2.0 WORKING GROUPS

2.1 Disbanded Working Groups

2.1.1 WG 78--Photosynthetic Pigments in Oceanography

Work continues on the second volume of *Photosynthetic Pigments in Oceanography*. Approximately US$10,000 has been donated from various sources to offset the printing cost and/or buy copies. Cambridge University Press has reconsidered its earlier decision and agreed to publish the book. Only two chapters remain to be completed.

2.2 Current Working Groups

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

Terms of Reference:

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

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Roger Flather	UK	Yeli Yuan	CHINA-Beijing
Vladimir Gryanick	RUSSIA		

Associate Members:

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

Executive Committee Reporter: Lawrence Mysak

From: Chris Mooers [mailto:cmooers@cecs.pdx.edu]
Sent: Friday, August 07, 2009 1:54 AM
To: ed.urban@scor-int.org
Cc: Peter Craig; Norden Huang
Subject: Re: Annual Report to SCOR

Ed

Our book has gained important momentum recently now that we have received a draft of the penultimate chapter. CUP has been very patient and has given us another six-month extension until JAN. - Chris

2.2.2 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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Susana Vinzon	BRAZIL
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Ray Cranston	CANADA
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Steve Kuehl	USA
John Milliman	USA
Pedro Walfir M. Souza Filho	BRAZIL
Colin Woodroffe	AUSTRALIA
Marek Zajaczkowski	POLAND

Executive Committee Reporter: Bjørn Sundby

SCOR/LOICZ/IAPSO WG 122
MECHANISMS OF SEDIMENT RETENTION IN ESTUARIES

FITH REPORT - AUGUST 2009

Chairs:
Gerardo M. E. Perillo (Argentina) and James Syvitski (USA)

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Colin Woodroffe (Australia)	John Milliman (USA)
Steve Kuehl (USA)	Marek Zajaczkowski (Poland)

1. Activities 2008-2009

There were no meetings of the WG during the period of the present report. The activities were limited to developing a special issue of *Estuarine, Coastal and Shelf Sciences* for a series of papers. At the present time there are a total of 7 papers submitted and 2 others to be submitted shortly. Submitted papers are in different stages of the editorial procedure.

Paper titles and authors for the ECSS special issue are as follows

Amos, C.L., Villatoro, M., Helsby, R., Zaggia, L., Umgiesser, G., Venturini, V., Are, D., Sutherland, T.A., Mazzoldi, A., Rizzetti, F., The measurement of sand transport in two inlets of Venice lagoon, Italy.

Andersen, T.J., Pejrup, M., Lanuru, M., van Bernem, C. and Riethmueller, R., Erodibility of a mixed mudflat dominated by microphytobenthos and Cerastoderma edule, East Frisian Wadden Sea, Germany.

Araújo da Silva, C., Walfir M. Souza-Filho, P., Carvalho Mendes, A., Berrêdo, J.F., Lessa, G.C., Sousa da Silva, M., Torres dos Santos, J. and Prost, M.T., Estuarine funnel morphology and sedimentary distribution in a mixed-energy coastal environment, Marapanim, Brazilian Amazon coast

Gao S, Wang Y P, Gao J H, 2009. Sediment retention at the Changjiang sub-aqueous delta, in response to catchment changes.

Pejrup, M. and Mikkelsen, O.A., Controlling the in situ settling velocity of cohesive sediment in estuaries.

Pratolongo, P.D., Perillo, G.M.E. and Piccolo, M.C., Combined effects of waves and marsh plants on mud deposition events at a mudflat-saltmarsh edge

2-6

Szczucinski W., Zajaczkowski M., Scholten J., Sediment accumulation rates in subpolar fjords; impact of post-"Little Ice Age" glaciers retreat, Billefjorden, Svalbard.
Uncles, R. J. and Stephens, J.A., Turbidity and sediment transport in a muddy sub-estuary.
Uncles, R.J., Bale, A.J. and Stephens, J.A., Measurement floc size in a muddy estuary
Vilela, C.P. X., Vinzon, S.B. and Freire, L.C.S., Fine sediment retention in the macro tidal open coast of Amazon

It is expected that the special issue could be published (at least in electronic format) by the end of the 2009.

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

Terms of Reference:

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

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Executive Committee Reporter: John Compton

-----Original Message-----
From: Karin Lochte [mailto:Karin.Lochte@awi.de]
Sent: Friday, August 28, 2009 12:14 PM
To: ed.urban@scor-int.org
Cc: marie-alexandrine.sicre@lsce.ipsl.fr; 'John Compton'
Subject: Re: Annual Report from WG 124 to SCOR

Dear Ed,

I tried to ring you today, but was unsuccessful. I am sorry for not delivering a report, but there is little to report.

Let me explain to you our plans for progress. There is a manuscript being submitted by the Alan Kemp and colleagues addressing the role of diatoms in linking surface processes to the sea floor and in providing mass transport.
My enquiry with the other WG members resulted in the conclusion that we will produce one review paper instead of the originally planned 5 papers. It will use as a frame my presentation presented last year on the SCOR meeting and is based on some of the texts already written by the members in preparation of the originally planned manuscripts. The reason for this change is that I do not see that the originally planned manuscripts will be forthcoming in due time. A small group (Wolf-Gladrow, Klaas, Lochte) will prepare the outline of the review and we expect input from our members. Timeline is: Outline until November, input until March, finalisation until June. I hope this will work

Best wishes,
Karin

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

Terms of Reference:

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

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

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Todd O'Brien	USA	Harold Bachelder	USA – Sponsored by PICES
Mark Ohman	USA	Juha Flinkman	FINLAND
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Executive Committee Reporter: Annelies Pierrot-Bults

From: Mackas, Dave [mailto:Dave.Mackas@dfo-mpo.gc.ca]
Sent: Monday, August 31, 2009 3:09 PM
To: ed.urban@scor-int.org
Subject: RE: Annual report to SCOR From WG 125

Ed - The Progress in Oceanography special issue on zooplankton time series is still ongoing. We had a deadline of last week, but a few key papers are not quite completed(including my own and one by Hans, so the leaders are not setting the best of examples); I expect the submittal process may trickle on to mid-September, but no longer than that. Fortunately, all the late arrivals are by people who write comfortably in English, so they may well catch up with the papers now out for review.

The number of papers will be at least 14; a couple additional are iffy. All those that have been reviewed so far have been rated as 'accept after suitable revision'. Projected publication date remains 2010, unless we run into a major unforeseen snag .

How much money is still available in the WG125 budget (to subsidize color figures in the printed issue)? Progress in Oceanography charges ~$400 per color figure (actually, per color page, if the figs can be arranged so that more than one are on a page). I think many of the figures in Todd OBrien's paper on biomass time series would have more legibility and impact if printed in color. Same may be true for Hal's paper on spatial autocorrelation.

Is this enough status report, or do you have additional questions?

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Zooplankton and Climate: Response Modes and Linkages

by David L. Mackas

The 2008 International Symposium on "*Effects of climate change on the world's oceans*" included a 1-day open workshop, "*Zooplankton and climate: Response modes and linkages among regions, regimes and trophic levels*", which examined zooplankton time series and their links with ocean climate. Demographic characteristics of marine zooplankton make them especially suitable for exploring the mechanisms responsible for ecosystem variability at interannual to decadal time scales. The workshop was held on May 18 and designed as a forum for the viewing and discussion of time series analyses recently carried out by SCOR Working Group (WG 125) on *Global Comparison of Zooplankton Time Series* (http://wg125.net/), which also had a working meeting on May 15–16, at Instituto Español de Oceanografía's Centro Oceanográfico de Gijón. However, the May 18 workshop also included a number of excellent presentations by authors not formally associated with the SCOR Working Group.

The 16 presentations covered a wide but relevant range of topics: data 'tools'; the spatial 'zones of influence' for different modes of physical climate variability; a between-region comparison of trends and amplitudes for anomalies of total zooplankton biomass/biovolume; temperature effects on community size structure and seasonal timing (phenology); 'invasions and outbreaks' by gelatinous zooplankton; spatial and interannual variability of isotopic composition and trophic level; variability of species composition and diversity; and poleward displacements of zoogeographic distributions. In this article, I will give only a few graphical examples and an overall 'highlights and consensus' summary. The full list of presentation titles and abstracts (plus pdf copies of some of the presentations) can be accessed on the symposium website at www.pices.int/meetings/international_symposia/2008_symposia/Climate_change/structure.aspx. Many of these will also be written up for publication in an upcoming special issue of *Progress in Oceanography*.

There has been very good buy-in by the international community of marine zooplanktologists to the WG 125 goal of global comparison. We currently have access to over 100 multi-year zooplankton time series from over 25 countries (and are continuing to gain more). One consequence of this massive response is that WG 125 needed to assemble a suite of 'entry-level' data analysis and visualization tools that could be applied to compare across diverse sampling designs (frequent and regular sampling of a single near-shore station, seasonally-repeated survey grids, and more irregular repeat coverage within defined statistical areas); sampling methods (horizontal, vertical or oblique net tows with different net designs and mesh sizes); and measurement currencies (displacement volume, dry-weight biomass, carbon biomass, numeric abundance at varying levels of taxonomic aggregation). Our step-wise approach (implemented mostly by Todd O'Brien and illustrated in **Fig. 1**) has been to estimate average seasonal cycles from log-transformed raw time

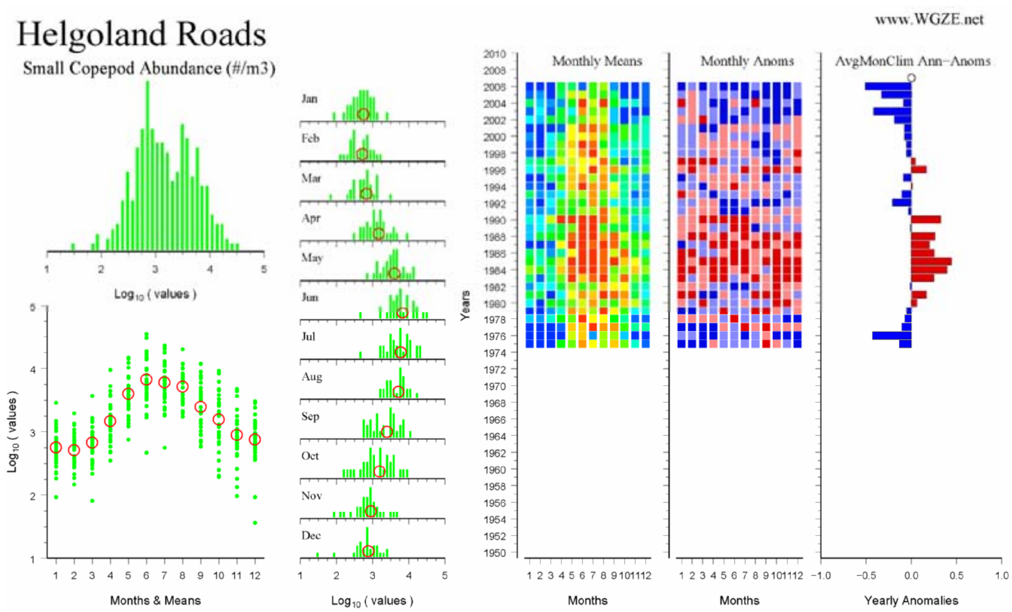

Fig. 1 Graphical output from the WG 125 toolkit, as applied to W. Greve's Helgoland Roads time series. The green dots and bars in the three left-side panels show overall and within-month frequency distributions of individual data points. Red circles overlaid on the bottom-left graph show the average seasonal cycle. Color-coded pixels in the middle panel show ranking of within-month means. The right-side panels show monthly and annual-average anomalies from the seasonal climatology.

series, then use these to calculate anomaly time series (multiplicative deviations from the seasonal climatology), and finally to display both data and anomalies as color-coded month-*versus*-year pixel grids that show which seasons/years have unusually high or low values of the variable being measured. These simple graphical displays have been useful not only for comparison among time series, but also for within-time-series quality control and hypothesis building.

Nearly all of our available zooplankton time series provide one or more indices of 'total amount': biovolume, biomass, or total abundance. How do the amplitudes of fluctuations and trends differ among regions? One approach is to classify and map time series based on the max-to-min or RMS 'span' of their anomaly time series (**Fig. 2** from O'Brien *et al*.). The strongest interannual variability was in the time series from sub-polar regions, from the eastern boundary current upwelling systems, and from the ocean margins off Korea and Japan. The weakest range of variation has been on mid-latitude continental shelf regions and marginal seas.

Another important question is which time series are most 'synchronous', and how their temporal correlations vary with spatial separation. Hal Batchelder presented a preliminary but interesting spatial auto-correlation analysis (**Fig. 3**) of the 'biomass' time series. He found that these time series tend to be positively but relatively weakly correlated across separations smaller than a few thousand kilometers, and that the spatial autocorrelation is stronger in the Pacific than in the Atlantic. However, there is no evidence supporting a 'global synchrony' similar to that suggested by catch time series of anchovy and sardines. Does this mean that fish 'regimes' are more teleconnected than zooplankton 'regimes'? Perhaps, but not necessarily – the zooplankton analysis is of a highly aggregated currency (total biomass), while the fish analyses are at species level. We are still working on the corresponding global species-level analysis for zooplankton, but comparisons within the California Current system show that the short-range spatial auto-correlation of zooplankton community variability is considerably stronger than the spatial autocorrelation of total zooplankton amount (**Fig. 3**). We need data to extend the species-level analysis to larger separations. Stay tuned,

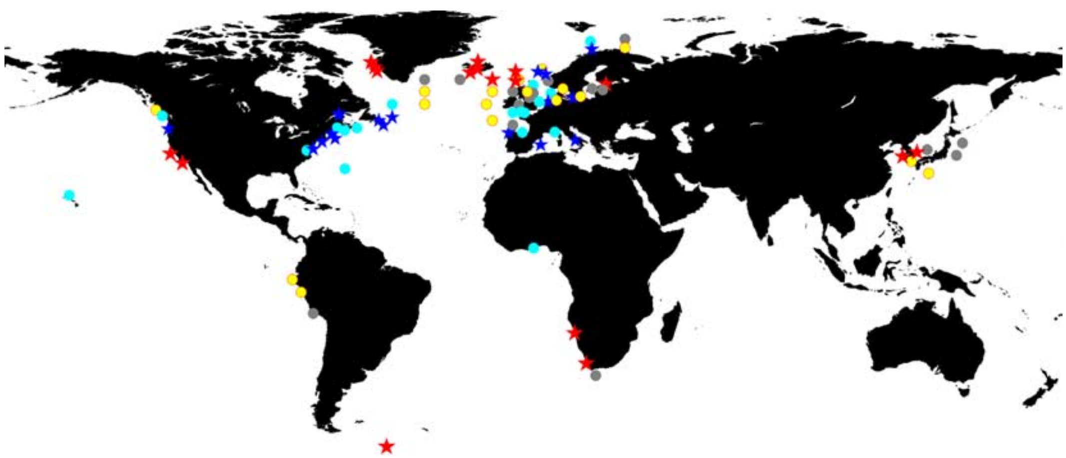

Fig. 2 Map of 'anomaly span'. Red and yellow symbols show locations of time series with a large interannual range; blue symbols have a much smaller range (some because they are brief). Grey symbols are intermediate.

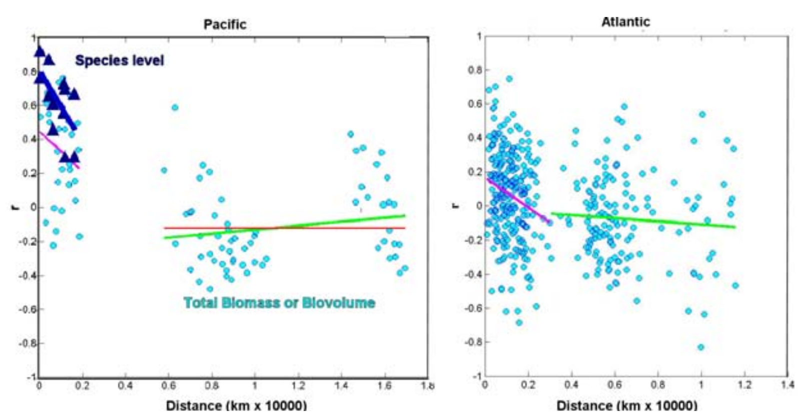

Fig. 3 Spatial correlograms for zooplankton anomaly time series from the Pacific (left, total biomass and community composition) and Atlantic (right, total biomass only). Data points are similarity (y-axis) vs. *separation (x-axis) of annual anomaly sequence for all pairs of time series with more than 12 years of overlap. Light blue circles are 'biomas/biovolume', dark blue triangles are species groups defined by zoogeographic zonation. In both oceans, correlation decays to zero at separations greater than a few thousand kilometers (*i.e*., there is little or no global synchrony). However, 'local' correlation is stronger in the Pacific than in the Atlantic, and is much stronger at species level than for total biomass.*

we will be extending this analysis (and please join us if you have any suitable time series data).

What else stood out as strong climate linkages? As noted above, several papers (Conversi *et al.*, Mackas *et al.*, Schlueter *et al.*) examined changes in zooplankton seasonal timing. All found that zooplankton phenology is very sensitive to ocean climate as indexed by water temperature during the growing season for a given species. But a very interesting composite result was that the temperature dependence is not uniform across species and regions. High latitude and 'spring' species show earlier seasonal maxima in years when temperatures are higher. Subtropical 'fall bloom' species show the opposite pattern – later maxima when temperatures are higher, suggesting that their population responses track autumn cooling and de-stratification, rather than spring warming and stratification. Species richness, average body size, and success of 'invading' (or merely 'expanding') species also show strong relationships to ocean warming. Again, stay tuned.

Post-workshop tapas and time series (what could be better?) The Pacific-resident author (David Mackas, blue-shirted male, a.k.a 'Canadian frog') compares data and wine preferences with Euro-princess colleagues (clockwise from left) Lydia Yebra-Mora, Delphine Bonnet, Maité Alvarez-Ossorio, and Maria-Luz Fernandez de Puelles. Photo courtesy Maite (camera and email) and Antonio Bode (shutterbug). Commentary from Maité: "[Frog is obvious but] I don't see any crowns [on the princesses]".

Dr. David Mackas (Dave.Mackas@dfo-mpo.gc.ca) is a Research Scientist with Fisheries and Oceans Canada at the Institute of Ocean Sciences and Co-Chairman of SCOR WG 125. He is also a member of several PICES Committees and expert groups, including WG on Comparative Ecology of Krill in Coastal and Oceanic Waters around the Pacific Rim.

(*continued from page 7*)

Day 3 allowed the group to refocus on the outstanding issues that had been identified during the previous two days of database beta-testing, discussions, and problem solving. Representatives from each country had an opportunity to provide input on their expectations of the final version of the database that WG 21 expects to have fully operational (if not fully populated) in time for the rapid assessment surveys to be conducted at two locations in China, prior to PICES XVII in Dalian. With an identified path forward that all attendees were comfortable with, including specific interim deliverables and associated timelines, the field trip portion of the meeting began. First, it was a boat tour of the port of Busan, arranged by Dr. Yoon Lee in conjunction with the local port authority. The group then proceeded on to Busan New Port which is currently under development and will greatly increase the shipping traffic in this part of the world once the expansion is complete. The day ended with the last group dinner associated with this inter-sessional meeting that allowed the participants to continue developing research collaborations and a better understanding of how non-indigenous species are impact-ting various PICES member countries.

Our meeting was a tremendous success thanks to Dr. Lee and his staff. Not only were meeting facilities extremely comfortable, the group meals every evening allowed participants to mingle in a less formal setting. In addition, we were able to sample a number of local delicacies (food and drink) and take in some of the sights this region has to offer. WG 21 continues to make significant advances towards better understanding non-indigenous marine species in the North Pacific and the dedication of its members will ensure that we are successful in all our endeavors, including completion of the database we beta-tested at our recent meeting in Busan.

Dr. Thomas Therriault (Thomas.Therriault@dfo-mpo.gc.ca) is a Research Scientist with Fisheries and Oceans Canada (DFO) at the Pacific Biological Station in Nanaimo, BC. Tom is working on aquatic invasive species (research, monitoring, risk assessment, and rapid response planning) both within DFO and through the Canadian Aquatic Invasive Species Network (CAISN). He also conducts research on forage fishes, notably eulachon and Pacific herring, from conservation and ecosystem perspectives. Tom is a Principal Investigator on the Taxonomy Initiative of PICES WG 21 that will include rapid assessment surveys for non-indigenous species in PICES member countries.

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

Terms of Reference:

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

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Sime-Ngando John Paul	FRANCE
Declan Schroeder	USA
Grieg Steward	UK
Dolors Vaqué	USA
	SPAIN

Executive Committee Reporter: Jorma Kuparinen

REPORT – 2009: Scientific Committee on Oceanic Research Annual report of Working Group 126 – *The role of viruses in marine systems*

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

Since our last report (June 2008), WG 126 has been focusing on the production of an online, freely available publication currently entitled ***Methods in Aquatic Virus Ecology*** **(MAVE)**. The special volume (funded by the *Gordon and Betty Moore Foundation*) will be assembled and published by ASLO (*Advancing the Science of Limnology and Oceanography*, formerly known as the *American Society for Limnology and Oceanography*). Currently chapters have been identified (see Appendix I), and papers submitted. Several chapters are at the in press stage and proofs being made. Only a couple of chapters remain in the review revision pipeline, and we remain confident of a completion of the project by the end of 2009.

Due to the above book commitments, the working group organizers asked for and received a one-year hiatus from meetings, so no major meeting was held in 2008. In July of 2008 most members of the group had already planned to attend the Aquatic Virus Workshop at the University of British Columbia as we mentioned in last year's report. We used this opportunity to discuss the book's progress, the 2009 meeting and to begin thinking about "the future".

In May 2009 the working group gathered for its final meeting at the University of Delaware. The meeting was hosted locally by Full Member and Associate Professor K. Eric Wommack. The meeting was a huge success with 77 registered participants (originally we had projected/hoped for 50). The meeting included a plenary presentation by Professor Graham Hatfull (University of Pittsburgh). .

Currently, the local organizers (Wommack and his postdoc, Dr Shawn Polson) as well as core member Wilhelm are writing a commentary for the ISME journal based on the outcome of this meeting. This arises from discussions with the ISME editors whom requested this piece. We anticipate submission of the article by October of this year (if not earlier). Modeled after the 2008 contribution of our group (Brussaard et al. 2008, as reported last year) the current commentary will focus on the role of viruses as ideal and tractable systems for molecular metagenomic studies, presenting both the advances and the caveats associated with such work.

The Future. As this was the last funded meeting of the working group, there was some concern for the future. The SCOR program has been able to bring together new collaborations that are helping to push the boundaries of virus ecology rapidly forward. Several members have asked us to gather information concerning a "renewal" of the project and core member Wilhelm has agreed to approach SCOR in this capacity. Other avenues of potential funding have also been discussed. One thing that is certain is that the ability to bring together the top researchers in this area from around the world has probably doubled the global rate of progress in this area of science, as a result of both collaboration and consultation within the group.

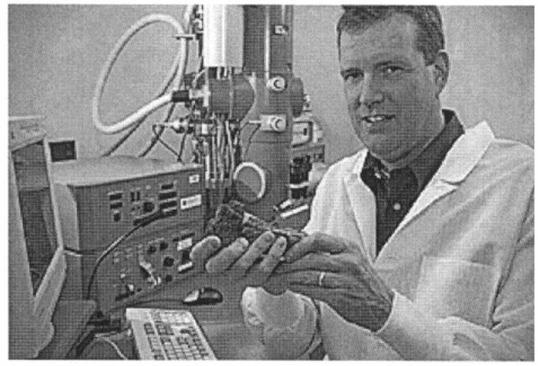
One piece of evidence regarding the success of this working group is the expansion of virus ecology into countries beyond North America and Europe. For example, three members of WG 126 (Wilhelm, Weinbauer and Associate member Feng Chen) have been asked to attend the meeting of the new Microbial Carbon WG (SCOR WG #134) in Xiamen, China in October of this year. Their efforts will be to expand the inclusion of viruses into microbial food webs/carbon cycling and to bring expertise to China on the role of viruses in these processes.

UDaily
Friday, May 22, 2009

UNIVERSITY OF DELAWARE

Delaware hosts meeting on ecology of viruses

10:01 a.m., May 21, 2009----An international group of 75 scientists gathered May 14-16 at the University of Delaware for a meeting focused on the ecology of viruses in aquatic and terrestrial environments, from the deepest part of the ocean to the soils of Delaware.



K. Eric Wommack of the University of Delaware is an expert on marine viruses.

The scientists came from across the U.S., Canada, Japan, Ukraine, Netherlands, Norway, Denmark and Chile, according to K. Eric Wommack, UD associate professor of plant and soil sciences, biological sciences and marine and earth studies who is affiliated with the Delaware Biotechnology Institute and who organized the meeting.

Wommack said the meeting marked the 20th anniversary of the discovery of extraordinary viral abundance in the ocean in 1989. "We now know that all of the viruses on earth, lined end to end would stretch to the nearest 60 galaxies -- 10,000 light years," he said.

Several talks during the meeting focused on the astonishing diversity of viral genes. "Using the tools of high-throughput sequencing to explore the genomes (DNA and RNA) of environmental viruses we have discovered that most viral genes are unknown and truly novel," Wommack said. "Because viruses are so abundant in soils and aquatic environments it is possible that we have little to no understanding of the most abundant genes on Earth."

The event's keynote speaker, Graham Hatfull, a Howard Hughes Medical Institute Fellow, spoke of his exploration of the diversity of viruses infecting a bacteria related to the one that causes TB.

Hatfull has brought genomic science to high school and undergraduate students and through an HHMI-funded program, well over 50 new viral genomes have been sequenced and annotated by these aspiring scientists

The group held an open discussion on the best technologies to explore the genetic diversity of viruses in the environment.

The meeting was supported by the Scientific Committee for Ocean Research (SCOR), the Gordon and Betty Moore Foundation Marine Microbial Initiative, the UD Center for Critical Zone Research and the Delaware EPSCoR program. Through these funds the SCOR viral ecology working group was able to support the attendance of dozens of graduate students and post-doctoral fellows.

UDaily is produced by the Office of Communications & Marketing
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APPENDIX I: CHAPTERS AND AUTHORS FOR METHODS IN AQUATIC VIROLOGY

1. Concentration of free viruses from water samples (Wommack; Sime-Ngando)
2. Separation of free virus particles from sediments in aquatic systems (Danovaro & Middelboe)
3. Counts of viruses by epifluorescence microscopy (Suttle & Fuhrman)
4. Determining virus abundance by flow cytometry (Brussaard)
5. Isolation of viruses infecting photosynthetic and non-photosynthetic protists (Nagasaki & Bratbak)
6. Isolation and life-cycle characterization of viruses infecting heterotrophic bacteria and cyanobacteria (Middelboe & Chan)
7. Temperate phages and lysogens (Paul & Weinbauer)
8. The isolation of viruses infecting Archaea (Stedmann and Dyall-Smith)
9. Purification of virus particles with centrifugal gradients (Lawrence & Steward)
10. Transmission electron microscopy of viruses and viral communities (Heldal & Ackerman)
11. Preparation and application of fluorescently labeled virus particles (Noble, Comeau)
12. Estimating viral-mediated mortality rates of prokaryotes method (Weinbauer, Rowe and Wilhelm)
13. Estimation of autotrophic mortality by the virus dilution method (Kimmance and Brussaard)
14. Isolation of nucleic acids from virus particles and communities (Steward & Culley)
15. Sequencing and characterization of viral genomes (Wilson, Schroeder and Johnson (Brode)
16. Construction and analysis of marker gene libraries (Short, Chen, and Wilhelm)
17. Fingerprinting virus communities by DGGE and PFGE (Schroeder, Saanda, Short)
18. Construction of microarrays and applications to virus analysis (Allen, Lindell)
19. Characterization of RNA virus communities (Culley)

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

Terms of Reference:

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

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Frank Millero	USA
Petra Spitzer	GERMANY
Dan Wright	CANADA

Associate Member:

Peter Tremaine	CANADA

Executive Committee Reporter: Lawrence Mysak

Progress Report to SCOR, July 2009

On SCOR/IAPSO Working Group 127 on the
Thermodynamics and Equation of State of Seawater

Full Members

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

Associate Members

Peter Tremaine (Canada)

1. Working Group Meetings

SCOR/IAPSO WG127 was approved in 2005, had its first meeting at Warnemünde in May 2006, and its second meeting at Reggio, Italy in May 2007. The third meeting was in Berlin from 3-9 September 2008. The fourth and final meeting of the Working Group is planned for 2-5 September 2009 in Arnhem, the Netherlands. We expect all Full Members to attend this meeting.

2. Requests to SCOR concerning membership or terms of reference

There are no requests for changes in membership or terms of reference at this time.

3. Activities between working group meetings

Many of the issues on our agenda are being pursued by individual members, and by subcommittees of WG127.

4. Next Working Group Meeting

The next meeting of the working group is planned for 2-5 September in Arnhem, the Netherlands. During the first two days, four members of WG127 will meet to discuss issues around the finalization of computer code and some aspects of the publication of our work. The next two days will be attended by all members of WG127, and the agenda will include the SI traceability of the measurement of Absolute and Practical Salinity and we also hope to meet with representatives of companies that manufacture oceanographic instrumentation, to discuss matters regarding the introduction of the new thermodynamic definition of seawater.

During the following week (6-11 September) IAPWS (the International Association of the

Properties of Water and Steam) has its annual meeting in Arnhem, and we expect that IAPWS will adopt the pure water part of the Feistel (2003) Gibbs function as an official IAPWS Release, minor revisions of IAPWS-95 on pure water and IAPWS-06 on ice, and that IAPWS will establish its planned Subcommittee on Seawater, to which WG127 members are expected to contribute oceanographic expertise.

5. Assessment of Progress

WG127 has continued to make great progress in the past 12 months and is within sight of achieving virtually all its objectives. During the past year our **International Thermodynamic Equation of Seawater 2010 (TEOS-10)** has been adopted as the standard definition of seawater for engineering purposes by IAPWS (at its International Conference in September 2008 in Berlin), and in late June 2009 by the Intergovernmental Oceanographic Commission (IOC) of UNESCO as the oceanographic definition of seawater.

During this past year WG127 has also progressed many of its publications, including the creation of the TEOS-10 Web site (http://www.teos-10.org) and the writing of a comprehensive TEOS-10 manual. UNESCO/IOC plans to publish this TEOS-10 manual in 2010.

Over the next year we need to continue working intensively on the computer codes, the journal publications and the TEOS-10 manual that describe our work and implement our findings. Given that oceanographic practice will be changing to the new thermodynamics on 1 January 2010, we request that WG127 continue in its present form until 31 December 2010 so as to be a source of advice regarding the introduction of this new standard.

Below we list twenty papers/documents that underlie TEOS-10 (eighteen of which have been written by WG127 members). The primary and secondary standards have been blessed by IAPWS and IOC, while the tertiary standard algorithm is recognized as a work in progress. This document and algorithm is the only viable method to estimate Absolute Salinity globally to date, and it is hoped that in a decade or so, this aspect of our understanding of seawater may improve significantly. This will only occur if more samples of seawater are analysed for density directly; a technology that exists today. We are therefore advocating that observational programs such as CLIVAR commit to such measurements on cruises under its auspices.

In summary, as of July 2009 WG127 has published the key papers defining the thermodynamic properties of seawater, and the TEOS-10 definition of seawater has been adopted by both IAPWS and IOC. Hence the academic work required to address WG127's main objectives is virtually complete. The work remaining in order for WG127 to complete its main goals is

(i) To document its work in a way that will assist oceanographers to adopt these advances,
(ii) to finalize the writing, testing and description of suitable sets of computer algorithms that implement the TEOS-10 seawater thermodynamics,
(iii) to complete the publication of the algorithm that WG127 recommends for the calculation of Absolute Salinity from measurements of Practical Salinity,

(iv) to assist and guide the oceanographic community in adopting the new approach to seawater properties.

It is very satisfying to have TEOS-10 adopted by both IAPWS and IOC and we remain committed to completing the tasks of publishing several papers and manuals and to disseminating TEOS-10 computer software to the oceanographic community.

Trevor J McDougall
Chair, SCOR/IAPSO Working Group 127

Papers Describing the TEOS-10 Thermodynamic Definition of Seawater

Primary Standard Documents

IAPWS, 1995: Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use, The International Association for the Properties of Water and Steam. Fredericia, Denmark, September 1996, available at http://www.iapws.org/relguide/IAPWS95.pdf

IAPWS, 2006: Release on an Equation of State for H_2O Ice Ih, The International Association for the Properties of Water and Steam, Witney, UK, September 2006, available at http://www.iapws.org/relguide/Ice.pdf

IAPWS 2008: Release on the IAPWS Formulation 2008 for the Thermodynamic Properties of Seawater, The International Association for the Properties of Water and Steam, Berlin, Germany, September 2008, available at http://www.iapws.org

Millero, F.J., Feistel, R., Wright, D.G., and McDougall, T.J., 2008: The composition of Standard Seawater and the definition of the Reference-Composition Salinity Scale, *Deep-Sea Res. I*, **55**, 50-72.

Secondary Standard Documents

Feistel, R., 2003: A new extended Gibbs thermodynamic potential of seawater. *Progr. Oceanogr.*, **58**, 43-114.

IAPWS, 2009: Supplementary Release on a Computationally Efficient Thermodynamic Formulation for Liquid Water for Oceanographic Use, The International Association for the Properties of Water and Steam, Arnhem, Netherlands, September 2009, proposed Release.

Tertiary Standard Documents

McDougall, T. J., D. R. Jackett and F. J. Millero, 2009: An algorithm for estimating Absolute Salinity in the global ocean. *Ocean Sci. Discuss.*, **6**, 215-242. http://www.ocean-sci-discuss.net/6/215/2009/osd-6-215-2009.html and from http://www.TEOS-10.org. [This paper and its computer algorithm contain the state of the art today for estimating Absolute Salinity from field measurements of Practical Salinity. As more measurements become available in coming years, it is expected this algorithm will be improved.]

McDougall, T.J., R. Feistel, F. J. Millero, D. R. Jackett, D. G. Wright, B. A. King, G. M. Marion, C.-T. A. Chen and P. Spitzer, 2009: The International Thermodynamic Equation Of Seawater 2010 (TEOS-10): Calculation and Use of Thermodynamic Properties, IOC *Manuals and Guides No.* xx. UNESCO (English), 150pp. in preparation

Background papers to the declared standards

Wagner, W. and Pruß, A., 2002: The IAPWS formulation 1995 for the thermodynamic properties of ordinary water substance for general and scientific use. *J. Phys. Chem. Ref. Data,* **31**, 387-535.

McDougall, T.J., 2003: Potential enthalpy: A conservative oceanic variable for evaluating heat content and heat fluxes. *Journal of Physical Oceanography*, **33**, 945-963.

Feistel, R. and W. Wagner, 2006: A New Equation of State for H_2O Ice Ih. *J. Phys. Chem. Ref. Data,* **35**, 2, 1021-1047.

Feistel, R., 2008: A Gibbs function for seawater thermodynamics for −6 to 80 °C and salinity up to 120 g kg^{-1}. *Deep-Sea Res. I*, **55**, 1639-1671.

Feistel, R., D. G. Wright, K. Miyagawa, A. H. Harvey, J. Hruby, D. R. Jackett, T. J. McDougall and W. Wagner, 2008: Mutually consistent thermodynamic potentials for fluid water, ice and seawater: a new standard for oceanography. *Ocean Science*, **4**, 275-291. http://www.ocean-sci.net/4/275/2008/os-4-275-2008.html

Marion, G.M., F. J. Millero, and R. Feistel, 2009: Salinity/temperature ranges for application of seawater $S_A - T - P$ models, *Ocean Science*, submitted.

Millero, F.J., 2000. Effect of changes in the composition of seawater on the density-salinity relationship. *Deep-Sea Res. I* **47**, 1583-1590.

Millero, F.J., F. Huang, N. Williams, J. Waters and R. Woosley, 2009: The effect of composition of the density of South Pacific Ocean waters, *Mar. Chem.*, submitted.

Millero, F.J., J. Waters, R. Woosley, F. Huang, and M. Chanson, 2008: The effect of composition on the density of Indian Ocean waters, *Deep-Sea Res. I*, **55**, 460-470.

McDougall, T.J., R. Feistel, F. J. Millero, D. R. Jackett, D. G. Wright, B. A. King, G. M. Marion, C.-T. A. Chen and P. Spitzer, 2009: *The International Thermodynamic Equation Of Seawater 2010 (TEOS-10): Calculation and Use of Thermodynamic Properties*, Global Ship-based Repeat Hydrography Manual, IOCCP Report No. 14, ICPO Publication Series no. 134, 150pp.

Papers describing computer software

Feistel, R., D. G. Wright, D. R. Jackett, K. Miyagawa, W. Wagner, U. Overhoff, C. Guder, G. M. Marion, V. Tchijov, A. Feistel, J. H. Reissmann, 2009: Numerical implementation and oceanographic application of the thermodynamic potentials of water, vapour, ice, and seawater. Part I: Background and equations. *Ocean Science*, in preparation.

Wright, D. G., R. Feistel, D. R. Jackett, K. Miyagawa, A. Feistel, C. Guder, G. M. Marion, U. Overhoff, J. H. Reissmann, V. Tchijov, and W. Wagner, 2009a: Numerical implementation and oceanographic application of the thermodynamic potentials of water, vapour, ice, and seawater. Part II: The library routines. *Ocean Science*, in preparation.

TEOS-10 web site

We have created and are maintaining the web site http://www.teos-10.org which serves many of the TEOS-10 papers and the TEOS-10 manual as well as key computer software.

Improved seawater thermodynamics:- How should the proposed change in salinity be implemented?

by SCOR/IAPSO Working Group 127
Membership of SCOR/IAPSO Working Group 127 on "Thermodynamics and the Equation of State of Seawater" : Trevor J. McDougall, Chair, Chen-Tung Arthur Chen, Rainer Feistel, Valentina N. Gramm-Osipova, David R. Jackett, Brian A. King, Giles M. Marion, Frank J. Millero, Petra Spitzer, Dan Wright. Associate Member: Peter Tremaine,
Corresponding author: Trevor.McDougall@csiro.au

Background

The SCOR/IAPSO Working Group 127 on the "Equation of State and Thermodynamics of Seawater" is charged with providing improved algorithms and descriptions of the thermodynamic properties of seawater. The working group has made significant progress on many of its goals, and it is now time to seek the advice of the oceanographic community regarding the best practical ways of adopting these developments into oceanographic practice. The Working Group has met twice to date, once in Warnemünde in 2006, then in Reggio Calabria in 2007. Our next meeting is in Berlin in September 2008.

The working group will soon provide the most accurate algorithms to date for the thermodynamic properties of seawater (such as density, entropy, enthalpy, specific heat capacity, etc). In order to achieve such accuracy it became evident that a salinity variable is required that more accurately represents absolute salinity than does the conductivity-based Practical Salinity. Spatial variations in the composition of seawater upsets the relationship between Practical Salinity S (which is a function of conductivity, temperature and pressure) and Absolute Salinity S_A (defined as the mass of dissolved material per mass of seawater solution). If the thermodynamic properties of seawater are to be written in terms of just one type of salinity, then they are much closer to being functions of (S_A,t,p) than being functions of (S,t,p). Moreover, Absolute Salinity is a conservative property (that is, it is conserved when turbulent mixing occurs) whereas Practical Salinity is not conservative.

Absolute salinity for seawater of Reference Composition

In order to progress toward evaluating Absolute Salinity our first task was to define the relative concentrations of the constituents of Standard Seawater. This we have done, and this work is published in Millero et al (2008a). The abstract of this paper is as follows.

> "Fundamental determinations of the physical properties of seawater have previously been made for Atlantic surface waters, referred to as "Standard Seawater". In this paper a Reference Composition consisting of the major components of Atlantic surface seawater is determined using these earlier analytical measurements. The stoichiometry of sea salt introduced here is thus based on the most accurate prior determination of the composition, adjusted to achieve charge balance and making use of the 2005 atomic weights. Reference Seawater is defined as any seawater that has the Reference Composition and a new Reference-Composition Salinity S_R is defined to provide the best available estimate of the Absolute Salinity of both Reference Seawater and the Standard Seawater that was used in the measurements of the physical properties. From a practical point of view, the value of S_R can be related to the Practical Salinity S by
>
> $S_R = (35.165\,04\ /\ 35)\ \mathrm{g\ kg^{-1}} \times \cdot S$.
>
> Reference Seawater that has been "normalized" to a Practical Salinity of 35 has a Reference-Composition Salinity of exactly $S_R = 35.165\,04\ \mathrm{g\ kg^{-1}}$.
>
> The new independent salinity variable S_R is intended to be used as the concentration variable for future thermodynamic functions of seawater, as an SI-based extension of Practical Salinity, as a reference for natural seawater composition anomalies, as the currently best estimate for Absolute Salinity of IAPSO Standard Seawater, and as a theoretical model for the electrolyte mixture "seawater".

As described in this abstract, *for seawater of standard composition* we have been able to relate the Absolute Salinity to the Practical Salinity; for example, at a Practical Salinity of 35, seawater of Reference Composition has an Absolute Salinity of 35.165 04 g kg^{-1}. We expect shortly to be able to recommend an algorithm that accounts for the variation of seawater composition from the standard composition. That is, we soon expect to be able to recommend an algorithm $S_A = S_A(S_R\ ,,,)$ where the extra arguments will be either measured parameters (such as total alkalinity, silicate and nitrate) or more simply the spatial locations longitude, latitude and pressure. Millero and Kremling (1976), Millero (2000) and Millero et al (2008b) are precursor papers to such an algorithm.

Advantages of Absolute Salinity over Practical Salinity

Absolute Salinity has the following advantages over Practical Salinity for oceanographic use.

1. The definition of Practical Salinity S on the PSS-78 scale is separate from the system of SI units. Absolute Salinity can be expressed in the unit (g kg^{-1}). Adopting this SI unit for salinity would terminate the ongoing controversies in the oceanographic literature about the use of "psu" or "pss" and make research papers more readable to the outside scientific community and consistent with SI.
2. The freshwater mass fraction of seawater is not $(1 - 0.001\,S)$. Rather, it is $(1\text{-}0.001 S_A\ /(\mathrm{gkg^{-1}}))$, , where S_A is the Absolute Salinity, defined as the mass fraction of dissolved material in seawater. The values of $S_A\ /(\mathrm{g\ kg^{-1}})$ and S are known to differ by about 0.5%. There seems to be no good reason for continuing to ignore this known difference, e.g., in ocean models.
3. PSS-78 is limited to the salinity range 2 to 42. For a smooth crossover on one side to pure water, and on the other side to concentrated brines up to saturation, as e.g. encountered in sea ice at very low temperatures, salinities beyond these limits need to be defined. While this poses a challenge for S, it is not an issue for S_A.
4. The theoretical Debye-Hückel limiting laws of seawater behavior at low salinities, used for example in the determination of the Gibbs function of seawater, can only be computed from a chemical composition model, which is available for S_R but not for S.
5. For artificial seawater of Reference Composition, S_R has a fixed relation to Chlorinity, independent of conductivity, salinity, temperature, or pressure.
6. The next largest improvement in the equation of state of seawater will come from incorporating variations in the composition of seawater, that is, from calling the equation of state with Absolute Salinity rather than with Reference Salinity. The determination of Absolute Salinity is facilitated by the introduction of the Reference Composition and Reference Salinity.
7. Absolute Salinity S_A is a conservative variable, whereas, in the presence of compositional variations, Practical Salinity S (which is essentially determined by conductivity alone)

is not a conservative variable. All of our oceanographic practice assumes that "salinity" is a conservative variable (e.g. ocean model codes, the practice of mixing along straight lines on salinity-potential temperature diagrams, inverse modelling etc).

Expanding on point 7 above, it seems clear that we presently use Practical Salinity S as though it is a conservative variable, and yet we now know that it is not; for a given Absolute Salinity, Practical Salinity varies by up to 0.02 between different major ocean basins (Millero, 2000). This non-conservative regional variation in Practical Salinity is at least seven times the error with which salinity can be measured by modern instrumentation at sea. This difference of 0.02 in Practical Salinity causes differences in density that are also several times greater than the remaining uncertainty in the best algorithms for the density of seawater. It seems that in our oceanographic practice we intuitively ascribe the conservative properties of Absolute Salinity to our "salinity" variable, which to date has been Practical Salinity. For example, if we were intent on interpreting the salinity of an ocean model as Practical Salinity, then the salt conservation equation should contain a non-conservative source term to take account of the spatial variations in the composition of seawater.

Here we summarize the reasons why Absolute Salinity is the preferred salinity variable for oceanographic research.

- It will be preferred by journals since it is an SI unit.
- It is the natural salinity variable for ocean models since they assume that their salinity variable is conservative, hence it should be used to initialize ocean models at all depths.
- It is the natural variable to use in inverse models, budget studies and on salinity-temperature diagrams because its conservative nature justifies turbulent mixing occurring along straight lines on such a diagram.
- The freshwater fraction and the meridional freshwater flux follow naturally when using Absolute Salinity but not when using Practical Salinity.
- By using Absolute Salinity in the algorithm for the equation of state, the effects of the spatial variations of seawater composition are accounted for, while if Practical Salinity is used in such a call to the equation of state, a density error is incurred.
- It is the common salinity variable used in engineering, natural and geosciences outside oceanography, where Practical Salinity is often unknown or misconstrued.
- It is applicable to low concentrations in brackish lagoons and river mouths, to high concentrations in freezing or desiccating brines, as well as at higher temperatures in desalination plants, whereas Practical Salinity is defined only in the range $2<S<42$.
- If necessary for chemical or biological reasons, all partial ion concentrations in a sample are easily available, to which Practical Salinity is unrelated.

The SCOR/IAPSO Working Group 127 regards these as compelling reasons for adopting Absolute Salinity as the new preferred salinity variable in the analysis of oceanographic data. Accordingly we are formulating new algorithms for density, enthalpy, entropy, potential temperature, sound speed, etc in terms of Absolute Salinity, temperature and pressure (Feistel (2008)). The extended validity range of the new formulas in temperature and salinity precludes using Practical Salinity as the independent variable of these thermodynamic quantities. For example, *in situ* density will have the functional form and potential temperature will have the functional form $\theta(S_A,t,p,p_r)$ Absolute Salinity S_A will be defined as $S_A=S_R+\delta S_A$ where Reference salinity S_R is simply proportional to Practical Salinity S as described in Millero et al (2008), namely by

S_R = (35.165 04 / 35) g kg^{-1} × S ,

and δS_A is the difference between Absolute and Reference Salinities. δS_A will be available as a look up table as a function of latitude, longitude and pressure and also as an alternative linear relationship of nutrient and silicate concentrations, or for example, as a Calcium excess estimate from the river discharge into estuaries. We expect to have algorithms available before the end of 2008.

How to adopt Absolute Salinity?

Having made the case that Absolute Salinity possesses many advantages over Practical Salinity, how should present oceanographic practice adapt to incorporate these advantages?

The obvious thing to do would be to decide on a date on which the whole community ceases to use Practical Salinity and switches to using Absolute Salinity. However the algorithm to convert Reference Salinity to Absolute Salinity is less mature and will probably remain a "work in progress" for several years. Moreover, data that are stored in archives should have a very close connection to a measurement (like temperature or conductivity) rather than being the result of an algorithm that is likely to change with time. Hence one cannot really imagine storing Absolute Salinity in data bases. Rather, the closest thing to do in this vein is to store Reference Salinity.

Storing Reference Salinity in data centres would have the advantage that it is an SI unit. However before the equation of state (or other thermodynamic quantities) can be evaluated using the new software, the Reference Salinity data need to be converted to Absolute Salinity using the most up-to-date version of this software. Moreover, the community cannot completely abandon Practical Salinity since it will remain as the salinity variable in the archives for cruises undertaken before the change-over date. By changing the salinity variable that is reported from cruises to data bases from Practical Salinity to Reference Salinity the possibility of contamination of the data archives arises as salinity of one type is incorrectly labeled and stored as the other type of salinity.

In the long run, as with many other historical non-SI units like torr, cal or dyn, it would seem to be an advantage to use only Reference Salinity and abandon the use of Practical Salinity completely. If Reference Salinity were the salinity variable to be used in all of the revised thermodynamic algorithms, the argument for "biting the bullet" and abandoning Practical Salinity as much as possible would seem to be the correct path. But it is Absolute Salinity that we seek, and Reference Salinity is only part way towards the evaluation of Absolute Salinity. Given this, is it worthwhile changing the present archiving practice in favour of a variable (Reference Salinity) that is still not the final salinity that we will use (Absolute Salinity)?

Any choice of action inherently involves compromises, and the best course of action is not obvious to the Working Group. As a way of focusing the discussion we outline two possible routes for adopting the advantages of Absolute Salinity, labeled Option 1 and Option 2.

Option 1

- Change from reporting Practical Salinity to reporting Reference Salinity to national and international data bases. This implies that the data bases store Practical Salinity from the old cruises and store Reference Salinity from new cruises (from say 1st January 2010).
- Provide software (for example, of the form $S_A(S_R,x,y,p)$) to produce the best available estimate of Absolute Salinity from Reference Salinity (using additional information on

position or water properties).

- Have all the thermodynamic software in the form $p(S_A,t,p)$.

Discussion of Option 1

The main advantage of Option 1 is that the community eventually ceases to use the non-SI unit Practical Salinity, and instead uses the two SI salinity measures, Reference Salinity and Absolute Salinity.

A drawback of Option 1 is that there will be cases of contamination of the data bases where cruise salinity is labeled and stored as Reference Salinity whereas in fact it is Practical Salinity data, and vice versa. This kind of error presently contaminates the temperature, oxygen and pressure/depth data bases.

Since both S and S_R are simply measures of conductivity, and since they are simply proportional to each other, will it be seen that we are taking a course of action that has potential for confusion for only academic benefit?

Recall that scientific work and papers are mostly done with potential temperature θ rather than in situ temperature t so the first thing that one usually does with the S, t, p data from a data centre is to form θ. Similarly, scientific work and papers should be done with Absolute Salinity rather than Reference Salinity so the first thing that one needs to do under Option 1 with the S_R, t, p data from a cruise or from a data centre is to form not only θ but also S_A. This analogy with what we already do with storing the measured variable t but using the derived variable θ is very close.

Under Option 1 we cannot imagine that the community can altogether forget about Practical Salinity however, as the data from older cruises (e.g. all of WOCE) is stored in data centres in terms of Practical Salinity. This data will need converting first to Reference Salinity and then to Absolute Salinity before the thermodynamic routines such as potential temperature, density, potential enthalpy etc, can be called by oceanographic researchers.

There will be some instances when the new software is called with the salinity data being S and in those instances an error will be made. This type of error is an undesirable consequence of both Options 1 and 2.

Option 1 requires manufacturers (such as Seabird) to change what they presently do. The instruments will need to output their salinity in terms of Reference Salinity. Also the ampoules of standard seawater will need to quote their salinity in terms of Reference Salinity. The transition date of say 1st January 2010 has to be handled very carefully in these respects. Further, anyone wanting to make use of older ampoules will have to be aware of the transition and how to deal with it.

Option 2

- Continue to report Practical Salinity S from cruises and to have <u>only</u> Practical Salinity S stored at national and international data centres.
- Provide software (for example, of the form $S_A(S,x,y,p)$) to produce the best available estimate of Absolute Salinity from Practical Salinity (using additional information on position or water properties).
- Have all the thermodynamic software in the form $p(S_A,t,p)$.

Discussion of Option 2

By reporting <u>only</u> S in data bases we would expect to greatly reduce the possibility of salinity data being mislabeled in data bases.

Since both S and S_R are simply measures of conductivity, option 2 is consistent with the argument that there is little value in replacing one measure of conductivity (namely Practical Salinity) with another (namely Reference Salinity) in data bases. Rather, under Option 2 data centres store S and S alone.

As mentioned above, scientific work and papers are mostly done with potential temperature θ rather than *in situ* temperature t so the first thing that one usually does with the S, t, p data from a data centre is to form θ. Similarly, scientific work and papers will be mostly done with Absolute Salinity rather than Practical Salinity so the first thing that one needs to do under Option 2 with the S, t, p data from a cruise or from a data centre is to form not only θ but also S_A. This analogy with what we already do with storing the measured variable t but using the derived variable θ suggests that storing S but using S_A will not cause oceanographers any serious difficulties.

There will be some instances when the new software is called with the salinity data being S and in those instances an error will be made. This type of error is an undesirable consequence of both Options 1 and 2. However this error will affect the results and the publications arising out of those who make this error, but this error will not contaminate an archived data set.

Option 2 does not require manufacturers (such a Seabird and the Standard Seawater Service) to change what they presently do. Rather, Option 2 puts the responsibility for the changes in the hands of practicing research oceanographers.

Request for your input

The above two options are just two of many options; please do not feel constrained in your comments to these options. We seek input from the oceanographic community on how to gain the advantages of adopting Absolute Salinity in our oceanographic research work. The key issue seems to revolve around which type of salinity is required to be reported to and archived by oceanographic data centres. We encourage frank responses. Each response will be thoughtfully considered by the Working Group.

Please email your comments to trevor.mcdougall@csiro.au with the words "Comment for WG127 on how to adopt Absolute Salinity" as the message title.

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From: http://www.ioc-unesco.org/index.php?option=com_content&task=view&id=144&Itemid=112

A Pinch of Salt

If oceanographers could distinguish by taste the various salts and minerals in the ocean, seawater would be a great deal easier to analyse. The scientists would sip from their sample jars, swish the water across their palates then spit the water back overboard, licking the residual salt from their lips as they nodded in agreement and exclaimed, ‘Ah, yes, a fine example of North Atlantic 35.' Or would they? Perhaps the flavor of dissolved carbon dioxide might linger a moment in their mouths, or the tips of their tongues would find a bit of calcium carbonate chalking the back of their teeth. Such oddities would tell them that the water was not like the usual North Atlantic vintage.

Rather than taste seawater to determine its salinity, oceanographers electrocute their samples and measure how easy it is for the electricity to flow through the water. This measurement of conductivity accounts for the electrolytes from dissolved salts but misses other dissolved material in seawater. The conductivity method, or ‘Practical Salinity Scale,' has been used by marine scientists since 1978. UNESCO incorporated the scale into the 1980 equations for calculating the density of seawater.

Now, a more accurate way of identifying ‘Absolute Salinity' everywhere in the ocean has been devised and incorporated into a Thermodynamic Equation of Seawater. The new equation is set to become the next oceanographic standard as of 2010, after becoming an industrial standard last year. Any company interested in providing drinking water for desert cities near the coast, for example, will use the new method of calculation in building seawater desalination plants. The thermodynamic equation will also make climate models even more accurate than at present. **On 24 June, experts attending the 25th assembly of UNESCO's Intergovernmental Oceanographic Commission (IOC) in Paris recommended that the entire oceanographic community adopt the thermodynamic equation and the use of Absolute Salinity.**

(Follow this link for the full report of the Assembly's Adopted Resolutions. The resolution on the Thermodynamic Equation appears on page 12 of the report or page 14 on the pdf.)

‘I was not familiar with seawater 20 years ago,' says Rainer Feistel of the Leibniz-Institut für Ostseeforschung in Warnemünde (Germany). But the mathematician and physicist had a good handle on energy conservation, thermodynamics and the maths behind complex systems. In the late 1980s, after nearly a decade in Berlin, Feistel moved back home to the Baltic Sea region and started applying his skills to oceanography. The equations he found himself navigating worked fine for the open ocean but developed inconsistencies in regions that were strongly influenced by river drainage, evaporation, precipitation or extremes in temperature. ‘As you go to points where there are sensitivities, it's a real mess,' Feistel says. The Baltic Sea was one such region. ‘I was surprised,' he says. ‘There was a missing mathematical component, a "Gibbs function" which physicists had determined for all sorts of various fluids, except apparently seawater. Named after American mathematician Josiah Willard Gibbs (1839-1903), the ‘Gibb's function' defines a fluid in terms of its energy and heat transfer, or thermodynamics.

What's in a salt?

‘In chemistry, any positive and negative ion bound together is called a salt,' explains molecular geneticist and chemosensation (taste and smell) expert Hiroaki Matsunami of Duke University in the USA. In the ocean, salts dissolve into free-floating negative and positive ions, also known as electrolytes. These charged particles are what make it possible for electricity to flow through water. The same ions that make up the salt used in foods - sodium (Na^+) and chloride (Cl^-) - account for more than 86% by weight of the 11 major ions in the sea and are what gives the ocean its salty taste. Dried, these ions form table salt and get sprinkled over food.

After chloride and sodium, the ocean's next most common ions are sulfate (SO_4^{2-}) and magnesium (Mg^{2+}). How would the ocean taste if these ions were more common? ‘I tasted magnesium sulfate and it tasted really bad but I wouldn't call it bitter,' Matsunami says of the ingredient used in bath salts.

For a century, oceanographers calculated salinity based primarily on measurements of the most common salt ion: chlorine (*see box below: The search for salinity*).

Water warmer than that above it will rise, just like a hot air balloon rises above the cooler, denser air surrounding it. That is why freshwater from rivers and rain will float on a calm surface and why cold or salty water tend to sink

The shortfalls of the conductivity method

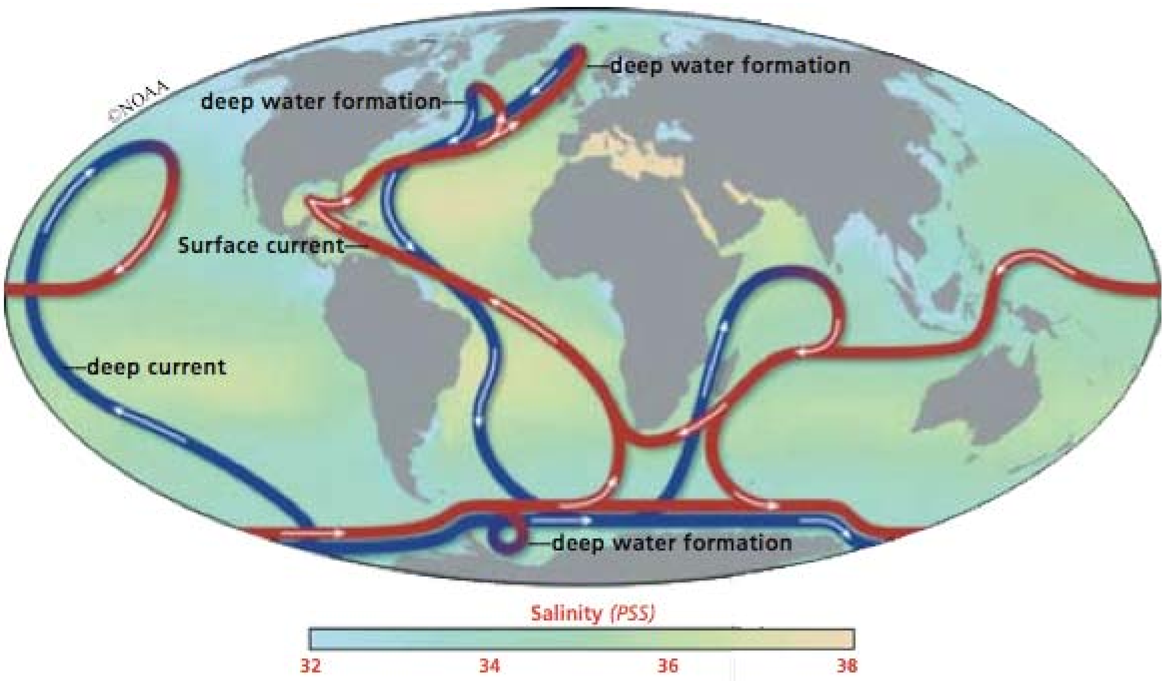
The conductivity method established in 1978 improved accuracy, as it tracked all the ions in the sea and not just chloride. But calculating salinity from conductivity, as opposed to old-fashioned chemical analysis, required sacrificing the definition of salinity. This is because conductivity measures only free-floating ions or electrolytes, the same dissolved salts that are found in power drinks. In fact, any non-conductive material, such as dissolved silicon dioxide and carbon dioxide, 'is simply ignored' when it comes to practical salinity, Feistel says.

The Baltic Sea is a prime example of seawater with an unusual composition, far different from the North Atlantic standard[1]. It has electrolytes that conduct electricity but they are not the typical sodium chloride. The vast rivers of Poland and Russia drain into the Baltic Sea, bringing with them dissolved calcium carbonate ($CaCO_3$) from the limestone river beds. When $CaCO_3$ dissolves, it dissociated into the conductive ions Ca^{2+} and CO_3^{2-}. These ions prefer to be bound together but, if they can't be, they will often bind to other molecules floating in seawater, changing the mass of the molecules and wreaking havoc with conductivity measurements.

The switch to Absolute Salinity

Feistel's re-evaluation of the 1980s equations provided seawater with a 'Gibbs function'. The previous mathematical equations for determining the properties of seawater had not accounted for water's ability to transfer heat from warmer to cooler currents. Nor did the old equations set a standard for comparing how difficult such a transfer of energy might be, based on the water's inherent pressure and volume. The thermodynamic equation of seawater chews up all of the old equations and spits out a neat new bundle of computer algorithms that modellers crave.

In 2010 for the first time, the algorithm for measuring salinity will incorporate more than dissolved salt into the conductivity conversion. Millero, who worked on the 1980 equation of seawater, and Feistel are helping to bring about the change. They have been working with modeller Trevor McDougall of the Centre for Australian Weather and Climate Research in Hobart as part of an international team established in 2005 by the Scientific Committee on Oceanic Research and the International Association for the Physical Sciences of the Ocean. They are incorporating the location of the conductivity measurements with chemical analysis from those regions into the new Absolute Salinity calculation. The team has also redefined how the properties of seawater are calculated using this new Absolute Salinity method and combining it with the principles behind thermodynamics to form a single new thermodynamic equation for seawater.



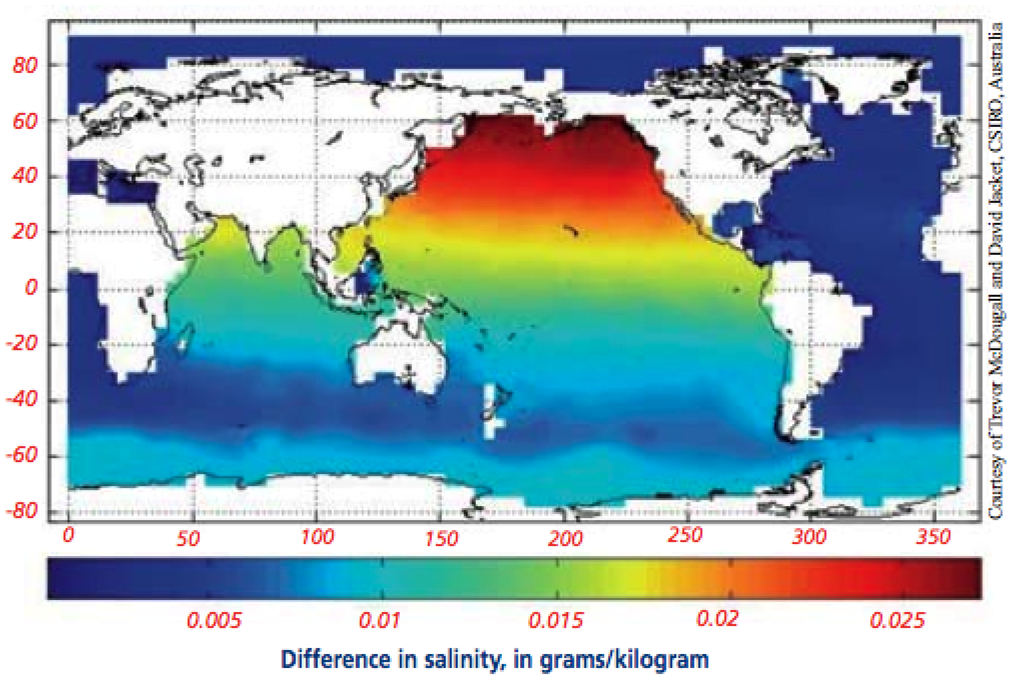
This map measures the equivalent parts of salt per thousand parts of water in the world's oceans, using the Practical Salinity Scale. It also shows the path followed by the ocean conveyor belt, with the warm surface currents in red. The ocean conveyor belt is driven by differences in seawater density

Ensuring any climate model is worth its salt

The fundamental properties of sea water - salinity, temperature and pressure, along with the freezing and boiling points, heat capacity, speed of sound and density - are intricately tied together. Being able to measure salinity is important, as salinity levels are indicators of climate change. They indicate how much freshwater is evaporating from the oceans. Parts of the Atlantic Ocean appear to be getting saltier, for instance. A possible explanation could be that trapped heat from higher atmospheric concentrations of CO_2 is causing more seawater to evaporate than before, leaving the salt behind.

Secondly, salinity levels affect water density. Density especially determines whether a current rises towards the surface or sinks towards the seafloor, as the denser the seawater, the deeper it will sink. Density depends on temperature, pressure and the amount of dissolved material in the water. Knowing the density of seawater is crucial to monitoring the Earth's climate. The ocean transports heat via currents collectively called the ocean conveyor belt in a process known as thermohaline circulation. In the Arctic and Antarctic Oceans, cool and salty waters sink to form deep water currents. Over thousands of years, these currents travel around the world until they reach areas of upwelling which bring them to the surface. Once at the surface, the sun-warmed, rain-freshened currents head back to the poles where the formation of ice allows the cycle to continue. A massive input of freshwater, such as from melting polar ice caps, can prevent the surface water from sinking and slow down or even stop the ocean conveyor belt, potentially causing great changes to the Earth's climate. ‘Every climate model worth its salt depends on our ability to know if hot water goes up and cold water down, as well as how far and how fast,' observes Keith Alverson, head of the Ocean Observations and Services section of the UNESCO-IOC.

This map shows where the measurement of salinity is most affected by the new Absolute Salinity method (in grams of dissolved material per kilogram of water). Absolute Salinity takes into account all dissolved material and not just salts, unlike the Practical Salinity Scale. The deep red colour is accounted for by additional silicon dioxide in this part of the Pacific Ocean that the Practical Salinity Scale was not picking up. The darkest blue shading indicates little or no change



Several factors influence ocean circulation patterns: wind, rain, seafloor topography, the conditions of the surrounding water, as well as the moon and the rotation of the Earth. Ocean circulation models include all of these factors and the computer algorithms that generate the models take weeks to run. Climate change models, which incorporate the ocean's ability to transport heat, take even longer. ‘To see what model works best, what fits with the Earth's climate record from the past then run the model forward a century or two can take the best part of a year,' McDougall says. To incorporate non-electrolytes into the equation for salinity then merge the various other equations for different seawater properties into one, McDougall's team has relied on theories from Josiah Gibbs. They are mixing 19th century theory with 21st century computer algorithms.

Based on what they have run so far, McDougall estimates the new equation will show a 3% change in how the ocean circulates heat from the equator to the poles. The other change he is noticing is a 0.5°C difference in the surface temperature of the equatorial Pacific Ocean in both the east and west. Off the coast of Peru, trade winds drive warm surface water away from shore and cold, nutrient-rich, deep water upwells to fill its place. The warm water pools further to the west, warming the air above it and increasing precipitation over Indonesia. During El Niño years, the reduction in the strength of the trade winds allows the warm, nutrient-consumed water to stay closer to the Peruvian shore. The winds push the rain only as far as the central Pacific and Indonesia experiences droughts.

The new thermodynamic equation for seawater allows models to account better for changes in density and for heat transfer as a result of rain falling on the Earth's surface. ‘The main reason to do this work is to make these models as accurate as possible,' McDougal concludes.

By Christina Reed[2]

The search for salinity

‘The exact chemical composition of seawater is unknown at the present time,' says Frank Millero of the Rosenstiel School of Marine and Atmospheric Science at the University of Miami in Florida (USA). It is not for want of trying. Marine scientists have been searching for the ‘magic formula' for measuring salinity for over 150 years.

As early as 1865, Danish marine geochemist Georg Forchhammer found 27 different substances in seawater he sampled from different regions of the ocean. ‘Next to chlorine, oxygen and hydrogen, sodium is the most abundant element in seawater,' he wrote. Other major substances he found included sulphuric acid, soda, potash, lime and magnesia. ‘Those which occur in less but still determinable quantity are silica, phosphoric acid, carbonic acid and oxide of iron,' he concluded. His tables were used until 1902 when Danish oceanographer Martin Knudsen filtered and distilled North Atlantic water as a seawater standard that all marine scientists could use to calibrate their instruments easily and compare their samples from around the world with a control.

In the 1930s, the introduction of instruments that could measure seawater’s electrical conductivity set sailors scrambling to determine whether chemical analysis or the new physical analysis worked better to determine salinity. Conductivity won and by the mid-1950s, deploying a rosette of sampling tubes equipped with conductivity, temperature and depth recorders (CTDs) was becoming a routine part of oceanographic cruises. To maintain consistency, a change to the international standard for seawater was made in 1978 that allowed oceanographers to compare conductivity to a Practical Salinity Scale.

Unlike the Practical Salinity Scale, which accounts only for ions, the new Absolute Salinity will incorporate non-electrolytes using tables that account for how these additional substances vary region by region. Once again, the latitude and longitude at which the seawater samples are taken will play an important role in calculating salinity.

[1]Water from the North Atlantic with a salinity of about 35 parts of salt per thousand parts water has traditionally been used as a control for comparing other water samples.

[2]Freelance science journalist working with UNESCO-IOC. Author of Marine Science: Decade by Decade (2009), a history of 20th century oceanography; c.reed at unesco.org
This story, 'A Pinch of Salt', will be available in the UNESCO newsletter *A World of Science* , vol. 7, no. 3, July-September 2009. For more information visit the IOC 25th Assembly Resolution on this subject.

Certified Research and Development Need - CRDN

Refractive Index of Seawater

The SCOR/IAPSO Working Group 127 on “Thermodynamics and Equation of State of Seawater”, WG127, has examined the published work available for the determination of the refractive index of seawater under the conditions appearing in the ocean and adjacent seas.

The information and devices available are not sufficient to permit:

(a) The construction of a comprehensive and accurate ‘optical equation of state’ of seawater over the entire ranges of interest in oceanographic research, providing the density of standard seawater as a function of temperature, pressure, refractive index and wavelength.

(b) The description of the impact of important regional composition anomalies of seawater on its refractive index as compared to that of standard seawater over the entire ranges of interest

(c) The technological development of long-term stable, fast, high-resolution optical in-situ sensors attached to instruments for use by sea-going oceanography, applicable over the entire ranges of natural conditions

Although encouraging this work, WG127 is not able to provide financial support. The WG127 contact can provide any further development information and will liaise between research and development groups. This CRDN is intended to support project applications of these groups at funding authorities.

Issued by the

SCOR/IAPSO Working Group 127 on
Thermodynamics and Equation of State of Seawater

at its Meeting 6th - 11th May 2007 in Reggio/Calabria, Italy

Certified Research and Development Need - CRDN

Refractive Index of Seawater

Background

The next important progress in observing and modelling the thermodynamic properties of the seas will come from the appropriate consideration of natural or anthropogenic chemical composition anomalies of seawater (Millero et al. 2007). For this purpose, at least one additional independent variable beyond conductivity, temperature and pressure must be measured and evaluated in oceanographic observations, stored in data bases and implemented in numerical models. The resolution of this parameter achieved by measuring instruments/sensors must be comparable to those of temperature and salinity in terms of its impact on density.

The density anomalies to be regularly detected and resolved are estimated as given in Table 1.

Table 1: Density anomalies observed in different regions

Region	Anomaly ppm	Source
North Pacific	15	Brewer & Bradshaw (1975)
Coastal waters	40 - 60	Connors & Kester (1974)
Red Sea	35	Poisson et al. (1981)
Indian Ocean	6	Poisson et al. (1981)
Baltic Sea	120	Millero & Kremling (1976)
in general	50	Fofonoff (1985)

The refractive index of seawater is the currently most promising parameter to be measured for this purpose. The resolution achieved with prototype instruments, the accuracy of related experimental data and the feasibility of constructing in-situ optical field sensors support this approach. The refractive index can recognise the presence of non-dissociated dissolved species like organic silicate which do not influence the conductivity of seawater.

The regular use of optical sensors attached to conventional CTD instruments can reveal the spatial and temporal variability of composition anomalies, as e.g. observed in the Baltic Sea by occasional studies on the decadal time scale.

Although the measuring principle is known for more than a century, and its usability has been demonstrated several times, the construction of practically applicable instruments has suffered in the past from various technological difficulties. Up to now, no robust sensor for sea-going oceanography has yet become available for general use.

The Range of Properties Required

Experimental data, theoretical descriptions and the applicability of in-situ sensors should cover the ranges of naturally occuring oceanic conditions, –2 to 40℃ in temperature, 0 to 40 in practical salinity, 0 to 100 MPa in pressure.

The resolution of refractive index measurements as well as the corresponding uncertainties of theoretical formulas are required to be 1 ppm at atmospheric pressure, and 3 ppm at high pressures, corresponding to 4 ppm and 10 ppm in density, respectively. The response time of the optical sensor should be comparable to the response time of high-precision temperature sensors, its desired long-term stability is several months, in particular for applications in automatic observational systems. Synchronous measurement at several optical wavelengths in the visible range is considered as helpful.

Previous Work and Current Studies

The functioning of the physical principle and of sensor prototypes was reported by many authors (Miyake 1939, Seaver 1987, Mahrt and Waldmann 1990, Seaver at al. 1997, Esteban and Cruz-Navarrete 1999, Waldmann 1999, Alford et al. 2006). None the less, practically working ‘optical CTD’ instruments sufficiently stable for regular field applications are still not available today.

An accurate ‘optical equation of state’ of pure water is already available (IAPWS 1997), consistent with the thermodynamic formulation IAPWS-95 for fluid water. Related investigations on seawater should preferably be conducted relative to pure water.

An ‘optical equation of state’ is available for seawater as an empirical refractive index formula with 27 coefficients for wavelengths 500 to 700 nm, temperatures 0 to 30 °C, practical salinities 0 to 40, and pressures 0 to 110 MPa (Millard and Seaver 1990). Its uncertainty ranges from 0.4 ppm for pure water at 1 atm to the insufficiently accurate figure of 80 ppm for seawater at high pressures. Its consistency e.g. with the ITS-90 temperature scale or the latest pure-water standard (IAPWS 1997) requires verification. The equations of Matthäus (1974) and of Quan and Fry (1995) are valid for atmospheric pressure only. The latter is valid between 0 and 30 °C, 0 and 35 salinity, 400 and 700 nm wavelength, with an uncertainty of 15 ppm.

Theoretical or experimental studies on the refractive index of seawater with anomalous composition are almost completely missing (Heydweiller 1913, Fajans and Joos 1924, Frenkel 1955, Leyendekkers and Hunter 1976).

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CRDN Issue Date: May 9th, 2007

CRDN Review Date: September 2008

CRDN Expiration Date: May 9th, 2010

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

Terms of Reference:

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

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Executive Committee Reporter: Peter Burkill

Natural and Human-Induced Hypoxia and Consequences for Coastal Areas: Current Status

Annual Report – 2008/2009

1. Introduction

SCOR WG #128 was officially approved in August 2005. The first meeting of this Working Group was organized at Vienna, Austria on April 6-7, 2006, and coincided with the EGU Annual Assembly. During the Vienna Meeting, members of WG #128 revised the terms of reference of the group, discussed possible activities between the first and second WG meetings, final results to be expected from this Working Group, and the plan for its second meeting in 2007.

The second meeting of WG#128 was held 22-23 September 2007 at Shanghai, China, and coincided with the IMBER/LOICZ Open Science Conference on Continental Margins: "Impacts of Global, Local and Human Forcings on Biogeochemical Cycles and Ecosystems". During the Shanghai Meeting, members of WG #128 reported their progress on the preparation of syntheses that are related to the terms of reference of this SCOR Working Group through oral presentations and discussion, and then the preliminary list of synthesis papers was revised.

2. Activities since January 2008

Activities of WG #128 were mostly undertaken by e-mail among WG members, long-distance phone calls, and occasional simultaneous participation of several WG members to international conferences (e.g., 4th IGBP Congress at Cape Town, South Africa in 5-9 May 2008). The outcomes of the second WG #128 Meeting at Shanghai in 22-23 September 2007 include

- revising the list of synthesis papers to summarize the work done by this working group,
- using the Web site created by the LOICZ International Project Office (IPO) for the working group to share references and post the draft manuscripts for synthesis work,
- identifying contributions to other organizations (e.g., meetings and other activities) from members of WG#128 (e.g. Las Palmas Conference in Spain), and
- discussing the venue and time for the third WG meeting and final products of this group.

In the period of 30 March–2 April 2009, the two co-chairs of this Working Group met at Shanghai to evaluate activities of the group since its second meeting in September 2007 and to discuss on the progress of preparation for the *Biogeosciences* Special Issue on "Coastal Hypoxia".

Owing to limited funding, the idea of having the third and final meeting of WG #128 was cancelled, and the budget has instead been reserved to cover the publication of synthesis papers in a special issue of *Biogeosciences*, see the section below.

3. Final results of WG #128

The major activity for this Working Group after its second meeting, in Shanghai, has been to prepare the manuscripts of synthesis papers. The preliminary list of 14 synthesis papers was discussed and revised during the Shanghai meeting. New contributions from WG #128 members were also considered and finally 12 titles were proposed, together with the names of lead authors (see below). Scientists from the broader scientific community were also approached and invited to participate in the synthesis work of the group and to contribute as co-authors of synthesis papers led by members of WG #128. During the group's second meeting, there was agreement to publish these synthesis papers in an EGU open-access journal such as *Biogeosciences*, although special issues of other oceanographic journals were also discussed as possible outlets for the papers. Later, when the first paper on historical records of hypoxia led by Dr. Andy Gooday was getting close to completion in May 2008, it was realized that publication of a special issue in *Biogeosciences* would be far too costly for the WG to fund. We have discussed page charges with the editorial office of *Biogeosciences* and efforts have been made to obtain extra financial support from other sources. However, these initiatives did not solve the problem of covering the publication costs for 12 papers in total, and SCOR finally agreed to cover the page charges for authors who needed it, in lieu of funding a third meeting of the WG.

The original deadline of submission of synthesis papers for the special issue of *Biogeosciences* was 30 June 2009. But the preparation of manuscripts has been delayed for a variety of reasons. After making contact with the editorial office of *Biogeosciences*, an extension of submission deadline to 31 August 2009 has been approved by *Biogeosciences*.

As for the progress of manuscript preparations and submission, the latest information (as of July 2009) about the date of completion of synthesis papers is given below:

Five synthesis papers have been submitted to *Biogeosciences* and posted on the *Biogeosciences Discussions* Web site (http://www.biogeosciences-discuss.net/special_issue33.html) as discussion papers between February 27 and July 14, 2009:

- Historical record of coastal eutrophication-induced hypoxia (Leading author: Andy Gooday)
- Effects of natural and human-induced hypoxia on coastal benthos (Leading author: Lisa Levin)
- Coastal hypoxia and sediment biogeochemistry (Leading author: Jack Middelburg)
- Impacts of hypoxia on the structure and processes in the pelagic community – zooplankton, macro-invertebrates and fish (Leading author: Werner Ekau)
- Coastal hypoxia responses to remediation (Leading author: Mike Kemp)

As of July 22, four other synthesis papers have been circulated among co-authors of this Working Group and invited co-authors from the broader scientific community, and are expected to be submitted by the August 31 deadline, including

- Global oxygen trends in the coastal ocean (Leading author: Denis Gilbert)

- Hypoxia/anoxia as a source of N_2O and CH_4 greenhouse gases (Leading author: Wajih Naqvi)
- Overall summary (Leading author: Jing Zhang)
- Modeling of hypoxia/anoxia (Leading author: Angelica Peña)

A tenth paper is under preparation, and will probably be submitted to *Biogeosciences* by August 31:

- Dynamics and distribution of natural and human-induced coastal hypoxia (Leading author: Nancy Rabalais)

There remain two other synthesis papers, for which the submission dates are unknown, including

- Shelf hypoxia driven by open ocean boundary climate variability (Leading author: Pedro Monteiro)
- Pelagic microbial communities and biogeochemical cycling (Leading author: Osvaldo Ulloa)

Unfortunately, if these two synthesis papers are submitted after the August 31 deadline, they will likely be treated as regular submissions and it will not be possible to include them in the special issue on hypoxia. The two co-chairs will continue to encourage Drs. Monteiro and Ulloa to write and submit their papers by August 31.

4. Web site of WG #128

A Web site was created (http://kopc01.gkss.de:8080/LOICZWG128Wiki/Wiki.jsp) for SCOR WG #128 with the help of the LOICZ IPO through Nancy Rabalais, LOICZ SSC Vice-chair, to help establish the cross-link between the two organizations since early 2007. The idea was to have a joint facility for sharing the references of WG #128 and to have a password-enabled Web site that WG members can use for circulation of manuscripts and open discussion on WG-related activities. With help from the LOICZ IPO, information of this Working Group is cross-linked with the LOICZ Web site, which is highly appreciated by this WG. This is considered to be an active, dynamic link between SCOR WG #128 and LOICZ. With ID and passwords provided by LOICZ, every WG member can upload their synthesis manuscripts and/or check with papers led by other WG members. We take this opportunity to acknowledge once again the support that LOICZ has provided in establishing and maintaining this Web site.

5. Other activities of WG#128

Contribution to other international conferences and organizations by this SCOR WG #128 include

- IMBER OSM "IMBIZO" at Miami of United States (Jing Zhang) on 9-13 November 2008
- Argo Workshop at Hangzhou of China (Denis Gilbert) on 25-27 March 2009.
- GEOTRACES Arctic Ocean Planning Workshop at Delmenhorst of Germany (Jing

Zhang) in 8-10 July 2009

- A special session on oceanic oxygen change (coastal and open ocean) at the 2009 Goldschmidt conference in Davos, Switzerland (Denis Gilbert)
- COMARGE Workshop on Habitat Heterogeneity, held at Scripps Institution of Oceanography, 8-12 September 2008 (Lisa Levin and Andy Gooday)

Publications that are related to WG #128:

- Gooday, A.J., Bett, B.J., Escobar, E., Ingole, B., Levin, L.A., Neira, C., Raman, A.V., Sellanes, J. in revision. Biodiversity and habitat heterogeneity in oxygen minimum zones. *Marine Ecology*, in press.
- Osvaldo Ulloa et al. Special Issue on the Oxygen Minimum Zone of the eastern South Pacific (http://www.sciencedirect.com/science?_ob=PublicationURL&_tockey=%23TOC%236035%232009%23999439983%231194058%23FLA%23&_cdi=6035&_pubType=J&_auth=y&_acct=C000023958&_version=1&_urlVersion=0&_userid=496748&md5=a19436caaa84649f33f04d853b9aa78b). *Deep Sea Research II*, in press.
- Rabalais, N. N. and D. Gilbert. 2009. Distribution and consequences of hypoxia. Chapter 11, pp. 209-225 in E.R. Urban, Jr., Bjørn Sundby, P. Malanotte-Rizzoli, and Jerry Melillo (eds.), *Watersheds, Bays, and Bounded Seas: The Science and Management of Semi-Enclosed Marine Systems*. Island Press, Washington, D.C.
- Rabalais, N. N., R. E. Turner, D. Justić, and R. J. Díaz. Published online Mar09. Global change and eutrophication of coastal waters. *ICES Journal of Marine Science* doi:10.1093/icesjms/fsp047.

6. Links with other international programs

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

IMBER (Jing Zhang, Jack Middelburg, Wajih Naqvi)	GEOHAB (Pedro Monteiro)
LOICZ (Nancy Rabalais)	SCOPE (Venu Ittekkot)
GLOBEC (Werner Ekau, Anja van der Plas)	Argo (Denis Gilbert, Osvaldo Ulloa)
SOLAS (Osvaldo Ulloa)	IOC/WESTPAC (Jing Zhang)
Census of Marine Life - COMARGE/CHESS (Lisa Levin)	

7. Completion of the Working Group Activities

The major task at this time is to complete the special issue of “Coastal Hypoxia” in *Biogeosciences*, as this is the key final product of this Working Group.

As approved by SCOR on its annual meeting in 2008, there will be no third meeting of this WG #128, the budget having been used to cover the publication cost (i.e., page charge) of the *Biogeosciences* Special Issue on “Coastal Hypoxia”.

2.2.8 WG 129: Deep Ocean Exchanges with the Shelf (with IAPSO) (2006)

Terms of Reference:

1. Establish the current state of knowledge and make recommendations for future research related to the following topics:
   - Processes due to shelf waves, internal tides, shelf break upwelling, storms and extreme events that produce effects over time scales of weeks to one or two years;
   - Transport over the shelf and shelf break of riverine and estuarine input of sediment and fresh water (this aspect includes the Arctic and Antarctic coastal zones, but does not include investigating the sources of sediment and fresh water on the shelves);
   - Dissipation of tidal motion along the continental margins on time scales of hours to days;
   - The physical controls of chemical and biological fluxes between the shelf and the open ocean that can affect the ecology of such regions; and
   - Coupled physical-chemical-biological models, generally at local to regional scales, that have a more realistic description of the exchanges at the shelf edge;
2. Determine where further observational programmes (using improved technology) are needed to improve understanding of shelf break processes and to provide help with the formulation of more realistic models of the fluxes between the shelf and the deep ocean;
3. Serve as an international forum for oceanographers to discuss current research on the interaction between the coastal zone and the deep ocean, by using the services and membership data base provided by IAPSO;
4. Foster collaboration between developed and developing countries that have interest in the shelf zone; limited-area models are required to help scientists in countries that do not have access to large computers, and
5. Produce a comprehensive, published final report incorporating the latest results on the above topics. This report will be in a form of a special issue of a peer-reviewed journal or a book by a major publisher.

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SCOR/IAPSO WG 129 Deep Ocean Exchange with the Shelf

3rd Annual Report - 29 July 2009

1. DOES Workshop in Cape Town

A SCOR/IAPSO workshop on Deep Ocean exchange with the Shelf (DOES) was held at the Breakwater Lodge at the Victoria and Alfred Waterfront in Cape Town, South Africa on 6-8 October 2008. The workshop was financially sponsored mainly by SCOR through NSF and ONR. Some additional financial support was given by IAPSO, IUGG and the South African CSIR. Attendance varied from day to day and averaged about 45 scientists from 18 countries. There were 16 invited lectures, 22 posters spread over two sessions and six working groups that discussed the future work needed to enhance our understanding of Deep Ocean Exchange with the Shelf, both through observations and modelling.

The Workshop attendance included young scientists from Benin, Ghana, Namibia, Senegal, Togo and South Africa as part of SCOR and IAPSO outreach. To further the outreach activities, a special meeting on deep ocean hydrographic cruises was held on 9 October at the Old Aquarium at Sea Point, Cape Town led by Piers Chapman (TAMU) assisted by Alejandro Orsi (TAMU) and Chris Duncombe Rae (U. Maine).

A full report on the Workshop was submitted to Ed Urban on 16 January 2009 (see http://www.scor-int.org/Publications/FinalDOESreport_16Jan2009.pdf).

2. DOES Special Issue

A special issue of the open access European Geophysical Union journal *Ocean Science* is planned for publication in 2010. The following five papers have already been submitted (the first one is about to appear in *Ocean Science*, the other four are under review):

- The Kuroshio exchange with the South and East China Seas -Takeshi Matsuno et al.
- Carbon export and sequestration in the southern Benguela upwelling system - Howard Waldron et al.
- Deep ocean exchange with west-European shelf seas - John Huthnance et al.
- The role of submarine canyons in deep-ocean exchange with the shelf - Susan Allen and Xavier de Madron.
- Transformation of an Algulhas eddy near the continental slope - Sheekela Baker-Yeboah et al.

The authors mentioned above participated in the Cape Town meeting. Another five papers are almost ready for submission and a further three have been requested following the DOES symposium in Montréal.

3. DOES symposium, Montréal

Piers Chapman and John Johnson convened a symposium on Deep Ocean Exchange with the Shelf at the IAPSO meeting in Montréal, Canada on 20-21 July 2008. There were four invited talks, 12 contributed talks and six posters. About 40 scientists attended this symposium.

4. DOES WG meeting, Montréal

Alongside the IAPSO meeting in Montréal, a meeting of the group was held. Items discussed included the following:

a. Additional papers for the DOES special issue—Invited speakers Katja Fennel and Sheekela Baker-Yeboah are producing papers for the special issue. Contributing speakers Ricardo Matano, Anna Wåhlin and Xinyu Guo will be invited to submit papers.

b. World Shelf Atlas—Following the workshop in Cape Town, details for a World Shelf Atlas are being collected as spreadsheets with properties of the shelf tabulated for the shelves around all the world oceans. A long discussion was held on the best way to present this material for future use. It was agreed that a set of maps showing different properties would be ideal, but that some assistance was required to help produce these maps.

c. Bibliography—It was agreed that the DOES Bibliography would be more useful if it could be turned into a database. Some assistance would be required to do this. Both the bibliography and the atlas could be dealt with by a new graduate with computer skills employed for 2 or 3 months, before starting full employment; funding for this needs to be sought.

d. World Ocean Shelf Group—The Cape Town workshop recommended setting up a World Ocean Shelf Group. Discussion led to the view that an umbrella group under the auspices of SCOR or IOC or IAPSO was needed that would encourage and facilitate bilateral and multi-lateral collaboration between research groups. Such collaboration already exists around Australia, around Antarctica, in the East China Sea and off West Africa.

e. Global Cross Shelf Exchange Experiment—This proposal from Cape Town was discussed at length. It was agreed that this proposed experiment would have to be funded by national research agencies and that the best way forward would be by using the World Ocean Shelf Group to build cooperative links between national groups and gradually cover more of the ocean shelves.

5. Final Report

Piers Chapman and John Johnson will meet in Norwich, UK in October to work on the WG 129 Final Report.

2.2.9 WG 130: Automatic Visual Plankton Identification

(2006)

Terms of Reference:

- To encourage the international co-operation of software developers and marine scientists to use and enhance an appropriate open-source development platform, so that a common toolset can be built up over time that is of value to the community
- To evaluate the limits of taxonomic resolution possible from image-based classifiers and develop means of improving the taxonomic resolution that can be achieved from plankton images. The working group will establish a basis for standards in taxonomic reporting by automatic labelling instruments.
- To review existing practices and establish standards in the use of reference image data used for training automation machines and in training people.
- To establish a methodology for inter-comparison/calibration of different visual analysis systems.
- To develop open-source software for application by the marine ecology, taxonomy and systems developers. Publish the products of reviews by members of the Working Group, selected presented papers and workshop reports in an internationally recognised, peer-reviewed journal or a book by a major publisher

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SCOR Working Group 130: Automatic Visual Plankton Identification
2009 Annual Report

SCOR WG130 on the FlowCAM demonstration cruise [Photo: Rubens Lopes]

Summary

This report summarizes the activities of SCOR Working Group 130 over the past year culminating with our annual meeting held in Baton Rouge, Louisiana, USA. The group was initiated in 2007 to address research issues associated with automated approaches for identifying and classifying plankton from image datasets. The plankton science community is presently at a critical juncture. We have reached the point where suitable imaging hardware is available at reasonable cost and there are several commercially available instruments (e.g., Zooscan, FlowCAM, VPR), which are in service and under routine use. Innovative prototype imaging systems are also entering research programs at regular intervals. The greatest impediment to widespread adoption of new imaging hardware has been the availability of intuitive, low-cost/no-cost software capable of harnessing the torrent of information that imaging systems can provide. The challenge that our Working Group has accepted is to combine the best features of the

currently available software packages. It is essential that we obtain and distribute this software quickly so that the broader oceanographic community can begin the critical task of analyzing archived and recently collected data on plankton. This is the only way that we will be able to address questions relating to regional and global climate-related changes in ocean productivity, fluctuations in fish-stock abundance, carbon sequestration, and human-health linkages to ocean ecology. Through the activities of our group and research in related laboratories, we are rapidly moving to the point where we can demonstrate to the broader oceanographic community how automatic image classification can provide ecologically meaningful data that could not otherwise be obtained in a reasonable timeframe. These techniques compliment current genetic-based analyses and depend upon the continued cooperation and collaboration with taxonomists and systematists. This third meeting of our working group afforded an opportunity to review and discuss the present state-of-the-art in plankton recognition and classification. It also allowed hands-on training with two commercially available instruments (Zooscan and FlowCAM) and sharing of advances made in laboratories around the world.

Background

SCOR WG130 was initiated in 2007 to address research issues associated with automated approaches for identifying and classifying plankton from image datasets. Our first meeting was held in Hiroshima, Japan in 2007 following the 4th Annual Zooplankton Production Symposium. The second meeting of the working group was held near the town of Ubatuba at the Hotel Recanto das Toninhas on May 7–9, 2008. Funding for the second meeting was facilitated by a generous grant from the Brazilian petroleum company Petrobras to working group member Rubens Lopes. The third meeting of our working group was held in Baton Rouge, Louisiana at Louisiana State University with support from SCOR and an NSF grant to Mark Benfield.

As a scientific community and a SCOR working group, we must be aware of the current status of automatic imaging and automated recognition of marine plankton. We need to emphasize to the taxonomic/biodiversity community that given the present state of development of machine vision technology, we are not attempting to develop imaging systems to address their problem of detailed taxonomic identification (i.e., to species level) of plankton in the oceans. Rather, we are going to provide more effective tools for the ecological marine research community.

The current available commercial imaging systems, such as FlowCAM, Zooscan and the Video Plankton Recorder (VPR), and the open-source Zoo/PhytoImage-scanner combination, are adequate for many marine scientists working on ecological research. There is no need to dramatically improve the image quality and resolution to the point that we might attempt to recognize morphologically similar species or classify organisms to fine levels such as the developmental stages of Crustacea. Taxonomic resolution to genus/family and even order may contain sufficient information to satisfy the research criteria of many ecological programmes. In some cases, where species diversity is low and species of interest possess distinctive morphologies, species-level classifications may be feasible.

The current imaging systems afford researchers practical tools that permit acquisition of samples with higher spatial and temporal resolution, greatly increase the numbers and throughput of samples, and provide meaningful results consisting of taxonomically explicit abundances and sizes in near-real time. Many also provide concurrent acquisition of other physical and chemical data at sea.
The plankton science community is presently at a critical juncture. We have reached the point where suitable imaging hardware is available at reasonable cost and there are several commercially available instruments (e.g. Zooscan, FlowCAM, VPR), which are in service and under routine use. Innovative prototype imaging systems are also entering research programs at regular intervals. The greatest impediment to widespread adoption of new imaging hardware has been the availability of intuitive, low-cost/no-cost software capable of harnessing the torrent of information that imaging systems can provide. To this end, there are now several software packages that enable the user to acquire and isolate images of individual organisms. These images can be sorted into libraries of known taxonomy, which can then be used to train a classification algorithm. The accuracy of the classifier can be evaluated and when a satisfactory classifier has been developed, it can be used to classify large datasets of images containing organisms of unknown taxonomy, into classes of interest. The output counts of each class can then be combined with metadata on volume sampled, fraction of total sample imaged, and time, latitude, longitude, and depth to produce abundance estimates for each class of interest.

The challenge that our Working Group has accepted is to combine the best features of the currently available software packages—two of which are designed to work with specific imaging hardware, and foster the development of new, flexible, open-source software suites capable of performing the complete series of tasks necessary to extract useful ecological information from raw data. It is essential that we obtain and distribute this software quickly so that the broader oceanographic community can begin the critical task of analyzing archived and recently collected data on plankton. This is the only way that we will be able to address questions relating to regional and global climate-related changes in ocean productivity, fluctuations in fish-stock abundance, carbon sequestration, and human-health linkages to ocean ecology.

Through the activities of our Working Group and research in related laboratories, we are rapidly moving to the point where we can demonstrate to the broader oceanographic community how automatic image classification can provide ecologically meaningful data that could not otherwise be obtained in a reasonable timeframe. These techniques complement current genetic-based analyses and depend upon the continued cooperation and collaboration with taxonomists and systematists.

This third meeting of our working group afforded an opportunity to improve our understanding of available software and hardware, summarize interim results from ongoing research in the field, and to develop strategies to share and advance automated imaging and processing tools within the aquatic ecology fields. We discussed progress in studies designed to be published in a dedicated volume of the *Journal of Plankton Research*. A pre-meeting Zooscan workshop provided an opportunity to learn how to use this instrument to process mesozooplankton samples. Plans were made to present progress in image classification at the next Zooplankton Production Symposium in Chile, at the ASLO Aquatic Sciences Meeting in Puerto Rico, and at the ICES ASC in 2010. Our final meeting will be held at one of these venues. At the end of the meeting we took a research cruise through Louisiana wetlands to demonstrate the use of a FlowCAM.

Working Group 130 Terms of Reference

1. To encourage the international co-operation of software developers and marine scientists to use and enhance the open-source development platform, so that a common toolset can be built up over time that is of value to the community;
2. To evaluate the limits of taxonomic resolution possible from image-based classifiers and develop means of improving the taxonomic resolution that can be achieved from plankton images. The working group will establish a basis for standards in taxonomic reporting by automatic labeling instruments;
3. To review existing practices and establish standards in the use of reference image data used for training automation machines and in training people;
4. To establish a methodology for inter-comparison/calibration of different visual analysis systems; and
5. To develop open-source software for application by the marine ecology, taxonomy and systems developers. Publish the products of reviews by members of the Working Group, selected presented papers and workshop reports in an internationally recognized, peer-reviewed journal or a book by a major publisher.

Agenda

Tuesday May 12, 2009

09:00 – 18:00 Zooscan Workshop (Room 2266, Energy, Coast, and Environment Building)

The goal of this workshop was to provide a complete overview of how to optimally employ the Zooscan system to process and identify plankton samples. Marc Picheral (France), Rubens Lopes (Brazil), Luciana Sartori (Brazil), and Jens Rasmussen (UK) were all in attendance, so we had lots of experts. We also had the new LSU Zooscan at our disposal.

09:00–09:15 Mark Benfield: Welcome
09:15–10:00 Marc Picheral: Theory and principals of operation
10:00–10:15 Coffee Break
10:15–12:00 Marc Picheral et al.: Sample preprocessing and image acquisition

12:00–13:00	Lunch
13:00–15:00	Marc Picheral et al.: Creating a training set
15:00–15:15	Coffee Break
15:15–17:00	Marc Picheral et al.: Building and using a classifier
17:00–18:00	Marc Picheral et al.: Interpreting results

Wednesday May 13, 2009

Time	Activity
09:00–09:30	Welcome, Overview, Logistics
09:30–10:30	Brief Progress Reports on Research Topics for Journal Volume
	09:30 Christian Briseño: Rapid sample processing with PICT
	09:35 Bob Williams, Rubens Lopes, Marc Picheral: Zooscan intercomparison study
	09:50 Phil Culverhouse: Human performance experiment
	10:05 Rubens Lopes: comparison of automatically- and manually-derived biomass estimates from scanned zooplankton samples
	10:15 Josue Borrego: Discrimination of morphologically-similar zooplankton
10:30–11:00	Coffee Break
11:00–11:30	Steve Murtagh: PICT Software Developments
11:30–12:00	Steve Murtagh: PAS Software Developments
12:00–13:00	Lunch
13:00–13:30	Philippe Grosjean: Intercalibration of FlowCAMs using Zoo/PhytoImage
13:30–14:00	Philippe Grosjean: Zoo/PhytoImage Version 2
14:00–14:30	Jens Rasmussen: Zooscan Research at the FRS
14:30–15:00	Josue Borrego: TBA
15:00–15:30	Coffee Break
15:30–16:00	Marc Picheral: Automated Imaging Analysis of Mesozooplankton using Zooscan
16:00–16:30	Jens Rasmussen: ZIMNES
16:30–17:00	Nick Loomis: Image analysis methods fish and habitats

Thursday May 14, 2009

Time	Activity
09:00–09:30	Introduction
09:30–10:30	Break out groups to plan experiments for forthcoming journal volume
10:30–11:00	Coffee Break
11:00–12:00	Summaries of break-out group discussions
12:00–13:00	Lunch
13:00–15:00	Phil Culverhouse: Group exercise in classifying plankton using web-based classification tool

15:00–15:30	Coffee Break
15:30	Return to Faculty Club/Hotel
16:30	Pick-up for trip to New Orleans
18:00–23:00	New Orleans French Quarter Excursion/Dinner

Friday May 15, 2009

Time	Activity
09:00–09:30	Phil Culverhouse: Update on SCOR WG130 Website
09:30–10:30	Discussion: Planning for Special Session and 2010 Meeting
10:30–11:00	Coffee Break
11:00–11:15	Mike Sieracki: Ocean Obs09 and White Paper
11:15–11:30	Cabell Davis: Digital Holography Update
11:30–12:00	Wrap-up, Summary, Report Tasks
12:00–13:00	Travel to Thunder Bayou (Lunch in Vans)
13:00–19:00	FlowCAM sampling trip

Brief Progress Reports on Research Topics for Journal Volume

Phil Culverhouse summarized discussions with two potential journals to publish a volume dedicated to research on automated plankton identification. The consensus was that the *Journal of Plankton Research* represented a good avenue for disseminating the work of this group.

Christian Briseño: Rapid sample processing with PICT

Manual processing has been the standard methodology for identifying and sorting images of plankton contained in regions of interest (ROI) generated from Video Plankton Recorder (VPR) collections. Because of the high data volume generated by the VPR, extracting the information from the ROIs is very time-consuming. This created the need for an automatic or semiautomatic processing tool. PICT is a software developed by the University of Massachusetts, Amherst, that allows the semiautomatic sorting of plankton images extracted from VPR data sets, giving the researcher some degree of control over the identifying process. We propose an experiment to compare the time it takes processing ROIs from data collected in Wilkinson Basin on cruise Oceanus 334 during December 1998. These data were already sorted and processed manually using ThumbsPlus 7 software. The times spent processing such ROIs were kept in a log book and can be used to compare the time spend sorting the same ROIs with PICT.

Semiautomatic processing can speed up the image identification and sorting. However, accuracy is also important. It is desirable to reproduce the estimated abundances and their distributions obtained with the manually sorted data. Target taxa will be pteropods, diatom rods, *Calanus* *finmarchicus*, ctenophores, siphonophores, siphonulae, marine snow, and small copepods. We propose to compare the abundances obtained from the semi-automatic processing with those obtained with the manually sorted (and already tested) abundances for the calanoid copepod *C. finmarchicus*. The degree of agreement between the distributions of *C. finmarchicus* obtained from both manual and semi-automatic sorting will determine the accuracy of PICT. Understanding how PICT performs will allow us to speed the identifying process up and generate abundance maps from VPR collections not yet processed and much needed to understand the ecology of this ecologically important copepod, and other similarly important planktonic organisms.

Bob Williams, Rubens Lopes, Marc Picheral: Zooscan intercomparison study
A set of plankton net hauls taken over a 24 hr period in 1975 from Weather Station 'India' (59^{o} 00'N 19^{o} 00'W) in the North Atlantic Ocean have been made available for this intercalibration. Using a Longhurst Hardy Plankton Recorder, plankton samples were collected by oblique hauls in the upper 500m. There were approximately 40 individual samples in each haul.

The LHPR samples were analyzed in 1975 using standard sub-sampling techniques for species composition and abundance. Wet and dry weight biomass for each profile was obtained by weighing approximately 50 individual specimens and developmental stages of all the major copepods and size groups for the larger organisms. Length/weight regressions were obtained for all abundant groups and species.

The list of species and developmental stages occurring in these LHPR samples is available in XLS format; they will be put on the SCOR Web site (as all results and data). The samples collected in the upper 100m to the surface in the two LHPR oblique net hauls, LH17 and LH19, were selected for further analysis. This gave a total of 22 samples.

In preparation for Zooscan imaging, the preserved plankton samples were re-suspended in 50% ethanol from 5% formalin. The majority of the LHPR samples were sub-sampled into two size fractions i) > 1mm (designated d1) and ii) > 1mm (designated d2). Depending on the abundance of organisms in the size fractions (optimized to obtain over 500 specimens spread across the Zooscan imaging surface) the sub-samples they were either further sub-sampled or the whole sample scanned.

At the Villefranche-sur-mer laboratory (VLFR), vignettes were obtained using Zooscan and sorted into 15 categories: Aggregate; Appendicularia; Chaetognatha; Copepoda: Calanoida: *Calanus finmarchicus*; *Euchaeta norvegica*; *Metrida lucens*; Copepoda: Cyclopoida: *Oithona* spp.; Copepoda:small; Euphausiacea: adults; and Euphausiacea: calyptopis; Egg-like; Fiber; Ostracoda and Other for this exercise. The Zooscan was trained using these sub-samples and the sub-samples returned to their vials.

The specific categories used for further analysis will be: i) Appendicularia; ii) Chaetognatha; iii) Copepoda: Calanoida: *Calanus finmarchicus*; iv) *Euchaeta norvegica*; v) *Metrida lucens*; vi) Copepoda: Cyclopoida: *Oithona* spp.; vii) Copepoda:small (includes developmental stages); viii) Euphausiacea: adults and fucilia; and ix) Euphausiacea: calyptopis; x) Ostracoda.

Four experiments were completed on these hauls, the purpose of which is to

1) demonstrate calibration exists between different Zooscan instruments
2) define error-bars (i.e., quantify variance) between abundance estimates across sub-samples of a net haul
3) compare machine abundance estimates with those obtained by Williams in 1975
4) derive coefficients for dry weight calculated automatically by Zooscan from data supplied by Williams and compare results to dry weight measurements made in 1975
5) compare abundance measurements made by Williams to those by machine to those by independent ecologists on the same set of sub-samples.

Vials were then sent to Rubens Lopes in Sao Paulo, Brazil, and will subsequently be sent to Mark Benfield/Malinda Sutor in Baton Rouge for replicated treatments. Following the above protocol the contents of each vial will be imaged, sorted and identified automatically using the classifier generated from the original training set. This will act as an intercalibration of three Zooscan instruments, one in France, one in Brazil and one in the United States.

This intercalibration will also compared to the original manual identification, abundance estimates and dry-weight calculations previously measured in 1975 in the laboratory. Numerical estimates were obtained from Stempel-pipette sub-samples, identified under microscopic examination of the smaller organisms in Bogorov trays and full counts of the larger organisms from Petri dishes. These data are held by abundance and depth distributions in Excel files.
The training set so-derived and inter-calibrated was then used to automatically label specimens from other previously un-seen (by Zooscan) LHPR hauls. [to be provided by Bob]

In addition, human factors. Vials LHPR17 vial 12,13 & 14, LHPR 19 vials 6,7 & 8 will be each analysed for the 10 categories established by VLFR during the Zooscan training process (see above). A minimum of 3 experts (ecologists or taxonomists) at each site (VLFR, San Paulo & Baton Rouge) will manually inspect and record tally category counts. These will then be used to compare against Williams original tallies and against the above machine tallies. Consensus will be established and sources of variation explored.

We can expect the following results. First, a graph of calibration across the three Zooscan instruments (see Fig. 1). Second, graphs of variance, showing range bars of variation (see Fig. 2).

And finally, a histogram showing consensus by category across machine and human inspectors (Fig. 3).

The purpose of these experiments is to demonstrate the contribution of machines to making sample analysis reliable. This is in several parts, first to give confidence to the wider community that the instruments are easy to calibrate and inter-calibrate, second to show that the machine abundances (and derived dry weights) show good correspondence to that measured originally, and third to establish that the results from machines show less variation than humans can achieve on the same data.

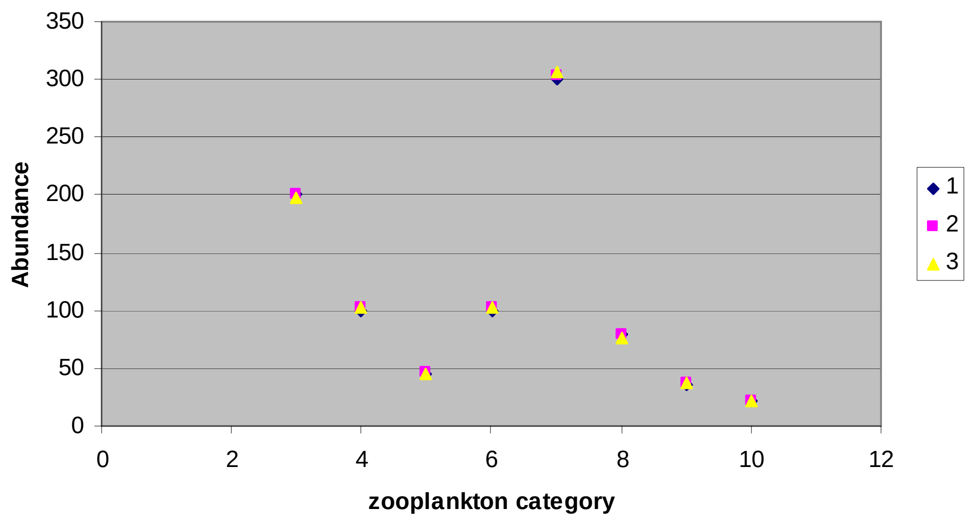


Figure.1 Hypothetical Zooscan calibration chart for instruments held at VLFR, Sao Paulo and Baton Rouge

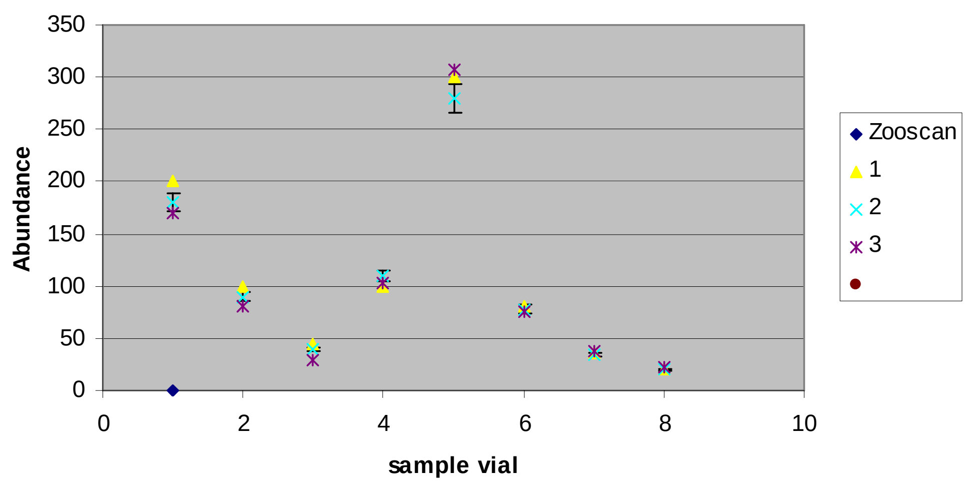


Figure 2. Hypothetical influence of sub-sampling on training performance, 3 replicates (one per lab).

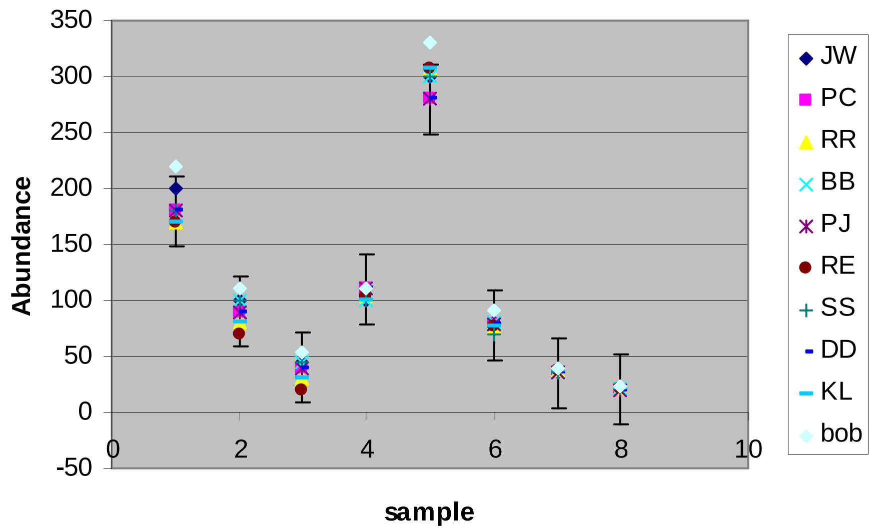


Figure.3 Hypothetical variance in category across human experts (note that these samples will have been fully analyzed by both machine and human).

Phil Culverhouse: Human performance experiment

This is a set of simple microscope-based experiments that explore the variance within and between participants engaged in visual identification of marine plankton.

There is an abundance of literature on the topic of human vigilance during inspection tasks. The evidence is that people are not 100% perfect at performing repetitive inspection tasks. This set of experiments will collect data on how good a consensus can be obtained from marine scientists (ecologists, biological oceanographers and taxonomists) engaged in the simple task of identifying objects and placing them in classes, when looking through a microscope at sample dishes of zooplankton or phytoplankton.

The experiment has two parts that will reveal how consistent people are at rapid assay of key genera in a sample chamber. They will use a standard laboratory microscope. The experiment requires that at least 3 people complete the tasks at each laboratory.

The samples will be taken from LHPR hauls 17-12, 13, 14 & 19-6, 7, 8; these samples must not be used for training the Zooscan classifier, but rather be used to assess the classifier performance. This, in turn, can be used to compare performance with our human subjects. Thus, an audit trail of validations from Zooscan, to experts, and back to Bob's original identifications can be made. The biomasses can also be estimated and compared to the original dry weights.

Rubens Lopes: comparison of automatically and manually derived biomass estimates from scanned zooplankton samples

One expected journal article will be Lopes, R., R. Williams, and C. Davis. Allometric coefficients for zooplankton biomass estimation using automatic plankton analysis, which will address three questions:

(1) Do we have sufficient and reliable allometric relationships covering: (a) most marine zooplankton taxa, (b) all bio-regions and depth layers, and (c) different classification levels (from species to phyla)?;
(2) Are available allometric relationships appropriate to estimate zooplankton biomass from images and what are the constraints of automatic vs manual measurements in different taxa?; and
(3) How do we apply coefficients built from microscopic observations to different image types (scanner, video cameras , photography)?

Tasks to accomplish include collating allometric coefficients from the literature; re-analyzing available data (if possible); identifying major gaps (taxa, region, etc.); investigating the effect of image segmentation on morphometric features of different taxa; correlating microscope-derived coefficients with image features; and comparing results across imaging devices. With respect to comparisons of manual versus automatic measurements, we will use Zooscan images and graphs comparing the prosome length and the major length, as well as total body length and major length of some important groups of the zooplankton.

Josue Borrego: Discrimination of morphologically similar zooplankton
The main objective of Borrego's group is to develop algorithms to identify species that are similar to one another in appearance. Their approach is to use training images to build a composite spectral filter, a nonlinear operation to correct, for example, for non-uniform background. A paper is in press on this work in the *Journal of Optical Engineering*. The group has done work on copepod species and is now working on other taxa. They need more types of zooplankton specimens. Hans Verheye is providing the physical specimens for this work. They have achieved 95% identification accuracy with this method. The method is invariant to scale, noise, and non-uniform illumination. They submitted a paper describing the method with respect to invariance to scale, rotation, and position. The method uses a nonlinear filter and spectral filters including FFT (Fast Fourier Transform) and polar mapping transformation. With different morphologies they obtain composite non-linear filters, and compare them using an invariant digital correlation system. Borrego showed a plot of mean correlation value versus different copepod species, and female versus male. They used 10 images to build a filter, with 20 images not trained. The method separates male and female of different species.

Borrego then showed a flow chart of the procedure using filter transforms. Using Euclidean distance in feature space, they compared target and problem images in feature space. Seven copepod species were used with thirty male/female pairs, forming a database of 420 images. The method gives vectoral signatures. They tested rotation invariance by rotating images 180 degrees. The algorithm is in Matlab. They developed a software GUI in .NET called SisRec for end-user support. Using the GUI you can see images and steps of process in gui, which makes it simpler. Phillipe asked if there is a command line interface, that is, non-gui? Answer: yes. SiSRec will be distributed to SCOR WG130 members for testing.

Steve Murtagh: PICT and PAS Software Developments

PICT, short for Plankton Interactive Classification Tool, is designed to help experts label images using active learning. When an image is labeled by the expert, PICT updates a classifier and moves images with high-confidence predictions to class-specific bins. The expert can correct mistakes made by the classifier and put images in 'trash' and 'unknown' bins which the classifier does not train on. There are also options the expert can change to speed up PICT, such as not automatically updating or changing the confidence threshold.

PAS, short for Photo Analysis System, is an architecture for the classification of images. First, sets of images and their associated metadata are imported. Then the user creates a dataset for processing, called a selection. Next, the user can run the images through a variety of image processing and feature extraction algorithms. Some are provided with PAS and the user can add more by importing functions written in MATLAB or ImageJ. Labeling can be done through PAS or PICT. Classifiers are built using the Weka classification toolkit. Once a classification experiment is run, the user can examine the results in PAS to determine what errors were made and how to correct them. Also, all the necessary information for running an identical experiment that produces identical results is stored, so that experiments can always be repeated.

Philippe Grosjean: Intercalibration of FlowCAMs using Zoo/PhytoImage

The objectives of this study are to (1) propose a method for using the FlowCAM with Zoo/PhytoImage; (2) to compare results obtained with three different FlowCAMs and three operators using common samples; and (3) to assess whether a training set made with one FlowCAM can be used to predict objects isolated by another FlowCAM.

The study used three FlowCAM models made in 2004, 2007, and 2009. Each had the same camera and resolution. All systems used the same version of the FlowCAM software. Version 1.2.2 of PhytoImage was used. Calibration was conducted using flow cytometry beads as well as neutral gray filters with OD 0.3, 0.6, and 0.9. FlowCAM parameters were fixed (4X magnification, autoimage at 8Hz and a flow rate of 1 mL s^{-1}. The visual spreadsheet configuration file was exchanged among each system and only the calibration data were recalculated for each FlowCAM. Samples were passed to each FlowCAM in random order.
Three pure phytoplankton cultures (*Chaetoceros compressus*, *Dytilum brightwellii*, and *Thalassiosira rotula*) were used. Training sets were constructed by scanning the pure cultures to minimize the influence of manual classification error. The test samples were a mix of the three pure cultures although users were not aware of the exact composition of each blend.

Results indicated good prediction capability when using the classifier constructed by the machine from pure cultures. When classifiers made from other FlowCAMs were used (alien classifier) the prediction was not as good. For instance, a classifier developed on the Spanish FlowCAM (SP) was not useful for the other FlowCAMs. This appears to be related to the poorer image quality from the SP FlowCAM. Classifiers from other FlowCAMs could be used on the SP FlowCAM.

In summary, FlowCAMs are intercomparable but require clearly defined protocols to ensure compatibility. FlowCAMs require calibration. The Zoo/PhytoImage software with the FITVIS plug-in does a good job in analysis of FlowCAM data including automated classification in this relatively easy example. A training set constructed by the same instrument that is being used as a classifier will work well; however, caution must be used when using classifiers constructed from different machines. Since this issue appears related to image quality variations among machines, it is recommended that a better tool be developed to install the flow cell in the correct focusing plane of the instrument.

Philippe Grosjean: Zoo/PhytoImage Version 2

The software is both a toolbox containing specialized functions for plankton analysis and a graphical user interface (GUI) permitting easy execution of canned processes. The software is open source (GPL 2 license for most of it), written in R and Java (image analysis and Image J). Version 1.0 runs on Windows only, though there are plans for a cross-platform version. The software works with both the image and the metadata. For each sample, measurements, metadata, and vignettes are compressed into a single file (ZID: ZooImage data file). A training set is constructed with multiple levels for grouping and automated classifier generation and analysis. The end products of the analysis are ecologically meaningful parameters: numbers, size spectra, biovolumes and biomass per group.

Changes anticipated for version 2 include releasing versions for Windows, Linux, and the Mac OS-X. Internals will be rewritten to make it easier to expand the software using plug-ins. The image analysis tools will be simplified and integrated into the R environment. Collaborative development of the software will be facilitated using version control (R-Forge). Weka and Rattle will be integrated into the software so that complex machine learning models can be reused within Zoo/PhytoImage. Support for acquisition from digital cameras, microscopes, FlowCAM (including real-time analysis) will be implemented. Several original tools for choosing groups, detecting outliers, and modeling and correcting error will also be introduced to version 2. Another important aspect of version 2 relates to quality assurance. Steps are being undertaken to ensure that the software calculations give expected results and it is reliable and consistent from platform to platform and version to version.

Jens Rasmussen: Zooscan Research at the FRS (Marine Scotland)

This presentation summarized some recent technological developments at the Fisheries Research Service (now Marine Scotland) relevant to imaging and the ZIMNES online taxonomic identification Web site. New systems included the e-Holocam, a holographic imaging system, and the ARIES towed sampling system on which the e-Holocam has been deployed. Laboratory recordings showed very detailed behavioral information on copepods. The scanned volume is small and storage requirements are very large. At present, the system is still under development with a private company.

The Zooscan that is being used in the lab is an older model. The funds to acquire the system were in place before funding for a project to use the system. The currently funded project (which started in 2008) is to try and model food web dynamics at a monitoring station that has been running for 12 years. The focus is on size-structure and biomass. At the Stonehaven monitoring station, they already collect and analyze 200 µm samples and a meso-ring net and finer mesh samples. The idea is to use the Zooscan and combine it with the existing zooplankton sampling. The larger mesh samples will be run through the Zooscan to get existing groups, use these data to calculate feeding rates, and model each species for one day. They will start with the observed plankton abundances (from weekly sampling data). Using functional groups may improve model performance. Size data from the scans will help the modelling work significantly, even at lower taxonomic resolution. The staff need to be trained in this new endeavour. There is a lot of conceptual interest but also some skepticism that needs to be overcome.

They have tried and tested some elements of Zooscan. Image acquisition and calibrations were performed successfully. Particle separation and measurements were completed successfully. This has partially been done as a supervised student research project. There were some initial gray-level calibration issues that have now been resolved. The student project focused on pre-picked samples containing copepods and chaetognaths. The Zooscan was used to estimate size distributions from replicated samples collected at different tidal phases. There were a large number of organisms in the samples, well beyond the number practically achievable using manual sample analysis. There was also a component of the project that examined good and bad particles (artifacts that were other than copepods or chaetognaths).

Work is now beginning on the larger mesh samples. Subsampling techniques require a lot of consideration. It is also important to try to define cut-off points between different meshed samples. This has relevance for how one combines size distributions obtained with different mesh nets.

A short training session was conducted in early May 2009. The focus was on background scans, subsampling and replications, how to acquire the scan, and how to deal with large amounts of information. Data management issues include backing up data, mirroring data, and transferring data over networks. Current developments include a new plankton database that will store data with the same data model as used in microscopic analysis.

In general, the attitudes towards the project are positive but the expectations are for much higher sample throughput than is practical. There is still a lot to do and finer mesh samples may prove problematic.

Marc Picheral: Automated Imaging Analysis of Mesozooplankton using Zooscan

This presentation summarized the latest developments in ZooProcess and Plankton Identifier software for use with the Zooscan system.

We know that extensive, historical zooplankton collections exist worldwide. The rationale behind the Zooscan is that access to the information contained in such plankton samples can be difficult because they are fragile, formalin is carcinogenic and not all labs are equipped with safe working space, there can be a long lag between sample collection and processing (when conventional methods are employed), and the intercomparability of data depends on how the samples were processed.

The Zooscan system was constructed to allow the construction of a homogeneous, permanent and secure digital plankton archive. There are five steps associated with the Zooscan: (1) Collecting and saving samples; (2) Making images (Zooscan and ZooProcess); (3) Processing Images (ZooProcess); (4) Automated Identification (Plankton Identifier); and (5) Data Analysis (Matlab, R, Excel …).

The Zooscan is an instrument that uses a scanner sensor with a custom-built lighting system and a watertight scanning chamber into which zooplankton samples can be poured, digitized at high-resolution, and recovered without damage. Zooscan is now commercially available from Hydroptic. ZooProcess is free software written using ImageJ built-in functions that helps to scan samples, archive metadata and process information, process images, process plankton to access morphological features, separate touching vignettes, extract vignettes for training sets or identification, and provide basic image statistics. Plankton Identifier is free software that allows the automatic identification of objects (plankton or particles) from a set of images with their associated data. Plankton Identifier uses TANAGRA data mining software. There is a Zooscan Users Forum that has been established to share solutions and advances associated with the Zooscan. This is the best way to obtain support.

To go from a sample to a dataset, one starts with the sample. The quality of the image depends to a large extent on the quality of the sample. In addition to the sample, there are metadata, which are used to keep a record of the sampling and environmental parameters. Finally, there is a log that keeps track of all procedures and settings that have been performed on the sample. What is needed to provide identification and scientific knowledge are calibrated images and measurements of the constituent organisms in the image.

Sample preparation consists of replacing the preservative with fresh or salt water. If the number of organisms in a sample is too high, it can be sieved into different size-class aliquots and subsampled. These different aliquots can be scanned using the Zooscan after targets are carefully separated from each other by the operator.
The first operation of ZooProcess is scanning a blank background image. This should be done on a daily basis. Both the background image and the raw image are normalized and subtracted in a process that results in a corrected scan image (VIS image) with the metadata and a log file. This then provides a corrected VIS image, a segmented image (which shows you what targets have been extracted from the background), an outline image showing the perimeters of the segmented targets, and a PID file (containing the log file, metadata, and measurements made on the targets).
Archiving is an important step. It is essential to archive the best quality image, the associated metadata, and the scanning parameters. Raw images should be archived. Raw images are 16 bit, 15 x 25 cm scanned at up to 2400 dpi, and containing up to approximately 5000 objects per image. The pixel resolution is 10.56 microns. The image sizes are 350 Mb for a small frame and 700 Mb for a large frame, when saved as a 16 bit grayscale image.

Image normalization includes correction for color balance (LUT and Gamma correction), a median filter is performed, the image is then rotated and flipped. The RAW image is saved in the _raw folder (as ZIP format) and the processed image is saved in the _scan folder. Image normalization also converts a raw 16 bit image to an 8 bit normalized image. There is an algorithm that measures the median gray level of the raw image. Then there is a ratio that is applied to the median optical density to obtain the white point. The black point is the product of the median gray level and the log of the OD x the ratio.

The next step is removing the background from the image. This is a simple subtraction of the normalized background from the normalized raw image. Then the outline of the frame is removed. Image normalization is an essential step if images acquired from one Zooscan are to be used in another system. ZooProcess includes an optical density (OD) calibration tool. A series of normalized discs of 0.3 an 0.9 OD are scanned and processed exactly as a plankton sample to obtain a normalized image.

The next step after verifying that your system has measured the ODs correctly, is to segment your images. This produces a list of objects from the selected size range (ESD) and outlines of each object. Optional tools include the ability to manually separate vignettes that contain more than one valid object. All measurements are saved in the process ID file (PID file). Computed parameters include position (X,Y), width, height, gray level (min, max, mean std deviation, mode, median, skewness, kurtosis, sum), size (area, perimeter, feret, minor axis, major axis), shape (X,Y, skeleton area, circumference, fractal dimension), new shape and texture parameters, and derived parameters. Derived parameters are not saved in the PID file.

Jens Rasmussen: ZIMNES

The Zooplankton Identification Manual for North European Seas (ZIMNES) was created as a knowledge transfer project, funded by UK NERC, aimed at providing consolidated information on important zooplankton groups through a user-friendly Web-based manual. The project aims at both experienced and inexperienced researchers, providing textual and photographic material for training and identification purposes along with literature references and a glossary.

The project is officially finished, but the Web site is editable and continues to be updated by collaborators. It currently holds 1013 interlinked taxonomic entities (372 species, 267 genera), and descriptive text and photos for approximately 200 species.

A range of improvements to the Web site functionality is planned and in development (although on a voluntary basis). The platform that holds the taxonomic information is called phpTaxonomy, and is freely available for open-source development of similar species libraries, and a potential extension to the existing functionality would be to use the structure to store vignettes of plankton species used in the automated identification libraries utilised in image-based identification software for plankton analysis. It is available at http://www.sahfos.ac.uk/taxonmanual/index.php

Nick Loomis: Image analysis methods fish and habitats

Nick began by showing the Digital Holographic Imaging (DHI) system. He briefly described the basic mechanism of how DHI works, and then showed a movie of reconstruction and a mosaic of images. He also showed a picture of Davis holding the prototype underwater DHI unit.

Nick then talked about the SEABED autonomous underwater vehicle and benthic image analysis. He described the image analysis methods he used to classify seafloor images by habitat type. He used Varma Zisserman classification, which is bag-of-words filter method that uses textrons in two-stage pass filtering. The features used are patch-based. Varma Zisserman uses filterbanks that are low-dimensional projections of underlying image patches. The method uses patches directly as filters and uses a 3x3 pixel section of image as texture word, textron. The confusion matrix computed from classification by this method shows 92% accuracy for 5 classes of habitat seafloor type.

Why do image patches work? Because they describe gradients and represent higher dimensions, similar to kernel methods. They tend to be generic feature selectors, but with similarities. Nick also showed patches of 7x7. The patches provide habitat patch dictionaries. He also used boosted multi-class dictionary (Torralba et al).

Nick also used feature space transforms. Using raw patches he achieved 85-90% accuracy, and eigenvector transform gives about the same accuracy. Independent components analysis finds distinguishing patches and gives 87-95% accuracy, 8% better. Transforms of features may give better discrimination. Patches are small and are optimized matched filters that are independent.

Nick also did object detection using boosting, which allowed him to determine quickly if there is an object in an image. The number of boosting rounds increases TP rate, using adaboost. He used a linear combination of weak classifiers to obtain an amazingly fast face detector (2001 paper). Nick showed a 2D example of adaboost combining weak features to give better decision boundary. Phillipe pointed out that boosting is sensitive to errors in the training set.

Nick then talked about Graphical Processor Units (GPUs), which are very useful for rapid parallel processing with ~300-400 processors. You can use the CUDA library from NVidia, OpenGL from Apple, OpenGPU, GpuCV, and openCV libraries.

Nick concluded that computational speed is no longer a restriction and showed a movie of SEABED image analysis. Phil Culverhouse asked if it speeds up ransack, to which Nick answered “yes.” Mark asked about local habitats in Louisiana, and Nick said it would be useful. Is the water clarity a problem? Potentially, but the image preprocessing (e.g., color correction) can help a lot. Can you tie it in with acoustics? Yes, it would be very interesting to do this.

Summary of Breakout Group Discussions

Meeting participants separated into break-out groups to discuss the following topics: Rapid sample processing with PICT; Intercomparison study and Human performance study; Comparison of biomass estimates from zooplankton images; Discrimination of morphologically similar zooplankton; Intercalibration of FlowCAMs using Zoo/PhytoImage; Data File standards (parameters and metadata); and Review paper topics: new systems, categorisation etc. Summary points developed in these discussions follow.

Rapid Sample Processing with PICT:

- This study will use data from research cruises in the Gulf of Maine that have already been sorted by a human with records of the time required to complete sorting. The same data will be sorted using PICT to compare the amount of time required to complete the same classification. Since classifications may contain errors, the distributions of organisms obtained from PICT sorting will be compared with previously Kriged distributions to quantify the impact of various levels of error tolerance specified within PICT.

Human Performance Study:

- Rationale: Experts are not perfect and this has an impact on training data bias. Many in the oceanographic community feel manual methods are ok. Machines are not perfect classifiers yet and experts are used to generate training sets for machines.
- We will use the WS India reference set and select samples that have low numbers of specimens (LH17-12,13,14 and LH19-6,7,8) for our manual inspection studies.
- Normal = manual methods will be used for tally counting
- Human performance will be assessed and compared to machine performance.

Intercomparison Study:

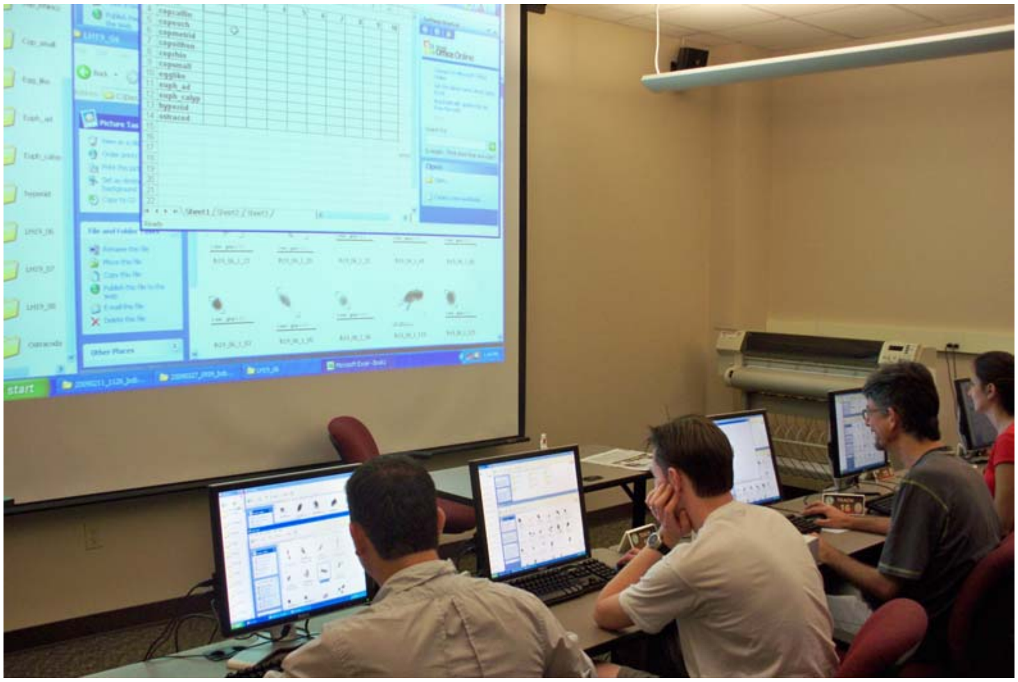
- There will be a difference between comparisons conducted at one site among different machines relative to comparisons conducted serially at different sites among different machines. When samples are compared at one site, the production of artifacts (fragments, aggregates) is likely to be reduced.
- Need to demonstrate that physical calibrations can be conducted among different machines. Next we need to demonstrate that the different machines can produce acceptable estimates of sizes of individual and size spectra.
- What is the capability of the system to provide a training data set for different zooplankton categories that has utility among different instruments?

Comparison of biomass estimates from zooplankton images:

- A literature review will be conducted for various allometric equations available to estimate biomass from length and width measurements. Hans Verheye is already preparing a manuscript on morphological relationships for copepods. Bob Williams has length:weight regressions (as well as wet:dry mass, carbon etc) for almost all the taxa in his dataset. He will put this information on the Web site for the community.
- It is also important to investigate the influence of different segmentation techniques on length estimates of organisms. It would be ideal to include manual (microscopy) measurements on the same organisms. This would require a substantial amount of effort. It is questionable whether there is time for this level of comparison. For underwater vision systems, the animal is not constrained to lie within a specific orientation. In the VPR and UVP, the width is less variable than length given the freedom of the animal to be oriented in three dimensions.
- FlowCAM versus Zooscan: this comparison would examine the influence of *in situ* orientation relative to settled orientation on biomass size distribution estimates. Obviously, there is only a limited size range that is common to the two systems. This will involve Mike Sieracki's and Rubens Lopes' labs.

Human Performance Experiment

A short exercise was conducted to familiarize all members with the challenges associated with classifying organisms to create a training set. Phil Culverhouse presented a brief tutorial on the organisms present in a test set. Each person then was presented with a series of approximately 300 zooplankton images from the North Atlantic Ocean, imaged by HAB Buoy, and had to classify them into pre-defined categories. Members were asked to operate at their normal pace of identification as if they are using a microscope.

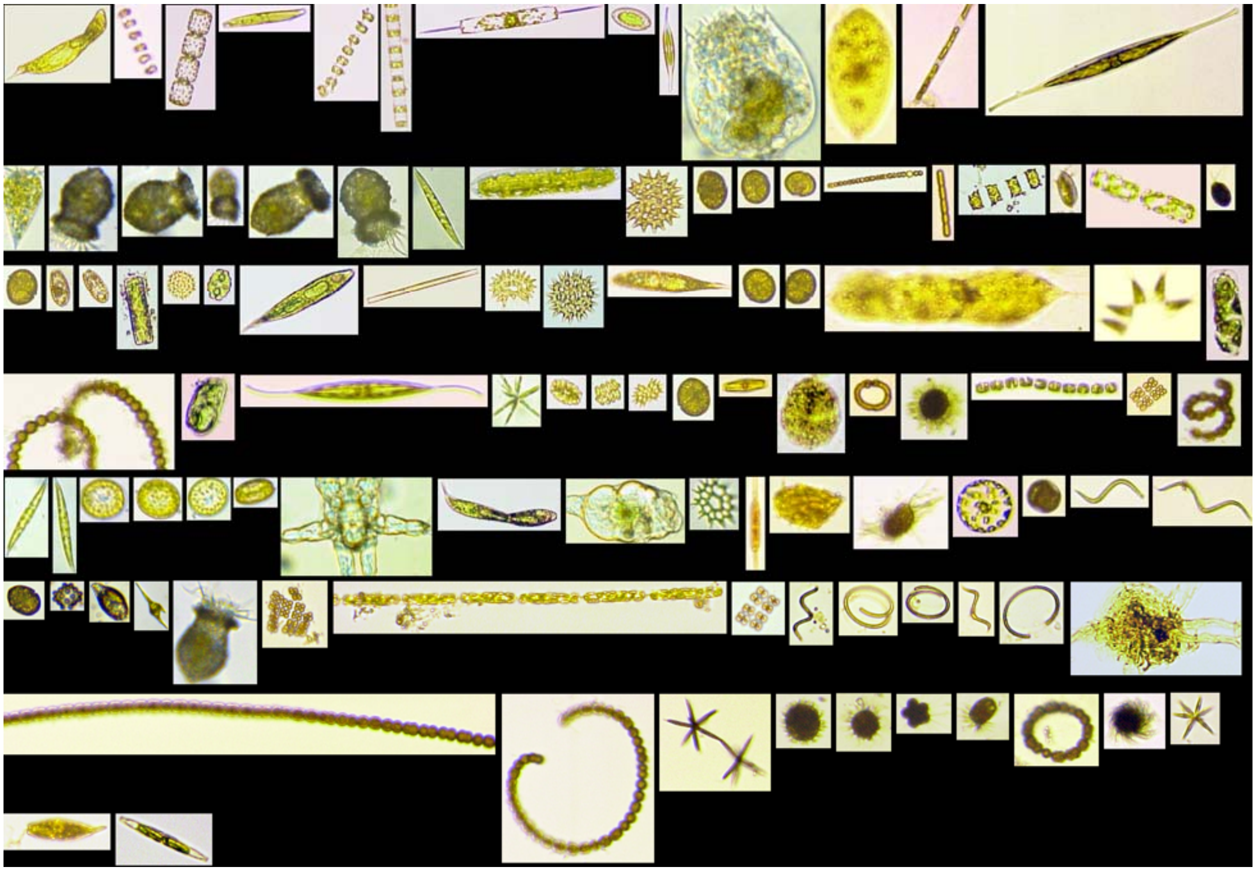


Human performance training exercise.

The results were illuminating and highlighted individual differences among observers, with up to 20% variation in counts per category across the group.

FlowCAM Demonstration Cruise

The group spent an afternoon touring a Louisiana bottomland hardwood swamp forest while working with a FlowCAM to examine phytoplankton and microzooplankton within a freshwater to brackish gradient.



Examples of FlowCAM images, some of which were acquired during the demonstration cruise.

Web site report

The Web site (see http://www.scor-wg130.net/index.cfm) has been updated with current meeting contents. Images for the icons have been obtained from Bob Williams and are to be added. A new archive section has been created that will hold our collected journal publications as a "one-stop shop" for people researching automated visual identification of plankton.

Discussion on conference planning for 2010/2011

The final session of the meeting focused on how best to disseminate our work. It was accepted that the SCOR WG130 Web site, together with journal and conference papers address part of our dissemination plan. However, developing a conference on research in automatic plankton identification (RAPID) must be a focus of the group for the coming period.

The current year provides an opportunity to present some of our findings at the SCOR Workshop on Ocean Observations (Ocean OBS09) in Venice, Italy. Mike Sieracki will be in attendance and will present our white paper at that conference. A copy of the draft white paper is included in Appendix C. Mike is also Chief Scientist for one of the legs of the Tara Oceans Project cruise. This cruise includes a substantial *in situ* and laboratory plankton imaging component. Tara

Oceans has asked our Working Group to endorse their initiative. A draft letter requesting clarification on the Tara Oceans data policy was prepared for Dr. Karsenti. Once clarification has been received, and if the data policy is for open access, then the Working Group will endorse this project.

It was agreed that 2010 was too short notice for any large-scale effort, but that 2011 was appropriate. There are two relevant large conferences running in 2011: the Zooplankton Productivity meeting in Chile and a meeting with substantial attendance by phytoplankton ecologists in 2011 (such as the ASLO Aquatic Sciences meeting in San Juan, Puerto Rico). Mike Sieracki felt that it was important to cover both with special sessions and/or tutorials on Flowcam/Zooscan/ZooImage, given that the audiences are mutually exclusive with the present focus on either zoo- or phytoplankton. It was agreed that members of the working group would make every effort to develop special sessions for both conferences, allowing us to disseminate to the widest possible audience.

Since the meeting we have been invited to participate in the Zooplankton productivity meeting and are exploring participation in a forthcoming phytoplankton meeting to be coordinated by Mike Sieracki.

Next Meeting of WG130

The next meeting will be held in Villefranche sur Mer in 2010 at the invitation of Gaby Gorsky.

Appendix A: List of Participants

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Gabriel Gorsky, CNRS, Laboratoire Océanologique de Villefranche sur mer.
Xabier Irigoien, AZTI (Institute for Fisheries and Food Science), Spain
Dhugal Lindsay, JAMSTEC, Japan
Norm McLeod, Department of Palaeontology, The Natural History Museum, UK
Sun Song, Institute of Oceanology, Chinese Academy of Sciences, PRC
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Appendix C: OceanObs'09 Symposium White Paper: Optical plankton imaging and analysis systems for ocean observation

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Plankton form the base of the marine food chain; link the atmosphere and deep ocean elemental fluxes, processes, and cycles; and can cause invasions and blooms that are harmful to marine ecosystems and humans. Plankton are intimately associated with the biochemistry of the ocean and can act as sentinel organisms as ocean properties, such as temperature, acidity, and chemical composition, change over time. As human population increases and environmental pressures reach the global level, the response and health of ocean ecosystems will become more critical to the sustainability of the Earth. Historically, ocean observing systems have monitored physical and chemical properties, with biological measurements limited to simple proxies such as turbidity and chlorophyll fluorescence. Current and future ocean observing systems will need to monitor plankton communities.

Monitoring plankton is challenging. Communities are diverse and dynamic. Populations at a particular location come and go on short time intervals. Populations form patches at multiple scales and in three dimensions due to stratification, shear, and advection, as well as growth, grazing, and sinking. Plankton imaging and analysis systems have been developed to identify and enumerate living (plankton) and non-living particles in natural waters (Benfield et al. 2007). Digital image data can be analyzed to reveal abundances, size spectra, and biomass distributions of planktonic organisms as well as non-living particles. Detrital aggregates, or marine snow, are composed of living and non-living particle matter and play important roles in the time-variable export, regeneration and deep-water delivery of carbon and nitrogen. In-situ particle and plankton imaging and analysis systems provide a technique for examining the size spectra of these fragile and patchy aggregates, and facilitate the quantitative examination of aggregate shape, sinking rate and composition over large ocean areas (Gorsky et al., 1992; Jackson et al., 1997; Pilskaln et al., 1998; Pilskaln et al., 2005; Checkley et al. 2008).

In many cases, abundance and taxonomic information is needed at the genus or species level. The zooplanktor *Calanus*, for example, is an oil-rich copepod and its dense aggregations form a key food source for migrating baleen whales. Certain dinoflagellate species produce potent neurotoxins that can accumulate in shellfish and sicken or kill fish, marine mammals, and humans when eaten. Ideally, automated instruments would be able to recognize specific types of particles and organisms at fine taxonomic resolution, and under different environmental conditions, from oligotrophic blue waters to hypereutrophic coastal waters. Recognition of phytoplankton (e.g., Sosik and Olson 2007, Fig. 1), zooplankon (Davis et al., 2004; Hu and Davis, 2006), and ichthyoplankton to the family, or even genus level is currently possible in many cases (Grosjean et al., 2004). Recognition at higher levels (e.g. functional groups), combined with morphometric features to estimate biomass, is useful for food web and ecosystem modeling (Irigoien et al., 2009; Zarauz et al., 2008).

State of the art

Planktonic organisms smaller than abiout 20 µm (protists and prokaryotes) generally have simple shapes (e.g. round, oblong, or filamentous) that are not useful to discriminate taxa. For larger planktonic organisms, morphology is the traditional taxonomic descriptor with greater discriminating power. Morphology can be captured in digital images. Rapid advances are being made in electro-optical technology, resulting in new and better ways of illuminating, detecting, and imaging plankton *in situ*. Prototype or commercially available high-resolution imaging and analysis systems now exist that detect plankton across a wide range of size scales (e.g., Davis et al. 2005; Olson and Sosik 2007; Dominguez-Caballero et al. 2007). The hardware technology of these instruments is maturing.

Data analysis and software systems are not as mature as the hardware technology for plankton imaging. Typically, images are collected and then either stored or transmitted with minimal real-time analysis. Image collections are subsequently analyzed for abundances, particle/organism size, and identification. Automatically discriminating types of organisms from images is challenging. Small differences in illumination can yield large differences in image quality, so images taken from different instruments are difficult to compare quantitatively. Orientation of the organism in the image can induce large differences in the imaged structure. In the typical development path, experts classify a subset of images of organisms into classes that can be morphotypes and/or taxonomic categories. This set of expert-classified images forms a training set against which classification algorithms can be developed and tested. A full classifier scheme must include a number of elements: the training set; image analysis methods such as image correction, segmentation and feature extraction; and a classification algorithm, such as neural network, support vector machine, or decision tree; or an ensemble of algorithms. Independent quantification of error rates is also desirable for many applications. General training sets of expert-classified plankton images may not be practical since previous work suggests they must be different for differing imaging systems, and must be specific to a certain plankton community composition, or set of target organisms encountered. It has been shown that taxonomic experts are not unanimous, even when considering images of organisms with relatively distinct morphology (Culverhouse et al. 2003). The state of the art for automated image classifiers for a 10 – 30 class problem is 70 – 80% accuracy (e.g. Blascho et al. 2005). This is approaching the level of agreement among human experts. Bias due to errors in classification can be statistically corrected if the prior probabilities of the occurrences of the types are known (Solow et al. 2001; Hu and Davis, 2006). A carefully collected expert-derived training set can provide these prior probabilities. Misclassification may also be reduced by considering results from multiple classifier approaches (e.g. Hu and Davis 2006), or optimizing class selection (Figure 2, Fernandes et al. 2008). More work on handling the errors in classification, and on tools and protocols for creating appropriate and unbiased training sets is needed.

Integration to ocean observing systems

Ocean observing systems must include plankton imaging instruments. These instruments have proven powerful in many biological oceanographic applications. They have been used for phytoplankton, zooplankton, marine snow particles, and metazoans including invertebrates and eggs, larvae, and adults of fish. Recent progress with plankton imaging instruments and associated analysis software has been reviewed (Wiebe & Benfield 2003; Benfield et al. 2007). Some instruments view an illuminated volume of relatively undisturbed water, while others pump water into a defined view area (imaging-in-flow). Instruments have been deployed from ships, either in towed, or vertical profiling modes. They have been deployed on remotely operated vehicles (ROVs), fixed moorings, Lagrangian floats, and autonomous underwater vehicles (AUVs). These diverse platforms, all capable of accommodating plankton imaging and analysis instruments, will be important components of future ocean observing systems.

Plankton imaging and analysis instruments are complex compared to many marine optical sensors (e.g., fluorometers and turbidity meters), but they provide a more direct measure of plankton (and other particulate material), and much more morphological and taxonomic information. There are a variety of optical sensors that measure proxies of plankton or particle load, such as light scattering, beam attenuation (transmittance), and chlorophyll fluorescence. Acoustic sensors can measure sonic backscattering from plankton and fish. Direct imaging systems deployed in strategic ways within ocean observing systems can serve to validate and expand interpretation of data from proxy sensors, which are typically smaller in size, cost, and power demand and thus can be deployed more widely in space and time. New low-power digital holographic systems (Loomis et al. 2007, Davis 2008) are being integrated into oceanic profiling floats creating the potential for remote sampling of plankton taxa throughout the world ocean.

Many harmful algal species can be identified by morphology, so cell imaging has the potential to provide sentinel early-warning systems for harmful blooms in coastal waters (Campbell et al.

2008). Often the critical abundance of a HAB species can be very low (less than 10 individuals per cubic meter), making it difficult to collect sufficient specimens for training a classifier.

Challenges/future

There are several hardware challenges with integrating plankton imaging instruments into ocean observing systems. The development of compact in-situ optical sensors capable of discriminating target particles against a high background of non-target particles suspended in the water column is one of the most demanding tasks in coastal regions. In the oceanic realm, where phyto- and zooplankton densities are usually low, the challenge is to synoptically observe a large volume of water with a sufficiently broad depth of focus, rather than scanning small volumes over time. In either case, sensors need to resolve a wide plankton size spectrum, from microbes to large crustaceans and fish larvae. The use of spatial filters and other optical signal processors such as those suggested by Strickler and Hwang (1998) may help to achieve such capabilities. In current systems illumination, camera, onboard logic, and data storage consume significant power compared to other simpler in-situ instruments. Engineering to reduce power consumption will be an ongoing effort.

Coccolithophorids, a particular group of nanophytoplankton, produce carbonate shells with particular birefringence properties. These organisms may be particularly susceptible to ocean acidification. Imaging of birefringence patterns can distinguish these cells (Figure 3) and it is possible to imagine in situ instruments optimized to detect and monitor populations of coccolithophorids.

Like all optical instruments (indeed, virtually all in-situ sensors), surface biofouling can degrade performance during long-term deployments. These problems are being addressed by placing copper sources near the optical surfaces, mechanical shutters, or cleaning mechanisms. Optimal design issues include whether to put more computer logic closer to the imager for “smart” image digitization, or more removed from the sensor for post-acquisition processing. Placing computer logic near the sensor is needed, for example, to compress the images for efficient storage and transmission. In a sentinel system for harmful algae, it might be necessary for recognition of target species to be done at the sensor in real-time. Full real-time image recognition for complex planktonic communities on a remote platform is a primary goal for hardware and software development. Progress has been made in real-time recognition of fish eggs from natural waters (Iwamoto et al. 2001). Continued work to identify features and create improved classification algorithms is needed. It has been suggested that a community effort of open source software development is the best way to make progress in this area (RAPID: Research of Automated Plankton Identification; Benfield et al. 2007).

Examples of such software development include, but are not limited to, the Photo Analysis System (PAS), the Plankton Interactive Classification Tool (PICT) and Zoo/Phytoimage. PAS and PICT are being developed at the University of Massachusetts Amherst (Mattar et al. 2009). PAS is a web-application that provides the functionality for experts to upload their images and algorithms, process images, hand-label examples, train classifiers and use those classifiers to automatically label new images. Zoo/Phytoimage has been successfully employed in a number of studies (Irigoien et al, 2008; Bell and Hopcroft, 2008) as tool for automatic identification of scanned meso- and macrozooplankton images. More recently, a plugin has been developed to handle phyto- and microzooplankton images generated by the FlowCAM (Grosjean and Denis, 2007. PAS and PICT are expected to be publicly available in summer 2009 (http://vis-www.cs.umass.edu/~pas). An international SCOR working group is currently addressing the future development needs, such as standardization and specifications, of automated visual plankton identification (http://www.scor-wg130.net/). Zoo/PhytoImage is available at http://www.sciviews.org/zooimage).

Ocean observing systems of the future will include plankton imaging and analysis instruments to monitor diversity and alert experts to unexpected, new, or invasive, taxa. They will be part of coastal sentinel systems providing early warning of harmful blooms. They will monitor the structure and health of marine food webs and provide insights into the productivity of marine ecosystems. They will help constrain particulate carbon fluxes along onshore-offshore gradients and vertical particle flux in the open ocean. Plankton imaging and analysis instruments will be key components of future coastal and oceanic ocean observing systems in their critical role of monitoring the health of marine ecosystems. A better understanding of the dynamics of ocean life will allow more rational management policies designed to protect the ocean and its life and, ultimately, ours.

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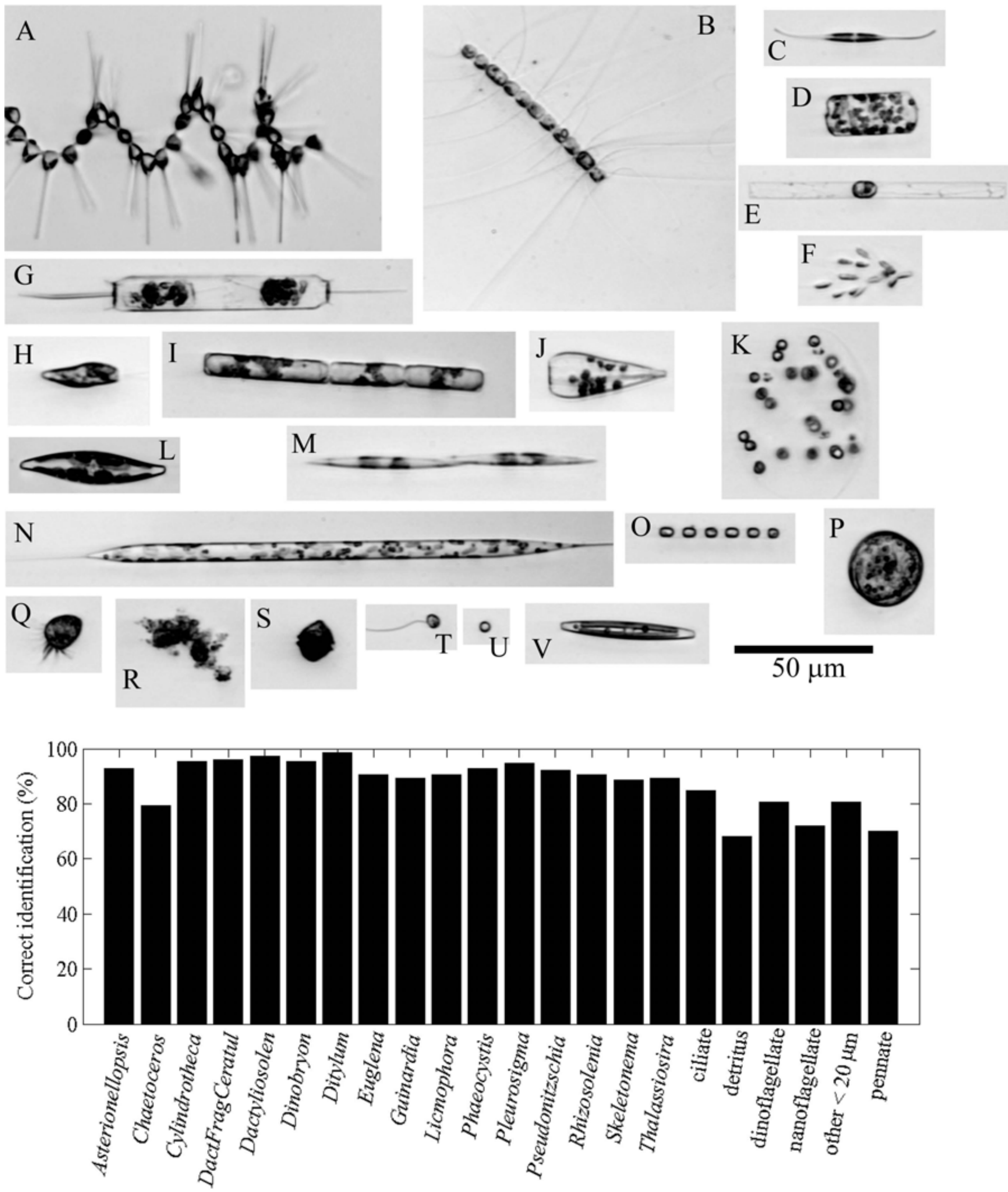

Figure 1. Example images and automated classification results for 22 categories identified from Imaging FlowCytobot (Olson and Sosik 2007) observations in Woods Hole Harbor. Most categories arephytoplankton taxa at the genus level: *Asterionellopsis* spp. (A); *Chaetoceros* spp. (B); *Cylindrotheca* spp.(C); *Ceratulina* spp. plus the morphologically similar species of *Dactyliosolen* such as *D. fragilissimus* (D);other species of *Dactyliosolen* morphologically similar to *D. blavyanus* (E); *Dinobryon* spp. (F); *Ditylum*spp (G); *Euglena* spp. plus other euglenoids (H); *Guinardia* spp. (I); *Licmophora* spp. (J); *Phaeocystis* spp.(K); *Pleurosigma* spp. (L); *Pseudonitzschia* spp. (M);

Rhizosolenia spp. and rare cases of *Proboscia* spp.(N); *Skeletonema* spp (O); *Thalassiosira* spp. and similar centric diatoms (P). The remaining categories aremixtures of morphologically similar particles and cell types: ciliates (Q); detritus (R); dinoflagellates > ~20 µm (S); nanoflagellates (T); other cells < 20 µm (U); and other single celled pennate diatoms (V).Reproduced from Sosik and Olson (2007).

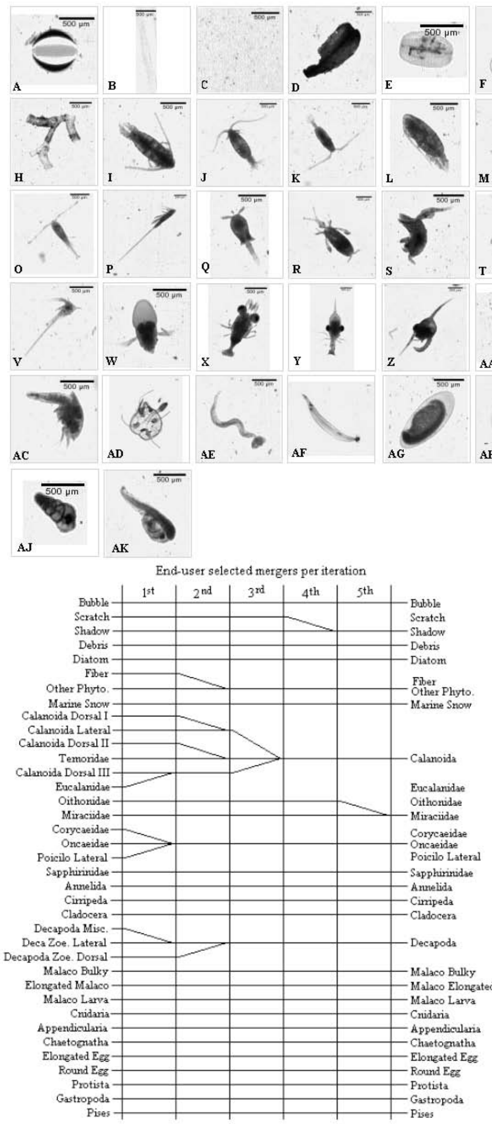

Figure 2: Images of mesozooplankton obtained using a commercial scanner and extracted with ZooImage (http://www.sciviews.org/zooimage/index.html). Bubble (A), Scratch (B), Shadow (C), Debris (D), Diatom (E),Fiber (F), Marine Snow (G), Other Phytoplankton (H), Calanoida Dorsal I (I), Calanoida Dorsal II (J), CalanoidaDorsal III (K), Calanoida Lateral (L), Eucalanidae (M), Temoridae (N), Oithonidae (O), Miraciidae (P),Corycaeidae (Q), Oncaeidae (R), Poicilo Lateral (S), Sapphirinidae (T), Annelida (U), Cirripeda (V), Cladocera(W), Decapoda

Miscellaneus (X), Decapoda Zoea Dorsal (Y), Decapoda Zoea Lateral (Z), Malacostracea Bulky (AA), Elongated Malacostraca (AB), Malacostraca Larvae (AC), Cnidaria (AD), Appendicularia (AE),Chaetognatha (AF), Elongated Egg (AG), Round Egg (AH), Protista (AI), Gastropoda (AJ), Pisces (AK). See Table VI. Graphical representation of different class accepted mergers by the end-user to improve classification. Reproduced from Fernandes et al (2008).

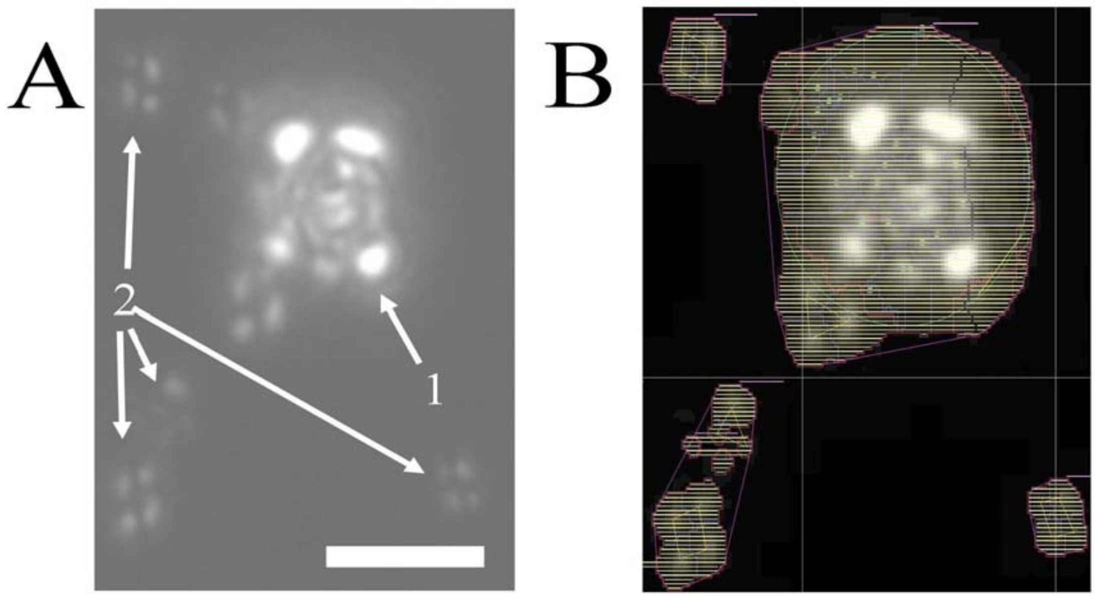

Figure 3. Coccolithophores are calcifying algae found throughout the world ocean which have great biogeochemical relevance due to their calcium carbonate coccoliths which contribute 25%of all marine sediments. Automated means to define and enumerate them are critical. A) Microscopic birefringence image of plated coccolithophore (1) and detached coccoliths (2) in seawater sample from the Gulf of Maine, viewed under cross-polarized light. Plated coccolithophores appear as round groups of white dots against a dark field whereas individual coccoliths appear as groups off our symmetric dots in this image. Scale bar is 5um in length. B) Results of classification algorithm CCC which identifies and enumerates free coccoliths, plated coccolithophores and aggregates of coccoliths based on their distinct birefringence patterns. A complete description of the algorithm will be published elsewhere.

2.2.10 WG 131: The Legacy of in situ Iron Enrichment: Data Compilation and Modeling (2007)

Terms of Reference:

- Compilation of a database for open access (via the Internet) of the following experiments:
  - the 1999-2001 era (IronEx-1, IronEx-2, SOIREE, EisenEx, SEEDS-1), plus 1992 S.O. JGOFS;
  - the 2002 experiments (SOFeX-North, SOFeX-South, SERIES); and
  - the 2004 experiments (Eifex, SEEDS-2, SAGE, FeeP), plus natural fertilizations CROZEX,
KEOPS

This effort will include a commonly agreed data policy for users to best acknowledge the original data producers (e.g., by offering co-authorship and perhaps assignment of digital object identifiers for individual data sets). Obviously, a practical description of methods used, calibration etc. (so-called metadata) will also be included. In essence, the WG members are committed to send their data files to the common data centre, and encourage their colleagues in any given experiment to do the same. Finally, an official data publication or publication(s) will be placed in a suitable venue, for example, in the special issue on the SCOR WG (see item 4. below) and in *Eos* (Transactions Am. Geophys. Union). In 2006-2007 efforts are already underway for compilation and rescue of the EisenEx dataset, also there is very good progress for SEEDS-2, SERIES, CROZEX and KEOPS. However, the statement in the original proposal that no meeting would be necessary to achieve the first term of reference was overly optimistic. It appears that a face-to-face meeting sponsored by SCOR or some other internationally recognized organization is necessary to work out the details of bringing together the data sets in a way that will make it possible to achieve the other terms of reference.

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Executive Committee Reporter: Mike MacCracken

Fe_Synthesis Project Summary / Data Management Status Report
Prepared by Steve Gegg (BCO-DMO) 5 August 2009

Data and Meta Data Links:
Fe_Synthesis Program: http://osprey.bcodmo.org/program.cfm?id=10&flag=view
Fe_Synthesis Projects:
http://osprey.bcodmo.org/program.cfm?flag=viewp&id=10&sortby=program

General Comments:

- Using data and other information located on the BCO-DMO site, data inventories have been generated and uploaded to the database for IronEx1, IronEx2, SEEDS_2001 and SEEDS_2004. These may prove useful to keep track of data as contributed.
- A small collection of data were located for IronExI and IronEx2 on the BCO-DMO site and have been processed and uploaded to the database.
- A CTD Sampling log has been uploaded for SEEDS_2004
- No new data have been received at BCO-DMO from outside sources or via Doug Mackie. There is mention of SERIES data being worked up by Doug Mackie in a mid-March/2009 e-mail, but to date no files have been forwarded. If they have been and were missed, please re-send.
- All data entered in the database have "current state" flagged as "Preliminary but not done". This indicates that they still require someone (Doug Mackie??) to go through them and provide feedback on any changes, edits, etc. required. Once this process has been completed to everyone's satisfaction, the data sets will be flagged as "Final".

  Particular attention needs to be paid to the parameters - units, descriptions, etc.

  Other items of note have been included in the Acquisition and/or Processing descriptions (in the BCO-DMO database) in bold and/or italicized text.

- Minimal metadata exist for IronEx1 and IronEx2. These are specifically pointed out because some data for them have been located. Little to no metadata exist for SERIES and SAGE.

The project documentation reports generated for SEEDS_2001 and SEEDS_2004 by Doug Mackie are extremely useful. If any such documentation exists or has been or can be generated for the other projects, it would be a significant contribution.

Project Specific Comments:

SOIREE

Status unchanged since previous update. Data have been uploaded to the database but inclusion of metadata and parameters remains a work in progress.

SEEDS 2001

Using information in Doug Mackie's Project Documentation and additional information in the original .xls files and the Doug Mackie-generated .csv files, metadata and parameters have been added to database. Two data sets with extensive parameters, microzooplankton and sinking particles, still require parameter entry. Work in progress.

The "TEP" data set with caution/error warnings from Doug Mackie has still not been included.

SEEDS 2004

An inventory was generated based on information provided by Doug Mackie in the project documentation report.

One CTD sampling log was processed and uploaded to the database. An extensive list of parameters still needs to be added.

This remains the only data set delivered to date. Other .csv files only contain station lists and locations duplicated in the CTD sampling log. There may be one or two that have slightly different information (additional stations) which will get added once they have been double checked.

IronExI

An inventory was generated based on information located in existing files. Three data sets were located in the collection of files and have been added to the database. They are:

CTD log
Station list
Variability Estimates

No other data have been received.

IronExII

An inventory was generated based on information located in existing files. Six data sets were located in the collection of files and have been added to the database. They are:

Cast Log
Event Log

CO2
CTD, TM Rosette CTD, nutrients and chlorophyll
MLML Fe
POC

No other data have been received.

SERIES
A mid-March/2009 e-mail from Doug Mackie indicates that work is being done on data from SERIES. To date, and as best as I can tell, no data have been received. If this is an error on the part of BCO-DMO, please re-send the data.

SOFEX
Data and metadata have been uploaded to the database.

SAGE
Status unchanged. No data received.

EIFEX

EisenEx
No movement other than discussion of linking to the PANGEA site by BCO-DMO has taken place for EIFEX and EisenEx data.

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2.2.11 SCOR/LOICZ WG 132: Land-based Nutrient Pollution and the Relationship to Harmful Algal Blooms in Coastal Marine Systems
(2007)

Terms of Reference:

1. Integrate the existing IOC-HAB database and nutrient loading databases into a compatible GIS format.
2. Advance the development of a GIS coastal typology database.
3. Interrogate the above databases for relationships between HAB species, nutrient loading/forms/ratios, and coastal typology and develop broad relationships between nutrient loading and distributions of specific HABs.
4. Explore possible changes in HAB occurrences in the future (year 2030), using the relationships developed above (3.) and global nutrient export patterns under the Millennium Assessment scenarios for 2030.
5. Publish the results of these analyses in peer-reviewed scientific journals. Papers will be developed on 1) the global perspective, including the next generation of global nutrient and HAB maps; 2) regional highlights; and 3) individual case studies. We will also develop articles for the GEOHAB newsletter and for the GEOHAB and Global News websites, and a graphic-rich report (under the GEOHAB umbrella) that will be targeted for management.

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Mingjiang Zhou (China-Beijing)	

Executive Committee Reporter: Jorma Kuparinen

Progress report of SCOR/LOICZ Work Group 132

Land-based Nutrient Pollution and the Relationship to Harmful Algal Blooms in Coastal Marine Systems

For the period August 2008-July 2009

Patricia Glibert, University of Maryland Center for Environmental Science
Lex Bouwman, Netherlands Environmental Assessment Agency
Work Group co-chairs

Contents

Summary

The first year of SCOR/LOICZ Working Group 132 primarily involved data collection and preparation of data sets for further analysis. The global datasets that are now available and being used include the coastal typology, GlobalNEWS annual river nutrient export data, aquatic plant and shellfish aquaculture, maps for several harmful algal species (HABs), including *Noctiluca*, *Prorocentrum minimum* and *Pseudo-nitzschia*. Regional studies (Humboldt Current LME, Yucatan, Africa, Europe, North America, Gulf of Oman region, Asia) provide useful background information to complement the global HAB data and findings.

Also during the first year, the approaches for analyzing data were developed, including simple techniques for allocating and delineating the areas of influence of river nutrient outflow and

aquaculture, as well as the approach for analyzing relationships between nutrient loading and occurrences of HABs.

A group Web site was established with project description. Since data are only now becoming available, the Web site will be used as a platform for exchange of data, papers and other information relevant to the work group and will be further developed in the coming year

1. PROGRESS OF THE WORK

This second report presents the progress made by SCOR/LOICZ WG 132 in its first year. The report of the the first working group meeting in 2008 (28-31 July 2008, GKSS-Forschungszentrum, Geesthacht GmbH Geesthacht, Germany) includes nine planned major activities and their timing for the period August 2008 up through the second group meeting, 13-16 October 2009 (see timetable below). The progress for each of these activities will be discussed below (sections 1.1. to 1.9.). Finally, miscellaneous activities are discussed in section 1.10.

SCOR-132 activities and timing for the period August2008-October 2009.

	Aug-08					Jan-09			Apr-09			Jul-09			Oct-09
Activity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Coastal typology															
2. Global NEWS nutrient loading data															
3. Maps of nutrient loading by aquaculture															
4. First analysis of satellite data vs. nutrient loading															
5. Map of Noctiluca occurences															
6. Database structure															
7. Selection of statistical techniques															
8. Collection of HAB data															
9. Analysis of available HAB maps related to question 1															

1.1.Coastal typology

The group at Utrecht University prepared the coastal typology database. A classification of near-shore coastal systems allowed the definition of the estuarine filter of river inputs to the ocean (Figure 1). This typology is object-based and spatially explicit at a 0.5 degree resolution, and is based on hydrological, lithological and morphological criteria. A total of four main operational types act as active filters of both dissolved and suspended material entering the ocean from land: small deltas (type I), tidal systems (II), lagoons (III) and fjords (IV). Large rivers (V) bypass the nearshore zone, while karstic (VI) and arheic coasts (VII) act as inactive filters. Types I, II, III and IV account for 32, 22, 8 and 26% of the global coastline, respectively, while 12% does not possess a coastal filter. The STN-30 v6 landmask, and river basin delineation and location of river mouths is the same the one used in the GlobalNEWS project, allowing for development of consistent allocation procedures.

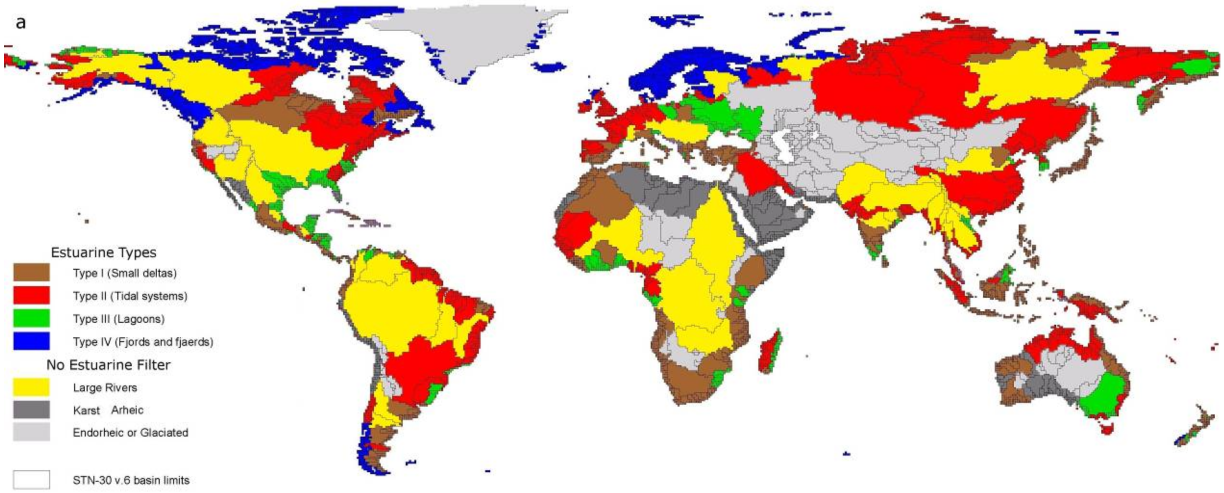

Figure 1. River basins (STN-30 v.6) connected to estuarine types (Dürr et al., submitted).
The map of coastal types has already been used for allocating aquacultural production systems in the coastal zone and preparing the approach for assessing the areas of influence of rivers in the coastal zone.

Two applications of the coastal typology are still in preparation, but when completed this material will be made available to the working group. These include (i) global mapping, regional and global budgeting of material fluxes, to nutrient modeling; and (ii) the application of a similar typology approach to the continental margins.

1.2.GlobalNEWS nutrient loading data

The UNESCO-IOC GlobalNEWS group has now completed all papers for a special issue in *Global Biogeochemical Cycles*. These papers—and associated data—provide the all-important global estimates of nutrient export, the basis of comparison to global HAB distributions. The river nutrient export data (dissolved inorganic, organic and particulate C, N and P; Dissolved Si) as well as the Index for Coastal Eutrophication Potential have been made available for the years 1970, 2000, and 2030 and 2050 for the four Millennium Ecosystem Assessment scenarios (Figure 2) (Seitzinger et al., 2009).

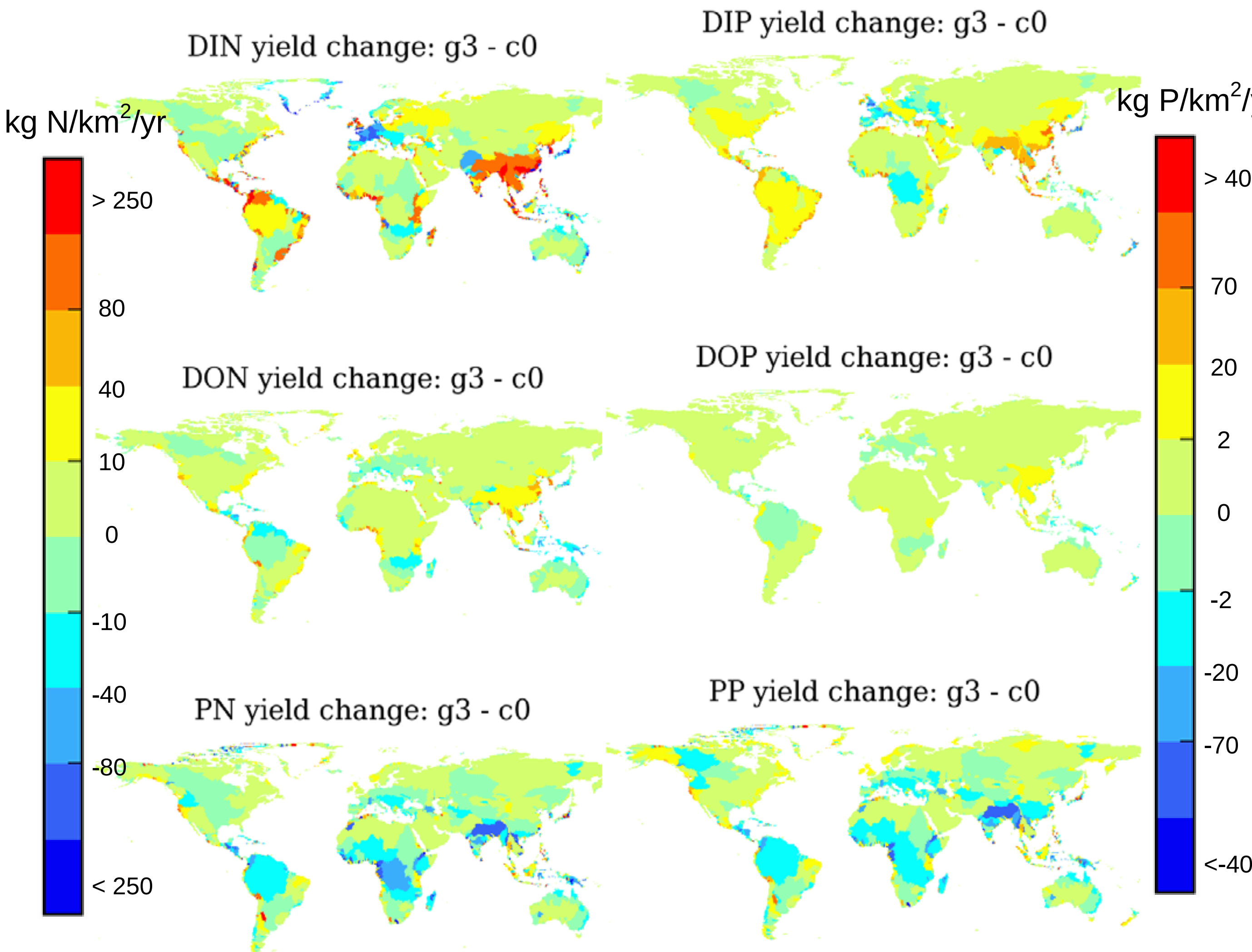

Figure 2. Change in yields (kg km^{-2}yr^{-1}) between 2000 and 2030 from the 5761 basins in the NEWS model for DIN, DON and PN, and DIP, DOP and PP under the Global Orchestration scenario (Seitzinger et al., 2009).

The approach for generating monthly river export data from the annual NEWS output on the basis of monthly runoff has been developed, and the monthly data will be available prior to the second meeting of the working group in October.

1.3.Maps of nutrient loading by aquaculture

The work on developing global estimates of nutrient export from aquaculture started in November 2008. A simple global model approach was developed to estimate the N and P uptake by aquatic plant production and N and P transformation to dissolved and particulate N and P by shellfish aquaculture. The model was used to estimate impacts for the period 1970-2000, and for 2030 and 2050 for the four Millennium Ecosystem Assessment scenarios, consistent with the GlobalNEWS scenarios (Figure 3). Results indicate that the nutrient release from shellfish aquaculture increased from negligible amounts to 2 Tg for N and 0.3 Tg for P in 2006, with a doubling between 2000 and 2006. In 2006, aquatic plant production absorbed about 0.15 Tg yr^{-1} of ammonia and 0.015 Tg yr^{-1} of phosphate. Application of the model to the scenarios indicates that N and P release from aquaculture grow much faster than that of global river export, to values of up to 7.0 and 1.4 Tg yr^{-1} for N and P, respectively, in 2050. Maps for nutrient uptake by aquatic plant production, nutrient transformations by molluscs and nutrient loading by crustaceans are now available. The work on nutrient loading from herbivorous and carnivorous finfish is in progress, and results will be available prior to the October meeting of the Working Group.

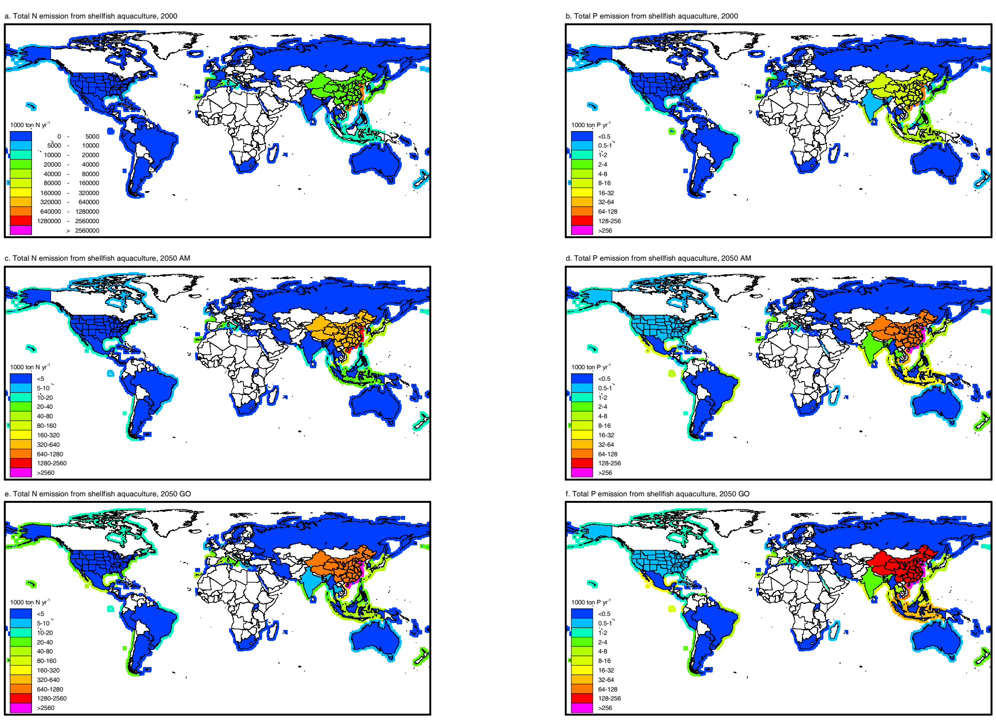

Figure 3. Spatial distribution of release from shellfish production of N (a) and P (b) in 2006, and 2050 for the AM (c and d) and GO scenarios (e and f). Colors for land area indicate the total country N or P release from inland freshwater production, and colors of coastal areas indicate country emissions from marine production of shellfish (Pawlowski et al., 2009). Spatial allocation using the coastal typology and other information on physical conditions in coastal marine systems will be prepared for the second meeting of the Working Group.

1.4. First analysis of satellite data vs. nutrient loading

Satellite data on chlorophyll, ocean color, sea surface temperature have been be collected in the first year, transformed to a common format and resolution. The Global Coastal Ocean Model (GCOMS) is a coupled hydrodynamic ecosystem model based on POLCOMS and ERSEM. It is a unique system that allows the simulation of the global coastal ocean using the same model and is therefore ideal for comparative studies.

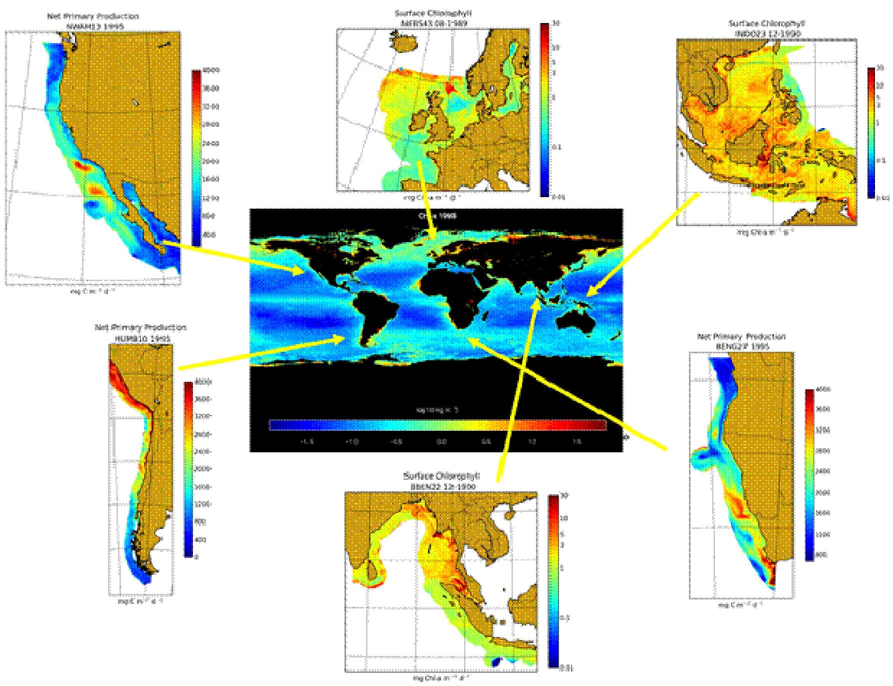

Figure 4. Selection of economically important LMEs where the GCOMS model is used to analyze impacts of nutrient loading using the outputs of GlobalNEWS.

We have run the GCOMS model for a selection of economically important LMEs, using the outputs of GlobalNEWS to represent the land-derived nutrient inputs. Simulations of the present-day states have been made (Figure 4). Simulations forced with pre-industrial (1860) and future (2080-2100) climate states are in the process of being run. These simulations will be analyzed to assess the impacts of high nutrient loads on algal biomass and primary production. The model runs can be coupled to the HAB maps that we will have in spatially explicit form by the time of the second working group meeting (currently *Prorocentrum, Pseudo-nitzschia, Noctiluca* (both red and green forms)).

1.5. Maps of HAB occurrences

In order to develop spatially explicit HAB maps, several hundred literature references were reviewed for documenting incidences of *Prorocentrum minimum, Pseudo-nitzschi*a and *Noctiluca* (both red and green forms). The conversion of the locations into GIS format is in progress. Maps are being developed that are compatible with the GlobalNEWS data sets and will be ready by the second Working Group 132 meeting. A review paper on "*Noctiluca scintillans*: Dynamics, ecology and global distribution" will be submitted to the special volume arising from the GEOHAB Open Science meeting in Beijing. As time permits, maps of additional species will also be developed for analysis at either the second or third meetings of Working Group 132.

The global data is complemented with HAB data from specific regions, including the Humboldt Current LME, Yucatan, Africa, North America, Europe, Asia, and Gulf of Oman region. Brief reports from some of these are in Annex D. The global and regional HAB data will be presented at the second work group meeting in Beijing. An important issue for discussion will be how to merge the data into the global datasets. Where time series exist, these data will be compared to hind-cast global export data.

1.6. Selection of statistical techniques

A first proposal for linking river export data, coastal types and aquaculture was prepared. This simple approach uses so-called areas of influence for nutrients in river plumes and from aquacultural production, accounting for the coastal type. The software will be tested and discussed at the second work group meeting in Beijing. Regarding the analysis of possible relationships between nutrient loading, nutrient forms, and nutrient rations a first method proposed is a YES/NO approach. This involves the analysis if reported occurrences (by species) are within the area of influence of a river or aquaculture site, considering loads of total nutrients (N, P, Si), dissolved and particulate forms, and nutrient ratios. This approach will be discussed and tested at the second working group meeting in October. The refining and actual analysis will take place in the second year of the working group.

1.7. Analysis of available HAB maps

The first key question of the working group relates to the possibility that certain types of coastal ecosystems (estuaries, lagoons, fjords, deltas, etc.) show a propensity to the development of HABs or specific HAB species. The overlaying of spatially explicit maps of HAB occurrences for *Noctiluca* (see 1.5), *Prorocentrum minimum* and *Pseudo-nitschia* and coastal typology to investigate possible relationships is in progress and will be presented and further elaborated at the second working group meeting in October 2009. *Karenia* and possibly *Alexandrium* may be available for analysis after the meeting. For maps of species-specific HAB occurrences, this exercise is planned to be completed in the second year of the project.

1.8. Miscellaneous activities

A working group Web site (http://www.scor-int.org/Working_Groups/wg132.htm) was established with basic information about the group (e.g., membership, terms of reference) and LOICZ hosts a work space for the working group (http://kopc01.gkss.de:7777/loiczdb/faces/app/SearchProjects.jspx). Since data are now becoming available, the Web site will be used as a platform for exchange of data, papers and other information relevant to the work group.

2. Changes in group composition

Willem Stolte from Sweden resigned from the working group because a change in position made continuation of his participation impossible. Hans Dürr (Utrecht University) kindly accepted the invitation to replace Willem.

3. Papers evolving from or relevant to the SCOR/LOICZ 132 working group

Dürr H.H., Laruelle G.G., van Kempen C.M., Slomp C.P., Meybeck M., Middelkoop H. (2009). World-wide typology of near-shore coastal systems: defining the estuarine filter of river inputs to the oceans. Estuaries and Coasts (submitted).

Herrera-Silveira, J.A., Morales-Ojeda, S.M. (2009). Evaluation of the health status of a coastal ecosystem in southeast Mexico: Assessment of water quality, phytoplankton and submerged aquatic vegetation. Marine Pollution Bulletin, 59: 72-86.

Pawlowski, M., Bouwman, A.F., Beusen, A.H.W. C.C., Overbeek (2009). Estimating past and future global contributions of nitrogen and phosphorus from shellfish and aquatic plant aquaculture. Marine Pollution Bulletin (in preparation).

Seitzinger, S.P., Mayorga, E., Kroeze, C., Bouwman, A.F., Beusen, A.H.W., Billen, G., Drecht, G.V., Dumont, E., Fekete, B.M., Garnier, J. Harrison, J.A. (2009). Global river nutrient export trajectories 1970-2050: A millennium ecosystem scenario analysis. Global Biogeochemical Cycles (submitted).

4. Work group meetings

1. 13-16 October 2009 in Beijing, in conjunction with the 2nd Open GEOHAB Meeting on HABs and Eutrophication.
2. Fall 2010, in conjunction with the 14th International HAB meeting in Greece—The third and final workshop will be to assess the scenarios developed from applying the Millennium Assessment projections; to critique, interpret and discuss all the findings of the working group; and to prepare the final manuscripts and report.

Annex A

Terms of reference for the work group

1. Integrate existing databases and nutrient loading databases into a comparable GIS format;
2. Advance the development of a GIS coastal typology and its relationship to HABs;
3. Interrogate the above databases for relationships between HAB species, nutrient loadings/forms/ratios and coastal typology and develop broad relationships with specific HAB species;
4. Explore possible changes in HAB occurrences in the future (for example, year 2030) using the relationships developed above and global nutrient export patterns under the Millennium Scenarios;
5. Publish the results in peer-reviewed scientific journals, and develop articles for GEOHAB and LOICZ newsletters as well as other outlets. Papers may cover the global perspective, regional time series and individual case studies.

Key research questions

Do relationships exist between HABs and nutrient loading and can we quantify those with respect to:

1. Typology of coastal marine ecosystems (based on physical and biological parameters)?
2. Spatial variation of nutrient loading, forms and ratios?
3. Temporal variation of nutrient loading, forms and ratios?
4. Relative contribution of different nutrient sources including aquaculture to nutrient loading?

Annex B

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Annex C

Agenda for the second work group meeting
Beijing, 13-16 October 2009

The two main goals for the second work group meeting are to:

- Statistically analyze species distribution with respect to nutrient loading, nutrient forms and nutrient ratios, coastal type, and nutrient loading from marine aquaculture (shellfish, finfish) and impact of aquatic plant production.
- Develop syntheses and papers based on these analyses

Day 1
The first day will be used to present and discuss the progress in the various activities:

- Introduction – Pat Glibert
- Global NEWS data and scenarios – Lex Bouwman
- Coastal typology and applications – Hans Dürr
- Global aquaculture – Lex Bouwman
- Global HAB maps and regional syntheses
  - Prorocentrum minimum and Pseudo nitzschia - Pat Glibert
  - Noctiluca - Paul Harrison
  - Europe – Richard Gowen
  - Gulf of Mexico and Pacific Coast California-Peru – Jorge Herrera
  - Humboldt Current LME – Sandor Mulsow
  - Gulf of Oman - Adnan Al-Azri
  - Asia – Paul Harrison and Mingjiang Zhou
  - Africa- Grant Pitcher
- Comparison of modeled impact of nutrient loading with satellite data – Icarus Allen
- Proposal for analysis of relationships between nutrient loading and HABs – Arthur Beusen

Day 2 and 3
Days 2 and 3 will be used to analyze the available databases and do a first approach to assess relationships between nutrient loading and HAB occurrences. Participants will bring all their data and material for testing different approaches, discuss alternatives and specify activities for the second year of the work group.

Day 4
Day 4 will be used to summarize the discussions and plan future work. Specific issues for

discussion include:

- Updating of the project website; make data available
- Detailed planning of activities for the second year of the work group
- Planning of papers on the basis of this work group

Annex D

Regional HAB data

Humboldt Current

In the northern part of the Humboldt Current-LME, HABs occur nearly every year and sometimes several times a year. In this region, nutrient loading is low because of scarcity of rivers. Recently (2006 to present), both PSP and DSP have been reported. Data will be reported in the next meeting of WG 132. The southern part of the HC-LME region is an enclosed sea, surrounded by 10 important watersheds and since the early 1980s it has been “the site” for fish farming activities. The frequency of HABs is much higher than in the northern part. Fish farming activities account for as much as 100 to 300 kg of N km^{-2} y^{-1}, in addition of the DIN supplied by the rivers in this region. The link between nutrients and HABs seems logical, but difficult to express in a cause-effect relationship. However, the link between nutrient loading and the collapse of the salmon farming industry in this particular region is very significant.

Yucatan Peninsula

The marine coastal ecosystem of Yucatan Peninsula is in good condition; however, differences were observed between subregions that can be attributed to local forcing functions and human impacts. Specifically, the central region showed symptoms of initial eutrophication due to nutrient inputs from human activities. The eastern region showed a meso-eutrophic condition linked to natural groundwater discharges, while the other two subregions—western and Caribbean—exhibited symptoms of oligo-mesotrophic condition.

Gulf of Oman Region

For the Gulf of Oman region and Arabian Sea a time series covering the period 2003-present is available. The data comprise phytoplankton information, nutrient and physical parameters. Data collection will be continued. An interesting event regarding the possible causes was a red tide outbreak (*Cochlodinium polykrikoides,* the first record of this species in this region) in 2008 and 2009 lasting almost 8 months.

2.2.12 SCOR/IAPSO WG 133: OceanScope
(2008)

Terms of Reference

1. Identify ocean observations and scientific needs with respect to parameters and geographic location
2. Given these needs, identify and prioritize marine routes for sustained ocean observations
3. Classify and identify commercial vessel types suitable for sustained observations
4. Identify available technologies that can enhance vessel capability for ocean observations
5. Identify and prioritize instrument needs to meet *future* mission requirements
6. Identify and develop procedures (hardware and software) to meet communications needs
7. Develop procedures and algorithms for managing data flow, handling, and archival. Address related issues of data ownership (e.g., when routes occur within national Exclusive Economic Zones), data availability and data dissemination. In general, the expectation is that data would be made freely and widely available to all interested users.
8. Address what kind(s) of organizational structure(s) will best serve to initiate, implement, and sustain an integrated international merchant marine-based ocean observation program, linked closely to existing ocean observing systems and programs with access to appropriate and sufficient long-term funding sources (e.g., an "Ocean (or Interior) Space Center")

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P.C. Reid (UK)	Joe Cox (USA)
Fred Soons (Netherlands)	Rich Findley (USA)
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Javier Valladares (Argentina)	Arnold Furlong (Canada)

Yasuo Yoshimura (Japan)	John Gould (UK) Gwyn Griffiths (UK) James Hannon (USA) Van Holliday (USA) Paul Holthus (USA) Robert Luke (USA) Jerry Mullison (USA) Glenn Pezzoli (USA) Steve Piotrowicz (USA) Tom Sanford (USA) Corinna Schrum (Norway) Satheesh Shenoi (India) Peter Sigray (Sweden) Denise Smythe-Wright (UK) Darryl Symonds (USA) Michael Twardowski (USA)

Executive Committee Reporter: Missy Feeley

Report to SCOR/IAPSO re 'OceanScope' Working Group meeting in Montreal

The first working group meeting took place on July 17-19, just ahead of the IAPSO conference in Montreal (see Appendix A for the meeting schedule). All eleven Full Members[1] and an additional 12 attended, as Associate Members took part in the deliberations (see Appendix B for the complete list of participants). The first day was devoted exclusively to a set of overview discussions to discuss science, vessel and instrumentation issues. The objective was to bring all of participants up to a common frame of knowledge about the issues likely to define and constrain the development of the OceanScope paradigm. On the second day, participants worked through each of the terms of references (ToRs) in plenary discussion. This approach proved to be quite effective, and had the beneficial effect of engaging all members, with their diverse backgrounds of expertise, in the discussion. The third day (in the morning only) was devoted to developing homework assignments for each of the ToRs and determining if they covered all the relevant issues. During these discussions, various suggestions were made to supplement or restructure the original ToRs. These included the possibility of adding a couple of new ones pertaining to capacity building, outreach, the feasibility of phased implementation and a strategy for developing a sustainable partnership with the maritime industry. There are a number of challenging issues and exactly how the group will address these will be explored during the coming months. The final decision of the WG was to settle on a time and venue for the next meeting. The dates 12-14 April in London were suggested, and these are now firm and the International Chamber of Shipping (ICS) has offered to host the meeting at its headquarters. I think everyone is very excited about this. Detailed minutes of all discussions were taken by Drs. Ortner and Flagg.

The following list hints at the wide scope of issues identified during our discussions and the homework assignments already made:

1) Identification of vessel classes and their suitability for water column studies from the perspective of vessel type and expectation that a vessel will remain on the same route.
2) The downdraft and presence of bubbles are the main limitation to acoustic remote sensing from vessels. Where do we place instrumentation to minimize their impact?
3) Design technologies to minimize demands on vessels: Do we use seachests, or can instruments be attached externally using magnets with only a small electric penetration?

---

[1] After the original 10 Full Members were approved, a case was made that one very important technology was not represented, so the SCOR Executive Committee took the unusual action of allowing the group to add an 11th Full Member.

4) Identify and prioritize instrumentation needs for immediate use and for future applications. This will depend upon both observational priorities and technological capabilities.
5) Address issues of data collection, processing and dissemination. All agreed that OceanScope should be viewed as an ocean monitoring activity and that the data must be made freely available.
6) Address issues pertaining to the collection and dissemination of data collected while vessels transit EEZs.
7) Articulate a phased approach to implementing OceanScope (initial, intermediate and fully implemented phases).
8) Explore and articulate strategies for partnering with the merchant marine shipping industries such as working directly with the ICS to enlist the support of the Roundtable and other Direct Entry Organizations representing vessel type consortia, alternatively working directly with specific companies (or both).

During the winter months we will review, revise, amend, expand, as needed the homework material. Most of this will be done by teleconference and email, but it is likely that Rossby and Ortner (and others interested) will meet and work together on integrating the input received for a few days early next year. Although the initial research and homework writing will be done in terms of the supplemented ToR list, we anticipate that the material will be re-organized into a few major categories and topics in the draft Implementation Plan. Ideally, at the conclusion of the April meeting (or shortly thereafter), a first draft of the Implementation Plan can be circulated for comment. At this stage we hope that the third WG meeting will be advisory or supervisory to an actual Implementation Program.

Appendix A: SCOR/IAPSO WG 133: OceanScope Meeting #1

As noted earlier, the “OceanScope” concept envisions a new paradigm for the systematic and sustained observation of the ocean water column. It proposes to develop a partnership between the ocean observing community and merchant marine industry so that a number of synergies can be realized which to date have not been possible, notwithstanding a very high level of cooperation between individual ship operators and scientists. The vision includes an enhanced ability to identify routes and operators in all oceans, new instruments and technologies developed and optimized for automated operation on commercial vessels, and real-time data streams, automated data processing and distribution to the user community. You have already received a copy of the proposal and discussion notes regarding the first eight terms of references. To augment this information, it seems sensible to start the working group deliberations with a set of overview presentations bring us all “up to speed.” So I propose a set of overviews (not too formal) along the following topics:

Observables Science (physics, chemistry, biology, routing, other?) I propose to NOT include the atmosphere, but focus on the water column on the grounds that 1) that is where we are really hurting, 2) limit the scope of topics to cover, and 3) avoid unnecessary overlap with ongoing VOS/SOOP activities.

Vessel-related technologies Hydrodynamics and mechanics of ships (hull design impact on flow and drawdown of bubbles; acoustical issues?)

Instrumentation technologies 1) Remote sensing, 2) expendable probes, 3) towed systems, and 4) through-hull systems. Limpet technologies.

Communication, processing, distribution Software issues (automation will be crucial to streamline processing and thus constrain costs, and to facilitate real-time distribution. Data should be freely available. Restrictions due to EEZ concerns will in some cases be an issue and should be discussed)

A brief discussion will be conducted on how the proposed Implementation Plan might be realized. (The real point is that we all will want to know if this has any chance of being implemented. It will be too early to know of course, but 1) encouragement helps and 2) the quality of the Implementation Plan will be very important.)

Proposed schedule for the working group meeting

Day 1: Primarily devoted to reviews of the above topics, each followed by open discussion.

Welcome: Prof. Lawrence Mysak, President of IAPSO

Introductory overview: Tom Rossby

Observables:

- Physics: Kuh Kim
- Biology: Chris Reid
- Chemistry: Ute Schuster
- Cruise Ship and Cargo Vessel Perspectives: Peter Ortner

Vessels: Markku Kanerva

Instrumentation:

- Remote sensing, acoustic: Jerry Mullison; optic: James Churnside
- Seachests vs. limpets: Charlie Flagg
- Expendable probes: James Hannon
- Flow-thru systems: David Hydes
- Moving vessel profilers: Arnold Furlong
- Other: a few slides on towed systems

Communications:

- Data management: Glenn Pezzoli
- EEZ issues: Fred Soons

After overview talks, prepare to break into sub-working groups. These can be organized along the above topics, or they could be based on the various terms of references (ToRs). I suggest we see how the discussions develop before deciding exactly how to proceed.

Refreshments and cash bar.

Day 2: This will be the main working day during which OceanScope starts to take shape. After brief plenary session, we will break up into various groups to develop in some detail the themes/ToRs. These should be developed as input towards the OceanScope Implementation Plan.

Initial (brief) report-out at mid-day and in late PM? These plenary breaks will also allow for any necessary regrouping.

Day 3: (half-day only)

Plenary meeting to hear reports from the sub-groups, each followed by brief review/discussion.

Decide on co-chairs and membership for subgroups who will complete the writing of the various chapters for first complete draft of the Implementation Plan.

Discuss OceanScope poster to be presented at the September OceanObs09 conference in Venice.

Brief final review: What have we accomplished, and what should we have ready for the next meeting (in about a year?)? Are there new issues to explore/develop during this period? Where shall that meeting take place? How long should it be?

Appendix B: Participants at First Working Group Meeting

<u>SCOR/IAPSO</u>
Joe Cox, CEO, Chamber of Shipping of America, representing the ICS
David Hydes, Scientist, National Oceanographic Centre, Southampton, UK
Markku Kanerva, Director, Deltamarin, Turku, Finland
Kuh Kim, Professor, Seoul National University, Seoul, Korea
Peter Ortner, Professor, University of Miami, USA
Chris Reid, Senior Fellow, SAHFOS, Plymouth, UK
Tom Rossby, Professor, University of Rhode Island, USA
Ute Schuster, Senior Research Associate, University of East Anglia, UK
Fred Soons, Professor, Utrecht University, The Netherlands
Javier Valladares, Navy officer (ret.) and Science advisor, Argentina
Yasuo Yoshimura, Professor, Hokkaido University, Japan

<u>Associate Membership</u>
Jim Churnside, Scientist, ESRL/NOAA, Boulder, CO, USA
Rich Findley, Director, Marine operations, Fort Pierce, FL, USA
Charlie Flagg, Professor, Stony Brook University, Stony Brook, NY, USA
Arnold Furlong, Director, ODIM Brook Ocean, Dartmouth, NS, Canada
Don Scott, Engineer, Sippican, Marion, MA, USA (representing James Hannon)
Robert Luke, VOS program manager, NOAA, Stennis Space Center, MS, USA
Jerry Mullison, Engineer, RDInstruments, San Diego, CA, USA

Glenn Pezzoli, Manager, SOP Program, Scripps Institution of Oceanography, La Jolla, USA
Steve Piotrowicz, Argo Program Manager, NOAA, Washington DC, USA
Corinna Schrum, Professor, University of Bergen, Norway
Peter Sigray, Professor, University of Stockholm, Sweden
Denise Smythe-Wright, Scientist, National Oceanographic Centre, Southampton, UK

2.2.13 SCOR WG 134: The Microbial Carbon Pump in the Ocean
(2008)

Terms of Reference:

- Summarize representative microbial data on biomass, production and diversity of functional groups (AAPB, CFB, Roseobacter, Archaea) and overall microbial communities, as well as DOC data focusing on the context of RDOC dynamics along environmental gradients (productivity/temperature/salinity gradient such as estuarine to oceanic waters); Establish the current state of knowledge about microbial processes that produce RDOC at the expense of DOC, and identify essential scientific questions regarding microbial carbon pump to be addressed in the future;
- Assess the available techniques for quantifying microbial functional groups and demonstrating the bioreactivity of marine DOC, document state-of-the-art techniques and parameters addressing microbial processing of organic carbon, and establish/standardize key protocols for the essential observation/measurements;
- Convene International Workshop(s) and publish a special volume in an internationally recognized peer-reviewed journal, or a protocol book (practical handbook) by a major publisher on measurements of the key parameters related to microbial processing of carbon in the ocean.
- Make recommendations for future research related to the microbial carbon pump in the ocean, toward development of a large-scale interdisciplinary research project.

Co-chairs:

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Other Full Members	Associate Members
Xosé Antón Álvarez-Salgado (Spain)	Ronald Benner (USA)
Arthur Chen (China-Taipei)	Craig Carlson (USA)
Dennis Hansell (USA)	Feng Chen (USA)
Gerhard Herndl (Netherlands)	Sang-jin Kim (Korea)
Gerhard Kattner (Germany)	David Kirchman (USA)
Michal Koblížek (Czech Republic)	Ingrid Obernosterer (France)
Nagappa Ramaiah (India)	Carol Robinson (UK)
Colin Stedmon (Denmark)	Richard Sempere (France)
	Christian Tamburini (France)
	Steven Wilhem (USA)
	Susan Ziegler (Canada)

Executive Committee Reporter: Bjørn Sundby

WG134 First Meetings

27-30 October 2009

Xiamen, China

Session I

General meeting: Bridging biology and chemistry in oceanography

October 28th 2009

Speaker	Title of talk
1. Nianzhi Jiao	Microbial Carbon pump in the ocean--- from theory to practice: The known, unknown and what we need to know
2. Farooq Azam	Microscale interactions of bacteria and the regulation of Microbial Carbon Pump
3. Gerhard Herndl	Archaeal and bacterial carbon cycling in the deep ocean
4. Dennis Hansell	DOM global distributions and Deep ocean DOM sinks
5. Gerhard Kattner	On the extreme complexity of dissolved organic matter: a major reason for its slow degradation?
6. Chen-Tung Arthur Chen	Horizontal and vertical flux of DOC in the South China Sea and the West Philippine Sea.
7. Jizhong Zhou	Explore carbon metabolism functional genes in the ocean through GeoChips
8. Markus Weinbauer	Towards a viral oceanography: Twenty years of research on marine viral ecology and biogeochemistry
9. Steven Wilhelm	Viruses and the marine carbon cycles: moving beyond models
10. Feng Chen	Linking functional genomics to microgeochemical roles in the sea
11. Colin Stedmon	A global perspective on the optical properties of DOM: insights into DOM biogeochemistry
12. Chuanlun Zhang	Archaeal and bacterial carbon cycling in the deep ocean
13. Richard Sempere	DOM biogeochemistry in Mediterranean Sea. Influences of river inputs, exchanges through straits, biology and solar

	radiation.
14. Susan Ziegler	Tracking autotroph-heterotroph carbon flow and the release of dissolved organic carbon from stream biofilms using a stable isotope probing approach
15. Michal Koblížek	Use of specific biomarker molecules for measurements of bacterial growth rates. Implications for DOC cycling in the sea.
16. Xosé Antón Álvarez-Salgado	Optical properties of marine HMW-DOM and their transformation by the heterotrophic activity in the oceans
17. Nagappa Ramaiah	An overview of bacterial abundance and production in the carbon cycling in biogeochemically disparate regions of the Indian Ocean
18. Xu Yongfu	A test on RDOC based ocean carbon cycle model
19. Meixun Zhao	Phytoplankton community structure changes and their implications for ocean carbon sequestration
20. Hongbin Liu	The role of picophytoplankton in microbial food webs and carbon cycle in the ocean
21. Sang-jin Kim	Microbial decomposition of DOM in the marine environments
22. Christian Tamburini	Effect of pressure on prokaryotic degradation of organic matter according its quality/composition

Session II:

Closed WG Workshop

Oct. 29th -- 30th, 2009

WG main topics and corresponding discussion leaders

1. MCP WG terms of reference, missions, desired outcomes, and future planning: Jiao & Azam
2. Carbon metabolism of functional groups of microorganisms: Herndl & Zhou
3. Contribution of bacteria and viruses to DOM transformation: Weinbauer & Stedmon
4. Discrimination and quantification of functional microbial groups: Wilhelm & Koblížek
5. DOC composition, distribution and oceanic DOC sink: Hansell & Kattner

2.2.14 SCOR/InterRidge WG 135: Hydrothermal Energy Transfer and its Impact on the Ocean Carbon Cycles
(2008)

Terms of Reference:

- **Synthesize** current knowledge of chemical substrates, mechanisms and rates of chemosynthetic carbon fixation at hydrothermal systems as well as the transfer of phytoplankton-limiting micronutrients from these systems to the open ocean.
- **Integrate** these findings into conceptual models of energy transfer and carbon cycling through hydrothermal systems which would lead to quantification of primary production in view of a future assessment of the contribution of these systems to the global-ocean carbon cycle.
- **Identify critical gaps** in current knowledge and proposing a strategy for future field, laboratory, experimental and/or theoretical studies to bridge these gaps and better constrain the impact of deep-sea hydrothermal systems on ocean carbon cycles.

Co-chairs:

Nadine Le Bris
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Chris German
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Other Full Members	**Associate Members**
Wolfgang Bach (Germany)	Julie Huber (USA)
Loka Bharathi (India)	George W. Luther III (USA)
Nicole Dubilier (Germany)	W.E. Seyfried, Jr. (USA)
Katrina Edwards (USA)	Stefan Sievert (USA)
Peter R. Girguis (USA)	Margaret K. Tivey (USA)
Xiqiu Han (China-Beijing)	Andreas Thurnherr (USA)
Louis Legendre (France)	Toshitaka Gamo (Japan)
Ken Takai (Japan)	Françoise Gaill (France)

Executive Committee Reporter: Missy Feeley

SCOR/InterRidge WG 135

Hydrothermal Energy Transfer and its Impact on the Ocean Carbon Cycles

Co-Chairs: Nadine Le Bris (France) and Chris German (USA)

2009_WG report

1. Membership

The WG membership list has been completed with 3 associated members. Dr. Toshi Gamo (ORI, Tokyo, Japan), who is also a member of the GEOTRACES International Scientific Steering Committee, will help us to develop links between our Working Group and that particular SCOR programme.

A mirror to our SCOR Working Group has also been created under the auspices of the InterRidge programme, replacing a pre-existing WG on Biogeochemical Interactions at Hydrothermal Vents. Two members of the former InterRidge WG have joined our SCOR-IR group: W.E. Seyfried (U. Minnesota, USA) and G.W. Luther (U. Delaware, USA), strengthening the geochemistry and biogeochemistry components of our collective expertise, respectively.

Extension of the representation of Southern Hemisphere countries has not been achieved yet, despite various contacts we have made and invitations extended to colleagues in New Zealand, Chile and South Africa. Actions are pending to further develop interactions with these countries.

2. Sessions in international conferences

In 2009, WG-related sessions were held at two international conferences: the ALSO Aquatic Science Meeting, Jan. 25-30 (Nice France) and the Goldschmidt conference, June 22-26 (Davos, Switzerland). Both had similar topics but were directed to different scientific communities (oceanography and geochemistry, respectively).

The ASLO session 'From molecules to organisms: Chemoautotrophic pathways and mechanisms of energy transfer in extreme marine environments' gathered 18 presentations. Most of these contributions were related to hydrothermal vent systems or chemoautotrophy. The Goldschmidt session 'Pathways and regulation of energy and carbon transfer in extreme deep-sea environments' participated to the Theme 16 'Life on the edge: extreme environments'. A total of 14 contributed presentations were dedicated to hydrothermal systems and to chemoautotrophy.

Several hot topics in relation to our WG objectives were identified through these sessions. Additionally, these sessions helped us start to establish a core group of experts around whom we can plan for the community-wide workshop we have planned for 2011.

3. First working group meeting

The first meeting of the working group has now been scheduled for November 23-24, 2009, in Woods Hole (USA). Main points to be discussed will be the strategies to address our terms of reference and the definition of a preliminary agenda for the next 3 years. This will include the definition of sub-groups (water column, deep-biosphere, seafloor ecosystems) and the links with initiatives like GEOTRACES, IODP, and any future programmes emerging from CoML beyond 2010. We expect to reach preliminary agreement on the 2011 workshop organisation committee and place of the venue during the course of our November meeting.

Working Group Updates

Biogeochemical Interactions at Deep-Sea Vents

Chair - N. Le Bris (IFREMER, France)

Members

The WG for Biogeochemical Interactions at Deep-Sea Vents had one new change in membership for 2008: Huaiyang Zhou has joined the IR WG for Deep Earth Sampling, and we invited Xiqiu Han (Second Institute of Oceanography, China) to join our WG in replacement. Xiqiu's expertise in oxygen and carbon isotopic signatures of chemosynthetic processes fits perfectly with the WG objectives, and she will bring a complementary view from China.

IRTI

Many of our WG activities in this past year have been as a follow-up to the InterRidge Theoretical Institute on Biogeochemical Interactions at Deep-Sea Vents (Woods Hole, Sept. 10-14, 2007), with the help of the IR office, WHOI colleagues and chairs of the discussion groups (see article in 2007 InterRidge Newsletter). Our workshop report is available at: http://www.interridge.org/files/interridge/IRTI_2007_rept_full_posted_NLB.pdf.

The development of original strategies and collaborative projects was a main objective of the IRTI. Beyond smaller-scale initiatives, the proposition for a coordinated action on an international basis was issued from the workshop. A common concern about the capacity of hydrothermal systems to derive chemical energy to fix CO_2 into biomass arose from four of the IRTI discussion groups (plume biogeochemistry, life in extreme environments, hidden biosphere, long-term seafloor ecosystems changes) and provided the basis for such an initiative.

Below, we highlight in particular two direct outcomes from the IRTI:

- a SCOR proposal for a synthesis and modelling effort on which a future large-scale biogeochemical flux experiment will be based (developed from the several discussion groups mentioned above), and
- interactions with the GEOTRACES program (another SCOR-affiliated program) that developed more specifically from the discussion group on plume biogeochemistry.

New SCOR Working Group

A major achievement of our WG in this past year is the approval of a new SCOR Working Group, to be co-funded by InterRidge, on "Hydrothermal energy transfer and its impact on ocean carbon cycles." This new Working Group will be co-chaired by Nadine Le Bris (IFREMER, France) and Chris German (WHOI, USA). Currently, the proposal is posted on the SCOR website at: http://www.scor-int.org/2008GM/Ridges.pdf. We will also create a mirror webpage for this new SCOR-InterRidge initiative as part of the on-going IR WG for Biogeochemical Interactions at Deep-Sea Vents.

Hydrothermal venting is widespread throughout all ocean basins, and the local fixation of carbon and the export of biolimiting nutrients to the broader ocean may be much greater than previously recognized. Recent advances in molecular methods as well as in situ and in vivo experimentation now provide us new opportunities for a coordinated, integrating effort in which interdisciplinary approaches and modelling can be proposed. The main objective is to set the basis for a revised consideration of the diverse pathways of CO_2 fixation driven by hydrothermal processes and the potential contribution that they may make to the global ocean carbon cycle. Our new SCOR support should allow larger initiatives to be organized on this topic, involving a broader community of researchers, including other IR WGs.

This is the first SCOR Working Group in over ten years to be stimulated from InterRidge activities. We congratulate those involved with the proposal and thank all who were involved with the discussions at the IRTI. Please feel free to contact Nadine (Nadine.Le.Bris@ifremer.fr), Chris (cgerman@whoi.edu), or the InterRidge office (coordinator@interridge.org) with questions or suggestions for the new SCOR Working Group.

Links with the GEOTRACES program

GEOTRACES is one of the newest SCOR-affiliated programs and seeks to conduct a series of 2-D cross sections of the oceans, spanning entire ocean basins, to characterize global-ocean biogeochemistry on scales comparable to the WOCE program's physical oceanographic studies. In the USA the first priority is a trans-North Atlantic geochemical section, currently planned to be conducted in 2010, that will include one station at the TAG hydrothermal mound. A second priority for U.S. GEOTRACES, identified at a meeting held in Oct. 2008, will be to run a pair of sections in the eastern Pacific. One will run from north to south between Alaska and Tahiti and intercept dispersing hydrothermal plumes that span the Pacific basin, emanating from (from North to South): the Juan de Fuca Ridge, Loihi Seamount (Hawaii), East Pacific Rise (EPR) 9-10°N and EPR 10-20°S. The complementary E-W section will run between Tahiti and Peru, where the western half of the section will be designed to sample along the axis of the dispersing hydrothermal plume that originates at the southern EPR (the world's biggest plume, originating from the world's fastest-spreading ridge). The eastern half of the same section will provide a contrast with the iron and manganese-rich lenses of water that make up the oxygen minimum zone that extends offshore from the Peru Margin - one of the most highly productive regions of surface ocean. The time frame for these section studies is currently anticipated to be 2012-2014. We expect that our WG will work together with GEOTRACES in the development of these programs and, in particular, a complementary process-oriented and submersible-led investigation of the high-temperature vent-sources for the southern EPR plume, focussed along the super-fast SEPR ridge-axis.

Links with other IR WGs

The activities of our WG are tightly connected with other IR WGs. Members of the Vent Ecology, Deep Earth Sampling, and Monitoring and Observatories WGs actively participated in the IRTI, and several are also involved in the SCOR Working Group. The development of interdisciplinary approaches and dedicated tools, in turn, provide inputs to the reflexion of these WGs. We will continue developing synergies in the future with other IR WGs. Particularly, we will be pleased to provide contributions to future InterRidge Theoretical Institutes and workshops.

Upcoming events

- ASLO Aquatic Sciences Meeting, Nice, France, Jan. 25-30, 2009. Session: From molecules to organisms: Chemoautotrophic pathways and mechanisms of energy transfer in extreme marine environments.
- Goldschmidt Conference, Davos, Switzerland, June 2009. Session: Pathways and regulation of energy and carbon transfer in extreme deep-sea environments.

Deep Earth Sampling

Chair - B. Ildefonse (Univ. Montpellier II, France)

Members

The WG for Deep Earth Sampling has one new member in 2008: Huaiyang Zhou (Tongji University, China).

Recent events

- A Magellan workshop "Lithospheric heterogeneities, hydrothermal regimes, and links between abiotic and biotic processes at slow spreading ridges," partly funded by InterRidge, was held in September 2008 in Montpellier, France (see article, this volume).
- IODP recently set up a Thematic Review Committee (Oceanic Crustal Structure and Formation; www.iodp.org/trc/), which met in Oct. 2008 in Zürich, Switzerland. A report should be available soon on the IODP web site.

Future of the WG

Our WG was formed in 2004 as part of the InterRidge Next Decade Plan. Following our activities associated with the Mission Moho Workshop in 2006 and a group proposal submitted to IODP in 2007, it was time in 2008 to either disband the WG or move forward with a new mandate. We held several discussions over email prior to the 2008 IR Steering Committee meeting. At this recent IR STCOM meeting, it was recognized the importance of our WG in this upcoming year as the IODP INVEST workshop in September 2009 (listed below) will be receiving input for planning the next decade of IODP science beyond 2013. The Steering Committee emphasized the importance of our WG in contributing to this planning for the future of scientific ocean drilling. Thus, we will continue the WG, with a more focused mandate to provide inputs on priorities and targets to the 2009 IODP INVEST workshop. In the short term, we are planning to meet for a discussion just prior to the AGU Fall Meeting in December 2008. We also plan to identify money and time to possibly organize a dedicated WG meeting next year, before the INVEST workshop. In addition, the IR Steering Committee recognized the need for a liaison between this IR WG, representing the IR community-at-large, and IODP.

Upcoming events

- AGU Fall Meeting, Sunday, December 14, 2008, WG meeting with discussion open to other community members who are interested in joining our planning effort for the 2009 IODP INVEST Workshop (contact Benoit Ildefonse for details on this meeting: Benoit.Ildefonse@um2.fr).
- ECORD Summer School on Geodynamics of Mid-Ocean Ridges, 31 August - 11 September 2009, Bremen, Germany, http://www.glomar.uni-bremen.de/ECORD_Summer_School_2009.html. The IR WG members are involved in organizing this summer school with colleagues from MARUM and the IODP core repository in Bremen. We hope to attract about 30 Ph.D. students and postdocs, to work on geody-

2.3 Working Group Proposals

2.3.1 Evaluating the ecological status of the world's fished marine ecosystems

Proposal for a SCOR Working Group on
"Evaluating the ecological status of the world's fished marine ecosystems"

Abstract

An Ecosystem Approach to Fisheries (EAF) is being adopted globally. To make progress towards implementing the EAF, carefully selected and appropriate indicators are required to translate ecosystem impacts and changes into management measures that can be assessed for their effectiveness. The scientific community is challenged to provide a generic set of integrated ecological indicators to accurately reflect the effects of fisheries on marine ecosystems, to discriminate these effects from other ecosystem drivers and to facilitate effective communication of these effects to managers, policymakers and the public. Building on the work of SCOR/IOC Working Group 119 on "Quantitative Ecosystem Indicators" (2001-2004), and the IndiSeas Euroceans WG (2007-2009), this ICES SCOR WG proposal, "Evaluating the status of the world's fished marine ecosystems" subject to multiple drivers, aims to provide a concrete framework for evaluating the status of marine ecosystems.
We propose a comparative statistical approach to explore and analyse the response of a suite of ecological indicators to ecosystem change across a broad range of ecosystem types; to develop models to explore the combined effects of fishing and climate on indicators trends and to develop rigorous means of testing indicator responsiveness and performance. Furthermore we intend to forge links with other research fields (climate change, conservation biology, sociology and economics) to promote an integrative ecosystem approach to marine resources.

Background and Rationale

Societal and scientific background

After decades focused on the study and management of single species, fisheries management is evolving towards ecosystem-based approaches. These regard the ecosystem as the most relevant unit for management, □aponicas□i that resilient ecosystems are crucial to maintain the sustainability of marine goods and services. Efforts are now being made to measure and alleviate the ecosystem effects of fishing (Hall 1999) and focus is very much on how an ecosystem approach to fisheries may be implemented (Garcia and Cochrane 2005). The FAO Reykjavik declaration of 2001, reinforced at the World Summit on Sustainable Development in Johannesburg in 2002, requires nations to develop and start implementing an Ecosystem Approach to Fisheries (EAF) for reconciling conservation and exploitation objectives by the year 2010. Nations are further required to restore depleted fish stocks by 2015, and to establish representative networks of Marine Protected Areas by 2012.

To fulfil these objectives, a strategy based on innovative and integrated science is urgently needed to translate the complexity of marine ecosystems into comprehensible signals and to propose operational management frameworks (e.g. FAO 2003, Link 2005). The response of the fisheries scientific community has been to develop tools to enable an ecosystem approach to fisheries, a fundamental component of which is the development of ecosystem indicators (Daan *et al.,* 2005), to evaluate the status and dynamics of ecosystems, or components thereof

The groundwork has been established by the SCOR/IOC WG 119 (Cury and Christensen 2005) which reviewed the relevance of a wide range of ecological indicators according to the following criteria:

- ecological significance (i.e. are the underlying processes essential to the understanding of the functioning and the structure of marine and aquatic ecosystems?)
- measurability: availability of the data required for calculating the indicators
- sensitivity to fishing pressure
- awareness of the general public.

It also provided some of the theoretical background to understand which processes and fishing effects are captured by ecosystem indicators. This review □aponicas□i ecosystem indicators into three main types: size-based (Shin et al. 2005), trophodynamic (Cury et al. 2005) and species-based indicators.

What is now needed to implement EAF worldwide is a concrete framework to facilitate the application of ecosystem indicators as a tool for diagnosing the ecological state of the world's marine ecosystems and subsequently as a means of initiating appropriate fisheries management responses that would address and alleviate the impacts of fishing on ecosystems. A start has been made by the IndiSeas WG, established under the auspices of the EUROCEANS European NoE (Network of Excellence), to look at "EAF Indicators : a comparative approach across ecosystems". The objective of the IndiSeas WG was to use a comparative approach to evaluate the status of marine ecosystems in a comparative framework and to guide fisheries management in each ecosystem. Ecological indicators from 19 fished ecosystems were assembled, examined and reviewed with respect to several criteria, before agreement was reached on an initial suite of eight ecological indicators consider most suitable to evaluate ecosystem effects of fishing. An IndiSeas website has been created to present part of the results of this work, which includes a "dashboard" of these indicators, developed for □aponicas□ion purposes for the non-scientists (see www.indiseas.org, opened to the public in April 2009). A series of 9 scientific papers[1], exploring the □aponica of the suite of the minimal set of 8 ecosystem indicators has been submitted to ICES Journal of Marine Science. One clear result from this WG is that (a) further work is required to select indicators that are robust to ecosystem type, (b) the performance of

[1] The Indiseas suite of papers will be published in the ICES Journal of Marine Science. See Annex A for details.

these indicators can be ambiguous and (c) it can be difficult to discriminate the effects of fishing from environmental drivers. Ecological indicators only tell part of the ecosystem story.

Objectives

The goal of this proposed working group "Evaluating the ecological status of the world's exploited marine ecosystems subject to multiple drivers" is to bring together a broader group of experts to further explore, test and expand the development of a suite of robust ecosystem indicators for detecting ecosystem change in response to fishing and environmental impacts. Specifically we propose to:

(i) to develop rigorous means of testing indicator responsiveness and performance,
(ii) develop reference points for the suite of indicators,
(iii) add climate and biodiversity/conservation indicators, and link with parallel projects undertaking global applications of socio-economic indicators, to a set of integrative ecological indicators developed during the first phase of IndiSeas (see below),
(iv) develop models to explore the combined effects of fishing and climate on indicators trends,
(v) build from the database and working relationships developed through the IndiSeas WG, review further indicators and include more ecosystems in the project, and
(vi) evaluate the exploitation state of marine ecosystems in a comparative framework from all three tiers of an EAF (ecological, social, economic) using a comparative statistical approach.

The following questions will be addressed by the WG:

- Are the analyses and methods of synthesizing information from ecological indicators, as proposed during the first phase of IndiSeas, sufficient and helpful as a means of moving towards ecosystem diagnosis and formulating recommendations for management purposes?
- Which complementary indicators should be used to synthesize and communicate ecosystem status in terms of climatic change, biodiversity/conservation and socio-economics?
- How can we compare the status of exploited marine ecosystems under multiple drivers (fishing, climate) and objectives (ecological, social, economic)?
- How well do indicators reflect actual change?

There are many proposed ecosystem indicators, but in most cases their □aponica has not been explored across different ecosystems. There are several reasons why a comparative approach is adopted in this WG:

- With the difficulty in establishing baseline levels and reference points for most ecosystem indicators, the comparative approach across ecosystems will provide a range of reference values against which each ecosystem can be assessed. These comparative analyses allow the opportunity for taking a broader ecosystem perspective, help to avoid repeating the same fisheries management mistakes as may have been the case in some ecosystems in the set considered (i.e. provide early warning signals), and permit the ability to draw generalizations important to understanding ecosystem response to external drivers;

- The comparative approach will also help in selecting robust ecological indicators that will be meaningful and measurable over a set of diverse and contrasted situations;
- The comparative approach between ecosystems, together with the communication of results to the public at large are also aimed at creating an incentive for politicians to consider their management options, with informed responsibility for the ecological, social and economic quality of marine world ecosystems.

Timeliness and relevance to other international activities

The proposed WG will greatly benefit from the advances made by the SCOR/IOC WG 119 (2001-2004) and the IndiSeas WG. While SCOR/IOC WG 119 focused on theoretical and conceptual studies, the selection of relevant ecological indicators and on local empirical studies, the IndiSeas WG undertook much of the groundwork for the present proposed SCOR WG. It has developed a minimal suite of ecological indicators, a database for 19 ecosystems and working relationships with over 30 scientists from adjacent nations. It is timely to take advantage of this work to expand the range of ecosystems and indicators, to focus on the further development and testing of this expanded suite of indicators and to use this capability to test indicators across a range of ecosystem types with differing fishing histories. This is seen as a substantial step towards implementation of an Ecosystem Approach to Fisheries.

In 2007 and 2008, the European Network of Excellence (NoE) EUR-OCEANS (www.eur-oceans.eu) supported two IndiSeas meetings dedicated to the first stage of a global comparative approach. Yunne Shin and Lynne Shannon were co-leaders of these meetings, which assembled expertise from around the world, and then applied a suite of ecological indicators to 19 ecosystems. These meetings and inter-sessional work have culminated in a suite of papers that evaluate the status of the 19 ecosystems and explore the use, application and interpretation of the indicators (submitted to ICES early June 2009). These results have raised many questions about the performance of indicators, their robustness, the type and number of indicators required and the enigma of ecological reference points.

The proposed SCOR WG will be able to take advantage of the momentum of the IndiSeas WG. The proposed membership is expanded to include scientists from other disciplines and ecosystems to bring new perspectives and necessary expertise. The recently opened IndiSeas website will help to attract experts from other ecosystems to join the analyses and expand the suite of indicators. This expansion of the initial indicator suite based on fisheries and fish surveys data is seen as a major challenge and highly necessary if we are to progress with EAF worldwide. Through associations with experts in these fields, the proposed SCOR WG will undertake analyses of the expanded suite of indicators and attempt to assemble these in a unified approach.

The SCOR “label” will ensure the success of the WG as it will provide an international visibility which will attract top scientists across several fields working on a common ecosystem approach to marine resources and will ensure that the scientific analyses are undertaken with rigour and complete neutrality. This last point is critical as we aim at transferring our scientific knowledge to other spheres. We also plan to build bridges with other research fields (socio-economics and climate change) so again, having the visibility of SCOR will greatly facilitate conducting inter-disciplinary studies.

Finally, there is a growing body of researchers working on different systems and types of ecosystem indicators for EAF for whom the final symposium would be useful (see below). There is a developing need for comprehensive, international scientific discussion of the use, testing and performance of ecosystem indicators for EAF. The ICES SCOR WG will provide the scientific groundwork; the symposium will provide the opportunity for further progress and communication of knowledge and experience.

Terms of reference

The proposed working group would:

1. **Review the protocols developed by IndiSeas to diagnosis the exploitation state of marine ecosystems using ecological indicators.** This stage involves the review and selection of adequate statistical methods for characterizing trends in indicators (autocorrelated regression, GAMs, first and second-order derivatives), for detecting similarities between indicators (PCA analyses, mutual information index) and for establishing a classification of marine ecosystems according to fishing impacts (decision tree analysis, scoring and ranking ecosystems). This step will be enriched by input from new participants (representing new types of ecosystems such as coral reef ecosystems, or new disciplines such as physical oceanography), and on reviews provided for the suite of 9 papers submitted to ICES Journal of Marine Science.

2. **Testing the performance of ecosystem indicators in fisheries management.** How well do ecosystem indicators detect fisheries effects? How sensitive are they to changes in the ecosystem and how well do they guide management decisions? These are crucial questions in the development of indicators and are often ignored. Performance testing is a formal procedure to assess whether an indicator and accompanying decision rule actually guides decision-makers to make the “right” decision. Performance testing scores the ratio of “right” decisions to “wrong” decisions. The suite of indicators developed by the IndiSeas

WG provides an initial unique opportunity to test these indicators across a broad range of ecosystem types. Conclusions should be very robust.

3. **Developing reference points for indicators.** Establishing reference points for ecosystem indicators has proven to be a major challenge to implementing EAF, due to the complexity of ecosystems and their response to fishing. A key benefit of the comparative approach proposed for this SCOR WG is that it provides empirical data on ecosystem indicator □aponica across a range of ecosystem types and states. These data will be used to explore whether, minimally, limit thresholds can be identified, and whether possible target reference points can be proposed. The use of simulations using a set of various ecosystem models (EwE, Osmose, Atlantis) can also help in reconstituting pristine states of the ecosystems. There are several candidate ecosystems in which such multi-models comparative approach can be undertaken as the models are already parameterized, and the specialists/developers of the models are part of the present WG: South Africa, North Sea, Australia, West Coast Canada.

4. **Studying the joint effects of climate and fishing changes on the selected indicators.** Time-series analyses will be undertaken of fishing effort and regional climate indices. Ecosystem models will also be used to assess the specificity of ecosystem indicators to fishing effects versus climate effects: EwE, Osmose and Atlantis models will be used in this regard. This task can be done in synergy with actions planned within the FP7 European MEECE project (www.meece.eu) in which some of the participants of the present proposal are involved (Y. Shin, L. Shannon, J. Blanchard), and which can be expanded to other world ecosystems.

5. **Integrating conservation and biodiversity issues in the diagnosis of ecosystem states.** Biodiversity is a key ingredient for resilient, robust and resistant ecosystems. All too often however, species, habitats or even whole ecosystems are negatively affected by fishing and mitigation approaches are necessary in addition to avoiding damage through wise management. We plan to expand the set of eight ecological indicators to add a set of indicators that will quantify the biodiversity and conservation risks in ecosystems.

6. **Integrating socio-economic issues.** EAF has many facets, and one which is too often ignored is the realm of socio-economic indicators of the effects of fishing on ecosystems. As yet, the development of socio-economic indicators lags that of ecological indicators, and thus there is less to work with. However, we aim to link with projects like Questfish, and other regional/local-scale projects addressing the human dimensions of EAF, to review

existing socio-economic indicators and then apply the criteria outlined above to select a subset of socio-economic indicators for inclusion in the generic dashboard of indicators.

Working Group Composition

We propose that the WG will have 3 co-leaders, Alida Bundy, Yunne-Jai Shin and Lynne Shannon. The composition of the WG is necessarily international in accordance with its objectives. Participation by an expert from each ecosystem is a pre-requisite for adequate comparative analyses and proper scientific guidance in each ecosystem. With the proposed list of members, at least 22 marine ecosystems will be considered from the first year of the WG. All scientists proposed have comprehensive, expert knowledge of ecosystem functioning and the ecosystem approach to fisheries. The WG also includes scientists having expertise in socio-economic, biodiversity and climate indicators. The geographical coverage ensures that each type of ecosystem is well represented, as well as three major oceans (Pacific, Atlantic, Indian oceans). Among the Full Members, the group has 2 scientists from developing countries and 5 women, providing good geographic and gender balance. Additional breadth will be achieved through Associate Members.

Full members

Name	**Country**	**Institution**	**Expertise**	
			Ecosystem	**indicators**
Alida Bundy, co-chair	Canada	DFO	Temperate	fisheries, trophodynamic
Yunne-Jai Shin, co-chair	France	IRD	Upwelling	size-based
Lynne Shannon, co-chair	South Africa	MCM	Upwelling	fisheries, trophodynamic
Marta Coll	Spain	ICM/CSIC	Temperate	trophodynamic
Jorge Tam	Peru	IMARPE	Upwelling	fisheries, trophodynamic
Nick Dulvy	Canada	SFU	Temperate	Biodiversity
Beth Fulton	Australia	CSIRO	Temperate	fisheries
Jason Link	US	NOAA	Temperate	fisheries
Ian Perry (to be confirmed)	Canada	DFO	Temperate	fisheries, climate
Claude Roy	France	IRD	Upwelling	climate

Associate members

Name	**Country**	**Institution**	**Expertise** **Ecosystem**	**indicators**
Vera Agostini	US	Nature Conservancy	Upwelling	biodiversity
Icarus Allen	UK	PML	Temperate	climate
Edward Allison	Malaysia	Worldfish Centre	Tropical??	Socio-economic
Kerim Aydin	US	AFSC	high latitude	fisheries, climate
Julia Blanchard	UK	CEFAS	Temperate	size-based
Fatima Borges	Portugal	IPIMAR	Upwelling	fisheries
Ratana Chuenpagdee	Thailand	CDC	Tropical	Socio-economic
Philippe Cury	France	IRD	Upwelling	Fisheries, trophodynamic
Ibrahima Diallo	Guinea	CNSHB	Tropical	fisheries
Sheila Heymans	Scotland	SAMS	Temperate	Biodiversity
Larry Hutchings	South Africa	MCM	Upwelling	Climate, fisheries
Astrid Jarre	South Africa	UCT	Upwelling	socio-economic
Edda Johannesen	Norway	IMR	high latitude	fisheries
Didier Jouffre	Senegal	IRD	Tropical	biodiversity
Pierre Labrosse	Mauritania	IMROP	Tropical	socio-economic
Steve Mackinson	UK	CEFAS	Temperate	fisheries, climate
Hicham Masski	Morocco	INRH	Upwelling	fisheries
Sergio Neira	Chile	U Concepcion	Upwelling	trophodynamic
Henn Ojaveer	Estonia	EMI	Temperate	fisheries
Khairdine Ould MA	Mauritania	IMROP	Tropical	fisheries
Trevor Platt (to be	UK	PML	Temperate	Biological

confirmed)				oceanography; climate
Jake Rice	Canada	DFO	Temperate	fisheries
Marie-Joëlle Rochet	France	IFREMER	Temperate	size-based
Djiga Thiao	Senegal	CRODT	Tropical	fisheries
Verena Trenkel	France	IFREMER	Temperate	fisheries
Dawit Yemane	South Africa	MCM	Upwelling	biodiversity

Planned activities and Products

If approved, the first task of the working group will be to meet to address TOR 1, and to plan for the other TORs. The intent is to institute 5 task groups to address TORs 2 – 6, and to plan for two more annual meetings. All terms of reference will be addressed at each of the annual meetings. However, the main emphasis of meeting 2 will be on TORs 2 and 3, and the main emphasis of meeting 3 will be on TORs 4-6. In general, the work of this group will involve the group of ecosystem and indicator experts meeting once per year with inter-sessional targeted work being undertaken at their home institutions. Progress reports will be written and sent out to other experts for comment. It is proposed that the first annual meeting takes place between March and May 2010.

Products of the WG will be oriented towards an International Symposium in the final year and a special Journal edition. Furthermore, as ecosystems and indicators are developed and tested, these, and the associated protocols will be made available on the IndiSeas website.

In addition to assuming current coordination tasks (delivering annual reports, searching for additional fundings, distributing documents and data to each participant, organizing annual meetings, coordinating activities between meetings), each co-leader of the WG would assume the main responsibility of each of the following deliverables and TORs as indicated.

- Alida Bundy (TORs 1,3,6) will lead TOR 3 “Developing reference points for indicators”. She will also be responsible for the organization of an **international symposium** at the end of the WG (2012). It will be the opportunity for the worldwide network to present their results on the use of ecosystem indicators in diagnosing ecosystems’ states and implementation of Ecosystem-based fisheries management.

- Yunne-Jai Shin (TORs 1,2,4) will lead TOR 4 “Studying the joint effects of climate and fishing changes on the selected indicators”. She is also responsible for the continued delivery of the **website** dedicated to inform the general public about world’s marine ecosystems.

- Lynne Shannon (TORs 1,3,4,5) will lead TOR 5 “integrating conservation and biodiversity issues in the diagnosis of ecosystem states". She will be responsible for the edition of a **special Journal issue** following the international symposium (2012).This special issue will include papers from the WG, the International Symposium and solicited reviews and analyses.

It is anticipated that members of the Committee will lead the task groups associated with TOR 2 and 6.
Some additional sources of funding are already identified: IRD (Institut de Recherche pour le Développement) for inviting experts from developing countries to annual meetings, and the European project MEECE (2008-2012, www.meece.eu) will provide the persons-month necessary to maintain and expand the website. Other sources will also be explored.

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Annex A

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2.3.2 Coupled climate-to-fish-to-fishers models for understanding mechanisms underlying low-frequency fluctuations in small pelagic fish

Abstract. The low-frequency variability of small pelagic fish abundance is one of the most emblematic and best-documented cases of fish population fluctuations not explained wholly by fishing effort. Over the last 25 years, diverse observations have been integrated into several hypotheses; however, due to limited-duration time series, hypothesis testing has proven extremely difficult with the available statistical and empirical tools. As a result, the mechanistic basis for how the physics, biogeochemistry, and biology interact to result in the various patterns of synchronous variability across widely separated systems remains unknown. Identification of these mechanisms is necessary in order to explore projections and to build scenarios of the amplitude and timing of stock fluctuations, and their responses to human interactions (fisheries) and climate change. The proposed working group (WG) aims to implement and integrate state-of-the-art modeling tools and expertise to tackle this important scientific and environmental problem. We will use spatially and temporally explicit models that mechanistically represent the feedbacks among the various components of the climate-to-fishers system. We propose to take advantage of the unique opportunity of the present existence of several nationally funded projects to study – via modeling approaches – the causes of low-frequency variability of small pelagic fish. The establishment by SCOR of this WG will enable the coordination and integration of these ongoing modeling efforts into a global view of the synchrony/asynchrony phenomenon. At the same time, the WG proposes to gather, update and enhance available datasets, historical information and knowledge from the different oceanic systems (e.g., Eastern and Western North Pacific, Southeast Pacific and Southeast Atlantic). These datasets will be used to force the models as well as evaluate the model results against observations. The WG requests three years of support, complementing nationally funded projects, the recent SPACC and GLOBEC synthesis efforts, and other related activities, to facilitate a needed international effort in this area. The support will be used to hold annual meetings, produce two scientific reports and at least one paper in a primary literature journal. Furthermore, we are committed to continue searching for complementary financial support to broaden our capacities and outreach. The results of this WG will contribute to the understanding and managing of small pelagic fish stocks, which are of significant economic and ecological value, in the context of low-frequency fluctuations due to climate change, fishing, and other factors.

Scientific rationale and relevance. Climate-scale variability and its impact on fish resources have only recently become widely accepted (e.g., Cushing 1992; Lehodey et al. 2006; Fréon et al. 2009). They were first detected by Ljungman in the 1880s who published an analysis of the Baltic herring catch fluctuations showing a 55-year cycle due to natural conditions, apparently forcing the schools to change their spawning and feeding places (Parrish et al., 2000). The most compelling example of climate-driven fish stock changes is probably the fluctuations of sardines and anchovies described since the early 1980s, the so-called Regime Problem (Lluch-Belda et al., 1989, 1992; Schwartzlose et al., 1999). Landings of sardines show synchronous variations off Japan, California, Peru, and Chile, with populations flourishing for 20 to 30 years and then practically disappearing for similar periods. Periods of low sardine abundance have coincided with increases in anchovy populations. Benguela

Current sardine and anchovies, in the Atlantic Ocean, appear to be in synchrony with Pacific stocks, but in opposite phase (i.e., Benguela sardine stocks flourishing during periods of high anchovy in the Pacific, and vice versa). As demonstrated through paleo-reconstructions based on sardine and anchovy scales (Baumgartner et al., 1992), and because synchrony takes place even when different fishery management schemes exist among systems (Schwartzlose et al., 1999), fluctuations appear to be at least partially fishery-independent. Further, because of the large spatial and coherent temporal scales involved, a single global driver linked to large-scale atmospheric or oceanic forcing has been proposed to explain the variations in the different systems. The Regime Indicator Series (RIS; Lluch-Cota et al., 1997), synthesized from the catch series of the four mentioned systems, has been related to the low-frequency component of different climate series, including the Pacific Decadal Oscillation and the North Atlantic Oscillation (Chavez et al., 2003) and the low-frequency signature in global ocean temperature (Tourre et al., 2007), but no mechanism linking the physics to the biology and synchronously operating in widely separated systems has been demonstrated. What remains elusive is a mechanistic basis for how the physics, biogeochemistry, and biology interact to result in the various patterns of synchronous variability across widely separated systems. **Understanding these mechanisms is necessary to explore projections and build scenarios of the natural-driven amplitude and timing of stock fluctuations, and their responses to human interactions (fisheries) and climate change.**

Background and proposal. It has been more than 25 years since the paper by Kawasaki (1983) first called attention to the synchrony among catch series of the three main sardine fisheries in the Pacific basin (Japan, California and Humboldt), and more than 20 years since SCOR WG 98 on Worldwide Large-scale Fluctuations of Sardine and Anchovy Populations was formed to explore the then-called Regime Problem. Other significant efforts were the development of the GLOBEC SPACC program (SPACC, 2008) and the IRI workshop in Honolulu in 2001 (Bakun and Broad, 2001). The early reports were highly successful in documenting the fluctuations, alternation and synchrony, and in pooling existing hypotheses to explain them; however, testing was out of their reach, mainly because *a)* retrospective studies are limited at best, to less than a century of catch series, to a few decades of physical oceanography and climate time series, and to even fewer long-term ecosystem observations; and *b)* the development of reliable modeling tools that allow adequate exploration of this problem has only taken place during the last few years.

The primary question for our proposed WG is *which model scenarios can generate low-frequency variations in the abundance of small pelagic fish (periods of increasing, high, decreasing, and low abundance), and do they correspond to prevailing conditions observed during the different regimes in the different systems.*

We will approach this question by testing and contrasting the three main groups of synthetic hypotheses of the Regime Problem today:

1) Environmental conditions control the low-frequency variability in the fish populations through: a) the link of reproduction success to alternating strong and weak modes of boundary current flow, and the resulting conditions of distinct

nearshore and offshore habitats (MacCall 2001), b) temperature control of the populations expansion and contraction via adult spawning behavior and effects on early life stages (Lluch-Belda et al. 1991; Takasuka and Aoki 2006), and c) the food availability and composition (enrichment) determining population success (Van der Lingen et al. 2001).

2) Fishing pressure can reshape, and even suppress the low-frequency synchrony signal by impacting the population dynamics: *a)* affecting longevity and the capacity of the populations to survive adverse environmental periods, *b)* changing the populations reproduction and migratory capacities by altering the size classes (fecundity, swimming), and *c)* because population productivity might depend on migratory behavior that recruits learn from older fish, fishing could affect the chain of transmission, potentially causing instability and collapse (Petitgas et al. 2006).

3) Rapidly evolving adaptive response mechanisms being the cause of low-frequency biomass and distribution changes, including individuals' affinities, ethological inertia (school trap), and strong selection pressure (fishing or predation; Bakun, 2001).

To contrast these hypotheses, and building and integrating findings of the projects outlined below, the WG will compare existing data, analyses, and models of the oceanography, ecology and fisheries of several small pelagic systems, including the California Current and the Gulf of California, the Benguela Current, off Japan, and the Humboldt Current system. We will consider models that represent the physical-to-biogeochemical-to-fish linkages both in individual- and concentration-based frameworks. Among these are the physical circulation model (ROMS) already implemented in some of the systems (Curchitser et al., 2005); a Nitrogen-Phytoplankton-Zooplankton-Detritus model (NEMURO; Kishi et al. 2006), and its extension in NEMURO.SAN (Rose et al., 2006) which is an individual-based model (including bioenergetics) for the small pelagic fish populations (sardine and anchovies) and their predators including fishing pressure; ATLANTIS, an Ecosystem Box-Model with detailed coupling between physical and biological processes (Fulton et al., 2004); and OSMOSE, an Individual Based Model based on predation rules and trophic interactions (Shin et al., 2004). These models have their own strengths and weaknesses, so comparing the results of different models will allow exploration of the fishery systems from different perspectives as well as the construction of ensembles of solutions allowing for consideration of likelihoods and uncertainties in relation to the proposed scenarios. The
models we propose to use are fully coupled, spatially explicit physical/biological models. The physical models are general circulation models (GCMs) capable of describing the time evolution of the three-dimensional ocean circulation, including changes in currents, temperature and salinity. They can be driven by historical reanalysis or by future projections as given by the IPCC class of models. The biological models (including models for top-predation—fishers) vary in design but all can mechanistically respond to the environmental conditions supplied by the physical GCM.

We will contribute to the solution of the Regime Problem by studying the particular case of low-frequency fluctuations of sardine and anchovy abundance within a particular system, or by contrasting different systems during the same time period. Sardine and anchovy were selected as target fish species because they are a well-studied pair of small aponic that co-occur in multiple ecosystems that demonstrate low-frequency alternations in abundance within ecosystems and basin-scale synchronies among ecosystems. We propose to carry out this study through the combination of historical data and by the use of emerging modeling tools.

Justification of the group. Our proposal is timely because state-of-the-art information on the topic is to be delivered by 2010 by GLOBEC and SPACC as part of their syntheses, and the simultaneous existence of several model-based projects that the WG members already lead. Regarding modeling and data synthesis, there are two particularly relevant workshops programmed for the upcoming GLOBEC Open Science Meeting in June 2009, one on “Modelling ecosystems and ocean processes: the GLOBEC perspective of the past, present and future”, and another on “Worldwide large-scale fluctuations of sardine and anchovy”, both chaired by proposed members of this WG. We can also capitalize on the recently established inter-disciplinarity between physical oceanographers, modelers, and fisheries scientists owing in part to international initiatives. Of particular relevance is that, during the last few years, some of the proposed WG members, fisheries and physical oceanography scientists, have already collaborated in workshops organized by PICES, GLOBEC, APN and CAPaBLE projects (Werner et al. 2005, 2007; Kishi et al., 2006), to discuss strategies and possibilities to deal with the Regime Problem with a completely fresh approach and a brand new toolbox of models and analysis techniques.

Regarding related modeling studies underway, several projects relevant to our proposed WG efforts have been funded to deal with the model implementation and data analysis. The WG will build on these as we coordinate our approaches to enable a more integrated and global treatment:

- *US CAMEO program (Comparative Analysis of Marine Ecosystems):* jointly funded by the US NSF and NOAA (Curchitser, Rose, Megrey, MacCall, Checkley and Werner with in-kind collaborative efforts from Mexico, Canada and Japan) to develop physics-to-fish-to-fishers models for the California Current and for the Oyashio/Kuroshio Current System. In this 2-year effort, short-term (one year) and long-term (decadal) simulations of sardine dynamics will be performed for the two systems to demonstrate the utility of physics to fish to fishers modeling and the power of the comparative approach for understanding how bottom-up (climate and physics) and top-down (predation and harvest) factors can affect small pelagic fish abundances.
- *UK QUEST.FISH* (Barange, Blanchard): which has as objectives to estimate primary (phytoplankton) and secondary (zooplankton) production in key coastal-ocean fisheries around the world under climate change scenarios; link primary production to fish production and fisheries catches and to develop climate-forced models of fish biomass and production; investigate the socio-economic consequences of climate-driven changes in fish production for global fish-based commodities, such as fishmeal; and develop improved ways of assessing

vulnerability of fisheries to future climate change, in the context of other drivers of change: supply-demand changes, governance scenarios, macro-economic change.

- *Japan SUPRFISH project (Studies on Prediction and Application of Fish Species Alternation):* Ito has been funded by the Ministry of Agriculture, Forest and Fisheries to elucidate mechanism of the fish species alternation and develop mathematical models representing fish species alternation. *Japan DoCoFis project (Dynamics of Commercial Fish Stocks):* Ito and Kishi have been funded by Fisheries Agency to investigate climate change effects on commercial fish stocks. *Japan CREST program (Core Research for Evolution Science and Technology):* Yamanaka has been funded to develop next generation mechanistic models for marine ecosystems.

Ultimately, our proposal is opportune because small pelagic fish remain the most important large fishery and source of marine protein (about one-third of total marine catch), as well as one of the most unpredictable in terms of population levels and, thus, are difficult to manage. These difficulties are occurring in times when fisheries management paradigms are changing rapidly, when yearly technological advances result in new levels of observational and analysis capabilities, and most importantly, when nations are fully committed to reduce extreme poverty and hunger in less than a decade (UN Millennium Development Goal).

Terms of reference. To accomplish our goals we propose meeting once a year for a three-year period, with participation of Full, Associate (collaborators with already secured SCOR independent funding) and Corresponding members (when possible and based on other funding sources). The WG will:

- Gather and update available datasets, historical information and knowledge from the different sardine-anchovy systems (e.g., Eastern and Western North Pacific, Southeast Pacific and Southeast Atlantic).
- Carry out a detailed review of the existing hypotheses on the Regime Problem, supporting facts and contradictions, to identify the specific questions to be asked to the data and models in order to test the different components of the synthetic hypotheses described above, based on the outcomes of the GLOBEC Open Science Meeting, and the upcoming GLOBEC and SPACC synthesis books.
- Analyze and compare modeling approaches and strategies for their applicability for dealing with the three core hypotheses of drivers of low-frequency cycles: environmental variation, fishing pressure, and adaptive mechanisms. Each of the modeling approaches has strengths and weaknesses; taken together, most of the ingredients for a comprehensive or optimally-scaled model likely exist. Assembly of the efficient evaluation of the modeling approaches, development of a set of specific strategies for developing new models and improving the existing models, and rapid exchange of people's experiences about what approaches show promise and noted weaknesses in these approaches. Identify what aspects of the modeling exist and what components either need enhancement or simplification or need to be added. Produce reports the on current understanding of the regime problem in small pelagic fish, including a description of the existing hypotheses and fundamental questions, a report on the

state-of-the-art approaches and strategies for extending existing models and developing new models to deal with bottom-up (environmental) and top-down (fishing) effects, and a report that summarizes and synthesizes the modeling results to date related to the studied systems. The workshops will provide the forum for furthering model development.

Timetable:

- Meeting 1 (2010)—Update methods, data and contacts, establish experimentation, data-gathering and modeling strategies, and generate a technical report on the topic's state of the art.
- Meeting 2 (2011)—Discuss preliminary modeling results, make systems comparisons, deal with modeling milestones, and generate a second report on the modeling tools.
- Meeting 3 (2012)—Integration, discussion and writing of the final report, which will be a scientific paper reporting our results. We will further transmit our results through diverse scientific presentations at congresses and symposia, and in particular by bridging to as many related programs and groups as possible (PICES-FUTURE, ICES, IMBER, CLIOTOP, SCOR WG 125 on Global Comparisons of Zooplankton Time Series and other SCOR WGs, etc.).

The chairs will be responsible for 1) implementing and maintaining a website for the working group, for members to share information, data and tools, and for other scientists and general public interested in the topic; 2) delivering the annual reports and the scientific paper; and 3) dissemination of progress and main achievements through specialized newsletters, maintaining an updated calendar of events, providing documents and material to all members willing to present at congresses or seminars, and interacting with other groups.

Deliverables

- Yearly reports to SCOR during the duration of the WG
- Contributed papers and presentations in scientific meetings
- One paper (final report) in a primary literature journal
- Publicly available data and modeling tools
- A web site for the group

Additional products may be possible as we secure additional funding (e.g., from START and APN) and incorporate more experts.

Membership. Designed to cover knowledge in the fields of physical, ecological, fisheries and socioeconomics sciences, on the four main small pelagic systems (California Current System, Japan, Humboldt, and Benguela), and on each of the models and tools to be used. Additional details on each of the proposed members is available in the temporary website http://www.pescamexico.org/scor/.

Name	Country	System	Expertise
Full members			
Akinori Takasuka	Japan	NW Pacific	Fisheries/ Plankton
Beth Fulton	Australia	SW Pacific	Ecosystem modeling, ATLANTIS
Carl van der Lingen	South Africa	SE Atlantic	Fisheries Ecology
Enrique Curchitser	USA	All systems	Physical oceanography, ROMS (***Co-Chair***)
Julia Blanchard	UK	All systems	Socioeconomic modeling, QUEST_Fish
Kenneth Rose	USA	All systems	Bioenergetics modeling, NEMURO.SAN
Luis Cubillos	Chile	SE Pacific	Fisheries Sciences
Salvador Lluch-Cota	Mexico	NE Pacific	Fisheries Ecology (***Co-Chair***)
Shin-ichi Ito	Japan	NW Pacific	Physical oceanography, NEMURO
Yunne Shin	France	All systems	Ecosystem modeling, OSMOSE
Associate members *(This is a preliminary list of participants fully involved in the activities, but not financed by SCOR. The number will depend on our ability to obtain funds from other sources)*.			
Alejandro Pares	Mexico	NE Pacific	Mexican Pacific ROMS
Bernard Megrey	USA	NE Pacific	Fisheries, ecosystem modeling NEMURO.SAN
David Checkley	USA	NE Pacific	Plankton expert, SCOR WG 125
Francisco Werner	USA	All systems	Physical modeling, coupling NEMURO
Manuel Barange	UK	All systems	Ecological and socioeconomic models
Michio Kishi	Japan	NW Pacific	Physical-biological modeling, NEMURO
Miguel Bernal	Spain	All systems	Fisheries scientist, statistical models
Morgane Travers	France	All systems	Ecosystem indicators, end-to-end models
Ryan Rykaczewski	USA	All systems	General Circulation Models
Samuel Hormozabal	Chile	SE Pacific	Physical oceanography, links to biology
Yasuhiro Yamanaka	Japan	All systems	Climate change, Earth System Modeling
Corresponding members *(These are scientists with long experience in the Regime problem. All were members of SCOR WG98 that we will invite into the discussions, at least through email/video links)*.			
Alec MacCall	USA	NE Pacific	SCOR WG98
Andrew Bakun	USA	All systems	SCOR WG98
Daniel Lluch-Belda	Mexico	NE Pacific	SCOR WG98
Jurgen Alheit	Germany	SE Pacific	SCOR WG98, SPACC
Tuyoshio Kawasaki	Japan	NW Pacific	SCOR WG98

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2-126

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North Pacific
Marine Science
Organization

PICES

August 14, 2009

Dr. Edward R. Urban
Executive Director
Scientific Committee on Oceanic Research
College of Marine and Earth Studies
Robinson Hall
University of Delaware
Newark, DE 19716, USA

Dear Dr. Urban,

The North Pacific Marine Science Organization (PICES) would like to offer its strong support to a proposed SCOR Working Group on "*Coupled climate-to-fish-to-fishers models for understanding mechanisms underlying low-frequency fluctuations in small pelagic fish*".

The activities of the proposed SCOR Working Group will complement the effort of the joint PICES/ICES Working Group on "*Forecasting Climate Change Impacts on Fish and Shellfish*" (WG-FCCIFS) established in 2008 (http://www.pices.int/members/working_groups/WG-FCCIFS/). WG FCCIFS is taking a global view of assessing the impacts of climate change on fish and shellfish. The focused efforts of the new SCOR Working Group will provide valuable information on the mechanisms underlying the response of small pelagic fish to changing climatic and oceanographic conditions. Knowledge of these mechanisms will form a basis for forecasting responses of these valuable fish resources to global warming. It will be important to have strong links between SCOR Working Group on small pelagics and WG-FCCIFS.

As evidence of our support, PICES is prepared to finance an Associate Member to be, most likely, selected from the list of recommended Associate Members included in the Working Group proposal. We hope that this Associate Member will act as a liaison between the new SCOR Working Group and WG-FCCIFS.

Sincerely yours,

ABychkov

Alexander Bychkov
Executive Secretary, PICES

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Integrated Marine Biogeochemistry and
Ecosystem Research

www.imber.info

10 August 2009

Ed Urban
Executive Director
SCOR

IMBER Support for SCOR Working Group Proposal

Dear Ed

IMBER would like to support the SCOR Working Group proposal on *Coupled Climate-to-Fish-to-Fishers Models for Understanding Mechanisms Underlying Low-frequency Fluctuations in Small Pelagic Fish*.

We believe that this proposal will contribute to IMBER in two key ways. Firstly, the aim of the project is to determine and understand the mechanisms underlying fish stock fluctuations and to project and develop scenarios incorporating their response to human pressure and climate change. This fits directly into Themes 1 (Interactions between biogeochemical cycles and marine food webs) and 2 (Sensitivity to global change) of the IMBER Science Plan.

Secondly, the group proposes using retrospective analyses and modelling to couple the physical and chemical environments with the trophic dynamics between the various functional groups, which is consistent with IMBER's end-to-end food web philosophy.

Kind regards

Julie Hall

Julie Hall
Chair, IMBER SSC

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2-128

2.3.3 Sea ice biogeochemistry

Proposal for a SCOR working group on Sea ice biogeochemistry

This WG has the aim of understanding the coupling between ice physics and biogeochemical processes at the sea-ice-atmosphere interfaces as a prerequisite to quantify the role of ice-covered oceans in climate change scenarios, in the past, present and future.

Background and rationale

Near-future climate change is predicted to have its strongest impact in polar regions due to direct changes in surface area of polar oceans and ice sheets and to subsequent feedback processes. At both poles, climate change is already apparent in reduced sea ice extent. In the Antarctic, reductions in sea-ice cover are observed in the Bellingshausen/Amundsen seas (Cavalieri and Parkinson 2008). In the Arctic region, both ice extent and thickness are reducing rapidly, with a record low summer ice extent in 2007. The observed reductions appear to be ahead in time of current model forecasts (Perovich and Richter-Menge 2009), illustrating both the rapidity of the observed change and the difficulty of understanding and modeling all the feedbacks involved in the change.

Current global models include the seasonal wax and wane of sea ice, but restrict associated properties to only a few physical features. In such models, sea ice's main impact is on Earth's radiative balance through its albedo, on deepwater formation and on air-sea-exchange processes of gases. The latter impact refers to sea ice as a "cap" on the ocean surface (Stephens and Keeling 2000). Emerging views indicate, however, that sea ice itself plays an important role in the biogeochemical cycling and exchange of climate gases. A better understanding of these processes is warranted in order to improve climate change models and associated feedbacks. It is important to realize that sea ice may not completely disappear from polar regions, but will definitively experience a profound change in its dynamics and properties.

Sea ice as a habitat, reaction surface, source, sink and barrier for gas exchange
Sea ice is not only an active site for important and specific conversion processes, but also a source and sink for climate gases. Although the mechanism remains enigmatic, sea ice is involved in the photochemical production of reactive halogen species and subsequent destruction of ozone in the boundary layer. This has important implications for the oxidative capacity of the atmosphere and influences the atmospheric composition of trace gases (Simpson et al. 2007). In addition, sea ice is a potential major source for the climate-cooling gas dimethylsulfide (DMS), containing concentrations of DMS and associated compounds that are 3 orders of magnitude higher than observed in the water column (Trevena and Jones 2006; Stefels and Tison manuscripts in prep.). Recent evidence also shows that sea ice can be an important sink for CO2 through physical (CaCO3 precipitation as ikaite crystals (Dieckmann et al. 2008)) and biological

processes (Delille et al. 2007). Several other trace gases have been measured in high concentrations at the ice edge, but the exact processes, in-ice and in-water, are largely unknown.

By definition, biology is the source of (volatile) organic compounds and the important role of sea ice can at least partly be explained by the high algal biomass found within confined ice layers. In Antarctic sea ice, high biomasses may be due to high in-ice iron concentrations, with concentrations an order of magnitude higher than in the underlying water (Lannuzel et al. 2007). Especially in the Arctic were sea ice is formed close to land, sea ice can become in important vehicle for capturing and concentrating material that originates from land and is transported through the atmosphere. This highlights another important role of sea ice in biogeochemical cycles, namely the seeding of surface waters with nutrients, iron and potentially other trace elements upon seasonal ice melt. As a result, such sea ice-influenced surface waters act as a CO2 sink, which is irrespective of the sink within the ice itself (Arrigo et al. 2008).

Apart from the need for a better understanding of the biogeochemical cycles in sea ice for future climate models, this is also important for unraveling palaeoclimatology. Sea ice extent is an important indicator for past climate. Proxies in Antarctic ice cores are used to reconstruct regional sea ice extent. One of these proxies is methane sulfonic acid (MSA), an atmospheric oxidation product of DMS. The current idea is that extensive winter sea ice results in high plankton productivity and associated DMS production in surface waters during seasonal ice melt, with subsequent increased MSA levels deposited in nearby snow. The mechanisms that relate marine DMS to MSA in snow are however enigmatic (Preunkert et al. 2008) and both positive and negative MSA-sea ice correlations have been observed (Röthlisberger and Abram 2009). An explicit contribution from sea ice itself so far has not been considered, which seems unrealistic given the observed high DMS levels in ice.

Recently, also the previously mentioned hydrated carbonate crystal, ikaite, has been found in Antarctic ice cores (Sala et al. 2008). It is hypothesized to be derived from the sea ice surface, where ikaite typically forms at the early stages of sea ice formation. Combining knowledge on sea-ice related processes involved in the formation of both MSA and ikaite with data analyses from firn, will improve our understanding of palaeoclimate.

More specific, though by no means exclusive, questions that need to be addressed and that can be used to structure the discussions during the first meeting are:

- What are the main climate-relevant compounds and processes associated with sea ice? Until now, the main focus of the published studies was on DMS and CO2, but very little is known about other VOC's.
- How can we compare and quantify the relative contribution of different pathways of the main climate gases in time and space? Pathways to distinguish are direct ice/snow-

atmosphere interactions, direct water-atmosphere interactions and indirect impact of ice melt on surface waters and subsequent sea-air fluxes.

- What is the difference between first-year ice and multi-year ice with respect to their quantitative contributions to gas fluxes? With ongoing climate warming, the relative contribution of multi-year ice will reduce, especially in the Arctic.
- How will major and minor elemental cycles influence in-ice food web structure and how will this feed back on ice structure and stability? Relevant topics are pigment layers that influence ice structure and stability via internal absorption and energy deposition; porous flow/transport of nutrients; the effects of organics and polymers on freezing; and special upper level habitats which cannot be captured in one dimensional models (rafting).
- What are the major differences in biogeochemical fluxes between the Arctic and Antarctic? There are distinct differences between Arctic and Antarctic sea ice, with respect to physical, chemical and biological features that largely can be attributed to difference in snow cover. With the expected increase in precipitation in the Arctic, this may change in the future.
- What is the relative contribution of sea ice and surface water to MSA and ikaite deposited on land? In order to improve a proxy-based reconstruction of past sea-ice extent, a mechanistic understanding of the transportation of ikaite and the flux of DMS and derived compounds from ice and water is needed.

In addition to the above science questions, the working group should also critically address the technical challenge of measuring gas concentrations and production rates in ice.

In recent years, there has been an increasing awareness that understanding sea-ice biogeochemistry is crucial to understanding the controls of the Earth System (e.g. as formulated in the ESF LESC Exploratory Workshop (EW04-034) on "New perspectives on sea-ice research for the next 10 to 20 years", held in Germany, December 2005). To achieve this, a multidisciplinary approach is needed. In the proposed SCOR WG, we intend to bring together sea-ice specialists from multiple disciplines and modelers of sea ice systems and the Earth system, in order to:

- explore existing knowledge on the role of sea ice in influencing fluxes of climate-relevant gases,
- discuss and formulate the relevant biogeochemical processes and specify gaps in our knowledge,
- explore and compile available field data needed for model validation, and
- stimulate integrated model development.

Given the international character of both the issue (climate change) and the scientists involved, a SCOR working group would be an excellent mechanism to assemble current expertise.

Relevance to other activities of SCOR or other international organizations

This proposed working group is closely related to the IGBP core-project SOLAS (Surface Ocean - Lower Atmosphere Study), which is co-funded by SCOR. SOLAS' primary objective is: "*To achieve quantitative understanding of the key biogeochemical-physical interactions and feedbacks between the ocean and atmosphere, and of how this coupled system affects and is affected by climate and environmental change*." SOLAS has recently formulated several new topical areas that deserve special attention because of their urgency in global change. With this initiative, SOLAS intends to stimulate international collaboration. One of these topics concerns sea-ice biogeochemistry. The proposed SCOR WG is therefore timely and would provide an important boost for this SOLAS initiative. Funding by SOLAS itself for such activities is very limited. The European COST Action 735 ('Tools for Assessing Global Air–Sea Fluxes of Climate and Air Pollution Relevant Gases'), which is also a SOLAS-related activity, may provide additional funds for organizing workshops on this matter, which increases the possibilities for successful meetings.

It is also important to mention that this initiative intends to benefit from the momentum generated by the IPY programs. OASIS is one such a, closely related, IPY program and several of its associated investigators are listed on this working-group membership list.

<u>Terms of reference</u>
The proposed working group will

1. Summarize existing knowledge on climate-relevant gases in and associated with sea ice. This includes the identification of processes that control the production and fluxes of these gases and an inventory of quantitative data of gases as well as other biogeochemical parameters needed for model validation.
2. Identify gaps in our knowledge and assess what more should be done by further observational programs to improve this knowledge and to build on existing databases.
3. Bring together modellers and experimentalists to derive model parameterisations for climate-relevant gases from sea ice and water.
4. Quantify to the best of our knowledge the impact of sea ice on the production and loss of climate gases and how these will feedback on ongoing climate change.
5. Produce a comprehensive, published final report incorporating appropriate results from the above topics.

<u>Products</u>
Since it is the main objective of this working group to fill the last major gap in Earth's biogeochemical cycles, it is of great importance that both experimentalists and modelers are involved in this endeavor from the very start. Therefore we envision starting with a meeting to bring these specialists together in the first year. The meeting will be used to summarize existing knowledge on climate-relevant gases in and associated with sea ice, to identify the major processes that are needed for model development and to formulate a program for the next two

years during which different thematic groups will work on the quantification of the identified processes.

During the first meeting, we will also identify scientists who are not yet but should be member of the proposed working group and identify existing science initiatives that can contribute to the goal of this SCOR working group. Each thematic group will have a responsible chair to organize her/his theme in the next year and keep track of progress. For the first meeting we will seek co-sponsorship from the EU's COST Action 735 (to which Stefels is member of the management committee) and other sources.

During the following 2 years thematic workshops will be organized to work on the identified processes, with the aim of developing important parameterizations for these processes and to build databases and, if possible, climatologies for climate relevant gases. We envision organizing these workshops as special sessions of larger interdisciplinary symposia, such as the AGU/EGU/ASLO conferences.

At the end of the third year, a special issue of a peer-reviewed journal will be published, in which the major findings of the thematic workshops are summarized and new, coupled sea ice-ocean-atmosphere models are presented. During the first year opportunities will be sought to present the outcome of the working group during a symposium. The Alfred Wegener Institute for Polar research (Bremerhaven, Germany) is a potential organizing institute.

Working group composition

The working group members have been chosen for their expertise in studying sea-ice associated biogeochemical cycles. They are chosen such as to cover a wide spectrum of sea-ice disciplines, but with an emphasis on disciplines dealing with biogeochemistry at the ice-atmosphere and sea-ice interfaces. Since the collaboration between modelers and experimentalists is a prerequisite for this WG to succeed, the composition of the group of full members reflect this. Each of the members, both full and associate, is leading in her/his field of research, is involved in many ongoing international polar programs and capable of encouraging and involving other specialists and collaborators in their field of research. All proposed members, both full and associate, have been approached and have confirmed their membership, if the group and the membership are approved.

Full members	**Institute**	**Country**	**Specialization**
Jacqueline Stefels (co-chair)	Univ of Groningen	Netherlands	Biochemistry, S-cycle
Gerhard Dieckmann	Alfred Wegener Institute	Germany	Biochemistry, C-cycle, sedimentation

(co-chair)	for Polar Research		
Jean-Louis Tison	Univ Libre Brussel	Belgium	Glaciology, gas composition
Lucie Carpenter	Univ of York	UK	Atmospheric chemistry, halogens
Scott Elliot	Los Alamos Nat Lab	USA	Sea-ice and global ocean modeling
Maurice Levasseur	Université Laval, Québec	Canada	Biochemistry, S-cycle, Fe
Caroline Leck	Stockholm University	Sweden	Atmospheric chemistry, aerosols
Kevin Arrigo	Stanford University	USA	Biochemical modeling, Fe- and C-cycle
Igor Semiletov*	Pacific Oceanological Institute, Russian Academy of Sciences	Russia	Atmospheric CO2 and CH4 balance
Associate members	**Institute**	**Country**	**Specialization**
Klaus Meiners	Antarctic Climate & Ecosystems CRC	Australia	Ecology, optical properties
Veronique Schoemann	Univ Libre Brussel	Belgium	Biology and biochemistry, Fe-cycle
Martin Vancoppenolle	Université catholique de Louvain	Belgium	Sea-ice biophysicochemical modeling (LIM)
Michel Gosselin	University of Quebec, Rimouski	Canada	Biology, S- and C-cycle
Lisa Miller	Institute of Ocean Science, Sidney	Canada	Atmospheric chemistry, CO2 fluxes
Nadja Steiner	University of Victoria	Canada	Sea-ice/biogeochemical modeling, S-cycle
Søren Rysgaard	Greenland Institute of Natural Resources	Denmark / Greenland	Biogeochemistry, Photobiology, microbiology, C-cycle
Gerrit de Leeuw	University of Helsinki	Finland	Aerosols
Bruno Jourdain	Univ Joseph Fourier, Grenoble	France	Atmospheric chemistry
Ellen Damm	Alfred Wegener Institute for Polar Research	Germany	Methane chemistry
Lars Kaleschke	University of Hamburg	Germany	Sea-ice remote sensing, atmospheric chemistry, modeling

Dieter Wolf-Gladrow	Alfred Wegener Institute for Polar Research	Germany	C- Fe chemistry modeling
Jun Nishioka	Hokkaido University	Japan	Iron biogeochemistry, Sea of Okhotsk
Agneta Fransson	University of Gothenburg	Sweden	Inorganic carbon dynamics
Eric Wolff	British Antarctic Survey	UK	palaeoclimatology
Roland von Glasow	Univ East Anglia	UK	Atmospheric chemistry and physics, modeling
David Thomas	Bangor University	UK	Biochemistry, nutrients, C-cycle
Stathis Papadimitriou	Bangor University	UK	Chemistry, C-cycle, isotopes
Paty Matrai	Bigelow Laboratory for Ocean Sciences	USA	Biology, S-cycle
Paul Shepson	Purdue University	USA	Atmospheric chemistry, ozone, halogens
David Kieber	State Univ of New York	USA	Photochemistry, aerosol chemistry
Clara Deal	IARC, Univ of Alaska Fairbanks	USA	Sea-ice modeling, S-cycle

* Also research associate professor at IARC, Fairbanks

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27th August 2009

Dr. Jacqueline Stefels
University of Groningen
Centre for Ecological and Evolutionary Studies
Department of Plant Ecophysiology
PO Box 14
9750AA Haren
The Netherlands

Dear Dr. Stefels,

I am writing on behalf of the SCAR AGCS ('Antarctica and the Global Climate System') Steering Committee to express our strong support for your proposal for a SCOR Working Group on Sea Ice Biogeochemistry. We believe that the activities that such a Working Group would promote and undertake in relation to the transfer of climatically active gases (such as CO_2 and DMS) in the sea ice zone would address several key aspects of Antarctic climate and its global ramifications, as well as important questions regarding the use of sea ice extent proxies measured in ice cores. Both of these themes are at the heart of AGCS research, via programmes such as ASPeCt and ITASE. If your proposal to SCOR is successful, we would very much welcome the participation of Working Group members in our AGCS Steering Committee meetings, and would be keen to organize jointly sponsored workshops on themes of common interest.

I look forward to a fruitful collaboration with you, and wish you very best of luck with your proposal.

Yours sincerely,

Alberto C. Naveira Garabato, on behalf of the SCAR AGCS Steering Committee

2.3.5 Climatic Importance of the Greater Agulhas System

Proposal for a SCOR-WCRP sponsored Working Group on the *Climatic Importance of the Greater Agulhas System*

Abstract

The overarching goal of this SCOR working group is to improve understanding and awareness of the global climate impacts of the greater Agulhas Current system. Although this system is, by nature, regional, our thrust is about understanding changes in the Atlantic Meridional Overturning Circulation (AMOC) and climate that are forced from the southern hemisphere - i.e. by Agulhas leakage - hence the implications are of truly global significance. Moreover, our working group membership is distributed globally. We plan to achieve our goals through the enhancement of collaboration and cooperation within our small, yet global scientific community, and by promoting enlargement of the community. We will hold regular planning meetings to produce a review publication and a steering report that raise the profile of this important region, both in terms of its climatic significance and in terms of the representation it deserves as part of the Global Ocean Observing System. Finally, we will organise a Chapman Conference. WCRP provided comments on this proposal and has agreed to co-fund our group, if approved by SCOR.

Rationale

Mounting evidence from palaeoceanographic and modeling studies suggest that the Agulhas Current and its interocean flux are drivers of global climate change (see Background). For example, through their southern influence on the AMOC, changes in the flux of warm, salty waters from the Indian Ocean may have triggered the end of ice ages, as well as effecting shorter-term climate variability. This puts the importance of the greater Agulhas Current system on a par with Heinrich (land-ice release) Events and deep convection, in terms of northern hemisphere climate. Yet, owing to the relative isolation of the region from the US and Europe, few modern observations and even fewer palaeoceanographic time series exist over the region and it is substantially underrepresented in international monitoring efforts.

It is important that this SCOR working group begin work as soon as possible, to facilitate collaborations to build the best possible research programs in the region and pass on recommendations for future sustained observations as part of IndOOS. The need for such an activity is well identified by our community, as demonstrated by good attendance at a recent unfunded workshop in Kiel, Germany. Ideas and outcomes from this workshop have been used to produce this document. Now is a time of heightened research activity in the region, that will provide unprecedented coverage, new data, and insight into dynamical and climatic mechanisms. There are several Africa-based initiatives (e.g. Agulhas-Somali Current Large Marine Ecosystem project, ASCLME; South African Environmental Observation Network, SAEON), a Dutch program (INdian-ATlantic EXchange in present and past climate, INATEX), a US experiment (Agulhas Current Time-series, ACT), a German program with a hierarchy of models, a recently-funded Japanese climate modeling project (Prediction of Climate Variations and Its Application in the Southern African Region), and two European palaeoclimate programs (Agulhas Warm Water Transports: Climatic Dimension for Southern Africa and Europe, and GATEWAYS - Multi-level assessment of ocean-climate dynamics: a gateway to interdisciplinary training and analysis). There is an urgent need for better linkages between these groups and others in our community, to share resources, data, and even ship-time and to identify collaborations that will maximize the opportunities for data collection in the region while these programs are ongoing. For example, floats, coral coring, coastal altimetry, and air-sea interaction programs were identified as missing important elements for an observational program. Better collaborations between field scientists and modelers, and between modeling groups are also called for.

Our rationale is aligned with the SCOR call for working group proposals for 2009, which encourages topics related to ocean dynamics and heat transfers, both of which strongly characterize the Agulhas and its inter-ocean exchange. Moreover, SCOR is the best vehicle for our endeavor given that our international community is widespread and that we would seek input from SCOR's Committee on Capacity Building. Many scientists find themselves the sole person or group at their institutions pursuing research in the region and scientists from African countries which abut the Agulhas Current system lack the resources to participate in international meetings and workshops. A truly international and multi-disciplinary approach is needed to strengthen collaborations and identify the questions that will lead to a faster advancement of understanding with respect to the significance of the region as a southern-hemisphere driver of climate change. Our needs fit squarely into the remit of SCOR as a non-governmental organization for the promotion and coordination of international oceanographic activities.

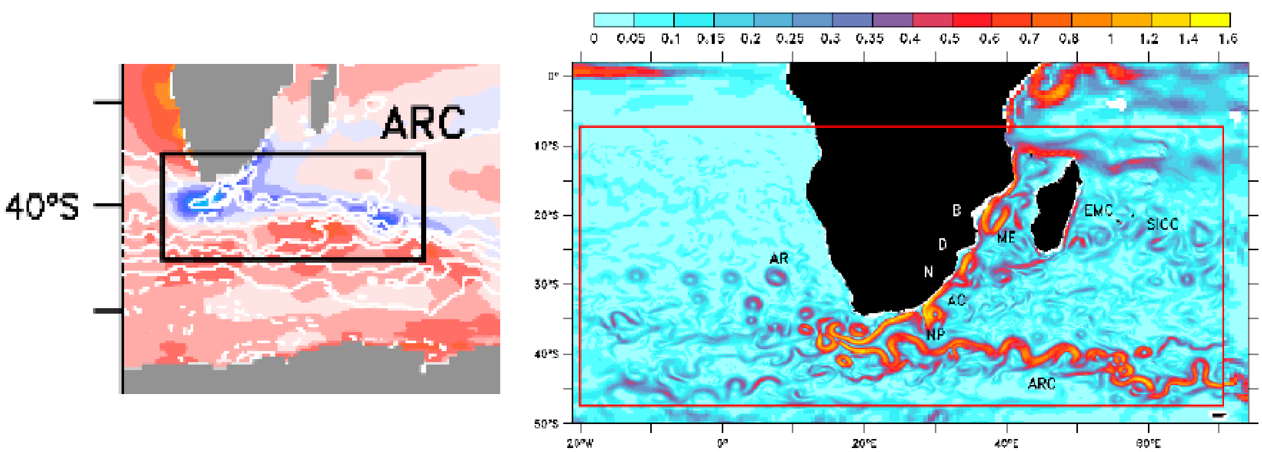
Scientific Background

The greater Agulhas Current system forms a key component of the global thermohaline circulation (Lutjeharms, 2006) and its dynamics are somewhat different from other major western boundary currents, both because of the presence of Madagascar and because the continental boundary ends equatorward of the large-scale wind forcing (Figure 1). Warm, salty waters from the Red Sea, Indonesian Throughflow, and the tropical Indian Ocean are fed into the Agulhas Current from the north and east (Gordon, 1986). Through large air-sea fluxes (Figure 1, left panel)), the Current's variability is strongly linked to patterns of rainfall over eastern Africa (e.g. Reason and Godfred-Spenning, 1998). At the southern tip of the African continent the Agulhas Current retroflects, with most of its water being returned into the South Indian Ocean as the Agulhas Return Current. At the retroflection, large Agulhas Rings are formed by a process of loop occlusion (Lutjeharms and Gordon, 1987). This process leads to a significant portion of Agulhas water, carrying anomalous amounts of heat and salt, being leaked into the South

Atlantic Ocean. Palaeoceanographic studies suggest (Peeters et al., 2004) that changes in this leakage are intimately linked to the end of each global glaciation.

Figure 1: Left panel shows mean air-sea heat flux (Wm^{-2}) over the Agulhas Current, Retroflection, and Return Current region (ARC). This region exhibits the largest surface heat fluxes in the southern hemisphere. Right panel shows 5-day mean speeds (ms^{-1}) at 100 m depth from a nested, high resolution model (from Biastoch et al., 2008b). The features of the greater Agulhas system are clear, as is the exchange of waters with the Atlantic.

In model simulations, variations in the Agulhas leakage are on a par with that of deep water formation in the North Atlantic, in terms of making a comparable contribution to variations in the strength of the Atlantic meridional overturning circulation (Biastoch et al., 2008a), an important element of the global climate system. We fully expect further research to find evidence of links to Southern Ocean overturning also, linked to high eddy heat diffusivity across the meandering Agulhas Return Current (Sallee et al., 2006). Yet, how the Agulhas and its



interocean leakage varies is not well understood. There is evidence for control by mesoscale disturbances, such as Mozambique eddies and Rossby waves (Biastoch et al., 2008b; Schouten et al., 2002). These can trigger solitary meanders in the trajectory of the Current which can cause upstream retroflections – preventing inter-ocean leakage – and set the rate of formation of Agulhas Rings. The strength of the Agulhas transport also exerts a control through inertial processes (de Ruijter et al., 1999: van Sebille et al., 2009), whereby a weaker transport appears to lead to a stronger leakage. Shifts and intensity changes of the large-scale wind field also effect the leakage and its properties (Oke and England, 2004), although exactly how is not yet clear.

On a global basis, this region remains one of the poorest understood. Even limited oceanic investigations here have made major and basic discoveries over the past few years. It has, for instance, been shown that no continuous Mozambique Current exists, instead there is a train of eddies (de Ruijter et al., 2002). A new current, the South Indian Ocean Countercurrent, has been discovered to carry water eastward across the subtropical gyre (Siedler, 2006; Palastanga et al., 2007). An undercurrent to the Agulhas has been detected (Beal and Bryden, 1997) substantially modifying the thinking on the volume flux of the Agulhas Current. This is indicative of the pioneering nature of much research in the system. In order to bring an understanding of the key elements of this circulation and its impact on climate to the same cognitive level as other systems, it is highly desirable and urgent that significant resources and well-planned research programs be targeted to the region.

Terms of Reference

The specific goals of our proposed working group are to:

- Facilitate collaboration between existing and planned (observational and modeling) studies in the greater Agulhas Current system, such that we minimize the gaps in the research, maximize the scientific outcome, and encourage estimates on the robustness of key findings (e.g. multiple model ensembles).
- Write a review paper (for publication in a peer-reviewed journal) that highlights the importance of the greater Agulhas system in terms of global climate, reviewing the current levels of both understanding and uncertainty as to how changes in the system come about, how they effect climate, and vice versa.
- Identify key components of the circulation which deserve further study through physical/palaeo observations and/or models, some of which may act as indices/proxies (through sustained observation) that can help describe the state of the Agulhas system on decadal to climate time scales. Communicate these findings to regional and international strategic planning committees, such as CLIVAR, GOOS, GEOSS, GO-SHIP etc.
- Write a proposal for, and organize, a Chapman Conference on the "Climatic Importance of the Greater Agulhas System", to be held in 2012.

List of Products

- Kick-off article in *EOS*.
- Review paper in a peer-reviewed journal.
- Report on recommendations for future research programs and sustained observations, for dissemination to CLIVAR, GOOS, GEOSS, GO-SHIP etc
- Chapman Conference on the "Climatic Importance of the Greater Agulhas System".

Collaboration and Capacity building

We will enlist the help of the SCOR's Committee on Capacity Building for ways in which our group and its activities can help build scientific capacity in East African nations, such as Mozambique, Tanzania, and Kenya. More resources in these nations would greatly increase the feasibility of sustained observations over the region in the future. We note that two of our members (Juliet Hermes and Johann Lutjeharms) are involved in the Agulhas-Somali Current Large Marine Ecosystem (ASCLME) project, funded by the United Nations Development

Program, which shares some of our goals. We will seek a collaboration with ASCLME for a joint planning meeting/workshop and for in-kind support for attendance of these scientists at our SCOR meetings. Communication with International CLIVAR VACS (Variability of the African Climate System) and US CLIVAR WBC (Western Boundary Current ocean-atmosphere interaction) groups will also be sought to identify common ground and establish possible collaborations. We note that committee member Meghan Cronin is on the WBC panel.

Timeline

Once funded, our new SCOR working group will announce itself in an EOS article, in order to reach other scientists conducting related research, encourage their participation, and facilitate their interaction with members of the community.

Our first working group meeting will be held in conjunction with the Ocean Sciences meeting in Portland, Oregon, in February 2010. This meeting will focus on (1) putting together the review article, as described in our terms of reference, (2) encouraging working group members to participate in regional and international strategic panels, and (3) discussing strategies for identifying key components of the Agulhas system for further study / sustained observations.

Our second working group meeting will be in early 2011, possibly in South Africa in conjunction with ASCLME to facilitate capacity building efforts. Here we will focus on (1) a final discussion and submission of review article, (2) initiating a Chapman Conference proposal and identifying a lead convener and (3) outlining a report which will include recommendations on the direction of future research and the requirement for sustained observations in the region. The Conference proposal will be submitted within a few months of this meeting.

Finally, a third working group meeting, potentially also in an African nation, but perhaps at EGU, will aim to (1) have a final discussion about the report on future directions for the region, with dissemination shortly afterwards, and (2) follow up on planning for, and organization of, the Chapman Conference, which should be held within six months of this meeting.

Our final product is to hold a Chapman Conference for the community. (AGU guidelines specify a timeline of 12 to 15 months between proposal acceptance and the actual event.) Such a conference will allow for plenty of scientific discussion, an increase and strengthening of collaborative ties - particularly with African colleagues, and ultimately a more productive outlook for future research, resources, and observation programs, that will accelerate our understanding of the Agulhas and its role in climate.

Chairs and Working Group Members

Our proposed working group has two enthusiastic co-Chairs, representing observations and modeling: Lisa Beal at the Rosenstiel School of Marine and Atmospheric Science at the University of Miami, and Arne Biastoch at the Leibniz-Institut für Meereswissenschaften (IFM-GEOMAR). Plus seven other full members, representing a good balance of expertise, nationality, seniority, and gender (see Table). Each member volunteered their time and ideas at our recent workshop, in which we discussed and initiated this SCOR proposal. The exception is Meghan Cronin whom we recruited after the workshop to fulfill an identified need for expertise in ocean-atmosphere processes.

The group seeks one more member, preferably from the field of fisheries/ecosystems or meteorology/climate, and from a developing African nation. We have identified David Obura (ecosystems, Kenya) or Alberto Mavume (ocean/atmosphere, Mozambique) as possible members, subject to advice from SCOR.

Name	Seniority	Affiliation	Expertise
Lisa Beal (co-Chair)	jr/mid	University of Miami, USA	physical oceanography
Arne Biastoch (co-Chair)	jr/mid	IFM-Geomar, Germany	ocean modeling
Johann Lutjeharms	sr	University of Cape Town, South Africa	physical oceanography
Rainer Zahn	sr	Univ. Autònoma de Barcelona, Spain	palaeoclimatology
Will de Ruijter	sr	Universiteit Utrecht, The Netherlands	theory / physical oceanography
Juliet Hermes	jr	South African Environmental Observation Network, South Africa	regional ocean modeling / coastal observations
Tomoki Tozuka	jr	University of Tokyo, Japan	coupled climate modeling
Graham Quartly	mid	National Oceanography Centre, UK	bio-physical satellite oceanography
Meghan Cronin	mid	NOAA-PMEL, USA	air-sea interaction

In addition, we have a roster of eleven volunteer Associate members: Herman Ridderinkhof (physical oceanography, NIOZ, The Netherlands), Alan Meyer (satellite oceanography, CSIR, South Africa), Jens Zinke (marine geology, U. Amsterdam, The Netherlands), Frank Peeters (palaeoceanography, U. Amsterdam, The Netherlands), Deirdre Byrne (physical oceanography, U. Maine, USA), Shekeela Baker-Yeboah (dynamical theory, MIT, USA), Paolo Cipollini (coastal altimetry, NOC, UK), Ian Hall (palaeoclimatology, Cardiff U., UK), Veronique Garcon (biophysics, LEGOS, France), Wonsun Park (climate modeling, IFM-Geomar, Germany), and Pierrick Penven (regional ocean modeling, IRD, France). Once again, all these associate members attended the recent workshop, at which they shared ideas for this proposal and asked to be involved.

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16 June 2009

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Dear Rainer:

Thank you for the copy of the proposal you submitted to SCOR seeking designation of a Working Group tasked with focusing on the "Climatic Importance of the Greater Agulhas System". There is little doubt that the Agulhas and related currents play a key role in modulating interocean exchange between the Atlantic and Indo-Pacific Oceans, and very likely as a prime driver of climate change over a wide spectrum of timescales. Yet the Greater Agulhas System is notably understudied and concerted large-scale efforts to systematically investigate this region, as you note, are just now getting underway. Your proposal to designate a Working Group to link the relevant investigators working in the Agulhas system is both timely and important.

I am pleased to inform you that the IMAGES Program (International Marine Global Change Study) is highly enthusiastic about your proposal to SCOR and agrees to act as a co-sponsor of your initiative. This co-sponsorship would ideally include support from IMAGES for the participation of a designated representative or liaison that serves to link the Agulhas Working Group and the IMAGES community.

I trust that SCOR will act in a positive way with regards to your proposal to create a Working Group and look forward to the scientific opportunities that will arise as a result of our future interactions.

Warm regards,

Larry C. Peterson

Larry C. Peterson
Professor, Marine Geology & Geophysics
Chair, IMAGES Executive Committee

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2.3.6 Patterns of Phytoplankton Dynamics in Coastal Ecosystems: Comparative Analysis of Time Series Observation

A Proposal for Forming a SCOR WG:
Global Patterns of Phytoplankton Dynamics in Coastal Ecosystems:
Comparative Analysis of Time Series Observations

1. Introduction

Background & Rationale

Marine ecosystems are changing rapidly in response to natural processes, human activities, and climate change. These drivers of change have become the subject of an increasingly intense focus from both research and management perspectives. There are important scientific questions that need to be addressed with regard to natural vs human-induced changes including: 1) the qualitative characters of the ecosystem responses ("what changes?"), 2) their amplitudes ("by how much?"), and 3) their timing and spatial and temporal scales ("when and where are rates of change most profound?"). Phytoplankton are excellent indicators of marine ecosystem change. They are ecologically and biogeochemically important and relevant indicators, since they conduct a large share of system-scale primary production and hence C cycling and they are highly sensitive to a suite of environmental stressors. There is much accumulated evidence that diverse ocean regions undergo strong and sometimes abrupt changes in phytoplankton composition, and productivity at roughly decadal intervals (i.e. regime shifts). This variability is associated with corresponding changes in atmospheric, hydrologic, chemical, and higher trophic-level biological processes and state variables. However, our understanding of global change is incomplete because we have not adequately explored, inventoried, nor compared available observational data. Nor do we know how to anticipate the timing and direction of the next major shifts.

The understanding of climate change vs anthropogenic influence in coastal ecosystems is important in sustainable management of coasts. A recent example of a climate change-induced shift in biological communities was reported by Cloern et al. (2007) for San Francisco Bay. The abrupt change in the biological communities was first detected as increasing phytoplankton biomass and the occurrences of new seasonal blooms that began in 1999, overriding the influence of changes in the input of nutrients. There were coincidental higher level biotic changes, including sharp declines in the abundance of bivalve molluscs, the key phytoplankton consumers in this estuary, and record high abundances of several bivalve predators: Bay shrimp, English sole, and Dungeness crab. The phytoplankton increase is consistent with a trophic cascade resulting from heightened predation on bivalves and suppression of their filtration control on phytoplankton growth. These community changes in San Francisco Bay across three trophic levels followed a state change in the California Current System in the form of sudden increased upwelling intensity, amplified primary production, and strengthened southerly water flows. These diagnostic features of the East Pacific ‘‘cold phase’’ led to strong recruitment and immigration of juvenile flatfish and crustaceans into estuaries where they feed and develop. This study utilized three decades of observations to reveal a previously unrecognized mechanism of ocean–estuary connectivity. This shows that interdecadal oceanic regime shifts can propagate into estuaries and coastal waters, altering their community structure and efficiency of transforming land-derived nutrients into algal biomass.

In October 2007, nearly 100 phytoplankton ecologists gathered in Rovinj, Croatia and attended the AGU Chapman Conference: “Long Time-Series Observations in Coastal Ecosystems: Comparative Analyses of Phytoplankton Dynamics on Regional to Global Scales” (http://www.agu.org/meetings/chapman). They initiated an analysis of phytoplankton changes in many different coastal marine ecosystems around the world, but the comparison and synthesis of the differences between those ecosystems are a huge task, it could not be completed during the 5 day conference and therefore a smaller working group that works over a longer period, is needed to continue the analysis of these valuable data sets not only in science, but also for management needs.

Proposed SCOR Working Group

We are proposing to form a SCOR Working Group to focus on coastal ecosystems (estuaries, fjords, bays, sounds, open waters of the continental shelf, etc.) where perturbations from terrestrial, atmospheric, oceanic sources and human activities converge to cause changes that ramify across local and global scales. Human pressure on coastal regions and continental margins is increasing with expanding urbanization and the conflicting demands of tourism, agriculture and aquaculture, water diversions, wind parks and other developments. Our proposal to develop a SCOR Working Group grew out of the recent AGU Chapman Conference: “Long Time-Series Observations in Coastal Ecosystems: Comparative Analyses of Phytoplankton Dynamics on Regional to Global Scales” (convened by James Cloern and Nenad Smodlaka, October 8-12, 2008, Rovinj, Croatia). This conference convened over 150 researchers, managers and agency representatives from many countries and provided an excellent opportunity to identify and compare long-term coastal phytoplankton data sets broadly distributed throughout the northern and southern hemispheres.

There was a strong consensus at this conference that a more detailed, global comparison of phytoplankton time series would be timely, technically feasible, and an extremely valuable next step to more fully understand commonalities and contrasts with regard to ecological responses to natural and man-made changes captured by our global network of coastal phytoplankton time series.

Such an analysis must be an international cooperative effort. The relevant data sets are in many places and have been collected by many independent researchers, agencies and nations. Many of the necessary data are available now, and the Working Group can begin immediately. Endorsement and sponsorship by SCOR will help us attract and retain approvals and financial support from national agencies.

The Chapman Conference was a meeting organized by individual scientists and managers; not by an organization. The WG formation would carry forward the momentum by helping set up the platform to work with scientists in various regions on a continuing basis for several years and also possibly to take a lead in promoting a second Chapman conference in the near future (as yet, there is no actual activity for organizing the second Chapman conference). Without an organizational approach in the form of a SCOR WG, there will be no platform to gather scientists to more fully analyze and synthesize these valuable data sets.

2. The Nature of the Scientific Opportunity and Management Needs

Phytoplankton

Phytoplankton are dominant marine primary producers; they mediate nutrient flux and cycling as well as transfer of organic matter to higher trophic levels, including invertebrate grazers, planktivorous fish, and carnivores. Hence, they are a key link between nutrients and secondary production. As key primary producers, phytoplankton reflect immediate effects of changes in the input of nutrients in coastal ecosystems. Because different phytoplankton groups require different nutrient ratios, their composition responds to changes in the ratios of ambient nutrients. For example, diatoms require silicate and their relative abundance may be regulated by Si concentrations relative to other nutrients. Phytoplankton productivity and floristic composition are subject to physical forcings such as horizontal exchange between estuaries and the open sea (Cloern et al. 2007) and vertical mixing regimes, and they are also regulated by light fluctuations, and temperature. Changes in phytoplankton productivity and composition can be driven by climatic forcing and variability such as monsoons (Yin 2002), typhoons or hurricanes (Paerl et al. 2001, 2006) and rainfall (Paerl 1995; Adolf et al. 2006). In addition, phytoplankton are broadly distributed and abundant, and can be quantified by relatively simple and intercomparable sampling methods. Finally, demographic traits of phytoplankton make them particularly suitable for comparative analysis of ecosystem changes across regional to global scales.

Regional and Global Comparisons

We believe that large-scale (between-region and between-ocean) comparisons of phytoplankton time series are the essential next step. Local- and regional-scale observational programs are maintained in coastal marine waters of all continents, but their data remain largely isolated. Our goal is to locate, assemble, and synthesize multi-decadal observations to obtain quantitative and descriptive depictions of phytoplankton variability as an indicator of environmental change. We envision a global phenology of phytoplankton at the land-sea margin and a conceptual model from which coastal ocean observing systems can be built. As a logical outgrowth of (and next step following) the Chapman Conference, the working group will focus on a comparative analysis of ecosystems to address three guiding questions:

1. *What are the dominant scales of variability in phytoplankton biomass, abundance, floristic composition, species composition, and/or species diversity? Is there evidence for secular trends or regime shifts? With which criteria can we best differentiate long-term from episodic, seasonal and interannual signals?*

2. *Is there evidence for external forcings of variability and change (e.g., effects of climate change, basin scale oscillations, land-based inputs, atmospheric deposition, alien species)? Are changes coherent in space and/or time?*

3. *Are there consistent patterns among ecosystems in terms of relationships between environmental drivers, responses in phytoplankton biomass and changes in species/floristic composition?*

To date, relatively few between-region comparisons of phytoplankton time series have been completed. All previous comparisons have been at smaller scales (within an individual current system, or at one ocean basin), compared to the global scale that include inter-regional comparisons that we are proposing.

The Chapman Conference was focused on the land-sea interface where changes are driven by complex interactions between human disturbance and climate variability. This proposed working group will continue to focus on coastal ecosystems influenced by connectivity to land: estuaries, river plumes, mangroves, bays, lagoons, inland seas.

Existing time series data of phytoplankton

Many researchers and governmental agencies around the world have relied on phytoplankton as a key indicator of water quality monitoring programs and many data sets have been presented in the Croatia AGU Chapman conference. Those data sets are included in Table 1 (attached at the end of this document).

Data availability for the proposed WG

We already have a number of data sets with excellent global representation of coastal systems that are available for the WG. They will be contributed by the members and associate members, as shown in Table 2.

Table 2. Data available from participants of the proposed WG members and associate members.

Name	Country	Ecosystem	Series
Susan Blackburn	Australia	South Pacific Ocean	1993-2007
Robert Le Borgne	New Caledonia, France	West Coast of South Africa SW Pacific	1993-2007
Jacob Carstensen	Denmark	Kattegat, Atlantic	1993-2007
James E. Cloern	U.S.	North & South San Francisco Bay, Western Paficic	1969-2007
Lawrence W. Harding, Jr.	U.S.	Chesapeake Bay, North Atlantic	1989-2007
Snejana P. Moncheva	Bulgaria	Black Sea	1954-2003
McQuatters-Gollop, Abigail	UK	CPR (North-East Atlantic including European shelf; North Sea, Irish Sea, English Channel, North-West Atlantic including Scotian Shelf, Grand Banks; North Pacific)	1948-2007
N. Ramaiah	India	Bay of Bengal, Indian Ocean	1962-1965, 2001-2006
Clarisse Odebrecht	Brazil	Patos Lagoon estuary and Cassino Beach surf-zone, South America (32º S)	1986, 1988-1990, 1992-2009
Hans W. Paerl	U.S.	Neuse River-Pamlico Sound, Atlantic	1993-2006
Elgin S. Perry	U.S	Chesapeake Bay, Atlantic	1985-2004
C J M Philippart	The Netherlands	Wadden Sea, North Sea	1995-2004
Ted Smayda	U.S.	Narragansett Bay, Atlantic	1974-2007
Kedong YIN, Paul J. Harrison	China (Hong Kong)	Subtropical South China Sea	1991-2004
A. Zingone	Italy	Gulf of Naples, Mediterrenean Sea	1984-1991, 1995-2009

We will consult with other individuals (in Table 1) about their willingness to participate in our

WG analysis and synthesis. Scientists and managers are willing to contribute their data sets for specific purposes such as synthesis, correlations, and comparisons in general, which has been demonstrated in Cloern and Jassby (2008) who received over 100 data sets (the condition was that the data would only be used for this specific purpose). In addition, we hope to have a second Chapman conference in the near future under the SCOR WG leadership, which would provide the opportunity for identification of more data sets and to conduct a more thorough regional and global time series synthesis.

The analysis and synthesis of many datasets are crucial to achieve the WG objectives. The WG members and associate members have the necessary skills to complete the tasks proposed in this WG since they have all conducted analysis and synthesis of their data for regional ecosystems. For example, Cloern and Jassby (2008) have synthesized many data sets in the paper "Complex seasonal patterns of primary producers at the land-sea interface". The WG participants have two statisticians, Carstensen and Perry. The WG participants not only have skills in manipulation of large databases, but also have comprehensive knowledge of phytoplankton ecology in the context of environmental change, anthropogenic influence and climate change. Lastly, they have contributed numerous publications emphasizing the importance of synthesizing human and climatic drivers of phytoplankton community structure and function.

The data sets listed above are by no means complete (they were from the Chapman Conference only). The CPR dataset, although not included in the original proposal, is included here as the CPR has comprehensively sampled phytoplankton biomass as well as the abundance of nearly 200 phytoplankton taxa in coastal ecosystems including the North Sea, Irish Sea, English Channel, European Shelf, North Pacific, Grand Banks, and Scotian Shelf as well as the open ocean since 1948. No other ecological datasets have sampled marine and coastal plankton at this comprehensive spatial and temporal scale.

Data Archiving and Database Centre

There is certainly a need for compiling and archiving those data sets into a mega database. We will facilitate migration of individual datasets to a permanent and secure electronic archive based on the scientist's willingness of participation and data accessibility. Requirements for development of a fully-stocked phytoplankton data-base greatly exceed the resources of this WG. However, we expect to produce a small working proto-type, based on some existing archive (to be identified) to demonstrate the value of sharing data through an international databse, as demonstrated by SCOR WG125: Global Comparisons of Zooplankton Time Series.

Methodological opportunities and issues
Several methodological issues affect the analysis of phytoplankton time series and only a brief summary is given here. However, even though these issues will complicate our work, we can still obtain a meaningful global comparison.

The first issue is diversity of the sampling methodology. No phytoplankton sampling method is perfect, and there have been differences in sampling methodology both within and between data sets, particularly for earlier data. However, we do not expect these differences to be a serious technical barrier to between-region comparisons. A key reason for this is that our analysis focuses on comparisons of anomaly time series rather than of regional climatology. Hence, we are primarily interested in the temporal variability of relative abundance, not the spatial variability of absolute abundance. Several of the proposed WG members have expertise in evaluating effects of changes in sampling methodology within individual time series.

A second issue is consistency of taxonomic identification within and among data sets. Again, 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 improved over even a few years ago. Good computer tools for dealing with the diverse origin and moderately large data sets are now more available, cheaper, 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 phytoplankton data sets will be a major technical problem. In fact, we have already assembled several key data sets as part of the Chapman Conference.

The final issue is the use of statistical tools. During the Chapman Conference, several statistical experts were invited to help participants to perform statistical analyses on their own data set. They demonstrated how to deal with temporal and spatial autocorrelation, and with data gaps. This knowledge will be utilized by our SCOR WG in the next phase of global time series analysis. Application, evaluation, and bundling of these statistical tools for distribution/publication will be another important WG product.

3. Proposed Terms of Reference

- Identify existing long time series of phytoplankton data in coastal oceans around the world
- Facilitate migration of individual data sets to a permanent and secure electronic archive (Requirements for development of a fully-stocked phytoplankton data-base greatly exceed the resources of this WG. However, we expect to produce a small working proto-type,

based on the existing archive (to be identified) to demonstrate the value of sharing data through an international database.)

- Develop the methodology for global comparisons for within-region and within-time-period data summarization (e.g. spatial, seasonal and annual averaging, summation within taxonomic and functional group categories). The goal is to clarify what level of detail provides the optimal tradeoff (i.e. 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 data sets.
- We will carry out a global comparison of phytoplankton 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 phytoplankton variability (e.g. changes in total biomass, species composition shifts, among different geographic distribution).
  - Amplitude of variability, both for total biomass and for individual dominant species, and a comparison to the amplitude of population fluctuations.
  - Likely causal mechanisms and consequences for the phytoplankton variability, based on spatial and temporal coherence with water quality time series.
- Through comparative analysis, we will address the 3 guiding questions.

4. Time Frame and Expected Products

We will begin work in 2010 and will continue for three years. We will convene annual WG meetings (each about 4-5 days), and a larger open attendance workshop or conference in the final or penultimate year. For each year, expected activities and products include:

Year 1: Summarize and evaluate methods, results, and questions arising from the phytoplankton 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 phytoplankton biomass, major groups and/or species-level phytoplankton taxonomic composition, phenology, and physical and biological environmental indices). Identify and address obstacles to pooled analyses (e.g. incomplete processing, differences in formatting, differences in resolution). Develop the “best practice” recommendations for data sampling and analysis methodologies.

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 time intervals of particular interest. Post selected tools and data on a web or ftp site (initially closed, and eventually public).

Year 3: Complete comparative analyses of phytoplankton 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" time series sampling and analysis methodologies.

5. Proposed Working Group membership

Our primary selection will be based on a broad experience with phytoplankton time series, combined with geographic representation and local knowledge of the content for each regional data set. Our suggested list of full members (total 10) includes the following candidates:

Co-Chair, **Kedong Yin**, Australian Rivers Institute, Griffith University, Brisbane, Queensland, Australia, k.yin@griffith.edu.au

His data set will cover subtropical coastal waters in the South China Sea, which receives the outflow of the 2nd largest river (Pearl River) in China.

Yin's research interests include: coastal dynamics of nutrients; eutrophication processes; ecology and oceanographic processes of harmful algal blooms, in coupling processes with environmental variability, and climate changes; and a plenary speaker on "the dynamics of phytoplankton species composition in subtropical waters of south China during the last 15 years".

Co-Chair, **Hans W. Paerl**, Institute of Marine Sciences, University of North Carolina at Chapel Hill, Morehead City, North Carolina, USA, hpaerl@email.unc.edu

His interest is to examine how phytoplankton composition change responds to natural disasters.
Paerl is the Kenan Professor of Marine and Environmental Sciences and his research interests include; microbially-mediated nutrient cycling and primary production dynamics of aquatic ecosystems, environmental controls of harmful algal blooms, and assessing the causes and consequences of man-made and climatic (storms, floods) nutrient enrichment and hydrologic alterations of inland, estuarine and coastal waters. His studies have identified the importance and ecological impacts of atmospheric nitrogen deposition as a new nitrogen source supporting estuarine and coastal eutrophication. In 2003, he was awarded the G. Evelyn Hutchinson Award by the American Society of Limnology and Oceanography for his work in these fields and their application to interdisciplinary research, teaching and management of aquatic ecosystems.

Susan I. Blackburn (female), CSIRO Marine and Atmospheric Research and the Aquafin CRC, Hobart, 7001, Australia; susan.blackburn@csiro.au

Her data represent temperate waters in the south Pacific Ocean.
Dr Susan Blackburn is a Principal Research Scientist with CSIRO Marine and Atmospheric Research and Head of the CSIRO Collection of Living Microalgae. Her research spans

phytoplankton environmental issues and bioapplications of microalgae. Working with harmful algal bloom (HAB) species for over 20 years, Dr Blackburn has combined ecophysiological studies in culture with field studies to elucidate regulation of HABs and interrogate life history details, toxin production, molecular characterization and processes, and trophic interactions, particularly of HAB species in south eastern Australian waters. Within CSIRO, nationally and internationally Dr Blackburn research informs system-wide environmental management and prediction of phytoplankton dynamics and algal blooms through biogeochemical modelling.

Jacob Carstensen, National Environmental Research Institute, Denmark, jac@dmu.dk

His data set represents a temperate inland sea (Kattegat) of the Atlantic Ocean.

Carstensen is a statistician working within marine ecology, in particular long-term trends of ecosystem quality indicators in response to anthropogenic pressures. Particular scientific fields of interests are: biogeochemical processes, phytoplankton community structure and bloom mechanisms, hypoxia, and nutrient management for marine ecosystems.

James E. Cloern, U.S. Geological Survey, Menlo Park, California, USA, jecloern@usgs.gov

His data are from San Francisco Bay and represent many phenomena associated with anthropogenic influence vs climate change.
Cloern has strong expertise in phytoplankton ecology, particularly phytoplankton response to eutrophication and climate changes. He is very experienced in the synthesis of long term data set, and wrote "Phytoplankton bloom dynamics in coastal ecosystems: a review with some general lessons from sustained investigation of San Francisco Bay, California" in 1996. In 2001, he comprehensively reviewed global data in coastal waters and wrote a conceptual review that was published in Mar Ecol Prog Series, "Our evolving conceptual model of the coastal eutrophication problem", which has greatly stimulated coastal eutrophication research. The paper has been cited 373 times.

Paul J. Harrison, Atmospheric, Marine and Coastal Environment Program, Hong Kong University of Science and Technology, Hong Kong SAR, China Harrison@ust.hk

Harrison is a biological oceanographer with expertise in nutrient dynamics and phytoplankton ecology and recent interest in eutrophication, harmful algal blooms and hypoxia. He is a member of SCOR WG 132 "Land-based Nutrient Pollution and the Relationship to Harmful Algal Blooms in Coastal Marine Systems" and will coordinate activities between the two WGs if this WG is funded.

McQuatters-Gollop, Abigail (female), Sir Alister Hardy Foundation for Ocean Science, Citadel Hill, Plymouth, PL1 2PB, United Kingdom, abiqua@sahfos.ac.uk

Working on the CPR data set which includes a measure of phytoplankton biomass as well as the identification and abundance of nearly 200 phytoplankton taxa in the North Sea, Irish Sea, English Channel, European Shelf, North Pacific, Grand Banks, and Scotian Shelf as well as the open ocean since 1948.

Clarisse Odebrecht (female), Institute of Oceanography, Federal University of Rio Grande-FURG, Cx.P. 474, 96201-900 Rio Grande, RS, Brazil, doclar@furg.br

Her data are from South America coastal temperate waters (Patos Lagoon estuary and sandy beach surf-zone).

She is a Professor and leader of the research group: Ecology of Marine Phytoplankton and Microorganisms at the Federal University of Rio Grande-FURG, Brazil. Her main research topics include: taxonomy and ecology of marine phytoplankton, harmful algal blooms, coastal eutrophication and studies on microalgae in marine aquaculture.

N. Ramaiah, National Institute of Oceanography, Dona Paula, Goa 403 004, India; telephone: +91 832 2450515; fax: +91 832 2450602; email: ramaiah@nio.org)

His data represent coastal tropical waters in the India Ocean.

Katja Philippart (female), Royal Netherlands Institute for Sea Research (The Netherlands), Texel, The Netherlands, katja@nioz.nl

Her data are from the Wadden Sea, another example where major engineering works have occurred along the coast.

Philippart is a marine ecologist and her research combines laboratory experiments, field studies, statistical analysis of long-term field observations and modeling techniques to investigate the underlying mechanisms of long-term dynamics within shallow marine coastal communities. Her emphasis is on understanding the role of human influences (eutrophication, fisheries and global warming) within these ecosystems in regulating primary and secondary producers, within the North Sea, Venice Lagoon and the Banc d'Arguin. At present, she coordinates relevant research projects, viz. JetSET (long-term field observations in the western Wadden Sea), and the recently funded national research project (2008-2013) dedicated to monitoring primary production in the western Wadden Sea as a baseline for management of human activities in coastal waters (IN PLACE). She is the Editor-in-Chief of the Journal of Sea Research since 2000, co-author of Marine Coastal Dimension of Climate Change in Europe (EU-IES, 2006, Ispra), and the leading author of Climate Change Impacts on the European Marine and Coastal Environment (ESF-Marine Board, 2007, Strasbourg).

Adriana Zingone (female), Stazione Zoologica A. Dohrn, Villa Communale, Italy, zingone@szn.it

Her data set are in the Gulf of Naples, Mediterranean Sea

Zingone is an expert in taxonomic and morphological studies on marine microalgae, and spatial distribution of phytoplankton diversity in marine waters. Her research findings based on biological time series data contributed to revising paradigms and myths of phytoplankton ecology. She also reviewed seasonal patterns in plankton communities in a pluri-annual time series at a coastal Mediterranean site (Gulf of Naples): an attempt to discern recurrences and trends.

Potential Candidates for Associate Members include:

Borgne, Robert Le, Centre IRD de Noumea, B.P. A5, 98848 Nouméa Cédex, New Caledonia, leborgne@noumea.ird.nc

His data are from coastal waters off Abidjan, Western Africa and Noumea, SW Pacific in New Caledonia

Elgin, Perry, USA, eperry@chesapeake.net

Perry has worked with Harding on the Chesapeake Bay long time series data set.

Dr. Perry is a statistics consultant providing experimental design and data analysis expertise to researchers involved with environmental research and regulation. Dr. Perry was trained in applied mathematics at the Univ. of Maryland in an interdisciplinary program that included course work and research in mathematical statistics, numerical analysis, and zoology. The majority of Dr. Perry's consulting experience involves collaboration with clients who are conducting research and monitoring of Chesapeake Bay. These clients include: the U.S Geological Survey, USEPA Chesapeake Bay Program, Maryland Sea Grant, Maryland Department of Natural resources, Horn Point Laboratory, Chesapeake Biological Laboratory, Wye Research and Education Center, Virginia Department of Environmental Quality, and U.S. Army Corps of Engineers.

Malone, Thomas C., Ocean US Office for Integrated and Sustained Ocean Observations (US), Washington, DC, **USA**, t.malone@ocean.us

He is working with GOOS and his participation will be helpful for coastal observation systems that plan to incorporate phytoplankton into their monitoring program in the future.

Malone has published over 100 peer-reviewed papers on phytoplankton and coastal ecosystem dynamics, science and policy, and integrated ocean observing systems. Chair, IOC-WMO-UNEP-ICSU Coastal Global Ocean Observing System Panel (1998-2000), and Co-Chair, IOC-WMO-UNEP-ICSU Coastal Ocean Observations Panel (2002-2005)

Moncheva, Snejana P. (female), Institute of Oceanography, BAS, Bulgaria, snejanam@abv.bg

Her data set is an extremely long time series (1954-2003) from the Black Sea.Perry,

Picher, Grant, Marine and Coastal Management, Private Bag X2, Rogge Bay 8012, South Africa gpitcher@sfri2.wacpe.gov.za.

He has access to a 20 yr time series of dinoflagellate abundance from the South African coastal upwelling zone.

Smayda, Theodore J., Graduate School of Oceanography University of Rhode Island Kingston, RI 02881 USA tsmayda@gso.uri.edu

Smayda has a rare long term data set for Narragansett Bay during 1974-2007, another case study for temperate waters.

Smayda is a well known phytoplankton ecologist. His major research themes include seminal works on phytoplankton suspension, species succession in marine environments and population dynamics related to diatom and harmful algal blooms. Armed with the skills of knowing the major marine species, an enviable knowledge of the international literature and a constantly inquisitive mind, Smayda continues to delve into insights related to the dynamics that drive phytoplankton blooms. His recent collaborations with the freshwater phytoplankton ecologist Colin Reynolds in generating his present concepts on species strategies, community assembly and development of blooms offer another cornerstone from which to examine the HAB paradigm. His first comments on the importance of life cycles, nutrients and eutrophication in driving the spreading of the bloom phenomena on a global basis were quickly adopted by others and presented or reiterated in colleague's publications. In this regard, he has been a trend setter of ideas that have stimulated others to explore further. In 2002, he received **XHAB2002/ISSHA Yasumoto Lifetime Achievement Awards.**

Yoo, Sinjae, Korea Ocean Res. & Dev. Inst. Sa-Dong 1270, Ansan, South Korea sjyoo@kordi.re.kr

His data set from satellite images represents temperate coastal waters in Pacific Ocean where anthropogenic influence from land runoff is increasing.

Yoo has been studying interannual variation of chlorophyll *a* in the North Pacific ecosystems using satellite image data. He also has been studying primary productivity of the Yellow Sea and East Sea by using ship-board and satellite observations.

6. Funding

We will contact various organizations such as LOICZ, IMBER, GEOHAB, PICES, IOC, ICES and Census of Marine Life and expect to attract co-sponsorship and additional financial support in the form of travel funding for associate WG members, especially from the developing countries.

Full members from developed countries will be asked to cover part of the cost of their own travel and accommodation from other sources, if SCOR has a budget limitation to fully support our proposed WG.

Our proposal has been strongly supported by PICES and PICES will fully support an associate member, Sinjae Yoo.

7. Interactions with other organizations or programs.

We will maintain our interactions with organizations such as IMBER, LOICZ, GEOHAB, PICES, IOC and CoML during the WG's active period. For example, we will send them our annual meeting notices before meetings and our annual reports for their feedback.

We will try to establish a strong interaction and working relationship with the SCOR WG 125 on zooplankton time series and SCOR WG 132 on HABs. This interaction will be very beneficial as they are dealing with the similar challenge of analyzing global time series data sets.

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Biomass in Coastal Waters of Hong Kong in the Vicinity of the Pearl River Estuary. Mar. Ecol. Prog. Ser. 245: 111-122.

Table 1. Data sets presented at the Chapman Conference in 2007, Croatia.

Theme 1: dominant scales of variability in phytoplankton biomass, abundance, floristic composition, species composition, and/or species diversity			
Name	**Country**	**Ecosystem**	**Series**
Paulo C. Abreu	Brazil	Patos Lagoon Estuary	1986-1990, 1993-2007
Susan I. Blackburn	Australia	Huon Estuary, Tasmania	1996-2005
H. O. Briceño	U.S.	Biscayne Bay, Florida Bay, Florida Shelf	1989-2007
Francisco.P. Chavez	U.S.	Monterey Bay	1988-2007
James E. Cloern	U.S.	North & South San Francisco Bay	1969-2007
Valerie David	France	Gironde Estuary	1978-2003
S. Fonda Umani	Italy	Gulf of Trieste	1986-2005
Miles Furnas	Australia	Great Barrier Reef Lagoon	1992-2007
S.A. Gaeta	Brazil	Brazil Coastal Waters	2004-2007
Charles L. Gallegos	U.S.	Rhode River Estuary	1969-2007
Amatzia Genin	Israel	N Gulf of Aqaba	1988-2007
Rita A. Horner	U.S.	Washington Coast	1997-2007
Arantza Iriarte	Spain	Bilbao & Urdaibai . Estuary	1997-2007
Jacco C. Kromkamp	The Netherlands	Oosterschelde/Westerschelde	1987-2006
Robert Le Borgne	France	Ivory Coast, New Caledonia	1969-1979, 1979-1989
WKW Li	Canada	Bedford Basin	1967-2007
Michael W. Lomas	U.S.	Bermuda Atlantic Series	1989-2007
Emma Orive	Spain	Nervion River Estuary	2000-2006
Elgin S. Perry	U.S	Chesapeake Bay	1985-2004
N. Ramaiah	India	Bay of Bengal	1962-1965, 2001-2006
Diana Sarno	Italy	Gulf of Naples	1984-1991, 1995-2008

Dietmar Straile	Germany	Lake Constance	1980-2006
Sanna Suikkanen	Finland	Northern Baltic Sea	1979-2003
Alexander Vershinin	Russia	NE Black Sea	2001-2006
Hidekatsu Yamazaki	Japan	Tokyo Bay	1996-2006
Theme 2: evidence for external forcings of variability and change			
Name	Country	Ecosystem	Series
Ana B. Barbosa	Portugal	Ria Formasa Lagoon	1991-1993
Vanda Brotas	Portugal	Tagus Estuary	1999-2007
Rita B Domingues	Portugal	Guadiana River Estuary	1999-2005
Naomi Greenwood	U.K.	Liverpool Bay	1989-2006
Malcolm S. Robb	Australia	Swan Canning Estuary	
Bradley Eyre	Australia	Moreton Bay & Brunswick Estuary	1984-1991; 1995-2007
David G. Borkman	U.S.	Narragansett Bay	1959-1997; 1999-2006
Jonathan H. Sharp	U.S.	Delaware Bay	1980-2003; 1950s – present
Larry W. Harding, Jr.	U.S.	Chesapeake Bay	1989-2007
Hans W. Paerl	U.S.	Neuse River-Pamlico Sound	1993-2006
Clarisse Odebrecht	Brazil	Patos Lagoon Estuary, Cassino Beach	1987, 1989-1990, 1992-2006
M Ribera d'Alcalà	Italy	Gulf of Naples	1979-2006
Alina Tunin-Ley	France	Ligurian & Tyrrhenian Seas	1908-1914, 1929-1931, 1969-1970, 1984, 1988, 2002-2005

Nenad Smodlaka	Croatia		1987-2007
Jacob Carstensen	Denmark	Kattegat	1993-2007
Daniel Conley	Sweden		
Hans Christian Eilertsen	Norway	Norwegian Coast/Barents Sea	1974-2007
Karen Helen Wiltshire	Germany	North Sea Helogland	10 years
Xavier Desmit	The Netherlands	North Sea	1975-2003 ; 1990-2006 (Phyto)
Martina Loebl	Germany	Belgian, Dutch, German Coastal	1990-2005
C J M Philippart	The Netherlands	Wadden Sea	1995-2004
Jennifer L. Martin	Canada	Bay of Fundy	1980-2007
Michael L. Parsons	US	N Gulf of Mexico	
Trevor Platt	Canada	NW Atlantic, remote sensing	1990-2005
Theme 3: consistent patterns among ecosystems in terms of relationships between environmental parameters, phytoplankton biomass and changes in species/floristic composition			
Name	Country	Ecosystem	Series
Malcolm C. Baptie	U.K.	North Sea, UK NE coast	1969-2007
Mauro Bastianini	U.K.	Gulf of Venice	1986-2007
Suncica Bosak	Croatia	N Adriatic Sea	1998-2006
Eileen Bresnan	Scotland	NE Scotland Coastal	1997-2007
Maria Degerlund	Norway	Norwegian coast/Barents Sea	3 decades
R. H. Freije	Argentina	Bahía Blanca Estuary	1978-2006
Inga Hense	Germany	Baltic Sea	1975-2006
Carlton D. Hunt	U.S.	Boston Harbor, Cape Cod Bay, Massachusetts Bay	1992-2008

Tapan Kumar Jana	India	Sundarban Mangrove Forest	1988-2001
R. Kraus	Croatia	Northern Adriatic	1972-2006
Dongyan Liu	China	Jiaozhou Bay	
A. Lincoln MacKenzie	New Zealand	Marlborough Sound, Tasman & Golden Bays	1993-2007
Ivona Marasović	Croatia	Northern Adriatic	1962-1982
Snejana P. Moncheva	Bulgaria	Black Sea	1954-2003
Patricija Mozetic	Slovenia	Gulf of Trieste	1984-2006
Tatyana Osadchaya	Ukraine	Black Sea	1998
Edward J. Phlips	U.S.	Indian River Lagoon	1997-2007
Igor G Polikarpov	Ukraine	Sevastopol Bay	1937-1938, 1960-1968, 2001-2007
Kevin G. Sellner	U.S.	Chesapeake Bay	1984-2007
Ted Smayda	U.S.	Narragansett Bay	1974-2007
Kuninao Tada	Japan	Seto Inland Sea	1991-2006, 1973-2005
Norbert Wasmund	Germany	Baltic Sea, Mecklenburg Bight	1979-2006
Kedong YIN	Hong Kong	Hong Kong Coastal	1991-2004
A. Zingone	Italy	Gulf of Naples	1984-1991, 1995-2009

North Pacific
Marine Science
Organization

PICES

August 14, 2009

Dr. Edward R. Urban
Executive Director
Scientific Committee on Oceanic Research
College of Marine and Earth Studies
Robinson Hall
University of Delaware
Newark, DE 19716, USA

Dear Dr. Urban,

The North Pacific Marine Science Organization (PICES) would like to offer its strong support to a proposed SCOR Working Group on "*Global Patterns of Phytoplankton Dynamics in Coastal Ecosystems: Comparative Analysis of Time-Series Observations*".

Analysis of long-term data sets has provided the basis for many important insights into the changes occurring in marine systems and, as the proposal indicates, there are many phytoplankton data sets from diverse parts of the globe that warrant a comparative examination. This examination will undoubtedly supply important information on teleconnections and other complex mechanisms operating in today's changing ocean climate. The 2007 Chapman Conference has provided an excellent background for this Working Group, and it is clear that the suggested analyses will greatly improve our understanding of marine responses to climate change, natural or anthropogenic.

PICES was a strong supporter of the establishment of SCOR Working Group 125 on "*Global Comparisons of Zooplankton Time Series*", and we are very satisfied with its achievements. We consider the new Working Group as a logical methodological continuation of Working Group 125 and would be pleased to be involved in its activities. If the proposed Working Group is approved, PICES will nominate and support an Associate Member to serve on the group – Dr. Sinjae Yoo from the Climate Change Research Division of the Korea Ocean Research and Development Institute (KORDI), Republic of Korea (sjyoo@kordi.re.kr). Dr. Yoo has worked extensively on coastal and oceanic phytoplankton of the NW Pacific Ocean, and we believe he will bring valuable information to the proposed Working Group from a region that is currently not well represented in your data sets.

Sincerely yours,

ABychkov

Alexander Bychkov
Executive Secretary, PICES

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Executive Secretary
Alexander S. Bychkov

United Nations Educational, Scientific and Cultural Organization

Intergovernmental Oceanographic Commission

Australian Government Bureau of Meteorology

Government of Western Australia

wa.gov.au

Dr Ed Urban
Executive Director SCOR
College of Marine and Earth Sciences
Robinson Hall
University of Delaware
Newark, DE, 19716 USA

26 August 2009

Dear Dr Urban

I write in respect to Dr Yin's SCOR proposal "Long Time-Series Observations in Coastal Ecosystems: Comparative Analyses of Phytoplankton Dynamics on Regional and Global Scales", submitted to SCOR in 2009.

Dr Yin first brought this proposal to my attention during 2008 and I am pleased to see it now submitted to SCOR.

The generic merits of developing a better characterization of phytoplankton dynamics around the globe are for many of us in this field of bio-physical oceanographic research and application, obvious. In my view, the proposal states its case in a compelling and well structured manner, demonstrating a strong scientific motivation and societal relevance for the work. There is a strong need to establish and maintain long time-series of such a key environmental parameter in order to have local, regional and comparative characterizations of primary producers now and into the future. This is particularly so as anthropogenic impacts manifest as a result of exploitation of natural resources (potential trophic cascade effects), environmental pollution and climatic induced changes (such as from temperature and acidification forced by global warming and related carbon dioxide impacts in the atmosphere and ocean). The changes that will occur in oceanographic characteristics (eg currents, S-T structures) as the earth's water properties change from global warming will both impact on primary producer populations, but could also be better understood by characterizing changes in the dynamics of these organisms as surrogates of hydrodynamic change.

The proposal is timely in respect of the urgent need to establish and enhance long-term data on phytoplankton characteristics and dynamics. The proposal demonstrates a global brief, and is strongly underscored by the wide spectrum and high scientific standing of the listed committed participants.

The UNESCO IOC Perth Office would encourage the proponents if successful to use the marine scientific networks established through the Office to support the proposal's scientific objectives, including:

- The Indian Ocean Global Ocean Observing System, and projects it supports such as the hydrodynamically oriented Indian Ocean Panel of GOOS/CLIVAR and the complementary prospective bio-geochemical/ecological science alliance (likely to

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formed under IOGOOS and IMBER) called SIBER (Sustained Indian Ocean Biogeochemical and Ecological Research);

- South East Asian Global Ocean Observing System;
- Pacific Islands Global Ocean Observing System;
- Western Australian Global Ocean Observing System;
- Australian Integrated Marine Observing System.
- Furthermore, the IOC's Ocean Sciences Section will have an institutional interest in the proposed Working Group.

I would happy to facilitate liaison between these entities (which the UNESCO IOC Perth Office either facilitates, sponsors or works closely with) and Dr Yin's proposed phytoplankton Working Group.

There is a clear and pressing need for the type of long term data and associated ecological understanding proposed by Dr Yin's proposal.

The UNESCO IOC Perth Regional Programme Office lends its strong support to the SCOR Working Group proposal and wishes it every success.

Regards

Dr Nick D'Adamo
Officer in Charge, UNESCO IOC Perth Office

CC: Dr Kedong Yin

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2.3.7 **Coastal Lagoons**

Background and Rationale:

Scientific importance: Coastal lagoons, fragile ecosystems that fringe 13 % of the worlds' coastline, are in the frontline of the battle between the activities of humans on the land and the encroaching oceans and seas. These semi-enclosed systems are also vulnerable to contamination buy pollutants. They maybe overfed by nutrients and become hypoxic, or choked by opportunistic green algae. Coastal lagoons maybe starved of sediment by dams and coastal groynes or chocked by sediment from runoff from cleared land. The IPPC report of 2007 alerted even skeptical scientists to the urgency of climate change issues. However, in the past 2 years, change is accelerating so that consequences of climate change (e.g. sea-level rise) maybe years rather than decades away.

Societal importance: Coastal lagoons are highly productive coastal systems and their shallow harbors and beauty have long attracted human settlement. The lagoons have provided a wealth of shellfish and fish, salt, sand and gravel providing a bounty of ecosystem goods and services. Homes, holiday homes, hotels proliferate around them, and whole cities maybe built on them or around them. They are important cultural centers as well as important natural habitats for water birds and dugongs.

Timeliness of working group: the new data on the rate of climate change and sea-level rise make these issues urgent. Venice is about to install an enormously expensive flood defense system that may well be inadequate in a few years. New discoveries about ecosystem change, tipping points and regime shifts are vital to our understanding of coastal lagoon ecosystems. This is a new opportunity, to address some of the intractable issues that hamper progress in management, conservation and restoration of lagoons alongside mitigation and adaptation to change.

Advantages of the SCOR mechanism: Scientists working on lagoons meet each other fleetingly at big international conferences such as ASLO or CERF where they have proposed a special session, (see list of previous activities of members on page 3), at but there is no time to fully discuss and synthesize the information, especially on a global scale. The SCOR mechanism would bring international scientists together for a week at a time, time enough to prepare papers and chapters together.

Benefits of International Approach: One of the problems of coastal lagoon scientists even finding each others' research is the variety of names that coastal lagoons have. *Ria* in Portuguese, *Lagoa* in Brazilian, *Marismas* in Spanish, *Cienaga* in Venezuelan, *Bays* in Maryland, *Etang* in French, *Laguna* in Italian… This certainly doesn't help in Web of Science searches! The working group will bring together lagoon experts from N. America, S. America, Europe, Africa, Asia, Australia and Central America to work together on a timely synthesis of coastal lagoon science in the context of global change.

Complementary sources of funding: Additional funding may sought from lagoon networks such as the Italian "Lagunet", the Portuguese "Planet" and the Spanish "Red Marismas". The proposed Chairperson of the WG is also Chairperson of LOICZ: Land –Ocean Interactions in the Coastal Zone, core project of IGBP and IHDP, the International Geosphere-Biosphere Programme and the International Human Dimension Programme for research into global change. Additional funding may also be sought from LOICZ, IGBP and IHDP. Whenever possible, the Working Group meetings will be held in conjunction with other meetings to save both travel time and money.

Relevance to other Activities of SCOR and other International Organizations:
Several of the themes that we wish to explore are relevant to some of the other working groups, past and present. Certainly there are links to WG 122 and also to the new Hypoxia working group. The proposed themes and activities are relevant to LOICZ, IGBP, IHDP and IPPC.

Terms of reference: the working group will synthesize information on Coastal Lagoons on a global scale with respect to 4 main themes.

Theme 1: Vulnerability of lagoons to change and multi-stressor effects;
Theme 2: Societal and economic value of lagoon ecosystems;
Theme 3: Human risk and vulnerability to change in lagoons;
Theme 4: Conservation, management, restoration, mitigation, adaptation.

The mechanism will be a series of 4 meetings spaced over the 4 years of the WG "life cycle". The European networks are well established so the WG meetings will be held in Morocco, Brazil, India and Colombia to facilitate the globalization of the network. The meetings will last 5 days and will include a field trip to a local lagoon. The final meeting will lead up to the 1st International Conference on Coastal Lagoons and the inauguration of a Global Association of Lagoon Science (GALS).

Products:
- Four joint LOICZ-SCOR reports with the outcomes of each of the 4 meetings
- Four pamphlets targeted at managers and policy makers, synthesizing the outcomes of each of the 4 meetings and making recommendations related to the 4 themes.
- A special issue of *Hydrobiologia* and /or a special issue of Estuarine and Coastal Shelf Science
- A book on lagoons in the context of global change

Proposed Working Group Composition:

Name	**Gender**	**Geographical representation or Nationality**	**Expertize**	**Membership**
Alice Newton	F	UK	Global change and lagoons	1 Chairperson
William Dennison	M	USA	Human impact assessment and reporting	2 Full
Saida Niazi	F	Morocco	Sea Level change	3 Full
Masumi Yamamuro	F	Japan	Ecosystem change	4 Full
Timothy Carruthers	M	Australia	Ecosystem impact or multi-stressors	5 Full
Purvaja Ramachandran	F	India	Driver- Pressure- State –Impact-Response	6 Full
Elisa Fernandes	F	Brazil	Pollutant dispersion	7 Full
Rutger de Wit	M	France	Aquaculture and fisheries	8 Full
Georg Umgeisser	M	Germany	Disaster Impact and Mitigation, Floods	9 Full
Gianmarco Giordani	M	Italy	Biogeochemical cycles	10 Full
Ana Cristina Cardoso	F	Portugal	Link to policies	11 Associate
Angel Rufaza	M	Spain	Eutrophication impacts	12 Associate
Juan Restrepo	M	Colombia	Erosion and sediment supply	13 Associate
Pierluigi Viaroli	M	Italy	Hypoxia- Dystrophic crises	14 Associate
Sergej Olenin	M	Lithuania	Non indigenous species	15 Associate
Snejana Moncheva	F	Bulgaria	Toxic algal blooms	16 Associate
Ayshen Ergin	F	Turkey	Tourism and leisure, marinas	17 Associate
Magdy Khalil	M	Egypt	Water, mineral, sediment and salt extraction effect	18 Associate
To be determined			Valuing lagoon ecosystem goods and services	19 Associate
To be determined			Human health and risk	20 Associate

Previous activities of the members

September 2003: Special Session on Coastal Lagoons at Estuarine Research Federation Conference "Estuaries on the Edge" Seattle, USA, 14th to 18th September 2003

November 2003: 1st European Lagoon Conference Southern European Coastal lagoons: the influence of River basin- Coastal Zone interactions Ferrara, Italy 10th-12th November 2003

October 2005: 2nd European Lagoon Conference, Klaipeda Lithuania 4-9 Oct. 2005

June 2006: workshop on Coastal lagoons Research and Management in the International symposium "Research and Management of Eutrophication in Coastal Ecosystems" 20-23 June 2006 in Nyborg, Denmark

November 2007: 1ST LAGUNET Conference, 3rd European Conference on Lagoon Research at Naples, Italy 19-23rd November 2007

May 2009: LOICZ crosscutting workshop on Coastal Lagoons, Rabat (Workshop Co-organizer)

Planned activity:

December 2009: 4th European Conference on Lagoon Research, 14-18 Dec. Montpellier, France
http://www.ecolag.univ-montp2.fr/lagoon-conference

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SCOR SCIENTIFIC SUBSIDIARY BODIES - as of August 26, 2009

		CHAIR / CO-CHAIR	*REPORTER*
WORKING GROUPS			
WG 111	Coupling Waves, Currents and Winds in Coastal Models	Huang/Mooers	Mysak
WG 122	Mechanisms of Sediment Retention in Estuaries	Perillo/Syvitski	Sundby
WG 124	Analyzing the Links Between Present Oceanic Processes and Paleo-records (LINKS)	Lochte/Sicre	Compton
WG 125	Global Comparisons of Zooplankton Time Series	Mackas/Verheye	Pierrot-Bults
WG 126	Role of Viruses in Marine Ecosystems	Weinbauer/ Wilhelm	Kuparinen
WG 127	Thermodynamics and Equation of State of Seawater	McDougall	Mysak
WG 128	Natural and Human-Induced Hypoxia and Consequences for Coastal Areas	Zhang/Gilbert	Burkill
WG 129	Deep Ocean Exchanges with the Shelf	Johnson/Chapman	Mysak
WG 130	Automatic Plankton Visual Identification	Benfield /Culverhouse	Burkill
WG 131	The Legacy of in situ Iron Enrichment: Data Compilation and Modeling	Boyd/Bakker	MacCracken
WG 132	Land-based Nutrient Pollution and the Relationship to Harmful Algal Blooms in Coastal Marine Systems	Glibert/Bouwman	Kuparinen
WG 133	OceanScope	Rossby/Kuh	Feeley
WG 134	The Microbial Carbon Pump in the Ocean	Jiao/Azam	Sundby
WG 135	Hydrothermal Energy Transfer and its Impact on the Ocean Carbon Cycles	Le Bris/German	Feeley
SCIENTIFIC STEERING COMMITTEES, PANELS, etc			
GLOBEC	Global Ocean Ecosystem Dynamics SSC	Perry	Burkill
GEOHAB	Global Ecology and Oceanography of Harmful Algal Blooms SSC	Raine/Kudela	Hong
SOLAS	Surface Ocean - Lower Atmosphere Study SSC	Wallace/Takeda	Hong

IMBER	Integrated Marine Biogeochemistry and Ecosystem Research TT/SSC	Hall/Roman	Sundby
	GEOTRACES	Anderson/ Henderson	Sundby
IOCCP	International Ocean Carbon Coordination Project	Sabine	Fennel
	Panel on New Technologies for Observing Marine Life	Rogers	Feeley
	Committee on Capacity Building	Ittekkot	Sundby
	SCAR/SCOR Expert Group on Oceanography	Rintoul/Hofmann	Kuparinen

AFFILIATED PROGRAMS

CoML	Census of Marine Life	Poiner	Burkill
iAnZone	International Antarctic Zone	Orsi/Bergamasco	Kuparinen
IMAGES	International Marine Global Changes	Peterson	Compton
InterRIDGE	International RIDGE Studies	Lin/German	Labeyrie
IOCCG	International Ocean Colour Coordinating Group	Yoder	Kuparinen
	Ocean Mixing Processes	McKinnon	Fennel

PARTNER ORGANIZATIONS

IGBP	International Geosphere-Biosphere Programme	Nobre	Fennel
POGO	Partnership for Observation of the Global Oceans	Haymet	Burkill
SCAR	Scientific Committee on Antarctic Research	Kennicutt	Kuparinen
SCOPE	Scientific Committee on Problems of the Environment	Sala	Pierrot-Bults
IOC	Intergovernmental Oceanographic Commission	Valladares	Fennel
WCRP	World Climate Research Programme	Busalacchi	MacCracken
PICES	North Pacific Marine Sciences Organization	Wada	Hong
AOSB	Arctic Ocean Science Board	Loeng	Kuparinen