS Article Removed

2.1.2 Working Group 107: Improved Global Bathymetry

Date: Tue, 15 Oct 2002 10:49:00 +0100
From: Laurent Labeyrie <Laurent.Labeyrie@lsce.cnrs-gif.fr>
Subject: Re: RE: SCOR 107
To: "Summerhayes, Colin" <C.Summerhayes@unesco.org>
Cc: EDWARD R URBAN <scor@jhu.edu>, "Unluata, U." <u.unluata@unesco.org>

Dear Colin
…. The sub-committee I had in charge during the last SCOR meeting was in fact very supportive about the importance of the job you did with your working group, and the need to improve bathymetric data collection and distribution. Our suggestions were sought for improvement of the WG output, not a critic about your work. The sub committee demands were

1. Report needs editing, reorganization (main chapters+annexes)+updating, including modeling part, transfer of data, handling and distribution of data "free of charge" by NGDC, missing section on what should do people who have bathymetric data : formats, where to send it, and no precise and practical way-forward proposition. Send the report to the sub-committee members, Birger Larsen ready to help in detailed review
2. Writing of a short paper <all scientists>, type EOS, to advertise the report and necessity for collecting and providing bathymetric data.
3. Presentation at GEBCO conference

Suggestions and Status, from your mails:
1- to find support for a 6 months post-doc position, able to update the main parts of the report, reorganize it for publication. This is too late.

2- to see with you how an easy to read, widely distributed (EOS type) paper could present the main conclusions. Smith is working on it.

3- missing points :

- people who read the text and have under hand available data (either maps or tracks or gridded data), what should be done about it? This could be included in Smith paper.
- Even well organized groups as InterRidge or IMAGES cannot resolve the issue within their program. SCOR will have to help definition of a permanent network between such SCOR related programs and world data centers to develop solutions. SCOR should proceed

3- Presentation at GEBCO conference: Does somebody in your group could do it?

2-4

4- Last point : <free availability of data>: The present system is not efficient.

4.1-gridded data needs expensive Not Friendly user software (as GMT) for quality plotting. The only (to our knowledge) friendly, multi-platform (mac, PC), free software is panMap from PANGEA, but it handles only contour plots.

4.2 NGDC has begun distribution of the high resolution gridded bathymetric data, but at 25$ the CD, with 3 CD to cover, partially, the Mississippi margin, 3 CD for the Esat coast. This is VERY expensive.

NGDC should be approached for developing freeware software, and free ftp distribution of their data.

Cheers
Laurent
--

From: Ed Urban [mailto:scor@jhu.edu]
Sent: mercredi 2 avril 2003 17:50
To: Summerhayes, Colin
Subject: Short Article about WG 107

Dear Colin,

Has there been any progress on the short article about the outcome of WG 107's activities since we last corresponded about this? As you may remember, SCOR wanted to take a look at the article before it is submitted for publication.

Best regards,

Ed

Date: Thu, 03 Apr 2003 17:16:38 +0200
From: "Summerhayes, Colin" <C.Summerhayes@unesco.org>
Subject: RE: Short Article about WG 107
To: 'Ed Urban' <scor@jhu.edu>

Hi Ed,

As I think I mentioned to you at the time, I passed on this task to one of the Committee Members, Walter Smith, and he was going to do it. I think he's been a bit busy lately.
Colin

2.1.2 Working Group 108: Double Diffusion
(1996)

Copy of WG 108 cover removed

2.2 Current Working Groups

2.2.1 Working Group 109: Biogeochemistry of Iron in Seawater (with IUPAC) (1997)

Terms of Reference:

- To review critically the current state of knowledge of the biogeochemistry of iron in seawater. The review will cover chemical speciation, analytical techniques, transformation between different forms of iron, fluxes and distribution of iron, bio-availability of iron and also the evidence for iron limitation of primary production in High Nutrient-Low Chlorophyll (HNLC) areas of the ocean.
- To identify priorities for future research in the areas covered by the review.
- To forge links between scientists working on iron chemistry in seawater (mainly SCOR-affiliated) and in other aquatic environments (mainly IUPAC-affiliated).
- To publish the review and recommendations as a joint SCOR-IUPAC volume in the well-established series on Analytical and Physical Chemistry of Environmental Systems, published by John Wiley.

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Frank Millero	USA
James Moffett	USA
B. Sulzberger	SWITZERLAND
Hein de Baar	THE NETHERLANDS
Tim Jickells	UK
Patrick Buat-Menard	FRANCE
William Sunda	USA
Andrew Watson	UK
J. Webb	AUSTRALIA

Executive Committee Reporter: Robert Duce

Report from SCOR WG 109, June 2003

As noted in the 2002 report, the main task of the Working group was completed with the publication of the book "The Biogeochemistry of Iron in Seawater". The group has, however, remained active through the subgroup on iron standards in seawater, chaired by Jim Moffett (USA).

This group's activity centred on an intercomparison exercise for low (sub-nanomolar) iron concentrations in seawater, using a bulk water sample collected on board *RV Polarstern.* This group held its final workshop in San Francisco on December 5, 2002. 22 scientists took part (USA 16, Europe 5, Japan 2, Australia 1), together with two observers from NSF. A draft report is in the process of being finalised, and it is intended that the results of the intercomparison will be incorporated into a paper for *Marine Chemistry*. The meeting also discussed a number of follow-up activities, which are in various stages of planning and funding. The tone of the meeting is best summarised by the final paragraph of Jim Moffett's draft report:

> "With a mean value of 0.67+/-0.3 nM for the entire data set, it is clear that the intercomparison has not achieved the objective of demonstrating to the larger scientific community that Fe investigators can agree on concentrations with the precision required for this analyte, given its oceanic distributions. Nevertheless, the tone of the meeting was very positive, with considerable progress made towards identifying ways to improve the procedures for conducting a follow-up large volume exercise, together with refining and standardizing analytical methods. I think that the representatives of the U.S. National Science Foundation, who provided much of the support for the meeting, came away with a good impression of how the trace metal community can work together."

On behalf of the subgroup, we thank SCOR for their support of this activity. The SCOR funding provided has generated very high added value in the intercomparison now completed, and even more importantly has helped to get underway a continuing process towards low concentration iron standard materials for seawater.

Keith Hunter
David Turner

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

Terms of Reference:

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

Co-Chairs:

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Members:

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

Associate Members:

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

Executive Committee Reporter: Ilana Wainer

Date: Sun, 06 Jul 2003 23:18:29 -0400
From: "Christopher N.K. Mooers" <cmooers@rsmas.miami.edu>
Subject: SCOR WG111 Report
To: scor@jhu.edu
Cc: norden@neptune.gsfc.nasa.gov

SCOR WG111 has been totally focused on moving ahead with its book project this past year. The majority of the lead authors for the several chapters were able to meet with the majority of the editors for several days (18 to 21 NOV 02) in Goa, India to review the status of their chapters, make adjustments in coverage and preparation procedures, and re-vitalize the overall activity. Presently, most of the chapters exist in draft form, a book proposal is under review by Cambridge University Press, and the peer review an*d editorial processes will commence soon, under the editorial leadership of Peter Craig, CSIRO. Hence, late 2004 appears to be a realistic publication date.

- Chris

[Note from EU: The remainder of the funds in the grant from the U.S. Minerals Management Service will be used to support preparation of the book. The working group has not requested any additional funds from SCOR.]

SCOR WG111 Book: Coupled coastal wind, wave and current dynamics
(Drafted 8 JUL 03)

Editors: Peter Craig, Norden Huang, Chris Mooers, and Satish Shetye

Chapter/Subsection Title

1 – Introduction ***Chris Mooers***

- Coastal Ocean Circulation
- Atmospheric Forcing
- Coastal Atmospheric Processes
- Air-Sea Coupling
- Surface Waves and Turbulence
- Bottom Boundary Layer, Variable Topography, and Internal Waves
- Coastal Ocean Response
- Summary

2 – Coastal ocean circulation dynamics ***Jason Holt***

2.1 Introduction
2.2 Shelf-sea processes: forcing and response

2.2.1 Atmospheric forcing
- Wave response
- Diffusive response
- Advective response

2.2.2 Tidal forcing
- Wave response
- Diffusive response
- Advective response

2.2.3 Buoyancy forcing
- Advective response
- Wave response
- Diffusive response
- Sea-ice processes

2.3 Comprehensive studies of shelf-sea dynamics: models
2.3.1 General features of coastal-ocean circulation models
2.3.2 Public domain circulation models
2.3.3 Developments in coastal ocean circulation models
2.4 Comprehensive studies of shelf-sea dynamics: observational strategies for model validation and calibration
2.5 Synthesis between coastal-ocean models and observations
2.6 Conclusion

3 – Coastal surface gravity wave dynamics ***Paul Hwang***
3.1 Introduction
3.2 Fetch-limited growth of wind-generated waves
3.2.1 Introduction
3.2.2 Similarity laws of fetch growth
3.2.3 Discussion
3.2.4 Summary
3.3 Duration-limited growth of wind-generated waves
3.3.1 Introduction
3.3.2 Fetch to duration translation
3.3.3 Comparison with observations
3.3.4 Summary and conclusions
3.4 Net growth rate of the wind-generated wave system
3.4.1 Introduction
3.4.2 Derivation of the retention rate of wind waves
3.4.3 Effect of directional distribution function
3.4.1 Summary
3.5 Observations of finite depth wave evolution
3.5.1 Introduction
3.5.2 Governing equations
3.5.3 Experimental description
3.5.4 Non-dimensional growth curves
3.5.5 Spectral evolution
3.5.6 Directional spreading
3.5.7 Summary

3.6 Nonlinear processes in finite depth wind-wave evolution
3.6.1 Introduction
3.6.2 Finite depth spectral balance
3.6.3 Quadruplet or 4-wave interactions
3.6.4 Triad or 3-wave interactions
3.6.5 Conclusions

3.7 Surface wind stress and wind input function
3.8 Breaking and dissipation function
3.9 Wave-induced surface currents
    3.9.1 Langmuir circulation
    3.9.2 Stokes drift
3.10 Recent Observations
    3.10.1 Directional wavenumber spectra
    3.10.2 Finite water observations
3.11 Conclusions

4 – Coastal atmospheric circulation dynamics ***Chris Reason***
Introduction
4.1 Coastal atmospheric phenomena
    4.1.1 Air-sea interaction and surface fluxes
    4.1.2 Flux parameterisations in the constant flux layer
    4.1.3 Air-sea interactions in coastal zones
    - Boundary layer adjustment
    - Flow which is mainly on-shore
    - Flow which is mainly offshore

    4.1.5 Sea/land breezes
    4.1.6 Coastal fog
    4.1.7 Evaporation and precipitation regimes
4.2 Atmospheric circulation systems and coastal impacts
    4.2.1 Monsoons and seasonal migration of the ITC
    4.2.2 Tropical cyclones and hurricanes
    4.2.3 Cold-air outbreaks and extratropical cyclones
    4.2.4 Alongshore wind jets, barrier winds and coastally trapped disturbances
    - Alongshore jets
    - Supercritical flow in the coastal zone
    - Coastal jets induced by onshore flow and landfalling extra-tropical cyclones
    - Coastally trapped disturbances

    4.2.5 Mesoscale offshore jets
    - Gap winds
    - Mistral, tramontana and cierzo winds
    - Katabatic cold offshore jets
    - Warm offshore (foehn type) jets (Santa Ana and berg winds)

4.3 Coastal atmospheric circulation models

4.4 Coastal atmospheric chemistry
    - Introduction
    - Gas exchange, cloud formation and precipitation
    - Coastal aerosols, cloud interactions and deposition

4.5 Conclusion

5 – Coastal ocean turbulent fluxes ***Hans Burchard***
5.1 Introduction
5.2 Turbulent regimes
    5.2.1 Surface Boundary layer
    5.2.2 Bottom boundary layer
    5.2.3 Internal waves and turbulence
    5.2.5 Estuarine Turbidity Maxima, stratification and turbulent mixing
    - ETM Particle Trapping Mechanisms
    - ETM Particle Trapping and Particle Properties

5.3 Observation and data interpretation
- 5.3.1 Micro-structure shear-probe observations
  - Introduction
  - Shear probe constructions
  - Problems, limitations and measurement strategy
  - Example of measurements
- 5.3.2 Near-bed high resolution ADCP data
  - Introduction
  - The variance method
- 5.3.3*. Observing turbulence beneath breaking waves
- 5.3.4. Particle-Image Velocimetry in the BBL
  - Introduction
  - Instrumentation
  - Example data
  - Estimating the Reynolds Stress
  - Future developments

5.4 Modelling
- 5.4.1 Statistical turbulence closure models
- 5.4.2. Empirical turbulence models
  - Introduction
  - The K-profile parameterization
  - Coastal applications and comparisons with second-order closure models
- 5.4.3 Large eddy simulation
  - Introduction
  - Coastal applications
- 5.4.3. Lateral mixing parameterizations
- 5.4.4. Sensitivity of 3D model results to turbulence parameterizations
  - Introduction
  - A Case study for the Baltic Sea
  - The turbulence models
  - Results
  - Discussion and conclusions

5.5 Summary

6 – Coastal Atmosphere – Wave - Ocean Coupling ***Shuyi Chen***

6.1 Introduction

6.2 Surface fluxes
- 6.2.1 Air-sea Exchange Coefficients
- 6.2.2 Wave-state Dependency

New section for insertion? Internal Boundary Layer in the Coastal Zone

6.3 Wind-wave interaction

6.5 Wave-current interaction

6.6 Bottom-Friction Enhancement (may be combined into Ch 5 or 7)

6.7 Full Atmosphere-Wave-Ocean Coupling

7 – Coastal ocean transport Patrick Lutyen

Introduction

7.1 Ecosystem Modelling
- 7.1.1 Lagrangian approach
  - Introduction
  - Lagrangian and individual-based models
  - Planktonic biota and their environment
  - Interaction in the plankton
  - Plankton distributions
  - Summary

7.1.2 Eulerian approach
- General description
- Eulerian vs Lagrangian method

7.1.3 Physical aspects of ecosystem modelling
- Vertical exchange processes
- Numerical aspects and vertical diffusion
- Advective transport

7.2 Sediment dynamics
7.3 Transport of buoyant and dissolved contaminants
7.3.1 Transport in the coastal environment: Lagrangian and Eulerian perspectives
7.3.2. Dissolved and particulate matter
7.3.3. Transport of buoyant material
7.4 Summary/Conclusion

8 – Research Issues and Strategies ***Chris Mooers***
8.1 Coastal ocean circulation dynamics
8.2 Surface wave dynamics
8.3 Coastal atmospheric circulation dynamics
8.4 Coastal ocean turbulent fluxes
8.5 Coastal atmosphere – wave ocean coupling
8.6 Coastal ocean transport

2.2.3 WG 112: Magnitude of Submarine Groundwater Discharge and its Influence on Coastal Oceanographic Processes (1997)

Terms of Reference:

- To review and assess deficiencies in our knowledge concerning the magnitude of fluxes of SGD.
- To define the existing methods and tools useful for measurement of groundwater fluxes to the coastal zone.
- To examine the possibility of using a typological approach to assess SGD over broad areas.
- To review and assess the chemical (nutrients, pollutants) consequences of SGD and to suggest follow-up studies of the physical and ecological consequences.
- To prepare a series of manuscripts for a special issue of an international journal that will describe the "Influence of submarine Groundwater Discharge on Coastal Marine Processes."
- To prepare a final report to SCOR within four years and an interim report on the first term of reference within two years.

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Toshitaka Gamo	JAPAN	Makoto Taniguchi	JAPAN
Willard S. Moore	USA	Igor S. Zektser	RUSSIA

Associate Members:

Henry Bokuniewicz	USA	June Oberdorfer	USA
Jaye Cable	USA	Leslie Smith	CANADA
Jeffrey Chanton	USA	B.L.K. Somayajulu	INDIA
Gerry Jacobson	USA	Luigi Tulipano	ITALY
		Chung-Ho Wang	China-Taipei

Executive Committee Reporter: Robert Duce

MAGNITUDE OF SUBMARINE GROUNDWATER DISCHARGE AND ITS INFLUENCE ON COASTAL OCEANOGRAPHIC PROCESSES

(http://www.jhu.edu/~scor/WG112.htm)

Co-Chairs: Bill Burnett & Evgeny Kontar LOICZ Liaison: Robert Buddemeier

ANNUAL REPORT
(June 2003)

Introduction and Objectives

The overall goal of WG 112 is to define more accurately and completely the magnitude of submarine groundwater discharge (SGD) and how it may influence chemical and biological processes in the coastal ocean. To this end, the members of the working group have organized themselves into three task-oriented units based on the following goals: **Calculation and Modeling**; **Measurement, Sampling, and Experimental Design**; and **Typology, Integration and Globalization**.

We summarize below the main activities of our working group since our last annual report (August 2002).

Accomplishments in 2002-2003:

- Published a feature article in *EOS* on the two SGD method assessment intercomparisons (Florida and Australia) conducted up to that date, co-authored by several working group members. The reference citation is shown at the bottom.
- Jointly with IOC and IHP/UNESCO, a SGD session was organised during the "International Conference on Low-lying Coastal Areas – Hydrology and Integrated Coastal Zone Management," 9-12 September 2002, Bremerhaven, Germany.
- Participated in a Cooperative Research Program (CRP) project with the International Atomic Energy Agency (IAEA) and UNESCO's International Hydrological Program (IHP). The fieldwork in 2002 was in Donnalucata, Sicily during March 18-24, 2002. This is a known site of extensive groundwater discharge to the ocean.
- Participated in a meeting held at the IAEA Headquarters in Vienna, Austria during December, 2002. Preliminary assessments of the results of the fieldwork in Sicily conducted earlier that year was presented by several WG members. Reports were prepared based on these results and papers are planned for submission during 2003.
- Members of the WG established an IUGG joint commission on "Groundwater-Seawater Interactions" between IAHS (International Association of Hydrological Sciences) and IAPSO (International Association for the Physical Sciences of the Ocean). The commission operates under the following terms of reference:

1. To foster research concerning the flow of groundwater into the coastal zone. This will be done by holding symposia, conducting meetings at IAPSO and IAHS events, and preparing proposals to sponsor research.
2. To participate in research on submarine groundwater discharge within developing countries. This research will be conducted at the highest level with full participation from scientists within the developing countries. Members of the joint commission will collaborate with scientists from developing countries to develop proposals to national and international agencies to sponsor such research.
3. To engage in capacity building and training so research concerning groundwater discharge to the coastal zone may be conducted in areas where there is a deficiency in such studies. The capacity-building activities will be conducted via training workshops, joint research projects, and fellowships for scientists from developing countries to visit laboratories with active programmes in this field.

- Two symposia were organized during 2002 for the 2003 IUGG Congress in Sapporo, Japan: (1) "Groundwater Inputs to the Ocean" (JSP-03) and (2) "Quantitative Approaches to Hyporheic Flows and Their Biogeochemical Consequences" (JSH-03). Approximately 50 abstracts were received for these symposia.
- Developed a proposal to the Asia Pacific Network (APN) to perform a direct measurement study of submarine groundwater discharge into Lingyagen Gulf, The Philippines. The proposal includes a significant training and capacity-building component. Unfortunately, the proposal was declined – resubmission is being considered.
- A proposal was submitted by WG members to the Southeast Asia Regional Committee for START (SARCS) entitled "Contribution of Carbon and Nutrient Species into SE Asian Waters via Submarine Groundwater Discharge." This project was funded and will support measurements in the Gulf of Thailand.
- WG members prepared a contribution to a synthesis chapter ("Dynamics of the Coastal Zone," James Syvitski, lead author) on SGD for the LOICZ volume and participated in the LOICZ Synthesis and Futures Meeting in Miami in 2002.
- Organized and participated in a 3rd SGD assessment intercomparison (co-sponsored by IOC and LOICZ) on Shelter Island, New York during May, 2002.
- Our major effort during 2002 was the preparation of a special issue of the journal *Biogeochemistry* on submarine groundwater discharge. This is intended to be the major product of the Working Group. All papers were submitted during 2002 and most of them have now been reviewed. We anticipate that this volume will be published by the end of 2003. The list of papers and current status is presented below.

Publications

Burnett, W.C., J. Chanton, J. Christoff, E. Kontar, S. Krupa, M. Lambert, W. Moore, D. O'Rourke, R. Paulsen, C. Smith, L. Smith, and M. Taniguchi, 2002. Assessing methodologies for measuring groundwater discharge to the ocean. EOS, 83, 117-123.

Kontar, E.A., Burnett, W.C., and Povinec, P.P., 2002. Submarine Groundwater Discharge and Its Influence on Hydrological Trends in the Mediterranean Sea. Proceedings of the CIESM Workshop: Tracking long-term hydrological change in the Mediterranean Sea. Monaco, 22-24 April, 2002, 109-114.

Kontar, E.A., Shapiro, G.I., and Lobkovsky L.I., 2003. Estimation of the Impact of Submarine Groundwater Discharge on the Biogeochemical Parameters of Coastal Waters. Proceedings of the International Open Science Conference on Ocean Biogeochemistry and Ecosystems Analysis. IOC/SCOR, Paris, 7-10 January 2003, PS1: 2.13, 44.

Taniguchi, M., W.C. Burnett, J.E. Cable, and J.V. Turner, 2002. Investigations of submarine groundwater discharge. Hydrological Processes, 16, 2115-2129.

SCOR Working Group 112

"Submarine Groundwater Discharge: Its Measurement, Modelling, and Globalization"
Special Issue of Biogeochemistry -- W. Burnett and J. Chanton, Guest Editors

Authors	Tentative Title	Status
W. Burnett , J. Chanton, E. Kontar	Preface to Special Issue	pending
W. Burnett, H. Bokuniewicz, M. Huettel, W. Moore, M. Taniguchi	Groundwater and Pore Water Inputs to the Coastal Zone	accepted
M. Taniguchi, W. C. Burnett, C. F. Smith, R. J. Paulsen, D. O'Rourke, S. Krupa and J.L. Christoff	Seepage meter results from Florida Intercomparison experiment	accepted
W. Moore	Ra isotope studies at the Florida intercomparison	accepted
M. Lambert et al.	Seepage estimates during the Florida intercomparison based on continuous radon measurements	accepted
L. Smith	Hydrogeological modelling results from the Florida intercomparison experiment	revision pending
J. Chanton et al.	Geochemical evidence for tidally-driven seepage in the Florida Keys	revision pending
J. Turner and A.J. Smith	A Review of SGD Estimates on the South West Coast of Western Australia and Experimental Designs of SGD Investigations – CS Inter-comparisons	review pending
M. Taniguchi, J.V. Turner and A Smith	Evaluations of groundwater discharge rates from subsurface temperature in Cockburn Sound, Western Australia	revision pending
A.J. Smith and S. P. Nield	Groundwater discharge from the superficial aquifer into Cockburn Sound Western Australia: Estimation by inshore water balance	revision pending
J. Oberdorfer	"Groundwater Modelling Estimates of SGD: How Do These Relate to Other Quantitative Methods?"	revision pending
Georgia Destouni and Carmen Prieto	On the possibility for generic modelling of submarine groundwater discharge	revision pending
H. Bokuniewicz, R. Buddemeier, Bruce Maxwell, Casey Smith	The typological approach to submarine groundwater discharge (SGD)	revision pending

Updated June 9, 2003

2.2.4 WG 113: Evolution of Asian Monsoon in Marine Records: Comparison Between Indian and East Asian Subsystems (1997)

Terms of Reference:

- To review the present status of our knowledge of Indian and East Asian monsoon evolution, to define similarities and differences in their histories based on records developed to date.
- To define the key climate proxies necessary for effective comparison of the two subsystems in their evolution over different time scales in response to tectonics, orbital forcing, and ocean circulation.
- To provide recommendations for the East Asian monsoon studies on the basis of experience from the Indian Ocean.
- To propose a cooperative research effort in the region through various agencies and programs such as IMAGES and ODP, in order to promote and coordinate paleo-monsoon studies, including organization of an international symposium, preparation of a paleo-monsoon volume, and new ODP/IMAGES cruise proposals.
- To prepare a final report within four years.

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Executive Committee Reporter: Laurent Labeyrie

SCOR/IMAGES WG 113
Evolution of the Asian Monsoon in Marine Records:
Comparison between Indian and East Asian Systems

SEAMONS *(SCOR-IMAGES Evolution of Asian MONSoon)*

Report-2003

The Working Group is in its final phase, publication of results. Two publications are expected within this year:

1) Special Issue of *Marine Geology* titled "Asian Monsoons and Global Linkages on Milankovitch and Sub-Milankovitch Time Scales", edited by S. Clemens, P. Wang and W. Prell, with 15 papers;
2) Final report in scientific paper format, titled "Evolution and Variability of the Asian Monsoon System: Current Status and Outstanding Issues", by P. Wang, S. Clemens, L. Beaufort, P. Braconnot, G. Ganssen, Z. Jian, P. Kershaw, and M. Sarnthein, SCOR/IMAGES Working Group 113 SEAMONS to be published in *Quaternary Science Reviews.*

The Special Issue is scheduled to appear within the next 5 months, and the final report paper is under internal review and should be published within this year or early next year. As decided at our Aix-en-Provence meeting last year, the results from the Amsterdam meeting (meeting #1) have been incorporated into the final report.

Working Group 113 has one final application: If appropriate, we would like to request funds (~$2,000 U.S.) to offset the costs of purchasing reprints of the above two publications.

Sincerely,
Pinxian Wang, Chair
Steve Clemens, Secretary

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2002 SEAMONS Working Group Report:
(SCOR-IMAGES Evolution of Asian Monsoons)

GENERAL INFORMATION

Meeting Location and Dates:
CEREGE, Aix-en-Provence, France Sept. 2-4, 2002

Members in Attendance:
WANG Pinxian (Chair, China), SARNTHEIN Michael (Germany), CLEMEMS Steven (USA), BEAUFORT Luc (France), GANSSEN Gerald (Netherlands), KERSHAW Peter (Australia), BRACONNOT Pascale (France)

Members not in Attendance:
SAITO Yoshiki (Japan)
RAMESH Rangaswamy (India)
KUTZBACH, John (USA)

Invited Speakers:
France-Lanord, Christian. C.R.P.G.-C.N.R.S., France
Moron, Vincent, CEREGE, France

G. Participant:
JIAN Zhimin (Tongji University).
The Working Group decided to add Dr. Jiang, who took the work on monsoon proxies left from the Amsterdam meeting, as a new member.

Sponsors:
SCOR
IMAGES
PAGES

Day I. Monday, Sept. 2, 2002

Scientific Presentations
Welcoming remarks by Luc Beaufort (the meeting host) were followed by scientific presentations by working group members Wang, Kershaw, Gansen, Sarnthein, invited speakers France-Lanord and Moron, and guest participant Jian. The presentations included:

How old is the Asian monsoon system ? (by P. Wang)
The sedimentary record of erosion since Miocene: Climate and tectonics (C. France-Lanord)

A mid-Brunhes development of precession-controlled summer monsoon variability off NW Australia (P. Kershaw)'
Decadal-Centennial scale monsoon variations in carbon isotopic records (G. Ganssen)
High-resolution monsoon studies: Progress in the South China Sea (M. Sarnthein)
Supercycles of monsoon variations in carbon isotope records (P. Wang)
Searching Asian monsoon proxies (Z. Jian)
Interannual variability in AGCM simulation of West African monsoon (Vicent Moron)

Day II. Tuesday, Sept. 3, 2002

Working Group Discussions and Final Report Writing
Morning discussions centered on the form of the final SCOR report. It was decided that the report would take the form of a monsoon overview for publication in a journal such as *Quaternary Science Reviews.* The remainder of the morning was devoted to developing a comprehensive outline and assigning writing tasks to WG members. Pinxian Wang accepted responsibility for the collecting the various contributions and developing the manuscript. The afternoon session was devoted to writing.

Day III. Wednesday, Sept. 4, 2002

Final Report Writing
The entire day was devoted to writing. Sections not completed at the meeting are to be delivered to Pinxian Wang for incorporation in the manuscript by the end of November. The outlines of the final report were adopted as the following:

Evolution and variability of the Asian monsoon system: State of the Art and Outstanding Issues
--- Introduction
--- Proxies
--- Temporal variability
--- Millennial to decadal variations
--- Orbital forcing
--- Tectonic forcing and long-term evolution
--- Recommendations

2.2.5 WG 114: Transport and Reaction in Permeable Marine Sediments (1998)

Terms of Reference

- Review the available methods and suggest sampling schemes and devices for the measurement of both biogeochemical variables (e.g., solute and suspended matter concentrations and fluxes) and flow velocities and their patterns in permeable sediments from different environments.
- Explore the development of models for the description of reaction and transport in permeable sediments and their implementation into standardized "user-friendly" codes.
- Encourage the participation of the marine science community in research on permeable sediments by organizing a special meeting/symposium or a special session at one of the front-line international scientific conferences. Publish the best of the submitted papers, along with review articles by the WG members, in a broadly read journal.
- Determine if the study of reaction and transport in permeable sediments would be significantly enhanced by the development of a coordinated international research program (as has been done for carbon cycling with JGOFS), or if this goal would be better served by an enhanced presence in an existing program, such as LOICZ.

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Ian Webster	AUSTRALIA
Jan Marcin Weslawski	POLAND
Pat Wiberg	USA

Associate Members:

Richard A. Jahnke	USA
Jack J. Middleburg	NETHERLANDS
Carolyn Oldham	AUSTRALIA
Frank Sansone	USA
Björn Sundby	CANADA

Executive Committee Reporter: Laurent Labeyrie

Report of the 17 June Meeting in Lewiston, Maine, USA, of SCOR WG on
Transport and Reaction in Permeable Marine Sediments

- WG 114 met at Bates College in Lewiston , Maine, in conjunction with the Gordon Research Conference on Permeable Sediments. In attendance were:

  Full: Bernard P. Boudreau (co-Chair) –Canada
  Markus Huettel (co-chair) - Germany
  Ian Webster - Australia
  Gary Taghon - USA
  Pat Wiberg - USA
  Jan Marcin Weslawski - Poland

  Associate: Richard A. Jahnke - USA
  Frank Sansone - USA
  Carolyn Oldham - Australia
  Bjorn Sundby - Canada

  Jack Middelburg (The Netherlands), Anton McLachlan (Sultanate of Oman) and Peter Nielsen (Australia) were unable to attend. Stephan Forster (Germany) has resigned his position because of a change in his career direction. Wim van Raaphorst (Netherlands) died in a tragic accident earlier in the year; he will be sorely missed.

  This WG met during the GRC that it had organized, with the strong support of SCOR WG 112. Eight member of WG 114 acted as either Plenary Speakers of Session Chairs. Four members of WG 114 were also Plenary Speakers. The meeting was considered by all to be a great success. There were 72 attendees (normal for a first-time meeting), but more importantly 70% were attending their first GRC and 56% were non-Americans, both unusually high statistics for a GRC. We believe our WG has done a good job of "selling" our topic globally.

  The agenda for the meeting identified the following main subjects for discussion:

  (1) Recommendations on continuing the GRC on Permeable sediments and nominations for co-chairs and co-vice-chairs;
  (2) Web site location;
  (3) Other products from this WG;
  (4) Fate of WG 114.

  Item 1: The WG voted to ask the GRC organization to hold another GRC on Permeable Sediments, but that the date be set to 3 years hence (June 2006). The one-year delay was recommended to get the Permeable Sediments GRC out of synchronicity with the GRC on Chemical Oceanography in order to avoid splitting part of the potential audience. Recommendations were made for co-chairs and co-vice-chairs to the GRC attendees, and we are pleased that Ian Webster will be Co-Chair of the next meeting (with Tim Shaw, nominated by

WG 112), while Markus Huettel and Carolyn Oldham will be co-vice-chairs (with Matt Charette, nominated by WG 112).

Item 2: With Markus Huettel's move to Florida, the WG 114 web site will need to be moved. B. Boudreau volunteered to house it on his server. This will involve no cost and there is no rental or user fee on his server; on the other hand, there is no "regular" maintenance either. The WG found this acceptable. The move will be implemented ASAP, and the German server will be asked to create a "pointer" to the new site.

Item 3: The WG discussed options for other "hard" output from its activities. There was no enthusiasm for a special session with published papers at an international meeting. The group discussed the possibility of a reprint volume of past seminal papers on permeable sediments. B. Boudreau volunteered to investigate this possibility.

Item 4: The group decided that it should remain in existence, if somewhat dormant, until the next GRC on Permeable Sediments. The WG could then play the role of a contact and publicity group for that meeting.

We anticipate no financial request to SCOR in the coming fiscal year.

2.2.6 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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Van de Wyngard		Svein Sundby	NORWAY
K.K.C Nair	INDIA	Hans Verheye	SOUTH AFRICA

Associate Members:

Erika Head	CANADA	Juha Flinkman	FINLAND

Liaison from SCOR WG 118 (New Technologies for Observing Marine Life): D.V. Holliday (USA)
Executive Committee Reporter: Julie Hall

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SCOR WG 115: Standards for the survey and analysis of plankton

Chairman: S.I. Heaney

The main developments since the first meeting of the Working Group in Honolulu during February 2002 have been:

1. The development of a Web site in collaboration with the Sir Alister Hardy Foundation for Ocean Science (SAHFOS). This can be accessed through the main SCOR Web site www.jhu.edu/scor/ as well as by means of the SAHFOS web site www.sahfos.org .

The format of the web site has been commented upon by members of the Working Group and, as a result, modified to include nets as a means of plankton sampling, as these remain the principal method of sampling by many developing countries. The Web site will provide information under the headings of home meetings, instruments, surveys, methods, databases, science issues, capacity building and links which are expanded using drop-down menus. For example, methods are subdivided into standard operating procedures, quality control, statistical analysis and risk assessments.

The aim is to actively encourage contributions from biological oceanographers and instrument manufacturers and designers to provide information on methodologies for survey design and analysis as well as instrument and sensor performance characteristics. Much remains to be done in collating data and information onto the Web site but it is hoped that once its existence becomes better known progress will accelerate. The Web site database should provide much of the information needed for the second meeting of the Working Group and also the means of addressing its first four terms of reference:

- To review the present methods of collection, analysis and curation of plankton samples by agencies involved with time-series measurements and uses that 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 the logistical requirements, identify improvements that could be made in existing instrumentation for use in attached or towed bodies for plankton surveys.

2. SCOR has approved one full member, Dr. Sun Song (China-Beijing) and two Associate Members, Dr. Juha Flinkman (Finland) and Dr. Erica Head (Canada). These are most welcome additions and will give geographical coverage in the Pacific Rim, the Baltic and North West Atlantic as well as expertise and experience with new instruments and emerging technologies.

3. Interaction with WG 118, New Technologies for Observing Marine Life, has been maintained but unfortunately expected participation by an observer at the Peru meeting of WG 118 in October 2002 failed due to an unforeseen problem. Continued interaction between Working Groups 115 and 118 as well as with WG 119, Quantitative Ecosystem Indicators for Fisheries Management, will be developed.

Meeting in Concepción, Chile – November 2003

Planning for this meeting is well advanced, with an expected high level of attendance by both full and associate members as well as an observer from WG 118. It has also been agreed with SCOR to invite a few scientists from South America to enhance the development of standards for survey and analysis of plankton, technology transfer and networking for the region.

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

Terms of Reference:

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

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Deborah K. Steinberg	USA
Tom Trull	AUSTRALIA

Associate Member:
Anthony F. Michaels USA

Executive Committee Reporter: Laurent Labeyrie

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

Annual report - 2003

2003 Activities

Working Group 116 had a rather unexpected postponement of our meeting scheduled for April 11-14 in Xiamen, China. As Chair, and in consultation with the WG members, I had to make the decision not to hold our meeting as planned due to the threat of SARS. Ed Urban was appraised of this action and we are moving ahead with rescheduling our second meeting. All of this is quite unfortunate, as first due to SCOR budget problems one year and now SARS, it has been 2 years since our first WG meeting in July 2001, and without a second meeting our activity report is lacking in significant advances. I will detail below our Xiamen plans, outline a new schedule for Nov. 2003 to hold this meeting, and then suggest a new idea to finish our activities in 2004 with a final workshop in conjunction with other non-WG 116 scientists.

Xiamen plans (taken from Feb. 2003 email to WG 116 members & followed by daily agenda as planned)

Hi SCOR WG 116. Greetings in 2003!

I wanted to update you on our April 2003 WG meeting in Xiamen so you can be making travel arrangements. The general plans have not changed since my Nov. 8th email and the dates are still April 14-18. SCOR has agreed to support a 4 day gathering and as mentioned earlier, our local hosts at the University of Xiamen can extend this by a day for those of us willing to present science talks to University staff and students.

At this meeting, we will need time for participants to update and refresh the group as to our own work related to the WG theme and WG relevant meetings we've attended since Amsterdam (est. 30-45 min. for each WG member report). One goal was to publish a short *EOS* article on the activities of our group, and I think we should be able to begin and finish this in Xiamen.

Most of our time should be spent informally and in a couple of breakout groups outlining, assigning writing duties and starting on the two main WG products- namely a couple of papers on sediment trap and thorium-234 methods for POC flux. We'd suggested earlier shooting for two synthesis/methods type papers reviewing strengths and pitfalls of these methods. The new electronic methods Journal associated with Limnology and Oceanography seems like an appropriate place to submit and I've spoken to the editor Paul Kemp and he was supported. Much of the discussion on content of these papers can be as a group since we are a small WG, but it makes sense when it comes to writing assignments and tasks, to split in to two sub-groups, perhaps with some overlap of individual members.

Our bibliography is another WG product that I want to talk about. Also, attached to this email

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(actually I'll send separately, as it is a larger file) is something new- a spreadsheet that is a data base of prior published 234Th derived POC fluxes with a comparison when available to local production rates to look at global estimates of the export:production ratio. Essentially this started as an attempt by my group to update my 1998 GBC paper, and has grown considerably. It could use additional input and discussion as to whether or not this is a useful stand-alone product or should be woven in to another manuscript type format, or?

Also we should talk in Xiamen about other possible WG products, and plans for our final meeting, including expanded membership for this final event? and/or holding a WG meeting in association with one of the new field programs in the Mediterranean (Fowler et al.) or Pacific (Buesseler et al) or any other ideas you might have.

A rough schedule would thus include:
Monday

Four afternoon talks? 30-40 min. each (schedule 1 per hour?).
Evening- University sponsored Dinner? (or Thursday?)

Tuesday
SCOR WG meeting- need room for n=10 w/overhead and PowerPoint

Wednesday
Morning SCOR breakout session- need two rooms for n=5-6 each.
Afternoon day, WG n=10 together

Thursday
Morning SCOR breakout session
Afternoon- tour Xiamen

Friday
Morning SCOR n=10 together
Afternoon- Talks to Xiamen University

Titles/breakdown for talks
Monday talks
Sarin- "Time-series sediment trap results from Bay of Bengal: Fluxes of Th- & U-series nuclides"
Gustafsson- "Sediment traps, 234Th proxy, and a SPLITT vision"
Buesseler-"Why dump iron in the ocean?"
Trull- "Southern Ocean control of atmospheric CO_2: modern observations contributing to the interpretation of ^{13}C and ^{15}N records in sedimentary organic matter"

Friday talks
Fowler- "The Use of Bioindicators in Monitoring Heavy Metals and Radionuclides"
Steinberg- -"Zooplankton in the ocean's "twilight zone": Effects on particle flux

and remineralization"
Harada- "Carbon cycle study in the western North Pacific and its application to the environmental assessment for the purposeful CO_2 sequestration in the deep ocean"

November 2003 postponed meeting plans

Our plans for Nov. 2003 are identical in scope to Xiamen. After many exchanges, we have firmly agreed upon dates- Nov. 3-7, but not the location. These dates should allow the same WG members to meet, with the exception of C. Min, who cannot attend, and A. Antia, who now can attend. The total will decrease by 1 since C-L Wei regretfully left the WG. Dr. Wei had not attended our first meeting and his duties and interests have changed significantly in the now 2 ½ years since inception of the WG, so in an email to Ed Urban and the Chair, he resigned as a WG member.

We did not want to risk rescheduling our meeting in Xiamen, thus we have sought and obtained two offers to host the meeting at alternate locations, using roughly the same $13,500 budgeted for Xiamen. The first is from Sarin to host our group in Ahmedabad, India. Dr. Sarin is exploring this option further. A second option came from our Associate Member, Dr. A. Michaels, to host the meeting at a USC Marine Center on Catalina Island, off Los Angeles, California, USA. Due to his role as Director of the Wrigley Institute at USC, he can offer very competitive day rates that would allow us to utilize this modern offshore conference (and marine lab) facility for our group. We will make a final choice in late July/August. Most important to the WG were picking the dates in November, and both Ahmedabad and Catalina are available and would have similar overall costs to SCOR.

2004 plans and final SCOR WG meeting

SCOR WG116 has now faced two delayed meetings and two retirements from the group. We feel strongly that the original focus and tasks can be completed, but we are hesitant to wait too much longer to complete our activities. Of recent interest and relevance to WG116, is a plan for a 3-4 day workshop being spearheaded by Dr. Claudia Benitez-Nelson and Dr. Willard Moore (both at Univ. of So. Carolina), to invite 20-30 Scientists to WHOI in the summer of 2004 for a workshop on ^{234}Th methods and in particular, the divergent views on C/Th ratios and how to best apply this approach for upper ocean C fluxes. This plan is in its very early stages, and most of those potential participants listed below have not been approached, nor has secondary funding been secured. However, from conversations at NSF and concern that the C export community is in great need of a consensus on the reliability and accuracy of our C export methods, we feel that with SCOR support in hand for WG 116 participation (we'd overlap WG116 meeting with this larger workshop, to ensure ample time to discuss shallow trap issues as well) and using this summer to approach this larger group of potential participants, we would be able to secure ample support and participation in this activity. Travel would be required for 8 WG members (Buesseler would be the no-cost host at WHOI), estimated at $16,000. A more detailed cost breakdown provided at the end of this report. Through the US JGOFS Planning Office, Buesseler has had significant experience at hosting similar meetings at WHOI, and the facilities are excellent and with advanced booking, hotel

reservations in the summer period are not an obstacle. Copied at the end of this report is a DRAFT outline of the program and possible participants.

We propose that the format of this meeting is similar to an Alkenone workshop co-chaired in Oct. 1999 at WHOI by T. Eglinton, M. Conte, J. Hayes and G. Eglinton and described in: http://www.agu.org/journals/gc/gc0101/2000GC000122/article2000GC000122.pdf . The idea is in plenary talks and break-out groups, discuss all of the issues related to the ^{234}Th approach, and then request using the electronic journal G^3, a series of publications on the outcome, timed as well to the release of an *EOS* article on the meeting. This format served the paleoceanographic community very well to resolve and document many of the important issues they were facing about accuracy and reliability of the alkenone paleotemperature proxy methods. By enlarging our WG to include many other experts, we think the overall impact of WG 116 papers would be much larger. We are thus very eager to see this type of activity approved soon, so that we can move ahead with planning this event and securing additional funds. We are seeking 2 or 3 well respected and knowledgeable meeting chairs, and have preliminary agreement from Dr. W. Moore and hope to encourage Drs. R. Anderson and K. Bruland to co-chair this meeting.

Summary

WG 116 has had a number of setbacks in its meeting schedule, but with Nov. 2003 plans in place and SCOR support for WG participation in this larger gathering in 2004 specific to our charge, we anticipate that our charge will be met and products of the highest scientific caliber will result from this activity. As planned, we expect no further meetings would be needed beyond 2004 and papers would be completed by 2004 and published in 2005.

WG 116 2003 annual report- supplemental materials

2004 cost estimates- meeting
Woods Hole, USA

	travel	1	2	3	4	
Buesseler	0	0	0	0	0	0
Sarin	1500	225	170	170	170	2235
Fowler	1200	225	170	170	170	1935
Trull	1500	225	170	170	170	2235
Antia	1200	225	170	170	170	1935
Steinberg	400	225	170	170	170	1135
Gustafsson	1200	225	170	170	170	1935
Ming	1500	225	170	170	170	2235
Harada	1500	225	170	170	170	2235
Michaels (no cost)						15880

(daily expenses estimated from $125/night hotel; $45/day per diem & $50 local transportation added to day 1)

2004 summer workshop- suggested participants
(**not ready to be released**):
All WG 116 members- Buesseler, Sarin, Fowler, Trull, Antia, Steinberg, Gustafsson, Min, Harada

Claudia Benitez-Nelson
Willard Moore
Mike Bacon
Matthew Charette
Tom Church
Kirk Cochran
John Dunne
Jane Foster (UK)
Laodong Guo
Brad Moran
Jim Murray
Matthew Quigley
Peter Santchi
Sabine Schmidt (France)
Graham B. Shimmield (UK)
B.L.K. Somayajulu
James Waples
Masatoshi Yamada (Japan)
Katumi Hirose- (Japan)
Nicolas Savoye- (Belgium)
Laurant Coppola- (France)
Lisa Miller- (Canada)
Minhan Dai (China)

2.2.8 WG 118: New Technologies for Observing Marine Life (1999)

Terms of Reference:

- To identify and bring to the attention of the international community of fisheries scientists, marine biologists and others, the potential benefits of emerging technologies in the detection of marine life.
- To explore the relative merits of different technologies and identify those that deserve further research based on their potential for making significant contributions to the detection of marine life.
- To prepare a summary of the results of the Working Group's discussion so as to make it as widely available as possible.

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Mariano Gutierrez Torero	PERU

Executive Committee Reporter: Julie Hall

THIRD MEETING

28-30 OCTOBER 2002

EL PUEBLO HOTEL, LIMA, PERU,

Notes From Meeting

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1. OPENING COMMENTS

(a) Welcome & local arrangements

David Farmer welcomed the group to Lima, introduced his co-chair Van Holliday and defined the group's purpose. He reminded us that WG 118 was primarily a discussion group and outlined the agenda. He then introduced Mariano Gutiérrez Torero, who welcomed the group to Peru on behalf of IMARPE and dealt with logistical arrangements for the meeting.

(b) Objectives and agenda

Van Holliday presented the group's Terms of Reference for the benefit of new members and as a reminder of the tasks that remained to be done before the group reported in 2003. The full Terms of Reference (http://www.jhu.edu/scor/wg118front.htm) are:

- To identify and bring to the attention of the international community of fisheries scientists, marine biologists and others, the potential benefits of emerging technologies in the detection of marine life.
- To explore the relative merits of different technologies and identify those that deserve further research based on their potential for making significant contributions to the detection of marine life.
- To prepare a summary of the results of the Working Group's discussion so as to make it as widely available as possible.

(c) CoML and WG 118

Jesse Ausubel (Alfred P Sloan Foundation) gave a comprehensive presentation about the origins and aims of CoML (http://www.coml.org/), which are to assess and explain the diversity, distribution and abundance of marine life and to make clear statements about what was known,

unknown and unknowable. He outlined some of the main drivers for the initiative, which included the need for marine protected areas and sustainable fisheries and concerns about habitat loss, pollution and global climate change. Limited knowledge of the biology of the oceans, which was based mainly on catch statistics for about 200 commercially exploited species living on the continental shelves, provided the incentive for undertaking the task now. Ninety-five per cent of the oceans remain unexplored biologically; there have been few surveys of the "whole water column," and no comprehensive ecosystem surveys. CoML's aim is to complete a suite of major oceanic research projects by 2010, concentrating on species diversity and habitat, and complementing, rather than competing with, existing initiatives such as IGBP, with its primary focus on biomass, carbon flux and global change. Technology has a vital role to play in realising CoML's goals. It was also the rationale for WG 118, whose role was to identify the potential benefits of emerging technologies and bring them to the attention of the international community of fisheries scientists, marine biologists and others concerned with the biological welfare of the oceans.

The Grand Challenge questions for CoML are:

- what did live in the oceans;
- what does live in the oceans;
- what will live in the oceans; and
- how to access and visualise data on living marine resources?

The programmes dealing with these four questions are History of Marine Animal Populations (HMAP), New Field Projects, Future of Marine Animal Populations (FMAP) and Ocean Biogeographic Information Systems (OBIS), details of which can be found on CoML's Web site http://www.coreocean.org/Dev2Go.web.There are currently seven field projects (NaGISA, GoM, MAR-ECO, ChEss, POST, TOPP and CeDAMar) in the second programme, but the ultimate aim was 25-30 projects with worldwide coverage.

After summarising progress with the four programmes, Jesse Ausubel explained CoML's institutional structure and arrangements for developing partnerships with existing governmental (e.g., ICES, IOC, FAO) and non-governmental organisations (e.g., ICSU, IPPECA, OGPA). He also stressed the importance of education and outreach to all age groups throughout the life of the CoML programme. Apart from intrinsic merit, education would generate public clamour and bring pressure to bear on governments, which would inevitably continue to be the primary source of funding for marine research for the foreseeable future.

The presentation was followed by an extensive discussion during which Jesse Ausubel answered a variety of questions about the CoML programme, many of which focused on OBIS (http://www.iorbis.org). At the general level there was concern about the possible misuse of data and the potential conflict between premature or unwise use of marine resources on the one hand and the introduction of unnecessary regulations on the other. On balance, it was agreed that benefits probably outweighed risks and that data should be equally available to those wishing to exploit ocean resources and those wishing to conserve them. Detailed questions about OBIS concerned: incentives to provide data; compatibility with other marine databases; the need to structure the database to anticipate future questions; the need to recognise the particular needs of taxonomists;

problems of data entry; the need for dialogue between designers and users; IP issues; and sources of funding.

2. REPORTS AND ACTIVITIES

(a) Mar del Plata

Geoff Arnold summarised the presentations given at the previous meeting of the WG in Mar del Plata, Argentina in October 2001. He highlighted the technical problems identified by the leaders of the first six CoML Pilot Projects and David Farmer commented on potential solutions and needs for further research and development. The full report of the Mar del Plata meeting can be found at http://pulson.seos.uvic.ca/meeting/scor2001/list2.html.

(b) AGU/ASLO Ocean Sciences

Emmanuel Boss gave a presentation entitled 'Taxonomic recognition of plankton using optics' (http://www.marine.maine.edu/~eboss/presentations/Boss_SCOR_2002.pdf), which dealt with the detection of micro-plankton species. In general, cells <20µm in diameter look very similar and it is difficult to differentiate species by morphology. Cells can, however, be differentiated by functionality, presence of specific organelles and pigments, or by genetic information. Optical properties of cells can be used either for single particle or bulk particle analysis. Single particle techniques include flow cytometry (forward scattering, side scattering & fluorescence), imaging cytometry (fluorescence & microscopy), imaging in flow (microscopy) and multi-angle light scattering. Bulk particle analysis can employ spectral absorption and fluorescence of specific pigments, multi-angle light scattering of specific morphology and internal structure and remotely sensed reflectance. Both approaches have an important role because analysis of complex plankton communities with limited resources requires a compromise between getting accurate population counts and cell measurements and accurate species identification. The corollary of this Sieracki "uncertainty principle" is that it is very difficult to get high-resolution measurements and taxonomic identification from an ecologically significant number of samples.

Imaging cytometry using digital analysis of epifluorescence microscope images is ideal for analysing prokaryotes and heterotrophic protists from natural marine samples. Such imaging systems provide rapid determination of cell abundance and sizes for calculating size spectra and biomass. Flow cytometry is ideal for detecting and quantifying prokaryotes and pico- and nano-phytoplankton from natural samples. "Allometric analysis" uses plots of side scatter and forward scatter; 'taxonomic analysis' uses plots of fluorescence and forward scatter. The FlowCAM instrument, which can be installed on a floating dock or in the flow system of a ship underway, images cells in flow using a chlorophyll fluorescence trigger. Cell sizes are measured directly from the images and the instrument is ideal for analysis of microplankton (>20µm), including phytoplankton and ciliates. New methods of deployment allow *in-situ* cytometry to be undertaken from a boat, a mooring or a submarine (e.g., AUTOSUB). SIPPER (Shadowed Image Particle Profiling & Evaluation Recorder), which produces shadow profiles of larger organisms (e.g., chaetognaths, copepods, euphausiids, pteropods, salps, siphonophores, fish larvae and many other

organisms) can be deployed in an AUV or in a towed package for high-resolution *in-situ* measurements. A variety of SIPPER images can be found at http://cot.marine.usf.edu/multimedia.sap.

Size-fractionated *in-situ* absorption spectroscopy can be used to produce spectral distribution curves from different size fractions (e.g., <5µm, 5-20µm, >20µm) of a bulk sample. Dominant species in each size fraction can be identified microscopically and species composition confirmed by the spectral characteristics of the relevant cell pigments. Fourth-order derivative spectra and similarity indices can be used to differentiate between mixed assemblages of phytoplankton.

Taxonomic data can be derived by remote sensing of spectral reflectance, which can be expressed as a function of the backscattering to absorption ratio. These two properties are in turn parameterised by linear combinations of optically active components, which include water, particles, phytoplankton, coloured particulates and dissolved organic materials. Assuming spectral shapes for each component (eigenfunctions), magnitude (eigenvalues) can be estimated by non-linear regression. Observed spectral reflectance curves can be compared either with a single phytoplankton eigenfunction (standard model) or with a species-dependent reflectance inversion model based on six phytoplankton absorption eigenfunctions, whose spectral differences are due primarily to pigment composition and secondarily to relative pigment concentrations. The more advanced model can be used to derive the species compositions, which can be validated by direct sampling and identification.

Bench-top methods based on the optical properties of both single cells (e.g., flow-cytometry) and bulk cells (e.g., absorption spectroscopy) are now being packaged for *in-situ* analysis on moorings, hydrocasts and AUVs. In the future, molecular techniques will be combined with single cell optical methods to provide genetic taxonomic data. Optical properties of bulk cells will be utilised by routine use of inversions of hyper-spectral remote sensing. One *in-situ* flow cytometer is in commercial production, although not yet fully debugged. A silhouette flow camera and several remote-sensing instruments are also available.

(c) POGO + IOC/CoML Workshop (Thailand)

Elgar Desa reported first on the POGO (Partnership for Observation of the Global Oceans) Workshop held in Dartington (UK) in June 2001 and entitled 'Biological observations of the global ocean: requirements and how to meet them'.

Topics discussed at this workshop were: biodiversity and conservation; sustainable management of living resources ('responsible fisheries'); oceanic biota & global change; bio-invasion; ocean fertilisation; and threatened habitats (corals and seagrasses). For each of the three related scientific issues (global change and the carbon cycle; constraints on primary production and remineralisation; biodiversity and ecological function) key variables and measurements were identified. For biodiversity & ecosystem function, highest priority was afforded to ocean colour, CPR and CTD. DNA probes were also accorded high importance and recommended for development to the operational level, together with functional groups (DNA), image analysis, molecular data banks, and microscopy. Appropriate sensors and platforms are: time-series stations and oceanic

observations; small AUVs; volunteer observing ships (VOS); Argo-type autonomous floats (with a variety of sensors for fluorometry, oxygen, CTD, photosynthetic yield, nutricline); bioprobes (telemetry tags on mobile marine mammals); and research vessels. The workshop discussed OBIS and drew lessons about data management and the distribution of biological observations from GOOS, IOC, PICES and CoML. It also recommended various ways of building research capacity, which included links with graduate education in marine science and contact with local scientists and research cruises. In relation to biodiversity, it was concluded that there was a need to embed biological observations in a physical context (CTD), to develop a number of emerging technologies to an operational level, and to conduct low-cost surveys at large scales. In this context, the key emerging technologies are DNA probes, flow cytometers on buoys (automated); holographic cameras and small AUVs of the hovering type.

Elgar Desa's second report concerned the IOC/CoML workshop on marine biodiversity held at the Marine Biological Centre in Phuket in October 2001. The purpose of this workshop was to introduce and expand CoML activities in SE Asia and to introduce SCOR WG 118 to scientists in the WESTPAC region. Regional participation was from Singapore, Philippines, Thailand, Indonesia, Malaysia, China, Vietnam, Cambodia and Australia. The workshop addressed two questions: (1) to what extent is advanced sampling/identification technology known and being used in SE Asia?; and (2) what are the major needs for new technology in the region? Discussion revealed that most researchers are aware of and use the following technologies: video cameras and microscopes; DNA probes (in the Philippines); electronic keys for taxonomy; data buoys; ROVs (limited use in Malaysia because of cable problems); GIS; satellite ocean colour; and acoustics (mainly for fisheries investigations). Reactions to emerging technologies were varied. Some scientists felt there was no pressing need, others welcomed it but expressed the need for training, and others felt it was too costly; there were also reservations about ocean colour imagery because of cloud cover. Most regional participants agreed that their needs are: training to organise, clean up, catalogue and expand available databases; references on “species”; computer-aided taxonomists; image-processing techniques; and appropriate technologies for shallow water ecosystems, including high-resolution digital cameras and expertise in DNA probe technology for species identification because of genetic diversity in the region. The output of the workshop is available as eight reports on CD (Country Reports, IOC Workshop on the Census of Marine Life in South East Asia, Phuket, Thailand, 10-12 October 2001). It was concluded that, whilst there is considerable local awareness of the rich biodiversity in the region, there is a need to organise available information and to introduce low-cost surveys to rapidly monitor and identify biodiversity over large scales.

(d) ICES Annual Science Conference 2002

Olav Rune Godø reported on the CoML session ('Where new technology might be used') at the ICES Annual Science Conference in Copenhagen in October 2002. Although the session was well attended and the programme included 30 papers, most presented data, only a few indicated needs and even fewer dealt with technology. Despite this, the key technical challenges appeared to be how to: quantify visual observations or transects; apply standard methodologies in deep water; collect information from available sources; understand temporal variability during surveys; and understand differences in catch results.

One interesting French presentation (L18) compared results of close-up studies with ROVs and landers equipped with video cameras and bait, with data from fishing gear. Because of behavioural reactions of fish to noise and artificial lights, fish that are often caught in trawls are rarely seen on video. The need therefore is for cheaper, faster and less noisy platforms that provides a larger sampling volume and does not affect the behaviour of the organisms under investigation. For deep-water observations, such as are needed for CoML's MAR-ECO project, it would be necessary to apply standard acoustic techniques in deep water using towed vehicles and AUVs, together with complementary sampling techniques involving fishing and video observations. Stomach sampling was also needed for diet analysis and here the challenge was to catch fish at depth to avoid regurgitation, a problem to which the Icelandic automatic tagging and fish-collecting machine might provide a solution (see http://www.star-oddi.com/). Temporal resolution during snapshot surveys might be studied with instrument rigs that recorded acoustic measurements and environmental factors (as described in paper L10) and ships of opportunity. Because of sampling bias, catch results could not be taken at face value and interpretation required visual validation and an understanding of the processes between the application of the technology and the received results.

In discussion, it transpired that, although ICES is addressing ecosystem problems, it still has a fisheries bias and is not fully integrated the CoML approach. ROV technology is very noisy and, although it is improving, does not yet allow quantitative sampling. Quieter vehicles with laser cameras and acoustic imaging or visualisation would be very useful, particularly if the technique allowed species recognition.

(e) SCOR Working Groups 119 and 115

Van Holliday reported that he is keeping a watching brief on SCOR WG 119 (Quantitative ecosystem indicators for fisheries management) in order to see if it identified any needs for new technology. He also attended the first meeting of WG 115 (Standards for Survey and Analysis of Plankton) as an invited observer. This group had been identified as a likely source of information on technologies needed by biological oceanographers for surveying and sampling plankton. The terms of reference for WG 115 and 119 can be found at http://www.jhu.edu/scor/wkgroups.

The WG 115 meeting included a series of short presentations designed to define the breadth of the scientific questions, challenges and “hot topics” that need to be addressed by biological oceanographers globally. These talks provided graphic illustrations of some of the issues relevant to future discussions of WG 115 and WG 118. They identified a number of basic needs, which included: ensuring that monitoring surveys in different oceans produce comparable data; providing basic technology, research vessels and trained staff in countries with limited resources; preserving, curating and archiving samples for long periods; sampling over the correct scales of space and time to identify the unaliased and unbiased patterns required to understand cause and effect; developing techniques for rapid synoptic surveys over wide areas at reasonable cost to allow ecosystem management.

Whilst its Terms of Reference strongly encourage it to consider the addition of unconventional technologies to existing plankton survey and sampling methods, WG 115's first meeting was

largely concerned with the Continuous Plankton Recorder and its unique place in plankton monitoring. As a result, consideration of new technologies was limited to a discussion of optical and acoustic methods of plankton sampling and assessment at a generic level. Following presentations on these two subjects, WG 115 divided into four discussion groups, one of which considered a standard package of additional measurements that should be made in conjunction with routine plankton surveys. The initial list of ancillary measurements identified and prioritised by this group was: latitude, longitude and time associated with each sample; sample depth(s); temperature; salinity; irradiance or PAR (photosynthetically active radiation); wind speed and direction; fluorescence; and flow. The group also suggested the collection (where possible) of data from multi-frequency acoustics, a variety of optical instruments (e.g., transmissometers and scatteromemeters), bioluminescence sensors and the Optical Plankton Camera (especially the new imaging version when commercially available).

With respect to future deliberations of WG 118, Van Holliday drew a number of conclusions about the use of new technology in plankton sampling, which can be summarised as follows. Current CPR programmes address only a small fraction of the issues that biological oceanographers must consider, if they are to understand the processes that determine the distribution of plankton in space and time at all scales from that of individual organisms to ocean basins. Although monitoring programmes such as the CPR can reveal shifts in species distribution, monitoring programmes cannot provide all of the information needed to develop predictive capability and provide sound management advice. For this it is necessary to conduct process studies with much greater spatio-temporal resolution than can be provided by conventional methods. Advanced technologies exist to overcome these problems and the challenge is how to get them into the hands of trained users. New and improved sensors are, however, still needed to examine the small-scale distributions that are now known to be ecologically critical. For example, whilst modern optics and acoustics have shown that some sub-meter scale vertical structures may contain 80-90% of the plankton biomass in the water column, no techniques exist to collect zooplankton from within them. Techniques for sampling phytoplankton in these structures are also limited. Some of these structures are known to harbour seed organisms for harmful algal blooms and current sampling methods are unlikely to detect these "seeds" before they bloom and become a health issue.

Avoidance, extrusion and sampling at critical scales (i.e., Shannon or Nyquist rate sampling) in 4-D space in a heterogeneous environment from a moving, heaving platform are all real and demanding problems. As a community, biological oceanographers need to detect and localise biological and physical structure in the water column with high-tech sensors in order to direct their limited sampling effort efficiently. Because of limited budgets, they also need to develop sensors that can be deployed on cruises and moorings whose primary purpose is oceanography or meteorology.

Training is a critical issue in some disciplines, where the disappearance of specialist skills (e.g., plankton taxonomy) may result in failure to progress. We need more scientists and engineers trained to collect, maintain, calibrate and interpret data from high-technology sensors and also more people to develop new technology. In developing countries, there are well-trained scientists with invaluable knowledge of understudied areas of the world's oceans who could make a major contribution to biological oceanography, if they could be given access to medium- or high-tech instruments. One way to achieve this might be to persuade international funding agencies (e.g., the

World Bank) to contribute to the acquisition of these instruments, thereby widening the scope of international programmes. Another approach would be to simplify the funding of multi-national efforts to attack specific research objectives. Finally, it would be valuable to find ways of funding the development of medium-tech, low-cost, low-maintenance sensors that could be used by all nations to expand the ocean areas from which data can be currently obtained. If successful, such an initiative could well triple or quadruple the number of biological oceanographers worldwide.

(f) SAFAE

Van Holliday also reported on the Symposium on Acoustics in Fisheries and Aquatic Ecosystems, which took place in Montpellier, France in June 2002. Subjects included some unsophisticated papers on seabed classification, as well as a range of fisheries topics and the usual contributions on target strength and reflectivity. Two hundred and eight papers were presented and 84 of these will be published in the *ICES Journal of Marine Science* and *Aquatic Living Resources* after peer review.

(g) PICES

Gaby Gorsky reported on the technical theme session he attended during the PICES meeting in Qingdao, China in October 2002. He also gave a resume of the talk he had given entitled "Can optical methods quantify, identify and measure zooplankton effectively?" Full details can be found at http://www.sciviews.org.

Topics discussed during the PICES technical theme session included systems of managing and merging complex data (difficult to implement with biological data), data collection using large arrays of optical instruments at locations with large concentrations of zooplankton, and global sensing using passive floats with satellite data retrieval. Instruments included a prototype system for collecting discrete samples in thin layers, which is being developed in Japan and consists of a set of small packed tubes in a towed body, and an optical plankton camera, which was developed in Russia. The camera, which produces silhouettes of plankton using a narrow sheet of light, has been abandoned because results showed major disagreements with net catches.

Gaby Gorsky began his talk by reminding the PICES meeting of the close connections between top predators and plankton and the increases in the abundance (e.g., Black Sea) of phytoplankton and gelatinous zooplankton that could follow overfishing. He also reminded them of the avoidance problem and the difficulties of obtaining representative samples with a conventional plankton sampler. He then reviewed the relative merits and capabilities of modern optical plankton sampling instruments, which included towed instruments (e.g., optical plankton camera, video plankton recorder), vertical profilers (UVP, ZOOVIS, LAPIS) and towed platforms, such as SIPPER, FLOWCAM and ZOOSCAN, as well as various holographic cameras. ZOOSCAN, for example, could sample up to 6000 organisms per day and produce a master data table with measured parameters and an image for each individual. Identification, which is largely automatic, is based on a training set (look-up table) of images and a neural network. A new look-up table is needed for each region with the images in the same proportion (e.g., 80% copepods) as the local organisms.

Despite substantial progress with optical instruments in recent years, there are still a number of major problems to be solved, mainly related to resolution, field of view, identification and the probability of non-detection. Fields of view, for example, are generally very small except for LAPIS, which has a field of view of 2 x 4 m^2. Rapid advances in image processing and computing indicated, however, that significant further advances are possible in the near future, particularly if optical instruments are used in combination with acoustics to increase the sampling volume and laser illumination.

(h) Fisheries Acoustics, Japan

Kouichi Sawada gave a presentation on new acoustic technologies that are being developed in Japan to quantify and identify fish during fisheries surveys (http://cse.fra.affrc.go.jp/ksawada/NacoustTecJ.htm). These developments include target strength analysis software (TSAN) to analyse echo traces for swimming vectors, TS and tilt angles and a quantitative echo-sounder for fish identification, which is based on frequency dependent characteristics of sound scattered by different groups of species. This sounder is a dual-frequency instrument (38 & 120 kHz) which is being developed by the KAIJO Corporation under contract with Marine Fisheries System Association of Japan (MFSAJ). It will display fish length distributions, as well as single targets and fish school information. The Furuno Corporation is developing a quantitative scanning sonar based on the Furuno FSV-24 omni-directional sonar also under contract with MFSAJ. The new sonar will provide near-surface sampling, scan a large volume of water using a cylindrical array, and produce quantitative data using three-dimensional TS data and information on the direction of movement of the fish. Another instrument under development is J-Quest, which consists of a 70 kHz echo sounder (148 elements, beam width 8.4 or 11.8°) combined with a stereo camera, to be deployed in a towed body. In the longer term, Japan has plans to increase acoustic survey capacity by using fishing vessels as well as research vessels, together with AUVs for more detailed surveys. It is planned to make observations of whole ecosystems in important coastal waters with multidisciplinary methods including tomography. Other plans include a detailed study to investigate the effect of swim bladder shape and tilt angle on TS.

3. BRIEFS ON TECHNICAL AREAS NOT COVERED PREVIOUSLY

(a) Marine mammals

Dave Mellinger (*http://cetus.pmel.noaa.gov/dave/DaveMillinger.html*) gave a presentation about some of the new technologies used to study marine mammals, starting with a description of the satellite tags used by Bruce Mate of Oregon State University to track whales. Currently, these tags, which have a life of weeks to months, are attached sub-dermally to the largest whales and can thus not have a depth sensor. The position of the whale is determined with an accuracy (according to Argos) of 0.15 to 11 km. Earlier work with smaller odontocetes, using external tags with a depth sensor, also provided information about depth and dive duration, albeit with rather coarse

resolution. In the future, it is hoped to miniaturise the tags, extend their use and add sensors to measure depth, heart rate and body temperature.

Dave Mellinger's own work involves the use of passive acoustics to record whale sounds, identify them as to species, and count individuals by tracking position over time with fixed or mobile hydrophones and digital recording tags. Fixed listening stations have been used with both military and civilian sites in the USA, the central Atlantic and Australia. Autonomous hydrophones with beam-forming characteristics are positioned in the Deep Sound Channel, singly or in groups of three for target location, and used to record time series of acoustic pressure measurements (5 Hz to 5 kHz) for periods of 3 months to 2 years. These frequencies encompass the sounds emitted by mysticetes, lower-frequency odontocetes and many pinnipeds. Records are scanned for marine mammal sounds (using automated techniques to recognise calls) and for trends in abundance of calls with season. The method has shown the presence of sperm whales in the Gulf of Alaska and has provided information on seasonal abundance and geographical variation in abundance. Movements have been deduced by comparing occurrence of calls at different listening stations. Future technical needs include satellite data transmission, higher capacity recorders and an extension of the frequency to encompass the full vocal range of whales from 10 Hz to 100 kHz. Also required are better call recognition algorithms, better estimates of the range at which calls can be detected, and improved models (and data) for estimating the number of individuals present at a listening station. Threshold and data compression systems, which are lacking at present, also are desirable.

Mobile systems included towed hydrophones (100 Hz - 24 kHz) and drifting directional hydrophones or sonobuoys (10Hz - 22.5 kHz). The lower frequency limit for towed hydrophones, which have a range of 5-40 km, is set by towing noise (2 knots and up), which makes the technique poor for the larger whales with call frequencies at the lower end of the spectrum. Sonobuoys, which can radio data to a research vessel, have a range of 20 km but can be used in pairs to estimate the location of the whale. Future technical needs include better integration of acoustic and visual surveys, better field tools, better call recognition methods and better statistical methods. A workshop was held in November 2002 to discuss these issues.

Digital acoustic recording tags are placed on the outside of the whale with a pole - a difficult technique - and attached with suction cups. The tags, which have a life of only 8 hours, record sound (to 8 kHz), depth, pitch and roll and acceleration integrated over several minutes. They have been used to record dive profiles (750-800 m) and the distribution of different calls (regular clicks, creaks, rubbing sounds, etc.) during different parts of the profile. Future technical requirements include a tag life ≥1 day, a quieter pressure-operated vacuum pump to improve the performance of the suction cups, a 3-D velocity meter and a sensor for body heat.

(b) Molecular tools for analysing marine biodiversity and abundance

Pat Gaffney (*http://www.ocean.udel.edu/Level1/facultystaff/faculty/pgaffney/index.html*) began his review by contrasting patterns of variability in the marine (35 phyla) and terrestrial (28 phyla) environments and noting that high phyletic variability in the oceans is accompanied by very low species diversity. There are, for example, only 1500 species of copepods and 4000 species of

phytoplankton in the sea, compared to 1-8 million species of beetles and 250,000 species of plants on land. Similarly, there are only about 1200 species of bacteria in the entire ocean. Marine organisms are poorly known because of difficulties of observation, collection and culture and a shortage of taxonomists; there is also disagreement over phylogenetic relationships. Basic questions are therefore what organisms are present in the oceans and in what abundance?

The traditional approach to species identification, which is based on morphology, behaviour and ecology, is of limited value for various reasons including lack of expertise and shortage of time. These could be overcome by molecular techniques based on the polymerase chain reaction (PCR) and DNA sequencing. The PCR, which selectively amplifies a target DNA region to 10^6-10^9 above background, works with small samples and old, poorly preserved material. The amplification is equivalent to selecting a single sentence or paragraph from a book with 350,000 pages and making several million copies. Synthetic oligonucleide "primers," 15-30 nucleotides long, anneal precisely to target complementary sequences in template DNA. The primer is extended by DNA polymerase and heating through n cycles to produce 2^n copies. Different types of primer provide different levels of identification. Universal primers identify homologous targets in a wide array of species, such as all bivalves; specific primers work only with a selected taxon. The technique, which has revealed a vast, previously unknown, species richness among microbes, is biased against organisms with sequence differences in the primer site and doesn't work with viruses, for which electrophoretic methods provide an alternative.

DNA sequences can be determined directly by automated sequencing, which identifies the entire sequence of the target gene, or indirectly by a number of methods, such as restriction fragment length polymorphism (RFLP), hybridisation probes, DNA arrays, single nucleotide polymorphisms (SNP), and denaturing gradient gel electrophoresis (DGGE). In RFLP, the restriction enzyme cuts the DNA at or near the target sequence; an electrophoretic gel is then used to separate cut and uncut DNA. With hybrid probes a synthesised oligomer nests against the matching chromosome sequence and is labelled with fluorescene dye. FISH (fluorescent in situ hybridisation), for example, detects whole individuals of target microbial taxa. DNA arrays, which consist of small spots of DNA probes on glass, offer the most powerful tool. They can rapidly and simultaneously search large numbers (thousands to hundreds of thousands) of targets and provide some measure of quantity, as well as presence or absence. Cross-hybridisation of probes is currently a problem, as is cost, although competition in the biomedical field is rapidly driving costs down. SNPs are ubiquitous and thousands to millions of samples can be handled in a day when this technique is used in conjunction with temperature gradient capillary electrophoresis (TGCE). These indirect techniques offer the prospect of rapid, standardised identification and classification with no need for taxonomic expertise, although it is probably necessary initially to define how many base pair changes are typical of the differences between species in each taxon. Within a species there is typically 2% variation in a target gene, although there are slight variations between populations in different geographical areas. Automation of the entire process is possible and MBARI is designing a remote environmental sampler, although this may possibly be an unduly complicated approach. SNPs can be used for field studies of larval dispersal, survival and recruitment. They have been used, for example, to discriminate between different populations of oysters and DGGE has also been used for the same purpose. Pyrosequencing can identify small numbers of oyster spat with specific haplotypes from large numbers of samples taken over a wide area.

Some of these molecular techniques can be used for estimating abundance and biodiversity, as well as for identification. Hybridisation probes can be used in conjunction with cell count and fluorescence to measure abundance; quantitative PCR (e.g., Real-time PCR) can be used to determine how many target species are present in a toxic algal bloom, such as a red tide. Biodiversity has been investigated in *Limulus* populations on the Atlantic coast of the USA and in Patagonian tooth fish in the South Atlantic.

In discussion it transpired that molecular techniques could readily differentiate between vertebrates and invertebrates in fish stomach contents and, with appropriate probes, also identify individual species of prey. The quantitative measurements required to estimate digestion rates would, however, be more difficult. Scales and otoliths presented no problems and samples as old as 100,000 years would be acceptable. The techniques clearly have great potential in the context of the CoML initiative, although there are some caveats in relation to taxonomy.

(c) Phytoplankton

Acknowledging that phytoplankton and technology are both very big topics, Jan Rines (http://thalassa.gso.uri.edu/rines/scor) set out to explain the instrumentation that could assist the CoML programme. She also considered the broader interests of SCOR and showed movies of a variety of typical plankton organisms, which are usually small and often fragile. The big challenge is to describe the spatial and temporal scales of variation of the species-specific distribution of plankton and determine their relationship to the physical structure of the ocean. The technical challenges are to locate the plankton, which are small and ephemeral, collect them without damage, photograph and describe living cells, isolate cultures for molecular characterisation, preserve material for electron microscopy and match physical and bio-geographic data. The primary need is for directed sampling with optical, physical and acoustic instruments to obtain fine-scale profiles that could be linked with physical and other environmental data collected at the relevant spatial and temporal scales. Technology is also needed to map the information over large scales. Fine-scale profiles could be obtained with a number of instruments, which could be deployed from a ship or a mooring (e.g., ORCAS), or incorporated in an ROV (e.g., *Ventana*).

The technology also has important practical applications, because there is a need to identify and measure the abundance of the species of phytoplankton responsible for producing harmful algal blooms, such as paralytic shellfish poisoning (PSP), amnesiac shellfish poisoning (ASP), diarrhetic shellfish poisoning (DSP) and Ciguatera fish poisoning. The issues are the safety of seafood for human consumption and the protection of aquaculture stock. Although it involves bioassays with laboratory mice, monitoring for toxins is a much more rapid process than monitoring for the causative species, for which available techniques are slow (microscopy), inaccurate (clonal and physiological variability in toxicity) or have unknown specificity (antibody and nucleotide probes). New techniques, which avoid the inherent variability associated with the 'standard mouse', involve binding toxins to specific targets and are currently increasing the advantages of toxin testing over species identification. Some of these tests are available commercially (see e.g., MIST Alert™ at http://www.jellettbiotek.ca/).

(d) Zooplankton acoustics

Van Holliday (http://www.aard.tracor.com/AARDDefault.html) or (http://206.251.232.34) outlined some of the advances made in zooplankton acoustics as a result of the large increases in spatial and temporal resolution achieved over the past decade. State-of-the-art instruments now achieve vertical, horizontal and temporal resolutions of approximately 12.5 cm, 1 m and 1 minute, compared with equivalent values of ~2 m, 500 m and 1 hour in the early 1990s. At the same time, increased transducer bandwidths (spatial resolution) and higher data acquisition and processing speeds have been accompanied by reduced power needs. As a result, it is now possible to obtain fine-scale depth profiles from multi-frequency acoustic instruments used in conjunction with CTDs, neutrally buoyant floats and autonomous moorings. Moored instruments can be used to monitor the water column continuously for periods of up to six months and data can be telemetered over line-of-sight distances of 20-30 km. In addition to calculating the density and length distribution of the various types of scatterers and revealing the distribution and vertical movements of both neuston (e.g., *Pseudocalanus* and other crustaceans) and protists (e.g., *Noctiluca scintillans*), these instruments can detect micro-bubbles trapped on marine aggregates (marine snow) or living phytoplankton. They have also revealed the existence of decimetre-scale thin layers, which have been found in most sites so far inspected, and which can be vertically advected by internal waves with amplitudes of meters (e.g., 2-10 m) and periods of tens of minutes, or less. This makes conventional sampling extremely challenging, if indeed it can be done at all. Acoustics have shown zooplankton to concentrate on these thin layers during some nights, possibly to feed, and that they migrate into the water column but avoid the layers on other nights. Nearby direct sampling of phytoplankton during periods when the zooplankton are avoiding the layers has revealed the presence of toxic algal species in the layers.

The phytoplankton component of these thin layers has been sampled and characterised optically with an autonomous profiler such as ORCAS (Percy Donaghay - Graduate School of Oceanography, University of Rhode Island), which has a vertical resolution of 1 cm. Thin layers affect the structure and dynamics of marine ecosystems and appear to be of very great significance. However, a full understanding of critical scale structures, including function and structure, will only come from an examination of the sea at high spatial and temporal resolution over long periods. This will require the development and application of even better instruments designed to obtain information in all three dimensions and record time changes in the scattered signals. The value of such instruments will be enhanced if they are used in conjunction with a variety of high-tech optical instruments.

Further information is available from the following Web sites: http://es.ucsc.edu/coestl/ http://zooplankton.lsu.edu/scattering_models/MultifreqInverseMethods.html, http://www.gso.uri.edu/criticalscales/

(e) Lofoten monitoring

Olav Rune Godø pointed out that some geographical areas are more important than others. Significant events for the whole ecosystem may happen in a limited area over a very limited time scale, and at these *hubs* there are more dynamics and interactions - both biological (inter and intra-

specific) and with the environment – than elsewhere. Hubs present an opportunity to adopt a different strategy for monitoring marine resources. At present, surveys are usually made when dynamics are minimal and the snapshot that is obtained is compared with earlier snapshots made under similar circumstances. In contrast, because they are focused on highly dynamic locations, hubs provide an opportunity to gather information that helps understand dynamics and is important for ecosystem modelling.

In special cases, the entire stock, or a defined part of it (e.g., the spawning stock) passes a narrow section and, by using stationary sensors with online data availability, can be monitored more effectively than elsewhere in their distribution. This situation occurs, for example, with Norwegian spring spawning herring, which spend the winter in very large shoals in the narrow fjords near Lofoten, before spawning along much of the western coast of Norway, and subsequently feeding in the Norwegian Sea. The proportion of the spawning stock that overwinters in Ofotenfjord can now be monitored when it passes through an acoustic fence, erected as a demonstration project across the mouth of the fjord. Currently, the fence consists of upward-looking echosounders (38 kHz with a 32º x 8º manipulated beam) and a 200 kHz acoustic Doppler current profiler, combined with a 40-element, 12 kHz sonar directed horizontally from one side of the fjord to the other. The ADCP records the currents and bioflux at the mouth of the fjord, as well as behaviour of organisms (but not zooplankton) in relation to the tidal current. Flux data can be compared with targets tracked through the split-beam of the echosounders. A 32-bit broadband connection is planned to connect the project to the Institute of Marine Research in Bergen and also the Internet. In general, depending on the nature of the task, any kind of sensor (biological, physical or chemical) could be added or substituted, and the fence could also be patrolled by an ROV to provide additional coverage.

Future plans include building a similar fence from northern Norway to Bear Island to monitor the influx of water and biological material into the Barents Sea, whose productivity depends entirely on these inflows for heat and recruitment. The distance is 300 nautical miles and the task is feasible logistically because a gas field (Snøhvit) is to be built in a key area. A number of key research establishments and commercial companies with different technical interests (e.g., acoustics, AUV, ADCP, cabled sensors) are already involved and others may be interested.

(f) State of technologies in developing countries: progress report

Mariano Gutiérrez Torero (IMARPE) outlined the use of technology for observing marine life in developing countries and summarised their future needs. At present, almost all work is directed to the support of fisheries and, with the exception of acoustics, which are primarily used to map the abundance of exploited species, few technologies are available. Despite scientific and economic support from developed countries, most developing countries cannot afford the high costs of marine research and lack the trained staff it requires. The level of government support for fisheries investigations also varies from country to country, depending on the state of the economy and the importance of their fisheries. In some countries, a small amount of marine research is carried out by private universities, often with the help of international sponsorship (e.g., EU, JICA, NORAD, and FAO). Problems of coastal pollution and poor fisheries practices (e.g., discarding and by-

catch) are, however, rife and shared problems hard to solve. Progress has been impeded by the political problems of coastal states and these have also impeded the study of four of the most important marine ecosystems in the world - the Peru, Canary, Benguela, and Somalia Currents - which adjoin developing countries.

In general, developing countries need to increase their technical capabilities and expend more effort on identifying and monitoring key populations and communities in the main ecosystems. To do this, they need to acquire LIDAR, optics, broadband acoustics and other new technologies and, just as importantly, train scientific staff to use them. Developing countries also need to develop co-operative programmes with developed countries, seek funds from international agencies and set up international, multidisciplinary research units, which can use the new instruments and test them in the field under real conditions.

Following its previous meeting in Argentina in 2001, WG 118 initiated a sub-group to assist this process. The aims of the group, which consisted of F. Gerlotto (France), I. Hampton (South Africa), D MacLennan (UK), A. Madirolas (Argentina) and M. Gutiérrez (Peru), are to make an inventory of research programmes, scientific expertise, technology, research vessels and related infrastructure currently available in developing countries. The sub-group has begun by identifying developing countries with marine interests, and grouping them into 11 regions. On the basis of replies to an extensive questionnaire, the group then produced a series of maps of available resources, which included research vessels, detection technologies, portable oceanographic instruments, scientific expertise, remote-sensing programmes and international agreements for joint research. Historically, a paper by Venema (Successes and failures of fisheries acoustics in developing countries, Fisheries Research, 14, 143-58, 1992) provided a benchmark against which to assess progress.

Whilst the use of acoustics has increased significantly in some developing countries over the last decade, it is still primarily used to assess fish distribution and abundance and it is proving difficult for scientists in developing countries to publish their results. In South America, all countries now used acoustics, compared with only half in 1992, although in the Caribbean use is still irregular. In Africa, in contrast, whereas there have been acoustic teams in most countries in 1992 and extensive support from Europe, there are now few practitioners left. Similarly, in Asia, active acoustics teams are confined to Thailand and Indonesia, where previously there has been European support in several countries. Chile, South Africa, Argentina and Peru now have TS programmes, where previously there had been none. In 1992, foreign experts managed most acoustics programmes with the support of a few local staff; in 2002, following training by European nations, there are several national teams in developing countries. Similarly, whilst no developing countries are represented in international acoustic communities, such as the Fisheries Acoustics Science & Technology (FAST) working group at ICES in 1992, participation is now significant, if limited.

Although the group has made good progress with its initial enquiries, much still remains to be discovered and a formal approach is needed to obtain information from several countries.

(g) Self-contained acoustics; measurement systems or "Black box" technologies

Mariano Gutiérrez Torero (IMARPE) reported on the Eureka programme, which has been running in Peru since 1966, and spoke about proposals for the future use of acoustic 'black boxes'. The Eureka programme consists of a series of quick, cheap synoptic surveys to map fish distribution, measure relative abundance, establish demographic structure and determine oceanographic conditions. About half of the surveys are undertaken to establish if the spawning season is finished and fishing can start again. Another 20% are used to investigate the possibility of providing new quota when the existing catch quota has expired and a further 20% are used to locate fishing grounds, especially during winter, when fish populations are more widely dispersed. The remaining 10% are undertaken when new oceanographic conditions menace the stability of fishing operations. Each survey, which is financed by the fishing companies, takes 2 days and involves 25-50 purse-seiners, each of which carries 2-3 observers. Their job is to record the abundance and spatial distribution of fish by observing the echosounder and completing an acoustic logbook. Oceanographic data are obtained on key transects with CTDs, Hensen nets and phytoplankton nets. Logbooks are sent by fax to IMARPE, which completes a report within 3 days of the end of the survey showing, for example, changes in the centre of gravity of the anchovy population. Despite their utility, survey results are biased by the varying skill of the large numbers of observers and the difficulty of paying close attention to the echosounder screen throughout the survey. Most sounders lack a printer and there is also a lot of variation in performance between different instruments.

High costs and the need for trained observers have led to proposals to automate the surveys by installing acoustic black boxes on fishing vessels to record the digital signals from commercial echosounders. With calibrated sounders, observers would not be needed at sea and trained staff could concentrate on data processing. Under the ACTIVE proposal, each tamper-proof black box would record continuously and data would be removed periodically, using hard discs. The 25 fishing vessels used in the Eureka surveys sail no less than 900,000 nautical miles each year (equivalent to 130 surveys) and the data collection capacity could therefore be significantly increased. The main problem is that commercial echosounders usually produce a stepped acoustic pulse, rather than the square wave signal emitted by scientific sounders on research vessels. There will also be challenges with data processing and data security, as well as those entailed in securing and maintaining close and sustained collaboration between the scientists and the commercial fishing companies.

The ensuing discussion raised a number of pertinent points. These included the possibility of using a cheap, calibrated single-beam echosounder instead of the black box, the need to quantify (possibly with a multi-beam sonar) the relationship between avoidance and the noise levels of individual fishing vessels and the need to avoid using different frequencies on different vessels.

(h) Activities in Mexico

Carlos Robinson (Universidad Nacional Autónoma de México - UNAM) gave an account of research on pelagic fish carried out on the Pacific coast of Baja California since 1992. Single- and

split-beam echosounders (200 kHz) have been used to investigate the behaviour and abundance of schools of sardines and anchovies in relation to both seasonal and inter-annual changes in local oceanographic conditions. Low salinity and temperature prevailed between March and June under the influence of the California Current. In winter an influx of tropical water produced high salinity and temperature and there is also coastal upwelling at various times. The abundance of sardines and anchovies has fallen to zero after the 1997 El Niño, adversely affecting the fishery, whose main centre is the northern port of Ensenada. Since 1997, there has also been a conflict between catches and acoustic estimates of abundance of sardines, possibly because of detection problems.

Research on the fish behaviour is being undertaken in Bahia Magdalena, where small pelagic fish are abundant and where catches of sardine, anchovies and mackerel exceeded 30,000 metric tons per year, mostly caught within the bay itself. The aim is to track the migrations of Pacific sardine (*Sardinops caerulus*) and the red crab (*Pleuroncodes planipes*), which has apparently filled the ecological niche previously occupied by anchovy. Bahia Magdalena has semi-diurnal tides, whose range is 2 m. Chlorophyll concentrations occurred at the mouth of the bay with tidal upwelling on a rising tide.

(i) Activities in Colombia

Argiro Ramirez reported that acoustic surveys have been conducted in the Pacific since 1970 with assistance from FAO, NORAD and the EU. Surveys for medium size pelagic fish have been undertaken since 1995, using both fishing vessels and research vessels. In the Caribbean, there are similar surveys for small pelagic fish, using EK 500 echosounders. Future needs included multi-beam sonar, techniques for detecting near-bottom fish and 'fences' to detect migration.

(j) Activities in Venezuela

Alina Achury gave an account of the research being carried out in her institute, the Estación de Investigaciones Marinas de Margarita (EDIMAR), which is responsible for fisheries biology, marine biology, oceanography and aquaculture, as well as some special projects. Research, which is focused on five areas in the Caribbean, comprises optical observation of phytoplankton, optical observation of marine communities, acoustic surveys of sardine stocks, and the evolution of fish populations in the Orinoco Delta.

Phytoplankton studies include comparison of *in situ* optical and chlorophyll measurements with USF data from SeaWiFs images, in order to correct algorithms used with the SeaWiFs optical sensor. As part of the community study, results of a visual census of *Strombus gigas*, an endangered marine snail species, are being compared with satellite images from Landsat 7 and an important relationship has been found between density, age and the soil substrate. Acoustics have been used since the 1970s to monitor the distribution and abundance of small pelagic stocks, mainly sardines on the northeast coast. Sardines comprise 25% of the catch in Venezuela and about 150,000 metric tons are caught each year. Acoustics are also now being used to survey the fish populations in the Orinoco Delta, a remote region with great fishing potential. Distribution, density and species composition along the estuary all change seasonally.

In the future, EDIMAR wants to study the effects of upwelling on the distribution of sardines but this entails working in shallow water (0-20 m), where a research vessel is unable to work. This is a general problem in tropical waters and EDIMAR is considering the use of LIDAR or imaging sonar. Operating range might be limited with horizontal sonar, however, and during the subsequent discussion a number of other techniques for deploying an echosounder were suggested. These included an AUV, which could be fast and quiet, an unmanned catamaran, and a small manned boat.

(k) Activities in Chile

Jorge Castillo (IFOP) summarised the purpose of work to detect marine life in Chile. Aims are to describe the spatial distribution of exploited fish populations, measure their abundance and demography (including historical data), determine the effect of the environment on the resource and study the behaviour of fish schools. Investigations are financed by a tax on fishing companies through a Fund for Fisheries Research (FIP), which selects projects through open competition. New technologies under development include a sonar to detect loss of food in salmon farms and a pump for collecting the eggs of anchovies and other pelagic fish. These are being developed in conjunction with Biosonics and CUFES, respectively.

Fisheries investigations use echo integration to estimate the abundance of demersal species, such as hake, southern hake and hoki and (since 1998) for pelagic species, such as Spanish sardine, jack mackerel and anchovetta. The government uses the results to provide fishing forecasts. Two research vessels are available for acoustic surveys and some fishing vessels have EK60 sounders; some also have sockets into which scientists could plug an EK500 sounder. The acoustics team consisted of six scientists who conduct acoustic surveys and combine the results with data from oceanographic and ichthyoplankton surveys to produce an integrated analysis. The output is charts of the spatial distribution and abundance of anchovy and sardine, school size and location, and distribution in relation to bathymetry, temperature and salinity. In some instances distribution is influenced by freshwater run-off from rivers. Three-dimensional images of fish schools have revealed that the density of fish in the central hot spot of the school is often twice that of the average density in the school. (Gerlotto, F. & Paramo, J. (The three dimensional morphology and internal structure of Clupeid schools as observed using vertical scanning multibeam sonar, Aquatic Living Resources, Proceedings of the 6th Symposium on Acoustics in Fisheries and Aquatic Ecosystems, (in press)).

Future needs included the ability to investigate deeper resources, such as dory and orange roughy, and the inclusion of sonar in acoustic surveys to study school structure. It was suggested in discussion, on the basis of experience in Australia and New Zealand, that orange roughy might be identified and differentiated from other species by sonar reflections. Ray bending might, however, present problems with the use of sonar at great depths.

4. REPORTING AND OUTREACH PLANS

Van Holliday chaired a session to decide whether WG 118 should produce a one-off hardback report in 2003, as originally intended, or should change tack and record its findings on a dedicated Web site. It would make sense to incorporate the WG 118 site on the CoML Web site. During the meeting, Jesse Ausubel also specifically suggested that WG 118 should adopt a wider brief and remain in existence until the end of the CoML programme in 2010. A web site would be ideal for promulgating the group's deliberations and involving others, particularly the leaders of the CoML research projects. A site would also offer scope to publish technical methods, along the lines of the new electronic journal to be published by the American Society of Limnology & Oceanography; it could also be a good place in which to publish the results of research programmes in developing countries. A discussion page could be used to disseminate problems and discuss solutions and, with good management, would provide a new focus and bring in more people. Provided the WG is still active, funding would probably be forthcoming to allow a web site to evolve over the duration of the CoML programme.

After a short discussion, during which Olav Rune Godø pointed out that a final report from WG 118 later in 2003 would be too late for most of the CoML Pilot Projects, it was agreed that the group should opt for a web site. It was agreed that this should be based in the Graduate School of Oceanography (GSO) at the University of Rhode Island.

5. OVERVIEW OF TECHNOLOGIES DISCUSSED

After reminding the group of its Terms of Reference, David Farmer chaired a discussion about the technological needs of the CoML Pilot Projects. This was followed by a discussion of possible synergies between the various technologies.

(a) Technical needs of CoML Pilot Projects

(i) ChEss: The concept of this project (Biogeography of Chemosynthetic Ecosystems) is to explore the fauna and flora of hydrothermal vents in the North Atlantic using chemical sensors fitted to an autonomous underwater vehicle. This is cutting edge technology and there was some discussion about the availability, reliability and operational capability of both sensors and vehicles. Although AUVs are being used in survey work and costs have been calculated, application to oceanography is lagging and quite a lot more work is required before they became standard tools. Autosub is operational, but most other AUVs are not and the autonomous capability needed further development; steering and endurance are both issues. The operating costs of REMUS, which carries a sensor for bioluminescence, are reasonable, but it required support from a research vessel. Because they are designed for minimal weight and long life, gliding AUVs carried few sensors and there would be problems in trying to add more. A hovering AUV is desirable but is not available. The recent development by Al Hanson at the Graduate School of Oceanography, URI (akhanson@gso.uri.edu; http://www.subchem.com) of a sensor that could detect very low concentrations in real time and follow a chemical gradient is, however, close to satisfying the needs

of a 'sniffing' AUV. In general, however, sensor development is lagging.

(ii) NaGISA: This project (Natural Geography in Shore Areas) was described as the Coastal Survey of the Western Pacific (part of DIWPA) at the previous meeting of WG 118 in Mar del Plata in 2001. NaGISA is now funded (by the Sloan Foundation and Japan) and is already underway, although further participants are sought, for example in South America. The plan involves developing both skills and infrastructure. A system for taking bottom samples and recording videos is in place, but the identification of meiobenthos still presents a major challenge. Several possible solutions were identified. One option would be for roaming molecular biology laboratories to visit archives of samples and undertake data gathering and training exercises. Another would be for roaming taxonomists to visit the various observing sites to train local staff, who would subsequently be able to get supplementary help by exchanging electronic images with experts back in their home laboratories. This approach would tie in well with the NSF PEET programme (http://web.nhm.ukans.edu/peet/) in the USA, which requires experts to train 5 students.

NaGISA is likely to have both sorting and archiving problems, given the wide range of material (macrophytes to meiobenthos) that it proposes to collect and the lack of basic facilities (electricity and microscopes) in some areas. A basic data collection protocol based on digital images and sequences from stereoscopy and mosaics (underwater archaeology) offers the prospect of cheap storage in minimal space. Physical samples might perhaps be archived at regional nodes. But, regardless of the location of the archive, sub-samples must be preserved for subsequent genetic analysis. This is a simple process, which entails fixing material quickly in formalin and then transferring it to ethanol. Although it is possible to travel with amplified DNA, local archives will probably increase in importance as it becomes progressively harder to ship samples, because of CITES regulations or security precautions.

(iii) GoM: At the previous meeting of the WG in Mar del Plata, Ken Foote identified four challenges for the development and application of acoustics for use during CoML. The first two were to make good acoustic measurements and quantitative biological measurements; the third is to classify and identify acoustic targets. The fourth challenge is to extend the range of observation of optical instruments by integrating optical and acoustic technology. It was quickly apparent in discussion that, although no new technology could be recommended to GoM (Census of Marine Life in the Gulf of Maine) in the short term, there is considerable scope for acoustic species identification over the next 5-10 years. At high latitudes with a simple ecosystem, it is already feasible to distinguish between three dominant species of fish. In the tropics, however, with 2-300 species the problem is rather different. Here it is necessary to widen the scope of diagnostic features to include both the schooling behaviour of the fish and their behaviour in response to environmental factors, such as tides. Multi-beam sonars offer exciting prospects, although the instruments currently made by Reson and Simrad, which could be used in a towed body as well as from a ship, are expensive and limited in range by their operating frequency. Decreasing this frequency from 200 kHz to 80 kHz would give significant improvements.

Progress with acoustic identification in tropical regions, which would inevitably be slow, if tackled by individual research institutes, would be much faster and better co-ordinated if tackled by regional centres of excellence, which should be favourably regarded by international funding

agencies. Molecular biology, optical technology and taxonomy would be other obvious candidates for centres of excellence, each with its own range of expertise and matching technology. Although it would still be necessary to provide technology appropriate to local problems, the South American participants agreed that there is strong support for international collaboration among their countries. They welcomed the proposal for a system of complementary centres of excellence, which they see as a means of obtaining advanced technology and improving the infrastructure for marine research. At present, whilst some countries (e.g., Mexico) have good research vessels but poor technology, others have neither the vessels nor the technology. Mariano Gutiérrez Torero *agreed to set up a sub-group to discuss possibilities for centres of excellence and prepare an agreed statement of needs*. In addition to the World Bank, support might be forthcoming from the EU, which apparently provided resources to single laboratories when arrangements were made to ensure collaboration with institutes in neighbouring countries. Another way of stimulating development would be for SCOR/CoML to bring international meetings to the centres of excellence. For example, Bill Karp suggested that FA,ST would welcome an invitation to hold its 2004 meeting in Peru now that country is an observer at ICES. Sponsorship from FAO might also be possible. Although Venema's retirement removed FAO's internal driver for acoustics, FAO has recently joined the Fishing Technology and Fish Behaviour (FTFB) working group as a co-sponsor. FTFB and FA,ST both reported to the Fishing Technology Committee (FTC) at ICES.

(iv) POST: The concept underlying the Pacific Ocean Salmon Tracking project is a series of acoustic listening stations on the seabed off the west coast of Canada and the USA. Stations laid in lines across the narrow continental shelf will detect the passage of fish marked with a simple acoustic "pinger." Tagged salmon smolts will be detected as they pass the listening stations on their way to the Aleutian Islands and the open ocean and the date and time of passage recorded. Whilst this system works well in confined bodies of water, it may not be so practical in the open sea. The effective range of the listening stations is determined by the size and power of the tag, which is inevitably limited when tags are used with small fish; there is also an inherent weakness with the blind transmission technique. There are various solutions, one of which is to use a more intelligent system, for example, a transponding tag, as widely used in Europe for many years, and as discussed at the previous meeting in Mar del Plata. Another is the passive “fish chip” recently conceptualised by Tom Rossby at the University of Rhode Island, which will record the reception time of signals from a series of fixed transmitters and track fish in the same way that oceanographers track RAFOS floats. The new chip, which is very cheap to make, has been designed and tested in the laboratory. Funds are available for further development, including a miniature hydrophone, and it is planned to test the system in the sea in 2003, using a research vessel. This system has tremendous potential for the animal tracking community and it was agreed to *recommend that the PIs of the POST project should evaluate it as soon as it is possible to do so*.

In response to questions from Carlos Robinson and David Mellinger about possible effects of acoustic signals on other animals, Van Holliday and David Farmer pointed out that small fish tags produce no more noise than snapping shrimps and this will merge with the background noise within a few hundred metres. RAFOS signals are different, being transmitted in code at low power and at a much lower frequency, which changes with time. Neither is likely to have much effect on other animals, however, despite the problems of public perception that there have been with the ATOC experiments.

During further discussion, direct questions from David Farmer established that, although electronic tags are not currently used in South America, there is considerable potential to use them with both fish and marine mammals. Mariano Gutiérrez Torero explained that he wanted to use pop-up satellite-detected tags with tuna and hake and David Farmer drew attention to the opportunity to record oceanographic data from diving mammals at the same time as recording their behaviour. David Mellinger commented that Bruce Mate is keen to train people in South America to use electronic tags with marine mammals. Electronic tags are also highly suitable for benthic organisms as well as fish and mammals. As has been shown in Europe, where electronic tags have been applied to fisheries investigations for several decades, it is necessary to acquire descriptive data with individuals before trying to construct testable models of population behaviour. An automated tagging system allowed large numbers of pelagic fish to be tagged with PIT (passive integrating transponders) tags, which could detected relatively cheaply by scanning the catch on board the purse seine fleet. Data could be sent ashore by radio and the technique could provide a quantitative estimate of the stock, as well as information on its distribution. After discussion, it was *agreed to recommend the use of electronic tags in South America.*

Landers can be used to estimate the number of species and individuals in an area, using bait, a flash camera and a simple current meter, all relatively cheap and simple technology. More sophisticated systems (e.g., the AUDOS system developed by the University of Aberdeen in Scotland) are available with scanning sonar and other advanced technology. There are many opportunities to develop innovative methods of attraction and repulsion, using light, sound and other factors. For exploited species, landers can be combined with long-lines to obtain much better estimates of fish density than can be provided by the lander itself. Conceptually, too, there is no reason why landers should not be used in midwater as well as on the bottom. Because they are likely to provide new insights and support new research projects at low cost, *development and application of landers was recommended as a technical area deserving support*.

(v) MAR-ECO: This project (Patterns & Processes of Ecosystems in the Northern Mid Atlantic) planned to use acoustic surveys and a variety of other technologies, including landers and longlines, to investigate the ecology of the mid-Atlantic Ridge. Olav Rune Godø explained that the first major problem is to extend the operating depth of 38 kHz echosounders to 2000 m; at present the TVG (time varied gain) only worked to 800 m. There are also problems in deciding how to get an idea of seasonal variation, how to analyse results and get the maximum benefit from photo transects of the seabed recorded by ROVs and AUVs, and how to increase range by, for example, acoustic imaging. In the subsequent discussion, Van Holliday suggested that using a sweeping system on the timer might increase the range of the TVG and David Farmer commented that seasonal changes might be revealed by looking for differences between assembled images, using military signal processing technology developed for mine hunting. Sidescan sonar with accurate positioning and good data processing is also an appropriate and proven technology. Questar Tangent and Roxann, two commercially available systems used by the fishing industry to identify the nature of the seabed, are empirical and of uncertain scientific value. A physics-based investigation of the causes of backscatter, which is currently underway and which has been reported to IEEE Oceans in recent years, is likely to produce reliable tools for investigating bottom sediments within about 10 years (see *IEEE Journal of Ocean Engineering* 27(3): 341-601, July 2002, Special Issue on High Frequency Sediment Acoustics; E.I. Thorsos et al., An overview of

SAX99: Acoustic Measurements, *IEEE J. Oceanic Engineering* 26(1): 4 - 25, 2001; M.D. Richardson et al., An overview of SAX99: Environmental Considerations, *IEEE J. Oceanic Engineering* 26(1): 26 - 53, 2001).

These new tools would permit accurate descriptions of habitats, of the sort already required by EU governments ahead of the relevant technological developments. Changes in populations of benthic organisms could already be recorded by sequential surveys using a sidescan sonar and good quality GPS, a point illustrated by Van Holliday, who showed tracks of dispersing animals recorded with a 100 kHz sidescan sonar in a patch of the burrowing urchin *Brisaster*. Emmanuel Boss pointed out that LIDAR and laser line-scan could also be used for habitat mapping and Bill Karp mentioned that scientists at the NMFS laboratory in Seattle are evaluating technologies for characterizing demersal habitat including video, sidescan sonar, multibeam sonar, and laser line-scan. Laser line-scan also holds promise for assessment of crab abundance. It was pointed out that there is a seabed group in Seattle pursuing this subject. Jorge Castillo drew the group's attention to two requirements in South America, the first to survey fish populations around sea mounts using a combination of acoustics and optics, and the second to measure the size of fish with a stereo camera. As Van Holliday pointed out, the second problem could be solved by using the camera in conjunction with two parallel laser beams, separated by a known distance.

(vi) TOPP: This aim of this project is to understand how marine animals from several trophic levels use the distinct oceanic regions in the North Pacific. Advanced electronic tags will be used to identify migration routes and critical habitats and link behaviour and distribution to oceanographic processes. Available technology includes archival tags that could record high-quality data for several years and pop-up tags that could transmit data via the Argos satellite system. Whilst only a proportion of archival tags are ever recovered, pop-up tags could, at present, only transmit a limited amount of the data they recorded because of technical limitations of the Argos satellite system. This problem might be solved in future, now that the IRIDIUM system, which could transfer 100 times more data than Argos, is alive again. The float and glider community is converting to IRIDIUM and the U.S. government purchased a block of time, which is free to all PIs in the USA. At present, however, IRIDIUM could not be recommended to TOPP, or any other tracking project with marine organisms, because the transmitters are too large.

Although not of specific relevance to TOPP, there followed a general discussion of ways of transmitting oceanographic data via the IRIDIUM system using Argo floats and gliders, whose characteristics were summarised by Emmanuel Boss. Both platforms offer exciting possibilities for biological oceanography, if the physicists can be persuaded to add the extra sensors. There are many Argo floats in use in the open ocean, costs are coming down and programmes are underway to add optical sensors (e.g., beam transmissometer). Biofouling problems could be solved with copper shutters and floats could remain at 1000 m for 10 days. Gliders contain a bladder and are able to change their buoyancy and centre of gravity with moving internal parts. They have small wings and are designed to make double-oblique dives at speeds of 20-25 cm s^{-1}. On surfacing, they record their position by GPS and transfer data by IRIDIUM, or cellular phone link. Gliders could currently carry a CTD sensor and developments are underway to add sensors for measuring oxygen, fluorescence and backscatter (at two frequencies). They could maintain station for up to two weeks in a tidal regime with currents of 2 knots. Gliders are being developed in the USA by three groups,

one of which is a commercial company. At present, costs are about $30-40 k each.

In discussion, it was concluded that gliders have considerable potential for investigating smaller, coastal ecosystems at a much lower cost than a research vessel. They are non-intrusive, could be used for adaptive sampling and could be launched from a Zodiac in shallow water. At present, they are power-limited and could probably not carry a sonar. However, as Van Holliday pointed out, the power requirements of electronic devices decrease by an order of magnitude every few years. With appropriate sensor development, there is therefore considerable scope for the use of gliders over the next decade. More information is available from www.webbresearch.com/slocum.htm.

(b) Synergies between technologies

In the subsequent discussion, a number of synergies between the various technologies were identified. The interpretation of acoustic observations of secondary production can be assisted by rapidly profiling the water column with optical and other physical instruments on a winch-driven cable. The range-gating properties of LIDAR match those of sonar and offer excellent prospects for synergy. It can be used to map the seabed and is also an excellent search tool for identifying aggregations or other nodes of interest. This property suggests that LIDAR's primary role in CoML is likely to be in directing sampling to best effect and especially to sub-metre-scale features that now appear to be of very great importance. Greatly under-sampled, these features can contain as much as 80% of the local biomass, extend over tens of kilometres and persist for several weeks. Neither LIDAR nor acoustics will, however, take samples of the organisms making up these thin layers and this remains a challenge; a similar challenge exists for benthic organisms.

6. DISCUSSION AND CONCLUSIONS

The main discussion concentrated on ways of finding support for collaborative work in developing countries. This followed the structure suggested in David Farmer's preamble, which suggested the foundation of regional Centres of Excellence (CoE) coupled with a major training initiative that could also help develop the scientific and technical infrastructure in these countries. CoEs could act as a focus for selected topics, develop links with other institutes, both regionally and worldwide, and co-ordinate bids for international funding. Visiting scientists could leave instruments behind for subsequent use by newly trained staff in developing countries and could also demonstrate the benefits of collaborating with local university engineering departments to develop new equipment. Both initiatives ought to encourage scientists from temperate regions to work in tropical waters, share their expertise with developing countries and gain experience in different ecosystems, an initiative already underway via the Smithsonian Institute in the USA.

(a) Centres of excellence

Mariano Gutiérrez Torero agreed to lead *a small sub-group that would identify suitable subjects (e.g., acoustics, biotechnology, optics, taxonomy) for the proposed CoEs and investigate where they might be located and how they might be constituted*. To do this, it would be necessary to find out what facilities are already available in university departments and government institutes in various

countries, and identify the range of available skills. Involving specialists (e.g., physicists and engineers) with complementary skills would be an important task for nascent CoEs, as would solving the problem of accessing literature, which required a two-way link between developed and developing countries.

It was agreed that Mariano Gutiérrez Torero should select colleagues from South America and other parts of the world to form the sub-group. A brief statement and background notes would be needed for the SCOR report, followed later by a fuller proposal for action.

(b) Training

At David Farmer's invitation, Bill Karp agreed to co-ordinate *a sub-group to develop a training initiative for developing countries, with particular reference to South America*. Carlos Robinson also agreed to join the group. It was agreed that this group should work in close conjunction with Mariano Gutiérrez's group, from which they would be able to get details of the skill sets currently available in the developing countries. Bill Karp's group would need to identify sources of funding, as well as institutes and agencies (e.g., the International Ocean Colour Coordinating Group) able to provide suitable training. One initiative might be to set up a SeaWiFS station in South America via the University of South Carolina. This would provide valuable data (ocean colour and SST) for the region and should be quick and easy to set up, although three people would be needed to manage the station. Funding might be available from national governments or international aid programmes (e.g., from the EU).

Training in taxonomic skills is a major priority and one aim could be to set up teams of specialists within regional CoEs. This approach had worked very well some years ago when an expert team was created in Poland to identify ichthyoplankton from temperate seas. In addition to supporting Poland's own needs for biological oceanography, this initiative resulted in an influx of taxonomic work from research institutes in developed countries. Institutes that could offer training in taxonomy include UNESCO, the National Museum of Natural History in Paris, the British Museum of Natural History in London, Musee in Monaco and the Smithsonian Institute and California Academy of Sciences (http://www.calcademy.org) in the USA. Ken Sherman (CMER Program Director, National Marine Fisheries Service, Narragansett, RI 02882, USA) has contacts with both U.S. institutes and also experience of getting funding for plankton programmes from the World Bank and similar agencies. Contact will be made with Ken Sherman to seek advice.

In addition to training taxonomists, regional CoEs would be good places in which to provide both general and specific training, which could also be used as a way of developing collaborative research programmes with institutes in developed countries. Given the necessary funding through scholarships and similar schemes, training could also be provided by sending scientists to work on projects in developed countries, where they could register for higher degrees. Practical drivers of this sort are required to develop collaboration between the developed and the developing countries, which needed to be a two-way process.

(c) Funding

An approach to the World Bank would undoubtedly be needed and David Farmer agreed to discuss tactics with Ken Sherman (see also previous section). Private foundations could also help and the Sloan Foundation, which is sponsoring CoML, is particularly adept at using its funds to leverage money from major sources around the world. The most appropriate approach would therefore be to frame any case for financial support in terms of CoML's needs. The Lima meeting showed that are strong regional needs in South America.

The session concluded with brief discussions of several other items:

(d) Technology

Picking up from earlier discussions, it was agreed that considerable benefit would accrue to CoML, if LIDAR and Autonomous Underwater Vehicles could be brought into routine use. Despite their great potential, neither technology is at the level at which it could be used as standard equipment and there is, as yet, no commercial version of LIDAR. *An initiative is needed to define CoML's needs and accelerate the transition to routine use and this could entail setting up another sub-group*. Nanotechnology, an area of future interest, is a specialty of the Center for Ocean Technology at the University of South Florida, which is involved in the application of microelectromechanical systems (mems) and nanotechnology in harsh environments (http://cot.marine.usf.edu/mems/?sectionid=1).

(e) Links with OBIS

Whilst data fusion and data visualisation have been funded in other areas of science, these topics still present a great challenge for marine science, where there are so far few examples. One exception is Larry Meyer (University of New Hampshire), who is analysing 3-D images of fish schools and might be able to provide advice. Visualisation, which is an important first step prior to quantification, is an area in which OBIS could be expected to offer a solution, if it has the appropriate tools. So far, however, OBIS has not been able to implement acoustic data, which is disparate in nature, and this is *an area that required mutual discussion in the context of the future development of OBIS*.

(f) Web site

CoML's ultimate goal is to offer Spanish, French and Japanese versions of the items on its web sites. As a first step, it was agreed that WG 118 needed to produce its material in both English and Spanish and, in response to a request for help, Jorge Castillo offered *to co-ordinate the production of translations*.

It was suggested that the WG 118 site should have links to those of the other CoML working groups and this was agreed. A primer about plankton diversity should also be provided and Jan Rines offered to identify a suitable location that dealt with marine biodiversity. She subsequently

provided links to two National Research Council publications entitled *Marine Biodiversity* and *Perspectives on Biodiversity* (http://www.nap.edu/catalog/4923.html and http://www.nap.edu/catalog/9589.html, respectively).

(g) Use of CoML's name

In response to a question from Emmanuel Boss, David Farmer agreed to enquire if CoML would be prepared to lend its name to relevant activities, such as RV cruises.

7. RECOMMENDATIONS AND SUPPLEMENTARY COMMENTS

The WG agreed to the following recommendations:

(a) a sub-group should investigate the idea of regional Centres of Excellence for developing countries and produce a pilot proposal to cover Latin America;
(b) a second sub-group should investigate the training needs of developing countries and recommend ways and means by which these could be met and funded;
(c) the PIs of POST and TOPP should encouraged to evaluate the RAFOS 'fish chip' as soon as this technology receives funding for the next stage of development;
(d) the adoption of electronic tags to investigate distribution, migration and behaviour of marine mammals, fish and other organisms in Latin America should be encouraged;
(e) the development and application of landers is recommended as a technical area deserving support;
(f) a sub-group(s) should be set up to expedite the adoption of emerging technologies needed for the CoML programme, in particular LIDAR and Autonomous Underwater Vehicles (formulated after conclusion of meeting);
(g) a representative from MBARI should be invited to join WG 118 to assist expedite the development and uptake of new technologies (suggested by Dave Mellinger after conclusion of meeting).
(h) a representative of OBIS should be asked to brief WG 118 on present and future developments and, if appropriate, join WG 118 (suggested by Jan Rines after conclusion of meeting).

The WG placed on record the following supplementary comments:

(i) all biological samples should be preserved in a form suitable for genetic analysis.

The WG identified the need for technological developments in the following areas:

(j) sampling of zooplankton in thin layers;
(k) automated species identification by multi-frequency acoustics, in particular development of appropriate algorithms.

8. SUMMARY AND CLOSING REMARKS

David Farmer thanked Mariano Gutiérrez Torero for organising the meeting and for agreeing to take the lead with the development of future initiatives. Mariano Gutiérrez in turn thanked his wife and colleagues for the support and help they had provided him.

In the immediate future, the next steps are for Mariano Gutiérrez Torero to produce a short report recommending steps for the introducing new technology into Latin America and for Geoff Arnold to produce a report of the meeting. This should include references to sources of material presented to the meeting, which should be in the form of web site addresses if at all possible. David Farmer urged participants to provide Geoff with this information, as soon as possible.

The meeting closed at 3 p.m. on Wednesday 30 October.

2.2.9 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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H. Gislason	DENMARK	J. Steele	USA

(Continued on next page)

Associate Members:

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G. Daskalov	BULGARIA	J. Rice	CANADA
S. Garcia	ITALY	J. Rochet	FRANCE
A. Jarre	GREENLAND	K. Sainsbury	AUSTRALIA
K. Korateng	GHANA	Y. Shin	FRANCE
R. Lae	SENEGAL	P. Sunye	BRAZIL
S. Murawski	USA	K. Zwanaenburg	CANADA

Executive Committee Reporter: John Field

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Summary Report
OF THE
SCOR-IOC WORKING GROUP 119

"Quantitative Ecosystem Indicators for Fisheries Management"

6 TH JUNE 2003

1. Accomplishments OF SCOR-IOC WG 119 in 2002

A second working group meeting was organized between on 4-6 December 2002 in Cape Town, South Africa to evaluate and discuss the preliminary results of tasks forces and to organize the international symposium to be held in Paris in 2004. The meeting in Cape Town was attended by 18 members, 3 representatives (from SCOR, PICES and IOC) and 11 other participants. The list of participants is presented in Appendix 1. Seven task forces have been established to carry out the work of WG 119. One deals with environmental indicators (including habitat change), four with different types of ecosystem indicators (species-based, size-based, trophodynamic and integrated indicators) and the last two deal with selection criteria, data sets and frameworks for application.

The meeting was divided into 9 sessions – one for each TF (two for TF 6) and one to discuss the upcoming symposium. During the eight TF sessions intermediate results were presented and discussed and it was attempted to identify scientific directions that should be strengthened. Areas where the Task Forcess needed to interact were identified. In the symposium session, details of the organization and structure of the symposium were discussed. The flyer for the symposium was also finalized. Finally, the seven Task Forces met separately to discuss what would be done before the symposium in 2004 and what papers could be presented by each TF at the symposium. All the discussions and preliminary results, as well as the flyer and the symposium themes, can be obtained from www.ecosystemindicators.org.

2. PLANS FOR 2004

An International Symposium on "Quantitative Ecosystem Indicators for Fisheries Management' is organized at UNESCO Paris by SCOR and IOC, 31 March to 3rd April 2004. This symposium will be the culmination of the SCOR-IOC WG 119. Results from the members of the WG 119, invited keynote speakers as well as other contributions will be presented during the symposium. The presented papers will be published in a special issue of the *ICES Journal of Marine Science* in 2005 (Guest editor: Niels Daan). The Symposium will deal with two major themes. The first will provide an overview of the vast range of indicators of exploitation and state of ecosystems that are being developed for fisheries management from an ecosystem perspective. The second will cover the

scientific basis for integrating indicators into an effective EAF. This comprises the evaluation of indicators, the definition of operational frameworks and the communication to stakeholders of inferences based on indicators.

3. REQUEST FOR 2004

Funds to support travel by scientists from developing countries (and economies in transition) to attend the symposium are required. When allocating these funds, highest priority will be given to those who are seeking only partial support (e.g., waiving registration fee, hotel, per diem, or transportation). Applications can be found on the registration website (www.ecosystemindicators.org). SCOR could provide with $ 8,000-$ 10,000) to support these scientists.

The editing committee (V. Christensen, P. Cury and N. Daan) will have to meet in 2004, certainly several times to edit the *ICES J. Mar. Sci.* volume). It would be appropriate that SCOR allocate funds (about $ 5,000) for those meetings for publishing the results that constitutes the culmination of the WG.

Appendix 1.
List of Participants

Members

Philippe Cury, co-chair	South Africa/France
Villy Christensen, co-chair	Canada
Keith Brander	**GLOBEC/ICES**, Denmark
Ratana Chuenpagdee	Thailand/USA
Kevern Cochrane	**FAO**, Italy
Steven Cousins	UK
Georgi Daskalov	UK
Henrik Gislason	Denmark
Astrid Jarre	Greenland
Simon Jennings	UK
Daniel Pauly	Canada
Marie-Joëlle Rochet	France
Lynne Shannon	South Africa
Yunne-Jai Shin	France
Mike Sissenwine	NMFS/NOAA, USA
Tony Smith	Australia
John Steele	USA
Kees Zwanenburg	Canada

Representatives

John Field (Reporter of the SCOR/IOC WG 119)	SCOR, South Africa
Stewart McKinnell	PICES
Umit Unluata	IOC

Other Participants

Poul Degnbol	Netherlands
Laurent Drapeau	South Africa/France
Pierre Fréon	South Africa/France
Elisabeth Fulton	Australia
Larry Hutchings	South Africa
Bernard Megrey	USA
David Miller (raporteur)	South Africa
Coleen Moloney	South Africa
Franz Mueter	USA
Christian Mullon	South Africa/France
Dawit Yemane	Eritrea/South Africa

2.2.10 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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Marie-Joseph Chrétiennot-Dinet	FRANCE	J. Stefels	NETHERLANDS
Albert Gabric	AUSTRALIA	Marcel J.W. Veldhuis	NETHERLANDS
Ronald Kiene	USA	Maria Vernet	USA
M. Madhupratap	INDIA	Ingrid Zondervan	GERMANY

Executive Committee Reporter: Julie Hall

Report, SCOR Working Group #120, 2002-2003

Winfried W.C. Gieskes, Chairman of the Working Group
University of Groningen, Dept. Marine Biology
Haren, the Netherlands

The first meeting of Working Group #120 was held in early 2002 in Norwich, UK; a report was sent to SCOR shortly after. The second meeting was designed to fill gaps in knowledge of the role and position of marine phytoplankton in the flux of gases and elements that determine ecosystem functioning in relation to global climate. The Prymnesiophytes are the model group; the genus *Phaeocystis* was chosen as a focus of attention, although it was realised that it is not *per se* the most ideal one: coccolithophorid algae deserve much attention, too. To this end, experts were asked to attend the second meeting of the Working Group, scheduled for early May in Savannah, Georgia. At the Skidaway Institute of Oceanography, a group under the leadership of Dr. P. Verity unravels the interactions of *Phaeocystis* with its environment to assess the complex interplay network of biological and biogeochemical parameters. This is precisely the interest of the members and corresponding members of Working Group #120.

Unfortunately, the meeting was planned for early May.... when the War on Iraq was started and the SARS epidemic began to spread across the world. For these reasons several members of the Group suggested to postpone the meeting; others did not intend to travel; but some, on the other extreme side of the spectrum of opinions, felt that postponement would mean a yield to international terrorism – a political choice, so to speak. The decision was eventually taken to postpone until the end of 2003. The organisers of the meeting were disappointed; nevertheless, they were not unwilling to consider organising meeting no. 2 again, and again in Savannah by mid-December 2003. By then, much new material will be available, and it is expected that the scientific progress made in the meantime (from classical taxonomy all the way up to genomics, ocean-atmosphere interactions mediated by marine plankton, etc.) will guarantee a fruitful exchange of ideas.

2.2.11 WG 121: Deep-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.

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Toshiyuki Hibiya	JAPAN	Sybren Drijfhout	NETHERLANDS
Peter Killworth	UK	Gary Egbert	USA
Trevor J. MacDougall	AUSTRALIA	Ann Gargett	USA
Eugene Morozov	RUSSIA	Theo Gerkema	NETHERLANDS
David Salas de Leon	MEXICO	Barry Ruddick	CANADA
Anders Stigebrandt	SWEDEN		
Louis St. Laurent	USA		

Executive Committee Reporter: Roberto Purini

IAPSO/SCOR WG 121 on Deep-Ocean Mixing
Progress as of 30 June 2003

The inaugural meeting of this working group, which was formally approved by SCOR in October 2002, is scheduled to take place on 5-6 July 2003 at the site of the IUGG General Assembly in Sapporo, Japan. The working group membership is as follows:

There is little to report for this working group, the membership not having met as yet. Email correspondence among the membership over recent months has, however, served to establish some points of emphasis and to set a meeting agenda. This agenda will include, but is not limited to, the following (much summarized) issues:

- Discuss the group Terms of Reference as to current suitability, especially in view of work that has addressed deep-ocean mixing since they were compiled.
- Discuss how to optimally assess past results, in the light of where we wish to proceed and with some thought as to what is realistic to accomplish.
- Discuss how to approach the thorny problem of parameterization of mixing (sub-gridscale) processes within numerical ocean GCMs, and emphasizing the question "What do we want the parameterization to do?"
- Assess ways in which observational programs or techniques, especially those accessible to the oceanographic community as a whole, might be used to enhance our understanding of mixing, with an eye toward modeling the effects of mixing.
- Discuss the goals of, and mechanisms for establishing and maintaining, an ongoing, Web-based, virtual workshop that can serve as a platform for exchange of ideas related to ocean mixing.
- Discuss and firm up plans for an open workshop on deep-ocean mixing to be held during September 2004. The discussions will focus on the workshop emphases and goals. Victoria, BC, Canada is considered a likely location, and early September a likely time period.
- Discuss potential members to fill the single, remaining slot for a Full Member, and additional Associate Member slots.

A report of the inaugural meeting will be available on the SCOR Web site later this coming summer.

Robin Muench, chair, IAPSO/SCOR Working Group 121

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Summary of 1st Meeting
IAPSO/SCOR Working Group 121 on Ocean Mixing

The inaugural meeting of IAPSO/SCOR Working Group 121 on Ocean Mixing took place in Sapporo, Japan on Saturday 5 July 2003, in association with the IUGG and IAPSO General Assemblies and directly following a stimulating series of sessions that addressed ocean mixing. The first order of business was discussion of the group's tasks as defined in the Terms of Reference. In this context, the original name for the working group, "Deep-Ocean Mixing", was changed to simply "Ocean Mixing" in the belief that the original name might have led to confusion.

Past Work

This discussion focused on means through which existing mixing data might be archived and made available to that component of the ocean community not generally considered to be microstructure specialists. Issues addressed included the temporal and geographical distribution of available data, data formats and the crucial importance of metadata, definition of a target user group, and identification of a suitable archive site. The group concluded that both lowered acoustic Doppler current profiler (LADCP) and mixing data (probably as dissipation) should be included. CLIVAR and those research groups active in microstructure observation will be contacted, and discussions will be initiated concerning these issues.

Observational Issues

The group felt that we are within 10 years of being able to measure dissipation "routinely" in the sense, for example, that we now measure upper ocean currents using ADCPs. It was acknowledged that such measurements would perhaps not be "state of the art", but at the same time it was felt that they would be adequate for many, if not all, users. Though the most suitable means for such measurements need to be identified, "fast" CTDs and microstructure profilers appear to hold the greatest promise and are well along in their development. Identification of interested user groups, and the role to be played by "centers of excellence" that specialize in such observations, were felt to be of paramount importance. Specification of the data quality needed for a given task was considered equally crucial.

Mixing Parameterization in Models

This was considered the most pressing issue confronting the group and received the most attention. The topical area of "parameterization" is not well defined and begs for attention, possibly in the form of coordinated observational and numerical process studies. Researchers concerned with the issue should perhaps possess an analytical grasp of both the modeling and the observational aspects of a given issue. Other uncertainties contribute to our difficulties. Our geographical grasp of mixing is incomplete, and our understanding of processes in specific areas, for example, the lower thermocline, is poor. The relative importance of mesoscale and microscale processes in mixing is uncertain and controversial, and likely varies from area to area. Can we impose more or less predictable mixing, such as that driven by tides, onto a model? What happens when we resolve near-inertial energy in models? Will numerical diffusion negate the parameterization? While the group will attempt to define the more obvious issues, it will be the task of participants in the planned conference (see below) to address them

in depth and contribute to specific recommendations for future actions.

Web-Based Activities

Plans for a Web-based "virtual workshop" were given a reduced priority and placed on hold because of doubts concerning the efficiency of such a mechanism. Such sites are time consuming to maintain, and may not be well utilized because they are not highly visible to the community. Summary progress reports from the working group will be maintained on the SCOR Web site, and more detailed reports and other information are planned for individual Web sites that will be linked to the SCOR Web site.

Ocean Mixing Conference, and Publications Volume

A conference on ocean mixing is planned for late August-early September 2004. A possible, though not yet firm, site is Victoria, Canada. The conference will focus on our present understanding of mixing processes, their geographical distribution, and most importantly, their incorporation into ocean models. Cosponsors for this conference are being sought. It is planned to publish the conference results in a special journal issue, and discussions are presently underway to determine a suitable journal.

The Next Working Group Meeting

The second meeting of Working Group 121 is planned to take place immediately following the planned 2004 conference on ocean mixing. This will allow an immediate assessment of the conference and will facilitate future planning in light of the conference results. The group also discussed the possibility of using the Web-based access grid system for interim conferencing needs, and this possibility is being pursued.

Attendees:

Sybren Drijfhout (Netherlands)
Robert Duce† (USA)
Toshiyuki Hibiya (Japan)
Peter D. Killworth (UK)
Trevor McDougall (Australia)
Eugene Morozov (Russia)
Robin Muench, Chair (USA)
*Rob Pinkel** (USA)
Lou St. Laurent (USA)

†Robert Duce, President of SCOR, attended the meeting for a period as an invited guest.

*Rob Pinkel attended as a guest, at the invitation of the Chair, and has been recommended as an Associate Member of the group.

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

From *2002 SCOR Proceedings*: "A version of this proposal was presented at the 2000 General Meeting and the proponents were asked to revise and resubmit the proposal. Many comments were received from national committees on the revised proposal. Laurent Labeyrie, the proposal monitor, noted that the version of the proposal reviewed by national committees had a nice introduction, followed by a wish list of things to do, with well-defined terms of reference. The idea of the group is to look in much more detail at sediment processes in lower estuaries, and the impacts of various processes, such as changing sea level. The proponents were asked to revise the proposal; the revised proposal was received just prior to the meeting, so most of the comments from national committees were based on the previous version of the proposal. Labeyrie had been in direct contact with one of the proponents, especially in relation to links of the proposed group to LOICZ, which did not seem (in previous contacts) to be interested in the activity. Ed Urban noted that Hartwig Kramer from LOICZ would be attending the meeting later and could be approached about LOICZ participation in the activity. Wendy Broadgate reported that this proposal is strongly relevant to LOICZ II and that five of the proposed working group members are either on the LOICZ Scientific Steering Committee or may be asked to join it…Robert Duce summarized by stating that it is obvious that the national committees believe that this is an important topic. But many of the original problems remain in the second draft of the proposal…Labeyrie will be responsible for continued work with the proponents and the proposal. The proposal should include a major publication and a summary article in *EOS* or a similar publication. It should also include a clear link to LOICZ. The proposal will be considered by the Executive Committee before the 2003 SCOR Executive Committee meeting."

The SCOR Executive Committee considered and approved a revised proposal between meetings. The new working group will be WG 122. LOICZ has offered to support half of the expenses of regular working group meetings and IAPSO has asked to be a co-sponsor.

2.3 Working Group Proposals

Date: Thu, 03 Jul 2003 17:49:08 +0200
From: Michael Sarnthein <ms@gpi.uni-kiel.de>
Subject: Re: IMAGES activities
To: Ed Urban <scor@jhu.edu>

Dear Ed,

Thanks for your positive answer regarding the proposal to the SCOR Annual Mtg to fund future SCOR-IMAGES working groups.

The last IMAGES EXCOM has approved (co-) funding for the W.G. of Lynch-Stieglitz on the reconstruction of Past Ocean Circulation and has reserved funds for the next three years (5000 to 10,000 US $ per year).

If SCOR cannot commit funds for two IMAGES related working groups at once, we would be grateful if proposal #4 on Paleoproxies would be considered in a consecutive year as it also seriously addresses critical issues in the context of IMAGES objectives.

With best regards,

Michael

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2.3.1 Working Group to plan and implement GEOTRACES, a collaborative multi-national program to investigate the global marine biogeochemical cycles of trace elements and their isotopes

Note from Ed Urban: Organizers of GEOTRACES are involved with the SCOR/IGBP Ocean Biogeochemistry and Ecosystems Analysis project in discussions about the role of portions of GEOTRACES as components of the new project. Nonetheless, SCOR desires input on this proposal from its National Committees and others. Such input will be important to both GEOTRACES and the new project. There are obvious potential relations of GEOTRACES with other SCOR, IGBP, and WCRP projects.

Proposal to establish a SCOR Working Group to plan and implement GEOTRACES…

…a collaborative multi-national program to investigate the global marine biogeochemical cycles of trace elements and their isotopes

Submitted 30 April 2003 by:

Robert F. Anderson
Lamont-Doherty Earth Observatory
Palisades, NY 10964

On behalf of the GEOTRACES Planning Group

Robert Anderson – Lamont-Doherty Earth Observatory <boba@ldeo.columbia.edu>
Roger Francois – Woods Hole Oceanographic Institution <rfrancois@whoi.edu>
Martin Frank - ETH Zürich <frank@erdw.ethz.ch>
Gideon Henderson – Oxford University <Gideon.Henderson@earth.ox.ac.uk>
Catherine Jeandel - LEGOS (CNRS/CNES/UPS) <Catherine.Jeandel@cnes.fr>
Mukul Sharma – Dartmouth College <Mukul.Sharma@dartmouth.edu>

Abstract

A SCOR Working Group is proposed to provide a platform to plan and implement an international research program to study the global marine biogeochemical cycles of trace elements and their isotopes. Although the primary objective of the proposed program is an improved understanding of the marine biogeochemistry of trace elements, benefits of the program will extend into multiple sub-disciplines of oceanography, as described in the main body of this proposal. The proposed program will be global in its scope and international in the composition of its participants. Furthermore, the program will involve close linkages with several other major international oceanographic research programs. Consequently, the planning and implementation of this program are well suited to take place under the auspices of SCOR.

Activities of the Working Group will include: (1) Organizing national and international planning workshops; (2) Preparing Science and Implementation Plans; (3) Initiating efforts for intercalibration of analytical methods, and for the development of standard reference materials; (4) Defining a policy for data management and sample archival; and (5) Forging scientific linkages with other research programs holding overlapping interests. A working group of 10 members is envisioned initially, but it is anticipated that the size of the group will increase as funds from other sources become available to support the planning and implementation of the program.

Rationale

Trace elements and isotopic tracers play an important role in oceanography; for example, as: (1) limiting micronutrients that regulate ecosystem structure and the efficiency of the ocean's biological pump; (2) tools with which to evaluate export production as well as the rates of other processes involved in the ocean carbon cycle; (3) tracers of ocean circulation; (4) proxies used in paleoceanography; and (5) tracers of the transport and fate of pollutants. Much has been learned in recent years about the biogeochemical cycling of trace elements and isotopic tracers, but progress has been limited by the lack of any large-scale coordinated research effort in this area since the GEOSECS program in the early 1970's.

Great advances in the analytical capabilities to measure trace elements and isotopes in the ocean have been made in the quarter century since the completion of GEOSECS, but much remains to be learned about the sources, transport, chemical speciation, biological availability, internal cycling and fate of the broad spectrum of trace elements and isotopes of interest to marine biogeochemists. Advances in chemical sensors, analytical instrumentation, and modeling make possible now research that could not have been envisioned even a decade ago. With the definition of a number of high priority research questions, and the availability of analytical techniques that permit sampling at high spatial and temporal density, the community of marine biogeochemists believes that the time is right to mount a major international research program to study the global marine biogeochemical cycles of trace elements and their isotopes.

A global study of the marine biogeochemical cycles of trace elements will, simply by its scope, require the resources of many nations in order to achieve its objectives. Coordination and collaboration among international partners would benefit immensely from the status and the connections offered by a SCOR affiliation. In addition, the proposed program will share scientific interests with a number of other research programs. A SCOR affiliation would facilitate the development of scientific linkages with these programs.

Historical Background

Beginning in the late 1990's, informal discussions at international meetings revealed a widespread interest in mounting a coordinated research program to study the marine biogeochemical cycles of a broad array of trace elements and isotopes. To provide a venue for presenting current research interests, as well as to identify important outstanding research questions, a special session on "Trace Elements and Isotopes in Oceanography" was held at the Fall 2001 meeting of the American Geophysical Union (10-14 December, 2001). The session drew a total of 58 titles, illustrating the widespread interest in this topic.

An open forum held during the same AGU meeting was attended by more than 70 scientists, representing at least eight nations, who were uniformly enthusiastic about the timeliness of, and potential benefits from, a coordinated field program dedicated to the study of the marine biogeochemical cycles of trace elements and isotopes. There was a strong consensus among participants that recent advances in analytical instrumentation and seagoing technology, as well as new insights gained from small-scale and individual research projects, have placed the field in a position that is well poised to make major advances in our understanding of trace element biogeochemistry.

The enthusiastic response of participants in that open forum led to an effort to hold an international planning workshop. That growing effort eventually obtained support from the US NSF Chemical Oceanography Program and the French Centre National de la Récherche Scientifique, as well as from the Observatoire Midi-Pyrénées and the Université Paul Sabatier in Toulouse, France. A planning workshop was held in Toulouse on 13-16 April, 2003, and was attended by approximately 85 participants representing 15 nations. Objectives of the workshop were to:

1) Define the principal questions and hypotheses to be addressed in future research on the marine biogeochemistry of trace elements and their isotopes;
2) Identify and develop common interests and synergies that would benefit from a coordinated study of the marine biogeochemistry of trace elements;
3) Identify beneficial linkages between such a coordinated study and planned activities of other oceanographic research programs (e.g., CLIVAR, SOLAS, OCEANS, LOICZ, PAGES, RIDGE, MARGINS, etc.).

Deliberations during the workshop identified a number of research objectives for the program, and determined that an optimum strategy to achieve those objectives would involve a global study consisting of a number of ocean sections anchored by regional process studies tied to specific sections.

Process studies would focus on open questions pertaining to the sources, sinks and internal cycling of trace elements, such as the importance of riverine particles as sources, the mobilization and recycling of trace elements by redox processes in ocean-margin sediments, the removal of trace elements by scavenging in hydrothermal plumes emanating from mid-ocean ridges.

It was the consensus recommendation of workshop participants that the continued development and planning of a research program on marine biogeochemical cycles of trace elements and their isotopes should take place under the auspices of SCOR. That recommendation led to this proposal.

Workshop participants further approved by majority vote that the name of the program should be GEOTRACES. The name is not an acronym but, rather, reflects the intent to study the global marine biogeochemical cycles of trace elements and their isotopes.

Program Objectives

The broadly-defined goal of GEOTRACES is to generate a greatly-improved understanding of the marine biogeochemical cycles of selected trace elements as well as of stable and radioactive isotopes. In many cases these species serve as tracers of oceanic processes or they function as essential elements in biological processes. A coupled effort linking field studies, laboratory experiments and modeling to more fully elucidate the processes influencing the transport and cycling as well as biological impact of these tracers is envisioned. That information, in turn, would be exported to, and exploited by, other research programs, such as those mentioned in the next section.

More specific goals of GEOTRACES include the following:

1) To determine the global distributions of selected trace elements and their isotopes, and to generate a sufficient understanding of their biogeochemical cycles (sources, sinks, transport, transformations, chemical speciation, biological availability, fates, etc.) to apply that knowledge reliably to interdisciplinary problems.
2) To build and maintain a core community of marine scientists who understand the physical and chemical properties of trace elements and their isotopes, as well as their biological impacts, well enough to exploit them reliably in future interdisciplinary studies.

Beneficiaries and Linkages to Other Programs

Successful completion of the GEOTRACES program will lead to the following benefits:

1) An improved understanding of the global biogeochemical cycles of essential micronutrients that are believed to regulate the structure of marine ecosystems and the efficiency of the ocean's biological pump;
2) Improved techniques that use natural radionuclides to evaluate the flux of carbon exported from the surface ocean, as well as the dynamics of sinking particulate carbon and other parameters that

influence the ocean carbon cycle;
3) New tracers of ocean circulation that may result from an improved understanding of the processes by which ocean water masses become labeled with distinct isotopic signatures from selected trace elements;
4) The development and calibration of paleoceanographic proxies that are used to assess past changes in ocean circulation, ecosystem structure, biological productivity and carbon fluxes, chemical composition of seawater, continental weathering, and more; and
5) Insights into the transport and fate of contaminants for which natural trace elements and isotopes serve as chemical analogs.

The objectives of the GEOTRACES program, together with the anticipated benefits to be derived by fulfilling those objectives, lead to clear linkages to other oceanographic research programs. A non-exhaustive list includes several IGBP programs (OCEANS, SOLAS, LOICZ), as well as PAGES/IMAGES, CLIVAR, RIDGE and MARGINS. Developing the GEOTRACES program under the auspices of SCOR will facilitate the formation of linkages with these programs, and will further ensure that cross-fertilization between programs will lead to maximum mutual benefit through shared information. Furthermore, developing GEOTRACES under SCOR will facilitate the design and implementation of coordinated research activities in which GEOTRACES investigators collaborate with scientists from other programs in joint research initiatives.

Terms of Reference

The SCOR Working Group will serve as the initial core of a planning group who will lead the design and implementation of the GEOTRACES program. Tasks to be performed by that body include:

1) Organizing national and international planning workshops as well as special sessions at international conferences;
2) Preparing Science and Implementation Plans;
3) Initiating and overseeing efforts for intercalibration of analytical methods, and for the development of standard reference materials;
4) Defining a policy for data management and sample archival; and
5) Forging scientific linkages with other research programs holding overlapping interests to create synergies where possible and avoid duplication of efforts.

Meetings

Planning to date for the GEOTRACES program has successfully exploited major international conferences as venues for planning activities. This started with the Fall 2001 AGU meeting in San Francisco, and continued with a special session held at the EGS-EUG-AGU meeting in Nice, France, immediately before the planning workshop in Toulouse. The next event in this sequence will be a special session at the Goldschmidt Conference, to be held in Kurashiki, Japan, in September, 2003. It is anticipated that special sessions will continue to be held at international conferences, and that these

will serve as opportunities to schedule planning meetings of the SCOR Working Group.

National and regional planning workshops are being scheduled as well. The first will take place in London (UK) on 29th and 30th September 2003. A US planning workshop is scheduled for the first half of January, 2004, and an organizational meeting in Germany is planned for mid-summer 2003, although the venue is not yet established for either workshop. Organizing efforts for additional workshops is underway. In many nations, a SCOR affiliation would greatly facilitate the acquisition of local resources to hold these meetings.

Working Group Membership

Planning to date, including the organization of special sessions as well as the workshop in Toulouse, has been managed by the following group of marine scientists:

Robert Anderson – Lamont-Doherty Earth Observatory <boba@ldeo.columbia.edu>
Roger Francois – Woods Hole Oceanographic Institution <rfrancois@whoi.edu>
Martin Frank - ETH Zürich <frank@erdw.ethz.ch>
Gideon Henderson – Oxford University <Gideon.Henderson@earth.ox.ac.uk>
Catherine Jeandel - LEGOS (CNRS/CNES/UPS) <Catherine.Jeandel@cnes.fr>
Mukul Sharma – Dartmouth College <Mukul.Sharma@dartmouth.edu>

It is anticipated that each of these individuals will continue to devote a substantial level of time and effort to planning activities, regardless of their designation as full or associate members of the Working Group.

During the program-building phase of GEOTRACES, an evolving membership is envisioned. Initially, full members will be selected to help build national and regional GEOTRACES programs. Associate members will bring expertise in particular processes, and will provide linkages to affiliated research programs. As funds become available to support national and regional planning activities, full members will exchange places with associate members as appropriate to make the most effective use of funds available to support travel to planning meetings. This strategy is intended to maximize the effectiveness of the planning group.

Members:
Robert Anderson (US; Chair) – radionuclide tracers; biogenic particle fluxes
Gideon Henderson (UK; co-chair) – tracers of scavenging and ocean circulation
Bill Jenkins (US) – tracers of ocean circulation (CLIVAR link)
Tim Jickells (UK) – atmospheric sources (SOLAS link)
Martin Frank (Switzerland) – ocean circulation; particle fluxes; paleo proxies
Catherine Jeandel (France) – margin exchange; circulation tracers
Anton Eisenhauer (Germany) – isotope tracers; paleo proxies
Toshitaka Gamo (Japan) – trace element biogeochemical cycles
S. Krishnaswami (India) – margin sources; radionuclide tracers
Denis Mackey (Australia) – margin sources; bioactive trace elements

Associate Members

Roger Francois (US) – radionuclide tracers; ocean circulation
Mukul Sharma (US) – cosmogenic isotopes; hydrothermal fluxes
Chris German (UK) – hydrothermal fluxes
Per Andersson (Sweden) – riverine fluxes
Chris Measures (US) – atmospheric fluxes
Reiner Schlitzer (Germany) – inverse modeling

Each of the proposed members and associate members identified above participated in the GEOTRACES planning workshop in Toulouse, at which time the consensus recommendation was to propose that a SCOR working group take the lead on future planning activities. However, because of the short time since returning from the Toulouse workshop (less than 2 weeks at the time of this writing) it has not been possible to contact each of the individuals listed above to ascertain their willingness to serve as a working group member, or associate member. Furthermore, it is anticipated that the list of Associate Members will be expanded. Consequently, there may be changes in the proposed membership before the final proposal is presented to the SCOR Executive Committee.

2.3.2 SCOR/IMAGES Working Group to Investigate the Reconstruction of Past Ocean Circulation

Proposal for a Joint SCOR/IMAGES Working Group to Investigate the Reconstruction of Past Ocean Circulation

Abstract

Here we propose to form a working group, jointly supported by IMAGES and SCOR, which will (1) Assess currently available methods and data for assessing past ocean circulation and (2) Devise a plan for field and analytic studies which will lead to a better understanding of past ocean circulation on millennial time scales over the last 120,000 years. This plan will outline a coordinated international project which we will refer to as the Paleocean Circulation Experiment (PACE).

Rationale

Investigations of past climate over the last several tens of millennia have shown that climate can change quite rapidly. For example, at the end of the Younger Dryas temperature jumped about two-thirds of the way from glacial to interglacial values in only a decade. Because of their ability to store and transport heat, the oceans are an integral part of the climate system. It has been postulated that the rapid climate changes inferred from the paleo-climate data result from changes in the Atlantic ocean circulation [e.g. *Alley and Clark*, 1999; *Rahmstorf*, 2002; *Sarnthein et al.*, 1994].

This hypothesis was driven by data from shell chemistry of foraminifera from deep sea sediments which suggested that nutrients were arrayed differently in the Atlantic over the course of these climate changes. However, even for the Last Glacial Maximum the existing nutrient data is insufficient to quantify an alternative ocean circulation state [*Legrand and Wunsch*, 1995; *Winguth et al.*, 1999]. When we turn to the rapid climate change events that occurred during the last glaciation and over the course of the deglaciation, the circulation scenarios based on nutrient reconstructions only become more poorly constrained.

However, there are several less widely applied methods for assessing rates of paleo-ocean circulation. These methods include assessing deep water residence times from Pa/Th ratios in sediments, assessing deep ocean ventilation from radiocarbon measurements in benthic corals and foraminifera, reconstructing geostrophic flows using density gradients inferred from oxygen isotope measurements and reconstructing the strength of near bottom current speed from physical properties of deep sea sediments.

The work of this group will be to bring together experts in these fields along with physical oceanographers and ocean modellers to come up with an effective and realistic research plan which will lead to a robust reconstruction of past ocean circulation. We will focus our effort on two timescales. The first is the last 120,000 years (covering an entire glacial cycle, along with most of the millennial scale climate changes during the last ice age), and the second is a higher resolution look at the period covering the deglaciation (the last 20,000 years).

Scientific Background

Several decades ago it was realized that chemistry of the shells of benthic foraminifera (carbon isotope and Cd/Ca ratios) carried an imprint of the nutrient content of deep water masses [*Boyle*, 1981; *Broecker*, 1982; *Shackleton*, 1977]. This led rapidly to the recognition that the water masses in the Atlantic Ocean were arrayed differently during the last glacial maximum than they are today, and the hypothesis that the glacial arrangement reflected a diminished contribution of low-nutrient North Atlantic Deep Water [*Boyle*, 1992; *Curry and Lohmann*, 1982]. More detailed spatial reconstructions indicated a shallow nutrient depleted water mass overlying a more nutrient rich water mass in the glacial Atlantic, which led to suggestions of the vigorous formation of a shallower water mass also originating in the North Atlantic. These findings spurred advances not only in geochemistry but in oceanography and climatology as well, as workers in these fields attempted to simulate the inferred glacial circulation patterns and assess the vulnerably of the modern ocean to such circulation changes.

While the nutrient distributions in the glacial Atlantic Ocean were consistent with a diminished flow of North Atlantic deep water, they also could have reflected an increase in inflow from the South Atlantic and/or a shallower yet undiminished deep water mass. Clearly tracers capable of giving information on deepwater flow rate, rather than nutrient content alone, were needed to more fully constrain the glacial ocean circulation. Differences between surface water (measured on planktonic foraminifera) and deep water (measured on coexisting benthic foraminifera) radiocarbon concentrations provided the first rate constraint [e.g. *Adkins and Boyle*, 1997; *Broecker et al.*, 1988; *Shackleton et al.*, 1988] Reduced amounts of Pa relative to the more particle-reactive Th in the glacial Atlantic suggested that deep water was exported from the Atlantic during glacial times [*Marchal et al.*, 2000; *Yu et al.*, 1996]. More recently density gradients (geostrophic shear) in upper waters have been used to infer changes in the upper ocean return flow that compensates the deep water export [*Lynch-Stieglitz*, 2001; *Lynch-Stieglitz et al.*, 1999a; *Lynch-Stieglitz et al.*, 1999b].

However, even for the relatively well studied last glacial maximum, the existing data are not sufficient to constrain Atlantic Ocean circulation [e.g. *Broecker*, 2002; *Legrand and Wunsch*, 1995; *Winguth et al.*, 1999; *Wunsch*, 2003]. The lack of rate tracer data from many locations, inherent limitations in the nutrient tracer proxies, and insufficient chronological constraint probably all contribute to this inadequacy. Needless to say, the nature of last glacial maximum ocean circulation in the relatively data poor Pacific, Indian and Southern Oceans is even more poorly known than for the Atlantic. Again, while there is good evidence that the water masses were arrayed differently in these oceans, the data appears to be insufficient to quantitatively constrain the circulation changes. And, perhaps most importantly, even for the Atlantic Ocean, the time history of circulation changes over the millennial scale abrupt climate changes are also very poorly constrained. Evidence from carbon isotopes in benthic foraminifera is difficult to interpret, with carbon isotope excursions not related in a consistent one-to-one fashion with the millennial-scale variability observed in the surface ocean and ice cores. These inconsistencies are evident both for different events within individual sediment cores [*Elliot et al.*, 2002; *Oppo and Lehman*, 1995] and between different core locations for the same event [e.g. *Curry et al.*, 1999]. It is possible that the complex patterns seen in the carbon isotope records stem from the concurrent changes in deep water density as well as rates and location of formation. Adequate chronologic constraints are also necessary to reconstruct past ocean circulation states on these millennial time scales. For ages greater than 40,000 years before present, radiocarbon dating must be supplemented by other methods. As more attention focuses on the possibility that the meridional

overturning circulation plays a primary role in sub-Milankovitch scale climate variability, it is crucial that we know how the strength of the overturning circulation changed on these time scales.

Understanding how ocean circulation changed in association with the abrupt climate changes during and since the last ice age is of prime importance to a broad scientific community. There is no theoretical reason why the mass circulation of the glacial ocean cannot be reconstructed from a well designed data base of tracer distributions and measurements of paleo-geostrophic shear [*Wunsch*, 2003]. A systematic assessment of the methods of reconstruction of past ocean circulation, along with a well thought out plan for a substantial data gathering effort are clearly needed if the paleoceanographic community is to make substantial progress on this problem. Our effort will focus on the last 120,000 years, with a special focus on the last 20,000 years. The former time period covers an entire glacial cycle, and all of the millennial scale climate variability during the last ice age. The chronology for this interval is currently improving with innovations in U/Th dating as well as detailed work in paleomagnetism of sediments. The latter time period encompasses the last glacial maximum, the most recent Heinrich event, the Younger Dryas climate reversal on the deglaciation, as well as the Holocene and is entirely within the range of radiocarbon dating.

Terms of Reference

This working group will undertake the following tasks:

(1) *Assess the existing paleoceanographic methods for reconstructing the history 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?

(2) *Assess the available paleoceanographic data for reconstructing the history ocean circulation over the past 120,000 years.* Can robust conclusions on past ocean circulation be drawn from the existing data? For what time periods and locations?

(3) *Develop an effective and realistic implementation plan to quantitatively assess the hypothesized changes in ocean circulation during over this same timescale*. The group would identify a minimum array of global locations and data types which would help to constrain changes in ocean circulation linked to major climatic changes, bearing in mind the potential for collecting appropriate geologic material as well as the size of the expected circulation signal relative to the uncertainties in the methods. Through international cooperation within IMAGES and ODP existing cores would be identified and plans for new coring to meet these objectives would be discussed.

Relationship to SCOR Objectives

This working group is particularly relevant to SCOR for several reasons. (1) Any research plan for progress in reconstructing past ocean circulation will require the full coordination of efforts of the international community. SCOR has the experience and support to mount international working and operational groups. (2) In addition, this will be an interdisciplinary group which will draw on the full expertise of members of all fields of modern and paleo-oceanography (numerical analysis and modeling, physics, chemistry, biology, geophysics, geochemistry, sedimentology). (3) Ultimately any research plan will involve extensive sampling along the continental margins of the world ocean. The sampling will take place in the EEZ of many countries, including developing countries. It will be particularly valuable if young scientists from these countries are incorporated into the research program as Ph.D. students and post-doctoral scientists.

Relationship to IMAGES-PAGES-IGBP Objectives

A robust reconstruction of past ocean circulation is vital if we are to understand how ocean circulation is linked to the dramatic changes in climate that have occurred over the past 120,000 years, as well as to understand the role that changes in ocean circulation could play as the climate changes in the future. IMAGES strives to better understand the role of ocean circulation in climate through coordination of research on past climate from ocean sediments. This working group will link closely with other IMAGES working groups such as EPILOG which is re-evaluating last glacial maximum climate reconstructions and with the ice and continental pale climatologists working through PAGES. IMAGES has the experience with field programs involving international action, high sampling resolution and multi-proxy analysis, and the data quality assessment, distribution and archiving needs of such programs. It is anticipated that IMAGES will provide longer term support for the Paleocean Circulation Experiment (PACE) through working group meetings and workshops at the conclusion of the four year working group proposed here.

Meetings and Schedule of Work

Year 1: Meeting of Working Group at AGU December 2003. The first formal meeting will take place during December 2003 in San Francisco, California, USA in association with the fall meeting of the American Geophysical Union. At this meeting the goals and agenda of the working group will be laid out. Planning for the Year 2 workshop (goals, agenda, list of invited speakers) will be discussed.

Year 2: Workshop at Lamont-Doherty Earth Observatory, Palisades, New York, USA November 2004. This workshop will bring together experts in various methods of paleoceanographic reconstruction with inverse modelers who have worked on constraining past and present ocean circulation using sparse data sets. Talks will be given in these areas, as well as reviews of existing data sets. Ample time will be allotted to discussion. Additional funds will be secured from U.S funding agencies to bring in a diverse group of researchers in addition to the Working Group members. The workshop will conclude with a working group meeting outlining work assignments and schedule toward producing the planning document.

Year 3: Meeting at EGS April 2005. Finalize recommendations for planning document.

Year 4: By the end of Year 4, the planning document will be completed.

Products

(1) The primary product of this working group will be a comprehensive planning document for a large, coordinated international program to reconstruct past ocean circulation (PACE, Paleocean Circulation Experiment). This report will incorporate the results from the above assessments and be distributed as a pdf and printed document.

(2) A report to EOS, the newsletter of the American Geophysical Union, documenting the tasks and results of the working group.

(3) A set of papers in a specialized journal resulting from the presentations and discussions of the workshop.

(4) A set of downloadable overheads (pdf) for the IMAGES/PAGES website summarizing the results and plans of the working group.

Working Group Membership

The proposed membership attempts to strike a balance between experts in ocean modeling and inverse methods and experts on paleoceanographic reconstruction, between experts of various nationalities and between various SCOR membership categories.

Proposed Members:

Jean Lynch-Stieglitz (Chair)	USA	Stable isotopes/geostrophic shear Catherine Kissel
(vice-Chair)	France	Paleo-current from sediment properties and chronology
Jess Adkins	USA	Radiocarbon, porewaters
Gideon Henderson	UK	Pa/Th and chronology
Juan Carlos Herguera	Mexico	Stable isotopes
Olivier Marchal	USA	Inverse modelling
Jochem Marotzke	UK	Ocean modeling
Stefan Mulitza	Germany	Upper ocean temperature
Ein-Fen Yu	Taiwan	Pa/Th
Rainer Zahn	Spain	Stable isotopes, trace metals

Corresponding Members (or alternate members):

Eduard Bard	France	Chronology, sea surface temperature
Thierry Fichefet	Belgium	paleo-ocean modeling
Jerry McManus	USA	Pa/Th
Ulysses Ninneman	Norway	Stable isotopes
Andrew Weaver	Canada	Paleoclimate modeling

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2.3.3 Working Group on Analysing the Links Between Present Oceanic Processes and Paleo-Records

Proposal for a SCOR Working Group

ANALYSING THE LINKS BETWEEN PRESENT OCEANIC PROCESSES AND PALEO-RECORDS

Background and Rationale

In the last decade, studies at increasing spatial and temporal resolutions have highlighted that many of the key ocean processes show variability on all time scales from short events over seasonal to decadal or longer term. In most cases, the temporal scale of these variations and their feedbacks to different components of the Earth System cannot be observed adequately by direct observation. Modern oceanographic observations can only provide a snapshot of the present variability of the ocean, but over time scales exceeding the past few decades, this variability is not known. For example, the biogeochemical significance for carbon draw-down of major surface blooms cannot be assessed without examining evidence of their occurrence and variability in the past from the sediments. Although much progress in our understanding of the functioning of the ocean system has been gained by modern process studies, a much broader insight into the role and response of the ocean to climate change can only be achieved, if the period of direct observation can be extended to include past changes of the ocean system. Ocean properties of the past can be reconstructed from naturally occurring biological, geochemical and sedimentological indicators that are collectively known as 'proxies' and by the direct observations of ancient flux events preserved in laminated sediments.

Recent oceanographic experiments have highlighted the importance of certain key species as major drivers of biogeochemical processes, such as export of particulate organic carbon, nitrogen fixation, production of dissolved organic matter, and calcification. An example with major consequences for the oceanic pCO_2 is the evolution of plankton systems dominated by siliceous or carbonaceous species. Observations over the past few decades suggest that carbonaceous species are increasing in the North Atlantic (Deuser et al. 1995, Antia et al. 2001), but the underlying causes are not understood nor do we know whether such shifts have occurred regularly in the past due to variable preservation of these biominerals. Other examples are the long-term shift in nitrogen-fixing organisms observed at the time series station HOTS (Hawaii Ocean Time Series Station) (Karl et al. 1997, Karl et al. 2001) or an ecosystem shift detected in many variables in the Bering Sea (Coyle and Pinchuk 2002, Macklin et al. 2002, Iida et al. 2002) and Northern Pacific Ocean (Hare and Mantua 2000). Several recent oceanographic experiments have observed intriguing blooms of diatoms associated with nitrogen fixing cyanobacteria (e.g. Carpenter et al. 1999; Scharek, et al. 1999), but we rely on recent studies of ancient sediments (Kemp et al. 1999) to learn that such species have sedimented massively in the past and may, therefore, be key players in biogeochemical cycling. Changes in biodiversity, from plankton to higher organisms, are critical sources of information on pre-Anthropocene ecosystems' evolution. Documenting the shifts between these ecosystem states and understanding their causes, using combined insights from modern oceanographic experiments and proxies from the sediment record will provide insights into the physical and geochemical processes that drive ecological change and into

biogeochemical feedback processes. Unfortunately, there is still a considerable lack of proxies preserved in sediments for key plankton functional groups and species that do not leave an easily recognized fossil record, such as soft-bodied organisms without shells, although recent findings look promising (e.g. Dahl et al. 2003).

The knowledge of changes in paleoproductivity is a key to understanding how external factors affect biogeochemical cycles. Unfortunately, the intuitively-obvious approach to reconstruct past changes in ocean productivity from the profiles of organic carbon in the sediments is not valid, as there is no simple, direct relationship between the burial rate of organic carbon and the biological productivity of the overlying waters. Therefore, a range of different indicators of past productivity and nutrient utilisation have been developed, including specific organic biomarker compounds (e.g. alkenones from coccolithophorids; dinosterol from dinoflagelates; brassicasterol from diatoms or pigment transformation products of chlorophyll), barium (e.g. Dymond et al. 1992, Francois et al. 1995), $^{231}Pa/^{230}Th$ and $^{10}Be/^{230}Th$ ratios (e.g. Kumar et al. 1995, Anderson et al. 1998), species composition of planktonic and benthic foraminifera (e.g. Mix 1989, Herguera and Berger 1991, Thomas et al. 1995), diatom species assemblages (e.g. Sancetta 1992; Abrantes, 2000) and flux of diatom shell material (opal) (Ragueneau et al. 2000). Nutrient availability in the paleo-ocean has been reconstructed from the carbon isotopic composition and the Cd/Ca ratio of planktonic foraminifera (e.g. Labeyrie and Duplessey 1985, Ninnemann and Charles 1997), N isotopes (e.g. Calvert et al. 1992, Francois et al. 1992, Altabet and Francois 1994, Ganeshram et al. 1995, Sigman et al. 1999) and recently also Si isotopes (De la Rocha et al. 1998). Careful calibrations of such methods are essential and severe limitations inherent in these methods have been highlighted in many studies. Progress has been made through the comprehensive biogeochemical process studies of JGOFS. However, because this research was not always afforded high priority during the design of JGOFS programmes, progress occurred at a limited pace and much more remains to be done.

Paleoceanographic studies are an important approach to understand past biogeochemical states of the ocean, but they are also inflicted by a considerable degree of uncertainty. At present, the relationship between proxies and ocean properties are usually derived empirically. The danger with these empirical relationships is that they maybe valid only within the restricted parameter space of their calibration. Unequivocal interpretation of a proxy record requires a mechanistic understanding of the processes that control its formation and its preservation in the fossil archives. Such a mechanistic approach has been achieved only in few cases, as for instance for carbon isotope fractionation in foraminifera (Wolf-Gladrow et al. 1999, Zeebe 1999, Zeebe et al. 1999). This understanding of the genesis of a proxy signal is unfortunately not available for most proxies.

The rationale behind the formation of this SCOR Working Group is the recognition that considerable advances can be achieved, if a mechanistic understanding of the genesis of proxies as well as development of new proxies can be promoted. This, in turn, would allow the test of current hypotheses on the linkages between ocean biogeochemical cycles and climate. Expertise of scientist studying the modern ocean processes and those focussing on past changes in the ocean can be fruitfully combined to achieve progress in this important aspect of ocean research. Based on the considerable progress made in both fields in the last decade of IGBP research within the core projects PAGES, JGOFS and GLOBEC such a collaboration is timely and much supported by experts of both disciplines.

The proposed SCOR Working Group arises from a small task team initiated between JGOFS and PAGES/IMAGES, the Paleo-JGOFS Task Team (PJTT) with the following objectives: (i) improve the collaboration between the two core projects, (ii) identify regions of specific interest for future research and (iii) propagate these issues into the next phase of IGBP II ocean research programs. In the marine core projects of IGBP and WCRP, links between paleo- and present day oceanographic studies are included, for instance in CLIVAR, GLOBEC, SOLAS, LOICZ and OCEANS. However, these groups tend to narrowly focus on specific aspects and there is little or no exchange of information between them.

The development of a SCOR Working Group which can form a link between present and past ocean studies in all the different marine IGBP and WCRP programs it is now logical and timely.
Such a working group could:

- provide a common platform for scientific exchange between the different marine disciplines,
- foster the joint development or refinement of proxies between the different programs,
- bring together a wide range of expertise necessary to better interpret the paleo-records in the light of our present understanding of ocean ecosystem behavior,
- convey benefit to a wide scientific community within Global Change.

This proposal is addressed to SCOR as one of the governing bodies for all marine science programs within IGBP and WCRP.

Terms of Reference

The main objective of the proposed working group is to combine new insights gained from the study of modern biogeochemical processes and ecosystem dynamics, with paleoceanographic studies aiming to improve our understanding of past oceanic processes. In turn, accurate interpretation of the sedimentary record extends the temporal baseline of observation, thus allowing to better gauge the impact of anthropogenic disturbances against natural variability. To achieve this unifying vision, we must:

1) 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.

2) Refine established proxies, provide mechanistic understanding and foster the development of new proxies within integrated multidisciplinary process studies in the modern ocean.

3) Use proxy evidence from the sedimentary records to test hypotheses of the oceanic response to climate change.

ad 1) The importance of key oceanic processes, such as nutrient utilization, nitrogen fixation, changes

in plankton communities, atmospheric input of iron, inputs from terrestrial sources and changes in components of the higher food chain, have been highlighted by modern process studies. In particular, the potential biogeochemical significance of modern blooms has to be evaluated using key ancient sequences with resolution of fluxes on the time scales of modern ocean processes. Episodic sedimentation makes up the major part of the export to the deep ocean and of the sedimentary record. The sedimentological record has informed us about the significance of these surface events for carbon export and the frequency of their occurrence beyond the time coverage of modern observations. A correct assessment of this earlier variability and how it is linked to the type of production, export and biodiversity is critical as a reference for understanding our pre-industrial world. Proxies need to be refined or developed to reconstruct the history of these key processes. Biomarkers (including their isotopic composition) and molecular genetics are two new tools that are particularly promising for identifying changes in the biological components, which warrant further development.

The working group will address this question by identifying key processes and key organism groups which are major drivers of biogeochemical changes in the ocean and major carriers of paleo-signals into the sedimentary record. If deficiencies in the proxies are recognized, suggestions will be developed on how to improve them or which type of new proxies are most urgently required.

ad 2) Since the relationships between proxies and ocean properties are usually derived statistically, the interpretation of any proxy record is associated with large uncertainties. Therefore, in order to improve the interpretation and to deconvolute several processes indicated by one proxy, several proxies are often analysed in parallel. Many unresolved issues remain to be addressed and require a mechanistic understanding of the processes that control proxy formation and its preservation in the fossil archives. This can only be achieved by integrating process studies, field data basis and modelling. Such approach needs to be applied to a wide and growing range of proxies including siliceous, calcareous and organic microfossils, biomarkers, isotopes and geochemical markers.

Integrating the development and validation of paleoceanographic proxies carried out in different Global Change programs is a cost-effective way of refining their interpretation, and the working group will provide a platform for information exchange between scientists in the different programs. This may include: providing links between groups involved in proxy validation; integration of experimental work and proxy analysis; critical evaluation of proxies in a broad disciplinary context.

ad 3) Investigators have sought evidence in marine sediments for the ocean's role in regulating the atmospheric concentration of CO_2 as an important greenhouse gas. It has long been recognized that a change in the efficiency of the biological pump, which is manifest as a change in the inventory of dissolved inorganic nutrients residing in global-ocean surface waters, translates directly into a change in the concentration of CO_2 in the atmosphere (e.g., Broecker 1982; Sarmiento and Toggweiler 1984). Various factors, ranging from changes in wind-driven upwelling (Pedersen and Bertrand 2000), ocean nutrient inventory (Falkowski 1997; Ganeshram et al. 2000) to fertilization by eolian input of iron (Martin 1990) have been hypothesized to induce climate-related changes in ocean productivity. Much of the recent paleoproductivity research has been designed to test these hypotheses. The response of ocean ecosystems to changing environmental boundary conditions are also related to changes in species composition. However, the sensitivity of ocean ecology to perturbations driven by climate change in

the past is yet difficult to understand.

The working group will bring together the expertise of modern ocean process studies and paleoceanography to critically evaluate whether the hypotheses and interpretations developed in both fields of research are fully compatible. The results of such discussion groups will be published as joint review papers.

Proposed Working Group Composition
(at this point still tentative)

Co-Chairs
Karin Lochte (Institut für Meereskunde, Kiel, Germany) *Expertise*: plankton ecology, nitrogen cycle, microbial transformation of sinking material, benthic microbial ecology.
Marie-Alexandrine Sicre (LSCE, Gif sur Yvette; France) *Expertise*: Organic geochemistry, biomarkers, proxy calibration, oceanography, paleoceanography.

Members
Fatima Abrantes (IGM-DGM; Portugal), Expertise*: paleoceanography, micropaleontology, diatoms.*
Carina Lange (Universidad de Conception, Chile) Expertise: *Diatom specialist, export production from the photic zone to the sediment, preservation/dissolution, late Quaternary paleoceanography.*
Tim Baumgartner (CICESE, Mexico) *Expertise:* Paleoecology, paleoclimatology, investigation of stable isotopes in fish scales (member of GLOBEC) (to be confirmed)
Pedros-Alio, Carles, (Spain), *Expertise*: molecular biology (to be confirmed)
Frank Dehairs, (Belgium), *Expertise*: Stable isotopes, compound specific stable isotopes, trace elements in biogenic carbonates, proxies of new and export production.
Roger François (Woods Hole Oceanographic Institution, USA) *Expertise*: geochemistry, late Quaternary paleoceanography, radiochemical approaches, carbon and nitrogen isotope geochemistry, trace element proxies (redox-sensitive elements; paleoproductivity tracers).
Raja S. Ganeshram (University of Edinburgh; UK) *Expertise*: stable isotopes, paleo-nitrogen cycles (to be confirmed)
Alan Kemp (School of Ocean and Earth Science, University of Southampton; UK) *Expertise*: High resolution palaeoceanography and palaeo-biogeochemistry from laminated sediments. The role of diatoms in biogeochemical cycling.
Aldo Shemesh (Weizmann Institute Rehovot, Israel) *Expertise:* paleoceanography, geochemistry of isotopes, isotopic composition of biogenic silica, carbonate (to be confirmed)
Ein Fen Yu (National Taiwan Normal University, Taiwan) *Expertise*:
Dieter Wolf-Gladrow (AWI, Germany), *Expertise*: mechanistic models of paleo-proxies, in particular of isotopic signals.

Corresponding Members
F. Partensky (France)
R. Anderson (USA)
Jelle Bijma (Germany)

Christina De La Rocha (Cambridge, UK)
Richard Zeebe (AWI, Germany) .and more

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2.3.4 Working Group on the Physical and Biological Structure of Meso-scale Rings in World's Oceans

Proposal for a SCOR Working Group on the Physical and Biological Structure of Meso-scale Rings in World's Oceans

Abstract

We propose to create a SCOR working group on the physical and biological structure of meso-scale rings in the world's oceans. The ultimate goal of this internationally constituted working group will be to prepare a comprehensive summary of the salient facts concerning ring formation, structure, and their biological, physical, and biogeochemical dynamics with the ultimate aim of providing an assessment of the role of rings in the world's oceans.

Scientific Background

Rings, the most energetic class of meso-scale eddies, were first recognized in the 1950's and 60's through work in the Northwestern Atlantic Ocean (Parker 1971; Saunders, 1971; Fuglister, 1972). They are distinct from other meso-scale eddies in that they transport biological properties across major ocean boundaries that are distinctly different from those of the surrounding waters in which they move. During the 1970's and 80's major programs to study cold-core and warm-core rings in major western boundary current regions were carried out in the Northwestern Atlantic (Gulf Stream) and Pacific (Kuroshio/Oyashio) and Southwestern Pacific (East Australian Current). Rings that occur in the Agulhas Current, Brazil Current, and Antarctic Circumpolar Current have also been extensively studied. Recent efforts have surveyed near equatorial features such as those created in the North Brazil Current. Work has continued unabated in the Northwestern Pacific on warm-core rings of the Kuroshio/Oyashio region where rings define crucial fisheries habitats (Itoh and Sugimoto, 2001, 2002).

Early international cooperation on ring research resulted in three special volumes of papers (Trantor, 1983; Wiebe and McDougall, 1986; Joyce and Wiebe, 1992). In spite of this, a key point made in the third volume was that the current state of knowledge on many topics is rudimentary and much basic research on rings remained to be done (Wiebe and Joyce, 1992). A review of ring properties and some of the biochemical issues on a global basis is presented in Olson (1991). In the intervening period, more work on rings has been completed and the time is right for there to be an integrated synthesis of the various data sets (Crawford, 2001). The proposed SCOR working group would undertake this synthesis and the final product would be a book that would summarize what is known about the physics, chemistry, and biology of rings worldwide. A major goal of the proposed working group would be to attempt to revise and consolidate the early efforts of Olson (1991) and others to address the larger scale role of rings.

The global nature and the multi-disciplinary aspects of the proposed working group activities appears ideally matched to the SCOR international purview.

Statement of Work/Terms of Reference

The proposed working group would complete the following:

1) A compilation of all of the literature that has been published since the first compilation of the literature was done by Olson and Wiebe (1983).

2) Based on the literature and unpublished data, a book would be prepared along the lines of the draft outline provided in Appendix 1. This outline will be updated to include biogeochemical and further issues in biogeography and fisheries.

3) An assessment of the need for additional research on rings and other meso-scale eddies in the context of basin-scale studies of the distribution and dynamics of biological populations and biogeochemical fluxes.

Meetings:

It is proposed that the first formal meeting of this Working Group take place in Woods Hole in early August, 2004 or in Sendai, Japan, in early December 2004 with four subsequent working group meetings (two of which would involve smaller disciplinary groups). The final meeting could take the form of a symposium.

Working Group Membership:

Working Group membership is proposed to consist of international experts who have had long experience working on rings. We anticipate having ten official members including the two co-chairs when the membership is complete. In addition, we anticipate that there will be several Associate Members in order to include some of the younger scientist currently working on rings.

Potential working group members include:
T. Sugimoto (co-chair) Japan
P. Wiebe (co-chair) USA
Y. Endo (Japan)
T. Joyce (USA)
S. Pionkovsky (Ukraine/USA)
I. Yasuda (Japan)
D. Olson (USA)
G. Flierl (USA)

Others Potential Participants:

Professor Johann Lutjeharms, Oceanography Department, University of Cape Town, South Africa
Laurent M. Chérubin, Instituto de Oceanografia, Universidade de Lisboa, Lisbon, Portugal

Open (biogeochemist)*
Open fisheries biologist (possibly from South Africa)

* One of the candidates for open biogeochemist is Prof. Toshiro Saino in Nagoya University, Japan.

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Appendix 1: Working book title: Oceanic Rings; A multidisciplinary perspective.

I. Introduction

A) Defining the term “ring”
- 1) Fuglister's definition
- 2) Brief historical review
- 3) Other allied features in the ocean and atmosphere

B) Rings and their role in the ocean
- 1) Rings as part of the ocean circulation
- 2) Rings and the structure of the pelagic ecosystem

C) Rings as model environments
- 1) Definitive tests for ocean models
- 2) Distinct traceable features in which to study the marine ecosystem

Perhaps these next two sections could be appendices?

II. Some preliminary concepts: Pt. I Physical Aspects

A) Some tools from geophysical fluid dynamics
- 1) Equations of motion
- 2) Mixing and turbulence
- 3) Effects of rotation

B) Descriptive tools
- 1) Water masses and their analysis
- 2) An introduction to coordinate systems
- 3) Notes on the instrumentation used to study rings

III. Preliminary concepts: Pt. II Biological Aspects

A) Some preliminaries on marine ecology
- 1) Pelagic communities

2) Food webs; Energy flow
B) Tools in Biological Oceanography
1) Sampling of the marine ecosystem
2) Analysis techniques

IV. Formation and occurrence of rings
A) Parent currents and their properties
1) Oceanic jets: WBC's and their extensions, ACC
2) Water mass contrasts
3) Biological contrasts
B) Vortex formation
1) Meandering in zonal jets (Gulf Stream ex.)
2) Intrusive phenomenon (Brazil, Agulhas)
3) Source of ring core waters
C) Global distribution of rings
1) Map of ring locations
2) Brief description of different regimes

V. Ring structure
A) Density and velocity fields
1) Cyclonic/cold core rings
2) Anticyclonic/warm core rings
3) Gradient balance and structure of deep flow
B) Distribution of properties in rings
1) T/S anomalies in rings, water masses
2) Biogeochemical description; Nuts, Chl, O2
3) Species distributions

VI. Ring translation
A) Basic mechanisms
1) Beta--plane drift; shelf induced motion
2) Advection by larger scale circulation
B) Examination of fluid trapping in core
1) A Lagrangian view of the problem
2) Analysis of exchange mechanisms

VII. Evolution of rings in time
A) Observed trends in ring properties
1) Water mass anomalies and volume
2) Energetics and potential vorticity
3) Phytoplankton communities
4) Biomass and speciation in zooplankton
5) Fish and other higher trophic levels
B) Underlying mechanisms

1) Viscous versus radiative decay
2) Air--sea interaction effects
3) Enhancement of primary productivity
4) Differentiation of zooplankton community

VIII. Sub-ring scale processes

A) Submesoscale features
1) The ring front
2) Streamers and associated advective features
3) Convective cells in warm core rings
B) Fine and micro-scale processes
1) Intrusions and double diffusive mixing
2) Internal waves
3) Distribution of turbulence and microstructure
C) Biological interactions at small scales
1) Interactions at the ring front
2) Streamer events and off shelf advection
3) Biological mixing

IX. Global role of rings

A) Rings and the climatological fluxes
1) Meridional flux of heat and salt
2) Regional water mass modification and ventilation
3) Rings and the energetics of the ocean circulation
B) Rings and the ocean ecosystem
1) Biogenic fluxes and rings
2) Influence of biogeography
3) Interactions with recruitment processes

X. Rings and Fisheries Oceanography

A) Effect on fish migration routes
B) Effect on fish recruitment

XI. Ring Interaction with Continental Shelves

XII. Future Prospects

SCOR CHAIRS AND EXECUTIVE COMMITTEE REPORTERS/LIAISONS

		CHAIR / CO-CHAIR	REPORTER
	WORKING GROUPS		
WG 109	Biogeochemistry of Iron in Seawater	Turner/Hunter	Duce
WG 111	Coupling Waves, Currents and Winds in Coastal Models	Huang/Mooers	Wainer
WG 112	Magnitude of Submarine Groundwater Discharge and its Influence on Coastal Oceanographic Processes	Burnett/Kontar	Duce
WG 113	Evolution of the Asian Monsoon in Marine Records: Comparison Between Indian and East Indian Subsystems	Wang	Labeyrie
WG 114	Transport and Reaction in Permeable Marine Sediments	Boudreau/Huettel	Labeyrie
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 118	New Technologies for Observing Marine Life	Farmer/Holliday	Pierrot-Bults
WG 119	Quantitative Ecosystem Indicators for Fisheries Management	Cury/Christensen	Field
WG 120	Marine Phytoplankton and Global Climate Regulation: the *Phaeocystis spp.* Cluster as a Model	Gieskes	Hall
WG 121	Deep-Ocean Mixing	Muench	Purini
WG 122	Mechanisms of Sediment Retention in Estuaries	Kjerfve/Perillo	Labeyrie
	SCIENTIFIC STEERING COMMITTEES, PANELS, etc		
JGOFS	Joint Global Ocean Flux Study SSC	Ducklow	Field
GLOBEC	Global Ocean Ecosystem Dynamics SSC	Werner	Taniguchi
GEOHAB	Global Ecology and Oceanography of Harmful Algal Blooms	Gentien/Pitcher	Hall
SOLAS	Surface Ocean - Lower Atmosphere Study SSC	Liss	Labeyrie
CO_2 Panel	SCOR/IOC Advisory Panel on Ocean CO_2	Wallace	Field
IMBER	Integrated Marine Biogeochemistry and Ecosystem Research	Hall	Field
LOICZ	Land-Ocean Interactions in the Coastal Zone	Lindeboom	Hall
	The Ocean in a High-CO_2 World Symposium	Cicerone	Duce

AFFILIATED PROGRAMS

CoML	Census of Marine Life	Grassle	Taniguchi
iAnZone	International Antarctic Zone	Muench/Hellmer	Purini
IMAGES	International Marine Global Changes	Curry	Purini
InterRidge	International RIDGE Studies	Tamaki	Labeyrie
IOCCG	International Ocean Colour Coordinating Group	Platt	Field

	PARTNER ORGANIZATIONS	**CHAIR**	**LIAISON**
IGBP	International Geosphere-Biosphere Programme	Brasseur	Duce
POGO	Partnership for Observation of the Global Oceans	Kennel	Field
SCAR	Scientific Committee on Antarctic Research	Thiede	Hall/Labeyrie
SCOPE	Scientific Committee on Problems of the Environment	Mellilo	Pierrot-Bults