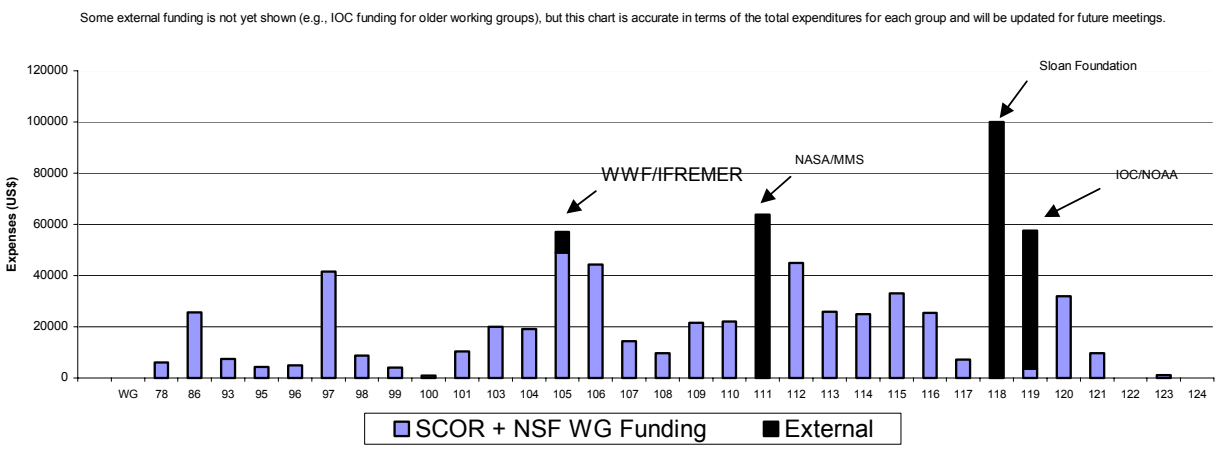
2.0 WORKING GROUPS REPORTS

Expenditures by SCOR Working Groups (1995-2004)



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

2.1 Disbanded Working Groups

2.1.1 Working Group 93: Pelagic Biogeography

This working group provided in 2004 its glossary of pelagic biogeography terms (see ww.jhu.edu/scor/Biogeography.htm). The terms are given in English and Spanish, with definitions in English and across reference list in Spanish. Translation of the terms into other languages may be desirable and feasible.

2.1.2 Working Group 107: Improved Global Bathymetry

A letter was prepared to national and international agencies and organizations related to bathymetric data. The draft letter was sent to the recipients before the official letter and GEBCO returned significant comments, encouraging SCOR to send such a letter, but with an entirely different content. A revised letter is being considered. The proposed article in EOS will need to wait until the decision on the letter has been made.

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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Andrew Watson	UK
J. Webb	AUSTRALIA

Executive Committee Reporter: Robert Duce

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No information was received from the WG chair or the subgroup chair. The work of the subgroup showed that a great deal of variability exists in measurements of low levels of iron in seawater, as measured by different laboratories.

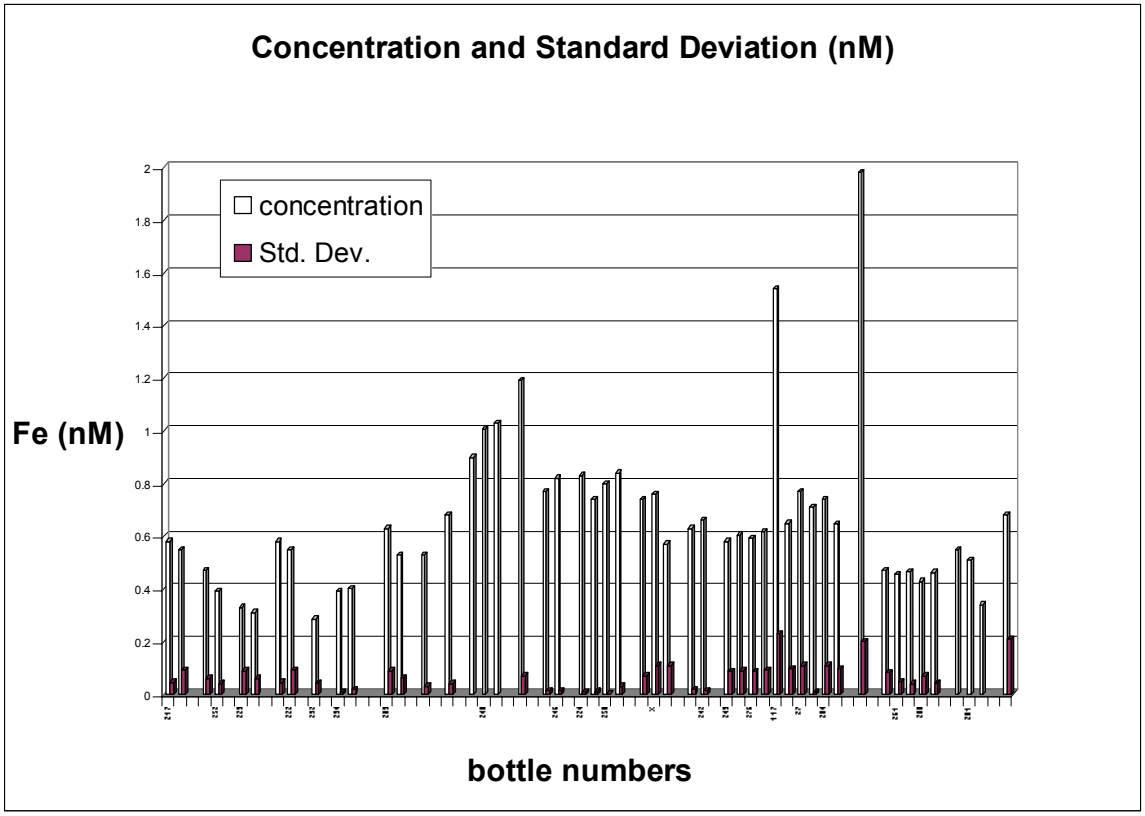

Figure courtesy of Jim Moffet, Woods Hole Oceanographic Institution

As a result of this demonstration by the subgroup, the U.S. National Science Foundation has funded an intercomparison cruise, as described in the following. The "SAFE Cruise" will involve 22 laboratories will participate in one cruise (15 Oct-8 Nov. 2004) to one open ocean station (30'N, 140'W) with low iron concentrations (0.05 to 0.08 nM) and one coastal station with high iron concentrations with the goal of establishing the following:

- the comparability of various measurement techniques;
- the differences, if any, in the sampling strategies used;
- the differences in filtration; and
- appropriate sample storage and distribution mechanisms.

Measurements of iron will be made both at sea and in the laboratory. In addition, surface and 1000 m depth samples will be distributed to other analysts both in the United States and abroad to ensure that all types of analytical methods for iron are considered and possibly for distribution as an interim iron standard.

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.

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Executive Committee Reporter: Ilana Wainer

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Date: Sat, 26 Jun 2004 08:41:33 -0400
From: "Christopher N.K. Mooers" <cmooers@rsmas.miami.edu>
Subject: SCOR WG111 Annual Report
To: scor@jhu.edu
Cc: Peter.Craig@csiro.au, norden.e.huang@nasa.gov

SCOR WG111 has again been totally focused on moving ahead with its book project this past year. Presently, most of the chapters exist in advanced draft form and our book proposal has been approved by Cambridge University Press, subject to some copyright matters being negotiated with NASA, our principal financial sponsor. The editorial process has commenced, under the rigorous and vigorous editorial leadership of Peter Craig, CSIRO. A clean version of the text will be sent to peer reviewers in October or so; then another round of revision will ensue. The final ms should be submitted to CUP for publication in March or so. Hence, mid-2005 now appears to be a realistic publication date.

Cheers,

Chris

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2.2.3 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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Date: Fri, 25 Jun 2004 09:46:36 -0300
From: "Bernard P. Boudreau" <bernie.boudreau@dal.ca>
Subject: Re: Request for Extension of WG 114
To: Ed Urban <scor@jhu.edu>
Cc: "Bernard P. Boudreau" <bernie.boudreau@dal.ca>

Dear Ed,

I haven't been in communication with Markus for a while, due to his move. I spoke to several members of the WG at the Winter ASLO meeting in Hawaii about the compilation, and I found a singular lack of interest. Yes, we had suggested it, but the idea seems to be losing steam. Many in the WG (but not me) have met at a session on Permeable Sediments at the ASLO Summer Meeting in Savannah. I don't know if they discussed the matter further.

At this point the EC can pull the plug on us or wait to see if something more concrete gets decided. I think the WG is more focussed on the next Gordon Conference than anything else. This is not satisfying from your point of view, but that is the course this seems to be running. Maybe Markus has a different perspective.

Bernie

2.2.4 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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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 WG115: STANDARDS FOR THE SURVEY AND ANALYSIS OF PLANKTON

Chairman: S I Heaney

Progress

The second meeting of the Working Group was held at the University of Concepćion, Oceanographic Laboratory, Dichato, Chile between 14-16 November 2003. The meeting was extended by one day as SCOR had agreed to invite a few scientists from South America to enhance development of standards for survey and analysis of plankton, technology transfer and networking for the region. SCOR had also approved an additional Full Member of WG115 to represent the Pacific Rim, Dr Sun Song, and Dr Juha Flinkman as an Associate Member representing the Baltic, both of whom brought new dimensions to the discussions.

The objective of achieving greater outreach to the South American region was achieved through a series of talks given to students at the main campus of the University of Concepćion on the long-term study of ocean plankton and recent developments and findings using the Continuous Plankton Recorder (CPR), the use of the CPR in the Southern Ocean and understanding the spatial distribution of plankton in this region and an overview of plankton studies in and their applications in China. At the Oceanographic Laboratory, Dichato, presentations were made of plankton studies on both Atlantic and Pacific seaboards by scientists from Chile, Argentina, Peru and Uruguay. (SCOR provided travel funds for some of these additional scientists.) These talks highlighted the considerable amount of effort on plankton surveys and analysis that has and continues to take place in both Atlantic and Pacific oceans and the common constraints of ship time, long-term funding, manpower for survey analysis and data processing to maintain national plankton surveys. There was also a joint initiative between two Working Group members and Chilean scientists to deploy a new multiplankton net from the University of Concepćion research ship.

A Web site for WG 115 has been developed with the help of the Sir Alister Hardy Foundation for Ocean Sciences (SAHFOS). This can be found at: http://192.171.163.165/SCOR/SCOR_title.htm. The intention is to use this to provide information under headings of home, meetings, instruments, surveys, methods, data bases, science issues capacity building and links which can be expanded by drop-down menus.

Issues

The meeting addressed six main issues:

1. Sampling strategies

A comprehensive overview of sampling strategies for plankton surveys was given by Svein Sundby. This included consideration of the interaction of physical, chemical and biological factors which affect the spatial distribution of plankton. The analysis concluded that

measurement of wind strength and light during plankton surveys can add much to analysis and understanding of plankton distribution and fish recruitment. These master variables are relatively simple and easy to measure and it was recommended that this information should be collected and spatially referenced, during surveys.

2. Methods for plankton surveys

In addition to the general factors influencing the distribution of plankton, the different requirements of global initiatives operating at different scales of time and space were considered. These included Living Marine Resources-Global Ocean Observing System, Global Ocean Ecosystem Dynamics and the Census of Marine Life, monitoring of harmful algal blooms and regional fisheries studies. The need to measure plankton biomass covering the entire spectrum from viruses to jellyfish was recognised along with the substantial technical difficulties in doing so.

3. Methods for plankton analysis

Different plankton sampling systems such as nets, CPRs, Optical Plankton Recorders, acoustical devices, Video Plankton Recorders and molecular techniques require much effort to count and identify the organisms in plankton samples and place the information into databases. It was considered that rapid advances in computer-aided image analysis will lead to many benefits, including image recognition, easy digital storage of images for quality assurance and data organisation.

4. Inter-comparison of sampling methods

The current knowledge was reviewed but comparisons between different acoustic and optical sampling systems were limited by lack of experts attending the meeting. A major problem is the inherent difficulties of these indirect systems in reliably distinguishing between different species with similar sizes and shapes which would limit comparisons with traditional net samplers. Further work is needed to enable a more comprehensive comparison of sampling methods.

5. Databases

A gridded database of over fifty years of CPR data of the North Sea which was the result of co-operation between Plymouth University and SAHFOS was demonstrated. This database is now available on CD and provides an interpolated spatio-temporal description of plankton sampled by the CPR from January 1947 to December 1997. Although this is a significant development, the WG concluded that it was beyond its scope and ability to become involved with databases further. However, it could contribute to the scientific issues pertaining to what information should be archived and how this might be organised and made available to the scientific community.

6. Archiving of samples

The curation of preserved samples of plankton was considered as a pressing issue as it can be difficult to secure the resources needed. Once lost, samples can never be recovered.

Collections require small but significant levels of maintenance if they are to serve as sources of material for checking taxonomy and for molecular and genetic studies. It is important that sample collections should not be moved but kept with the centres which collected them.

Advances in digital imaging have made it possible to easily and economically archive images obtained during identification and counting samples. This provides an additional form of information to be archived for future reference or image analysis. It was agreed that as the ability to collect digital images and store these is now within the capability of most laboratories, these images should be taken and archived along with a sub-sample of preserved plankton.

7. Future plans

The ability of the WG to progress its activities through its web site has been slowed by the time required to put material onto it and maintain it. The outputs of the Chile meeting and papers provided after will be used to build the Web site in the coming months. A series of tasks was delegated to members of the WG, some of which have already been completed, including a paper on sampling strategies.

The WG felt that a further meeting was necessary to complete the Terms of Reference which it had set. The most cost-effective way of achieving this could be to incorporate a final meeting with a symposium. The purpose of this would be to structure a meeting around the Terms of Reference of the Working Group with the intention of publishing the proceedings. A major challenge will be to merge past surveys with new requirements, opportunities and technologies for surveys and analysis of plankton. It is now timely to do this and feed the results into international initiatives such as GOOS and more regional fisheries studies which now require a more integrated ecosystem approach for management. The WG has made good progress and would seek support from SCOR to hold such a meeting, possibly in Plymouth in 2005 under the auspices of SAHFOS.

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

Annual report- 2004

Introduction

As reported earlier, our spring 2003 WG 116 meeting in China was postponed due to SARS and rescheduled for the fall of 2003. A suitable location and host was sought from among our group, and Dr Anthony Michaels offered to host the event at the USC Wrigley Institute for Environmental Studies marine lab on Catalina Island, California, USA. A summary of this meeting is attached that includes discussion of our plans for an August 2004 gathering at the Woods Hole Oceanographic Institution and some deliberations on final reports and a proposal for returning to China in spring 2005 for a final gathering.

Catalina –Nov. 4-7 2003 meeting report & future plans

WG members at meeting- Buesseler, Antia, Fowler, Gustafsson, Michaels (Nov. 4 & 6/7), Sarin, Steinberg, Trull

Seven WG and 1 Associate WG member met at the Wrigley Institute for Environmental Studies marine lab on Catalina Island for a 3.5-day SCOR WG meeting. The goal of the meeting was to review current status and progress in the use of upper ocean sediment traps to determine particle fluxes in the upper ocean. This WG also has an interest in radionuclide methods for determining particle export, which was also reported upon at the meeting; however, the focus on traps at this particular gathering was maintained in anticipation of a joint SCOR/NSF sponsored ^{234}Th workshop in August 2004 (see below). Thus, the general use of radionuclides to calibrate sediment traps was a topic of significant discussion, vs. the details of the use of ^{234}Th to determine export without the collection of sinking particles.

The first half of Day 1 included a review of the WG terms of reference, current products (reference list; ^{234}Th database), plans for future meetings, and most importantly, plans for paper(s) coming out of the Catalina gathering on traps and whether these should be narrowly focused, methods protocol works, and/or of a more synthetic nature, reviewing basic principles and highlighting examples where progress has been made. A point of departure for our WG is Wilf Gardner's paper initiated in 1995 in Villefranche and published in 2001 on sediment trap issues and accuracy. The WG members felt that considerable progress had been made in the last decade, but that many details on trap accuracy and protocols remained unpublished, almost leading to a "Zen" or "Art" of trapping, rather than shared and common understanding of the issues and best practices. Thus one goal of this WG is to report on these details in a fashion that will benefit both the interpretation of prior trap data, but also serve as a starting point for the next generation of ocean carbon studies in the post-JGOFS era. A recent and specific request by international JGOFS to update upper ocean sediment trapping protocols would also fit this goal. This WG is also interested in exploring issues concerning changes in particle flux vs.

depth between the surface and 1000m, where variability in remineralization ratios are key to understanding the impact on changes in ocean biogeochemistry on the global carbon budget and climate.

Day 1 & 2 continued with a series of presentations and discussion led by each of the WG members. Suffice it to say, that discussion was lively and the free exchange of ideas led quickly to an outline on Day 3 of a single, *Progress in Oceanography*-style paper tentatively titled "*Estimating upper ocean particle fluxes with sediment traps: a progress report*". One goal was to introduce the audience to the various reasons to measure particle flux, as the accuracy and reliability of the tool needs to be viewed within the context of the questions being addressed (section I, led by Buesseler/Michaels). Also the variability in particle type and sinking behavior will be reviewed. The paper is not seen as a comprehensive synthesis, rather as a presentation of examples under different oceanographic conditions of what is known regarding the issues of preservation/solubilization of particles in traps (Antia); the impact of swimmers on flux (Steinberg); hydrodynamical concerns (Fowler/Trull) and the calibration of sediment traps (Sarin/Gustafsson). It is meant to be provocative but positive in its focus on solutions and recommendations for better application of sediment trap technology.

The rest of the meeting was spent refining this outline and identifying specific tables and figures that will be either compiled or created specifically for this paper. Sections were assigned to WG members and a plan for sharing of draft text and figures/table in 2004 was agreed upon, along with a goal for exchange of materials in conjunction with the August 2004 meeting. The idea of co-production of Web-based products--photos of traps, swimmers, trap material, videos of marine snow, methods protocols, etc.--was especially attractive, with the thought that these Web-based materials would be hosted either by the Journal, or at WHOI.

It seemed to this WG that the delay between meeting #1 in Amsterdam in 2001, due to SCOR budgets (2002) and SARS (spring 2003) was excessive and that momentum had been lost, but that progress should now come quickly and meetings should be scheduled that build upon this renewed energy established at Catalina, and the August 2004 gathering that is planned to bring together a larger group of non-SCOR WG scientists to discuss ^{234}Th issues (methodology; modeling; C/Th ratios; oceanic Th speciation). At this meeting, entitled "Future Applications in the application of thorium-234 in Aquatic Systems" that is being organized by Dr. Claudia Benitez-Nelson for Aug. 16-19, http://www.geol.sc.edu/cbnelson/Thmeeting/ about 40 experts will meet for 3.5 days, including our WG members. We plan to add 2.5 days immediately following this gathering for just the 8 or so WG members, to work on finalizing the Catalina trap manuscript for submittal.

Also discussed was the need for a final SCOR WG meeting beyond 2004 assuming that the joint publications were proceeding on both traps issues (originating from this Catalina meeting) and the ^{234}Th approach (papers to be initiated in August 2004). To complete all of these various papers and efforts, we feel that a final gathering in spring 2005 would prove quite advantageous. We request that some SCOR support for a small 4th gathering be made available

to us, the idea being to return to our Xiamen, China plans that were cancelled in 2003. We feel that bringing this SCOR WG to an Asian meeting site would broaden our impact, and allow for greater collaboration and involvement than has been possible thus far with some of our Asian colleagues and their students. Our plans would include both smaller WG discussions for completion of manuscripts initiated in WHOI on ^{234}Th, and by then, we also expect to be in revision stages for our review article on upper ocean traps. As part of an outreach and education effort, we also propose to give a short series of lectures by WG members to the Xiamen University students, staff and other invited guests. Total budgets and plans would be similar to our 2003 proposal [about $15,800]. We expect to finish the WHOI meeting in 2004 under our original budget, due to cost savings and contributions by individual WG members and hosts, and joint sponsorship by NSF of the WHOI event.

Summary

Since our last report, our second WG meeting was held in November 2003 at Catalina and provided a productive setting for making considerable progress in the original SCOR WG terms of reference and in defining in detail, a set of products, time line for completion of a review paper on sediment traps, and assignment of joint tasks. We are particularly pleased that the August 2004 ^{234}Th workshop at WHOI was successfully funded, and thus now with joint NSF and SCOR support, we can bring a larger group together around one of our WG topics, and thus bring in new expertise to bear on the issue of the application of ^{234}Th in determining upper ocean particle fluxes. We hope to close out these SCOR activities in 2005, and suggest that a final workshop in Xiamen, China would be the best way to assure completion of these tasks.

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

Terms of Reference:

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

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(Continued on next page)

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REPORT
SCOR-IOC WG 119

'Quantitative ecosystem indicators for fisheries management'
www.ecosystemindicators.org

Report of the International Symposium held in Paris – UNESCO
31st March to the 3rd April 2004
Chairs: Philippe Cury (IRD) and Villy Christensen (UBC)

Spring in Paris helped to attract 250 participants from 43 countries to a symposium in early April this year. The symposium was on 'Quantitative Ecosystem Indicators for Fisheries Management' and it was hosted by the Intergovernmental Oceanographic Commission at the UNESCO headquarters next to the Eiffel Tower. Four years of preparation were over and the stage set with a program including 40 presentations and close to 150 posters.

The symposium was centered on using ecosystem indicators for fisheries management and, as such, reflects the growing understanding that exploited fish populations must be considered as integral components of ecosystem function instead of phenomena that operate independently of their environment. Internationally, there has been wide recognition of the need to move toward an ecosystem approach to fisheries (EAF), a development spearheaded by FAO through the *Code of Conduct for Responsible Fisheries*, and supported by many regional and national institutions as well as academia, NGOs and the public at large.

As we move to embrace an ecosystem perspective, we need new measuring sticks. Ecosystem approaches to fisheries include consideration of the interdependent way we utilize ecosystems. At a minimum, these components include ecological, economical, social, technological, as well as governance aspects. When considering the ecosystem, we must include not only the target species, but also their effects on dependent, competitor, and non-target species, as well as on the habitats shared by these species. An important question thus arises, related to trade-offs. Management interventions directed at one target species may have consequences for many other species, including species that are targets of other fisheries. How do we evaluate the trade-offs involved, and how do we determine what direction we, as a society, should take?

To evaluate such questions, it is important to form our decisions based on well-founded science as well as on information about societal priorities. At the Paris Symposium the focus was on the scientific aspects of ecosystem approaches to fisheries with the intention to provide information and guidelines about how to develop, test and apply indicators, or frameworks of indicators.

Internationally, the first major initiative related to the use of ecosystem indicators for sustainable fisheries development was taken by the Government of Australia in cooperation with FAO, through a Consultation in Sidney, January 1999, involving 26 experts from 13 countries. The consultation resulted in Technical Guidelines No. 8 for the FAO Code of Conduct for Responsible Fisheries: *Indicators for Sustainable Development of Marine Capture*

Fisheries. The Guidelines were produced to support the implementation of the Code of Conduct; they deal mainly with the development of frameworks, and they set the stage for using indicators in the decision process. The Guidelines do not, however, discuss the properties of indicators, nor how they are used and tested in practice. This instead became the task of an international working group, established jointly by the Scientific Committee on Oceanic Research (SCOR) and the Intergovernmental Oceanographic Committee (IOC) of UNESCO. SCOR/IOC Working Group 119 on *Quantitative Ecosystem Indicators for Fisheries Management* was established in 2001 with 32 members drawn from 19 countries. The working group was designed to support the scientific aspects of using indicators for an ecosystem approach to fisheries, to review existing knowledge in the field, to demonstrate the utility and perspectives for new indicators reflecting the exploitation and state of marine ecosystems, as well as to consider frameworks for their implementation.

The working group met twice to plan and report on progress, (1) in Reykjavik, October 2001, and (2) in Cape Town in December 2002, organizing its efforts with a series of task forces working in parallel on:

- Environmental indicators including habitat changes,
- Species-based indicators,
- Size-based indicators,
- Trophodynamic indicators,
- Integrated indicators,
- Selection criteria,
- Data sets and reviews, and
- Frameworks for implementing indicators.

As part of their work, the task forces have reviewed the current status of using indicators for ecosystem approaches to fisheries, as well as seeking to develop new theory, applying it, and evaluating performance of indicators. The major results of these endeavors formed the core of the presentations at the Paris Symposium.

More than 200 abstracts were submitted for presentation at the Symposium. The Program Committee of the Symposium thus faced a very difficult task in selecting presentations for oral and poster presentation. This was, however, a wonderful problem when planning a symposium and it clearly indicated that the timing was perfect for evaluating the role of indicators for an ecosystem approach to fisheries. This is also clear from the very generous and enthusiastic support the Symposium received from a number of organizations – the list includes SCOR, IOC, FAO, NOAA, Institut Français de la Biodiversité, the UBC Sea Around Us, South Africa's Department of Environmental Affairs and Tourism, ICES, Institut de recherché pour le Développement, Ifremer, PICES and GLOBEC.

Looking back at the Symposium, it is clear that we have moved a long way toward ecosystem approaches to fisheries within a relatively short time span. The presentations outlined a vast

array of well-defined indicators for fisheries management, described their properties, and evaluated how they can be used at the ecosystem level to describe impacts of fisheries, as well as to evaluate the relative contribution of environmental and fisheries impacts. Given the number of available indicators that have been developed and applied, it is also clear that emphasis has to be directed toward methodologies for selecting indicators and evaluating how capable indicators are of detecting trends in a noisy environment. While these topics were treated at the Symposium, it is yet too early to draw clear conclusions. It is noteworthy, though, that by being dealt with explicitly as part of the Symposium it is clear from the very onset of using indicators as part of ecosystem approaches to fisheries that:

- Environmental and low trophic level indicators capture most often environmental changes (bottom-up effects);
- Top predators or high trophic indicators capture changes that occur in the fish communities/fisheries (top-down effects);
- Several are best used for surveillance rather than for predictions;
- "the devil is in the details" and one should not use indicators without any expertise (interpretation is sometimes delicate);
- Indicators are conservative (they depict strong changes): they must be acknowledged despite lack of reference points (trends and rapid changes should be carefully considered);
- No single indicator is sufficient; we need a suite of indicators covering different data, groups and processes, as indicator performance may differ with ecosystem, history of exploitation, other pressures (e.g., pollution);
- Importance of considering both TRP (Target Reference Point-MSY) and LRP (Limit Reference Point -threshold values, range of values) in the same framework to define "ecosystem overfishing" and reconcile conservation and exploitation;

The conclusion of the Symposium, as expressed through the final panel discussion is clear: we have the science in place with regard to ecosystem indicators that is needed to make an ecosystem approach to fisheries operational. Knowledge, data and frameworks exist for defining, selecting, evaluating and implementing indicators.

The recommendations are:

- Reinforce (or start) the process of implementing ecosystem-based indicators (TRP&LRP) and framework for fisheries worldwide;
- Take a pragmatic approach to move towards EAF and to be evaluated scientifically;
- Use a step-by-step procedure to integrate scientific results (data, models, indicators) and management expertise in a spatially explicit manner (feedback between scientific expertise and management must be encouraged)

We anticipate that the special issue of the *ICES Journal of Marine Science*, due within a year, that will present the major findings from the symposium will serve to underline that the science

is ready, and we are sure the special issue will become a reference publication for the scientific aspects of using ecosystem indicators as part of an ecosystem approach to fisheries.

What is needed now are guidelines for how to implement ecosystem approaches for fisheries, and as part of those guidelines, how to operationalize the role of ecosystem indicators. This must be realized and actualized regularly as implementations take place worldwide with the scientific expertise, support and evaluation that is needed if we really want to make EAF operational and effective.

2.2.7 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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Second Meeting of SCOR Working Group #120

Report by W.W.C. Gieskes and S. Belviso
Savannah, Georgia, USA, 4-8 December 2003

Phaeocystis, major Link in the biogeochemical Cycling of Climate-relevant Elements

Taxonomic Aspects, Distribution, Life Cycle, Ecophysiology, Biotic Interactions, Biogenic Sulfur Gases and Fate in the Atmosphere, Modelling, and Project Positioning in "SOLAS" and "IMBER"

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1. Introduction: Roadmap towards the "Deliverable"

SCOR Working Group #120 was initiated at the end of the 1990s, during a symposium on DMS/DMSP followed by a *Phaeocystis* workshop. SCOR was willing to fund a new working group with a focus on this species group's role in the transfer of elements relevant to climate regulation such as carbon and sulfur, and the biogeochemical processes that influence such a

role; some SCOR delegates had asked for inclusion of other Prymnesiophytes, especially the coccolithophorids, in the working group's activities. However, the group members regarded species such as *Emiliania huxleyi* to play a too specific role in pelagic systems; they may eventually well be worth a dedicated SCOR Working Group. Before they gave the "green light" to the establishment of Working Group #120, most SCOR delegates expressed their wish of a firm focus on climate issues, including a modelling effort to link ecosystem models, *in casu* one with *Phaeocystis* as the central microalgal group, with climate models. Modelling (and not only globe-wide modelling of dimethyl sulfide, the climate-relevant biogenic gas that is closely associated with *Phaeocystis* activity and its interaction with the microbial foodweb) was one of the many items discussed during the recent second meeting of our Group, in Savannah, Georgia, USA, from 4 to 8 December 2003.

The meeting's attendance was truly international, with contributions from all over the globe. Unfortunately, some full members and corresponding members had seagoing and other scientific duties elsewhere or could not come for various logistic or financial reasons (to mention a few: Kiene, Walker Smith, Veldhuis, Peperzak, Chrétiennot-Dinet, Matrai, Vernet, Simo, Vézina, Gabric, Marchant, Qi) but this is the fate of a group in which most participants are actively occupied with research, not just administration. However, because the majority of the WG's full members were present, decisions have already been taken with regard to the organisation of the third and last meeting, and the format of the deliverable to SCOR at the end of the Working Group's lifetime, which is by the end of 2005. This could be, as was proposed already during the organisation activites preceeding the meeting in Georgia, a conference (Gordon-style) and a book with the proceedings. All agreed that during such a conference all aspects of the ecophysiology, taxonomy, biogeography, evolution and fate of *Phaeocystis*, its interactions with the biotic and abiotic environment (including chemical signaling and toxicity), and its role in biogeochemical cycling of climate-relevant elements should be reviewed; modelling should cover the whole range, from the cell, and lifecycle and network ecosystem models, all the way up to system simulation modelling and models of the fate of biogenic gases in the atmosphere and their role in solar radiation interception in relation to climate regulation; and developments of models to predict non-linear responses/switches will be followed in the time remaining until September 2005, the time of the planned *Phaeocystis* Conference, so attention can eventually be paid to this possibly significant, rather new development: predictability in the essentially chaotic plankton world.

Before the last meeting, now planned to take place in September 2005, Working Group members and others interested in *Phaeocystis* should be able to communicate intensively by electronic means, including a Web page. So far, efforts to set up such a page have failed but new developments are positive in this respect. Actually, a Working Group #120 information bulletin can soon be set up at the Marine Biology Department of the University of Groningen, The Netherlands, courtesy Dr Anita G.J. Buma. At present the bulletin is still empty. Contributions can be sent to w.w.c.gieskes@biol.rug.nl, who will forward them to Dr Buma. She can, of course, also be approached directly. Her e-mail address is a.g.j.buma@biol.rug.nl .

At the end of this report the forthcoming Web facility will be mentioned again, under 4.4: Communication.

Mission Statement of SCOR Working Group #120

Our Working Group has a natural ambition: to move to a position located at the interface of the new international programme SOLAS and the even newer, recent IMBER ("integrated marine biogeochemistry and ecosystem research"), the science and implementation plans of which have now been published. In these science plans, however, hardly any mention is made of "our" *Phaeocystis*: an omission that can hardly be understood in view of the Savannah meeting's discussions reported below. We wish to define the overall orientation of forthcoming research regarding the direct and indirect effects of climate change on *Phaeocystis* distribution, abundance, and ecophysiology and therewith on the cycle of carbon and sulfur.

2. State-of-the-Art and remaining Lacks of Knowledge

Christiane Lancelot presented, as a kick-off, a review of the controlling mechanisms of blooms of *Phaeocystis* worldwide. A manuscript with this title by Schoemann, Becquevort, Stefels, Rousseau and Lancelot has recently been submitted (*J. Sea Res*.). The geographical, globe-wide distribution of several species (*P. globosa, pouchetii, antarctica, jahnii, cordata, scrobiculata*) was discussed at the end of the presentation, and the bottom-up (micro- and macronutrients, T, light) versus top-down control (grazing, lysis/remineralisation, incl. aggregation and sedimentation) of blooms received much attention, as well as the transitions between the various life cycle stages recently described by Peperzak. Common to all species is the polysaccharide matrix of the colonies. Quantification in terms of carbon is based on conversion factors while pigment-based biomass assessment is "out": the fucoxanthins "hex-fuc" and "but-fuc" are not typical enough and moreover vary in dependence of light, iron availibilty etc., often in the same strain. Why stage transitions in the life cycle take place, from several non-motile to motile ones, is largely unknown. It appears to depend on turbulence in the water and nutrient depletion, while induction also takes place under reduced irradiance. Macroflagellates appear when cells are allowed to attach themselves to a solid substrate, and then colonies grow. Unresolved questions are still numerous: number of stages; how to identify stages; abiotic and biotic factors that regulate stages and transitions; endogenous clocks; what stages are most harmful? The ecological and biochemical relevance also deserves further attention, for example: are certain life forms related to predator avoidance (*i.e.,* colonies), to nutrient or light adaptation, to cycling in the microbial foodweb (*i.e.,* single cells only) and thus carbon retention in the euphotic zone while colonies would enhance the "biological pump"? The various species have been screened now as to the response of growth rate per day to temperature; this response has been compared with that of other important phytoplankton groups, such as coccolithophorids and diazotrophs (nitrogen gas fixers). At low temperatures *Phaeocystis* outcompetes these. Light availability is another issue. The idea of Arrigo (1998) has now been challenged by van Hilst and Smith: light-growth relations of diatoms seem to be

the same as for *Phaeocystis*, although the latter needs a higher light threshold for blooming. Adaptation to rapid light changes was discussed; diadino-diatoxanthin cycling tends to be rapid. Other aspects were discussed as well: relation to iron availibility, carbon dioxide uptake through carbon anhydrase activity (high at high pH, Elzenga *et al*., 2000), field dominance over diatoms at low carbon dioxide concentrations, the limited data collected as to inorganic nutrient concentrations, adsorption of iron and manganese on the colony matrix (possibly sequestered in the mucus for subsequent uptake by cells). Research on grazing and its impact on the life cycle is in progress (Escaravage, RIKZ, The Netherlands), as well as degradation of colony mucus (slow when bacteria are limited by nutrients); sedimentation and colony aggregation remains in the picture (SetCol experiments by C. leBlanc, in Lancelot et al., 2003). Finally, the question of physiological death was opposed to viral infection and colony disruption and resistance to viral attack (Hamm, 2000).

Peter Verity presented his group's studies on biocomplexity: bio-feedback as a basis for self-organisation in plankton ecosystems using *Phaeocystis* as a model complex adaptive ecosystem (see also Medlin and Verity, 2003). He reported on the mesocosm experiments in Bergen (Norway) in 2002 and 2003. Colonies seem to be derived from the sediment: mixing "empty" water with damp sediment resulted in colony presence, with 80-100 cells per colony. **Jenn Brofft** continued with an overview of molecular approaches of the Verity group to study biocomplexity of *Phaeocystis* systems. Gene hunting by differential display RT-PCR (*P. globosa* cells versus colonies) is applied to find out the nature of the difference between single cells and colonies: what genes/proteins are involved in the switch (genes switched on/off for metabolism processes)? This approach would give insight into the distinction between life history stages. The research centers around the following sequence: separate and visualise unique gene fragments by autoradiography after electrophoretic separation on acrylamide gels; analysis and identification of differentially expressed gene fragments; and observation in mesocosms of the *behaviour* of these genes. Medlin remarked that an alternative method is the use of subtraction libraries. The conclusion was that it seems more complex to live independently, as "single cells".

Jacqueline Stefels continued, with a review of work done in the framework of the European programme "IRONAGES". This contribution consisted of an approach to ecosystem modelling of DMS and DMSP. Starting point in this effort was the Archer model's DMS(P) module, with a basis of data on DMSP:C ratios in diatoms, Chrysophytes, Dinoflagellates, etc. (from Keller '89 and Corn '96) and DMSP:C proportions. She reminded us that the picoplankton consortium in the model is tricky because it contains so many widely different groups. The controls on phytoplankton DMSP production were listed, using data published mostly recently, for example, the relation between DMSP-intracellular concentration (mM) and light from Slezak and Herndl (2003), van Rijssel and Gieskes (2002), and van Rijssel and Buma (2002). From this relation and other ones (e.g., % change of DMSP per cell versus temperature, also with data from Sheets and Rhodes, 1996) algorithms were extracted for eventual use in modelling. DMSP production is also controlled by nutrients of course, but the iron:N ratio has been explored less. Other terms important for modelling were reported: 6-10% DMSP-p

appears to leak daily from the cells, a fixed proportion of cell carbon. Exudation should definitely be a term in the model. The grazing term concerns microzooplankton, macrozooplankton, and mesozooplankton; copepods accumulate DMSP; zooplankton should be divided in *at least* 2 groups. Bacterial consumption of DMSP, its enzymatic cleavage, and DMSP sedimentation are other important terms not to be missed.

Linda Medlin spoke on the phylogeny of colony-forming *Phaeocystis,* studied on the basis of ITS-1 to design a molecular clock to relate species divergence to geological events of the distant past. Her work with Vaulot, published from 1998, was mentioned. She highlighted the phenomenon that gene flow in the Arctic appears to be opposed to flow in the Antarctic, because water masses in these regions are respectively non-defined and defined. In fact, in the Antarctic populations can hardly "escape". The question was posed on what spatial scale currents can influence population structure in phytoplankton populations. An important development was reported: at the AWI (Germany) *Phaeocystis* will soon be a key species for institutional studies, at this institute for polar and marine research. An issue discussed later with her was the occurrence of *Phaeocystis* "look-alikes" such as *Corymbellus aureus*, a colony-forming Prymnesiophyte that is easily mistaken for *Phaeocystis* during surveys. It can bloom to considerable extent in regions where problems such as clogging of fisherman's nets by "slimy plankton" has been reported, for example, east of the Shetlands.

Sauveur Belviso highlighted the globe-wide distribution of DMS at the surface, using the Kettle (1999 and 2000, Kettle and Andreae as a reference) database, compared with the semi-prognostic approaches of Aumont (2003) and the mechanistic model of Chu *et al*. (also 2003), plus the analysis of Simo and Dachs (2002) and Belviso et al. (2003) to relate chlorophyll (respectively moderated by data on the mixed layer depth and the community structure of phytoplankton) with DMS distribution, also globe-wide and its seasonal distribution across Earth. It was of considerable interest to have this presentation, that focussed on a comparison of the various existing models brought forward and to see the discrepancies and similarities between model results.

The work of **Mtinkheni Gondwe,** presented by **Winfried Gieskes**, is based (as far as ocean DMS concentration distribution is concerned), on the Kettle database of 1999. Her analyses go a step further: they focus on the fate of DMS once it has reached the atmosphere, and how the various DMS derivatives that are produced under the influence of an array of atmospheric chemical reactions are spread across the globe's atmosphere to reach regions and often unexpected places where they interfere with solar radiation due to albedo caused by aerosols, haze, and eventually clouds, with a range of properties relevant to Earth's radiation budget, and thus climate regulation. The contribution of *Phaeocystis* to the DMS present in seas and oceans is of course not the only one; other plankton groups contribute much also (the coccolithophorids; picoplankton; etc.), but it is certain that biogenic sulphur with an ocean origin contributes greatly to the global sulfur budget and cycling -- indeed by far the most in the Southern Hemisphere.

Paul Wassmann dealt with the phenomenon of the variability in colony formation in Arctic environments: no colonies in the Chukchi Sea, elsewhere the other way around. Single cells and colony-cell carbon varies in proportions off Norway (White Sea, Barents Sea). Apparently, the presence of diatoms does not play a role here in colony induction; physiological factors may play a role in this respect, possibly also grazing (small colonies may be grazed continuously: screened samples developed into colonies, unscreened did not, cf. Escaravage, in prep.). Where there is much mesozooplankton, single cells predominated, not the colonies that were expected. Ecophysiology appeared not to be an adequate process to explain colony presence.

Maurice Levasseur reported on the programme "SERIES", the "subarctic ecosystem response to iron enrichment study", with the purpose to quantify vertical carbon flux upon enrichment, but DMS was also measured. Iron enrichment usually increases DMS underwater and the flux to the atmosphere. The iron-enriched "patch" became quite turbid (a bloom of microalgae); outside the patch the water was blue. Results raised interesting questions, such as: were bacteria that consume DMS(P) iron-limited here? In the bloom DMSP-p went up, then crashed, just like the biomass of nanoflagellates. This was related to a diatom increase in the bloom,that was accompanied by DMS crash. A physical model incorporating turbulent mixing of the upper water column, ventilation to the air above the sea, and photo-oxidation led to the conclusion that Fe increased DMS net production; DMS was "up" in the atmosphere as a consequence.

Dileep Kumar reported on monsoon-driven physical forcing in tropical regions, the Arabian Sea and the Bay of Bengal, and its consequences for CO_2 and DMS fluxes. The mixed-layer depth depends greatly on stratification following intense river discharge into the Bay, and pCO_2 and DMS are influenced by this regime, as well as the level of coastal hypoxia that increases the H_2S content; UV radiation has more influence (photo-oxidation increases) during stratification; altogether it is not surprising that chlorophyll is not related to DMS in the water in this region. In the Arabian Sea the relation between chlorophyll and DMS was reasonable. Grazing induced recycling of S and C in the upper part of the water column in both areas. Ocean biology will also in the future be connected with sea-to-air fluxes of both CO_2 and DMS. In fact, how monsoon regimes affect ocean biogeochemistry in the tropics is poorly understood so far.

Gillian Malin informed meeting participants about the UK SOLAS and AMT (Atlantic Meridional Transect) programmes. Both run until 2006. Over 10 million pounds have been allotted, but ships and airplanes are expensive..! Trace gases and sulfate in the atmosphere are central targets of study. A relevant Web page is http://www/pml.ac.uk/amt/index/htm.

Photochemistry and trace gas production will be analysed in detail; starting point is that pelagic system community composition influences aerosol formation over the remote ocean, and aerosol composition (also affected by the NH_3 radical derived from the sea's ammonia) has an effect on radiative forcing.

Marion van Rijssel turned the discussion back to *Phaeocystis*: she discussed its toxicity in the broad framework of allelopathic interactions in the plankton. Negative effects of *Phaeocystis* are known, for example, on cod larvae, and fish kills have been reported (Huang *et al*. 1999, He *et al*., 1999). Healthy colonies are not consumed, as seen often, and described by Estep in 1990. Senescent colonies stop mitosis in sea urchins. Bioassays have now been conducted with fish, *Artemia*, blood cells, etc. The marine bacteria *Vibrio fischeri* was incubated with mesocosm water during the experiments in Bergen, but no toxin seemed to be produced. However, an erythrocyte lysis assay revealed that hemolysis was related positively with chlorophyll concentration, in a dose-response related to temperature of the water. The haemolytic effect was ascribed to excretion by *living* cells, while there was also an effect of light. The work will be extended in cooperation with the Chinese group of Qi.

Jeremy Long, a PhD student in **Mark Hay**'s lab, asked himself if *Phaeocystis* can smell grazers. Chemical signalling in plankton is a known phenomenon (mate recognition, feeding, and chemical, behavioral and morphological defense, the latter in *Daphnia*: Wiltshire and Boerema). Hessen and van Donk (1993) reported the formation of colonies of *Scenedesmus* in the presence of grazers; the substance of the signal material is still not known. Tang (2003) found larger *Phaeocystis* colonies when exposed to chemical signals, and the ratio of single cells versus colony cells and grazer response may well be caught in a loop involving chemical signals. Research is now going on to find out if colony formation is influenced by either *Oxyrrhis* or the copepod *Acartia*. The latter's action is direct: it eats small colonies, or disrupts larger ones.... or, alternatively, it "signals" and therewith suppresses clony formation. There may be an adaptive value in having single cells: grazing loss to copepods would be lowered. On the other hand, another copepod, *Pseudiaptomus*, had a preference for single cells. The suppression cue should be isolated; Phaeocystis seems actually to be "able" to smell the threat of grazing... but does it really, and when does it?

Anne-Carlijn Alderkamp has studied polysaccharide patterns during the mesocosm experiment off Bergen in 2003. Water-soluble (mucopolysaccharides, extracellularly produced huge molecules and also the smaller laminaran, stored in the cells) and water-insoluble polysaccharides were followed over day-night cycles (the notion being: use of polysaccharides in the night) in bags with a bubbling device for stirring. Laminaran has a size of 20 glucose units; it is also found in diatoms that often accompany *Phaeocystis* blooms. In *Phaeocystis* it is now possible for the first time to make a distinction between mucus polysaccharides and laminaran. As the bloom declined sugar concentrations remained high; the percentage of sugars relative to POC increased as the bloom developed. Laminaran was stable over the course of the bloom, 80% of the total (the laminaran:mucus ratio did not change over time); in fact, up to 70% of POC is sugar; the sugar:POC ratio increases as cells cease to grow. The sugar per cell can double over a day, influenced by the stage of the bloom *and* by light availability. Only in darkness polysaccharides were consumed by *Phaeocystis*.

3. Modelling: State of the Art, Perspectives

Christiane Lancelot and **Bernard Patten** contributed most to this session. As a kick-off, the Belgian MIRO and SWAMCO models were reviewed by **Christiane Lancelot**: model construction, structure and parameterisation, and application to the North Sea (*P. globosa*) and the Ross Sea (*P. antarctica*). The construction is basically the interplay between observation, experimentation, and modelling. Phytoplankton, zooplankton and bacteria are the biotic components fed into a biogeochemical-mathematical model combining circulation (0-1-3D) and ecological (both direct and adjoint) sub-models. Validation and optimisation are done on the basis of monitoring and spatio-temporal surveys, the data of which are analysed statistically; the number of state variables is determined accordingly. This number is up to 32 (117 parameters) in MIRO, which is structured around C, N, P, and Si cycling in the North Sea's Southern Bight; other components are DOM, POM, OPC, OPM, bacteria, copepods, microzooplankton (feed on microalgae), diatoms. The release of POM and DOM after death of *Phaeocystis* is considered, next to a benthic module for recycling and exchange at the sediment-water interface. Runs of MIRO are accompanied by validation, inverse modelling, and consideration of trophic efficiency. One question is if all 117 parameters are needed. Key parameters are export to the benthos, POM degradation, diatom Si stoichiometry related to succession, and microzooplankton grazing. Notice that the model is a tool to improve knowledge, and to arrive at fluxes (primary production etc.) and carbon budgets from measured values. The trophic efficiency is up to 36% in the case of a diatom loop, but in a microbial network it is only 3%.... The N and P budget in the Southern Bight covered by MIRO is fuelled by the river Scheldt, but regeneration sources are important too.

*Interestingly (note added after the Savannah meeting), Dutch M. Sc. student **Inge Folmer** (University of Utrecht) recently won the prestigious Escher Prize for "best doctoral research" with the description of a biogeochemical model of the Westerscheldt; she worked closely together with the mathematics-trained Dr David Rodriguez Aguilera. Her model, in which hydrodynamical and biogeochemical characteristics are coupled, is an extended version of the one-dimensional model of Pierre Regnier. Inge is now working at the Université libre de Bruxelles (Belgium) where she continues her modelling efforts. Modelling of the Westerscheldt is not a goal per se, because the downstream compartment of this estuary is the coastal North Sea with its succession of diatoms and* Phaeocystis*, the plankton groups that should be treated as inter-related entities.*

The current SWAMCO's structure is similar to MIRO, but of course the sediment in the Ross Sea is at considerable depth so the associated processes are not considered here. The *Phaeocystis* module contains colony growth and mucus (3 state variables); mucus is also considered a pool for energy of the colony cells. In Schoemann et al. the following parameterisation is described: temperature regulation, low-high light affinity, affinity for phosphate (high, low saturation constant), Fe contents of cells and mucus and Fe:C ratios (the variation of which is under investigation), losses (no sinking, except as aggregates at the end of

blooms; no grazing on colonies), thresholds for colony disruption. SWAMCO runs have been made for the Southern Ocean, with *Phaeocystis antarctica* and especially its role in air-to-sea exchange of CO_2 in the Ross Sea. Terms such as export of POC and its C:N:Si:Fe ratio and the opposite process of upwelling are structured in the 1-D CLIO-SWAMCO biogeochemical model, with constraints such as meteorological forcing, input of bioreactive Fe, and sequestration of Fe in snow that is set free following snow melt in spring. Model runs are validated with material obtained during the AESOPS cruises: predictions of the magnitude of *Phaeocystis* blooms are compared to field data. One result: without "biology" the Ross Sea would be a source of CO_2, but *with* "biology" it is a sink because of the material flux downward.

Bernard Patten introduced his contribution to the studies of the group of Peter Verity of Skidaway Institute of Oceanography, Georgia, USA, that focus on *Phaeocystis* as a biocomplex life form on a biogeochemically complex planet. Dr Patten started with an introduction to modelling in general: "the essence of modelling is simplification". The purpose of his part of the work of Verity's group is to describe a conceptual life-cycle model for *Phaeocystis* and to explain how this model guides research on biocomplexity of pelagic ecosystems. For further information on network environmental analysis see Patten, B.C., 1978: Ohio J. Sci. 78: 206-222 in which environments are described as networks, with matter and energy transfers with relationships and transactions. In short: networks of *afferent* and networks of *efferent* transactions. This leads to complex adaptive hierarchical systems, with, for each compartment and component, a model with unit inputs etc. The structural analysis of networks is manyfold: pathway analysis, throughflow analysis, storage analysis, control analysis ("balance of nature"), and utility analysis..... the latter measuring direct and indirect values of costs and benefits conferred to objects and subjects by their participation in networks. The principles behind all this are called the "cardinal hypotheses":

network path proliferation (pathlengths lengthen)
network non-locality (direct over indirect causality)
network holo-control
network homogenisation
network amplification (through-cycling)
network unfolding
network synergism (dominance of indirect over direct benefits/costs)
network mutualism (interactions)
network aggregation (order of the system)
network enfolding (indirect causality into direct results)
network holo-evolution ("Gaia"-like)

All this forms the bio-feedback basis of self-organisation in plankton ecosystems, and *Phaeocystis* is an ideal organism group as a model complex adaptive hierarchical system if we wish to develop insight into a set of regulating factors important in generating the patterns of *Phaeocystis* life-cycle dynamics as observed in nature.

Stuart Whipple has written a manuscript that may be available soon. He uses 15 compartments, from solitary cells all the way up to senescent large colonies (*sensu* Kayser, Rousseau, and Peperzak).

Dr Patten reminded us that traditional views of the world are not enough, and what we miss can be learnt from models, preferably models that even include the behaviour of organisms *a la* Mark Hay's "smell" notion (e.g., snails smell their predators (crabs) and stop eating.... so algae bloom!). The models lead to critical points in the life cycle useful for experiments such as those done in Norway in 2003. The idea could be described like this: using conceptual modelling of *Phaeocystis* to guide a research team's study programme. The question remains: do we need all this complexity to learn things? Could we, for example, skip all transient stages, and/or take only the ecologically relevant parts? As a parallel: "where to strike the balance between "highways" versus "local roads" in a city?"

However all this may be, it can be concluded that models motivate science and the exporation of complexity: conceptual modelling is "organised brainstorming", a philosophically different approach from "standard" modelling", although the latter category also is a feedback system of modelling versus testing through experimentation, as was made clear by the first speaker (Christiane Lancelot).

4. Discussion: the "Deliverable" to SCOR

The discussion was focussed on the planning of activities of the last, third year of our Working Group. The webpage, long overdue, will soon be a reality because Dr. A.G.J. Buma is willing to hook a SCOR WG #120 Information Bulletin to the webpage of the marine biology department of the University of Groningen, The Netherlands. The report that you are reading can be found there soon; new information for the Bulletin can be sent to a.g.j.buma@biol.rug.nl; she can inform you how to reach the Bulletin. See for further information under 4.4, below.

The work necessary to end the life of the Working Group with a "deliverable" to SCOR was also discussed in Savannah. Most participants mentioned a "Gordon"-type conference as the final action. Timing: September 2005, late in the year because the spring is (in the northern hemisphere) the *Phaeocystis* season; 2005 seems to be appropriate because the invitation to join WG #120 was sent in September 2001 (first meeting was in Norwich, UK, in 2002). At the conference, the state of the art at that time can be presented, maybe in parallel sessions resulting in workgroups focused on information needed to eventually "feed" models. Our field of interest is really broad: as we saw during the meeting in Savannah we go all the way from genes to climate, placing "our" *Phaeocystis* in the context of biodiversity but also in the framework of international programmes that will be on their way by mid-2005 (SOLAS, IMBER; Science Plans and Implementation Strategies now available). Reviews should be

presented during the conference because many *Phaeocystis* issues have not been reviewed since 1994: particle flux; climate issues; virus issues; infochemicals and toxins (never reviewed so far....). Several model types will be ready to be discussed by mid-2005: the ones presented during the Savannah meeting of 2003 can be a major input during the **"*Phaeocystis Mega-symposium*"** as the final Working Group meeting has already been called. The product of the conference should be a Proceedings Book (title to be decided: striking enough to draw much attention of the scientific community at large) edited by a few members of SCOR Working Group #120.

Funding from the European Commission will be hard to obtain, although the EC tends to be positive towards cooperative projects with non-European citizens (USA, etc.). Jacqueline Stefels will look on the EU Web site. The possibility of partial SCOR funding has to be discussed with our SCOR contact person, Dr Ed Urban.

4.1. List of Issues to be presented at the Conference (Sept. 2005)

The "flavour" of the Savannah meeting was the feeling that we covered all: from molecules to climate. The organisation of the chapters listed below reflects this feeling of a comprehensive treatment of *Phaeocystis*. Those mentioned below could possibly contribute; most have not been approached yet.

1. **"Taxonomy"** . This title should cover items such as "history" and molecular clocks (*dixit* Linda Medlin: these clocks say that *Phaeocystis* is far more ancient than Coccolithophorids....), evolution of the colony, biogeography, changing distributions with global change, shifts from diatoms to *Phaeocystis*, methods to detect such phenomena (often overlooked material: the Continuous Plankton Recorder Survey that has run since 1948, covering the whole North Atlantic Ocean and the North Sea; the samples have been screened for *Phaeocystis* as to seasonal and annual distribution shifts around the British Isles, and off the Dutch coast). Names of potential contributors: Marchant, Medlin.
2. **Life cycle/cell types.** Potential contributors mentioned: Veldhuis, Chrétiennot-Dinet, Rousseau, Peperzak, Verity.
3. **The virus connection.** Workers at Royal NIOZ and in Bergen (Norway).
4. **Grazing.** This includes micro- and mesozooplankton. Contributions possibly from Nejstgaard, Verity, Tande, Kam Tang, Koski, Lang, Steinke, Stamhuis, Smalley..... includes also the infochemical groups.
5. **Vertical Transport.** This topic must also been seen in relation to climate issues. Wassmann..... who will find others.
6. **Mucus, carbohydrates and bacterial degeadation, TEP.** Contributions possible from Becquevort, van Rijssel, Alderkamp, Passow, Xavier Mari, Dutz.
7. **Toxicity and allelopathy.** HAB group; also van Rijssel, Jeremy Long, Qi, Eilertsen..... others will be approached in the next months.

8. **Physiological ecology and ecophysiology.** Also "bottom-up" issues, including the iron story; light. Contributions could come from Schoemann, Veldhuis, Rousseau, Stefels and Elzenga, Wassmann, Walker Smith, van Leeuwe...
9. **DMS(P) and trace gases in relation to climate.** Includes the role of *Phaeocystis* in the carbon cycle, in relation to climate. Includes modelling under water and in the atmosphere for the fate of derivatives such as MSA, and atmospheric and cloud chemistry. Stefels, Belviso, Malin, Lancelot, Levasseur, Bopp, Vézina, Blanchet, Gondwe, Kumar are just a few who might contribute.
10. **Modelling.** Verity group effort (see above, Patten's contribution), but also regional modelling, for example (see above), the Ross Sea (overview of regional models), models to understand life cycle phenomena, comparison of models as done by Belviso during the Savannah workshop. What level of complexity is needed for the modellers? How to deal with *Phaeocystis* peculiarities? How to deal with chaotic behaviour in plankton systems: non-linear modelling to cover the complex non-linear interactions between ecosystem components? Names mentioned as potential contributors: Gabric, Belviso, Lancelot, Arrigo, Whipple, Meyer-Reimer.
11. **Approaches to modelling and application to *Phaeocystis*.** Modellers will decide whether or not 10 and 11 should not be merged into one chapter.

Chairs of the Groups

The chairpersons should look around for all colleagues anywhere in the world (also Japan, Russia, New Zealand, Australia, South America, Asia, Africa.....) who are active in their area of interest. The following names were mentioned for "chairs":

1. "Taxonomy": Medlin
2. Life cycle: Rousseau
3. Virus: Batbak/Nejstgaard
4. Grazing: Nejstgaard
5. Vertical export: Wassmann
6. Mucus: Alderkamp
7. DMS(P): Stefels
8. Toxicity" van Rijssel
9. Physiological ecology: Verity or Schoemann
10. Modelling: Lancelot
11. Concluding chapter: recommendations, and statements *during* the symposium. Verity promises to collect these. This part (chapter 11) should contain a summary section where the climate link (SCOR's interest) is described clearly, with speculations on the meta-level. Future developments should be discussed here, to mention just *one*: **optics** (characteristic signals of colonies for detection by satellite remote sensing). A **socio-economic paragraph** would be welcome to discuss the alleged problems caused by blooms to the tourist and fishing industry: how much of the damage (is there any....) is caused by *Phaeocystis*, how much by other

blooming plankton species, some of which may have a similar "slimy" appearance.

4.2. Product of the Conference: a Book

The product of the conference will be the deliverable to SCOR: a book, to be published as soon as possible after the end of the meeting. Authors of chapters should provide draft manuscripts by early spring 2005. This leaves a few months for editors to write the introduction and conclusion chapter. Chapters can be discussed during the conference, then updated accordingly and sent out to external referees right after the conference. Chapters can be 20 pages long (figures included). The following should be done:

- editors (see below) suggest senior authorship
- focus on what's new and where it's going to
- milestone findings of the past
- keywords as aids in writing and for search in the future
- abstract is a must
- book title: not decided yet, eventually chosen from a set of draft titles

Once again: manuscripts must be ready at the conference (September 2005), so they can be updated depending on new "facts and figures" presented at the meeting. Authors should send draft manuscripts as pdf files to others for cross-referencing already in June 2005, no later; in fact, the manuscripts must be ready in March, to be reviewed in June 2005. No more than 4 months later the material should be submitted to the publisher so the book can be on the market 6 months after the conference. Reminders will be sent before the summer of 2004, rather soon.

Editors of the book: Gieskes (chair, SCOR Working Group #120), Belviso (co-chair), Lancelot, Verity, Stefels.

The publisher may well have his or her own ideas and wishes regarding the "flavour" of the book. A publisher could be Kluwer, or Springer, or a smaller company such as "bioPress" (Medlin sends an e-mail address), Blackwell, Elsevier, Taylor and Frances (who published the *Haptophyceae* book).

Costs of a publication has been estimated at around 300 Euro per book of 500 pages, but costs depend on who will be the publisher, how many copies..... illustration type, etc. SCOR will be asked if they fund publications like this one.

4.3. Where and when will the conference be organised?

This important topic was discussed at the very end of the Savannah meeting by just a few attendants. Many places were rejected, for many reasons. A very good, really serious option is

Tromsoe, in the north of Norway. In September the hotel and meeting facilities seem to be excellent (for example, hotel and conference rooms in one building), the climate is still favourable, and costs of travelling are (this is really unexpected) lower than costs involved with travelling to many other places that were discussed, mainly in view of major attendance from European countries; for others (from Australia, New Zealand, China, India) it does not make a difference: *everything* is far away for them.... Connections to Tromsoe are rather convenient from anywhere. *Another option* is a location in The Netherlands; Haren has been suggested as a good and even appropriate spot, for several reasons. This city, that houses the Marine Biology Department of Groningen University, can be reached somewhat better than Tromsoe, namely directly by train from Amsterdam (just over 2 hours' train ride from Schiphol airport). The feasibility of financial support for the Haren location is being investigated at the moment of writing.

4.4. Communication: Web site and mailing list

In order to improve communication between the working group members, corresponding members, and others interested in SCOR Working Group #120 a mailing list and a Web site will be created.

The mailing list and the Web site will be set up by the University of Groningen, the latter to be hooked up to the Web page (managed by Dr Anita G.J. Buma, mail a.g.j.buma@biol.rug.nl) of the marine biology department of the University of Groningen, The Netherlands, as mentioned already above. To access this site:

http://www.rug.nl/biologie/onderzoek/ Next, switch to the English version, and go to

"Research", click "Research Groups", and choose "marine biology", go to "news/jobs/announcements"

The Web site will contain:

- minutes of the meeting in Savannah (the present document)
- introduction to the mission of our group
- information on the thematic sub-working groups
- eventually a list of institutes and persons working with *Phaeocystis*
- list of *Phaeocystis* strains and cultures maintained, and where
- links to related projects
- database, with *Phaeocystis* reviews and papers in pdf format supplied by visitors to the Web site

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

Terms of Reference:

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

Chair:

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Full Members		**Associate Members**	
Chris Garrett	CANADA	Molly O'Neil Baringer	USA
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 2004

This working group was formally approved by SCOR in October 2002 and held its inaugural meeting at the site of the IUGG General Assembly in Sapporo, Japan. The working group membership is currently at full strength as follows:

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

Associate Members
Molly O'Neil Baringer (USA)
Sybren Drijfhout
Gary Egbert (USA)
Ann Gargett (USA)
Theo Gerkema (Netherlands)
Mark Merrifield (USA)
Rob Pinkel (USA)
Barry Ruddick (Canada)

The inaugural meeting was held too late in summer 2003 for the meeting summary to be included in the 30 June 2003 annual progress report. The summary is appended to this report as Attachment I and summarizes the issues discussed during that meeting.

Activities since the inaugural meeting have focused on organizing an international conference in order to better evaluate the state of ocean mixing research. Plans for this conference, which will be held in Victoria, Canada on 11-14 October of this year, are now fully developed. The venue is selected, invited speaker slots are filled, and the event is open for registration. A summary description of the conference is appended as Attachment II. (SCOR set up a Web site for the conference and is handling registrations.) An agreement is in place with Pergamon Press to publish a conference proceedings volume as a special issue of *Deep-Sea Research Part II.* This publication medium was selected for its reputation as a high quality, peer-reviewed journal, its global distribution, and its minimal cost to contributors. The proceedings volume will comprise a major portion of the final report for Working Group 121.

Some issues discussed during the inaugural working group meeting remain unresolved. Input gained during the conference, particularly during the many organized poster and discussion sessions, will provide essential direction.

The second formal meeting of Working Group 121 is scheduled to take place in Victoria, Canada on Friday, 15 October 2004 directly following the close of the Conference on Ocean Mixing. Discussion during this meeting is anticipated to focus on information gained and recommendations made during the course of the conference. In particular, we will be looking at issues that might not be covered in specific work submitted for inclusion in the proceedings volume and will discuss ways to include them in the working group's documentation.

Robin Muench, Chair, IAPSO/SCOR Working Group 121

ATTACHMENT I

Summary of 1st Meeting
IAPSO/SCOR Working Group 121 on Ocean Mixing
Saturday 5 July 2003, Sapporo, Japan

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 were 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" who 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. 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

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.

(Issued 28 July 2003)

ATTACHMENT II

SYMPOSIUM ON OCEAN MIXING – The First Announcement

Organized by: ***IAPSO/SCOR Working Group 121 on Ocean Mixing***

Location: Victoria Conference Centre
Victoria, Canada
11-14 October 2004

Scientific Advisors: The Working Group 121 membership (both Full and Associate) consisting of *Molly O'Neil Baringer* (USA), *Hans Burchard* (Germany), *Sybren Drijfhout* (Netherlands), *Gary Egbert* (USA), *Ann Gargett* (USA), *Chris Garrett* (Canada), *Theo Gerkema* (France), *Toshiyuki Hibiya* (Japan), *Peter Killworth* (UK), *Trevor McDougall* (Australia), *Mark Merrifield* (USA), *Eugene Morozov* (Russia), *Robin Muench* (USA, Chair), *Rob Pinkel* (USA), *Barry Ruddick* (Canada), *Louis St. Laurent* (USA), *David Salas de Leon* (Mexico) and *Anders Stigebrandt* (Sweden)

Conference Objectives:
Our understanding of ocean mixing processes has generally lagged our grasp of large-scale ocean circulation. Perhaps the greatest impact of this knowledge gap has been the inability of large-scale ocean models to parameterize these small-scale processes adequately. This lack of adequate parameterization has, in turn, limited the ability of models to recreate all pertinent aspects of the large-scale circulation or to provide credible predictions of reaction to various climate change scenarios. Recently, though, a number of elegant studies involving methods such as tracer releases and utilizing newly developed instrumentation have started to close the gap in understanding between the very large-scale and the very small-scale ocean processes. We are now acquiring a quantitative, as well as a qualitative, understanding of the interactions among mean and fluctuating currents, internal waves, seafloor topography and roughness, stratification, and both diapycnal and lateral mixing.

As a result of these developments over the past decade, we are now at a point from where we can see a rapid growth in our quantitative understanding of ocean mixing and in our ability to model the large-scale ocean. The challenge will be to coordinate developments in these two areas so that we can obtain the greatest possible benefit to both, and to oceanography in general. This was a primary sentiment underlying the formation of Working Group 121. The planned symposium is seen as a mechanism to encourage and accelerate the needed coordination through exchange of small-scale results within the context of large-scale processes. This exchange will rely on the active participation of internationally known experts in the fields of ocean mixing and large-scale modeling. Equally important is the participation of younger researchers, who will be responsible for the future nurturing of ideas which, it is hoped, may surface during the course of the symposium.

Structure of The Conference:
The conference will utilize invited presentations and contributed poster displays for development of ideas and results. The invited presentations are intended to provide points of focus and will consist primarily of overview talks addressing the major issues involved with ocean mixing, summarizing our present understanding, and speculating on future needs and trends. The poster displays should provide the material addressing the primary focal points and are anticipated to consist primarily of new results, program-specific and otherwise. Ample time will be provided, during coffee and lunch breaks and during dedicated poster sessions, for discussions and interactions among conference participants.

Expenses:
Funds for helping to defray conference costs are being requested, through formal proposal submission or request, from different agencies and countries. A conference fee, amount to be determined, will be charged to conferees to offset costs for refreshments and incidentals. It is planned to offer assistance in defraying travel and registration costs to qualified and needful attendees, especially to graduate students, postdoctoral fellows, and scientists from developing nations.

The Venue:
Victoria is situated on the southern tip of Vancouver Island, on the Strait of Juan de Fuca, in the province of British Columbia, Canada. Victoria is conveniently located with respect to Europe, Asia and the Americas and is easily accessed via international airports in Seattle, USA or Vancouver, Canada. A short connecting flight or scenic ferry ride serves to connect both of these airports with Victoria. The conference has been scheduled outside the summer tourist season in order to reduce lodging costs and ensure availability. The Victoria Conference Centre is a large, modern facility that will be well suited for this conference. Details can be found on their website at http://www.victoriaconference.com.

The Victoria region has a proud history of oceanographic research, being the site of both the University of Victoria and of the Institute for Ocean Sciences in nearby Sidney. Some of the earliest, pioneering observations of ocean turbulence were made in nearby tidal channels.

Conference Proceedings:
The conference proceedings will be published as a collection of peer-reviewed papers in one or more dedicated issues of *Deep-Sea Research II*. This medium combines global distribution of results with minimal publication costs and a reasonably short turnaround between the conference and final publication.

Contact Information:
Website for updated information: http://www.jhu.edu/scor/WG121Symposium.htm
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(Announcement published 4 November 2003)

IAPSO / SCOR OCEAN MIXING CONFERENCE
11 – 14 October 2004 – Victoria, British Columbia, CANADA

CONFERENCE PROGRAM

SUNDAY, OCTOBER 10, 2004

1400-1800	Registration and set up posters for the Monday session

MONDAY, 11 OCTOBER

0800-0900	Registration
0900-0915	Convene the conference (welcome, opening remarks, logistics announcements, etc.)

Session 1: Global concepts and large-scale models [Chair – P. Killworth]

0915-0945	Insights from simple concepts – the global picture [Carl Wunsch]
0945-1015	Mixing rates inferred from large-scale distributions [Anne-Marie Treguier and Bruno Ferron]
1015-1045	**Coffee Break**
1045-1115	The importance of sub-gridscale process representation in models [Bob Hallberg]
1115-1145	New closure models for diapycnal and isopycnal mixing [Vittorio Canuto]
1145-1215	Can eddies do it all? [John Marshall]
1215-1230	Discussion & make up time
1230-1430	**Lunch break/free time**
1430-1500	Topic and author TBD
1500-1530	Lateral processes derived from observations [Raf Ferrari]
1530-1800	Poster session #1, with refreshments
1800	Adjourn for the day

TUESDAY, 12 OCTOBER

0800-0900	Registration as needed, and poster setups
0900-0915	Convene (announcements, etc.)

Session 2: Observations [Co-Chairs – Lou St. Laurent and Trevor McDougall]

0915-0945	Observations of diapycnal mixing rates [Jody Klymak]
0945-1015	The technology of mixing observations [Jim Moum]
1015-1045	**Coffee Break**
1045-1115	Mixing derived from tracer release studies [Jim Ledwell]
1115-1145	Mixing derived from Lagrangian observations [Eric D'Asaro]

1145-1215	Inferring global ocean mixing with finescale internal wave-based parameterizations [Eric Kunze]
1215-1230	Discussion & make up time
1230-1430	**Lunch break/free time**
1430-1500	Mixing in the Southern Ocean [Karen Heywood and Alberto Naveira-Garabato]
1500-1530	Mixing in the Arctic Ocean [Mary-Louise Timmermans]
1530-1800	Poster session #1 (cont'd), with refreshments
1800	Adjourn for the day

WEDNESDAY, 13 OCTOBER

0800-0900	Poster setups
0900-0915	Convene (announcements, etc.)

Session 3: Processes [Chairs – Chris Garrett and Anders Stigebrandt]

0800-0900	Poster setups
0900-0915	Convene (announcements, etc.)
0915-0945	From internal waves to mixing [Toshi Hibiya]
0945-1015	Nonlinear internal wave interactions and spectra [Yuri Lvov/Kurt Polzin]
1015-1045	**Coffee Break**
1045-1115	The mixed layer and internal wave energy fluxes [Al Plueddemann]
1115-1145	Internal tides [Lou St. Laurent]
1145-1215	Numerical model studies of internal tides [Sonya Legg]
1215-1230	Discussion & make up time
1230-1430	**Lunch Break/Free Time**
1430-1500	Spectral evolution in numerical models [Jen Mackinnon]
1500-1530	Where is the internal wave energy dissipated? [Adrian New]
1530-1800	Poster session #2, with refreshments
1800	Adjourn formal sessions for the day
1900	Conference Banquet in the Empress Crystal Ballroom, with Guest Speaker [Walter Munk]

THURSDAY, 14 OCTOBER

0800-0900	Poster setups
0900-0915	Convene (announcements, etc.)
0915-0945	Double diffusion [Ray Schmitt]
0945-1015	The equation of state; does it matter? [Trevor McDougall]
1015-1045	**Coffee Break**
1045-1115	Density flows [Anna Wåhlin]
1115-1145	Boundary layer – interior interactions [Erika McPhee-Shaw]
1145-1215	Biogeochemical considerations: What can they provide us, and what do they need? [Bill Jenkins]

1215-1230	Discussion & make up time
1230-1430	Lunch Break/Free Time

Session 4: Towards the future [Chair – R. Muench]

1430-1500	What are some key science issues? [Dan Rudnick]
1500-1530	New methods for measuring mixing [Rob Pinkel]
1530-1600	Open round-table discussion on the subject of future priorities [led by the WG121 membership]
1600-1800	Poster session #2 (cont'd), with refreshments
1800	Final Conference Adjournment ceremonies, sharing of credits (and blame)

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

Terms of Reference:

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

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Eric Wolanski (Australia)

Associate Members

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Executive Committee Reporter: Laurent Labeyrie

SCIENTIFIC COMMITTEE FOR OCEAN RESEARCH (SCOR)
LAND-OCEAN INTERACTION IN THE COASTAL ZONE (LOICZ)
INTERNATIONAL ASSOCIATION FOR THE PHYSICAL SCIENCES OF THE OCEANS (IAPSO)

FIRST REPORT - JUNE 2004
WG 122
MECHANISMS OF SEDIMENT RETENTION IN ESTUARIES

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1.- Introduction

The interaction between fresh and salt water plays a critical role in determining the dynamics of estuarine circulation and sediment transport. Considerable research has been carried out on the formation of turbidity maxima, which form near the inside tip of the salt wedge as a result of strong density gradients. Only a few studies have addressed the role of turbidity maxima and other sediment retention mechanisms and the extent to which they are influenced by *i)* the geomorphology of the estuary, i.e. the presence or absence of tidal flats, marshes, mangrove wetlands, and the morphology of tidal channels, and *ii)* the propagation of the tidal wave along the estuary and the asymmetry and change of water level, currents, and change of tidal range. The interaction between the estuarine geomorphology, on one hand, and river and tide advection processes, on the other, are highly nonlinear, making it almost impossible to predict the extent to which an estuary will retain sediment or deliver sediment to the coastal ocean.

Sediments are delivered into the coastal zone by rivers, although, locally the effect of waves, tides, and storm induced coastal erosion and alongshore transport are also important factors in establishing the sediment budget. Rivers and estuaries retain and deliver sediment to the coastal ocean at different rates. Rivers/estuaries are known to supply a highly variable portion of the riverine sediment load into the coastal ocean. Sediment not exported to the ocean are retained

within *i)* the tidal portion of the river, *ii)* the estuary proper, *iii)* adjacent tidal flats and wetlands, and *iv)* deltas. Hardly ever has sediment retention been established along the total length of an estuary and explicitly for the different portions of the estuarine system from where tides are first measurable (typically ~100 km upstream) until the coastal ocean. It should be noted that the tidal portion of most estuarine systems typically exceed the portion of the estuary with measurable diluted salinity by a factor of 5-50.

The extent to which the river sediment load is retained within the lower reaches of a river system and the fraction of the sediment load that eventually escapes into the coastal ocean are a function of changing geomorphology as a result of a struggle between the relative energy supplied by the ocean-directed discharge of water and sediment and the dissipative energy of marine forces (tides and waves) acting on the discharge. The balance seldom reaches equilibrium as the relative energies of both fluvial and marine mechanisms continuously change on different time and space scales.

Many different sediment trapping mechanisms act individually and in combination to retain sediment in estuaries. All can be related to the interplay between geomorphology and the major dynamic "participants", including tides, waves, river discharge, groundwater discharge, longitudinal density gradients, vertical stratification, atmospheric forcing, and sediment load. The role of geomorphology change is often downplayed or ignored although it may be the most important factor. In fact, the shape of the coast and the estuary defines how tides propagate along the estuary.

As a corollary, the sediment trapping mechanisms vary along the estuarine zones from the coastal ocean to the tide-less lower river, because both geomorphology and the geomorphology-induced modifications of the dynamic factors vary. Measurements made in a single estuarine cross-sections or along a longitudinal transect yield the end results of the interplay between geomorphology and the dynamics factors. It is usually very difficult to identify individual trapping mechanisms.

The question should be asked is how different sediment trapping mechanisms, and mechanisms in synergism, affect the sediment retention index (R_i, Perillo, 2000; Perillo and Kjerfve, 2003) along the estuary. R_i is a function of space and time, because each factor, and their combined effects, are also functions of space and time. The most important factors probably include *i)* overall and local geomorphology, *ii)* overall sediment load and local sediment storage/erosion processes, *iii)* within-estuary tidal range, water level, and current variability, *iv)* tidal pumping, *v)* formation of turbidity maxima, *vi)* vertical and longitudinal salinity (density) gradients, *vii)* nearshore coastal dynamic processes, *viii)* climate dynamics, *ix)* relative sea level change, *x)* sediment-biological interactions, and *xi)* human structures in the estuary and coastal ocean.

Further complexities arise when time variability is considered. Events, such as exceptional precipitation in river basins, hurricanes, the El Niño-La Niña cycle, and earthquakes are capable of producing large-scale modifications to the dynamic sediment equilibrium in estuarine systems.

For example, the sediment input into the Chesapeake Bay during a couple of weeks of intense rainfall associated with the stalled Tropical Storm Agnes in 1974, has been estimated to equal the "typical" sediment input to the bay for 75 years.

In as much as natural processes are the major mechanisms controlling the dynamics and retention of sediment in estuaries, anthropogenic influences also require consideration. Sediment load is certainly controlled by dams. There currently are more than 2 million dams in existence globally. Other anthropogenic processes that influence sediment load, sediment retention, and estuarine geomorphology include irrigation, land clearing and deforestation, water and hydrocarbon extraction, sediment dredging and dredge material disposal, and artificial structures along river channels, within estuaries, and at estuarine mouths. For example, artificial structures such as harbors, jetties, and breakwaters have little or no capability to adapt to ever-changing water flow and sediment transport dynamics. Thus, the artificial "geomorphology" created by humans will only deteriorate with time, without becoming adapted to a system equilibrium. Artificial structures not only control circulation but actually change sediment erosion/deposition and the estuarine geomorphology through modifications of sediment trapping mechanisms and sediment retention.

2.- WG 122 Activities

2.1.- Constitution of WG

Although WG 122 was established in September 2003, actual constitution of their members was completed by March 2004.

2.2.- Meetings

The first meeting of WG 122 will be held at the University of Algarve, Faro, Portugal on September 12-16, 2004. The meeting will be hosted by Dr Alice Newton and supported by funds obtained from SCOR, LOICZ and a special grant from the US Office of Naval Research. The University of Algarve is also providing extra support with meeting room facilities and lunch for the participants.

2.2.1.- Meeting Goals

The first Working Group 122 workshop will focus on evaluation of sediment budgets and what can be deduced from the budget approach about retention of different sediment size fractions in estuaries, and also the processes responsible for sediment retention. This synthesis will cover local and global budgets and consider estuaries from the Tropics to the Arctic, geographically covering all continents with exception of Antarctica. The Working Group will summarize the present state of knowledge on sediment retention in the different estuarine zones from the lower reaches of rivers to the coastal ocean, and will compare the river sediment load to the flux of sediment transported into the coastal ocean as a function of different dominant mechanisms. The Working Group will also synthesize what is unknown and therefore identify questions and research needed to remedy deficiencies.

Furthermore, the meeting will cover basic organizational procedures for the WG members as well as the definition of the data base structure, advance of the WG web page under development, and future activities.

The workshop in Faro is the first meeting out of three planned meetings for this working group. The initial objective is to review and synthesize the knowledge of the state of retention of sediments in estuaries, compare sediment budgets for systems from different parts of the world from the Tropics to the Arctic, and compare and order the dynamic processes that dominate under different conditions.

2.2.2.- Meeting Program

The meeting is scheduled to last for five days with the participants asked to prepare overviews. The program consists of:

Sept 11	Participants arrive, official opening of meeting and icebreaker
Sept 12	Presentations of invited overviews on sediment budgets in estuaries
Sept 13	Round table discussion: Mechanism for sediment retention in estuaries Round table debate: Forecast of sediment load, retention, and export
Sept 14	Round table debate: Discussion of directions and assignments for meeting #2
Sept. 15	Round table debate: Organizational activities, database, etc.
Sept. 16	Field trip to a local estuary and concluding banquet. Participants depart

2.3.- Web Page

A web page for WG 122 is under construction within the server of the Centro Regional de Investigaciones Básicas y Aplicadas de Bahía Blanca (CRIBABB), Argentina, where the Instituto Argentino de Oceanografía (IADO) is located. This server is the main Argentine educational node for the southern portion of the country. At this time we are obtaining basic information, references and links from WG members and establishing the structure of the web page.

3.- Publications

Perillo, G.M.E. and Kjerfve, B., 2003. Mechanisms of Sediment Retention in Estuaries: New SCOR-LOICZ-IAPSOWorking Group 122 launched. LOICZ Newsletter 29:5-6.

4.- References

Perillo, G.M.E., 2000. Sediment budgets and fluxes in estuarine and coastal areas. IGBP-LOICZ Water Workshop, Boulder, Co. (oral presentation).

Perillo, G.M.E. and Kjerfve, B., 2003. Mechanisms of Sediment Retention in Estuaries: New SCOR-LOICZ-IAPSOWorking Group 122 launched. LOICZ Newsletter 29:5-6.

5.- Budget 2005

For the year 2005 the WG is planning a second meeting in Bahía Blanca, Argentina. The dates will be arranged at the Faro meeting, but it is estimated to be in September 2005. This meeting will follow approximately the same scheme of the one we are planning for Faro, having some introductory invited talks and round-table discussions to advance the definitions of the terms of reference. The meeting will include a visit to the Bahía Blanca Estuary, an example of an estuary that is exporting sediment with some worldwide unique features.

To organize the meeting we request $7,500 from SCOR that will be matched by LOICZ and we are planning to request further support from ONR which has supported the Faro meeting as well. Local support from the Instituto Argentino de Oceanografía is insured to cover meeting room and audiovisual expenses and reduced costs for lunches.

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

Terms of Reference:

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

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PACE WG Meeting 1
4/25/04 Villefranche-sur-Mer
Summary

Members present: Catherine Kissell, Jean Lynch-Stieglitz, Juan-Carlos Huerguera, Elena Ivanova, Jerry McManus, Olivier Marchal, Jess Adkins, Rainer Zahn

Guests: Eystein Jansen (PAGES/CLIVAR), Laurent Labeyrie

The working group was welcomed, and the charges of the group briefly reviewed:

> (1) Assess potential of existing proxies—are they good enough?
> (2) Assess existing data coverage—what can we say about past ocean circulation with existing data?
> (3) Is a large-scale coordinated field program (PACE) warranted based on the above? What would be the time and space covered by such an experiment? What proxies should be emphasized?

We had brief presentations (Jerry, Jess, Catherine, Rainer) of the "state of the art" of several proxies for past ocean circulation, with interspersed discussion that extended for much of the day. Proxies covered included radiocarbon, porewater $\delta^{18}O$ and chloride, $\delta^{18}O$ and Mg/Ca of foraminifera. The potential for these proxies in tracing water masses as well as reconstructing the density structure of the ocean was explored. We also discussed Pa/Th, which can be used to understand the residence time of water masses on broad spatial scales. We reviewed the use of carbon isotopes and trace metals in foraminifera, as well as Nd isotope ratios in sediments as water mass tracers. We also talked about using grain size and sediment composition to infer near bottom flows.

Olivier also discussed what would be required for reconstructing ocean circulation using inverse techniques. He emphasized that any method needs to take into account well-quantified estimates of errors in the data as well as the models. He felt that reconstructing past density (if it could be done accurately) would provide a powerful dynamic constraint. Tracers with well-known source functions such as radiocarbon could also be particularly useful, as well as Pa/Th in sediments. Tracers which involve reconstructing the biological carbon cycle more directly can be used as well, but introduce additional model uncertainties.

Eystein told us about his work with PAGES/CLIVAR. While this organization will continue to sponsor workshops and other synthesis activities, there is a general sense that PAGES/CLIVAR data products are also important. There is the possibility that a resulting field program (PACE) could fall under the PAGES/CLIVAR umbrella.

We had some discussion of the scope of our program. There is general agreement that the last 40,000 years or so provide an interesting laboratory with several possible large changes in ocean circulation. By the end of this working group, we will need to focus in on the particular time periods and resolution

required by PACE. There was also discussion about whether PACE should be focused on one ocean basin or be global in scope. It was agreed that this issue needs to be revisited after our workshop. We also discussed that our group can help to advocate for paleocirculation research efforts receiving time on various non-traditional research platforms (submersibles, pore water measurements from drill ships, etc.)

The next step for this working group is to organize a workshop on Past Ocean Circulation. This workshop has been tentatively set to take place in Atlanta during the week of March 21-25, 2005. We discussed that we'd like to have about 40 invited participants including paleoceanographers working on past ocean circulation, modelers of past ocean circulation, as well as a few modern observationalists who have experience designing programs to quantify present ocean circulation and its variability. We discussed the importance of keeping an open mind to all reasonable proxies at this stage, and making sure the speakers are able to address the calibration and errors associated with these proxies. Working group members will email the co-chairs with suggestions for invitees by the end of June. We intend to schedule a large amount of time for discussion of the presented research and consensus building for future efforts (which may involve breakout groups). The workshop will be open to all interested scientists and will include the opportunity to present posters.

The workshop will be followed by the next working group meeting, at which we will start the process of outlining the summary documents.

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

Terms of Reference:

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

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Report on the SCOR/IMAGES Working Group **LINKS**
"Analysing the links between present oceanic processes and paleo-records"

The WG was formally approved and installed in spring 2004. The first meeting of the new WG will take place in conjunction with the 8th International Conference on Paleoceanography (ICP-8) in Biarritz, France on 10 September 2004. A full day meeting is planned for this first workshop which will address the following topics.

Agenda of 1st LINKS Workshop:

- Introduction to the aims of the LINKS Working Group
- Introduction of members and their work
- Identification of focal themes for the WG (suggested issues):
    - What is the influence of phytoplankton blooms on sedimentary records of primary production?
    - How to detect changes in key species or functional groups? (development of new proxies)
    - How to detect changes in the carbon and nitrogen cycle? (integration of process studies, proxy analysis and modelling)
    - What are the linkages between iron, dust and phytoplankton now and in the past? (evaluation of hypotheses of the ocean's response to changing environmental conditions)
- Planning topics, participants, place and time for the following workshops
- Drafting of an outline of the workshop themes for the Web page and for newsletter communication

All full members of LINKS plan to attend the workshop and some additional members will presumably also participate, if they attend the ICP-8. The products of this first workshop will be

- plan and time table for the next workshops
- plan for publications
- Web page
- article for *EOS* and newsletters

Full Members of LINKS:
The following scientists are now accepted as full members of the group:

- Karin Lochte (Leibniz-Institut für Meereswissenschaften, Kiel, Germany, chair)
- Marie-Alexandrine Sicre (LSCE, Gif sur Yvette; France, co-chair)
- Carina Lange (Universidad de Conception, Chile)
- Frank Dehairs, (Vrije Univ. Brussels, Belgium),
- Roger François (Woods Hole Oceanographic Institution, USA)

- Raja S. Ganeshram (University of Edinburgh; UK)
- Alan Kemp (School of Ocean and Earth Science, University of Southampton; UK)
- Renate Scharek (Barcelona, Spain)
- Ein-Fen Yu (National Taiwan Normal University, Taiwan)
- Dieter Wolf-Gladrow (AWI, Germany)

Tentative budget:

2004
The 1st LINKS workshop it is held in conjunction with the ICP-8 and therefore some members do not require funding. The following funds are likely to be required for this meeting:

4 persons from Europe	ca. 500 US$ per person
2 persons from outside Europe	ca. 1500 US$ per person
10 x hotel costs	ca. 100 US$ per person/night
Estimated total costs	***ca. 6000 US$ for 2004***

2005
The second LINKS workshop will also be held in association with a major conference, most likely in the United States. Estimated costs for this workshop are:

5 persons from Europe	ca. 1000 US$ per person
1 person from Asia	ca. 1500 US$ per person
1 person from South America	ca. 500 US$ per person
10 x hotel costs	ca. 120 US$ per person/night
Estimated total costs	***ca. 8200 US$ for 2004***

2.3 Working Group Proposals

2.3.1 SCOR Working Group on Global Comparisons of Zooplankton Time Series

1. Background & Rationale

There is an increasing scientific and public focus on how climate variability and climate trends affect marine ecosystems. Important scientific questions include the qualitative character of the ecosystem responses ("what changes"), their amplitudes ("by how much"), and their timing and spatial and temporal scales ("when and where are rates of change strongest"). There is much accumulated evidence that living marine resources in individual ocean regions undergo strong, and sometimes abrupt, changes in stock size and productivity at roughly decadal intervals. This variability is associated with corresponding changes in the atmosphere, and in physical oceanographic, and lower-trophic-level biological processes and state variables. However, in general we do not know the mechanisms by which these changes occur, the relative importance of direct physical forcing vs. biological interactions, and if the dominant mode of biological feedback is "bottom-up", "top-down". or "wasp-waist" (Verheye and Richardson 1998, Cury et al. 2000, Tadokoro et al. in press). Nor do we know how to anticipate the timing and direction of the next major shift.

Perhaps the most provocative and influential example of large-scale, multi-year marine ecosystem variability has been the similarity in duration and phasing of major fluctuations in sardine and anchovy catch in widely-separated boundary current systems (e.g., Kawasaki et al. 1991; SCOR WG98 "Worldwide large scale fluctuations of sardine and anchovy populations" and Schwartzlose et al. 1999; the ongoing SPACC research program).

We are proposing a SCOR Working Group to do a similar global-scale comparison of low frequency variability of marine zooplankton communities. This idea grew out of a workshop convened by Ian Perry and Hal Batchelder during the recent "3rd International Zooplankton Production Symposium" (May 2003 in Gijon, Spain, co-sponsored by GLOBEC, PICES, ICES and the Spanish government). A summary paper from that workshop (Perry et al., in press) includes preliminary but provocative evidence for temporal coherence of zooplankton and climate variability in both the North Atlantic and the North Pacific (Fig. 1). There was a strong consensus at the Gijon workshop that a more detailed and more global comparison of zooplankton time series would be timely, technically feasible, and extremely useful.

Such an analysis must be an international cooperative effort – the relevant data sets are in many places and have been collected by many independent nations and agencies. However, many of the necessary data are available now, and the proposed Working Group could begin immediately. We are confident that we have grass-roots commitment by participating scientists. Endorsement and sponsorship by SCOR will help us attract and retain approvals and financial support from senior national agencies. We also expect to attract co-sponsorship and additional financial support in the form of travel funding for associate WG members (probably 3-5) from PICES, ICES, Census of Marine Life, and the national and international GLOBEC programs. We have been in preliminary contact with most of these organizations and programs (as of April 2004).

They agree with the need for such a group, and have confirmed their interest in and support for the activity.

2. The nature of the scientific opportunity

Why zooplankton?

For several reasons, multi-year zooplankton time series provide useful tools for examining climate-ecosystem interactions. First, mesozooplankton (about 0.1-2 cm body length) are a key link between primary producers and larger predators. Second, mesozooplankton are abundant, and can be quantified by relatively simple and intercomparable sampling methods. Third, and perhaps most important, demographic traits of zooplankton make them particularly suitable for analysis of interannual ecosystem changes. Life cycles of most species range from a few months to one year. Recruitment and mortality rates are slow enough that major population fluctuations are not missed by sampling at ~monthly intervals. But (unlike most fish and marine mammals) changes in population size are rapid enough to track seasonal-to-interannual changes in environmental conditions. Fourth, because few zooplankton taxa are fished, most zooplankton population changes can be attributed to environmental causes. Finally, because many fish are dependent on a zooplankton food source during their pre-recruit life history stages, zooplankton anomalies may be a useful leading indicator of what will happen to commercial fish stocks several years later (for two striking examples, see Batchelder et al. 2002 and Beaugrand et al. 2003).

Availability and diversity of zooplankton time series

Zooplankton time series of ten years or more in length are now available for many widely separated ocean regions (Table 1 from Perry et al. in press). The longest are the Continuous Plankton Recorder (CPR) surveys of the eastern North Atlantic (80+ years); the California Cooperative Fisheries Investigations (CalCOFI) surveys of the south-central California Current system (50+ years); Canadian and Japanese sampling in the subarctic NE Pacific (50+ years summer season, continuous 1958-1981); Japanese, Russian and Korean collections from the western margin of the Pacific and the Asian marginal seas (40-50+ years); sampling by IMARPE (Peru), IFOP (Chile) and other agencies in the Peru-Chile upwelling region (~40 years); U.S. and Canadian monitoring programs in the coastal NE Atlantic (~40 years); and several ongoing European sampling programs in the North Sea and Mediterranean (20-30 years). In several additional ocean regions (notably off South Africa and in the Arabian Sea) it may be possible to assemble very long time series by combining information from sequences of shorter observation programs.

Many important within-region analyses of these zooplankton time series have been completed, and are being widely noted by both the scientific community and by decision makers (e.g., Brodeur and Ware 1992; Roemmich and McGowan 1995; Beaugrand et al. 2003). Recurrent themes have been that:

- multi-year variability of zooplankton is large enough to be significant both statistically and ecologically,

- variability at the level of individual species or species guilds (when quantified) is often stronger than the variability of aggregate measures such as total biomass.
- there are many clear correlations of the interannual zooplankton variability with both the physical environment and with the distribution and productivity of harvested fish stocks.

There is growing evidence that zooplankton time series that go beyond biomass to include plankton compositional information are especially useful. In part this is because interannual-decadal changes in community composition, phenology, and physiological "condition" are often very strong. However composition-resolved time series also have greater information content and interpretability because they invite cross-referencing to large-scale distributions, physiology, predator-prey associations and behavioral and life history strategies. Many new and ongoing time series are therefore now adding a compositional component (e.g., "zooplankton species" is on the OCEAN.US IOOS list of "core variables"). For the historic biomass time series, this compositional information is often still available in the form of "samples in jars". Re-processing of older archived samples is underway in several regions (e.g., CalCOFI retrospective studies in U.S. GLOBEC; the Odate Project in Japan; and BENEFIT and BCLME programs in the southeast Atlantic, IAI/EPCOR funding for workup of Peru Current samples and data). We will include data from these re-analyses in our Working Group's comparison effort. A showpiece demonstration of value would do much to attract new funding for broader re-processing efforts.

The case for global comparisons

We believe that large-scale (between-region and between-ocean) comparisons of zooplankton time series are the essential next step. The sardine-anchovy story provides one clear example of how such a comparison can stimulate scientific progress. However, both similarities and differences between time series will be informative. If we do find that zooplankton variability has a very large spatial "footprint" (global to basin-scale coherence of type and/or timing, as suggested in Fig. 1), this will be very strong evidence that causal mechanism(s) are also large scale. Conversely, smaller scale forcing mechanisms that are confounded (either temporarily or permanently) within a single region often vary independently or inversely in other regions, allowing statistical discrimination. Third, because individual time series show serial autocorrelation, statistical degrees of freedom accumulate slowly – it takes a very long time to discriminate differences in strength and stability among local correlative associations. Between-region comparisons allow a form of ensemble averaging that is quicker and also very effective at testing the consistency and basis of association.

To date, relatively few between-region comparisons of zooplankton time series have been completed. All have been at much less than global scale (within an individual current system, or at most one ocean basin). Almost all of the basin-scale comparisons (with the notable exception of the CPR surveys) have been confined to estimates of total mesozooplankton biomass or biovolume. We now have access to both the data and the tools needed to carry out a global synthesis.

Methodological opportunities and issues
Several methodological issues affect the analysis of zooplankton time series. We have space here for only a brief summary (more detailed discussion is available in Perry et al. in press). However, our overall assessment is that these will complicate our work, but not prevent a useful global comparison.

The first issue is diversity of sampling methodology. No zooplankton sampling method is perfect, and we recognize that there have been differences in sampling methodology both within and between data sets. However, we do not expect these differences to be a serious technical barrier to between-region comparisons. One key reason is that our analysis focuses on comparisons of anomaly time series rather than of the regional climatologies – we are primarily interested in the temporal variability of relative abundance, not the spatial variability of absolute abundance. As practicing zooplankton field ecologists, we are also in a good position to recognize problem situations and taxa. Several of the proposed WG members have expertise in evaluating effects of sampling method changes within individual time series. We will also keep close liaison with SCOR WG 115 on "Standards for the Survey and Analysis of Plankton."

A second issue is consistency of taxonomic identification within and among data sets. Again, we are helped by the fact that we are primarily comparing anomalies relative to local norms, and looking for when, where, and how long the community changes. We also expect that all or most of our analyses will be weighted on the better-known taxa that dominate the community in each region.

A third issue is the volume, accessibility, and diversity of data. The situation here is much better than it was even a few years ago. Several key data sets have already been put in readily accessible form. Good computer tools for dealing with diverse-origin and moderately large data sets are now more available, cheaper, and more flexible and user-friendly. We anticipate that this trend will continue. Although data management work will be necessary, we do not expect that electronic assembly and consolidation of the zooplankton data sets will be a major technical problem.

The final issue is the diversity of visualization and statistical tools that have been applied in previous regional zooplankton analyses. Our intent is to use this diversity rather than try to eliminate it. We will apply a range of analytical tools and evaluate the degree to which they are effective, redundant, or complementary. As with data archival and formatting, many of the necessary tools are becoming much more available and user friendly. Other important practices and concepts, such as how to deal with temporal and spatial autocorrelation, and with data gaps, are not yet familiar to many zooplankton ecologists. Demonstration, evaluation, and perhaps packaging of these tools will be another important WG product.

3. Proposed terms of reference

- Identify and consolidate a globally representative set of "long zooplankton time series" (selected from the data sets listed in Table 1, plus perhaps from additional regions for which time series can be composited from a sequence of shorter programs). Where

appropriate, facilitate migration of individual data sets to a permanent and secure electronic archive.

- Develop and share protocols for within-region and within-time-period data summarization (e.g., spatial, seasonal and annual averaging, summation within taxonomic and age categories). The goal is to learn what level of detail provides the optimal tradeoff or information gain vs. processing effort.
- Based on the above, develop priorities and recommendations for future monitoring efforts and for more detailed re-analysis of existing sample archives.
- Once regional data sets are compiled and collated, carry out a global comparison of zooplankton time series using (in parallel) a diverse suite of numerical methods. We will examine:

    - Synchronies in timing of major fluctuations, of whatever form.
    - Correlation structure (scale and spatial pattern) for particular modes of zooplankton variability (e.g., changes in total biomass, replacement of crustacean by gelatinous taxa, alongshore or cross-shore displacements of zoogeographic distribution boundaries).
    - Likely causal mechanisms and consequences, based on spatial and temporal coherence with environmental and fishery time series.
    - Sensitivity and specificity of data-analysis tools.

4. Time frame and expected products

If this proposal is successful, we could begin work in early 2005 and would continue for three years. We would convene annual WG meetings (each of about one-week duration), and a larger open-attendance symposium in the final year. An ideal venue for the final session would be the next International Zooplankton Symposium, scheduled for 2007 in Japan. This would also include a collective scientific publication (either a special issue of an international journal, or a book). For each year, expected activities and products include:

- *Year 1*: Summarize and evaluate methods, results, and questions arising from the zooplankton time-series analyses that have been completed to date. For the proposed new comparative analyses, select and prioritize the set of regional time series, and the suite of variables from each time series that will be compared (e.g., total zooplankton biomass, major-group and/or species-level zooplankton taxonomic composition, phenology, and physical and biological environmental indices). Identify obstacles to pooled analyses (e.g., incomplete processing, differences in formatting, differences in resolution). Develop recommendations for data exchange and feasible enhancements of sample processing.
- *Year 2*: Begin comparative analyses. Evaluate sensitivity and specificity of data analysis (statistical) tools, and improve their availability and "user-friendliness". Identify time scales and date intervals of particular interest. Post selected tools and data on a Web or ftp site (initially closed, eventually public?).
- *Year 3*: Complete comparative analyses of zooplankton and environmental time series, incorporating any new data that have become available during years 1-3.

Identify synchronies (if any) in timing of fluctuations, and quantify correlation time and space scales. Prepare interpretive paper(s) for symposium presentation and publication. Prepare recommendations for "best practice" sampling and analysis methodologies

5. Proposed Working Group membership

Our primary goal is broad experience on zooplankton time series, combined with local knowledge of the contents and quality issues for each regional data set. However, we suggest that one member of the core working group should be a statistical specialist and another should strong data management expertise. Our suggested list (#11-15 could be Associate Members funded by other agencies):

1. David Mackas [cochair](Canada, northern California Current & subarctic NE Pacific)
2. Hans Verheye [cochair] (S. Africa, Benguela)
3. Andy Solow (primarily as statistics expert on spatially and temporally autocorrelated time series, but also familiar with NW Atlantic data sets)
4. Sanae Chiba (Japan, Kuroshio/Oyashio and oceanic NW Pacific) or other rep from Project ODATE
5. Mark Ohman (USA, CalCOFI region) or other CalCOFI rep
6. Gregory Beaugrand (CPR, NE Atlantic) or other SAHFOS associate
7. Young-Shil Kang (Korea, NE Asian marginal seas)
8. Sergei Piontkowski (USA but familiar with USSR and tropical oceanic data sets)
9. Patricia Ayon (Peru, IMARPE data set plus general Humboldt Current region)
10. Technical advisor on data management and formatting issues (e.g. someone from the US National Oceanographic Data Center)
11. (SPACC liaison e.g. David Checkley, USA or Claude Roy, France. Both would also provide expertise on oceanography of key Eastern Boundary Current ecosystems)
12. (additional N Atlantic, not CPR data)
13. (Bering Sea)
14. (Southern Ocean)
15. (Indian Ocean/Arabian Sea)

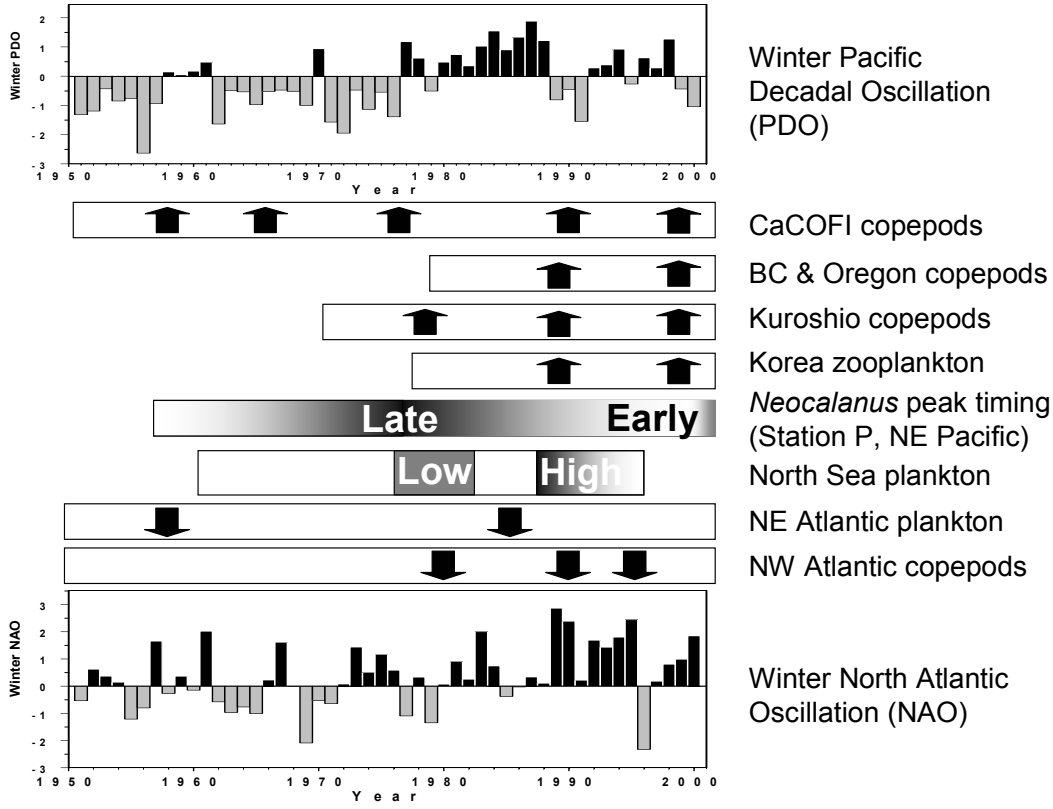

Fig 1. (from Perry et al., in press) Schematic showing timing of identified shifts in North Pacific and North Atlantic zooplankton abundance, community composition and/or life cycle timing, matched with time series for Pacific (PDO) and Atlantic (NAO) climate indices. Arrows indicate timing of zooplankton change, not direction. Source data are from: CalCOFI (Rebstock, 2002; McGowan 2003; Lavaniegos and Ohman 2003); British Columbia and Oregon (Mackas et al., in press); winter season Kuroshio region (Nakata and Hidaka 2003); Korean coastal waters (Kang et al., 2002; Rebstock and Kang 2003); Neocalanus life cycle timing (Mackas et al. 1998); North Sea (Edwards et al., 2002; Beugrand et al. 2003); NE Atlantic (Beaugrand and Reid 2003); NW Atlantic (Jossi et al. 2003)

Table 1. Representative long time series (with ≥10 years of consecutive sampling) zooplankton observation programs (summarized from Perry et al., in press)

Program	Start & end years	Location
North Pacific		
CalCOFI	1949 – continuing (quarterly)	California
Station PAPA	1956 – continuing (3 times per year)	North Pacific, 50°N, 145°W
Newport, OR, USA	Intermittent since 1969, continuous since 1996 (5 times per year)	Offshore transect at 44º39.1'N (Oregon)
Vancouver Island Shelf	1985 – continuing (3-5 times per year)	Southwest shelf of Vancouver Island
Odate plankton time series	1951 – continuing (monthly)	Western North Pacific (Kuroshio, Oyashio and transition region east of Japan)
Hokkaido University, Oshoro-Maru time-series	1953 – 2001 (annual)	western and central subarctic North Pacific, and Bering Sea (mostly along 180°E)
Japan meteorological Agency (JMA)	1967, 1972 – continuing (seasonal)	Several transects in western North Pacific (all around Japanese waters)
National Research Institute of Fisheries Science (Japan), fish egg and larvae survey.	1971 – continuing (annual)	western subtropical North Pacific (including Kuroshio region)
Hokkaido National Institute of Fisheries, A line monitoring	1987 – continuing (5-8 times per year)	western subarctic North Pacific (Oyashio region)
National Fisheries Research and Development Institute (Korea), oceanographic survey	1965 – continuing (6 times per year)	Korean waters
North Atlantic		
Continuous Plankton Recorder (CPR)	1931 – continuing (monthly)	North Atlantic
Helgoland Roads	1974 – continuing (daily to weekly)	Southern North Sea (54.19ºN 7.9ºE)
Dove Marine Laboratory	1968 – continuing	Central-west North Sea
Stazione Zoologica Anton Dohrn; Station MC	1984 – continuing (weekly to bi-weekly sampling)	Gulf of Naples (40°48.5'N, 14°15'E)
Station 'C', western Mediterranean	1985 – 1995 (weekly)	Gulf of Tigullio, Ligurian Sea, western Mediterranean
Plymouth Marine Lab, Station L4	1988 – continuing (weekly)	Western English Channel

Central Baltic (various agencies)	1976-continuing (seasonal)	Central Baltic deep basins
Icelandic Monitoring Programme	1961 – continuing (annual)	transects radiating from Iceland
Emerald Basin	1984 – continuing (twice per year)	Scotian Shelf, NW Atlantic
MARMAP and follow up program	1977 - continuing (quarterly)	NE United States continental shelf
Station "2"	1972-1997; 2002 – continuing (weekly)	Lower Narragansett Bay, RI, USA
South Atlantic		
Cape Routine Area monitoring programme, expanded in 1961 to Southern Routine Area monitoring programme	1951 – 1961 (monthly) 1961 – 1967 (monthly)	Western Cape coast of South Africa (32-34°S; 16°30'-18°15' E) Southwestern Cape coast of South Africa (32-38° S; 15°30'-22° E)
Pelagic Fish Stock Assessment surveys	1983 – continuing (3 times per year)	Most of South Africa's west and south coasts (28°30' S - 27° E)
Walvis Bay Routine Area monitoring programme SWAPELS Programme	1957 – 1965 (monthly) 1972 – 1989 (monthly)	Namibian coast, vicinity of Walvis Bay (21-24° S; 12°30'-14°30' E) Namibian coast (17°30'-27° S; 10°30'-15° E)
South Pacific		
IMARPE zooplankton sampling	1964 – continuing (seasonal)	Peru coast and continental shelf
IFOP zooplankton and icthyoplankton surveys	Dates to be confirmed	Northern Chilean coast
Southern Ocean		
Elephant Island	1977 – continuing	Elephant Island region of the Antarctic Peninsula

References

Batchelder, H.P. et al. 2002. The GLOBEC northeast Pacific California Current System Program. Oceanography, 15 (2): 36-47.

Beaugrand, G., Brander, K.M., Lindley, J.A., Souissi, S., and Reid, P.C. (2003). Plankton effect on cod recruitement in the North Sea. Nature 426: 661-664.

Beaugrand, G., and Reid, P.C. 2003. Long-term changes in phytoplankton, zooplankton and salmon related to climate. Global Change Biology, 9:801-817.

Brodeur, R. D., and Ware, D.M. 1992. Long-term variability in zooplankton biomass in the subarctic Pacific Ocean. Fisheries Oceanography, 1: 32-38.

Cury, P., Bakun, A, Crawford, R.J.M., Jarre, A., Quiñones, R., Shannon, L.J., and Verheye, H.M. 2000. Small pelagics in upwelling systems: patterns of interaction and structural changes in "wasp-waist" ecosystems. ICES Journal of Marine Science 57: 603-618.

Beaugrand, G., Reid, P.C., Rowden, A.A and Jones, M.B. 2002. Ocean climate anomalies and the ecology of the North Sea. Marine Ecology Progress Series, 239: 1-10.

ICES. 2003. Report of the Working Group on zooplankton ecology. ICES CM 2003/C:01. 56 p.
Jossi, J.W., John, A.W.G., and Sameoto, D. 2003. Continuous Plankton Recorder sampling off the east coast of North America: history and status. Progress in Oceanography, 58:313-325.
Kang, Y. S., Kim, J. Y., Kim, H. G., and Park, J. H. 2002. Long-term changes in zooplankton and its relationship with squid, Todarodes pacificus, catch in Japan/East Sea. Fisheries Oceanography, 11:337-346
Kawasaki, T., S. Tanaka, Y. Toba, and A. Taniguchi (eds.) 1991. Long-term Variability of Pelagic Fish Populations and their Environment: Proceeings of the International Symposium, Sendai, Japan 14-18 November 1989. Pergamon Press, Exeter, UK. 402 pp.
Lavaniegos, B.E., Ohman, M.D. 2003. Long term changes in pelagic tunicates of the California Current. Deep-Sea Research II. 50:2473-2498.
Mackas, D.L., Goldblatt, R. and Lewis, A.G. 1998. Interdecadal variation in developmental timing of Neocalanus plumchrus populations at Ocean Station P in the subarctic North Pacific. Canadian Journal of Fisheries and Aquatic Sciences, 55: 1878-1893.
Mackas, D.L., W.T. Peterson and J. Zamon. In press. Comparisons of interannual biomass anomalies of zooplankton communities along the continental margins of British Columbia and Oregon. Deep-Sea Res. II
McGowan, J.A., Bograd, S.J., Lynn, R.J. and Miller, A.J. 2003. The biological response to the 1977 regime shift in the California Current. Deep-Sea Research II, 50: 2567-2582.
Nakata, K. and K. Hidaka. 2003. Decadal-scale variability in the Kuroshio marine ecosystem in winter. Fisheries Oceanography 12: 234-244
Perry, R.I., H.P. Batchelder, D.L. Mackas, E. Durbin, W. Greve, S. Chiba and H. Verheye. 2004 in press. Identifying global synchronies in marine zooplankton populations: Issues and opportunities. ICES J. Mar. Sci.
Rebstock, G. A. 2002. Climatic regime shifts and decadal-scale variability in calanoid copepod populations off southern California. Global Change Biology, 8: 71-89.
Rebstock, G.A. and Kang, Y.-S.. 2003. A comparison of three marine ecosystems surrounding the Korean peninsula: Responses to climate change. Progress in Oceanography, 59: 357-379.
Roemmich, D. and McGowan, J. 1995. Climate warming and the decline of zooplankton in the California Current. Science, 267: 1324-1326.
Schwartzlose, R.A., et al. 1999. Worldwide large-scale fluctuations of sardine and anchovy populations. South African Journal of Marine Science, 21: 289-347.
Tadokoro, K., Chiba, S., Ono, T., Midorikawa, T. and Saino, T.. In press. Interannual variation in Neocalanus biomass in the Oyashio waterns of the western North Pacific. Fisheries Oceanography.
Verheye, H.M. and Richardson, A.J. 1998. Long-term increase in crustacean zooplankton abundance in the southern Benguela upwelling region (1951-1996): bottom-up or top-down control? ICES Journal of Marine Science, 5: 803-807.

2.3.2 Working Group to Investigate the Role of Viruses in Marine Ecosystems

Abstract
Viruses are a crucial component affecting the trophodynamics and composition of marine food webs. While it is clear that viruses are extremely abundant and are responsible for substantial mortality of heterotrophic and autotrophic marine microbes, there is still very limited quantitative information on the mortality imposed by viruses on marine prokaryotic and eukaryotic microbial communities. Data are particularly sparse for historically undersampled environments such as the open and deep oceans (including sediments) as well as the Arctic. Gaining a qualitative and quantitative understanding of the role of viruses in oceanic carbon and nutrient cycling, food web processes and their effect on community diversity is pivotal for assessing the stability of marine foods webs and understanding their effects on biogeochemical cycling.

The proposed working group would study the role of viruses in marine ecosystems over a period of four years, culminating in a final reports that (1) summarize past results on virus-meditated mortality of eukaryotic plankton and prokaryotes and its impact on oceanic carbon and nutrient cycling (2) coordinate data and international collaboration on the role of viruses in different water masses in particular in the open ocean and deep sea and (3) assess the current methodological limitations and develop recommendations for techniques to quantify virus-mediated mortality of microorganisms (eukaryotes and prokaryotes), their impact on carbon and nutrient cycling, and methods for assessing diversity in viral communities. An important aspect of the working group will be to stimulate research to investigate viruses and viral-mediated processes in different water masses, since this promises a better understanding of the effect of viruses on biogeochemical cycles. The working group will also establish and maintain a Web site as forum that can be used by the "viral community" for exchanging data, ideas and future plans.

Rationale
Understanding the role of viruses in oceanic carbon and nutrient cycling, food web processes and diversity is pivotal for assessing the stability of marine systems and their biogeochemical significance. This understanding is not only of scientific interest; it will also increase the predictability of the effects of global change on biogeochemical processes in the ocean. Moreover, quantitative data on the consequences of viral lysis are necessary to better understand the functioning of marine food webs. This will also facilitate the inclusion of viral effects into oceanic carbon models.

In addition to studying the role of viruses in surface open ocean and deep sea, we propose to assess the role of viruses in distinct water masses, that is, "oceanic rivers", which show a variable degree of mixing. We argue that this approach will increase our understanding of biogeochemical process, since it takes into account a basic oceanographic reality, that is, that the ocean consists of distinct water masses. Up to now, studies on microorganisms, which focus on distinct water masses, are sparse. A physical description of water masses (temperature, salinity, density) along with the assessment of viral parameters would be a first step to tackle this task.

The best mechanism to focus the scientific community on the role of viruses in marine ecosystems is a working group formed by SCOR. A non-governmental organization such as SCOR is the perfect forum to assemble the scientific expertise from different nations. Moreover, an international working group has the potential to implement this expertise in developing countries. SCOR is funding fundamental science and attracts top scientists to volunteer their time to participate in the group. This SCOR sponsorship also increases the chance to attract further funding for the activity of their groups. SCOR is the only organization ensuring that the activity is international and involves both established and young scientists as well as scientists from developing countries.

Scientific Background

Marine prokaryotic and eukaryotic microorganisms, that is, eukaryotic phytoplankton, cyanobacteria and heterotrophic prokaryotes (*Bacteria* and *Archaea*), are the main players in the marine carbon cycle. Dominance of autotrophic carbon fixation shifts from eukaryotic phytoplankton to unicellular cyanobacteria in offshore waters and thus the contribution of prokaryotes to primary production is higher in the open ocean than in coastal waters. Viral lysis of photosynthetic organisms results in a reduction of carbon fixation (Suttle et al. 1990). The world's ocean is inhabited by ca. 1.2×10^{29} prokaryotes producing ca. 9.3×10^{29} cells per year (Whitman et al. 1998), or in terms of carbon, about 10-20 Gt C y^{-1}. Thus global oceanic prokaryotic production amounts to about 50% of global oceanic primary production (20-30 Gt C y^{-1}). From this comparison, it becomes clear that the fate of this prokaryotic production is of crucial importance for the oceanic carbon cycle.

About 15 years ago, it was shown that viruses are the most abundant biological entities ("life forms") in the ocean. It is now known that viral lysis is a major mechanism causing mortality of eukaryotic phytoplankton and prokaryotes (reviewed in Fuhrman 1999 and Wommack and Colwell 2000). Mortality of cells at all trophic levels due to viral lysis has considerable implications for the flow of energy and matter through the microbial food web. Lysis (disruption of cells) removes production and converts biomass into dissolved organic carbon (DOC) and small particles (Wilhelm & Suttle 1999), which are available to heterotrophic prokaryotes. This constitutes a short-circuit in the marine food web, the "viral shunt" (Wilhelm & Suttle 1999), and increases the remineralization of DOC. A model suggests that between 5 and 26% of photosynthetically fixed carbon ends up in the DOC pool due to viral lysis. DOC is the largest pool of organic carbon in the ocean, equaling approximately the carbon present in atmospheric carbon dioxide. Heterotrophic prokaryotes are the only group consuming significant amounts of DOC. Intensive research has been performed on the ecology of oceanic phytoplankton and prokaryotes during the past decades. Thus, it is surprising how little is known about the regulatory mechanisms and the fate of autotrophic and heterotrophic production. This information is urgently needed, since cell death has a major impact on carbon fixation and remineralization and on the composition and reactivity of oceanic DOC (Nagata & Kirchman 1997) and thus on carbon and nutrient cycling in the ocean. Quantitative studies on the fate of eukaryotic phytoplankton production have rarely considered the potential role of viral infection. There is increasing evidence that viral lysis stimulates the role of prokaryotes as oxidizers of

DOC and remineralizers of CO_2, N, P and Fe. However, little is known about how this affects autotrophic carbon fixation. In addition, the finding that *Archaea* can be as abundant as *Bacteria* in deep marine waters (Karner et al. 2001), has raised considerable interest in the activity and biogeochemical role of this group. Almost nothing is known on viruses infecting pelagic *Archaea* and only a single experimental study suggests that their community composition is affected by viral infection (Winter et al. 2004).

Recent research using a metagenomics (community genomics) approach showed that viral diversity is extremely high (Breitbart et al. 2002) and accumulating evidence shows that viral infection is a driving force for microbial diversification and diversity (Weinbauer & Rassoulzadegan 2004). Since viral infection is typically species- or even strain-specific and depends on the abundance of host cells, viral lysis should prevent competitive dominants from taking over and thereby allowing the existence of highly diverse microbial communities. If this "killing the winner" hypothesis (Thingstad 2000) holds true, viruses should have a major impact on the diversity of cellular organisms and on their biogeochemical role. In order to test this hypothesis, it is necessary to develop (and apply) molecular tools so that we can monitor population dynamics of both viral and host communities simultaneously in the natural marine ecosystem. Viral diversity and activity is tightly linked to host diversity and eukaryote- and prokaryote-mediated ecosystem functioning. However, there is a lack of "hard" data on this influence in most parts of the ocean. While some data has been accumulated for coastal systems, the ocean and deep ocean (including sediments) are largely unexplored territory.

Statement of Work/Terms of Reference
The proposed working group would

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

Meetings. We propose the first meeting of the Working group (**1st SCOR workshop)** to be held in Spain in 2005 in conjunction with the meeting of the American Society of Limnology and Oceanography (ASLO) in Santiago de Compostela, Spain. At this meeting the final identification of the membership, fine-tuning of the Terms of Reference, and creation of an agenda will take place. A second meeting will be held in association with the workshop (proposed below) in the year following the first meeting. An International Symposium on Viruses in the Ocean will take

place approximately three years following the initial meeting in order to allow final discussion, input to the Working group's report, and culminate in a published proceedings.

2nd SCOR Workshop in 2006. An international workshop on oceanic viruses will be convened at the University of British Columbia in Vancouver (Canada) in order to facilitate input to the Working Group for fulfilling the above Terms of Reference. This workshop will be held after the summer ASLO meeting, which is taking place at the relatively closely situated city of Victoria (Canada). This meeting will be held approximately one year after the first meeting, a period necessary to allow for preparing the workshop agenda, issue announcements and invitations, secure needed funds, and make other necessary preparations. This workshop will provide the opportunity to invite additional specialists that can be included in the working group in order to increase the expertise of the Working Group.

Symposium in 2008. The symposium will be held at the Laboratoire d'Océanographie de Villefranche-sur mer (France). We will try to get additional money from the French Science Organization (CNRS), from regional governments, from the Federation of European Microbiology Societies (FEMS) and the European Commission. The project would be completed by September 2008.

Working Group membership

Working Group full membership is proposed to consist of ten specialists and will be international in scope. The members listed below have agreed to serve on the Working Group, pending approval and input of SCOR. The members consist of all scientists promoting the new field of marine viral ecology at the community level about 15 years ago, scientists from the "second wave" in this field and junior scientists. This mixture has the greatest chance for innovation and developing new perspectives. The chairs will attempt to provide balance and will address coordination, Web site maintenance, dissemination of information and preparation of the final, published report. Two chairs were appointed to make sure these duties will be addressed in an appropriate way by sharing the work load.

Full members		Associate members	
Markus Weinbauer, Chair	France	Jed Fuhrman	USA
Steven Wilhelm, Co-chair	USA	Gerhard Herndl	Netherlands
Gunnar Bratbak	Norway	John Paul	USA
Corina Brussaard	Netherlands	Telesphore Sime-Ngando	France
Eric Wommack	USA	Feng Chen	USA
Keizo Nagasaki	Japan	Grieg Steward	USA
Mathias Middelboe	Denmark	Roberto Danovaro	Italy
Curtis Suttle	Canada		

Two additional full members and additional associate members may be appointed preferably from developing countries.

References

Breitbart M, Salamon P, Andresen B, Mahaffy JM, Segall AM, Mead D, Azam F, Rohwer F (2002) Genomic analysis of uncultured marine viral communities. Proc Natl Acad Sci U S A 99:14250-14255

Fuhrman JA (1999) Marine viruses and their biogeochemical and ecological effects. Nature 399:541-548

Karner MB, DeLong EF, Karl DM (2001) Archaeal dominance in the mesopelagic zone of the Pacific Ocean. Nature 409:507-510.

Nagata T, Kirchman D (1997) Roles of submicron particles and colloids in microbial food webs and biogeochemical cycles within marine environments. Adv. Microb. Ecol. 15:81-103

Paul JH, Sullivan MB, Segall AM, Rohwer F (2002) Marine phage genomics. Comp Biochem Physiol B Biochem Mol Biol 133:463-476

Suttle CA, Chan AM, Cottrell MT (1990) Infection of phytoplankton by viruses and reduction of primary productivity. Nature 347:467-469

Thingstad T (2000) Elements of a theory for the mechanisms controlling abundance, diversity, and biogeochemical role of lytic bacterial viruses in aquatic systems. Limnol Oceanogr 45:1320-1328

Weinbauer MG, Rassoulzadegan F (2004) Are viruses driving microbial diversification and diversity? Environ. Microbiol. 6:1-11

Whitman W, Coleman D, Wiebe W (1998) Prokaryotes: The unseen majority. Proc. Natl. Acad. Sci. USA 95:6578-6583

Wilhelm SW, Suttle CA (1999) Viruses and nutrient cycles in the Sea. Bioscience 49:781-788

Wilson WH, Mann NH (1997) Lysogenic and lytic viral production in marine microbial communities. Aquat. Microb. Ecol. 13:95-100

Winter C, Smit A, Herndl G, Weinbauer M (2004) Impact of virioplankton on archaeal and bacterial community richness in seawater batch cultures. Appl. Environ. Microbiol. 70:804-813

Wommack, K.E., Colwell, R.R. (2000). Virioplankton: Viruses in aquatic ecosystems. Microbiol. Mol. Biol. Rev.64: 69-114

2.3.3 SCOR Working Group on the Presence and Abundance of *Benthosema pterotum* Myctophid Fish in the Northern Arabian Sea

Summary
The northwestern Arabian Sea is known to have a large stock of mesopelagic fish mainly *Benthosema pterolum*. Surveys from the 1970s and 1980s carried out in the region have estimated a standing stock of 100 million metric tons. It is in the interest of the regional countries to explore the fishery resources and other sea resources and use these sustainably. The present study is a four-year programme directed towards re-evaluating the potential resource of myctophid fish especially *B. pterotum* in the northern Arabian Sea. It is aimed toward conducting a resource survey that will provide information on the presence and abundance of this resource. And, it will investigate if there is a genetic difference between the populations of *B. pterotum* from different regions of the Arabian Sea (Pakistan, Oman, Iran). The first component of the study will be carried out by the national institutions: National Institute of Oceanography and the Marine Fisheries Department in Pakistan; the Omani Fisheries Department, Sultan Qaboos University, Muscat, Oman; Iran National Oceanographic Centre (INCO), in consideration for regional collaborative effort and in partnership with the scientists from the United States, Germany and the United Kingdom.

The working group is planned to meet 3 times during the four year programme, once at the start to coordinate the efforts and work plan, halfway to monitor and evaluate progress and discuss the preliminary results, finally to compile the final report and results of the project.

Scientific Background
The Arabian Sea in recent years has been the focus of attention for mega-scale oceanographic programmes. One such programme, the Joint Global Ocean Flux Study (JGOFS) program in the Arabian Sea, was designed to study the biological productivity in relation to the complex oceanography. Pakistan, through its collaborative oceanographic program NASEER (North Arabian Sea Environment and Ecosystem Research) with the US ONR (Office of Naval Research), was a contributor in these studies.

In a marine environment, the top predator in a food chain are marine mammals and larger fish such as tunas and mackerel, etc. In contrast, in the western Arabian Sea, this top predator is represented by smaller mesopelagic and mid-water fish such as the myctophids (lantern fish), Sternoptychidae (hatchet fish) and Gonostomatidae (bristle mouths). Past surveys carried out in the region have shown a tremendous biomass of the resource: (Gjosaeter, 1981); Aglen et al., 1982; Gjosaeter and Tilseth, 1983). Gjosaeter and Kawaguchi (1980) and Gjosaeter (1984) estimated a standing stock of 100 million metric tons for the mesopelagics of this region. This figure is comparable to the present total commercial fish catch of the world. However, smaller mesopelagics are also considered an important link in the food chain, with the cephalopod (squid and cuttlefish) and tuna as the top-predators.

The present study is directed towards evaluating this potential resource, that is, to conduct a resource survey that will provide information on the presence and abundance of the

mesopelagics especially *B. pterolum* in the Arabian Sea, and further to investigate if there are genetic differences between the populations of *B. pterotum* in the region. Amongst the mesopelagics, *Benthosema pterolum* (lantern fish) is reported to be the most abundant, followed by another species *B. fibulatum* (Gjosaeter 1981; Nafpaktis and Nafpaktis, 1969). *B. pterotum* are thought to be "annual fish", that is having a life cycle of one year, and their size ranges from 27 to 48 mm. Recognizing the abundance and potential abundance of *B. pterotum*, a fair amount of information is available on different aspects; however, very little information is available on how the physical environment of the Arabian Sea affects the fish population.

The fishery surveys and oceanographic information of the environment would be carried out by the participating regional countries (Pakistan, Oman, Iran), in consultation with full and associate members. The molecular genetics studies are proposed to be carried out at the University of California-Santa Cruz, USA, where Dr. Bernardi has been involved with carrying out similar kinds of studies from limited specimen from the myctophids from the Arabian Sea and with other fish species from different parts of the world, and has demonstrated that molecular techniques can be used as efficient biological tools for defining the patterns of distribution and population in marine organisms.

Rationale

Sustainable exploitation of marine resources is essential, to explore and exploit unconventional resources and identify new resources. The development of the fisheries sector could make a direct and significant contribution to raise the socioeconomic condition and nutritional status of the common man in the countries of the region.

Further, it is absolutely imperative that regional fishery resources are closely monitored and efficiently managed. This study could provide some information on the mesopelagic fish, a new potential resource that has in the past been estimated to exist in huge quantity in the northwestern Arabian Sea. The proposed study is targeted to investigate the presence and abundance of mesopelagic fish and the population genetics of the mesopelagic stock that exists in the northern Arabian Sea.

The outcome would have not only a scientific implication in terms of scientific cooperation amongst regional countries with the more developed countries, but also economic implications that would perhaps result in:

- Introduction of a new/unconventional fishery as a new income source.
- Possible potential of a revenue generation and employment.

Statement of Work/Term of Reference

1) The proposed working group is aimed towards collaborative research in applied fishery oceanography with a molecular genetics component.

2) The working group would share their resources to produce a comprehensive final report on the myctophid resources and their population genetics in the Arabian Sea.

Meetings: The working group is planned to meet 3 times during the four-year programme,

The first meeting of the group at the start, will be a workshop, a coordinating effort for the members, to finalize the working group, fine tune the terms of reference and also discuss the work plan and role of each member.

The second meeting/workshop would be midterm and will discuss the progress of the members and preparation of preliminary results, etc.

The final meeting of the working group would be at the conclusion of the program to compile the results, discuss the finding and prepare final report of the findings and discussion of a follow up strategy.

Working Group Composition

The members of the working group are aimed to be representatives of all the participating countries of the region: Pakistan, Oman and Iran:

- From Pakistan, 4 members are proposed: two senior members: Dr. M. M. Rabbani, Dr. Shahid Amjad and two junior members: Dr. Tariq Masood Ali Khan and Ms. Samina Kidwai, from the National Institute of Oceanography-Pakistan.
- From Oman. 2 members are proposed: from the Oman Fishery Ministry and the Sultan Qaboos University.
- From Iran, 2 members are proposed: from Iran National Oceanographic Centre (INCO), names to be submitted later.
- Two members from the USA, Dr. Georgi Bernardi, University of Santa-Cruz, California, and Dr. B. Zahuranec;
- Associate members from the University of Kiel, Germany and from the United Kingdom.

Full Members		**Associate Members**
Dr. M. M. Rabbani, Chair	Pakistan	Germany*
Dr. Shahid Amjad	Pakistan	United Kingdom*
Dr. Tariq Masood Ali Khan	Pakistan	
Ms. Samina Kidwai	Pakistan	
2 members	Oman*	
2 members	Iran*	
Dr. Georgi Bernardi	USA	
Dr. Bernard Zahuranec	USA	

*names to be submitted later on consent

References

Aglen A., J. Gjosaeter, B. Myrseth and S. Tilseth (1982). Surveys of mesopelagic fish Resources in the Gulf of Oman and the Gulf of Aden Jul-Aug 1979 and Jan-Feb 1982. Report of Surveys with the R/V Dr. Fridtjof Nansen, Institute of Marine Research, Bergen, Norway. 71 pages

Gjosaeter, J. (1981). Abundance and production of lantern fish (Myctophidae) in the western and Northern Arabian Sea. Fiskeridirektoratets Skrifter Serie Kavunderskelser, 17, 215-251.

Gjosaeter, J. and S. Tilseth (1983). Survey of mesopelagic fish resources in the Gulf of Oman, February 1983. Reports on surveys with R. V. "Dr. Fridtjof Nansen" Institute of Marine Research, Bergen. NORAD/FAO/UNDP project GLO/82/001, 1-28.

Gjosaeter, J. (1984). Mesopelagic fish, a large potential resource in the Arabian Sea. Deep-Sea Research 31, 1019-1035.

Gjosaeter, J. (1977). Aspects of the distribution and ecology of the myctophids from the western and northern Arabian Sea. Indian Ocean Fishery and development programme Pelagic Fish Assessment Survey North Arabian Sea, Bergen, Sept. 1977.

Final Report "Survey Results of "Dr. Fridtjof Nansen" ". Indian Ocean Fishery and development programme Pelagic Fish Assessment Survey North Arabian Sea, Bergen, Aug. 1976.

Survey Results of "Dr. Fridtjof Nansen" January-June 1977. Joint NORAD/Pakistan Project Fish Assessment Survey Pakistan waters, Bergen.

"Dr. Fridtjof Nansen" Surveys of Pakistan Fishery Resources, September 1983 to June 1984. Summary of Findings. UNDP/FAO Programme GLO/82/001.

Nafpaktitis, B. G. and M. Nafpaktitis (1969). Lantern fishes (Family Myctophidae) collected during cruises 3 and 6 of the R/V "Anton Bruun" in the Indian Ocean. Bulletin of the Los Angeles County Museum of Natural History, Science 5, 1-79.

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 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 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
WG 123	Reconstruction of Past Ocean Circulation (PACE)	Stieglitz/Kissel	Zatsepin
WG 124	Analyzing the Links Between Present Oceanic Processes and Paleo-Records	Lochte/Sicre	Wainer
	SCIENTIFIC STEERING COMMITTEES, PANELS, etc		
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	Duce
IMBER	Integrated Marine Biogeochemistry and Ecosystem Research	Hall	Field
LOICZ	Land-Ocean Interactions in the Coastal Zone	Talaue-McManus	Hall
	The Ocean in a High-CO_2 World Symposium	Cicerone	Duce
	GEOTRACES	Anderson/ Henderson	Duce
	Panel on New Technologies for Observing Marine Life	De Sa	

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
PICES	North Pacific Marine Science Organization	Alexander	