2.0 WORKING GROUPS

2.1 Disbanded Working Groups

2.1.1 WG 129: Deep Ocean Exchanges with the Shelf (with IAPSO) *Urban* (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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Gordon Swaters	CANADA
Olga Trusenkova	RUSSIA

Associate Members

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Xavier Durrieu de Madron	FRANCE
John Middleton	AUSTRALIA
Pedro Monteiro	SOUTH AFRICA
Jonathan Sharples	UK

The group completed its work by publishing a special issue of *Ocean Science:* Dee*p ocean exchange with the shelf, Editor(s): J. Johnson and P. Chapman. The special issue included the following papers (in order of publication). *Ocean Science*, as with other open-access journals, publishes the papers online and assigns a digital object identifier (DOI) when the paper is accepted for publication, so the first paper accepted does not need to wait for the last to be accepted.

The Kuroshio exchange with the South and East China Seas
T. Matsuno, J.-S. Lee, and S. Yanao
Ocean Science 5:303-312, 2009

A review of the role of submarine canyons in deep-ocean exchange with the shelf
S.E. Allen and X. Durrieu de Madron
Ocean Science 5:607-620, 2009

Deep ocean exchange with west-European shelf seas
J.M. Huthnance, J.T. Holt, and S.L. Wakelin
Ocean Science 5:621-634, 2009

Carbon export and sequestration in the southern Benguela upwelling system: lower and upper estimates
H.N. Waldron, P.M.S. Monteiro, and N.C. Swart
Ocean Science 5:711-718, 2009

Transformation of an Agulhas eddy near the continental slope
S. Baker-Yeboah, G.R. Flierl, G.G. Sutyrin, and Y. Zhang
Ocean Science 6:143-159, 2010

Surface expression of Mediterranean Water dipoles and their contribution to the shelf/slope – open ocean exchange
N. Serra, I. Ambar, and D. Boutov
Ocean Science 6:191-209, 2010

Malvinas-slope water intrusions on the northern Patagonia continental shelf
A.R. Piola, N. Martínez Avellaneda, R.A. Guerrero, F.P. Jardón, E.D. Palma, and S.I. Romero
Ocean Science 6:345-359, 2010

Exchange across the shelf break at high southern latitudes
J.M. Klinck and M.S. Dinniman
Ocean Science 6:513-524, 2010

The role of continental shelves in nitrogen and carbon cycling: Northwestern North Atlantic case study
K. Fennel
Ocean Science 6:539-548, 2010

The influence of the Brazil and Malvinas Currents on the Southwestern Atlantic Shelf circulation
R.P. Matano, E.D. Palma, and A.R. Piola
Ocean Science 6:983-995, 2010

Influence of cross-shelf water transport on nutrients and phytoplankton in the East China Sea: a model study
L. Zhao and X. Guo
Ocean Science 7:27-43, 2011

Preface "Deep Ocean Exchange with the Shelf (DOES)
J. Johnson and P. Chapman
Ocean Science 7:101-109, 2011

The group also updated its bibliography (see http://www.scor-int.org/Working_Groups/WG129/SCOR%20WG129%20DOES%20Bibliography.pdf). The group recommended that an atlas of continental shelf characteristics be produced. Having completed its work, the group was disbanded.

2.2 Current Working Groups

2.2.1 WG 125: Global Comparisons of Zooplankton Time Series (2004) *Costello*

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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Anthony Richardson	AUSTRALIA USA	Welbjørn Melle	NORWAY – Sponsored by ICES
Andy Solow		Luis Valdes	SPAIN

Executive Committee Reporter: Mark Costello

The group's special issue of *Progress in Oceanography* is nearly completed and there should be a final report from the group by the time of the SCOR meeting.

2.2.2 SCOR/IAPSO WG 127: Thermodynamics and Equation of State of Seawater (2005) *Morozov*

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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Brian King	UK
Giles Marion	USA
Frank Millero	USA
Petra Spitzer	GERMANY
Dan Wright	CANADA

Associate Member:

Rich Pawlowicz	CANADA
Steffen Seitz	GERMANY
Peter Tremaine	CANADA

Executive Committee Reporter:

Report to SCOR and to IAPSO from SCOR/IAPSO WG127

June 2011

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) (deceased 8th July 2010)

Associate Members

Peter Tremaine (Canada)
Steffen Seitz (Germany)
Rich Pawlowicz (Canada)

Working Group Meetings

SCOR/IAPSO WG127 has not met since the final (4th) meeting in September 2009 in Arnhem, the Netherlands.

Assessment of Progress

The 2010-2011 year started very badly for WG127 with the tragic and untimely death of one of our key members, Dan Wright of Canada. Dan played a central role in most of the achievements of SCOR/IAPSO WG127, and we still miss his energy and his wisdom.

2-8

Since the adoption of TEOS-10 by IOC in June 2009, the efforts of WG127 have centered on providing the oceanographic community with computer software and appropriate documentation to implement the new thermodynamic to the properties of seawater, ice and of humid air. The major outcomes of WG127 in the past twelve months can be listed as follows

- In mid 2010 two papers appeared in *Ocean Science* describing the most comprehensive set of ~400 computer functions (the Seawater-Ice-Air (SIA) library).
- In September 2010, the TEOS-10 Gibbs function for sea air (moist air in contact with seawater) was adopted as an IAPWS Guideline at the annual IAPWS meeting at Niagara Falls, Canada. This completes a series of four Gibbs functions, all constructed by Rainer Feistel (pure water IAPWS-09, seawater IAPWS-08, ice IAPWS-06, and sea-air IAPWS-10), which have been issued as Releases and a Guideline of IAPWS and which form the backbone of TEOS-10 for oceanographers.
- In October 2010, our web site www.TEOS-10.org was substantially upgraded by Dr Paul Barker (of CSIRO) and the SIA computer software library was served from this web site, along with version 2.0 of the Gibbs-Seawater (GSW) Oceanographic Toolbox of computer functions (also by Paul Barker of CSIRO). The two introductory documents "What every oceanographer needs to know about TEOS-10" and "Getting Started with TEOS-10 and the Gibbs Seawater (GSW) Oceanographic Toolbox" also appeared on the web site.
- Between October 2010 and May 2011 we have had 6000 hits on our www.TEOS-10.org web site, and 4000 of these visits have also viewed the software page.
- In early June 2011, version 3.0 of both the GSW and SIA computer libraries of TEOS-10 are being released on the www.TEOS-10.org web site. The GSW Oceanographic Toolbox now contains ~160 functions concerned with basic seawater properties and also with the use of TEOS-10 in the analysis of ocean data (geostrophic streamfunctions etc.). Each of the ~160 functions has its own help file.
- Coinciding with the release of version 3.0 of our computer software, we have printed 2000 copies of the introductory document "Getting started with TEOS-10 and the Gibbs Seawater (GSW) Oceanographic Toolbox" and plan to distribute these at upcoming oceanographic meetings (e.g. CMOS in Victoria B.C., and the IUGG in Melbourne, in June 2011) and to the major oceanographic teaching centers where it is hoped that this little document might form part of "Oceanography 101" courses.
- The GFDL/NOAA ocean model MOM4/MOM5 is being modified to be TEOS-10 compliant by a small group at CSIRO (Simon Marsland, Russ Fiedler, Steve Griffies (of GFDL, NOAA) and Trevor McDougall).
- Two members of SCOR/IAPSO WG127 (McDougall and Pawlowicz) are meeting four Seabird staff for a day of discussion in Victoria B.C. on Friday 10th June 2011. Seabird is keen to incorporate TEOS-10 into their software and the managing director and three other staff are coming to this meeting.

- In addition to these activities, we have continued to publish the pipeline of papers on TEOS-10. There are now just a few papers that are yet to appear in print.
- We have an agreement-in-principle from SCOR, IAPSO and IAPWS to combine SCOR/IAPSO WG127 and the Seawater Subcommittee of IAPWS into a single committee in the near future.

Next Steps

WG127 is now busy promoting and guiding the use of TEOS-10 in the oceanographic community, and this work will need to continue for several years. This activity does not, of itself, require face-to-face meetings of the working group.

There are a number of research areas which should be pursued in order to further the science of the thermodynamics of seawater. These science topics will be listed in the terms of reference of the new Joint Seawater Committee of SCOR/IAPSO/IAPWS, but in the absence of funding for face-to-face meetings, these topics will likely advance only slowly. If it is deemed appropriate at a later date to ramp up these activities, they may well be the subject of a subsequent proposal for a SCOR/IAPSO Working Group.

It is now recommended that WG127 continue as a SCOR/IAPSO Working Group until the establishment of the new SCOR/IAPSO/IAPWS joint committee. We in SCOR/IAPSO WG127 will now work on drafting the Terms of Reference of the new committee, and providing suggestions to SCOR, IAPSO and IAPWS regarding membership and the chair, with a view to having this joint committee established before 31 December 2011. As a quick reminder of the topics that will dominate the Terms of Reference of the new committee, we list;

(1) provide advice and support to the oceanographic research community and instrument manufacturers regarding the implementation of TEOS-10,
(2) refine the concepts and algorithms to advance the science of estimating Absolute Salinity,
(3) continue the work on the SI-traceability and the accuracy and long-term stability of IAPSO Standard Seawater,
(4) provide better estimates of seawater properties at high temperature and high salinity (for use, for example, in cooling towers of power stations and in desalination plants),
(5) encourage the use of alternative measuring technologies in the ocean (e.g. refractive index and densimeter measurements) which bear on the questions surrounding the several different definitions of salinity.

Trevor J McDougall
Chair, SCOR/IAPSO Working Group 127

2.2.3 WG 130: Automatic Visual Plankton Identification *Costello* (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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Executive Committee Reporter: Mark Costello

SCOR Working Group 130 Annual Report
Held at the PICES ZPS meeting 17th March 2011 Pucon Chile

Phil Culverhouse, Mark Benfield

Abstract
This report summarises the outputs of the SCOR WG130 and includes a report on the dissemination workshop on Automated Plankton Identification held at the Zooplankton

production Symposium in Pucon, Chile on 16 March 2011 convened by Mark Benfield and Phil Culverhouse. This report closes the business on working group 130.

Introduction

As a final dissemination output of the SCOR WG130 the PICES sponsored Zooplankton Production Symposium supported a workshop on automated visual plankton identification. Mark Benfield and Phil Culverhouse convened the workshop. The agenda is shown in Figure 1.

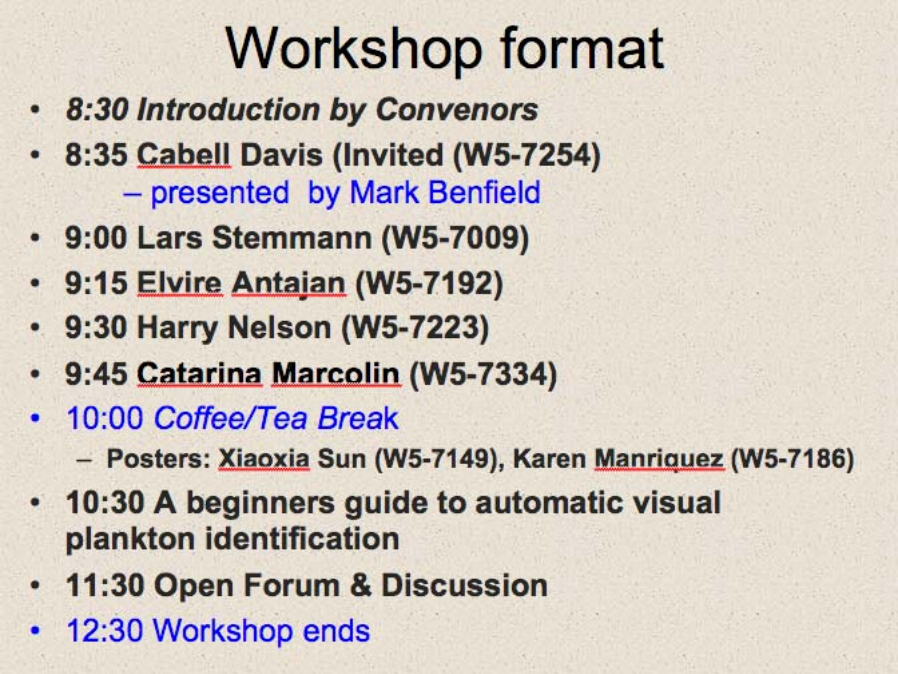

Figure 1. The agenda for the workshop

The workshop on Automated Plankton Identification was very well attended by a diverse range of users of *in situ* and laboratory systems and perhaps more importantly by people who are interested in adopting these new technologies.

The speakers gave a good introduction to current uses of the computer-based image analysis technologies, with three of the speakers comparing existing and new technologies, and one highlighting the development of a new semi-automatic system for high volume processing of biological sample data using Zooscan that automatically outputs data for use of the ecological modelling community.

Mark Benfield and Phil Culverhouse went through a demonstration of how one can use open source software and commercially available inexpensive hardware to semi-automatically process

plankton samples. This live demonstration was well received and one delegate commented that he had almost given up on the technology but was given a new sense of purpose as a result of this workshop.

The main discussion topics were instrument inter-calibration and accuracies of systems, as well as producing a means of globally accessing analysed and labelled image data sets and the creation of standards for specimen preparation prior to image collection. The issue of training workshops/summer schools was high in the agenda, as delegates felt there was insufficient funding to support the demand for PhD training in automated visual plankton identification. This type of new technology is best introduced through PhD training, as PhD students are often well placed to take up the challenges of new concepts and new work practices.

The workshop provided an opportunity to expand the membership in an international collaboration (RAPID). We have started a FaceBook page, although it was clear that some of the participants felt that social networking was not the preferred means of online collaboration, so we will look into some alternatives.

Progress against terms of Reference

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***.

   The group has been operating since 2007 and has held annual four meetings, in Hiroshima, Japan; São Paolo, Brazil; Baton Rouge, USA; and Villefranche, France. Meetings have always included presentations from commercial hardware developers (Flowcam, Zooscan, UVP), open-source software developers (Plankton identify, Zooimage, matlab toolkit, PICT and PAS) and also end-users from a variety of marine laboratories in addition to members and associate members of Working Group 130. The mix of backgrounds has made for interesting discussions and over time fostered collaborations across these diverse fields. So, as a direct result of the formation of WG130 all the laboratories below have established strong links:

   - Louisiana State University, Department of Oceanography and Coastal Sciences, 2179 Energy, Coast and Environment, Baton Rouge, LA 70803 USA
   - Centre for Robotics & Neural Systems, SoCaM University of Plymouth, Plymouth, PL4 8AA. UK
   - Department of Biology, Woods Hole Oceanographic Institution, Woods Hole, MA, 02543, USA
   - Numerical Ecology of Aquatic Systems, Mons University, Belgium

- Biological Oceanography, Marine & Coastal Management (Research, Antarctica and Islands), Rogge Bay 8012, Martin Hammerschlag Way, Foreshore, Cape Town, SOUTH AFRICA
- Department of Palaeontology, The Natural History Museum, UK
- CNRS/UPMC, LOBEPM, La Darse, 06234 Villefranche sur mer cedex 4, France
- Marine Scotland, Marine Laboratory, Zooplankton Ecology Group, PO Box 101, Victoria Road, Aberdeen, AB11 9DB UK
- Instituto Oceanografico, Universidade de Sao Paulo, Praça do Oceanografico 191, São Paulo, BRAZIL
- Shirshov Institute of Oceanology, Russian Academy of Sciences, Russia
- Optics Department, Division of Applied Physics, CICESE, Mexico
- Stazione Zoologica 'Anton Dohrn' Napoli, Italy
- Bigelow Laboratory for Ocean Sciences, USA
- Centro Oceanográfico de Gijón, Instituto Español de Oceanografía, Spain
- AZTI (Institute for Fisheries and Food Science), Spain
- JAMSTEC, Japan
- Institute of Oceanology, Chinese Academy of Sciences, PRC
- Plymouth Marine Laboratory, UK
- Sir Alistair Hardy Foundation for Ocean Science, Plymouth UK.
- Marine Scotland, Aberdeen, Scotland UK.
- INIDEP, Mar del Plata, Argentina

The links have been forged through meetings, and joint publications and joint research experiments between WG130 members, associate members and guests to WG130 meetings. This represents a significant proportion of the research community in the domain of computer-based visual identification of plankton.

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 labelling instruments.***

   Although it is still early days to be definitive in terms of taxonomic resolution, a number of papers have already been published that demonstrate the resolution of image-based plankton identification (please refer to the publications list in annex F, SCOR WG130 Annual report 2010).

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

   This has been completed in two stages. The first report was tabled to SCOR in 2008, the

second and final report was completed and included in the 2010 report. Also, it has been published on the SCOR WG130 website. The recommendations of this sub-group are a set of plankton taxa that can be monitored using automatic means, and also those that need to be monitored, and for which standard type-specimen collections must be established. Gorsky and others at LOV are constructing an archive of vignettes taken from Zooscan-processed samples. These archives are available as training sets for other Zooscan users. The Ocean Weather Station India samples are being processed in the same manner and will also form a reference data set in the future.

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

Tabled as a group discussion item in year one of the WG130, we now have established both a set of experiments to explore inter-calibration between instruments, but also to define the relationship between machine performance and human performance. Some of these experiments have been delayed by difficulties experienced in transporting plankton across international boundaries. However, we now are in a position to describe inter-calibrations between FlowCAM instruments through the use of Zoo/PhytoImage, and between a high-resolution digital camera, a scanner with ZooImage and Zooscan using Plankton identify.

There have been seven inter-calibration papers published since 2003 (see Table 1), All except two have been authored by at least one SCOR WG130 member. Four reviews have been published in this period; all were senior authored by SCOR WG130 members except Morales (2008), who cites the need for automation to cope with the decline of taxonomists in South America. There is also a trend in publications of increasingly large-scale studies, with one global-scale publication in 2008 (Stemmann et al. 2008). We can expect more of these extensive studies in the future.

year	total per annum	techniques	intercalibration	local studies	large studies	global studies	reviews	SCOR WG130 members
2003	10	4	1	5				5
2004	6	4		2				2
2005	5	4			1			3
2006	6	3		2			1	3
2007	12	8	1	1	3		1	5
2008	12	5	1	2	3	1	1	5
2009	15	5	2	3	4			10
2010	16	10	2	1	2		1	12

Table 1: Publications relating to automatic plankton identification 2003-2010

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***.

There are two truly open-source software toolkits being distributed at present:

Zoo/PhytoImage (Gosjean et al. 2004 for example) & ZooProcess/Plankton identify (Gorsky et al. 2010, for example). Both groups acknowledge that metadata is the most important facet of a sample that can form the basis of a common exchange format, both are contributing to the discussions on metadata and standards. It is also acknowledged that the DarwinCore2 metadata definition addresses many of the issues required of an exchange format. Both software toolkits offer links to a range of input devices, including flat-bed scanners, digital cameras, FlowCAM, Zooscan and UVP for example. Several SCOR WG130 members and associate members have had published, or plan to publish, inter-calibration and performance issues of these.

Four reviews have been published since 2003 (see Table 1); all were senior authored by SCOR WG130 members except Morales (2008), who cites the need for automation to cope with the decline of taxonomists in South America. The first review gave rise to the Research in Automatic Identification of Plankton (RAPID) group, a precursor to SCOR WG130. There is also a trend in publications of increasingly large-scale studies, with one global-scale publication in 2008 (Stemmann et al, 2008). We can expect more of these extensive studies in the future.

Review articles offer a way of promoting new ideas and methods in an easily digestible form for people new to the field. We report that Culverhouse et al. (2006) has been cited 16 times, and Benfield et al. (2007) has nine citations with all citations being to new authors. The groundbreaking Tara Oceans Project (http://oceans.taraexpeditions.org) identifies both reviews as defining the requirements of automation. It is too early to assess the impact of Sieracki *et al.* (2009). In her review of plankton monitoring and analysis in the oceans, capacity building requirements and initiatives in Latin-America, Morales (2008) places computer-based visual identification of plankton into the context of South American marine ecology. Three papers cite SCOR WG130 in their acknowledgements. The working group has also held a special session of the Summer ASLO/NABS meeting (June 4-9th 2010 Santa Fe, USA) on computer-based visual identification of plankton. Six papers were presented and the session was well attended.

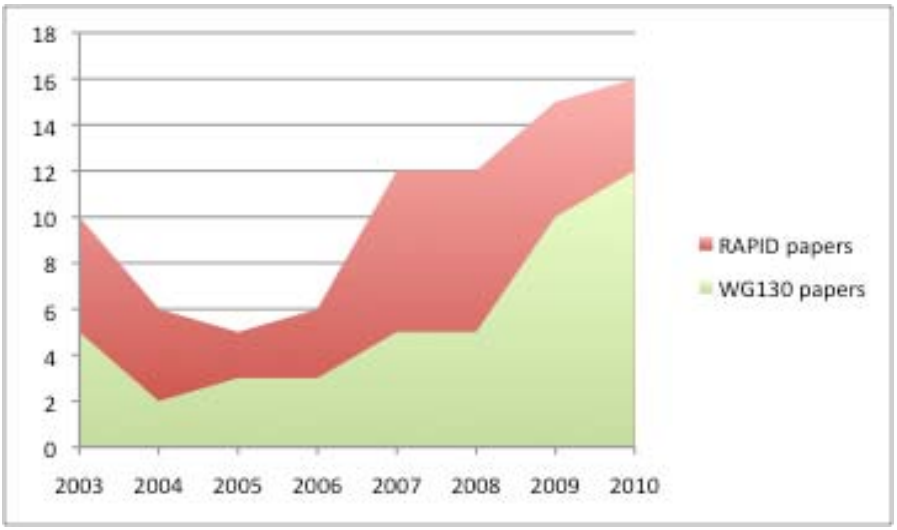

Figure 2: Research in Plankton identification - publications by year

The editors of *Nature* invited the working

group to submit an opinion article on automatic identification (MacLeod, Benfield and Culverhouse, 2010). This article acknowledges the value of SCOR WG130 in bringing a group together to collaborate on a new technology theme and developing it over a period of time.

We acknowledge the delays in getting experimental work completed and analyzed in time for an expected *Journal of Plankton Research* (JPR) publication in 2010. However, we are still in discussions with the editor of JPR on a special issue call. We are also in discussions with book publishers. Finally, the WG130 were invited to plan a conference one-day workshop on computer-based visual identification of plankton at the Zooplankton Productivity Meeting to be held in Pucon, Chile in March 2011. This has been delivered and reported above.

Conclusions

The Working Group has taken time to bond and become productive, but now it is cohesive. The members are becoming clearer in the needs of the wider community and we expect the *Nature* paper, the JPR special issue, the ZPS meeting in Pucon, and discussions with a book publisher to continue to raise the profile of computer-based visual identification of plankton. A strength of the group is that we represent both commercial and low-cost methods for automation, which will give both government laboratories and university laboratories in developed and developing countries access to the same quality of computer tools.

It is interesting to speculate on the growth of this field, Figure 2 suggests that we are still at the stage of early adopters to the technology and perhaps on the cusp of wider take-up, given the year-on-year growth in publications since 2005. The productivity of the SCOR WG130 members and associate members is plotted on the same graph against total publications in the field and indicates that our group is highly productive. The complete publications list has been made available on our SCOR WG130 website.

SCOR WG130 members continue to collaborate on Ocean Weather Station India data set experiments on inter-calibration. It is expected products of the working group's experiments will continue to be published in journals in the coming year. However, this is outside the life of SCOR WG130, which has been running since 2007, with additional funding being obtained by working group members since its inception to support the five-year programme of activities and meetings.

The members and associate members of this working group have decided to continue for another 4-year term, to continue to support the adoption of new software technology and to act as focus for innovation. This will be operated under the RAPID name, with a Facebook page to act as focus for grow our membership. A strong international effort is required to compensate for the decline in people skilled in plankton taxonomy. Growing the associated membership to fully include all research groups will further strengthen and facilitate growth in this important area.

We are currently seeking funding to assist in this goal.

Finally we would like to thank SCOR for supporting this working group's activities.

References

1. (cites WG130) Lerma-Aragn JR and lvarez-Borrego J (2009). Vectorial signatures for invariant recognition of position, rotation and scale pattern recognition. *Journal of Modern Optics.* Volume 56, Issue 14 August, pages 1598 1606.
2. (cites WG130) Sieracki,M.E.,Benfield,M.,Hanson,A.,Davis,C.,Pilskaln,C.H.,Checkley,D.,Sosik, H.M., Ashjian, C., Culverhouse, P., Cowen, R., Lopes, R., Balch, W., Irigoien, X., Optical Plankton Imaging and Analysis Systems for Ocean Observation, in Proc. *OceanObs09: Sustained Ocean Observations and Information for Society* Conference (Vol. 2), Venice, Italy, 21-25 September 2009, (Hall, J., Harrison D.E. and Stammer, D., Eds), ESA Publication WPP-306, 2010.
3. (cites WG130) Gorsky G Ohman MD, Picheral M, Gasparini S, Stemmann L, Romagnan J-B, Cawood A, Pesant S, Garci-Comas C and Prejger F (2010) Digital Zooplankton Image Analysis System. JPR volume 32 number 3 pages 285303.
4. (cites WG130) MacLeod N, Benfield M & Culverhouse P (2010) Time to Automate Identification. *Nature* 467 pp. 155-156 9 September 2010.

   This last one was developed by the group, but *Nature* required a small authorship list. The best we could offer for acknowledgement was the value of SCOR in bringing us together.

   Also if you are considering outputs from the group then this must be included, with 7 members and associate members focussing on the wider context of automated identification.

5. Benfield MC, Grosjean P, Culverhouse PF, Irigoien X, Sieracki ME, Lopez-Urrutia A, Dam HG, Hu Q, Davis CB, Hansen A, Pilskaln CH, Riseman E, Schultz H, Utgoff PE, and Gorsky G (2007) RAPID: Research on Automated Plankton Identification. *Oceanography* 20(2), pp. 12-26.

2.2.4 WG 131: The Legacy of in situ Iron Enrichment: Data Compilation and Modeling *MacCracken* (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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2-20

WG131 The legacy of in situ iron enrichment experiments

Annual report June 2011

The data collected in purposeful in situ iron enrichment experiments provide a valuable resource for understanding and modeling the functioning of the marine food web and carbon cycling in response to iron addition. Working Group 131 of the Scientific Committee on Oceanic Research (SCOR WG-131) has assembled the data and metadata for 9 in situ iron enrichment experiments in open access databases at the Biological and Chemical Oceanography Data Management Office (BCO-DMO, http://bco-dmo.org) and Pangaea (http://wdc-mare.org/) (Table 1). The data compilation ensures safe data storage and is a valuable resource for data access. In the last twelve months we have completed as much of the data and metadata collection as possible and have focused on:

a) Completion of the SEEDS II data and metadata compilation.
b) Filling in a 'hit list' of missing data and metadata for other studies in which we have already assembled most of the datasets.
c) Made further (unfortunately fruitless) attempts to entrain the Eifex community to provide data from their Southern Ocean experiment (they still have a data embargo as they have been trying to publish a high-profile manuscript on their experiment for the last four years).
d) Strengthened links between the BCO-DMO and Pangaea data management teams through valuable interactions and discussions between Cyndy Chandler and Reiner Sieger, respectively. This will facilitate easier access to the Eisenex datsets which reside on Pangaea.

Summary Table 1. An overview of the purposeful iron enrichment experiments which have participated in the SCOR WG131 data compilation effort. For summaries of each experiment, see Boyd et al. (2007).

Experiment	Data availability	Data base
IronEx I*	Few data	BCO-DMO
IronEx II	Most data	BCO-DMO
SOIREE	Most data	BCO-DMO
EISENEX	Most data	Pangaea
SEEDS I	31 data sets	BCO-DMO
SOFeX-S	(38) data sets	BCO-DMO
SOFeX-N	(38) data sets	BCO-DMO
SERIES	Most data	BCO-DMO
SEEDS II	Most data	BCO-DMO
SAGE	Most data	BCO-DMO
Eifex	No data	

*denotes that the experiment failed as the iron-labelled subducted under less dense waters after a few days.

References

Boyd, P.W., T. Jickells, C. S. Law, S. Blain, E.A. Boyle, K.O. Buesseler, K.H. Coale, J. J. Cullen, H.J.W. de Baar, M. Follows, M. Harvey, C. Lancelot, M. Levasseur, N.P.J. Owens, R. Pollard, R.B. Rivkin, J. Sarmiento, V. Schoemann, V. Smetacek, S. Takeda, A. Tsuda, S. Turner, A. J. Watson (2007) Mesoscale Iron Enrichment Experiments 1993–2005: Synthesis and Future Directions. Science 315, 612. doi: 10.1126/science.1131669.

In order to further communicate the availability of these datasets in the public domain, we had planned a workshop for 2011/12 that would have involved modelers, experimentalists and observationalists. This was to follow up on the successful launch of the WG131 databases at both AGU/ASLO/TOS Ocean Sciences (Portland) and EGU (Vienna) in 2010.

For a number of reasons this workshop did not materialize, and after discussions with Ed Urban and Mike McCracken we agreed to publicize the WG131 databases using an alternative route. We are currently preparing three popular articles – two shorter ones for *Eos* (Dorothee Bakker is leading this effort) and ESSD (Dorothee Bakker is also leading this with input from the U.S. and European data managers who kindly gave their time to WG131). A further longer article is also being prepared for *Oceanography* magazine, and the proposed outline for this article along with 4-5 colour figures has been well received by the Editor Ellen Kappel last month. The article will be submitted in mid August and will have the following outline.

Merits and legacy of the WG131 database

a) in a post-Lohafex world (Lohafex was the controversial Indo-German experiment that was ordered not to sail from Cape Town, South Africa by the German Government as it was in contravention of a *de facto* moratorium on such large-scale manipulation experiments) – the iron datasets represent a unique repository of physical, chemical, optical, biological and ecological datasets from 9 ocean iron fertilization studies (OIFS)
b) they provide a stern test for model validation - as OIFS were conducted in a wide range of waters from polar, subpolar and tropical sites
c) with the growing interest in geoengineering, these experiments represent some of the largest-scale perturbations on the planet—and reveal unanticipated results of perturbations
d) the indirect response of ecosystems to stimulating the growth of phytoplankton is an invaluable holistic view of the interplay of bottom-up environmental versus top-down ecological shifts in controlling biota that provide valuable insight into how ecosystems may be altered by another perturbation: climate change.

The article will also present two boxes that would should how to access and use this relational database.

Thanks to SCOR for continued support over the last three years.
Philip Boyd and Dorothee Bakker – co-chairs WG 31

Acknowledgements – our part-time research assistants Doug Mackie and Evelyn Armstrong (University of Otago, Otago, New Zealand), and our very helpful and flexible data managers at BCO-DMO (Cyndy Chandler & Steve Gegg) without whom this project would have not come to fruition. Thanks also to Reiner Sieger at Pangaea.

2.2.5 SCOR/LOICZ WG 132: Land-based Nutrient Pollution and the Relationship to Harmful Algal Blooms in Coastal Marine Systems *Taguchi* (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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Executive Committee Reporter: Satoru Taguchi

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 July 2010-June 2011

Patricia Glibert, University of Maryland Center for Environmental Science
Lex Bouwman, Netherlands Environmental Assessment Agency
Working Group Co-Chairs

This report is organized as follows:

I.	Completed work
II.	Ongoing activities, including preparation of the work group results for a journal special issue.
Annex A	The terms of reference and key research questions
Annex B	Members of the work group

I. COMPLETED WORK

SCOR/LOICZ Working Group 132 had its third meeting in October in Glyfada, Greece. The goals of the third work group meeting in October 2010 in Glyfada, Greece were to review model output and further statistically analyze species distribution with respect to nutrient loading, nutrient forms and nutrient ratios, coastal type, and nutrient loading and uptake by marine aquaculture based on the ERSREM model results obtained in the past year.

Specific issues for discussion included:

- Discuss outline for papers special issue.
- Updating of the project website; make data available.
- Discuss other ways to disseminate the data.

The major hypothesis that Working Group 132 tested is that increasing frequency and geographic distribution of HABs is at least in part due to nutrient pollution (Appendix A). Nutrient pollution from land comes via rivers from the runoff and leaching of nitrogen and phosphorus from fertilizers and manure, and from sewage water. One source for which we know very little on the global scale is aquaculture. Both shellfish and finfish aquaculture are currently increasing rapidly in many parts of the world, particularly in Southern and Eastern Asia.

The following activities have been completed:

1. The group used the annual global river export data for sediments and different forms of carbon, nitrogen, phosphorus and silica from the IOC Global Nutrient Export from WaterSheds (Global NEWS) for the period 1970-2000, and the period 2000-2050, as based on the Millennium Ecosystem Assessment (MA) (Seitzinger et al., 2010). In the reporting

year the group developed monthly estimates of river nutrient export based on river discharge including seasonal variation in nutrient ratios, as well as a new model for estimating river export of ammonia and nitrate.

2. Two papers describing the shellfish and finfish nutrient models have been resubmitted in revised form to the journal *Reviews in Fisheries Science*.
3. Routines were developed to combine the HAB maps with the nutrient inputs from rivers from the GlobalNEWS data, the coastal biogeochemistry model (Laruelle, 2009), and the new aquaculture spatial data and the coastal typology (Dürr et al., 2009).
4. Various papers from the work group have been published, are in review or in preparation, including papers on nutrient release from shellfish and finfish aquaculture, global distribution of red and green *Noctiluca*. A list is provided below.

Glibert, P.M. et al., 2010. Modeling of HABs and Eutrophication: Status, Advances, Challenges. *Journal of Marine Systems* 83(3-4):262-275.

Bouwman, A.F., Pawlowski, M., Liu, C., Beusen, A.H.W. and Overbeek, C.C., 2011. Past and projected nitrogen and phosphorus budgets in global shellfish and aquatic plant aquaculture. Revision submitted to *Reviews in Fisheries Science*.

Overbeek, C.C., Bouwman, A.F., Beusen, A.H.W. and Pawlowski, M., 2011. Past and projected nitrogen and phosphorus budgets and the use of feed in global finfish aquaculture. Revision submitted to *Reviews in Fisheries Science*.

Harrison, P.J., K. Furuya, P.M. Glibert, J. Xu, H.B. Liu, K. Yin, J.H.W. Lee, and D.M. Anderson. 2011. Geographical distribution of red and green *Noctiluca scintillans. Chinese J. Oceanology and Limnology. In press.*

II. ONGOING ACTIVITIES

5. An ongoing activity is the comparison of the data organized this way (see #3) with simulations with the POLCOM-ERSEM Global coastal ocean model for NW European shelf & Baltic, Benguela upwelling, Humboldt current, Indonesia and South China seas, Yellow Sea and Sea of Japan, California Current, Bay of Bengal, Mauritanian upwelling. These simulations are based on Global NEWS data and include 20 year hindcast, 20 year pre-industrial (~1860), 20 year future climate simulations (~2080-2100).
6. This comparison of nutrient loading versus production and growth of dinoflagellates (as an indicator of HAB formation) will also involve the data on HAB occurrences (regional time series of HABs and nutrient loading in South America, Gulf of Mexico, U.S.A., Gulf of Oman, and Hong Kong. The purpose is to study relationships between nutrient loading and the occurrence of HABs on the basis of detailed spatial and temporal information on the environmental conditions. This is an ongoing activity which is a guide to the second part of this work, that is, the analysis of relationships between nutrient loading and HAB occurrences at the global scale. The global maps of occurrences of *Prorocentrum minimum, Noctiluca, Pseudo-nitschia* and *Karenia* will be used for this purpose. The collection of such data from literature, reports and other sources to complement these maps has continued through 2010.
7. A special issue of a journal (to be determined- see below) is planned by the Working Group to highlight the emerging relationships between nutrient loads, phytoplankton production,

biomass and HABs. These papers build on the individual papers that have been published or are under review based on ideas developed by the working group.

Several journals have been contacted by the co-chairs to determine suitability. Major concerns are costs for a special issue, especially the cost of multiple color graphics. So far no decision has been made.

A report of the Working Group is also planned for the LOICZ 2011 Open Science Meeting.

References

Dürr, H.H. et al., 2009. World-wide typology of near-shore coastal systems: defining the estuarine filter of river inputs to the ocean. Estuaries and Coasts (in press).

Laruelle, G.G., 2009. Quantifying nutrient cycling and retention in coastal waster at the global scale, Utrecht University, Utrecht, 226 pp.

Seitzinger, S.P. et al., 2010. Global river nutrient export: A scenario analysis of past and future trends. Global Biogeochemical Cycles 23, GB0A08, doi:10.1029/2009GB003587.

Annex A

Terms of reference for the working 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 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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2.2.6 SCOR/IAPSO WG 133: OceanScope *Feeley* (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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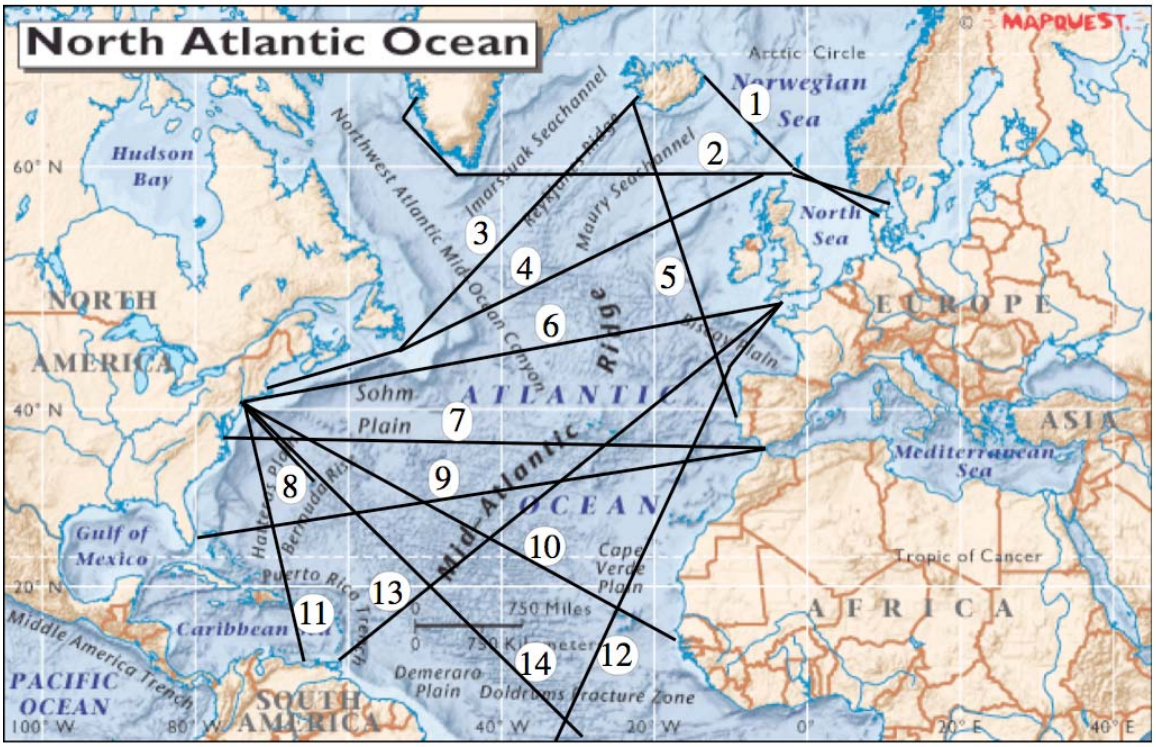
Executive Committee Reporter: Missy Feeley

The group is working with the Reporters (Lawrence Mysak for IAPSO and Missy Feeley for SCOR) and the SCOR Secretariat to produce a report for review. There are a few issues left to work out. The Reporters have begun to identify external reviewers for the report. An update will be available at the time of the SCOR annual meeting.

The report will propose a pilot phase based in the North Atlantic Ocean. The proposed network (which incorporates present commercial shipping routes on some of which oceanographic data are already being collected) would provide coverage of both subgyres (see figure below). Sections 1-6 would focus on the subpolar gyre and its exchanges with the Nordic (1) and Labrador Seas (3). Section 3 cuts across the subpolar gyre near where—according to some studies—the largest shifts in circulation occur. Section 6 corresponds to the frequently occupied 42°N section. Section 5 provides a valuable north-south transect through the eastern part of the subpolar gyre, where it is thought major shifts in the path of the North Atlantic Current/Subpolar Front take place. This section could also monitor the subtropical/subpolar transition of flows south versus north, biomass patterns both at the surface and at depth, and correlations between currents, biomass, and chemical patterns.

The subtropical sections (7-12) provide a mixture of roughly zonal (7-10) and meridional (10-12) coverage. Section 13 from the English Channel to the Caribbean Sea provides a valuable orthogonal (NE to SW) cut across the subtropical gyre. Sections 12 and 14 extend coverage to the equator and beyond. Section 12 would also provide valuable extension of section 5 farther south along the eastern margin of the North Atlantic.



Friday, December 17, 2010

Potential OceanScope routes spanning the North Atlantic Ocean. Routes 1-6 span the subpolar gyre and routes 7-14 the subtropics and tropics.

These routes are not traversed at equal frequency. Section 8 has weekly service; section 2 is repeated every three weeks. Typically, the longer the route, the less frequently it is revisited. This argues for instrumenting more than one vessel for the longer routes. This would not only double the sampling rate but also provide some insurance against complete loss of coverage when a vessel is assigned to another route. For discussion sake, it is assumed that two ships will be employed on routes 6, 9, 10, 12, 13, and 14. That yields a total of 20 vessels. During the Test Bed phase, OceanScope ideally would instrument all 20 vessels with "Core" instrumentation and at least three with additional instrumentation. Moreover, wherever possible OceanScope would integrate with the observations planned by present programs along the same lines. A budget estimating the cost of operating and installing this instrumentation as well as OceanScope administration is provided in the report.

As noted above, some of these lines are already being occupied and oceanographic measurements have been made on others for considerable periods of time. For example, CPR activities have been underway in the North Atlantic nearly a century, XBT operations have been underway for decades, and ADCP operations were started in 1992 on section 8 and 1999 on section 2. All of these and other databases provide a backdrop or point of departure for future activities.

2.2.7 SCOR WG 134: The Microbial Carbon Pump in the Ocean *Sundby* (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.

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Executive Committee Reporter: Bjørn Sundby

Annual Report of SCOR WG134
Microbial Carbon Pump in the Ocean

I. Meetings and Academic activities

1) The second WG meeting and the ASLO Emerging Issues Workshop on the Microbial Carbon Pump (MCP)

(San Juan, Puerto Rico, February 19-20, 2011)

The MCP was selected by the Association for the Sciences of Limnology and Oceanography (ASLO) as an Emerging Issue for the 2011 Aquatic Science Meeting. The second meeting of the SCOR WG134, led by Nianzhi Jiao and Farooq Azam, in conjunction with ASLO Emerging Issues Workshop on the MCP was held in Puerto Rico during February 19-20, 2011. Forty scientists (including the working group members) and students, from 12 countries, attended the workshop.

The workshop focused on discussions of the following topics: the biological origins of persistent DOC and its relationship with the refractory DOC (RDOC) pool in the ocean; analytical approaches to identification and quantification of the sources, sinks, and structural characteristics of RDOC; characterization of major fractions of DOC; supply of DOC from seabed seepage; and GeoChip-based high-throughput monitoring of C-cycling related genes. The group also discussed the need to integrate and reconcile the biological and geochemical processes and time-frames for the production of biologically resistant DOC. How much of the DOC that is transformed by the microbial community becomes recalcitrant compared to the total organic matter turnover? Another topic of discussion was the influence of fossil input on the apparent ^{14}C age of the DOC. The group also discussed the needed analytical approaches to identify and quantify the sources sinks and structural characteristics of RDOC. In addition, some related case studies, such as the finding of *Prochlorococcus* in the dark ocean in West Pacific Warm Pool (WPWP) area and its marginal seas, were also brought to the group's attention.

In order to address some of the MCP questions in the field, the working group proposed joint cruises along environmental gradients to the WPWP and the Arctic. In this context, research proposals are currently being prepared for the UK Natural Environmental Research Council and the Chinese Ministry of Science and Technology. If funded, the plan is then to request IMBER endorsement of the proposed research.

The next WG134 workshop addressing microbial transformation of DOC will be held in Hansa institute for advanced studies, Bremen, Germany in conjunction with the ISME conference in Copenhagen in 2012.

For more information about the SCOR WG134 please visit the SCOR Web site or WG134 Web site at: http://mme.xmu.edu.cn/mcp/eindex.asp.

2) ASLO Special Session 55 on the Microbial Carbon Pump in the Ocean
(February 17-18, 2011 San Juan, Puerto Rico)

The Special Session 55 "Microbial Carbon Pump: A multidisciplinary focus on origins, cycling and storage of DOM in the ocean" was chaired by WG134 members (Gerhard Kattner, Nianzhi Jiao, Farooq Azam and Steven Wilhelm). It attracted about 100 participants including researchers, young scientists and students at the ASLO Aquatic Science Meeting. This special session was comprised of a poster session (February 17) and an oral session (February 18). The main topics were:

- Microbial Carbon Pump: A mechanism for long-term carbon storage in the ocean. Talks presented an overview of the MCP as a formalized mechanistic framework to focus on the on the significance of microbial processes in carbon storage in the refractory DOM reservoir and for testing hypotheses on the sources and sinks of DOM.
- Bacterial contributions to the global ocean refractory DOM pool.
- Microbial carbon cycling in the meso- and bathypelagic North Atlantic and DOM accumulation, transformation and export in the North Atlantic Basin.
- Structural complexity and molecular diversity of the oceanic DOM pool.
- Molecular investigation of composition and surface-to-depth transformation of DOM in the east Atlantic Ocean using FT-ICR MS.
- Links between bacterial metabolism and organic matter origins; role of photoheterotrophic metabolism in carbon cycling; role of viral lysis for the composition and use of organic matter; interactions between autotrophic and heterotrophic bacteria and implications for carbon biogeochemical cycle.
- Linking microbial ecology to the biogeochemistry in the deep ocean using optimum multiparameter analysis.
- Export of DOM from marginal sea to the ocean.

3) Gordon Research Conference on Marine Microbes from genes to global cycles, (Tilton School, NH, USA, July 4-9, 2010)
Chaired by WG134 member David Kirchman and participation by other WG134 members, including Gerhard Herndl and Ingrid Obernosterer (Speakers), Nianzhi Jiao (Discussion leader), the GRC provided an opportunity to discuss microbial processes of carbon cycling and storage in the ocean with other microbial oceanographers.

4) A session on Marine Microbiology (ISME 13, Seattle, USA, August 22-27, 2010)
GW134 member Gerhard Herndl chaired an MCP-relevant invited oral session titled "Marine Microbiology: from the coast to the deep sea."

5) IMBC session on Biotic Carbon Sequestration.
A session on Biotic Carbon Sequestration Chaired by GW134 member Jiao Nianzhi at the 9th International Marine Biotechnology Conference, Qingdao, China, October 8-12, 2010.

6) AAPB workshop (Sept 22-24, 2010, Trebon, Czech Republic)
The workshop was chaired by WG134 member Michal Koblizek, with the aim to bring together microbiologists, environmental microbiologists, biochemists and biophysicists working on Aerobic Anoxygenic Phototrophic bacteria to exchange their ideas. The workshop also featured with technical practice.

7) AGU Fall 2010 Meeting
The MCP conceptual framework was presented in an invited talk by Nianzhi Jiao (Nianzhi Jiao & Farooq Azam, co-authors) at the session B33J-Linkages in Biogeochemical Cycles Between the Surface Ocean and Lower Atmosphere Over the Pacific Ocean of AGU Fall Meeting held at San Francisco, December 13-17, 2010.

8) 11th International Estuarine Biogeochemistry Symposium
The modification of organic matter was presented as a keynote lecture by the WG 134 member Gerhard Kattner (and Boris Koch coauthor: Estuarine and Coastal Transport and Modification of Organic Matter) at Session 5: High & Low Latitude River-Estuarine Systems at the symposium held in Atlantic Beach, NC, USA, May 15-19, 2011

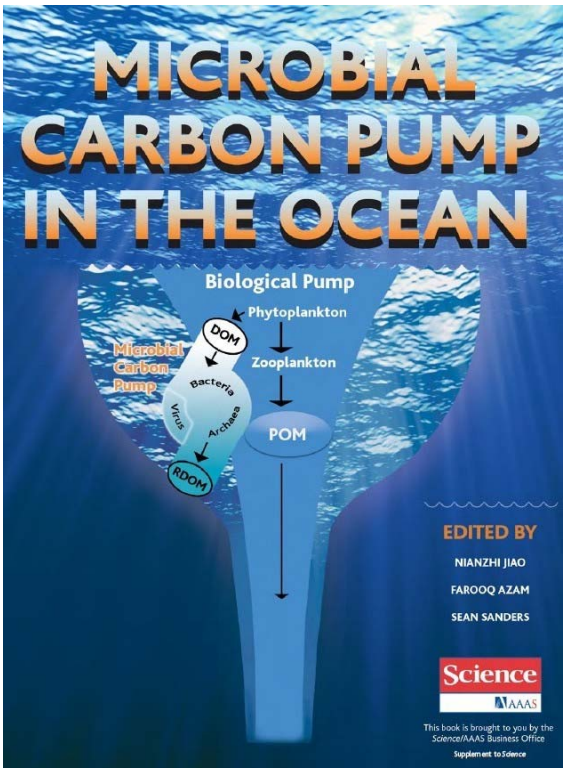
II. WG134 Publications

1) *Science* booklet on Microbial Carbon Pump in the Ocean, Editors: Nianzhi Jiao, Farooq Azam, Sean Sanders. Supplement to *Science***,** May 13, 2011.

This booklet includes 10 papers previously published in *Science* and 10 new articles by WG134 members. The collection covers the topics of microbial control of oceanic carbon flux as well as specific MCP-related topics, including production of RDOC by bacteria; chemical characteristics of DOC; community genomics of microbial assemblages; radiocarbon ages of organic compounds; biological carbon sequestration and carbon fixation; effects of bacterial activity on DOC composition; recognition of functional bacterial groups as energy and carbon sources; bacterial respiration of DOC under changing environmental conditions; viral lysis mediated redistribution of DOC; linking DOC export from the euphotic zone to microbial community structure; molecular characterization of DOC and constraints

for prokaryotic utilization; spectroscopic characterization of DOC; and application of GeoChips in monitoring carbon cycling and mechanistic modeling of DOC degradation.

The booklet appeared as a "Supplement to *Science*" on MCP, distributed worldwide with the *Science* May 13, 2011 issue. The electronic version is is available (free access) on the *Science* website at the following link: http://science.imirus.com/Mpowered/book/vscim11/i2/p1



2) ASLO Emerging issue workshop report, *Limnology and Oceanography Bulletin* 20 (2) June 2011, 37-38.

3) SCOR – ASLO Workshop on the Microbial Carbon Pump
Challenger Society for Marine Science, *Challenger Wave* – March 2011: 8-9

4) AEM special section
A special section on the MCP in *Applied and Environmental Microbiology* will be published in 2011.

III. Research Activities

1) A SOA (State Ocean Administration of China) project on prokaryotic carbon fixation and storage has been launched in 2011. Chief PI: Nianzhi Jiao

2) A proposal to UK Natural Environmental Research Committee (NERC) on the impacts of global warming on plankton community composition, organic carbon export and CO_2 production in the Arctic Ocean (PIs: C. Robison, G. Herndl, N. Jiao, G. Kattner, P. Serret, C. Stedmon) is under way

3) A cruise proposal to the Danish Center for Marine Research has been funded (Leader: C.A. Stedmon), which will be a part of the project "North Atlantic - Arctic coupling in a changing climate: impacts on ocean circulation, carbon cycling and sea-ice." The primary research focus that is relevant to the WG will be using RDOM signature of water masses to differentiate between and trace freshwater from the Arctic Ocean and Greenlandic glacial melt. Cruise will take place in September 2012.

IV. Academic Honors

WG134 member Gerhard Herndl received the Wittgenstein-Prize, the highest Austrian science prize (1.5M €).

2.2.8 SCOR/InterRidge WG 135: Hydrothermal Energy Transfer and its Impact on the Ocean Carbon Cycles *Feeley* (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.

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Wolfgang Bach (Germany)	Philip Boyd (New Zealand)
Loka Bharathi (India)	Thorsten Dittmar (Germany)
Nicole Dubilier (Germany)	Julie Huber (USA)
Katrina Edwards (USA)	Bob Lowell (USA)
Peter R. Girguis (USA)	George W. Luther III (USA)
Xiqiu Han (China-Beijing)	Tom McCollom (USA)
Louis Legendre (France)	W.E. Seyfried, Jr. (USA)
Ken Takai (Japan)	Stefan Sievert (USA)
	Margaret K. Tivey (USA)
	Andreas Thurnherr (USA)
	Toshitaka Gamo (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)

Annual Report 2011

1. Membership

The WG has welcomed a new associated member, Dr Sylvia Sander, from Marine and Freshwater Chemistry, Department of Chemistry, University of Otago, New Zealand. She is specialized in trace metal speciation in natural aquatic systems and has published several papers on the complexation of metals issued from vent by organic ligands (see Sander and Koschinsky in the list below). Beyond providing a very important and complementary scientific expertise, she will add to the international representation of the working group. New Zealand is indeed part of the South Pacific countries that were previously underrepresented in our group.

2. Annual meeting

The annual meeting will take place in Hangzhou, China on 10-11 October 2011. It will be hosted by Xiqiu Han at the 2nd Oceanographic Institute of China. To date, 6 Full Members (Loka Barathi, Pierre Legendre, Ken Takai, Chris German, Nadine Le Bris, Xiqiu Han) and 4 Associate Members (Silvia Sander, Toshi Gamo, Stefan Sievert, George Luther) have planned to attend. Support from InterRidge has been obtained (part of the 10 kUSD dedicated to the final workshop from IR) to for Associate Members' travel costs.

As presented in WG135 terms of reference and detailed in our last report, the meeting will be dedicated to draft two synthesis papers and set the plans for the 2012 international workshop. Synthesis will built on existing publications and on-going studies, particularly from working group members, which have developed at a substantial effort in the last 24 months.

3. Cruises and collaborations

In terms of field programs, the group members have been active in several new collaborative experiments or explorations for which discussions at the SCOR WG level have had significant outcomes. Several projects associating different WG members have been recommended for funding by NSF and are in the process of receiving official approval.

A non-exhaustive list of significant recent or forthcoming cruises is:

1) Fall 2010. MenezMAR cruise on the Mid Atlantic Ridge. (N. Dubilier, Chief scientist, W. Bach co project-leader, invited participants: N. Le Bris and P. Girguis). Interdisciplinary geological, chemical and biological studies at the Menez Gwen hydrothermal vent field on the Mid-Atlantic Ridge, at 37°50' N. Two of the objectives were particularly related to the WG focus: How does conductive heating of seawater and conductive cooling of hydrothermal fluids affect the composition of diffuse fluids and the vent biota? What are the dominant sources of energy for vent life in the subsurface, surface and hydrothermal plume?

2) Summer and January 2011 (C. German): a pair of forthcoming research cruises to the ultra-slow Mid-Cayman Rise with large emphasis on C-org cycling near-seabed and during the buoyant as well as non-buoyant phases of hydrothermal plumes.

3) Fall 2011. IODP drilling leg for deep biosphere (K. Edwards, as co-chief scientist and other WG members, including W. Bach)

4) 2012-2013. GEOTRACES cruise investigating biogeochemical cycling in the Sth EPR hydrothermal plume (as well as Peru upwelling) has (informally) been approved in the United States with C. German as Co-Chief scientist (alongside Jim Moffett for the Peru Margin component).

5) 2012-2013. Indian and Caribbean cruises (K. Takai, with other WG members) particularly focussing on the linkages between geosystem and ecosystem of hydrothermal vent via chemistry.

4. Publications in relation with the WG135 focus

A substantial number of papers have been published by WG members in 2010 and 2011, including several reviews on specific topics (list below). These works significantly expand our knowledge on 1) the rates and metabolisms fuelling autotrophic and methanotrophic carbon fixation, 2) the distribution and structure of chemosynthetic habitats on and below the seafloor and the diversity and variability of available chemical energy sources, 3) the flow of kinetically stabilized iron that can be exported from vents over long distances, and organic carbon export from vents. In addition, a couple of recent publications on the ocean circulation and dynamics near the crest of the EPR has been published (A. Thurner and co-workers), paving the way to further integration for an assessment of the impact of vent-derived material to the ocean carbon deep ocean budgets. An update of German and Von Damn 2004 overview paper on Hydrothermal Processes for the Treatise on Geochemistry can be mentioned, as well as an upcoming publication lead by Chris German and Bill Seyfried.

Publications by WG members (2010-2011):

Breier JA, Toner BM, Fakra SC, M.A.Marcus, S.N.White and C.R. German. Sulfur, oxides and organic matter aggregated in submarine hydrothermal plumes at 9°50'N, East Pacific Rise. Geochim. Cosmochim. Acta, in review.

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Chan, C.S., Fakra, S.C., Emerson, D., Fleming, E.J., Edwards, K.J. 2010. Lithotrophic iron-oxidizing bacteria produce organic stalks to control iron mineral growth; implications for biosignature formation. The ISME Journal 5: 717-727.

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Das, A., Fernandes, C. E. G., Naik, S. S., Nagender Nath, B., Suresh, I., Mascarenhas-Pereira, M. B. L., Gupta, S. M., Khadge, N. H., Prakash Babu, C., Borole, D. V., Sujith, P. P., Valsangkar, A. B., Shashikant Mourya, B., Biche, S. U., Sharma, R. And Loka Bharathi, P. A. 2011. Bacterial response to contrasting sediment geochemistry in the Central Indian Basin. Sedimentology, 58: 756–784.

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Gartman, A., M. Yücel, A. S. Madison, D. W. Chu, S. Ma, C. Janzen, E. L. Becker, R. A. Beinart, P. R. Girguis and G. W. Luther, III. 2011. Sulfide Oxidation across Diffuse Flow Zones of Hydrothermal Vents. Aquatic Geochemistry, in press.

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Hügler M and Sievert SM (2011) Beyond the Calvin Cycle: Autotrophic Carbon Fixation in the Ocean. Annual Review in Marine Science.

Hügler M, Petersen JM, Dubilier N, Imhoff JF, Sievert SM Pathways of Carbon and Energy Metabolism of the Epibiotic Community Associated with the Deep-Sea Hydrothermal Vent Shrimp Rimicaris exoculata (2011). PLoS One, 6, 1, e16018, 1-11.

Humphris, S.E, deMenocal, P.B, Edwards, K.J., Fisher, A.T., Saffer, D. 2011. The critical importance of scientific ocean drilling. EOS Transactions 92(10): 84-85

Kaye, J.Z., Sylvan, J.B., Edwards, K.J., Baross, J.A. 2010. Halomonas and Marinobacter are widespread euryhaline bacterial ecotypes from hydrothermal-vent, subseafloor and deep-sea environments. FEMS Microbial Ecology 75(1): 123-133.

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Luther, III G. W., A. J. Findlay, D. J. MacDonald, S. M. Owings, T. E. Hanson, R. A. Beinart and P. R. Girguis. 2011. Thermodynamics and Kinetics of sulfide oxidation by oxygen: a look at inorganically controlled reactions and biologically mediated processes in the environment.

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J.B.Sylvan, B.C.Pyenson, O.Rouxel, C.R.German & K.J.Edwards. Time series analysis of two hydrothermal plumes at 9°50'N East Pacific Rise reveals distinct, heterogeneous bacterial populations. Geobiology, in review.

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5. Additional information

Of interest to the WG135 is also the support that was provided by InterRidge as part of its fellowship programme to one student (D. Giovanelli) and a post-doc (E. Reeves), who are

conducting studies in direct link with our focus.

D. Giovannelli will visit Costantino Vetriani's laboratories at Rutgers University to develop a project entitled "Analysis of functional gene transcripts in microbial chemosynthetic biofilms from deep-sea hydrothermal vents". The aim of the proposed project is to investigate carbon fixation, respiratory metabolism and quorum sensing mechanisms in chemosynthetic microbial biofilm from deep-sea hydrothermal vents.

E. Reeves is a Postdoctoral Fellow at the MARUM Center for Marine Environmental Sciences, University of Bremen, Germany, working with Drs. Wolfgang Bach and Kai-Uwe Hinrichs. His proposal is entitled: "An organic geochemical investigation of sulfur-bearing ligand formation in ascending hydrothermal plume particulate matter". He will be working in collaboration with Drs. Chris German and John 'Chip' Breier at the Woods Hole Oceanographic Institution, USA. They will conduct a hydrothermal plume particle sampling campaign at hydrothermal sites in the Cayman Trough in 2011.

2.2.9 WG 136: Climatic Importance of the Greater Agulhas System (with WCRP and IAPSO) *Compton* (2009)

Terms of Reference:

- 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.

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Other Full Members Meghan Cronin (USA) Will de Ruijter (Netherlands) Juliet Hermes (South Africa) Johann Lutjeharms (South Africa) Graham Quartly (UK) Tomoki Tozuka (Japan) Rainer Zahn (Spain)	**Associate Members** Shekeela Baker-Yeboah (USA) Jeff Book (USA) Tom Bornman (South Africa) Paolo Cipollini (UK) Ian Hall (UK) Alan Meyer (South Africa) Wonsun Park (Germany) Frank Peeters (Netherlands) Pierrick Penven (France) Herman Ridderinkhof (Netherlands) Jens Zinke (Netherlands)

Executive Committee Reporter: John Compton

WG 136 Annual Report 2010/2011

SCOR/WCRP/IAPSO Working Group 136: On the Climatic Importance of the Greater Agulhas Current System.

Lisa Beal and Arne Biastoch, co-Chairs

1. 2011 WG Meeting

1.1 Organization, Participation, and agenda

SCOR/WCRP/IAPSO Working Group 136 (WG136) held their second meeting in May 2011. Because of the particular focus on collaborations between existing and planned studies of the region and on capacity building, the meeting was held in combination with the "In-Region Capacity Building Workshop of the WMO/IOC Data Buoy Cooperation Panel (DBCP)" in Mauritius (May 2-6, 2011). The Web site for the meeting can be found at http://www.jcomm.info/index.php?option=com_oe&task=viewEventRecord&eventID=780. Juliet Hermes (SAEON/SCOR) and Augustus Vogel (ONR Global) led organization of the meeting on behalf of SCOR WG 136, including the development of all of the capacity building workshops in which SCOR members participated. Overall organization was coordinated by Sidney Thurston (DBCP / NOAA).

Eight of ten full WG members (Johann Lutjeharms and Francis Marsac were unable to attend) and three associate members were present (for a full list of attendees see end of section 1). In addition, extra travel grants were raised through our Working Group (from various sources) to support the following attendees:

Name	Participation	Country	Funding
Pierrick Penven	workshop leader	South Africa	IUGG
Avelino Langa	Trainee	Mozambique	SCOR/NSF
Denis Macharia	Trainee	Kenya	SCOR/NSF
Charles Magori	Trainee	Kenya	ONR
Issufu Halo	Trainee	Mozambique	ONR
Mohamed Ngwali	Trainee	Tanzania	NOAA
Ranjeet Bhagool	Trainee	Mauritius	self-funded

Overall, about fifty people attended the meeting, with an approximately even balance between regional trainees and international scientists/trainers. Most trainees obtained travel grants from DBCP/JCOMM (Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology). Although planning was complex and sometimes challenging because of the partnership with DBCP, the group was able to interact with almost an order of magnitude more regional scientists as a result.

The meeting began with two days of talks by international scientists outlining measuring, modelling, forecasting, socio-economic, and outreach activities in the region, among others. A half day of talks was dedicated to AMESD (African Monitoring of the Environment for

Sustainable Development) activities, led by local host the Mauritius Oceanography Institute. Two and one-half days of capacity building workshops followed, and finally a half day for assessing the success of the meeting and workshops.

The SCOR agenda was formulated around the WG136 Terms of Reference:

1. To facilitate collaborations between existing and planned studies of the region.
2. Write a review paper on the climatic importance of the greater Agulhas. This was completed (see below).
3. Identify key components of the region that deserve further study and/or sustained observations.
4. Organize a Chapman Conference with participation of the African science community.

A further goal of the WG is to contribute to capacity building in East African countries that border the Great Agulhas System.

We dedicated a half day to open discussion on regional science and resource planning, a half day to discuss our Chapman Conference proposal, and a closed evening session to consolidate the science and resource planning discussion into explicit goals for sustained observations.

1.2 **Reports and Discussions on Current and Future Activities (TORs 1 and 3)**
In an open session, Beal summarized current activities known and/or conducted by WG members. These include Mozambique moorings (LOCO/INATEX), East Madagascar Current moorings, Agulhas Current moorings (ACT), a repeat hydrographic line from Cape Town to Antarctica (GoodHope), large marine ecosystem program (ASCLME), African Ceolocanth Program (ACEP), coastal observations maintained by SAEON (South African Environmental Observation Network), seismic/mixing measurements in Agulhas Return Current in early 2012, collection of palaeoclimate data from ocean sediments (GATEWAYS) and corals (CLIMATCH, MASMA), and idealized, regional, high-resolution, and coupled model analyses. The high-density XBT programs across the Agulhas Current off Durban (IX21, ~quarterly), and across the Agulhas leakage off Cape Town (AX25, ~semi-annually) should also have been acknowledged.

Regional scientists gave brief 5-minute reports on their activities. These included development of a Mozambique Channel model (Halo, Mozambique), a network of tide gauges along the East African coast (Magori, KMFRI, Kenya), deployment of drifting weather buoys (Stander, South African Weather Service), development of real-time satellite products (Arshad, Mauritius Oceanography Institute), the ODINAFRICA marine atlas (Abdoulkarim, National Oceanographic Data Centre, Comores), establishment of a core region (recognised biodiversity and resilience) for coral reef protection in the northern Mozambique Channel (Obura, CORDIO, Kenya), subsurface mooring off Pemba (Andre, Instituto de Investigacao Pesqueira, Mozambique), and ship measurements in the Mozambique Channel and off Mauritius to investigate the effects of mesoscale variability on marine ecosystems (Ternon, IRD, France). Tafesse Gurma of the National Meteorological Agency, Ethiopia requested help to establish a ship-of-opportunity program on nine commercial ships.

In particular, four significant new activities were described:

- Mike Roberts (DEA Oceans and Coasts, South Africa) reported on a new mooring line across the Agulhas Current (ALEX - Agulhas long-term experiment) at 32°S off Port Edward. Originally planned as coastal moorings, the array now covers the inshore flank and core of the Agulhas Current. It was discussed whether to approach long-term monitoring of the Agulhas here (by augmenting this array in the future), or at the ACT line (~34°S) taking advantage of the satellite proxy being developed and needing only a reference mooring or two. A decision is deferred until an assessment of the accuracy of the satellite proxy can be made.
- Meghan Cronin (PMEL, USA) reported on the air-sea flux mooring that got loose in the Agulhas Return Current in January 2011, probably because of high velocities associated with an upstream retroflection of the Agulhas current. The mooring was successfully recovered and is on its way back to PMEL. Potential new sites were discussed among the members, including farther east or farther north.
- Isabelle Ansorge (UCT, South Africa) mentioned regular transects down to Marion Island from Cape Town. Usually with XBT lines, this transect may be able to accommodate some measurements across the Agulhas Return Current in the future.
- Gary Brassington (Bureau of Meteorology, Australia) presented Bluelink, operational ocean forecasting around Australia (assimilating altimetry, SST, and *in situ* observations). There is an intention to extend Bluelink into the western Indian Ocean and Agulhas region.

In the course of an open discussion on resources in the region, led by David Vousden (ASCLME), it was identified that sharing of data and resources (e.g. ship time) are essential to achieve scientific goals for the region, which are based on creating collaborations that facilitate data collection, knowledge transfer, new research, and the building of a minimal network of sustained observations. To this end a memorandum of understanding was signed between NOAA and ASCLME (this was set by Vousden preceding the meeting) and, on an individual PI basis, many opportunities for sharing of ship time and pooling resources were discussed during the meeting. For example, ADCPs could be added to ATLAS moorings in the South Equatorial Current to measure ocean advection in addition to air-sea fluxes. The Seychelles might be able to provide a coastguard escort to protect against pirates during maintenance of the mooring at 8°S. Underway measurements added to the Marion Island cruises could be used to measure the Agulhas Return Current, and a small adjustment to the cruise track could provide measurements for comparison to the ARC buoy, when it is redeployed.

Following productive discussions on the elements that should make up a sustained observation system for the region (TOR 3), the priorities for sustained observations were determined as:

1. Agulhas System air-sea flux buoy
2. Long-term monitoring of Agulhas Current (transport and water masses)
3. Reference mooring in Mozambique Channel (leveraged on existent 10-year time series)

A short science planning document is being prepared (led by Beal, de Ruijter, and Ridderinkhof) that will target international planning committees such as the CLIVAR Indian Ocean Panel (IOP8 is in July and this report will be presented there), OceanObs, and GOOS, and can also be used by international and regional African scientists to leverage funding and participation. The southwest Indian Ocean is currently unrepresented in any ocean observing planning document, although it does appear as a priority in several OceanObs'09 white papers.

1.3 **Capacity Building (TOR 1 and further goal)**
Within NOAA's "In-Region Capacity Building Workshop of the WMO/IOC Data Buoy Cooperation Panel (DBCP)" SCOR WG members held training events for the 28 African participants. Organization was led by Juliet Hermes and Augustus Vogel and much preparatory work was done in the weeks leading up to the Workshop by Biastoch, Penven, Quartly, and Tozuka. Individual capacity building workshops included:

- Model Development Team: Introduction to Ocean Modeling (4-hour workshop designed and run by Biastoch and Penven)
- Observation Development Team: Remote Sensing (4-hour workshop designed and run by Quartly)
- Model Development Team: Seasonal Forecasting and SINTEX-F (2-hour workshop designed and run by Tozuka and Sasaki)

Despite some problems (last-minute organization, software issues, only 50% time spent on capacity building, large variety of student backgrounds) the workshops were enthusiastically conducted and well received. Detailed feedback and recommendations for future improvement of capacity building efforts were compiled by Hermes, presented at the meeting, and provided to the DBCP Workshop's reporter Johan Stander (SAWS) and organizer Sidney Thurston (NOAA). It is also available as supplemental information to this report upon request. Here we include two pieces of feedback direct from trainees which carried majority sentiment:

- "The software/programs being used in the modelling is technical, requiring time to learn and exercise these skills which were difficult to master in the limited time! – If the same participants come each year (as planned) this will help. Also if the whole week is dedicated to capacity building this will also help. The trainees have many limitations in using research platforms, such as Linux operative system, and limited scientific software. The trainers found very difficult to deal with such a problem. Time should be invested in well-equipping regionally balanced participants with necessary basics which will then be exercised in later sessions within the same workshop."
- "Though the trainees learned where to find the data, it seemed obvious that many do not know how to use it."

Networking lunches were organized to establish relationships and discussions between SCOR WG members and regional participants. These lunches were very successful and the participants were keen for even more social and scientific interaction with international scientists, if there had been more time. Some feedback from regional scientists about SCOR's capacity-building and networking lunches:

- "SCOR members were keen to share knowledge and new ideas as well as engage us in profiling and networking."
- "This was probably my first ever most interactive and knowledge intensive. The lunches proved fruitful get-together sessions with specific persons of interest. The great interest by SCOR members to share knowledge and ideas with "new" members was enviable."
- "It is important to mention that the meeting with some scientists have contributed enough to my scientific work on the eddies in the Mozambique Channel, which is in its final phase."
- "This workshop provided me with the best platform to know about climate change related research and monitoring programmes that are ongoing in this part of the world. It was also very enriching to learn from experts from all around the globe about their research activities and publications in our region."

1.4 **Chapman Conference (TOR 4)**
Will de Ruijter presented the first draft of an AGU Chapman Conference proposal, and led discussions to refine the proposed sessions, identify invited speakers, and establish a location. Although usually held in the United States, it makes more sense to hold a Chapman Conference on the Agulhas in Southern Africa where a large number of the scientists conducting research in the region reside. Moreover, AGU expressed great interest in supporting the first Chapman Conference to be held in Africa. It was therefore decided to hold it in South Africa, potentially in Grahamstown away from the distractions of a city like Cape Town, and where David Vousden of ASCLME agreed to act as local organizer.

With sessions focussing on the findings described in the *Nature* article, plus regional and ecosystem influences, the conference is designed to attract a broad community. Among the anticipated 120 participants are planned, for a good geographical balance between international and regional scientists, students and researchers/lecturers, to maximise the transfer of knowledge and expertise. Additional funding was discussed to support regional and international attendance. Many South African scientists in attendance were confident that they could find some funding from various agencies.

Will de Ruijter prepared a new version of the Chapman proposal taking into account many additional comments and amendments from SCOR members following the meeting. The proposal was submitted in June 2011 and the conference is proposed for September/October 2012.

1.5 **Membership and Attendees**
Due to his dedication to future activities in the Agulhas Current and significant contributions to discussions at the Mauritius workshop, Mike Roberts (Oceans and Coasts, Department of Environment Affairs, Cape Town) was asked to become an associate member of SCOR WG 136, which he accepted. During the course of the second period David Obura was replaced by Francis Marsac (IRD/UCT) as the tenth full WG member, who has since participated in the production of our Chapman proposal and shall reach out into the ecosystems community.

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Guests
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WG 136 Annual Report, June 2011.

2. Review Paper
Following the conclusions of the last meeting the group contacted *Science* and *Nature*. Both expressed interest in publishing a review paper on the Agulhas Current, but *Science* offered only a shorter Perspectives article. After a formal inquiry *Nature* was interested in a review article "On the role of the Agulhas system in ocean circulation and climate" which was submitted on 22 June 2010. The article, summarizing the modern observational and modeling findings as well as the evidence from palaeo measurements, was very well received by four reviewers and finally published on 28 April 2011.

Nature allowed only those authors to appear that actively wrote the article (L. Beal, W. de Ruijter, A. Biastoch, R. Zahn). However, since the activity was based on the discussions and iterations among the entire working group, *Nature* agreed to add "SCOR/WCRP/IAPSO Working Group 136" to the authorship, with a list of full and associated members at the end of the article. The article and the corresponding press releases were picked up in the media and led to several interviews and news articles in the United States, Great Britain, Spain and Germany. It was displayed on the front page of the U.S. NSF Web site.

3. Final WG Meeting in 2012
It was decided to hold the final WG meeting in coordination with the Chapman Conference, which is proposed for September/October 2012.

4. SCOR Products
To summarize the group's activities in terms of SCOR deliverables, four products were outlined in the group's SCOR proposal:

(1) Article in *EOS*

(2) Review paper [in *Nature*]
(3) Science Plan Report to CLIVAR, GOOS etc
(4) Chapman Conference proposal

(1) and (2) are fully completed, (4) has been submitted, and (3) is presently being circulated for comments from the working group and will be finalized in time to be presented at the next CLIVAR Indian Ocean Panel meeting in July.

REVIEW

doi:10.1038/nature09983

On the role of the Agulhas system in ocean circulation and climate

Lisa M. Beal[1], Wilhelmus P. M. De Ruijter[2], Arne Biastoch[3], Rainer Zahn[4] & SCOR/WCRP/IAPSO Working Group 136*

The Atlantic Ocean receives warm, saline water from the Indo-Pacific Ocean through Agulhas leakage around the southern tip of Africa. Recent findings suggest that Agulhas leakage is a crucial component of the climate system and that ongoing increases in leakage under anthropogenic warming could strengthen the Atlantic overturning circulation at a time when warming and accelerated meltwater input in the North Atlantic is predicted to weaken it. Yet in comparison with processes in the North Atlantic, the overall Agulhas system is largely overlooked as a potential climate trigger or feedback mechanism. Detailed modelling experiments—backed by palaeoceanographic and sustained modern observations—are required to establish firmly the role of the Agulhas system in a warming climate.

UNIVERSITY
OF MIAMI
ROSENSTIEL
SCHOOL of MARINE &
ATMOSPHERIC SCIENCE

Press Release

EMBARGOED by *Nature* until April 27, 2011 at 1800 hrs London time/1300 US Eastern Time

Threading the Climate Needle: The Agulhas System

Agulhas Leakage fueled by global warming could stabilize Atlantic Overturning Circulation

MIAMI – April 27, 2011 – The Agulhas Current which runs along the east coast of Africa may not be as well known as its counterpart in the Atlantic, the Gulf Stream, but researchers are now taking a much closer look at this current and its "leakage" from the Indian Ocean into the Atlantic Ocean. In a study published in the journal *Nature*, April X, a global team of scientists led by University of Miami (UM) Rosenstiel School of Marine & Atmospheric Science Associate Professor Lisa Beal, suggests that Agulhas Leakage could be a significant player in global climate variability.

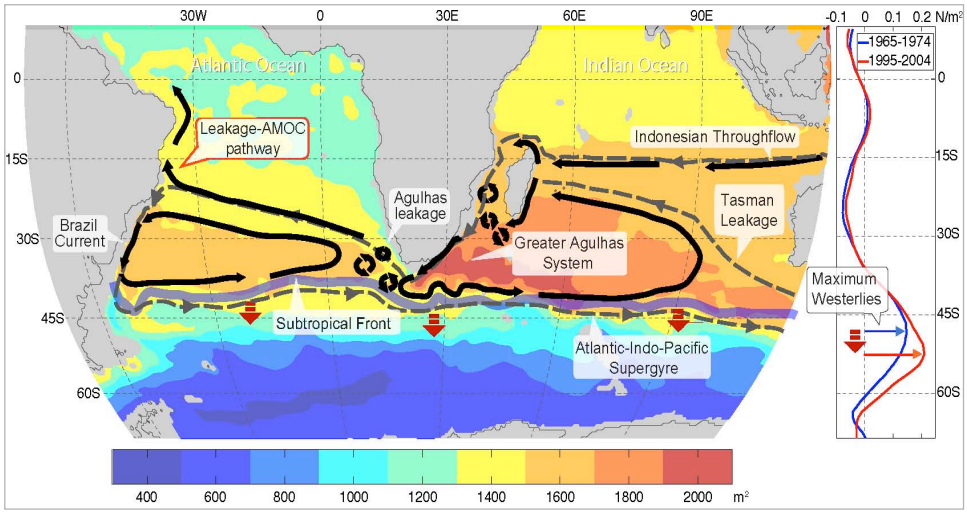

Figure shows Agulhas system and its leakage into the South Atlantic. The southward shift of the winds in a warming climate (right panel) cause a southward shift of the subtropical front (red arrows), enlarging the "gateway" for Agulhas leakage around the tip of Africa. Increased Agulhas leakage acts to enhance Atlantic overturning, which causes a feedback on climate. (Background colors are dynamic height integrated between 2000 m and the surface). Figure produced by Erik van Sebille, UM/RSMAS.

The Agulhas Current transports warm and salty waters from the tropical Indian Ocean to the southern tip of Africa, where most of the water loops around to remain in the Indian Ocean (the Agulhas Retroflection), while some waters leak into the fresher Atlantic Ocean via giant Agulhas rings. Once in the Atlantic, the salty Agulhas leakage waters eventually flow into the Northern Hemisphere and act to strengthen the Atlantic overturning circulation by enhancing deep water formation. Recent research points to an increase in Agulhas leakage over the last few decades caused primarily by human-induced climate change. This finding is profound, because it suggests that increased Agulhas leakage could trigger a strengthening in the Atlantic overturning circulation, at a time when warming and accelerated meltwater input in the North Atlantic has been predicted to weaken it.

"This could mean that current IPCC model predictions for the next century are wrong and there will be no cooling in the North Atlantic to partially offset the effects of global climate change over North America and Europe," said Beal, "Instead, increasing Agulhas leakage could stabilize the oceanic heat transport carried by the Atlantic overturning circulation."

There is also paleoceanographic data to suggest that dramatic peaks in Agulhas leakage over the past 500,000 years may have triggered the end of glacial cycles. This serves as further evidence that the Agulhas system and its leakage play an important role in the planet's climate.

(more)

"This study shows that local changes in atmospheric and oceanic conditions in the Southern Hemisphere can affect the strength of the ocean circulation in unexpected ways. Under a warming climate, the Agulhas Current system near the tip of South Africa could bring more warm salty water from the Indian to the Atlantic Ocean and counteract opposing effects from the Arctic Ocean," said Eric Itsweire, director of the National Science Foundation (NSF)'s physical oceanography program, which funded the research.

The study establishes the need for additional research in the region that focuses on Agulhas rings, as well as the leakage. Climate modeling experiments are critical, and need to be supported by paleoceanographic data and sustained observations to firmly establish the role of this system in a warming climate.

Lisa Beal is interviewed by radio during a rendezvous between RV Knorr and Clipper Stad Amsterdam off the African Cape. Photo credit Jerry Beard.

"Our goal now is to get more of the scientific community involved in research of the Agulhas system and its global effects. The emphasis has been too long in the North Atlantic," said Beal.

The scientific review team included UM's Lisa Beal, Wilhelmus P.M. de Ruijter of Utrecht University in the Netherlands, Arne Biastoch of Leibniz- Institut für Meereswissenschaften (IFM-GEOMAR) in Germany, and Rainer Zahn of the Universitat Autònoma de Barcelona in Spain, as well as members of SCOR Working Group 136 on the Climatic Importance of the Agulhas System, sponsored by the Scientific Committee for Oceanic Research, the International Association for the Physical Sciences of the Oceans, and the World Climate Research Program. The Scientific Committee on Oceanic Research is supported by the National Science Foundation, award no. OCE-0938349. Beal is funded by the National Science Foundation through the ACT (Agulhas Current Time-series) project, award no. OCE-0850891.

The ACT ocean observing program was launched in April 2010 to measure the variability of the Agulhas Current using a combination of current meter moorings and satellite data. Beal, who serves as chief scientist, spent one month aboard Research Vessel *Knorr* in the southwest Indian Ocean deploying oceanographic instruments. The data gathered *in situ*, when combined with along-track satellite information, will help increase our understanding of how the Agulhas system is changing in a warming climate. For information on the program, please visit http://act.rsmas.miami.edu

About the UM Rosenstiel School

The University of Miami's mission is to educate and nurture students, to create knowledge, and to provide service to our community and beyond. Committed to excellence and proud of the diversity of our University family, we strive to develop future leaders of our nation and the world. Founded in the 1940's, the Rosenstiel School of Marine & Atmospheric Science has grown into one of the world's premier marine and atmospheric research institutions. Offering dynamic interdisciplinary academics, the Rosenstiel School is dedicated to helping communities to better understand the planet, participating in the establishment of environmental policies, and aiding in the improvement of society and quality of life. For more information, please visit www.rsmas.miami.edu.

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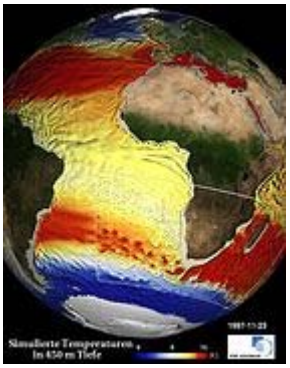
28.04.2011

AKTUELLES AUS DEM IFM-GEOMAR
28.04.11 08:00

Fernwärme für den Golfstrom?

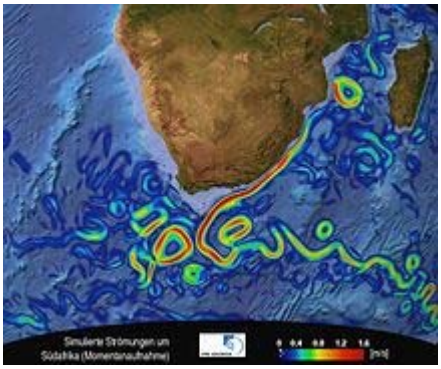
- Strömungen des Indischen Ozeans wirken bis nach Europa -

28.04.2010, Kiel. Vielen Europäern ist die Bedeutung des Golfstromsystems für das relativ milde Klima bekannt. Weit weniger geläufig ist die Fernwirkung von Meeresströmungen im Indischen Ozean bis in unsere Breiten. In einem Übersichtartikel, der am 28. April in der renommierten Fachzeitschrift Nature erscheint, hat ein internationales Wissenschaftlerteam unter Beteiligung des Kieler Leibniz-Institut für Meereswissenschaften (IFM-GEOMAR) den Kenntnisstand über die Bedeutung des Agulhasstroms für das Klima zusammengefasst.



Temperaturen und Strömungen in 450 m Tiefe des hochauflösenden Kieler Computermodells (Momentanaufnahme). Der Agulhasstrom fließt entlang der südafrikanischen Küste. Südwestlich von Kapstadt vollzieht er eine abrupte Kehrtwende zurück in den Indischen Ozean. Dabei schnürt er Wirbel („Agulhasringe“) ab, die warmes und salzreiches Wasser in den Atlantik transportieren.Strömungen um Südafrika (Momentanaufnahme).

Der Agulhasstrom - wie der Golfstrom - eine der stärksten Strömungen im Weltozean, fließt im Indischen Ozean entlang der südafrikanischen Küste. Südwestlich von Kapstadt vollzieht er eine abrupte Kehrtwende zurück in den Indischen Ozean. Dabei schnüren sich alle drei bis vier Monate mächtige Wirbel von mehreren 100 km Durchmesser, die Agulhasringe, vom Hauptstrom ab. Diese bringen warmes und salzreiches Wasser aus dem Indischen Ozean in den Atlantik und bilden somit ein Schlüsselelement der weltweit verbundenen Meeresströmungen. Ein Teil des Wassers aus dem Indischen Ozean landet auch im Nordatlantik und kann über den Golfstrom auch Auswirkungen auf unser Klima haben.



Der Agulhasstrom (rotes Band) fließt entlang der südafrikanischen Küste. Südwestlich von Kapstadt vollzieht er eine abrupte Kehrtwende zurück in den Indischen Ozean. Dabei schnürt er Wirbel ab, die nach Westen in den Atlantik driften. (Die Farben geben die Stärke der Strömung an.)

„Es klingt ein wenig abenteuerlich, dass Strömungen um Südafrika einen Einfluss auf unsere Breiten haben“, gibt der Mitautor der Studie, Privatdozent Dr. Arne Biastoch vom IFM-GEOMAR, zu. Dennoch sei seit langem bekannt, dass dem Agulhasstrom eine wichtige Rolle für den Nachschub salzreichen Wassers in den Atlantik zukommt. Nachdem Biastoch schon mehrere Schlüsselarbeiten zu dem Thema publiziert hat, wurde in der jetzt veröffentlichten Studie das weltweit vorhandene Wissen verschiedener Forschergruppen zusammengetragen. Neben Simulationen mit Ozeanmodellen benutzten die Forscher aktuelle sowie paläoozeanographische Messdaten, um dieses Phänomen und seine Einflüsse auf den Atlantik möglichst genau zu beschreiben. Dabei standen vor allem durch den Klimawandel bedingte Änderungen im Fokus, die zu einem erhöhten Zustrom von Wasser aus dem Agulhasstrom in den Atlantik führen könnten. Warum ist das so? Normalerweise begrenzen die westlichen Winde im

südlichen Ozean den Wasseraustausch zwischen dem Indischen Ozean und dem Atlantik. Die zunehmende Erwärmung führt auch zu einer Verlagerung des Westwindbandes nach Süden, wodurch sich der Korridor für einströmendes Wassers südlich von Afrika verbreitert. Modellsimulationen deuten auf eine Verstärkung dieses Trends hin.

Das so zusätzlich in den Atlantik eingebrachte Wasser wird entlang der brasilianischen Küste nordwärts transportiert, bis es schließlich im Bereich der Karibik seinen Weg in das Golfstromsystem findet. Dort eingespeist könnte das warme und sehr salzreiche Wasser aus dem Indischen Ozean dem durch verstärkte Niederschläge und Eisschmelze bedingten Aussüßungstrend im Nordatlantik entgegenwirken. Dieser wird in Zusammenhang mit einer möglichen Abschwächung des Golfstroms in Verbindung gebracht. „Wir vermuten, dass die Zufuhr aus dem Süden eine entscheidende Rolle in den Übergängen zwischen Eis- und Warmzeiten gespielt hat“, so Dr. Biastoch. „Die Fernwirkung des Agulhasstroms zeigen weiterhin sehr anschaulich die Komplexität der Wechselwirkungen in unserem Klimasystem und die weltweiten Verbindungen der Ozeanströmungen“, resümiert Biastoch.

Originalarbeit:

Beal, L.M., De Ruijter, W.P.M., Biastoch, A., Zahn, R., and the members of SCOR/WCRP/IAPSO Working Group 136, 2011: On the role of the Agulhas system in ocean circulation and climate. Nature, doi: 10.1038/nature09983

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Hochauflösende Versionen der Bilder

Temperaturen und Strömungen in 450 m Tiefe des hochauflösenden Kieler Computermodells (Momentanaufnahme).

Der Agulhasstrom (rotes Band) fließt entlang der südafrikanischen Küste.

Dies Pressemitteilung als pdf

[Zurück]

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Els corrents marins del sud d'Àfrica podrien estabilitzar el clima a Europa

- **Un consorci internacional de científics marins estudia l'efecte de l'aportació d'aigües salades del Corrent d'Agulhas a l'Atlàntic en condicions d'escalfament global.**

- **La investigació, publicada en *Nature*, suposa un enfocament alternatiu en relació als futurs sistemes de corrents en l'Atlàntic Nord.**

- **L'estudi està liderat per Rainer Zahn, professor ICREA del Departament de Física de la Universitat Autónoma de Barcelona (UAB) i investigador de l'Institut de Ciència i Tecnologia Ambientals (ICTA).**

Un dels corrents oceànics que ha cridat l'atenció de manera particular d'oceanògrafs i de climatòlegs és el Corrent del Golf. Aquest corrent, situat en el Golf de Mèxic, transporta enormes quantitats d'aigües càlides tropicals a l'Atlàntic Nord i aporta a Europa el seu clima habitable. Les prediccions climàtiques apunten al fet que això canviarà en el futur, afectant particularment el clima dels països de la zona mediterrània, amb condicions de major sequera. A mesura que l'escalfament global continua, l'Atlàntic Nord rep més precipitació i majors quantitats d'aigua procedents de la fusió de la capa de gel de Grenlàndia, reduint així la salinitat de l'aigua marina i afeblint el Corrent del Golf.

L'article que publica *Nature* descriu un enfocament alternatiu que suggereix que un flux d'aigua de l'Oceà Índic cap a l'Atlàntic Sud, al voltant de l'extrem sud d'Àfrica, és important també en relació als futurs sistemes de corrents en l'Atlàntic Nord.

El Corrent d'Agulhas, localitzat en el sud-oest de l'Oceà Índic, transporta aigües d'elevada salinitat a l'extrem sud d'Àfrica, on part d'elles escapen a l'Atlàntic Sud, contribuint a la fortalesa de la circulació global en aquest oceà. El treball descriu com aquesta aportació d'aigües salades procedents de l'Oceà Índic pot compensar la disminució de salinitat en l'Atlàntic Nord i, per tant, estabilitzar el Corrent del Golf i el clima a Europa. Aquests processos s'han simulat mitjançant models climàtics computacionals.

L'article revisa els coneixements actuals i enumera els passos a seguir amb l'objectiu d'avaluar amb major detall els processos involucrats en aquest sistema de corrents. Per demostrar la dinàmica del Corrent d'Agulhas, la seva sensibilitat al canvi climàtic i la manera en què transmet els seus senyals a l'Atlàntic Nord, els investigadors indiquen que es necessita la combinació d'estudis a llarg termini de canvis en la temperatura i en la salinitat del Corrent, l'anàlisi de la seva resposta a canvis climàtics en el passat i models de simulació per ordinador de major detall.

L'existència d'una connexió entre el Corrent d'Agulhas i el clima europeu està sent investigat pel grup del doctor Rainer Zahn des de fa 6 anys.

Els autors de l'article són membres d'un consorci de científics marins procedents d'Estats Units, d'Alemanya, d'Holanda, de Regne Unit i d'Espanya que col·laboren amb la finalitat d'estudiar les implicacions del Corrent d'Agulhas en el clima regional i mundial. Aquest grup, al seu torn, forma part del Comitè Científic d'Investigació de l'Oceà (SCOR, de les seves sigles en anglès) pertanyent al Consell Internacional per a la Ciència. Altres institucions involucrades són la Fundació Nacional per a la Ciència d'Estats Units, el Programa d'Investigació del Clima Global (WCRP), l'Associació Internacional de Ciències Físiques de l'Oceà (IAPSO) i el Programa Internacional d'Estudi del Canvi Global Marí (IMAGES).

Article de referència: Lisa M. Beal, Wilhelmus P. M. De Ruijter, Arne Biastoch, Rainer Zahn and the members of SCOR/WCRP/IAPSO Working Group 1365. "On the role of the Agulhas system in ocean circulation and climate". DOI: 10.1038/nature09983.

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Las corrientes marinas del sur de África podrían estabilizar el clima en Europa

- **Un consorcio internacional de científicos marinos estudia el efecto del aporte de aguas saladas de la Corriente de Agulhas al Atlántico en condiciones de calentamiento global.**

- **La investigación, publicada en *Nature*, supone un enfoque alternativo en relación a los futuros sistemas de corrientes en el Atlántico Norte.**

- **Al estudio contribuyó Rainer Zahn, profesor ICREA del Departamento de Física de la Universitat Autónoma de Barcelona (UAB) e investigador del Instituto de Ciencia y Tecnología Ambientales (ICTA).**

Una de las corrientes oceánicas que ha atraído la atención de forma particular de oceanógrafos y climatólogos es la Corriente del Golfo. Esta corriente, situada en el Golfo de México, transporta enormes cantidades de aguas cálidas tropicales al Atlántico Norte y aporta a Europa su clima habitable. Las predicciones climáticas apuntan a que esto cambiará en el futuro, afectando especialmente a los países de la zona mediterránea con condiciones de mayor sequía. A medida que el calentamiento global continúa, el Atlántico Norte recibe mayor precipitación y mayores cantidades de agua procedentes de la fusión de la capa de hielo de Groenlandia, reduciendo así la salinidad del agua marina y debilitando la Corriente del Golfo.

El artículo que publica *Nature* describe un enfoque alternativo que sugiere que un flujo de agua del Océano Índico hacia el Atlántico Sur, alrededor del extremo sur de África, es también importante en relación a los futuros sistemas de corrientes en el Atlántico Norte.

La Corriente de Agulhas, localizada en el suroeste del Océano Índico, transporta aguas de elevada salinidad al extremo sur de África, donde parte de ellas escapan al Atlántico Sur, contribuyendo a la fortaleza de la circulación global en este océano. El trabajo describe cómo ese aporte de aguas saladas procedentes del Océano Índico puede compensar la disminución de salinidad en el Atlántico Norte y, por tanto, estabilizar la Corriente del Golfo y el clima en Europa. Estos procesos se han simulado mediante modelos climáticos computacionales.

El artículo revisa los conocimientos actuales y enumera los pasos a seguir con el objetivo de evaluar con mayor detalle los procesos involucrados en este sistema de corrientes. Para demostrar la dinámica de la Corriente de Agulhas, su sensibilidad al cambio climático y la manera en que transmite sus señales al Atlántico Norte, los investigadores indican que se necesita la combinación de estudios a largo plazo de cambios en la temperatura y salinidad de la Corriente, el análisis de su respuesta a cambios climáticos en el pasado y modelos de simulación por ordenador de mayor detalle.

La existencia de una conexión entre la Corriente de Agulhas y el clima europeo está siendo investigado por el grupo del doctor Rainer Zahn desde hace 6 años.

Los autores del artículo son miembros de un consorcio de científicos marinos procedentes de Estados Unidos, Alemania, Holanda, Reino Unido y España que colaboran con el fin de estudiar las implicaciones de la Corriente de Agulhas en el clima regional y mundial. Este grupo, a su vez, forma parte del Comité Científico de Investigación del Océano (SCOR, según sus siglas en inglés) perteneciente al Consejo Internacional para la Ciencia. Otras instituciones involucradas son la Fundación Nacional para la Ciencia de Estados Unidos, el Programa de Investigación del Clima Global (WCRP), la Asociación Internacional de Ciencias Físicas del Océano (IAPSO) y el Programa Internacional de Estudio del Cambio Global Marino (IMAGES).

Artículo de referencia: Lisa M. Beal, Wilhelmus P. M. De Ruijter, Arne Biastoch, Rainer Zahn and the members of SCOR/WCRP/IAPSO Working Group 136. "On the role of the Agulhas system in ocean circulation and climate". DOI: 10.1038/nature09983.

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2.2.10 WG 137: Patterns of Phytoplankton Dynamics in Coastal Ecosystems: Comparative Analysis of Time Series Observation *Volkman* (2009)

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.

Co-chairs:

Kedong Yin
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Hans W. Paerl
Institute of Marine Sciences
University of North Carolina at Chapel Hill
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Other Full Members	**Associate Members**
Susan I. Blackburn (Australia)	Borgne, Robert Le (New Caledonia)
Jacob Carstensen (Denmark)	Elgin, Perry (USA)
James E. Cloern (USA)	Jassby, Alan (USA)
Paul J. Harrison (China-Beijing)	Kuparinen, Jorma (Finland)
Ruixiang Li (China-Beijing)	Leppänen, Juha-Markku (Finland)
McQuatters-Gollop, Abigail (UK)	Malone, Thomas (USA)

Todd O'Brien (USA) Clarisse Odebrecht (Brazil) N. Ramaiah (India) Katja Philippart (The Netherlands) Adriana Zingone (Italy)	Moncheva, Snejana P. (Bulgaria) Morán, Xosé Anxelu G.(Spain) Picher, Grant (South Africa) Smayda, Theodore J. (USA) Wiltshire, Karen (Germany) Yoo, Sinjae (South Korea) Zhu, Mingyuan (China-Beijing)

Executive Committee Reporter: John Volkman

SCOR WG 137:
Global Patterns of Phytoplankton Dynamics in Coastal Ecosystems: Comparative Analysis of Time Series Observations

Annual Report 2011

Kedong Yin and Hans W. Paerl

June 20, 2011

Abstract

The SCOR WG 137 had its first meeting in Hangzhou, China, during 17-21 October 2010, hosted by Prof. Zhu Mingyuan, the First Institute of Oceanography, State Oceanic Administration. At this meeting, key WG objectives and activities were addressed. Specifically; (1) members and other participants made presentations and had extensive discussions on their own estuarine/coastal case studies; (2) members were assigned to be responsible for working on terms of references; (3) members formulated 10 scientific questions for the WG to address, using individual data sets, case studies and published materials; (4) members agreed on the data policy and contributing data and (5) a plan was made for the 2nd meeting place. Thanks to the extraordinary effort by the member Adriana Zingone, the second WG meeting will be held in Villa Angelina in Massa Lubrense, Napoli, Italy, during September 27-30 2011 with partial funding from her Institute, Stazione Zoologica A. Dohrn, Villa Communale, Italy. The website for data sets has been set up and will be available soon.

Activities since June 2010 (last annual report)

1. The WG137 first meeting.
The following is the abstract, which was published in *EOS* (Vol 92 (10): 85 (2011), and is in Appendix 1.

The first SCOR WG 137 meeting was held in Hangzhou, China during 17-21 October 2010. To address the objectives of WG 137, participants and Chinese invitees focused the discussions on

(1) linking and utilizing research interests, available databases from relevant regions, ecosystems and specific sites, and other resources (monitoring and assessment programs, data management, analytical and statistical capabilities) to the WG objectives, (2) formulating directions, approaches and contributions for conducting comparative analyses using the available time series data sets, (3) defining research questions that will help achieve the overall goal of comparative analyses of human- and climatically induced changes of estuarine and coastal phytoplankton community structure and function, and (4) providing a time frame and assigning specific tasks for providing and analyzing comparative data sets.

During the meeting, participants were encouraged to make short presentations of local and regional data sets, conceptual and technical frameworks, and they were asked to formulate and address specific questions concerning the use and comparison of key indicators, trends and patterns of environmental change and to develop approaches for comparing these across geographically, climatically, hydrologically, biogeochemically and trophically diverse ecosystems and regions (agreed research questions). The presentations and discussions, which are summarized in this report, covered a wide range of systems, and included issues/problems and contrasts in forcing features impacting these contrasting ecosystems/regions. A list of relevant research questions to be considered for these systems, as well as systems yet to be included in the analyses, was formulated, and individuals were identified to lead team members to "fine tune" these questions and begin to apply them to respective systems. A synthesis of the general applicability and utility of these questions facilitating cross-system analyses will be developed. This will be based on input from respective teams. Terms of references were discussed and sent to participants. Procedures for communicating, archiving and accessing databases in a secure, but user-friendly manner, using a password-protected Web site were discussed and will be communicated to the members. The group collectively encouraged additional members who have yet to contribute relevant databases, to do so within this framework. It was decided that all written contributions and databases be finalized by 1 June 2011. The meeting participants encouraged non-participants to contribute to addressing the questions.

2. Data policy document draft

In the first meeting, participants discussed data policy, including data contribution, authorships, acknowledgements, and data availability and have achieved an agreement on the policy. After the meeting, the data policy document was drafted by member Todd O'Brien. The document is in Appendix 2.

3. Website for data sets

The website for data sets for SCOR WG137

http://www.st.nmfs.noaa.gov/nauplius/media/html/subform_multisite-login.html

4. Publications

The SCOR WG137 first meeting was reported in *EOS, TRANSACTIONS AMERICAN GEOPHYSICAL UNION*, VOL. 92, NO. 10, doi:10.1029/2011EO100007, 2011, titled:

"**Global patterns of phytoplankton dynamics in coastal ecosystems".**

5. Plan of the second meeting

The second meeting has been planned to take place in Villa Angelina in Massa Lubrense, Napoli, Italy, during September 27-30, 2011 with partial funding from Adriana Zingone's institute, Stazione Zoologica A. Dohrn, Villa Communale, Italy.

6. Membership

Richard J. Gowen was added as an Associate Member (his affiliation: Fisheries and Aquatic Ecosystems Branch, Agriculture Food and Environmental Science Division, Agri-Food and Biosciences Institute, Newforge Lane, Belfast, BT9 5PX, UK)

Appendix 1. Summary for the first meeting, Hangzhou, China, 17-21 October, 2011.

I.. Abstract: Published in EOS, Vol. 92 (10):85 (8 March, 2011)

Global Patterns of Phytoplankton Dynamics in Coastal Ecosystems

SCOR Working Group 137 Meeting; Hangzhou, China, 17-21 October 2010

Phytoplankton biomass and community structure have undergone dramatic changes in coastal ecosystems over the past several decades in response to climate variability and human disturbance. These changes have short- and longer-term impacts on global carbon and nutrient cycling, food web structure and productivity, and coastal ecosystem services. There is a need to identify the underlying processes and measure rates at which they alter coastal ecosystems on a global scale. Hence, the Scientific Committee on Ocean Research (SCOR) formed Working Group 137 (WG 137), "Global Patterns of Phytoplankton Dynamics in Coastal Ecosystems: Comparative Analysis of Time Series Observations" (http://wg137.net/). This group evolved from a 2007 AGU-sponsored Chapman Conference on "Long Time-Series Observations in Coastal Ecosystems: Comparative Analyses of Phytoplankton Dynamics on Regional to Global Scales."

At the inaugural meeting of WG 137 in China, presentations from participants covered conceptual models of phytoplankton community variability and quantitative approaches for extracting patterns from time series. These were followed by presentations of case studies to illustrate patterns of change contained in multi-decadal phytoplankton series. A case study of San Francisco Bay, California, illustrated that drivers of phytoplankton biomass operate on time scales from days to decades. A study of Neuse River Estuary, North Carolina, showed that coastal storms can overwhelm anthropogenic nutrient inputs in terms of controlling phytoplankton bloom duration and spatial extent. In Ringkøbing Fjord, Denmark, a hydrologic manipulation induced an ecological regime shift and community changes from phytoplankton to waterbirds. Long-term variations in nutrients were weakly correlated with biomass but strongly

correlated with phytoplankton community structure in the Dutch Wadden Sea. In the Huon Estuary, Tasmania, changes in chlorophyll *a* and the abundance of autotrophic dinoflagellates coincided with regional warming of surface waters. In the German Bight, a temperature increase of 1.7 °C since 1962 has led to a shift in seasonal patterns and dominant species of diatoms. Another case study showed that seasonal monsoons and Pearl River discharge interact to regulate red tides in Hong Kong coastal waters. Finally, in the Black Sea, trends of decreasing phytoplankton biomass and shifting seasonal patterns can be attributed to declining fertilizer use following economic collapse of the USSR and warming that has intensified stratification and reduced vertical mixing.

To address fundamental questions that emerged from the meeting, WG 137 will use data compiled from 84 sampling stations, representing research and monitoring programs spread across five continents, and is seeking additional time series of coastal/estuarine/near-shore phytoplankton and relevant hydrographic data. Investigators with decadal observational data are encouraged to contribute to this growing compilation and discuss interests in collaboration with chairs Kedong Yin (yinkd@mail.sysu.edu.cn) and Hans Paerl (hpaerl@email.unc.edu). The wealth of information in these data sets provides an unprecedented opportunity to develop a global analysis and investigation of the dynamics and status of ecosystems where land and sea meet.

—Hans Paerl, Institute of Marine Sciences, The University of North Carolina at Chapel Hill, Morehead City, North Carolina; E-mail: hpaerl@email.unc.edu; Kedong Yin, School of Marine Sciences, Zhongshan University, Guangzhou, China; and James Cloern, U.S. Geological Survey, Menlo Park, California

II. Proceedings of meeting

Date: October 17-21

Local host: State Oceanic Administration of China: Prof. Mingyuan Zhu, First Institute of Oceanography, State Oceanic Administration, Qingdao, China

Meeting Venue: Hangzhou Hua Jia Shan Resort, Hangzhou, China

1. Summary

The first SCOR WG 137 meeting was held in Hangzhou, China during 17-21 October 2010. To address the objectives of WG 137, participants and Chinese invitees focused the discussions on (1) link and utilizing research interests, available data bases from relevant regions, ecosystems and specific sites, and other resources (monitoring and assessment programs, data management, analytical and statistical capabilities) to the WG objectives; (2) formulating directions, approaches and contribution for conducting comparative analyses; (3) defining research questions that will help achieve the overall goal of comparative analyses of human- and climatically induced changes of estuarine and coastal phytoplankton community structure and

function; and (4) providing a time frame and assign specific tasks for providing and analyzing comparative data sets. During the meeting, participants were encouraged to make short presentations of local and regional data sets, conceptual and technical frameworks, and they were asked to formulate and address specific questions concerning the use and comparison of key indicators, trends and patterns of environmental change and to develop approaches for comparing these across geographically, climatically, hydrologically, biogeochemically and trophically diverse ecosystems and regions (agreed research questions). The presentations, and discussions, which are summarized in this report, covered a wide range of systems, and included issues/problems and contrasts in forcing features impacting these contrasting ecosystems/regions. A list of relevant research questions to be considered for these systems, as well as systems yet to be included in the analyses, was formulated, and individuals were identified as lead team members to "fine tune" these questions and begin to apply them to respective systems. A synthesis of the general applicability and utility of these questions facilitating cross-system analyses will be developed. This will be based on input from respective teams. Terms of references were discussed and assigned to participants. Procedures for communicating, archiving and accessing databases in a secure, but user-friendly manner, using a password-protected Web site were discussed and will be communicated to the members. The group collectively encouraged additional members who have yet to contribute relevant databases, to do so within this framework. It was decided that all written contributions and databases be finalized by 1 June 2011. The meeting participants encouraged non-participants to contribute to addressing the questions. The next meeting of the working group was proposed to take place in the fall of 2011 at a location yet to be determined (ideas and volunteer hosts welcomed!).

2. Meeting objectives

Overarching Objective

Identify and characterize effects of changes in anthropogenic nutrient inputs from climate (change) impacts on estuarine/coastal phytoplankton communities. Examine these effects along geographic and climatic (temperature, hydrology) gradients by comparing and synthesizing different regional datasets.

Key Question: Can we extract clear signals of climate-driven change from human-driven (beyond eutrophication) disturbance?

- Can we attribute changes in phytoplankton community structure/function responses to nutrient and/or climate driven changes? e.g., episodic tropical cyclone impacts?
- What is the interactive role of physical forcing in altering phytoplankton community composition?
- What are the mechanisms governing species composition?
- Can we use indicator species and/or functional taxonomic groups (i.e. diatoms, dinoflagellates, cyanobacteria, cryptophytes, chlorophytes) as 'Eco-Indicators' of these changes?

Key objectives of the meeting

- Present research interests and contributions in relation to WG objectives

- Develop directions for incorporating observational and research data in comparative analyses
- Research questions the Group will work on
- Provide a time frame for contributing and synthesizing data

3. Meeting Program and Presentations

October 16	Arrival and registration	
October 17	Day 1	Note 1
9.00 – 9.15	Mingyuan Zhu: Welcome address	
9:15-10:00	Hans Paerl and Kedong Yin: Developing a framework and consensus on overarching objectives –review the 10 questions and formulating hypotheses. Meeting objectives: data contribution, data policy and who does what on the raised questions	See the list of 10 research questions See the terms of references
10:00-10:30	Jim Cloern: Experience from Chapman – the power of global synthesis – leading to the overarching questions from the Denmark meeting	Abstracts and presentations attached
11:00-11:30	Todd O'Brien: Experiences from the WG125 Tools developed for visualizing patterns Data structure and status of data compilation	
11:30-12:15	Jacob Carstensen: Examples of statistical analysis of phytoplankton data	
13:30-15:30	Examples of how specific systems respond to human disturbance and climate variability Hans Paerl Effects of anthropogenic and climatic perturbations on US Mid-Atlantic estuarine phytoplankton dynamics Kedong Yin Coastal Ecosystem Dynamics in the Pearl River Estuarine Coastal Waters. James Cloern How Does Climate Variability Influence Estuarine-Coastal Ecosystems? Adriana Zingone Dissecting the winter-spring phytoplankton dynamics at the LTER-MC station	Abstracts and presentations attached

	(Gulf of Naples)	
16:00-18:00	Katja Philippart The Wadden Sea Peter Henriksen/ Hans Henrik Jacobsen Ringkøbing Fjord: flow-manipulations and food-web effects Peter Thompson Some trends in phytoplankton around Australia: coastal and estuarine examples	Abstracts and presentations attached
October 18	Day 2	Note 2
8:30-9:00	Paul J. Harrison: Summary/Perspectives of Day 1	Slides posted
9:00-10:30	Mingyuan Zhu Ecosystem Changes in the Yellow Sea Li Ruixiang: The long term change of phytoplankton in Sanggou Bay, a mariculture zone. N. Ramaiah, NAGAPPA: Spatio-temporal variability in species composition of phytoplankton in the coastal waters off Goa: a monsoon affected tropical coastal region Abigail McQuatters-Gollop: North Sea: the Continuous Plankton Recorder (CPR) Black Sea: phytoplankton	Abstract and presentation attached
10:45-	Alexandra Kraberg : Helgoland Roads: Phytoplankton data sets Sirpa Lehtinen : Northern Baltic Sea: Finnish Coast Monika Winder: The annual cycles of phytoplankton	Abstract and presentation attached
1:30-	Group discussions Developing a strategy and approaches to comparative analyses (inspired from the 10 proposed guiding research questions and additional questions). Using hypotheses & questions as a guide. GROUP1 (drivers): Jim Cloern & Katja Philippart/Rapporteur, Monika Winder What are the different anthropogenic and climatic	Table 1

	factors acting on the phytoplankton community and what time scales do they operate on (episodic, seasonal, inter-annual, long-term trends) across systems? Specific task is to develop a conceptual framework for developing criteria for doing cross-system analysis. GROUP2 (responses): Hans Paerl & Abigail McQuatters-Gollop/Rapporteur, Jacob Carstensen, Nathan Hall. What characteristics for the phytoplankton community are common across systems and which are considered to be system-specific? Which specific characteristics (pertaining to community structure and function) should we focus on in our attempts to find common patterns? Identification of specific indices.	Table 2
October 18 18:00—	Group Dinner West Lake performance	
October 19	Day 3	
8.30-	Report from the two groups to WG. Feedback between groups and entire WG. WGs will synthesize results from groups 1 and 2 by formulating conceptual framework, models and specific approaches to pursuing cross-system analyses of available data sets. Group 1: Katja Philippart Group 2: Abigail McQuatters-Gollop	
	The WG group continues, incorporates findings and feedbacks, and drafts documents (tables, figures, conceptual diagrams) on the conceptual framework to be draft proposal (roadmap) on how to proceed.	Research questions/who does what
The afternoon	Meeting break, a visit to Second Institute of Oceanography; and free time in late afternoon	
October 20	Day 4	
8.30 –	WG group discussion on how to link drivers to responses. Identification of which drivers acting on which time-scales should be linked to which responses! This will lead to the formulation of specific and concrete research questions with clear descriptions of how to pursue these and who will commit themselves (identify lead) to address these.	Research questions/who does what
13:00-	Products: Proposal on how to proceed with cross-	data policy

	system analysis. Draft before departure. Kedong in charge This should include: Approach and roadmap to comparisons, analyses, establish specific tasks and syntheses, including publications. Develop proposal for future synthesis at NCEAS?	document Terms of references Working research questions with 'who does what'
16.00 – 17.00	Planning next meeting, summarising future tasks and products. Tentative place is Naples, Italy. Adriana will let us know a suitable time window.	
17.00	Closing thoughts ands perspectives	

4. List of Registered Participants for SCOR WG137 Hangzhou meeting Oct 17-21, 2010

	Name	Affiliation	email
1	Yin, Kedong (co-chair)	School of Marine Sciences Sun Yat-Sen (Zhongshan) University Guangzhou, China Griffith Univeristy, QLD, Australia	k.yin@griffith.edu.au
2	Paerl, Hans W. (co-chair)	Institute of Marine Sciences, University of North Carolina at Chapel Hill, Morehead City, North Carolina, USA	hpaerl@email.unc.edu
3	Carstensen, Jacob	National Environmental Research Institute, Denmark	jac@dmu.dk
4	Cloern, James E.	U.S. Geological Survey, Menlo Park, California, USA	jecloern@usgs.gov
5	Hall, Nathan S.	Institute of Marine Sciences, University of North Carolina at Chapel Hill, Morehead City, North Carolina, USA	nshall@email.unc.edu
6	Harrison, Paul J.	Division of Environment, Hong Kong University of Science and Technology, Hong Kong	Harrison@ust.hk
7	Henriksen, Peter	National Environmental Research Institute, Aarhus University, Denmark	pet@dmu.dk
8	Jakobsen, Hans Henrik	National Environmental Research Institute, Aarhus University, Denmark	hhja@dmu.dk

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11	Li, Ruixiang*	First Institute of Oceanography, State Oceanic Administration, China	liruixiang@fio.org.cn
12	McQuatters-Gollop, Abigail	Sir Alister Hardy Foundation for Ocean Science, Citadel Hill, Plymouth, PL1 2PB, United Kingdom,	abiqua@sahfos.ac.uk
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19	Zingone, Adriana	Stazione Zoologica A. Dohrn, Villa Communale, Italy	zingone@szn.it
20	Zhu, Mingyuan	First Institute of Oceanography, State Oceanic Administration, Qingdao, China	zhumingyuan@fio.org.cn
21	Lu, Douding	Second Institute of Oceanography, State Oceanic Administration, Hangzhou, China	doudinglu@sio.org.cn
	Participants	First Institute of Oceanography, State Oceanic Administration, Qingdao, China	

	Local participants	Second Institute of Oceanography, State Oceanic Administration, Hangzhou, China	

5. WG137 Initial Data Prospects: following data sets have been identified

- North Sea / Baltic
  - SYKE (open Baltic Sea, Helsinki Bay)
  - Gulf of Riga
  - Danish Water Quality Data
  - Dutch Phytoplankton Data
  - German Wadden Sea (Norderney)
- North Atlantic (eastern)
  - *[Irish Monitoring - WGPME]*
  - *[Scottish Monitoring - WGPME]*
  - *[Spanish monitoring – WGPME]*
- Mediterranean
  - *[Naples]*
- North Atlantic (western)
  Chesapeake Bay
  Neuse-Pamlico Estuary
- South Atlantic (western)
  - Patos Lagoon (Brazil)
- Indian Ocean
  - Central Bay
- Pacific Ocean (western)
  - Pearl River
  - *[Sanggou Bay]*
- Pacific Ocean (eastern)
  - San Francisco Bay
- Australian Data
  - Peel Harvey
  - *[Southern Ocean CPR data]*

6. Data Policy

The primary goal of the WG137 data compilation effort is to assemble a globally distributed collection of coastal/estuarine/near-shore "phytoplankton" (and relevant hydrographic) time-series data in an effort to look at global patterns and ecosystem dynamics at multiple spatial and cross-disciplinary scales. WG137 recognizes that each investigator values his/her hard-collected data, and that they wish to protect it from misuse and/or unattributed use. WG137 also recognizes that, if combined with the 100+ other data sets of the anticipated WG137 contributions, these data could become part of something bigger and even more valuable to the scientific community. The intent of the WG137 data policy is therefore to protect these individual data components while at the same time facilitating the global scale investigations

being pursued by WG137.

Writing a meaningful and all-encompassing data policy is very difficult, as every set of data and conditions is different. For example, a grant-funded investigator with a spreadsheet containing five years of unpublished data is likely to have considerably different concerns from those of an investigator with a database full of government-funded water quality monitoring data (especially if these latter data are already online and publicly available). Both investigators, however, likely share the desire of making sure their data are fully understood and applied correctly, and that proper credit and/or acknowledgement is given to the investigators and/or institutions responsible for their work. That is the full intent of the WG137 data policy.

Benefits of being a Data Contributor:
"Free Advertising": Descriptive information for each time-series site submitted to WG137 will be featured in an online interactive map, available through the WG137.net Web site. This map-based interface is a public- and Google-visible interface that provides a standardized text and graphical summary of every monitoring site in the WG137 collection (along with hundreds of similar sites from ongoing WGPME, WGZE, and WG125 plankton time series efforts). By default, numerical data are actually not available through this site, while standardized Web links and email contact fields direct interested researchers to the original data holder (you) or a relevant Web site (your institution or project site).
"Co-Authorship and/or Acknowledgment": Acknowledgment will always be given to each contributor, for example, in a detailed appendix listing the 100+ sites (and PIs and projects) from which a small portion of data were used in a larger study. In these larger, multi-site studies (e.g., where only your "total diatom abundance" data may be just one of 100+ points on global map), giving co-authorship to the 100+ authors is probably not feasible. Co-authorship is possible, however, in cases where a smaller collection of data sets are intensively used in a more focused study (i.e., if your site was one of ten other sites looking at a specific species group within similar hydrographic environments). Co-authorship will be decided on a case-by-case basis (e.g., how many sites were used, did you also contribute expertise or writing help, etc.). In case this vagueness concerns you, remember that all of the WG137 members are data holders/contributors and accomplished scientists themselves, and are also sensitive to the same concerns and desires about ones data and/or acknowledgment.
"Pre-Publication Notification:" It is not the intent of WG137 to produce any rude surprises or results that may counter your own work. When results and summaries are being prepared towards the end of the WG137 working period, we will be sensitive to both consulting and alerting you of any results that may single out your sampling site or data. Based on the global scale of the WG137 research, this kind of situation is very unlikely. In the case of smaller WG137 focus studies, you would likely already have been consulted (and/or present in the discussion as a co-author).

Who will have access to the contributed data?
The "raw data" (*e.g.,* the original data files or spreadsheets which you submitted to WG137) will only be handled by and accessible to the WG137 data management team (Todd O'Brien and Jacob Carstensen). These data will be processed into standardized aggregate forms (*e.g.*, the raw data will be processed into monthly or weekly means, the variable names and/or units will be

standardized, etc.). These data are then loaded into the WG137 data system, to which only the WG137 topic leaders have access (controlled via username and passwords). This WG137 data system allows the topic leader to quickly search for and extract only those data from monitoring sites that match their query (*e.g.*, contains "species X" and/or "species Y" data, along with any co-sampled temperature and salinity data). Once extracted, only this tiny subset of the data (not the entire collection or the original data files) will be shared among the other WG137 members in that topic group. In any instance, none of these data will be shared outside of the WG137 topic groups.

FAQ

The following is an FAQ section listing some of the more common concerns of data submitting investigators. If your questions are not addressed by this document or the FAQ section below, please feel free to contact the WG137 Chairs at chairs@wg137.net .

- Question 1: "Someone in my lab is currently using our data to write a paper on a similar topic. If we contribute our data, will the WG137 research duplicate or contradict our findings?

  WG137 will be using a global collection of sites, frequently using data previously not available anywhere else. Duplication is therefore very unlikely. Contradiction of results is also unlikely, as WG137 claims would likely be on at completely different comparison scale and basis. In the case that your contributed data set was focused upon at a final level that could even possibly cause duplication or contradiction, the WG137 topic leaders would be in contact with you prior to any results writing or publication (see co-authorship section above). The WG137 papers are probably 3-4 years down the road. Your paper is more likely to be cited than duplicated by WG137.

- Question 2: "I was looking at the online map and I found a monitoring site where time-series data were actually available online?!! (Is this a mistake and/or why aren't all of the data available?)"

  The WG137 data policy is "by default, numerical data are not available through this site". In a growing number of instances, the data contributors have requested that their data are made available, usually with a time lag (allowing them time to publish but also advertising their efforts to the global community). Note that the online map also includes data from other projects with different data policies. Data contributed to WG137, however, will be held under the WG137 data policy and will not be made available unless permission is specifically granted from the contributor.

- Question 3: "What format do you require my data to be in for submission?"

  WG137 does not require specific formats. Most submissions are sent in CSV, plain text, Excel spreadsheets, or in Access databases. After receiving your data, we may then contact you briefly to verify column headings and/or methods.

- Question 4: "What variables (data types) are you interested in?"

  A table of variables in use and/or of interest will be available on the WG137.net web site. In general, any data representing the phytoplankton population and/or hydrographic conditions is of interest. As a rule of thumb, it is easier to provide everything than to try and re-send and/or include something later.

- Question 5: "Is it possible to become a member of WG137?"

  Membership is not required to collaborate with and/or co-author on any of the WG137 work. However, an associate membership is possible for individuals that contribute significantly to the working group. This action would be requested by the WG137 chairs and forwarded to SCOR for consideration. The benefits of this membership would be only in title and acknowledgement (e.g., an official letter from the SCOR acknowledging participation and/or membership). Financial support (e.g., for meeting attendance or research time) is extremely unlikely.

7. WG137 Proposed Terms of References and who is responsible

- Identify existing long time series of phytoplankton data in coastal oceans around the world (Todd O'Brien)
- Facilitate migration of individual data sets to a permanent and secure electronic archive (Requirements for development of a fully stocked phytoplankton database greatly exceed the resources of this WG. However, we expect to produce a small working prototype, based on the existing archive (to be identified) to demonstrate the value of sharing data through an international database. (Todd O'Brien)
- 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). (Todd O'Brien et al.)
- Based on the above, develop priorities and recommendations for future monitoring efforts and for more detailed re-analysis of existing data sets. (Todd O'Brien et al.)
- 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. (Katja Philippart et al)
  - 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). (Kedong Yin, Jacob Carstensen et al.)
  - Amplitude of variability, both for total biomass and for individual dominant species, and a comparison to the amplitude of population fluctuations. (Adriana Zingone et al.)

  - Likely causal mechanisms and consequences for the phytoplankton variability, based on spatial and temporal coherence with water quality time series (Jacob Carstensen et al).
- Through comparative analysis, we will address the 3 guiding questions (Jim Cloern and all others).
- The policy and agreement on data, authorship and acknowledgement (Todd).

8. Agreed Research Questions: who does what question

(non-participants are encouraged to add their names or raised their own questions)

Abigail McQuatters-Gollop, Hans Paerl, Nathan Hall, Katja Phillipart, Peter Thompson, N Ramaiah, Adriana Zingone**,** Monika Winder, Alexandra Kraberg, Sirpa Lehtinen, Kedong Yin, Todd O'Brien

- **Q1:** Do changes in nutrient supplies, sources (new vs. regenerated), concentrations and ratios cause shifts in phytobiomass and community composition?

Alexandra Kraberg, Nathan Hall, Abigail McQuatters-Gollop, Hans Paerl, Sirpa Lehtinen, Peter Thompson, Todd O'Brien

- **Q2:** Are there temperature thresholds that determine dominance of different phyto groups and do temp regimes and ranges govern interactions?

Adriana Zingone to lead, Jim Cloern, Hans Paerl, Nathan Hall, Todd O'Brien

- **Q3:** How is phytoplankton cell size a reflection of environmental conditions across systems?

Peter Thompson, Nathan Hall, Adriana Zingone, Sirpa Lehtinen

- **Q4:** What are the competitive advantages of motility and how do they relate to the vertical structure of the water column?

Peter Thompson, Paul Harrison, Hans Paerl, Kedong Yin, Kevin Sellner, Adriana Zingone, Lu Douding. Todd O'Brien

- **Q5:** How does variability of hydrology/salinity, residence time influence phytoplankton?

Adriana Zingone, Alexandra Kraberg, Abigail McQuatters-Gollop, Katja Phillipart, N Ramaiah, Peter Thompson, Lu Douding, Monika Winder, Li Ruixiang , Nathan Hall, Todd O'Brien

- **Q6:** What are the common seasonal patterns along single species & communities?

Peter Thompson, Jacob Carstensen, Todd O'Brien, Abigail McQuatters-Gollop, Monika Winder, Katja Philippart, Todd O'Brien

- **Q7:** What are the patterns that can be revealed by different time series analyses **method**s? (methods, tipping points/thresholds, early-warning signals)

Katja Philippart, Monika Winder, Abigail McQuatters-Gollop, Jim Cloern, Sirpa Lehtinen, Todd O'Brien

- **Q8:** How much local-scale variation can be explained by progressively larger scale variation?

Monika Winder Katja Philippart, Jim Cloern, Alexandra Kraberg, Sirpa Lehtinen, Hans Henrik Jakobsen, N Ramaiah. Todd O'Brien

- **Q9:** What role does bottom-up vs. top-down processes play in regulating planktonic communities? To what extent does phyto comp affect food quality?

Tasks

Jim Cloern, Abigail McQuatters-Gollop, Katja Philippart, Kedong Yin ….

- **Task 1.** What are the global patterns in processes of phytoplankton variability?

Paul Harrison, Adriana Zingone, Hans Henrik Jakobsen, Xu Jie …

- **Task 2.** Common Conversion Tables (biovolume, C, C:Chl*a*)

Zhu Mingyuan, Li Ruixiang, Kedong Yin

- **Task 3.** Review of Yellow Sea

Kedong Yin, Todd O'Brien, and others

- **Task 4.** Biogeography of phytoplankton

9. Notes of meeting proceedings

Notes during the meeting were made by Nathan Hall and Monika Winder. They are available upon request.

10 The abstracts of presentations made in the first WG meeting.

The following abstracts from the meeting are available upon request.

North America (USA)

Neuse River Estuary-Pamlico Sound

Assessing the interactive impacts of anthropogenic and climatically-driven environmental change on the structure and function of phytoplankton communities in the Neuse River- Pamlico Sound System, North Carolina, USA. By Hans W. Paerl, Karen L. Rossignol, Nathan S. Hall, and Benjamin L. Peierls. University of North Carolina at Chapel Hill, Institute of Marine Sciences, Morehead City, NC 28557 USA

San Francisco Bay
Overview of studies in San Francisco Bay to illustrate how climate variability influences phytoplankton variability at four time scales by James Cloern

India
Spatio-temporal variability in species composition of phytoplankton in the coastal waters off Goa: a monsoon affected tropical coastal region by N. Ramaiah and A A. S. Alkawri, National Institute of Oceanography, Council of Scientific and Industrial Research, Dona Paula, Goa 403004

Australia: Huon Estuary
Thompson, P.A., P. I. Bonham and K.M. Swadling. 2008. Phytoplankton blooms in the Huon Estuary, Tasmania: top down or bottom up control? Journal of Plankton Research. 30:735-753.

Australian Coastal Zone
(Thompson, PA , Baird, ME, Ingleton, T, Doblin, MA. 2009 Long-term changes in temperate Australian coastal waters and implications for phytoplankton. Marine Ecology Progress Series 384: 1-19.) Phytoplankton data are quite limited in this study.

Australia Swan River
A data set with 9 stations sampled weekly from 1993 to present from the Swan River are in the SCOR WG database. Phytoplankton are to Class only. Some papers by PT on this ecosystem include work on limiting factors.

Australia: Wilson Inlet
These data will also be included in the SCOR WG data set. The Inlet has a sand bar across the mouth that develops in Winter and breaks, or is broken, every year. Opening the bar dramatically impacts on the phytoplankton ecology of the Inlet.

Europe: Ringkøbing Fjord: flow-manipulations and food-web effects
Jens K. Petersen, Jens W. Hansen, Martha B. Laursen, Preben Clausen, Jacob Carstensen, Daniel J. Conley, Peter Henriksen and Hans H. Jacobsen

Europe: German Bight: Helgoland Roads
Karen. H Wiltshire, Alexandra Kraberg, Silvia Peters, Kristine Carstens
Biologische Anstalt Helgoland AWI, Kurpromenade 201, 27498 Helgoland, Germany

Worldwide
The annual cycles of phytoplankton biomass by Monika Winder[1*], James E. Cloern[2]
[1]John Muir Institute of the Environment, University of California, Davis, USA
Leibniz-Institute of Marine Sciences at Kiel University (IFM-GEOMAR), Kiel, Germany
[2]U.S. Geological Survey, 345 Middlefield Rd., Menlo Park, CA, USA 94025

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China: Hong Kong-Pearl River Estuary
Coastal Ecosystem Dynamics and Eutrophication in the Pearl River Estuarine Coastal Waters by Kedong Yin[1,2] and Paul J. Harrison[3]

[1] School of Marine Sciences, Sun-Yat Sen University, Guangzhou China; [2] Griffith School of Environment, Griffith University, Australia. [3] Division of Environment, Hong Kong University of Science and Technology, Kowloon, Hong Kong, China

Ecosystem Changes in the Yellow Sea
Zhu Mingyuan, First Institute of Oceanography, State Oceanic Administration, Qingdao, China

Italy: Gulf of Naples, Mediterranean Sea
Winter-spring phytoplankton dynamics at the LTER-MC station (Gulf of Naples) by Adriana Zingone, Laurent Dubroca, Daniele Iudicone, Francesca Margiotta, Maurizio Ribera d'Alcalà, Vincenzo Saggiomo, Diana Sarno, Stazione Zoologica Anton Dohrn – Napoli, Italy

2.2.11 SCOR/IGBP WG 138 on Modern Planktic Foraminifera and Ocean Changes *Fennel* (2010)

Terms of Reference:

1. Synthesize the state of the science of modern planktic foraminifera, from pioneering to ongoing research including
   - their spatial and temporal distribution in the world ocean
   - their calcification mechanisms and shell chemistry
   - and their eco-phenotypical and genotypical variability

   as a peer-reviewed publication in an open-access journal (**deliverable 1**).

2. Provide guidelines (cookbooks) in terms of species identification, experimental setup for culture studies, laboratory treatment prior to geochemical analysis (**deliverable 2**) by identifying existing gaps in the available knowledge in order to direct future research.

3. Establish an active Web-based network in cooperation with ongoing (inter)national research programmes and projects to guarantee an open-access world-wide dissemination of results, data and research plans (**deliverable 3**).

4. Document the work of the group in a special issue of an open-access journal (**deliverable 5**) in connection with a specialized symposium with special emphasis on modern ocean change i.e. thermohaline circulation and ocean acidification, during one of the AGU or EGU conferences, ideally held at the joint EGU/AGU meeting (envisaged for 2013 or 2014) and/or at the FORAMS 2014 meeting in Chile (**deliverable 4**).

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Jonathan Erez (Israel)	Kate Darling (UK)
Elena Ivanova (Russia)	Lennart de Nooijer (The Netherlands)
Margarita Marchant (Chile)	Steve Eggins (Australia)
Divakar Naidu (India)	Baerbel Hoenisch (USA)
Daniela Schmidt (UK)	Sangmin Hyun (Korea)

Howard Spero (USA) Richard Zeebe (USA)	Zhimin Jian (China) Thorsten Kiefer (Switzerland) Dirk Kroon (UK) Stefan Mulitza (Germany) Frank Peeters (The Netherlands) Ralf Schiebel (France) Michael Schulz (Germany) Kazuyo Tachikawa (France) Rashieda Toefy (South Africa)

Executive Committee Reporter:

SCOR/IGBP Working Group 138
Modern Planktic Foraminifera and Ocean Changes

Co-chairs: Gerald Ganssen (Amsterdam) and Michal Kucera (Tübingen)

First annual report: 1.7.2011

In the first half of 2011, the working group has consolidated its membership and revised its terms of reference (final approval: 16.2.2011), implementing the suggestions by the SCOR plenary meeting 2010 where the working group has been initially approved. The consolidation phase was completed in May 2011, resulting in the group now consisting of 10 full members and 15 associate members. The membership consolidation was important since one of the main goals of the group has been defined as an attempt to transfer expertise to the next generation of young researchers. As a result, the membership of the working group now reflects the ambition to achieve worldwide coverage and involve young researchers across gender boundaries. The team includes colleagues from 14 countries on five continents. One-third of the team is female and one-third consists of young researchers. Group membership details can be found in the attachment.

Activity 1: Kick-off meeting 29.8.-2.9. 2011

The first task of the working group has been to organize a kick-off meeting where the schedule for individual deliverables will be agreed and where teams will be assigned to individual tasks. To this end, the co-chairs met at the EGU meeting in Vienna in April 2011 and set up the logistics and agenda for the first meeting of the working group. We are pleased to report that the meeting organization has been completed and we are looking forward to welcome a core team of about 20 group members between 29.8.-2.9. in the historical premises of Het Bethanienklooster in Amsterdam. Additional funding for the kick-off meeting has been secured from the EuroProx project of the University of Amsterdam. The meeting agenda can be found in the attachment.

Activity 2: Engagement with the community & transfer of expertise

We decided to consistently pursue the objective of engaging the working group with young researchers from the very beginning of its existence. Therefore, one day of the kick-off meeting (1.9.2011) has been assigned to a Minisymposium, which will bring young researchers in contact with international experts in the field. The young researchers will present their results in a short oral and a poster presentation. During dedicated poster sessions the experts will discuss the posters and ad hoc groups will form where young researchers can give contributions to the

SCOR WG goals and in return can profit from the expertise of senior researchers for their future research. The afternoon and evening informal discussions and social programme will further facilitate exchange of ideas. An overarching aim is to establish a longer-term cooperation between the WG members and the young researchers, who will thus be able to closely follow and contribute to the aims of the SCOR WG. The Minisymposium has been widely advertised (see attached invitation) and we have been able to fill all 20 places within a few weeks after the call. The participants include PhD students and young postdocs from 13 institutes in 6 countries. Full list is attached.

Activity 3: Deliverable 2 – Guideline to the culturing of modern planktonic foraminifera

The expertise in handling of live planktonic foraminifera in cultures is essential for development of geochemical proxies and a better understanding of the physiology of the organism. At present, there are a handful of senior experts, with skills in this field that are not sufficiently documented. To close this gap, the working group identified as its first deliverable the development of a guideline for culturing work on planktonic foraminifera. Complementary support from within the working group has allowed Prof. Howard Spero to organize a filming team at the Santa Catalina Island marine station in California, who will produce a professional video documentary on the relevant procedures. The filming commenced in July 2011 and the first version will be presented during the kick-off meeting.

Outlook: Web platform

The next task immediately following the kick-off meeting will be the establishment of a Web-based resource for communication within the working group (foram-blog) and for structured access to information, data and images (wiki). The exact format and content will be agreed during the kick-off meeting. The preliminary plan is to make use of one or more existing online resources (such as eForams), which will assure long-term persistence of the content developed during the mandate of the working group.

Attachment 1: Membership of SCOR/IGBP WG 138

Full Members:
1. Co-chair: Gerald Ganssen (proxies), The Netherlands
2. Co-chair: Michal Kucera (ecology and diversity), Germany
3. Jelle Bijma (ecology), Germany
4. Jonathan Erez (calcification, symbiosis, proxies), Israel
5. Richard Zeebe (bio-physico-chemistry), USA
6. Howard Spero (calcification, symbiosis, proxies), USA
7. Margarita Marchant (ecology), Chile
8. Divakar Naidu (micropalaeontology), India
9. Daniela Schmidt (microstructure), UK
10. Elena Ivanova (paleo applications), Russia

Associate Members:
1. Frank Peeters (spatio-temporal distribution), The Netherlands
2. Stefan Mulitza (proxies), Germany
3. Michael Schulz (ecological modeling), Germany
4. Thorsten Kiefer (PAGES), Switzerland
5. Caroline Cleroux (deep dwelling species), USA/France
6. Ralf Schiebel (ecology and calcite budget), France
7. Lennart de Nooijer (calcification), The Netherlands
8. Steve Eggins (microgeochemistry), Australia
9. Kate Darling (genotypes), UK
10. Baerbel Hoenisch (bio-chemico-physics), USA,
11. Zhimin Jian (micropaleontology), China
12. Dirk Kroon (micropalaeontology and taxonomy), UK
13. Rashieda Toefy (ecology), South Africa (at SA SCOR expense)
14. Sangmin Hyun (paleoceanography, sedimentation), Korea (at Korea's SCOR expense)
15. Kazuyo Tachikawa (paleoceanography, proxies), France (at French SCOR expense)

Attachment 2: List of participants registered for the Minisymposium at 2.9.2011

Kristina Arthur, Free University Amsterdam, PhD student
Ralf Aurahs, University of Tübingen, Postdoc
Wouter Feldmeier, Free University Amsterdam, PhD student
Jeroen Groeneveld, AWI Bremerhaven, postdoc
Tim Haarmann , Bremen University, PhD student
Lukas Pieter Jonkers, University of Barcelona, Postdoc
Heather Johnstone, Bremen University, postdoc
Azumi Kuroyanagi, Tokio University, postdoc

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Gianluca Marino, University of Barcelona, Postdoc
Raphael Morard, Roscoff, Postdoc
Aurore Movellan, Angers University, PhD student
Victoria Peck, British Antarctic Survey, PhD student
Gert-Jan Reichart, Utrecht University, Academic
James Rae, Bristol University, PhD student
Tilla Roy, Gif-sur-Yvette, Postdoc
Paolo Scussolini, Free University Amsterdam, PhD student
Juliane Steinhardt, NIOZ, PhD student
Sanne Vogels, Free University Amsterdam, PhD student
Agnes Weiner, University of Tübingen, PhD student
Jos Wit, Utrecht University, PhD student

SCOR/IGBP Working Group 138

Modern Planktic Foraminifera and Ocean Changes

Kick-off meeting and first workshop

August 29th - September 2nd 2011
Amsterdam, The Netherlands
In the historical premises of
'Het Bethanienklooster': http://www.bethanienklooster.nl/

Preliminary Programme

Day 1: Monday August 29th
12.00h: welcome lunch
13.00h: brief introduction of own research by participants (max 10 minutes)
16.30h: discussion and structuring of the WG deliverables

Day 2: Tuesday, August 30th
9.00h - 18.00h: planning of actions and projects for the WG
defining task forces and sub-groups for specific deliverables

Day 3: Wednesday, August 31st
9.00h - 15.00h: meeting of small focus groups
collating data and material brought by WG members to contribute to WG deliverables

Afternoon: Amsterdam city tour

Day 4: Thursday, September 1st
9.00 - 17.00h: **Open Symposium: Young Researchers Meet SCOR Experts**

Including
Keynote lecture 1: „Eco-phenotypical and genotypical variability“ Michal Kucera
Keynote lecture 2: „Calcification mechanisms and shell chemistry“ Howard Spero
Posters and discussions and recruitment of young cooperators

19.00h: dinner boat cruise (including young researchers)

Day 5: Friday, September 2nd

9.00h: wrap up and conclusions, decision on next workshop
13.00h farewell lunch

Meeting organizers: Michal Kucera and Gerald Ganssen
Logistical Enquiries: Els Ufkes (Email: e.ufkes@vu.nl)

SCOR/IGBP Working Group 138

Modern Planktic Foraminifera and Ocean Changes

Invites applications from young researchers to participate at a focus Symposium
Young Researchers Meet SCOR Experts

Date: Thursday, September 1st, 2011
Venue: Het Bethanienklooster (http://www.bethanienklooster.nl/), Amsterdam, The Netherlands

The aim of this one day workshop is to bring young researchers in contact with international experts in the field. The young researchers are expected to present their results by means of a short oral and a poster presentation. During dedicated poster sessions the experts will discuss the posters in detail. Based on the poster discussions, ad hoc working groups will be formed where young researchers can give contributions to the SCOR WG goals and in return can profit from the expertise of senior researchers for their future research. The afternoon and evening informal discussions and social programme will further facilitate exchange of ideas. Participation in the workshop, including the social programme, is free of charge. The number of places is limited and the capacity will be filled on a first-come first-serve basis. The membership and terms of reference of the WG are available from here: http://www.scor-int.org/Working_Groups/wg138.htm

Programme

9.00h: Keynote lecture 1: Prof. Michal Kucera, University of Tübingen
„Eco-phenotypical and genotypical variability“
10.00h: Brief presentations by young researchers: within max. 5 minutes the participants will explain the highlight of their research and win the attention for their posters
12.30h: Lunch (including poster discussions)
14.00h: Keynote lecture 2: Prof. Howard Spero, University of California Davis
„Calcification mechanisms and shell chemistry“
15.00h: Posters and discussions (partly within separate topical sub-groups)
17.00h: Drinks and informal discussions
19.00h: Dinner boat cruise

The symposium is organized in association with the kick-off workshop of the SCOR/IGBP WG 138. One of the aims of stimulating the participation by young researchers is to establish a longer-term cooperation between the WG members and the young researchers, who will thus be able to closely follow and contribute to the aims of the SCOR WG.

Applications and enquiries should be directed to the meeting organizers:

Gerald Ganssen (g.m.ganssen@vu.nl) and Michal Kucera (michal.kucera@uni-tuebingen.de)

2.3 Working Group Proposals

2.3.1 Investigation of the Physical and Biological Determinants of Population Connectivity: Are Perceived Temperate-Tropical Differences Real? *Fennel*

Abstract
The proposed working group, co-chaired by RR Warner and JM Leis, will address the perceived vs. real differences in connectivity of marine metapopulations through larval dispersal in temperate and tropical environments. Space-based management of coastal oceans, including no-take marine reserves, is being developed worldwide. Proper design of marine reserve networks depends on knowing the extent to which the changes inside a protected community are reflected in the connections to other communities (e.g., supplying larvae to fished areas, or connecting to other reserves in a network). There are few differences between temperate vs. tropical areas in the positive response within reserves to protection, but at this point we do not know if there are fundamental differences in connectivity associated with different coastal environments. Managers and designers are unsure if lessons learned about connectivity in one realm are applicable to another. The working group will establish the critical determinants of geographical variation in connectivity, with an aim of providing clear guidelines for spatial design and management.

There are a number of reasons to expect that the scale and processes of connectivity might differ geographically; some arise from contrasts in species composition and community structure, some from temperature influences on physiology and development, and others from differences in physical processes. We will explore these perceived differences to determine which are real, which may be due to the different perceptions, perspectives, and research agendas of those working in the different environments, and which require further research. The working group will bring together scientists with expertise in marine community ecology, conservation genetics, larval biology, physical oceanography, and fisheries to consider the critical factors affecting geographical variation in connectivity.

Many of the factors that may affect the scale and processes of connectivity on a geographical basis are also projected to be themselves affected by global environmental change. Therefore, we will use the findings of this working group to explore how connectivity might change over time in any particular geographical area due to climate change.

In addition to a major synthetic review, the working group will produce a practical guide to the factors that might affect connectivity in marine systems, with special attention paid to how these factors might vary on a geographic basis or over decades of environmental change. The second meeting of the group will integrate our findings into marine spatial planning criteria, with explicit acknowledgement that a single-minded approach is simply inappropriate for places as complex as the coastal ocean.

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Background and Rationale

Marine spatial planning generates opposition from some stakeholders whose objections usually focus on the science behind marine reserve planning. Even when the science is sound, some claim that evidence gathered from one geographic area (say, temperate coastal waters) is not applicable to geographically distinct areas (such as coral reefs). The extent to which these are valid objections is unclear. For example, it has been suggested that the responses of organisms to protection in reserves may differ between temperate and tropical areas (Laurel and Bradbury, 2006). In contrast, Lester et al. (2009) demonstrated that temperate and tropical communities responded similarly to protection.

Most marine organisms have a pelagic propagule stage that poses a further challenge to spatial planning. Although the positive demographic responses of marine organisms to protection inside reserves are clear, we know much less about the fate of the increased reproduction that occurs inside of reserves. This question is critical, because it addresses both the service function of reserves (e.g., export of larvae to fished areas) and the design of reserves (e.g., networks connected through larval exchange; Warner and Cowen, 2002; Sale et al., 2005). Evidence is accumulating about the extent of larval export from reserves (Pelc et al., 2010), and the degree to which larvae may be able to influence their settlement location (Leis, 2007, 2010). However, at this point we have little ability to respond to the suggestion that connectivity between marine populations might vary geographically (e.g., as a function of temperature or underlying demography; Laurel and Bradbury, 2006; O' Connor et al., 2006). As estimates of connectivity and dispersal are important criteria in marine spatial planning (Botsford et al., 2003; Roberts et al., 2003), this limits the confidence of designers and managers to apply general criteria to local problems. This working group will examine and evaluate the potential importance of geographically varying physical and biological factors in affecting dispersal and connectivity in coastal marine environments, and will produce clear guidelines for the practical application of our findings.

A recent symposium convened by Leis and Warner on this theme (Larval Fish Conference, 2009) confirmed this is a problem of general interest, particularly to managers. A SCOR working group is the ideal vehicle to complete this process. Connectivity demands a multi-disciplinary approach, and because we seek to examine regional differences, and must involve workers from different perspectives and with different goals, a SCOR working group is the best way to go. Workers and funding agencies have tended to focus on their own discipline or region, often both, but the question demands a broader, more integrated approach. We have identified scientists whose depth of knowledge and strong interactive ability make them ideal participants in an SCOR working group setting. Two advantages accrue from developing a working group out of a symposium: 1st, many of the data required to address the problem have already been organized, allowing us to work efficiently; 2nd, we are much more aware of critical information gaps.

On the biological side, information on connectivity comes from studies in genetics, tagging, otoliths, larval biology, oceanographic sampling, and physiology (Leis et al 2011). Data are

rather sparse and the methods used vary from study to study. On the physical side, data from drifters, oceanographic models, and direct or remote measurements are more standardized, but the datasets can be enormous.

Terms of Reference
Working group activities will involve review of source-specific information assembled before the first meeting (Step 1 below), consideration the possible underlying causes for geographic variation (Step 2), publication of a synthetic review, including identification of research priorities (Step 3), and publication of specific guidelines for spatial planning (Step 4). Co-chairs Warner and Leis have track records of successful delivery of important 'group publications', including the much cited 'Open Populations' issue of Bull. Mar. Sci. (Warner & Cowen 2002), and Leis' larval-fish books (the most recent is Leis and Carson-Ewart 2004).

1. Assemble geographically specific information on the scale of connectivity and dispersal arising from the following sources:

- Genetics
- Recruitment patterns resulting from isolated sources
- Marking of internal hard structures /recruit recapture
- Naturally occurring elemental markers in internal hard structures/recruit recapture
- Oceanographic sampling of larvae
- Circulation modeling (tuned to species characteristics and latitudinal oceanographic variables, eg, thermocline depth, Coriolis force)
- Direct or remote measurements of current patterns
- Passive drifters
- Larval behaviour

2. Is there evidence of geographic variation in these estimates of connectivity? If so, ask two questions of the data:

2A. Might the geographic differences arise from differing methodologies/research targets? Listed below are some methodologies/research targets that may have a systematic tendency to influence the outcomes of a connectivity study, and may also have a geographic bias. In each case, the methodology/research target listed first tends to be associated with tropical studies, and the second with temperate, but fortunately there are many exceptions.

- Larval fish biology: Academic ecologists vs Agency fishery biologists
- Scale of study: Micro to mesoscale vs Meso to macroscale
- Study Species: Smaller, site-attached, non-exploited vs Larger pelagic/migratory, exploited species

- Research focus (Cowen & Sponaugle, 1997): variability in connectivity due to fluctuations in: Dispersal/retention vs Food availability
- Life-history styles – do they differ with latitude?
    - Anadromy – is it more important in temperate areas?
    - Spawning aggregations – are they more important in the tropics
- Definitions of "connectedness": Demographic (input affects local population dynamics) vs Genetic (input detectable in local genetics)

2B. If the differences are real, what are the underlying causes for geographic variation? The real-world phenomena listed below could vary geographically and could have a direct or indirect effect on dispersal and connectivity. Characteristics that could have an inherent correlation with latitude are marked with an asterisk (*). In some cases, for example larval swimming speed, there is empirical support for geographic differences, but for most items, support is theoretical to equivocal, and requires further investigation.

- Biological
    - Species assemblages and characteristics (Leis, 2007, 2010)
        - Larval swimming ability
        - Pelagic larval duration
        - Larval size and survival
    - Habitat distributions
    - Temperature-related physiological processes*
        - Swimming speed
        - Developmental rate

- Physical
    - Current and wind velocities*
    - Mesoscale eddies* (Siegel et al., 2008)
    - Coriolis force*
    - Upwelling*
        - Effects on retention
        - Effects on productivity
    - Depth of mixed layer*
    - Viscosity of seawater*
    - Bathymetry (steered flows)
    - Geomorphology – Islands and capes (retention in wakes, discontinuous habitat)

3. What is the relative importance of those factors that appear to be affecting geographic variation in connectivity? The product will be a major synthetic review of the causes and consequences of geographic variation in dispersal and connectivity: an important section will be an identification of knowledge gaps and research priorities.

4. Given the important factors affecting geographic variation in connectivity, how can we incorporate this knowledge into criteria and guidelines for marine spatial planning? In our second meeting, we will convene with spatial planning experts and managers to produce a straightforward set of guidelines that incorporate considerations of connectivity into local planning efforts.

Timetable of activities, products, and benefits

We propose to meet only twice, but for five days each time. This will be more efficient, reduce the carbon footprint of the project, and will help the group finish its work more quickly. Because of the longer meeting times, the group will need the full amount normally budgeted for a SCOR working group. If this is not acceptable to SCOR, we can rearrange the timing of our tasks to make it possible to meet three times in three years.

1st half of 2012: Detailed instructions sent to workshop participants with expertise in particular data sources (see Step 1, above). Each participant assembles information on the scale of connectivity and dispersal, paying particular attention to geographical variation.

Meeting one, TBA, possibly Sept 2012, 5 days: Terms of reference 1-3.

2. (Plenary) Receive reports of geographical variation (or lack thereof) in connectivity and dispersal based on different data sources.
3. (Subgroups) In smaller, focused groups, resolve:
   (a) whether differences actually exist, or are more a function of methodology;
   (b) if differences exist, identify causes – is it inherent in latitude, or a function of underlying species composition, bathymetry/geomorphology, etc.?
   (c) given the differences, how great an effect will these factors actually have on connectivity?
4. (Plenary) Entire working group reviews the subgroup reports and undertakes an initial ranking exercise to identify the most important factors that might affect connectivity on a geographic basis. This is not intended to give a simple answer as to whether connectivity might differ between tropical and temperate regions, but rather to assemble a list of the important factors to consider when estimating or modeling connectivity in a particular region.
5. Preparation of a report on the initial conclusions of the group in a venue such as *TREE*.

Date TBA: *Publication of a synthetic review of the important factors affecting geographic variation in connectivity and dispersal*. This will include a formal comparison to explore the relative importance of these factors.

Meeting two, date TBA late 2013/early 2014 (5 days): Terms of reference 1-4.

This meeting will consist of a subset of the participants from the first meeting. For the 1st 3 days, we will produce a working draft of the synthetic review. For the last 2 days, we will meet with a group of experts in marine spatial planning design and implementation. We will use our results

to modify existing design criteria for marine spatial planning to take into account factors affecting connectivity that arise from community composition and physical setting of the areas under consideration. While these factors may often reflect a tropical vs. temperate setting, our detailed approach will identify important factors on a case-by-case basis, and will include those factors likely to be altered by global environmental change. These guidelines will be made available in downloadable booklet form, with an intended audience of managers, planners, stakeholders, non-governmental organizations, and the general public.

Meeting Location

Connectivity is a multidisciplinary problem, so, our working group members come from a variety of disciplines. As a result, there is no conference that a high proportion of the members would be likely to attend and to which we can append our meetings. We therefore propose to hold the meetings at the University of California at Santa Barbara (where co-chair Warner is based: therefore, he does not require SCOR funding to participate), which is relatively centrally located to the working group members. The Marine Science Institute at USCB will host the meetings, and it is likely the working group will receive some support from the National Center for Ecological Analysis and Synthesis based at UCSB.

Working Group Proposed Composition

Full Members	**Country**	**Expertise**
Jeffrey Leis (co-Chair)	Australia	Larval-fish biology
Satoshi Mitarai	Japan	Marine biophysics
Ian Bradbury	Canada	Fishery & conservation genetics
Emanuel Gonçalves	Portugal	Marine community ecology, behaviour
Jean-Olivier Irisson	France	Biological oceanography, dispersal modeling
Trond Kristiansen	Norway	Physical oceanography, biophysical processes
Elizabeth North	USA	Larval biology and dispersal
Mary O'Connor	Canada	Physiology of marine animals
George Branch	South Africa	Marine ecology and biogeography
Yvonne Sadovy	China	Reproductive physiology, spawning behaviour
Full Member not requiring SCOR funding		
Robert Warner (co-Chair)	USA	Marine ecology and demography

Associate Members	Country	Expertise
Jennifer Caselle	USA	Marine ecology, population connectivity
Steven Swearer	Australia	Otolith microchemistry and dispersal
Robert Cowen	USA	Biological oceanography, larval dispersal
Paul Barber	USA	Marine phylogeography and genetics
Andrew Bakun	USA	Fisheries, biological oceanography
Ivan Nagelkerken	Netherlands	Marine ecology, population connectivity
Alan Shanks	USA	Larval invertebrate biology
Jon Hare	USA	Fisheries, larval biology

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2.3.2 Organic Ligands – A Key Control on Trace Metal Biogeochemistry in the Ocean

Compton

Abstract

The trace metals iron (Fe), copper (Cu), nickel (Ni), cobalt (Co), cadmium (Cd) and zinc (Zn) are essential micronutrients to marine phytoplankton, controlling primary productivity in up to half of the open ocean, from tropical to polar regions. Consequently, these metals exert a major influence on the global carbon cycle and play a key role in regulating global climate. However, the availability of these metals to the biota is governed by speciation, whereby trace metals are bound by organic ligands that may reduce or enhance metal bioavailability, depending on the metal and the resulting metal-ligand complex. Organic ligands are defined as molecules that can bind to, and form a stable complex with, trace metals in the aquatic dissolved (typically <0.2 μm) phase. Electrochemical techniques have shown that trace metals in seawater are overwhelming bound (up to 99.999%) by organic ligands, and that these ligands are ubiquitous in the ocean. More recently, organic geochemical techniques have shown that at least some Fe-binding ligands are produced by the biota. Over the past three decades, major advances in analytical techniques have led to a consensus on accuracy and precision for total dissolved trace metal analyses and dramatically improved our knowledge on the global and regional distributions of trace metals. In contrast, our understanding of trace metal-binding ligands and their pivotal biogeochemical functions remains at a comparatively early stage. ***To date, we know little about the composition, source and provenance of metal-binding ligands, which is hindering further advances in the field of trace metal biogeochemistry.***

The proposed working group would focus on advancing our understanding of trace metal-binding organic ligands in the oceans by bringing together expertise ranging from aquatic organic geochemistry to trace metal electrochemistry. Over a 4-year period the working group will (1) Summarize published results from electrochemical and organic geochemistry techniques to identify future collaborative research directions towards targeting specific approaches to determine the structure and source of metal-binding ligands; (2) Expand upon the ligand intercalibration programme, initiated by GEOTRACES, to evaluate key analytical issues with currently employed methodologies and determine how best to link ongoing efforts in trace metal and organic geochemistry to assess natural metal-binding ligands; (3) Identify how to best incorporate published and future data into biogeochemical models; (4) Employ a suite of proposed workshops and working group meetings as a forum to debate the nature of sampling strategies and experimental approaches to be employed in laboratory and field efforts that are needed to determine the composition and structure of these ligands; (5) Provide summarized recommendations at the proposed symposium for future research approaches into ligand biogeochemistry, especially with respect to complementing the ongoing decade-long GEOTRACES field efforts (*i.e.,* regional surveys and process studies) and the need for rapid incorporation of this research into biogeochemical models; (6) Establish a webpage for this SCOR working group, to promote a forum for discussion of ideas and results, soliciting input from the trace metal biogeochemistry, aquatic organic geochemistry and modelling communities,

and provide a platform to propose special sessions on trace metal-binding ligands at international meetings such as Ocean Sciences, AGU and/or EGU.

Rationale

Improving our understanding of the role of metal-binding ligands in oceanic biogeochemistry is extremely important, as these ligands control the bioavailability of trace metals, and, thus, influence pivotal global elemental cycles, such as carbon and nitrogen. To a large extent, we simply do not adequately understand the role or chemical structure of metal-binding ligands in the oceans. Thus, we cannot model them with sufficient confidence to predict how they, and consequently trace metal cycles, will respond to projected global alteration of continental aridity (dust supply), ocean acidification, and oceanic oxygen minimum zones due to a changing climate.

Historically, the primary technique for characterizing metal-binding ligands in seawater has been competitive ligand exchange-adsorptive cathodic stripping voltammetry (CLE-ACSV), which provides ligand concentrations and conditional stability constants for the ambient metal-ligand complexes. This technique, however, does not provide meaningful information on the structural characteristics required for identification of these ligands. In the past few years, analytical advances in organic geochemistry using liquid chromatography-electrospray ionization-mass spectrometry (LC-ESI-MS) methods, coupled with nuclear magnetic resonance (NMR), have led to novel research focused on determining the link between the binding strength of ligands measured in natural seawater and their structural identity. As CLE-ACSV provides ligand concentrations, but not structural characteristics, while LCESI-MS/NMR provides structural characteristics but no quantitative information on ligands, it is essential to combine these approaches in order to drive progress toward determining sources and composition of metal-binding ligands in the ocean. Each of these techniques alone constitute a powerful, though insufficient, approach to determining metal speciation- ***combining these approaches would constitute a significant step towards assessing metal-binding ligands in the ocean, and lead to new research directions for metal speciation similar to that achieved with 'The Biogeochemistry of Fe' (SCOR WG 109) for dissolved Fe analysis.***

It is timely to focus on the issue of trace-metal binding ligands now, as a SCOR-sponsored international programme, GEOTRACES, was launched in late 2009 with the goal of determining the distributions of trace metals in the global ocean. Trace metal speciation, at least for Fe, has been identified as a core measurement on the GEOTRACES section cruises. The GEOTRACES ocean section cruises commenced in 2010, generating a considerable body of metal speciation data for Fe, Cu, Co and Zn by CLE-ACSV from depth profiles on each cruise. Although the use of CLE-ACSV measurements on the GEOTRACES cruises will provide substantial insights into the distributions of metal-binding ligands measured and their respective binding constants, ***critically, they will not allow for characterization of the ligands themselves***, which requires the application of organic geochemistry techniques. Further, CLE-ACSV studies increasingly suggest that different types of metal-binding ligands (stronger vs. weaker, colloidal vs. truly

soluble) play distinct roles in the biogeochemical cycling of trace metals like Fe and Cu, and yet the identities and sources of these ligands remain elusive.

Given the need for a multidisciplinary solution to this problem, a SCOR working group, consisting of trace metal biogeochemists, aquatic organic geochemists and modelers, is the best mechanism to focus current international scientific expertise on metal-binding ligands. Appropriate scientific expertise will be assembled from different countries and an international working group will help develop this topic in developing nations. Other organizations cannot ensure that such an activity is suitably interdisciplinary, involving scientists from a wide range of disciplines and countries, while also helping train young scientists. A webpage will be constructed to help facilitate discussion between working group members, as well as to ensure other large science programs like GEOTRACES, CLIVAR and SOLAS (and a proposed geochemical global ocean survey similar to GEOTRACES) remain involved.
The results of this working group will be presented during the proposed symposium and published in a special issue of a journal or book, as well as a report to SCOR.

Background
A short background is provided here to summarize the issues that have motivated us to propose a working group on metal-binding ligands at this time.

Metal-binding ligands appear to facilitate bioavailability and uptake of the trace metals Fe and Co (Maldonado *et al.* 2005; Saito *et al.* 2005), while those binding Cu, Ni, Cd and Zn may sequester and decrease the bioavailability of these metals (Vraspir & Butler 2009). The pioneering work of Rue & Bruland (1995) and Gledhill & van den Berg (1994) established using CLE-ACSV measurements that dissolved Fe in the ocean was 99.99% bound to organic ligands, which in turn increased the solubility of this important micronutrient. Other trace metals such as Cu, Ni, Co, Cd and Zn are also bound to varying degrees by organic ligands, although there are considerably less data available on the organic complexation of these metals in the oceans. The lack of analytical technologies sensitive enough to directly characterize these organic ligands at ambient seawater concentrations has restricted research progress in this field until very recently. Siderophores produced by iron-limited bacteria to acquire Fe have been shown previously by CLE-ACSV to have similar measured stability constants as strong Fe-binding ligands (L1) measured in surface waters (Macrellis *et al.* 2001), and new approaches with LCESI-MS and NMR have now detected these siderophores directly in natural seawater (Mawji *et al.* 2008, Velasquez *et al*. 2011). Further, recent incubation studies of natural seawater have documented the production of strong Fe and Zn-binding ligands, presumably by the ambient biota, using CLEACSV (Buck *et al.* 2010; Lohan *et al.* 2005), as well as the production of siderophores by bacteria in seawater using LC-ESI-MS (Gledhill *et al.* 2004). This proposal aims to ***combine the strengths of both the biogeochemistry and aquatic organic geochemistry communities to take a substantial step forward in our knowledge of the source and provenance of metal binding ligands in the ocean.***

While most of the focus has been on Fe to date, very little is known about the composition and sources of other essential trace metal-binding ligands. Metal-binding ligands are typically present everywhere in the water column for the bioactive elements, suggesting that they are either highly recalcitrant, and/or a result of passive biological production *in-situ* (*e.g.*, remineralization). In the case of Fe, the bioremineralization of sinking particles contributes iron-binding ligands (Boyd *et al.* 2010), humic substances can bind Fe and may be the source of some Fe-binding ligands in the deep ocean (Laglera & van den Berg 2009), while zooplankton grazing on phytoplankton (Sato *et al.* 2007) and viral cell lysis (Poorvien *et al.* 2011) also release Fe-binding ligands. In surface waters, saccharides, which are an abundant component of the reactive dissolved organic matter (DOM) pool produced by phytoplankton (Benner 2011) have recently been shown to complex dissolved Fe and enhance Fe bioavailability to some phytoplankton (Hassler *et al.* 2011). In addition, hydrothermal input of organic ligands for both Fe and Cu to the deep ocean may be much larger than previously thought (Sander *et al.* 2007, Bennet *et al.* 2008, Sander & Koschinsky 2011), and has only just been incorporated into models for Fe cycling (Tagliabue *et al.* 2010). An over-arching question from these observations is: ***What is the relationship between the source and function of metal-binding ligands?***

The ubiquitous presence of metal-binding ligands, with similar ligand concentrations typically measured by CLE-ACSV for Fe, Cu and Zn, would seem to indicate that at least some of these ligands are not metal-specific (Hirose 2007). This is crucial as recent evidence suggests that Fe availability depends on Cu availability (Peers *et al.* 2005), with the bioavailability of both metals governed by organic complexation; similar synergistic behavior between other trace metals (*e.g.*, Co, Cd, Zn) may also be important. Further, these metal-binding ligands are all a component of the oceanic pool of DOM, which itself is largely uncharacterized other than the operationally defined refractory, recalcitrant and labile components. The working group will ***use compiled field speciation data to assess potential interplays between metal-binding ligands for the suite of bioactive metals and determine which DOM pools would be most appropriate to target for additional insights.***

Members of the working group in this proposal have recently set up a wiki on trace metal speciation data https://portal.ifm-geomar.de/web/tmsis/wiki/ to encourage community discussion of speciation techniques and of approaches to submitting speciation data for a database. Currently, in the absence of structural characterization of ligands, conditional stability constants (determined by measuring the binding capacity of these ligands using CLE-ACSV) provide the only means to distinguish between different ambient metal-ligand complexes in the ocean. The distinction between strong L1 and weaker L2 ligands remains an operational definition that varies between analysts, and is dependent on the method employed and the analytical window applied. Compiling published speciation data for the elements from different analysts will provide a broader perspective for the ligand class divisions and highlight discrepancies between chosen definitions. We additionally propose to enhance the intercalibration efforts pioneered by GEOTRACES with attention toward the other organically bound trace metals (Cu, Co, Ni, Cd, Zn). The compilation of published speciation data combined with continuing intercalibration

work for these methods will enable us to better ***characterize measured metal-binding ligand classes in terms of measured conditional stability constants and determine how to best standardize these ligand class definitions for future work.*** The interdisciplinary nature of this working group, including organic geochemists alongside analytical chemists and biogeochemists, will advance our understanding of the limits and potential applications of both CLE-ACSV and LC-ESIMS/NMR techniques to this problem. Assessing the available data from this perspective will allow insight into ligand sources and functions, as well as an additional framework for incorporating metal-binding ligands into models.

Modelling trace metal distributions is a formidable task at present. A good example is provided by recent attempts to model the Fe cycle, where models were restricted to broad assumptions because of poor knowledge about the speciation of Fe (see review by Boyd & Ellwood 2010). Even less is known about the speciation of other trace metals in the oceans, and these are typically left out of models despite their importance to phytoplankton growth and global elemental cycles. Thus, a primary goal of the proposed working group is to ***assess how to better incorporate metal-binding ligands into biogeochemical models***. Modellers require knowledge not only on the distribution of metal-binding ligands, but also on the speed of reactions between trace metals and these ligands. The database, workshops and interactive webpage will best facilitate evaluation of this issue, the results of which will be presented at the proposed dedicated symposium.

At present, GEOTRACES is primarily focused on accumulating field data for core parameters, including speciation, and does not have the resources to support the necessary synthesis activities proposed here. Therefore, to ensure that GEOTRACES maximally benefits from undertaken fieldwork, it is important that this SCOR working group is established as soon as possible and liaises appropriately with the GEOTRACES Scientific Steering Committee (SSC). Several members of the GEOTRACES SSC are included as members or corresponding members of this proposed working group. The synthesis activities proposed for this working group will both better help in interpretation of data on trace metals and ligands generated on the GEOTRACES cruises, as well as inform sampling and analytical strategies for future efforts. We anticipate that the combined interactions of the proposed working group will culminate in proposals targeting GEOTRACES process studies specifically designed to study ligand dynamics, ideally at an established reference site that may be used as a natural laboratory.

Statement of Work/Terms of Reference

1. To summarize published results on all aspects of metal-binding ligands in the oceans (*e.g.,* distributions, chemical structure, sources, sinks, stability constants), and to contribute to the organic ligand database for use in biogeochemical models and for those working in the field (including results from ongoing GEOTRACES, SOLAS and CLIVAR efforts).
2. To expand upon the ligand intercalibration programme, initiated by GEOTRACES, to evaluate key analytical issues with currently employed methodologies and determine how

to best link ongoing efforts in trace metal and organic geochemistry to assess natural metal-binding ligand.

3. To identify how best to incorporate published and future data into biogeochemical models.
4. To debate the nature of sampling strategies and experimental approaches employed in laboratory and field efforts in workshops and meeting discussions that are needed to enhance our understanding of the links between the provenance, fate, distribution, and chemistry and biological functions of these organic metal-binding ligands in the oceans.
5. To recommend future approaches to ligand biogeochemistry in a designated symposium, including ongoing GEOTRACES field efforts (*i.e.*, regional surveys and process studies), integration of CLE-ACSV and organic geochemistry techniques, and the need for rapid incorporation of this research in biogeochemical models.
6. To establish a webpage for this SCOR working group, to promote a forum for discussion of ideas and results, soliciting input from the trace metal biogeochemistry, organic geochemistry and modeling communities and provide a platform to propose special sessions on trace metal-binding ligands at international meetings such as Ocean Sciences, AGU and/or EGU.
7. To produce conclusions resulting from the outcome of the above objectives in the form of a Web site, a journal special issue or book, and a report to SCOR.

MEETINGS, WORKSHOPS AND SYMPOSIA:
It is proposed that the first formal meeting of this working group take place before the Ocean Sciences Meeting in Salt Lake City, Utah (Feb. 19-24, 2012). Preliminary communications leading up to this meeting will take place during the preceding year and will lead to identification of additional Corresponding Members, fine-tuning of the Terms of Reference, and creation of an Agenda. During the meeting, the WG will set up intercalibration efforts and start work on the format for the database and webpage, which will also act as a forum for information exchange and details of new meetings. Other funding sources for the intercalibration efforts, the workshop and final publication will be determined.

Approximately one year after the first meeting a second meeting and an international workshop on trace metal-binding ligands in seawater will be held. This will allow a nominal one-year period over which to structure the workshop agenda, issue announcements and invitations, secure needed funds, and make other necessary preparations. To keep costs at a minimum this would be in combination with the AGU Meeting in San Francisco, USA (Dec. 2012) The workshop will provide the opportunity for all Full and Corresponding members of the working group to discuss all points of the terms of references. Groups will be formed and tasks assigned to work on projects and prepare material to be presented at the special symposia and in the special issue or separate book.

Full members of the working group will meet again in year 3 to determine the progress made by different groups and discuss necessary actions to successfully present at a dedicated symposium

in year 4 during the Ocean Science meeting in 2015. That conference would also set the date for the fourth and final meeting during which the working group will be rounding off the results and outcomes and finalize the publications. Separate funding will be sought from EU-GEOTRACES, COST Action, and other sources for the working group third meeting. Place and exact time for this meeting are to be determined but could again be in combination with the Aquatic Sciences Meeting 2014.

Working Group Membership

The final working group membership is proposed to consist of 10 specialists, which along with the Corresponding members includes several who serve on the GEOTRACES Scientific Steering Committee (*):

Full Members

Name	**Affiliation**	**Specialty within the field of trace metal speciation in seawater**
Kristen Buck (proposed co-chair)	Bermuda Institute of Ocean Sciences, Bermuda	Trace metal biogeochemist; Organic complexation, expert in CLE-ACSV, bioavailability of trace metals
Maeve Lohan* (proposed co-chair)	University of Plymouth, United Kingdom	Trace metal/analytical biogeochemist; organic complexation, expert in CLE-ACSV, flow injection analysis
Sylvia Sander (proposed co-chair)	University of Otago, New Zealand	Analytical chemist; organic metal speciation by electrochemical methods, LC-ESI-MSMS, hydrothermal systems
Ronald Benner	University of South Carolina, USA	Aquatic organic geochemist; origin and reactivity of DOM
Katsumi Hirose	Meteorological Research Institute, Japan	Aquatic organic geochemist & trace metal biogeochemist; metal-organic matter interactions
Kathy Barbeau	Scripps Institution of Oceanography, USA	Trace metal biogeochemist; bioavailability and reactivity of different metal species, photochemistry
Michael Ellwood	ANU Canberra, Australia	Analytical chemist; organic complexation, expert in CLE-ACSV and ICP-MS

Martha Gledhill	National Oceanography Centre, Southampton, United Kingdom	Trace metal/organic geochemist; mass spectrometric determination of ligands in seawater, LC-ESI-MS
Alessandro Tagliabue	Laboratiore de Science du Climat et de l'Environment, France	Modeler; models of ocean biogeochemistry
Rujun Yang	College of Chemistry, Ocean University of China, China	Analytical chemist; organic complexation, metal complexation by humics
Associate Members		
Stan van den Berg	UK	
James Moffett	USA	
Phil Boyd*	New Zealand	
François Morel	USA	
Barbara Sulzenberger	Switzerland	
Ken Bruland*	USA	
Keith Hunter	New Zealand	
Mak Saito	USA	
Loes Gerringa	Netherlands	
Shigenobu Takeda	Japan	
Peter Croot	UK	
Rick Keil	USA	

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International

10 April, 2011

Executive Committee
Scientific Committee on Oceanic Research

Greetings,

We are writing to support the proposal to form a SCOR working group "**Organic Ligands – A Key Control on Trace Metal Biogeochemistry in the Ocean"**. Such a working group has potential to add substantially to our knowledge of the factors that regulate the supply of essential micronutrients to marine organisms as well as the implications for marine ecosystems. The objectives of this working group nicely complement those of the GEOTRACES program.

GEOTRACES aims to identify relevant processes, and quantify key fluxes, associated with the supply, removal and physical transport of trace elements and their isotopes in the ocean. Indeed, it is the prospect of obtaining a quantitative picture of the global marine biogeochemical cycles of trace elements and their isotopes that has motivated international collaboration under GEOTRACES. These geochemical mass budget terms will be derived in large part by applying inverse models of ocean transport to measured distributions of trace elements in the ocean.

Bioavailability and internal cycling of trace elements is governed by their chemical speciation, which is often dominated by organic complexes. This is particularly important for micronutrient elements, such as Fe, Co and Zn, which are thought to regulate the growth of certain organisms and thereby influence the biogeochemical cycles of carbon and major nutrient elements. However, a detailed investigation of the composition, structure and origin of organic ligands is beyond the scope of GEOTRACES. Furthermore, simply from a pragmatic point of view, a detailed knowledge of metal-organic complexes is not essential for evaluating the rate constants for supply and removal of trace elements. Another strategy to examine speciation is required, and the proposed working group brings a high level of skill to initiate work on that objective.

In summary, the proposed working group would be of outstanding value as a complement to GEOTRACES, leveraging new knowledge about trace element distributions to guide future research on the sensitivity of marine ecosystems to varying supply of essential micronutrients.

Sincerely,

Robert Anderson and Gideon Henderson
Co-Chairs, GEOTRACES SSC

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2.3.3 Deep-sea biodiversity Patterns of the South Atlantic Ocean *Costello*

1. Title: Deep-sea biodiversity Patterns of the South Atlantic Ocean

2. Background and Rationale

The deep sea is the largest continuous ecosystem of the planet, but also the least explored and understood. The traditional perception was that it comprised vast, remote, life-poor, and stable environments, isolated from other ecosystems and not affected by global-scale changes. However, it is now understood that deep oceanic waters can be diverse and productive. Some deep-sea habitats (especially ridge and seamount features) can host concentrations of commercial fish stocks, influence distribution of surface predators including tunas and whales, and may also contain minerals and resources with potential for seabed mining. Yet, studies have demonstrated that life in the deep ocean is vulnerable to the effects of climate change and human economic activities including fishing and mining. There is a pressing need to further describe, understand, and monitor such environments to determine human-induced and natural changes in the future.

Research under the umbrella of the Census of Marine Life (CoML) between 2000 and 2010 has highlighted that deep-sea habitats are not isolated, yet are connected in both horizontal space and dynamically linked to the water column (McIntyre, 2010). For example, seamounts in several areas of the world have similar faunal composition to ridges, canyons, and adjacent slope on continental margins (e.g. Rowden *et al*., 2010; Menot *et al*., 2010), although there is evidence that the structure and relative abundance of such communities may differ (e.g. McClain *et al.*, 2009). There can also be clear faunal breaks along mid-ocean ridges (Vecchione *et al*. 2010). These findings highlight the importance of understanding biogeographic patterns, and mechanisms of dispersal and connectivity whereby faunal communities in such habitats are linked across a range of spatial scales. Such understanding is an important input to aiding effective management of deep-sea resources to balance sustainable exploitation (fishing, mining, bioprospecting) and conservation of deep-sea ecosystems.

Oceans of the southern hemisphere have been much less researched and sampled than the northern hemisphere, especially the South Atlantic. The South Atlantic Ocean is the newest of all major oceans, formed by the separation of South America and Africa 175 – 90 million years ago, and is the only ocean basin to be directly connected to all of them (Levin and Gooday, 2003). It is also economically important as it sustains a large portion of the Atlantic pelagic (i.e. tropical tunas) and seamount fisheries. Despite its size and physical role in the world ocean ecosystem, our information about aquatic organism deep-sea diversity and distribution is scarce and mostly inferred by comparison with the North Atlantic.

Although the mid-ocean area is poorly known, there are a number of historical and very recent datasets that can contribute to a new analysis of biodiversity patterns in the region. In 2006 the South Atlantic MAR-ECO project was established to develop a strategy, based on the North Atlantic MAR-ECO (CoML) approach, to undertake a biological sampling program, spanning

microorganisms to whales, capable of (a) collecting comprehensive new data on South Atlantic deep pelagic and benthic diversity, and (b) developing new understanding of the deep-sea habitats and biodiversity between South America and Africa. Based on such new information needs for conservation as well as sustainable use of its resources would be identified. A significant survey took place in November 2009 using the R/V Akademik Ioffe through a collaborative effort between the CoML project MAR-ECO and the Shirshov Institute of Oceanology (Academy of Sciences, Russia). During a 34-day cruise from Gran Canaria Island (Spain) to Cape Town (South Africa), a team of scientists from Brazil, Uruguay, Russia and New Zealand conducted pelagic and benthic sampling events up to 4.7 km deep over areas of the southern Mid-Atlantic Ridge and the Walvis Ridge. Results are still preliminary and considerable effort is still required to process all biological samples. However provisional results indicate the survey collected approximately 1,120 records of organisms included in 175 fish taxa (Kobyliansky *et al.*, 2010), 50 cephalopods and over 200 benthic invertebrate species (Ascidiacea, Annelida, Porifera, Crustacea, Mollusca and other groups). Additional deep water diversity datasets from both South American and African continental margins and several seamounts have become available and were considered during a recent meeting of regional and international experts promoted by IOC-UNESCO ("Understanding deep-water biodiversity in the South Atlantic: options for conservation and sustainable use of resources in the high-seas", 7-8 April, Paris, France). These include data from historical cruises conducted by Russia and France between the 1960s and 1980´s (e.g. IFREMER "Walda" and "Walvis" cruises in Southeast Atlantic) and more recent initiatives such as (a) the Brazilian REVIZEE and the Spanish ATLANTIS projects in the Southwest Atlantic continental margin, (b) the joint Spain-Namibia cooperation project and IFREMER's Biozaire Project in the Walvis Ridge and Southeast Atlantic continental margin, and (c) the ongoing NOC Southampton deepwater camera survey in the Southern Mid-Atlantic Ridge (UK Atlantic Meridional Transect). Particularly important is the likelihood of acquiring new samples and information on midwater and benthic biodiversity of the seamount and ridges of the deep South Atlantic from new work planned by Brazil (e.g. MCT-III Commission of the R/V Cruzeiro do Sul to the Rio Grande Rise, June 2011) and other countries in 2011 and 2012.

These existing datasets, and the further planned sampling opportunities, create a new basis to address a number of scientific questions about deep-sea biodiversity patterns of the South Atlantic, including:

- Are the faunal communities of the Mid-Atlantic Ridge and seamounts related to and part of broader deep South Atlantic environments?
- Is the mid Atlantic ridge fauna different from that of continental margins?
- What are the environmental drivers of faunal composition and abundance (e.g. is there a relationship between surface production and abundance; do the physical ridges in the South Atlantic provide linkages or obstacles to faunal communities)?
- Is the MAR different from other ridge systems in the southern hemisphere?

Addressing these questions will fill critical gaps of knowledge on the deep South Atlantic Ocean, its biodiversity patterns and connectivity with other deep areas of the southern hemisphere. The results of this work will also be relevant to activities and processes carried out in the South Atlantic by (a) regional fisheries management organizations, principally SEAFO (Southeast Atlantic Fisheries Organization) and ICCAT (International Commission for the Conservation of Atlantic Tuna), (b) other international fora such as CBD (Convention on Biological Diversity), ISA (International Seabed Authority), FAO (UN Food and Agriculture Organization), and (c) international scientific initiatives such as INDEEP (International Network for Scientific Investigation of Deep-sea Ecosystems).

SCOR promotes international and multidisciplinary collaboration towards oceanographic research, and a comprehensive biodiversity study in the South Atlantic would be timely and relevant. There are significant science gaps to be filled. Furthermore, the South Atlantic Midoceanic ridge and related seamount chains are prominent structures of the deep seafloor that lie mostly outside EEZs of coastal countries, implying that commercial exploration, conservation and research initiatives have essentially been multinational and/or international enterprises. While the South Atlantic will be the location focus of the proposed working group, concepts and ideas that result will be applicable and comparable with other southern hemisphere mid-ocean ridges and deep-sea habitats.

3. Terms of Reference

1. To synthesise existing data on biodiversity of mid-ocean environments (associated with ridges and seamounts) in the South Atlantic Ocean.
2. To identify knowledge gaps and promote networking activity to explore opportunities for research of South Atlantic mid-ocean habitats.
3. To analyse and update descriptions of biogeographical patterns in the deep South Atlantic Ocean using new mid-ocean data, comparisons with continental margins and deep basins, and existing data from other southern hemisphere systems.
4. To coordinate the process of entry of existing and future South Atlantic data into the Ocean Biogeographic Information System (OBIS) and other appropriate databases (e.g., FAO VMEs (Vulnerable Marine Ecosystems), GOBI EBSAs (Global Ocean Biodiversity Initiative - Ecologically and Biologically Significant Areas), and Geology of the South Atlantic Ocean – GIS).
5. To provide appropriate information products to aid management of resources in the South Atlantic.

4. Timeline for activities:

Year 1

- Collate and synthesize existing biodiversity data
- Identify gaps in data and knowledge

- Identify priorities for new studies

  Product: Report on available data, gaps and priorities.

Year 2

- Update and incorporate new biodiversity data
- Biogeographic analyses (South Atlantic deep habitats comparison)

  Product: Report on initial biogeographic analyses
  Plan for future analyses and publication of results (e.g. journal special issue)

Year 3

- Update and incorporate new biodiversity data
- Biogeographic analyses, both South Atlantic and other oceans of the southern hemisphere

  Product: Final entry of new data into international databases (e.g., OBIS)

Year 4

- Final synthesis of knowledge

  Product: Set of scientific publications synthesizing biodiversity patterns in the South Atlantic. Provision of scientific advice to environmental and resource management bodies

5. Working Group Composition

Proposed Full Members

Name	Affiliation	Country	Expertise
José Angel Alvarez Perez *(proposed chair of the group)*	Universidade do Vale do Itajaí	Brazil	• Chair of the South Atlantic MAR-ECO project Steering Group • Cephalopod taxonomy and biology • Deep-water fishery
Andrey Gebruk	Shirshov Institute of Oceanology	Russia	• Benthic invertebrates • Biogeography
Irene Cardoso	Museu Nacional do Rio de Janeiro	Brazil	• Crustacean taxonomy
Luís Abellán	Instituto Oceanográfico Español	Spain	• Seamount ecology • Deepwater crustaceans

Tone Falkenhaug	Institute of Marine Research	Norway	• Zooplankton ecology
Malcolm Clark	National Institute of Water and Atmospheric Research	New Zealand	• Member of the INDEEP Steering Group • Seamount ecology and fisheries • SW Pacific deep-sea habitats
Rudi Cloete	National Marine Information and Research Centre	Namibia	• Member of the Scientific Committee of SEAFO • Deep-sea fisheries
Wayne K. Florence	Iziko South African Museum	South Africa	• Marine Invertebrates • Bryozoan Systematics • SABIF (local GBIF node) steering committee member
Ricardo Serrão Santos	Universidade dos Açores	Portugal	• Seamount, island and ridge ecology • Deepwater Fish
Claudia Silvia Bremec	Instituto Nacional de Investigación y Desarrollo Pesquero	Argentina	• Benthic invertebrates • Biodiversity
Provisional list of Associate Members			
André O.S. Lima	Universidade do Vale do Itajaí	Brazil	• Microbiology and Bioprospection
Alexey Orlov	Russian Federal Research Institute of Fishery and Oceanography	Russia	• Deep-water fish
Débora Pires	Museu Nacional do Rio de Janeiro	Brazil	• Deep-water corals
David Billet	National Oceanography Center	UK	• Deep-sea ecology • ISA LTC member
José Henrique Muelbert	Federal University of Rio Grande	Brazil	• Ichthyoplankton • Physical-Biological Oceanographic Processes
Luiz Fernando Loureiro Fernandes	Universidade Federal do Espírito Santo	Brazil	• Zooplankton
Odd Aksel Bergstad	Institute of Marine Research	Norway	• Demersal fish ecology • Mid-ocean ridges

Tim O'Hara	Museum of Victoria	Australia	• Lead of INDEEP biogeography working group • Brittle star taxonomy and ecology
Dylan T. Clarke	Iziko South African Museum	South Africa	• Marine Fishes/Invertebrates • Polychaete Systematics • Large Pelagics Fisheries
Patricio Arana	Universidad Católica de Valparaíso	Chile	• Deepwater fisheries • Seamount ecology
Alex Rogers	University of Oxford	UK	• Deep-sea ecology • SW Indian Ocean biodiversity
Natalia Venturini	Universidad de la Republica	Uruguay	• Benthos diversity and ecology
Luciano Fonseca	Intergovernmental Oceanographic Commission	France	• South Atlantic high-seas research and conservation

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2.3.4 Common Challenges in Establishing Ocean Observatories *Feeley/Wainer*

BACKGROUND

In a global context, the mission of ocean observatories[1] is to contribute to understand, track and predict the evolution of the world's oceans through continuous time series from the seafloor to the surface. The recent developments of cabled systems in particular, as shared infrastructures with multidisciplinary vocation and unprecedented instrument hosting capacity, have to respond and adapt to the diverse and fast-evolving needs of society. In that respect and in order to make the ocean observatories contribution to earth observation an effective component of the global observing system, as well as to ensure that the resulting infrastructure will deliver as planned, some challenges have yet to be overcome. Coordinating with on-going ocean observations programs, establishing cross-cutting scientific aspects across regions, establishing standard techniques and strategies to optimize sampling and produce more reliable predictions, find out and possibly demonstrate the means of integration of heterogeneous solutions within a global framework, put forward the means of responding to societal needs in a practical fashion, and guarantee the maintenance, sustainability, performance of the overall system, are some of the aspects covered in this proposal.

Keywords: Multidisciplinary ocean observatories, scientific challenges, technological challenges, earth observation, GEOSS, societal benefits, global integration, sensor interoperability, standardization, data interoperability, standard operations, maintenance, sustainability

TIMELINESS AND RELEVANCE

The motivation for the current proposal stems from:

1. The OceanObs conference held in 1999, where it was established that "Core principles of participation in the sustained observing system include recognition that users require rapid access to all relevant data, free of charge. An integrated system, making use of remotely sensed and in-situ observations is essential. Observations are openly shared in near-real-time when technically feasible. They are collected, analyzed, archived, and distributed to internationally agreed standards with agreed best practices."
2. The OceanObs conference held in Venice in 2009, where was obtained consensus on the need "to increase our efforts to achieve the needed level of timely data access, sensor readiness and standards, best practices, data management, uncertainty estimates, and integrated data set availability."
3. The expressions of interest received at the EU Maritime Day, held in Gijón (Spain) in May 2010, where a round table was organized with key representatives of some of the most relevant ocean observing systems to date[2]. As a major outcome the need for a better

[1] Ocean observatories are here defined as multidisciplinary suites of ocean instruments and sensors with long-term power supplies and permanent communications links that can feed data to scientific laboratories and the Internet.
[2] See Annex

global coordination of research activities in the field of ocean observatories has been identified. The tool to achieve this could be a Community of Practice Working Group (CoPWG) to discuss and agree upon scientific and technological aspects of global relevance, such as cross-cutting scientific themes, technological harmonization needs and solutions, personnel and instrument sharing, to name a few. Some efforts have already been initiated in order to address such practices.

The European Seas Observatory Network (ESONET (NoE and Vi), see [1-3]) and its infrastructure companion the European Multidisciplinary Seafloor Observatory (EMSO, see [4]) are good recent examples of such requirements and efforts. The perspective is also to meet the milestone of the Global Earth Observing System of Systems (GEOSS, [5-8]), when society should be able to search, access, and fully exploit earth observations for the benefit of society. Standard Development Organizations (SDOs) are already delivering on aspects such as data publication, access, and documentation and sensor interoperability [9-13]. Committees are also trying to tackle data uncertainty [14]. At science level, ocean acidification and ecosystem management are clear examples of a need for a global observation strategy and some actions are already in place to respond to these needs, such as the Global Ocean Observing System (GOOS, [15, 16]). Observatories that produce real-time and continuous data offer an excellent opportunity for these initiatives (Beside ESONET Vi and EMSO, see OOI [17], DONET [18], NEPTUNE Canada [19], MACHO [20], IMOS[1]). Global ocean science would benefit tremendously from utilizing the potential of these observatories. The working group will identify and try to solve the scientific and technological aspects to this aim.

TERMS OF REFERENCE

The primary objective of this group is to discuss and resolve those challenges which have been identified as common to ocean observatory initiatives. As the membership reflects, the involvement of persons directly involved in the scientific, technical and strategic management of ocean observatories will allow for both vertical and horizontal interactions. To achieve the objective, a set of scientific and technological aspects will be addressed, which have been identified by leaders of and key contributors to some of the most important ocean and earth observing initiatives today, spanning from hardware and software infrastructure specialists to large-scale stakeholders, and encompassing global integration aspects ranging from the observing system instrument layer up to data products, and the crucial cross-cutting role of ocean observing systems in GEOSS.

There are three terms of reference.

1. Develop a plan for joint action among multidisciplinary ocean observatories to address global crosscutting scientific issues
    - Identify scientific issues that are best addressed through global multidisciplinary observations

[1] http://imos.org.au/

- Establish criteria for reference observatories at key locations to evaluate and compare trends
- Identify key scientific and technological cross-cutting demonstration projects
- Demonstrate the benefit of continuous scientific time-series through specific examples

2. Develop a plan for integration of multidisciplinary ocean observatories into a global system of observatories
   - Identify synergies in regard to processes observed and future parameters to be included on relevant platforms between ongoing observation programs like ARGO and OCEANSITES and ocean observatories to be implemented
   - Develop requirements and procedures for rapid and free exchange of scientific and technical results. This implies to promote information and technological exchange between permanent ocean stations and coordinate global observing activities on particular processes of interest (e.g. geohazards, ocean acidification, baseline studies – e.g. ecosystem status). This process will imply to define routes to achieve interoperability between the systems i.e. define agreed upon deployment procedures, instrument integration, data exchange, common data policy procedures for standard instruments
   - Study and identify the possibilities to implement sensor interoperability concepts, like "plug and work"[1], harmonized timing protocols and software-based open standards in order to enhance the hosting capacity of observatories, optimize and reduce costs of instrument operation and exchange.
3. Identify how long-term sustainability of ocean observatories can be promoted.
   - Identify the key stakeholders for ocean observatories and how infrastructures can anticipate or adapt to unforeseen societal needs.
   - Define and plan the demonstration of a common long-term traceable Quality of Service[2] criterion, in coordination with GEOSS related tasks and committees
   - Identify or define needed protocols that enhance the long-term value and exploitation potential of observations

WORKING GROUP DELIVERABLES

Among other outcomes, we hereby provide a list of tangible products as a result of the group's terms of reference. A possible time distribution, as a first approach, could be that each of the following items provides the focus of a specific meeting (M[1..3]), some of them will be virtual. This list offers an overview of concrete objectives at the time of submission, i.e. their subject and

[1] Plug and work instruments or interfaces require minimal hardware and software configuration needs by embedding all necessary information to avoid generally time-consuming and error-prone processes of connecting an instrument to an observatory infrastructure.

[2] QoS, is here to be interpreted in the context of ocean observatories, thus will cover observatory quality performance, including observation quality assurance and control, uncertainty, measurement time gaps and delays, service cost, and implementing open public standards in this process. Exact criterion shall be defined as a WG activity. Also see [21].

timing may need to be updated in the course of the working group activities. In order to keep reporting concise, the format of each report will be similar to an executive summary.

M1/T1: Table of global cross-cutting scientific issues
M1/T2: Table of criteria to be addressed for key reference sites
M1/T3: Table of regions of mutual and global scientific and societal interest
M2/R1: Report on synergies with other global ocean observation networks
M2/R2: Report on requirements and plans for ocean observatories scientific and technical integration
M2/R3: Report on key elements and stakeholders for the long-term sustainability of ocean observatories
M3/R4: Report on global data and quality of service criterion with a focus on GEOSS
M3/P1: Review results and prepare for publication as peer-reviewed open-access publication.

Following completion of the group's terms of reference, a SCOR-affiliated group will be formed to implement the group's plans.

MODE OF OPERATION

Each meeting will be preceded by continuous remote discussions and preparation, utilizing web-based platforms, e-mailing and videoconferencing tools. First meeting may either be at the 2012 Ocean Sciences Meeting or the European Geosciences Union General Assembly 2012. At its first meeting, working group members will make short presentations about their activities, followed by agreement on how the terms of reference will be achieved and how to proceed with the planning. Discussion of potential funding sources for WG related activities will be part of the agenda. The final meeting of the group will be held in 2014. As stated above, each meeting will have a tangible deliverable as key product, beside the minutes to be distributed no later than 15 days after the meeting.

THE CASE FOR SCOR SPONSORSHIP OF THE WG

1. The Intergovernmental Oceanographic Commission (IOC), through GOOS, stands ready to co-sponsor and co-fund this joint IOC/SCOR Working Group (Contact: Thomas Gross).
2. The European Commission has expressed interest in the discussions taking place, highlighting that the science incentive, the governance, and the technology for those observatories remain a major challenge for ocean research in the next decades, that the creation of a working group should help in shaping a position from the Ocean Science Community with regard to the implementation of Ocean Observatories and that the results would be quite useful in the context of GEO and GEOSS.
3. SCOR has vocation to contribute to the field of Ocean Observing Systems. Relevant past SCOR Working Groups that have studied related topics include:
    - WG 16 General Problems of Intercalibration and Standardization

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- WG 21 Continuous Current Velocity Measurements
- WG 51 Evaluation of CTD Data
- WG 70 Remote Measurement of the Oceans from Satellites
- WG 88 Intercalibration of Drifting Buoys (formerly WG 66)
- WG 90 Chemical and Biological Oceanographic Sensor Technology
- WG 110 Intercomparison and Validation of Ocean-Atmosphere Flux Fields
- WG 115 Standards for the Survey and Analysis of Plankton
- WG 118 New Technologies for Observing Marine Life
- WG 130 Automatic Visual Plankton Identification
- WG 133 OceanScope (with IAPSO) (on building a vessel-based observatory)

MEMBERSHIP PROPOSAL

	Organization/ Observatory	Country	Full Members	Associate Members	Observers - Stakeholders
Eric Delory (co-chair) Joaquín Hernández Brito	PLOCAN /Ocean Observatory	Spain	X		
Christoph Waldmann (co-chair)	U. Bremen-MARUM	Germany	X		
Ingrid Puillat Jean-François Rolin	IFREMER /Coord. European Seas Observatory Network	France	X		
Stefano Nativi Monica Cesari	CNR /co-chair - GEO S&T Committee Coord. FP7 EGIDA Project	Italy	X		
Paolo Favali Laura Beranzoli	INGV /Coord. European Multidiscipli	Italy	X		

	nary Seafloor Observatory				
Chris Barnes Benoit Pirenne	U. VICTORIA /Coord. NEPTUNE[1] Canada	Canada	X		
Yoshiyuki Kaneda	JAMSTEC /Coord. DONET[2]	Japan		X	
Tim Cowles	Consortium for Ocean Leadership - Director / OOI[3]	United States		X	
Juanjo Dañobeitia Jaume Piera	CSIC-Unidad de Tecnologías Marinas - Director/ OBSEA & CSIC R/V	Spain	X		
Aurea Ciotti Rubens M. Lopes	U. Sao Paulo-CEBIMar – Instituto Oceanografic o	Brazil	X		
Tony Haymet	UCSD-SCRI PPS-Director	United States		X	
Bauke Houtman	National Science Foundation	United States	X		
Pinxian Wang	Tongji University, Shanghai	China	X		

[1] NorthEast Pacific Time-Series Undersea Networked Experiments
[2] Dense Oceanfloor Network System for Earthquakes and Tsunamis

[3] Ocean Observatories Initiative

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Ana Aricha	Ministry of Science and Innovation	Spain			**X**

Table Glossary
WG full members: Includes WG leaders and most active members. Also viewed as a permanent group, full members meet on a regular basis, validate, initiate, provide guidance and supervise themes of discussion and tasks proposed by the WG members.
WG associate members: Regularly participate to events, forums, and meetings organized by the WG, but not to the level of full members. Participate to WG discussions and projects tasks.
WG observers, **stakeholders**: have a more peripheral role in the activity of the WG. They have a critical role in providing feedback to the WG, particularly on key elements that should be considered within the WG activities.

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ANNEX

COMMON CHALLENGES IN ESTABLISHING OCEAN OBSERVATORIES

ROUND TABLE – GIJÓN, 19 MAY 2010 – *DRAFT TRANSCRIPT*
Were present: Jan Stefan Fritz, Paolo Favali, José Doncel Morales, Gilles Ollier, Jurgen Mienert, José-Joaquín Hernandez-Brito, Christoph Waldmann, Keith Alverson, Stefano Nativi, Eric Delory
Connected through Webex: Benoit Pirenne, Tony Haymet, Roland Person, Jean-François Rolin, Yoshiyudi Kaneda

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The following summarizes common and challenging aspects found in establishing ocean observatories, focusing on S&T objectives and global integration, as well as lessons learned, identified during the meeting.

S&T OBJECTIVES

- Provide global observation of ocean processes addressing different disciplines
- Establishing reference stations at key locations to evaluate and compare trends
- Integrate different observational platforms into a system of systems
- Assure rapid and free exchange of scientific and technical results
- Current programs are generally driven by a national or regional priority and despite the global coverage there is still a lack of cross-cutting scientific topics.
  Example: Impact of Climate Change on the Arctic, Global ocean acidification and carbon uptake
- Make sure that regional specificity does not prevent global integration
- A well-referenced scientific document produced and endorsed by the scientific community that justifies scientific aspects for ocean observatories should be made available in a form which is readable by funding agencies. For example, in Europe this document should be prepared for a so-called "impact assessment" for society.
- Produce the infrastructure "blue print" that will convince funding agencies
- Stabilizing the science needs would prevent unexpected budget changes in the short term and promote more stable cooperation across observatories.
- Guarantee that past and on-going investments in Europe are maintained
- Suggest alternatives medium to long term funding strategies (example: OOI technology research plan as first phase, scientific research as second phase
- The question of continuous collection and archiving of scientific datasets over time is considered as a societal benefit in itself for future generations, despite the possibility that some datasets may not be able to contribute with satisfactory predictions in a short term on certain aspects.
- Identify regions of interest may also be a good driver of global integration rather than scientific aspects only (e.g.: the Arctic).
- Consult with lead scientists and institution representatives to agree on specific cross-cutting aspects
- Clearly identifying who the stakeholders are will be critical to the identification of financial support
- Addressing the question of the choice between ocean observatories and expedition based research may be a key theme between scientific leads.
- Infrastructures and science plans can be addressed independently of the possible financial uncertainties. For example short-term and small projects can contribute to the larger plan right from the beginning (clustering idea).
- The idea of an infrastructure bottom-up approach is worth considering, bearing in mind the strong interest to connect with the broader system.
- Collaborations with non-scientifically driven initiatives may be of interest.

- Geohazards, ocean heat content and circulation, discovery and exploitation of ocean resources, midocean ridge processes (possibly at the origin of early life) are clear cross-cutting aspects. Current misunderstanding of the ocean as the ultimate sink for global carbon is also an important rationale for research. Variability of water masses implies the need for time series.
- Interoperability across disciplines is an important benefit for science, in particular for the discovery of unknown processes and relationships.

Conclusions from the session: identifying cross-cutting topics is a difficult task. Identifying regions of interest may help identifying them. Acidification, geohazards and heat content are some good examples of agreed upon global cross-cutting issue.

ASPECTS FOR PROMOTING THE GLOBAL INTEGRATION OF OCEAN OBSERVING SYSTEMS

- Information exchange on scientific and technical aspects of permanent ocean stations
- Coordinate global observing activities on particular processes of interest (geohazards, ocean acidification etc.)
- Define routes to achieve interoperability between the systems i.e. deployment procedures, instrument integration, data exchange, quality management
- Establish common data policy procedures
- Study and work on the possibilities to implement plug and work concepts.
- Use available GEO portals
- Make sure all observatories are able to share their data like in WMO. Data interoperability is not only a technological issue. Capturing knowledge properly in datasets must be addressed, including uncertainty.
- Sensor exchange is of common interest in the US and in Europe. This must be tested.
- Interoperability is still difficult to evaluate as a deliverable, quality of service as a result may be a good umbrella criterion to this aim
- Quality is important for real-time and to deliver on the operational aspect of observatories. A Quality of service criterion is to be discussed and interoperability to be included as a criterion to assess quality of service if applied.
- GEOSS enables the discovery of data and services. Discovering sensors and environmental models is a key functionality of the overall system.
- Semantic interoperability, taking in account aspects like different languages is also key to the success of information exchange.
- How to provide the right tools to the user to express what they request and how to express as a data provider what it is they are going to get from their request.
- While international standards are currently subsetting mainly regular grids, requests from non-regular grids remains a challenge.
- Defining interoperability needs between existing infrastructures ready to operate and in real need for data exchange (OOI & Neptune are clear examples already at discussion stage in that regard)

- Harmonize sensor quality assurance and quality control practices and documenting
- Plan an Architecture Implementation Pilot project for GEOSS: this is a lacking activity for ocean observatories
- Needs for a common data quality control strategy to be able to respond to models requests.

LESSONS LEARNED
• TAO maintenance and data services

Assuring the operation can be maintained (e.g. vandalism issues in TAO)

Business model should be established that includes the clear identification of observatory users and to set services according to user needs to make better predictions (lessons learned from El Niño event and TAO)

• GOOS S&T

Funding can be better justified at component level rather than at global level, despite the fact that synergies can be very rewarding.

• ION Network

Within the Geophysics ION network and IUGG: interoperability has been particularly identified as a main requirement for collaboration on geohazards. A strong community is needed to push in that direction.

• GEOSS/GEOBON

In GEOSS they have been able to manage a network of networks for biodiversity and learning from their experience and implementing some aspects could be an interesting exercise.

RELEVANT CURRENT INITIATIVES
NEPTUNE/Canada - OOI - ESONET/EMSO - DONET - MACHO - PLOCAN - RedICTS Marinas - EUROSITES - HYPOX - GEOSS – GOOS/Global Tropical Moored Buoy Array (TAO and other components)-

POTENTIAL NEXT STEPS (TO BE DISCUSSED IN A FUTURE MEETING)
- Identify interest groups that may support a global integration
- Identify points of contact for each initiative
- Establish an Ocean Community of Practice
- Establish global cross-cutting scientific topics

- Establish a communication platform for exchanging information (Website and physical meetings)
- Establish an international task force on global issues
- Find existing organization to support the objectives (e.g. SCOR)
- Establish a permanent committee (e.g. IODP, InterRidge)
- Create more tools for collaboration and contribution. example: Engage users in a data annotation effort from users which turn into contributors. Bridge the gap between a constant amount of scientist and an increasing amount of data.
- Promoting web communities and data sharing example, like through specific scientific examples across ocean basins.
- Properly coordinate existing infrastructures to comfort the bottom-up approach. A formal agreement between national and international initiatives through MOUs would also be valuable, mainly through the implementation of a coordinated and unique service provided to the users.
- Work towards an agreement between countries to invest in a legal entity for European infrastructures (ERIC).
- Write a proposal to create a working group within the UNESCO/IOC and invite all participants within this group.

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2.3.5 Subterranean Estuaries *Sundby*

Abstract
Situated at the boundary between the land and sea, coastal aquifers are one of the most under-studied interfaces in earth science. Recent studies have revealed that mixing between meteoric and marine groundwater in a coastal aquifer sets up an important reaction zone, characterized by strong physical and chemical gradients. This zone, termed the "subterranean estuary" (STE), may strongly influence the oceanic cycling of trace elements and attenuate land-derived anthropogenic contaminants (e.g., nutrients, trace metals). While much research has been conducted on quantifying rates of groundwater discharge to coastal waters (submarine groundwater discharge, SGD), there is significantly less understanding of the functioning of STEs and the extent to which they alter the chemical composition of SGD. However, this knowledge is critical in order to predict contaminant and natural solute loading to coastal waters via SGD and the impact of SGD on local, regional, and global metal, nutrient, and carbon budgets. It has become evident that STEs are complex and dynamic systems with their functioning controlled by interacting biogeochemical, microbial and groundwater flow processes. This working group will bring together an interdisciplinary team of international experts to integrate knowledge of these interacting processes, which have to date mostly been considered in isolation. The main outcomes of this group will be (i) a consolidation of existing knowledge on STEs and identification of priority research needs via a review paper, (ii) development of a classification system for STEs, and (iii) interdisciplinary process studies at 1-2 field sites and a companion journal special issue.

Rationale
Groundwater is often a dominant pathway for the transport of nutrients into the coastal zone in areas where increases in human population within coastal watersheds has led to significant groundwater contamination. With 75% of the world's population expected to live within 35 miles of a coastline by 2020, it is vitally important that we understand how anthropogenic contamination is transformed and attenuated in the environment as it is transported from land to the ocean. Recent studies have shown that mixing of meteoric and marine groundwater in subterranean estuaries (STEs) has the potential to reduce nutrient loading via groundwater through nutrient removal processes such as denitrification and phosphate sorption onto mineral surfaces. While mixing and contaminant transformation processes in surface estuaries are well studied and quantified, they remain poorly quantified for STEs, their underground equivalent.

Of the studies that consider groundwater as a source or sink in ocean trace element and isotope budgets, few consider that the meteoric groundwater endmember may be reworked during passage through the STE. Such changes may alter our understanding of the residence time of key elements in the ocean and by extension their use as tracers of paleo-ocean chemistry. This particular STE research focus is of special interest to the International GEOTRACES effort, a global program interested in a better understanding of sources and sinks of trace elements and

isotopes in the ocean.

While the biogeochemistry, ecology, and functioning of surface estuaries has been extensively studied, STEs are only beginning to be explored. When the study of STEs formally began approximately 10 years ago (Moore, 1999), the main motivation was to understand chemical cycling in these environments; most previous work focused on one aspect of STEs depending on the specific expertise of the research team. However, the community has come to realize that STEs are dynamic systems where the fate and transport of chemicals are controlled by complex interactions between geochemical, microbial and (groundwater and seawater) hydrological processes and the physical characteristics of the subsurface. Hence, the timing is ideal to organize a team of interdisciplinary scientists within the framework of a SCOR working group. Given the broad interest in STEs, we have commitments from 19 international experts in this field to serve as Full and Associate members on the working group.

Scientific Background

Fresh water flowing from aquifers into the sea may discharge from a seepage face, a narrow zone of sediment near the intertidal zone, or flow directly into estuaries or the continental shelf as submarine groundwater discharge (SGD). Fluctuations in coastal water levels (e.g., waves, tides) and the density difference between fresh groundwater and seawater leads to significant recirculation of saline water through the aquifer (Figure 1). The hydraulic gradient that drives freshwater toward the sea also drives the recirculating saline water back to sea. The fresh groundwater and the saline water mix prior to discharge producing a gradient in groundwater salinity from land to sea. Hence, SGD often consists of a substantial amount of brackish and saline water. The mixing of the fresh and saline water in the aquifer creates an important reaction zone that alters the chemical composition of the discharging fluid. This zone is referred to as a subterranean estuary (STE, Moore 1999). In contrast to surface estuaries, STE are usually characterized by longer residence times, stronger particle-water interactions, and lower dissolved oxygen.

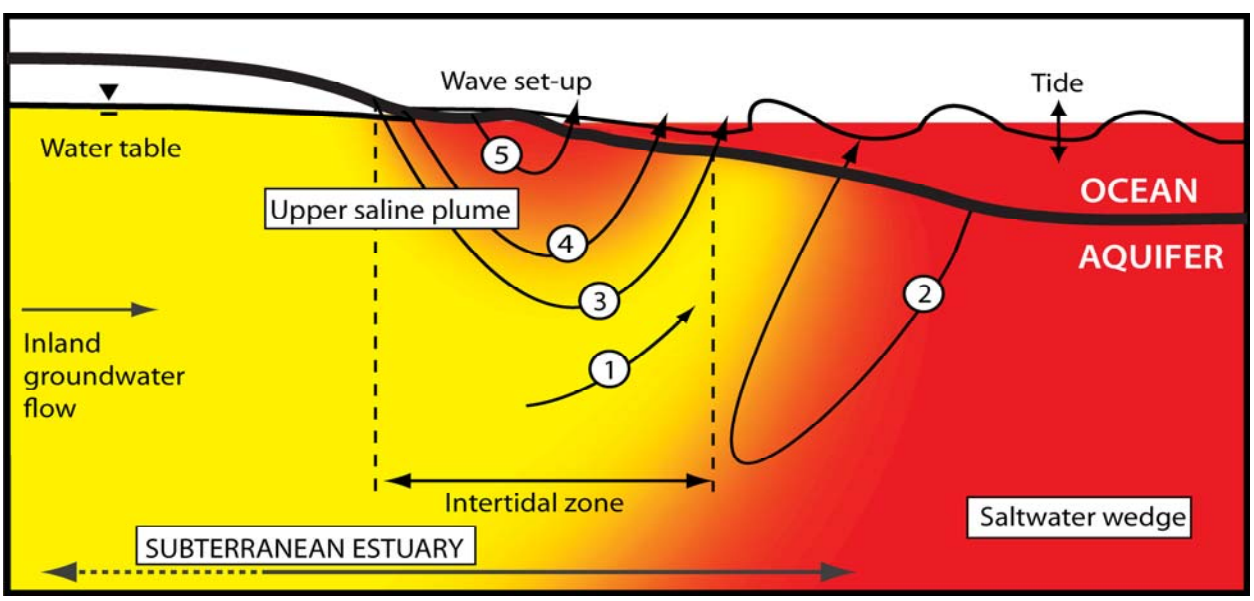

Figure 1. Conceptual view of STEs including major nearshore flow processes: freshwater discharge, (2) density-driven recirculation, (3) wave-set up driven recirculation, (4) tide-induced recirculation, and (5) recirculation driven by wave-bedform interactions. The degree of shading indicates a typical salinity distribution in a subterranean estuary subject to oceanic forcing. The flow processes set up strong physical and chemical gradients that affect the significantly alter the chemical composition of groundwater and recirculating water prior to discharge into coastal waters.

In coastal watersheds with soils of high hydraulic conductivity and permeable coastal sediments, groundwater-derived anthropogenic nitrogen can be a major source of pollution to coastal waters. It is not unusual to observe dissolved inorganic nitrogen (DIN) concentrations in groundwater 100-1,000 times greater than in the receiving waters (Slomp and van Cappellen, 2004). Advection through STEs, driven by fluctuations in coastal water levels and the regional groundwater hydraulic gradient, accelerates biogeochemical activity within the sediments. The recirculating saline water also introduces particulate matter into the system, which serves as a "bio reactor" for many metabolic processes. Understanding metabolic processes in the STE and associated SGD fluxes into the coastal ocean may help to reconcile large imbalances in the current global budgets of metals, carbon, and nitrogen.

The net effect of STE on land-derived nitrogen fluxes to coastal waters depends on a balance between the sources and sinks of reactive nitrogen within STEs. While organic matter mineralization associated with tidal pumping may dramatically increase the fluxes of land-derived nitrogen in some STEs (Santos et al., 2009), denitrification may attenuate terrestrial loads in other systems (Kroeger and Charette, 2008). In addition to denitrification, anaerobic ammonium oxidation (anammox) is a microbial process that may be so significant as to require recalculation of existing global N budgets (Dalsgaard et al. 2003, Kuypers et al. 2003). Anammox has not been fully investigated in these environments, yet preliminary evidence suggests that it may be an important pathway for dinitrogen gas formation (Kroeger and Charette, 2008).

Several recent studies provide evidence that biogeochemical reactions can lead to the large-scale enrichment of trace elements and isotopes in STEs and subsequently in the coastal ocean via SGD. For example, Shaw et al. (1998) and Windom and Niencheski (2003) reported groundwater barium (Ba) enrichments at intermediate salinities that far exceeded the background concentration in coastal waters. These observations were consistent with similar studies suggesting that groundwater is a major source of Ba (and its sister element radium [Ra]) to coastal waters (Moore, 1997; Duncan and Shaw, 2003). In a study of strontium (Sr) in the Ganges-Brahmaputra (G-B) delta, Basu et al. (2001) concluded that SGD was a potential source of strontium to the oceans equal in magnitude to the dissolved Sr concentrations carried to the oceans by the G-B river water. Their estimate of SGD-derived Sr was enough to have a major

effect on the Sr isotope composition of seawater, yet the role of Sr transformations in the STE was not considered.

Heavy metals of anthropogenic origin have been a recent focus of study in the STE. Beck et al. (2010) found substantial enrichments relative to surface water of cobalt and nickel in the mixing zone of a Long Island (USA) STE, which they attributed to the a redox-driven release with manganese (hydr)oxides. Bone et al. (2007) and Black et al., (2009) reported that mercury and monomethylmercury are actively cycled in the STE, which may exacerbate the impact of this land-derived contaminant in groundwater fed estuaries.

The mixing of fresh and saline water in aquifers has also been shown to remove dissolved materials from coastal waters. For example, Charette and Sholkovitz (2002) reported an accumulation of iron (hydr)oxides in the STE that were accumulating fresh and saline groundwater derived phosphorous. Both Windom and Niencheski (2003) and Duncan and Shaw (2003) observed significant uranium (U) depletion in STEs, which they attributed to removal under anoxic conditions during seawater recirculation through the aquifer. Charette and Sholkovitz (2006) showed that this removal process was strong enough to create a U deficit in the surface waters of a coastal bay. These observations have led to additional uncertainty in the marine U budget that require a reevaluation of U and U isotopes as paleooceanographic tools. STEs are also important for both Fe and Mn cycling. Dellwig et al (2007) observed that as a result STEs may cause the periodic enrichment and depletion of Mo in coastal environments.

Numerical model simulations are necessary to provide insight into the controlling processes and functioning of STEs and to translate local field understanding to a wide range of coastal conditions. Numerical variable-density groundwater flow models have been developed, in combination with field experiments, to understand the flow paths and the intensity of fresh-saline water mixing in STEs. Studies have identified that key factors that control the way coastal water levels and the saline-groundwater density contrast affect the extent of mixing and the configuration of the STE for sandy coastal aquifers (Michael et al. 2005; Xin et al., 2010; Robinson et al., 2007).

Reactive groundwater transport models have been used to further assess the impact of the flow and mixing processes in STEs on the transport of groundwater-derived anthropogenic contaminants. Studies focused on the transport of nutrients and aerobic biodegradable organic compounds (e.g., BTEX) have demonstrated considerable attenuation of contaminants in STEs (Robinson et al., 2009; Spiteri et al., 2008a,b). In order to improve predictions, however, numerical models must be validated with field studies with the reaction networks modified and extended as needed to incorporate real world geochemical, microbial and groundwater complexities. This requires strong interdisciplinary collaboration between field researchers (geochemists, geophysicists, microbiologists, hydrogeologists) and numerical modelers.

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Statement of Work/Terms of Reference

Our proposed working group ideally fits the SCOR mission of bringing together scientists of diverse expertise to solve a problem in ocean science that is hindering research. Two previously funded working groups had complementary themes but studied different problems to those outlined here. SCOR WG112 on Submarine Groundwater Discharge addressed the need for better quantification techniques of land-ocean fluid exchange. SCOR WG114 on Permeable Sediments studied the dynamics of flow and biogeochemical reactions in marine dominated coarse-grained sediments. In our case, we contend that our field has an incomplete knowledge of the driving forces of water recirculation and the groundwater flow and mixing dynamics within contrasting STE environments. This in turn has hindered our knowledge of the subsurface fluid chemical reactions (salinity, pH, oxidation-reduction) and whether or not dissolved constituents may be mobilized to the water column or sequestered in the STE. The answers to these questions are required to address local scale issues such coastal water quality and global scale problems such as trace element mass balances. To this end the proposed working group would engage in the following activities:

Task: Summarize past results on STEs including experimental and modeling findings and based on this information develop a list of key questions that require focused study in the future.
Deliverable: The related field of SGD has been covered in a large number of overview papers (e.g., Burnett et al., 2003, 2006; Taniguchi et al., 2002). To date there has not been such a synthesis on STEs. As an outcome of our first year meeting as a SCOR working group, we propose to write a review paper for publication in "Progress in Oceanography" or a similar journal.

Task: Development of a STE classification system.
Deliverable: There exists a logical and well organized classification system for surface estuaries (e.g. Durr et al., 2011). In general, there are two categories of classification: by geology (e.g. fjord-type) and by stratification/extent of fresh-salt water mixing (e.g., stratified, partially stratified and well-mixed). We aim to develop a similar system for STEs along the lines of that proposed by Slomp and van Cappellen (2004) and Robinson et al (2007). This will be disseminated on our working group website and as a peer-reviewed publication arising from our year 2 meeting.

Task: Conduct 1-2 process studies at locations mutually agreed upon by the committee.
***Deliverable*:** The first and second year meetings will provide the opportunity for members to identify and prioritize the major uncertainties and questions regarding the functioning of STEs. As a group we will seek external funding to conduct up to two process studies that will take place at contrasting STEs (according to our new classification system). These studies will require combined geochemical, hydrological and microbiological expertise and have both a field and numerical modeling component. The results will be published in a Special Issue of *Biogeosciences* (or similar open-access journal). As most of our members are actively working in

this research area, we do not feel that significant additional resources beyond the travel funds provided by SCOR will be required to carry out such a project.

Three working group meetings will be organized over a three year period and will be held in association with international meetings. The first meeting will occur in spring 2012, likely in conjunction with the annual European Geophysical Union meeting (Vienna). At this meeting the working group will outline how the terms of reference will be met, including delegation of tasks, and will also identify funding sources and sites for collaborative process field studies. Each group member will also present their research work. This will lead to discussion on key research needs for advancing understanding of STEs and detailed planning for a review publication. The group will also review existing modeling approaches, their limitations and outline the needs for future code development, including data requirements. Finally, we will discuss the uncertainties and required information for developing a classification system for STEs.

A second meeting will be convened approximately one year following the initial meeting. It is proposed that this meeting will be held in 2013, possibly in association with the American Society of Limnology and Oceanography's bi-annual winter meeting. The location however will be finalized at the first working group meeting. In addition to the working group meeting, a Special Session on STEs will be organized by the working group members.

The final meeting will take place approximately three years following the initial meeting and will enable the working group to complete publications and obtain input for the Working Group's final report. The location and timing of this meeting will be finalized at the first meeting of the working group and may be conducted in concert with one of the proposed process field studies.

Working Group Membership: Our working group membership will consist of 10 Full Members and 9 Associate Members all with expertise or interest in this field (Tables 1 and 2). The Full Members include those with expertise in geochemistry, geophysics, microbiology, and groundwater flow dynamics and with field and/or numerical modeling expertise. In addition to broad international representation, our membership includes a balance of junior and senior scientists. Co-chair M. Charette is a geochemist and has been involved in the study of subterranean estuaries since the landmark W.S. Moore paper in 1999. Co-chair C. Robinson has expertise in groundwater flow dynamics and numerical modeling and has published a series of well-cited papers on subterranean estuaries that arose from her Ph.D. in 2007.

Table 1. Full Members of the SCOR Working Group on Subterranean Estuaries.

Member	**Affiliation**	**Expertise**
Matt Charette (co-chair)	Woods Hole Oceanographic Institution, USA	Biogeochemistry of trace metals and nutrients
Clare Robinson (co-chair)	University of Western Ontario, Canada	Numerical modeling and groundwater flow dynamics

Hans Brumsack	Oldenburg University, Germany	Biogeochemistry of trace metals and nutrients
Jorge Herrera-Silveira	University of Merida, Mexico	Nutrient cycling and biological impacts
Guebum Kim	Seoul National University, Korea	Radionuclides and nutrient cycling
Jose Marcus Godoy	Pontíficia Universidade Católica do Rio de Janeiro, Brazil	Radionuclides
Vincent Post	Flinders University, Australia	Reactive transport modeling
Alyson Santoro	University of Maryland, USA	Microbiology and nitrogen cycling
Thomas Stieglitz	James Cook University, Australia	Geophysics
Yishai Weinstein	Hebrew University of Jerusalem, Israel	Radionuclides and nutrient cycling

Table 2. Associate Members of the SCOR Working Group on Subterranean Estuaries.

Member	**Affiliation**	**Expertise**
Pierre Anschutz	Université Bordeaux, France	Biogeochemistry and nutrient cycling
Aaron Beck	Virginia Institute of Marine Science, USA	Trace metal biogechemistry
Jaye Cable	University of North Carolina – Chapel Hill, USA	Biogeochemistry and nutrient cycling
Jordi Garcia-Orellana	Universitat Autònoma de Barcelona, Spain	Radionuclides
Kevin Kroeger	U.S. Geological Survey, USA	Biogeochemistry and nutrient cycling
Adina Paytan	UC Santa Cruz, USA	Biogeochemistry and nutrient cycling
Richard Peterson	Coastal Carolina University, USA	Radionuclides and geophysics
Isaac Santos	Southern Cross University, Australia	Carbon cycling
Caroline Slomp	Utrecht University, The Netherlands	Biogeochemistry, nutrient cycling, and modeling

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2.3.6 Patterns of rocky shore dynamics in coastal ecosystems: comparative analysis *Taguchi*

Scientific Background and rationale:
Compelling evidence signals that our climate is changing (e.g. Gooding et al. 2009) and is driving important shifts in the composition and structure of a diverse array of natural assemblages: terrestrial (e.g. Hughes, 2000), marine (Barry et al., 1995; Roemmich et al., 1995; Parmesan et al., 1999; Sagarin, 1999) and aquatic (Adrian, 1999). Given the close relationship between biodiversity and ecosystem functioning (Loreau et al., 2001; Gessner et al., 2004), any diversity loss will negatively affect the number and quality of services that a particular system might provide (Balvanera et al., 2006). Consequently, it is of paramount importance to be able to detect significant and persistent change in biodiversity within natural ecosystems and quantitatively describe associated effects on ecosystem functioning.

To detect changes in natural communities, and unequivocally relate them to anthropogenic impacts or climate disruptions, proper baseline data are of utmost importance. Obtaining this type of data is not, however, an easy task because: (1) we are dealing with a problem that is relatively new (or at least only recently considered as a problem), (2) the unequivocal establishment of cause-consequence relationships is complicated by the fact that we live in a world that is naturally heterogeneous and variable (Underwood, 1992; 1994), (3) drivers of change occur and operate at different spatial scales (Denny et al., 2004; Benedetti-Cecchi et al., 2010) and (4) it is not yet clear whether those drivers might act cumulatively, synergistically or antagonistically (e.g. Crain, 2008; Darling & Côté, 2008). A good starting point to tackle this problem would be to compare actual distributions of natural populations to long-term and spatially widely distributed datasets. Alternatively, standardized global monitoring programs can be put in place to assess change in biodiversity and relate those changes to possible anthropogenic causes and natural climate fluctuations. Whatever the case, it would be critical to select a suitable system that will allow for these types of comparisons.

Assemblages associated with intertidal rocky shores are particularly appropriate to study changes driven by global-scale anthropogenic impacts and climate change (e.g. Harley et al., 2006; Hawkins et al., 2008). From an ecological point of view, organisms living in these systems have a short life span and are slow-moving or sessile, consequently they respond very quickly to environmental change (e.g. Underwood, 2000). These organisms also are located within a strong terrestrial-marine gradient spanning relatively small spatial scales (Helmuth et al., 2002; Thompson et al., 2002), which exposes them periodically to extreme conditions and ultimately, many intertidal species have to live close to their thermal tolerance limits (e.g. Hawkins et al., 2003). Lastly, spatial and temporal distribution patterns in these systems, and the processes responsible for those patterns are fairly well understood at local scales (Menge & Branch, 2001; Robles & Desharnais, 2002). In addition, from a logistic point of view, intertidal rocky shores are relatively easy to access and to work on (no sophisticated research vessels are necessary, for example) and the surveys of organisms associated with these systems can be easily made because

they are macroscopic, slow-moving or sessile, belong to a wide number of functional groups and, most importantly, interact at spatial scales that can be easily handled by scientists (Underwood, 2000; Underwood & Chapman, 1996). Last but definitely not least, coastal rocky shores provide many important ecosystem services and benefits to human populations.

Due to these advantages, several comprehensive (spatially and/or temporally) databases related to assemblages associated with intertidal rocky shores have been built in different parts of the world, most notably in: temperate Australia (e.g. Underwood, 2000), Chile (Broitman et al., 2001), Japan (Okuda et al., 2004), Mediterranean (Fraschetti et al., 2005), South Africa (Griffiths et al., 2010), United Kingdom (e.g. Hawkins et al., 2008), and US West Coast (e.g. Blanchette et al., 2008); almost all of these are represented in the present proposal. In addition, under the umbrella of the Census of Marine Life initiative, two additional datasets have been assembled. The first was through the NaGISA project (Natural Geography in Shore Areas) that gathered information of rocky shore systems at a global scale in 182 sites contributing with 60,616 records of 3,972 taxa to the Ocean Biogeographic Information System (OBIS) (e.g. Cruz-Motta et al., 2010). The second was the SARCE regional initiative (South American Research group in Coastal Ecosystems) which formed in 2010 and initiated field campaigns on these types of assemblages along the Atlantic and Pacific coasts of the South American continent. Despite the availability of these valuable datasets, very few attempts have been made to compare or compile them (but see Blanchette et al., 2009) in order to test hypothesis about ecological patterns and or processes at global scales. It is possible that these comparisons of datasets and patterns have been hampered by differing methods and protocols, but it is more likely that this process has not happened yet due to a lack of a formal proposal to bring all of these researchers together within a working group. In this sense, SCOR provides a unique opportunity for this endeavor to take place.

Consequently, we are proposing to form a SCOR working group (detailed below) to pursue the following objectives:

1. Evaluate the possibility to consolidate and compare the results of observations and time series on coastal rocky shore biodiversity from different parts of the world,
2. Examine the methods used to monitor rocky shore biodiversity to provide recommendations about future sampling designs and implementation, and identify pressing scientific questions with social relevance.

If these two objectives are achieved, this proposed working group will generate the necessary information to build up a standardized time series against which future changes, such as shifts in coastal assemblages generated by temperature changes, species outbreaks or introduction of nonnative species can be measured. In addition, it might improve capacity building in developing regions. This will facilitate the modeling of IPCC scenarios within the intertidal region and our ability to make predictions at different spatial scales, from local, to regional, and global.

Terms of reference:
Building on the foundation of the Census of Marine Life project NaGISA (Natural Geography in Shore Areas, http://www.nagisa.coml.org/), the SARCE regional initiative (South American Research group in Coastal Ecosystems) and the several long term coastal observations carried out at different locations worldwide, we have established the following terms of reference that will (1) answer scientifically important and socially pressing questions, and (2) build capacity for scientists in developing countries.

- Identify and consolidate globally representative data sets on rocky shore ecosystems: collect and compare results from the monitoring of coastal rocky shore biodiversity [e.g. local/individual initiatives (non Census), global Census (NaGISA), regional SARCE 2010].
- Assess the strengths and weaknesses involved with data/methods/standardization and what should be done by further observational programs.
- Develop and share protocols/techniques that will help the scientific community worldwide on a longer term and connect to policy makers to support environmental impact studies in this area influenced by urban development and other human and climatic impacts (based on the comparative analysis of the methods that have been used and on the questions for future research and continued observation)
- Develop priorities and recommendations for future coastal marine observation efforts and re-analysis of existing datasets, on a global scale.

Products:
The products after developing these terms of reference are envisioned to be:

1. the consolidation of a network of researchers in coastal ecosystems at a global level
2. a special issue of a peer-reviewed journal or a paper in a high-visibility journal
3. a simple version of the paper or set of papers for policy makers explaining protocols and recommendations taking into consideration local/regional capacity and infrastructure

Working group Full Members
We have identified several important datasets around the world that should be represented for discussion in the working group: United Kingdom, US west coast (Oregon, California), Europe (Mediterranean, North Atlantic, and North Sea), East Asia, South Africa, Chile, and Australia, among others such as the global NaGISA and the South American regional SARCE. The work will be carried out by a group of ten Full Members and nine Associate Members. During the first working group meeting, a co-chair will be selected from among the Full Members, and additional Associate Members may be nominated if deemed necessary. The proposed list of members ensures wide geographic coverage, balance between developed and developing countries, and includes expertise in biological oceanography, benthic ecology, marine biology, and modeling. The names, affiliations and expertise of the people that have agreed to serve in the working group are:

Name	Affiliation/contact	Country	Expertise
Patricia Miloslavich (Chair)	Departamento de Estudios Ambientales and Centro de Biodiversidad Marina Universidad Simón Bolívar pmilos@usb.ve	Venezuela	Biological oceanography and marine biology and biogeography
Juan José Cruz-Motta	Departamento de Estudios Ambientales and Centro de Biodiversidad Marina Universidad Simón Bolívar juancruz@usb.ve	Venezuela	Benthic ecology in tropical ecosystems, Quantitative Ecology
Tim Glasby	Aquatic Ecosystems Unit (NSW) Port Stephens Fisheries Institute tim.glasby@industry.nsw.gov.au	Australia	Marine ecology in temperate ecosystems, large-scale monitoring of algae and invertebrates on rocky reefs, impacts of invasive seaweeds on native biota
Gray Williams	Swire Institute of Marine Science University of Hong Kong hrsbwga@hkucc.hku.hk	Hong Kong	Marine benthic ecology in tropical ecosystems, algal – herbivore interactions and the role of herbivore behavior influencing rocky shore community structure
Angela Mead	MA-RE Basics program University of Cape Town angela.mead@uct.ac.za	South Africa	Marine ecology – biogeography, bioinvasive species and spatio-temporal modeling of environmental and ecological data
Lisandro Benedetti-Cecchi	Dipartimento di Biologia University of Pisa lbenedetti@biologia.unipi.it	Italy	Marine ecology - processes influencing patterns of diversity,

			distribution, and abundance
Sergio Navarrete	Estación Costera de Investigaciones Marinas, Las Cruces Pontifica Universidad Católica de Chile snavarrete@bio.puc.cl	Chile	Marine community ecology, predator-prey interactions, recruitment and dispersal, biogeography and macroecology of marine ecosystems
Stephen Hawkins	Marine Biological Association of the UK, The Laboratory S.J.Hawkins@soton.ac.uk sjha@mba.ac.uk	United Kingdom	Biodiversity and marine ecology, behavioral ecology, taxonomy, and phylogeography
Masahiro Nakaoka	Akkeshi Marine Station Field Science Center for Northern Biosphere Hokkaido University nakaoka@fsc.hokudai.ac.jp	Japan	Marine ecology in coastal ecosystems, dynamics of marine populations and communities, and ecosystem function
Carol Blanchette	Marine Science Institute University of California carol.blanchette@lifesci.ucsb.edu	USA	Community marine ecology, processes controlling community structure at different scales and importance of benthic-pelagic linkages

Working group Associate Members

The working group will also benefit from a network of researchers with expertise in intertidal benthic ecology from around the world who are already engaged in research activities related to benthic dynamics in coastal ecosystems. Since this working group acts on a global scale, a relatively large number of Associate Members is beneficial to contribute from many countries and regions. Associate Members have been selected by their expertise and involvement in the implementation of research methods in rocky shores, publication history in the field, and capacity to move projects forward. Researchers of this network that have agreed to contribute with the proposed SCOR's working group are:

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Name	Affiliation/contact	Country	Expertise
Anthony Underwood	Centre for Research on Ecological Impacts of Coastal Cities Marine Ecology Laboratories A 11 University of Sydney tony.underwood@sydney.edu.au	Australia	Experimental marine ecology, experimental and sampling designs Monitoring and detection of environmental impacts
Rafael Riosmena-Rodríguez	Universidad Autónoma de Baja California Sur riosmena@uabcs.mx	Mexico	Communities associated to rhodolite beds
Fabio Bulleri	Dipartimento di Biologia Università di Pisa fbulleri@biologia.unipi.it	Italy	Marine benthic ecology and modeling
Katrin Iken	Institute of Marine Science University of Alaska, Fairbanks iken@ims.uaf.edu	USA	Trophic interactions between organisms and food web structures in polar regions
Gabriela Palomo	Museo Argentino de Ciencias Naturales gpalomo@macn.gov.ar	Argentina	Experimental marine ecology
Judith Gobin	Department of Life Sciences University of West Indies Judith.Gobin@sta.uwi.edu	Trinidad & Tobago	Marine ecology and polychaete taxonomy
Camilo Mora	Dalhousie University	Canada	Marine ecosystem modeling
Rosana Rocha	Universidade Federal do Paraná rmrocha@ufpr.br	Brazil	Tunicate and sponge taxonomy
Yoshihisa Shirayama	Japan Agency for marine earth science and technology (JAMSTEC), Natsushima Kanagawa	Japan	Marine ecology and biology. Taxonomy of meiobenthos

Timeline:
If approved by SCOR's Executive Committee, the group will meet three times between 2012 and 2014. To minimize costs, meetings will be held in conjunction with major conferences related to the field which many of the full members are already planning to attend. An opportunistic meeting will be organized with the group members attending the Second World Conference on Marine Biodiversity to be held in Aberdeen, Scotland on 26-30 September 2011. This first informal meeting will allow some working group members to initiate discussions about their scientific activities in coastal ecosystems and the databases associated to this topic. If the working group is approved, formal meetings will begin in 2012. The first meeting of the group is envisioned to take place during the XVII Simposio Ibérico de Estudios de Biología Marina, SIEBM-2012 (http://www.siebm.org/) that will take place either in Spain or Portugal. Another possible venue for this first workshop would be in conjunction with the 2012 Symposium on the Ocean in a High CO2 world that will be held in Monterrey, California. During this first meeting, working group members will make short presentations about their scientific activities related to the coastal ecosystem dynamics followed by (1) agreement on how the terms of reference will be met and assign responsibilities, (2) establish a detailed timeline for product delivery (e.g. publications) and workshops, and (3) discussion of potential funding sources for the group activities, including workshops.

For the 2013 meeting, there are three options for venues:

1. the 10th International Temperate Reefs Symposium: this symposium is convened every two years, and in 2011 it is being held in Plymouth, UK in late June; the 2013 location is yet unknown.
2. the XV Congreso Latinoamericano de Ciencias del Mar, which is also convened every two years, always in a Latin-American country (in 2011 it will be held in Santa Catarina, Brazil in November).
3. the 11th INTECOL 2013 to be held in August in London, UK with the theme "Ecology: into the next 100 years" to be held in conjunction with the 100 years of the British Ecological Society (BES).

During this second workshop, we will discuss progress and update on products and activities. The final meeting of the group will be held in 2014 along with the Third World Conference on Marine Biodiversity, the venue to be determined this year in Aberdeen. Another possible venue for this last workshop would be in conjunction with the 2014 meeting of the Ecological Society of America (ESA). This last meeting will be focused on the completion of publications and will provide additional opportunities for capacity building.

One of the responsibilities of the full members will be to actively search for funding opportunities within their countries/regions. For example, the TOTAL Foundation has been approached to sponsor research activities and workshops in the Caribbean and South American regions. The activities of this working group will be useful for several global ocean research

projects, including the new initiative entitled *Life in a Changing Ocean* born as a legacy of the Census of Marine Life. This initiative forms the mandate of the Global Marine Biodiversity Consortium, an international collaboration of scientists committed to expanding marine biodiversity knowledge to support healthy and sustainable ecosystems, which is envisioned to consolidate during the Second World Marine Biodiversity Conference. Other programs/ initiatives that will benefit from the outcomes of this working group are the IPCC, PISCO (US), the IOC (through data input in the open access database on marine biogeography OBIS), Monitoring Sites 1000 (Japan), SARCE (South America), among others. The working group will ensure the establishment of links to other global coastal ocean projects.

Capacity building

The group will contribute to capacity building in three ways:

1. by developing protocols/techniques that will be shared with the scientific community worldwide not only for research but also for education on a longer term as well as establish the connection with policy makers to support environmental impact studies in this increasingly impacted rocky shore environment.
2. by having three representatives from developing countries as Full Members of the group who work within the academia as lecturers in their home institutions teaching courses related to marine biology and ecology. In the same way, four representatives from the Associate Members are from developing countries; and
3. by having at least one and maybe two of the workshops in developing countries.

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2.3.7 Biogeochemical Exchange Processes at the Sea-Ice Interfaces (BEPSII) *Volkman*

Climate change has a strong impact on the polar regions. Current models are inadequate to quantify the role of ice-covered oceans in climate change scenarios, which is at least partly due to a lack of the representation of biogeochemical processes. This SCOR WG has the aim to identify the feedbacks between biogeochemical and physical processes at the ocean-ice-snow-atmosphere interfaces and within the sea-ice matrix. By bringing together experimentalist and modellers, a major improvement of sea-ice biochemistry models from the micro to the global scale will be achieved.

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 ice sheets and open water and to subsequent feedback processes. Our understanding of these processes and the accuracy of dedicated models is still in its infancy.
Due to inherently different properties of the polar regions, climate change affects the North and South Pole significantly different. In the Arctic region, both sea-ice extent and thickness are reducing rapidly, with a record low summer ice extent in 2007 and dramatic shifts from multi-year Ice to first-year ice.
In the Antarctic, a modest increase of the total sea-ice extent is observed, but with strong regional deviations: major reductions in sea-ice extent are observed along the west coast of the Antarctic Peninsula (Cavalieri and Parkinson 2008) with dramatic shifts in plankton biomass and diversity (Montes-Hugo et al. 2009). With these ongoing rapid changes, it is important to realize that while sea ice will not completely disappear from polar regions, it will definitively experience a profound change in seasonality with subsequent changes in its biogeochemical and physical properties.

Current global models Include the seasonal wax and wane of sea ice, but restrict associated properties to only a few physical features without considering biogeochemical effects. In such models, the major climatic effects of sea ice are associated with its albedo, deep water formation and air-sea heat exchanges. In terms of gas exchange, sea ice is represented as a “lid” on the ocean Surface (e.g. Stephens and Keeling 2000). In many respects, Earth System Models (ESMs) are characterized by important uncertainties in the polar regions: the observed reductions in Arctic sea ice appear to be accelerated with respect to current model forecasts (Perovich and Richter-Menge 2009); simulated primary production is systematically less realistic in polar regions compared to the rest of the ocean (Carr et al., 2006); end-of-the-century scenarios do not even agree on the sign of change of primary production in the Arctic Ocean (Steinacher et al., 2010). Also the Impact on CO2 fluxes when ice cover reduces is still unknown, with indications for both increased (Bates et al. 2006) and decreased (Cai et al. 2010) uptake. These examples not only illustrate the rapidity of the observed change, but also the difficulty of understanding and modelling the feedbacks involved in the change.

Emerging views indicate the importance of biogeochemical processes in and associated with sea ice for physical properties and exchange processes at the interfaces. Some examples:

- Sea-ice physical properties (porosity and strength) are affected by biology through the formation of exopolymeric substances (EPS) by algae and bacteria (Krembs et al. 2011).
- Trace metals, iron in particular, released from sea ice together with EPS during the spring ice melt are likely to play a pivotal role in triggering ice edge phytoplankton blooms (Lannuzel et al. 2010, Hassler et al. 2011).
- Model calculations have shown that phytoplankton blooms that occur concomitantly with the ice retreat along the Arctic coastal shelves strongly impact the Arctic climate through the trapping of solar heat. The resulting surface warming triggers a reduction of sea-ice thickness and concentration with subsequent feedback processes (Lengaigne et al. 2009).
- The recent discovery of marine gels as precursors for cloud condensation nuclei, extends the coupling between biology and climate through the production of dimethylsulfide (DMS) to a new source of organic compounds (Leck & Bigg 2010)
- Although the mechanism remains enigmatic, sea-ice surfaces are 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). Recent observation show that sea ice is also an important source for volatile organic compounds such as DMS (Tison et al. 2010), whereas areas of ice melt are sources for bromocarbons (Hughes et al. 2009). Bromocarbons may be important precursors for BrO. Since BrO oxidises DMS to DMSO, thereby reducing its potential to form cloud condensation nuclei, the potential simultaneous, biology driven, production of these volatile compounds may shed a different light on atmospheric processes, with direct consequences for current climate models (Breider et al. 2010).
- The complex inorganic carbon system in seawater is even more complex in sea ice, as extreme salinities and temperature result in precipitation of ikaite (Dieckmann et al. 2008). The complexity of the brine structure, the biological activity in brines and composition of the ice will ultimately determine whether the net effect of ice will be a sink or source of CO2 (Delille et al. 2007, Miller et al. 2011).

These are only a few examples that show the complexity of the processes we have to face when trying to understand the role of sea ice in the earth's system: processes at the micro scale have far-reaching implications for the regional to global scale. Hence, in order to understand this system it is a prerequisite that the main processes and feedbacks at each and every scale are examined from an integrated perspective. This is the aim of this working group, accomplished by active interaction between experimentalists and modellers. The experimentalists will need to assess the quality of the data that have been assembled and translate these in order to make them useful for modellers. The modelers will need to find ways to improve the flexibility of their models in order to translate processes from one scale to the other. Together they will identify, evaluate and parameterize the main biogeochemical and physical properties at the different

scales, with the ultimate goal of realistically implementing polar biogeochemical processes in both ocean biogeochemistry and ESMs.

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 at the different scales, in order to:

- Explore existing knowledge on the role of sea ice in influencing climate-relevant elemental fluxes,
- Discuss and formulate the relevant biogeochemical processes and indentify gaps in our knowledge,
- Explore and compile available field data needed for model validation, and
- Stimulate integrated model development.

The primary objective of SCOR is "to focus on promoting international cooperation in planning and conducting oceanographic research, and solving methodological and conceptual problems that hinder research". These are exactly the needs of the sea-ice community. Sea-ice biogeochemistry is an emerging topic, for which the scientific community is small, not organized and spread all over the world. A SCOR working group will give a strong impulse to assembling current expertise around this highly interdisciplinary topic.

Terms of reference

The proposed working group will bring together experimentalists and modelers that each have their own and combined goals.

1. In order to evaluate currently available data of important parameters affecting sea ice physics and biochemistry and to make recommendations for further data collection needed for the validation of models, a thorough evaluation of existing and new methods is required. The need for an evaluation arises from the specific challenges involved in sea-ice studies: sea ice is a complex medium, including ice matrices, brines, gases and solid salt precipitates and it exhibits substantial variability on all spatial and temporal scales. A comprehensive review of the current state-of-the-art in sea-ice biogeochemical methodology including an assessment of their relative strengths and weaknesses will be synthesised.
2. There is an urgent need to translate relevant processes from small-scale models to global ESMs. Since investment in development time for the insertion of new mechanisms into ESMs can be high, modelers not only need to develop simplified parameterizations, but also to develop small to intermediate scale models that are able to prioritize ice biogeochemistry to climate linkages.
3. Together experimentalists and modelers will summarize existing knowledge on biogeochemical and physical processes at the ocean-ice-snow-atmosphere interfaces and within sea-ice and identify gaps in model parameterizations of these processes. This also

includes recommendations for improved data collection and analysis by preferred methods for model calibration and validation.

4. From this collaboration, models will be developed that will quantify our knowledge on the impact of sea ice biogeochemistry on climate and how climate change feeds back onto sea ice.

Timeline and products

We will initially be focusing on synthesizing current knowledge and identifying gaps including the comparison of methods and available model parameterisations. Based on that we will proceed to bridging gaps by developing improved parameterisations and synthesize methods. We envision the work to be supported by funding on national levels with support for international collaboration via SCOR funding.

We intend to organize special sessions during larger scientific meetings such as AGU, EGU, ASLO, IGS-Sea ice conference and SOLAS-OSC. Additional funding for a 1-day discussion session preceding or succeeding an ASLO meeting will be investigated through ASLO's new Emerging Topics initiative. At least 3 meetings are scheduled: 1. To evaluate sea-ice biogeochemical methods and formulate a guide of best practice. 2. To identify gaps in model parameterizations and make recommendations for improvements. 3. To discuss and formulate the up scaling of relevant processes in models.

A final report in the form of a special issue of a peer-reviewed journal will be published, in which the major findings of the thematic workshops are summarized and new parameterizations for coupled sea ice-ocean-atmosphere models are presented.

Relevance to other activities of SCOR or other international organizations

The initiation of a sea-ice biogeochemistry network took place during a workshop organized under the aegis of the European COST Action 735 ('Tools for Assessing Global Air–Sea Fluxes of Climate and Air Pollution Relevant Gases'; a SOLAS-related activity), 12-14 April 2011, where sea-ice specialists from Europe, Canada, USA and Australia met. During this meeting, both modelers and experimentalists presented their work and discussed the need to form a network for future collaboration. As a result, the current SCOR proposal was formulated. It was also concluded that SCOR support may not be sufficient to achieve all our goals. Therefore, effort will be put in finding additional sources for collaboration in the coming months.

The 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.

It is important to mention here that this initiative intends to benefit from the momentum generated by the IPY programs. One such program is the Ocean-Atmosphere-Sea-Ice-Snow Pack (OASIS) project and several of its associated investigators are listed on this working-group membership list. During the OASIS-Telluride meeting in June 2011, further collaboration will be investigated. The research in this proposal is also endorsed by the Nordic Top-level Research Initiative (http://www.toppforskningsinitiativet.org/en) programme on interaction between the climate change and the cryosphere.

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 ocean-ice-snow-atmosphere interfaces. Since the collaboration between modelers and experimentalists is a prerequisite for this WG to succeed, the composition of the group of full members reflects this. Members are leading in her/his field of research, are involved in many ongoing international polar programs and capable of encouraging and involving other specialists and collaborators in their field of research. We made an effort in involving young scientists in this new network of sea-ice biogeochemists.

Full members	**Institute**	**Country**	**Specialization**
Jacqueline Stefels* (chair)	Univ. of Groningen	Netherlands	Ocean-ice, S-cycle
Delphine Lannuzel*	Antarctic Climate & Ecosystems CRC, University Of Tasmania	Australia	Ice---ocean trace Metal biogeochemistry
Jean-Louis Tison*	Univ Libre Brussel	Belgium	Ice physics and gas composition
Martin Vancoppenolle*	Université catholique De Louvain	Belgium/France	Small-scale modelling, Ice physics
Nadja Steiner*	IOS (Fisheries and Oceans Canada) and CCCma	Canada	Sea---ice, biogeochemical and earth system modelling
Gerhard Dieckmann*	Alfred Wegener Institute for PolarResearch	Germany	Sea-ice ecology, C-cycle
Sang Heon Lee	Pusan National	Korea	Ice and ocean prim

	University		prod
Ulrike Lohman	Institut für Atmosphäre und Klima,Zurich	Switzerland	Atmospheric chemistry, aerosols,modelling
Paul Shepson	Purdue University	USA	Atmospheric chemistry, ozone, halogens
Kevin Arrigo	Stanford University	USA	Biogeochemistry, remote sensing
Associate members			
Klaus Meiners	Antarctic Climate & Ecosystems CRC, University Of Tasmania	Australia	Ecology, optical properties
Bruno DeLille*	University of Liege	Belgium	Biochemistry, C-fluxes
Francois Fripiat*	Univ Libre Brussel	Belgium	Sea-ice, isotopic biogeochemistry
JiaYun Zhou*	Univ Libre Brussel	Belgium	Gas transfer in sea ice
Jan Bottenheim*	Environm Canada, Toronto	Canada	Atmospheric chemistry,OASIS
Michel Gosselin*	University of Quebec, Rimouski	Canada	Ice biology
Maurice Levasseur	Université Laval, Québec	Canada	Ocean-ice biochemistry
Lisa Miller*	Institute of Ocean Science, Sidney	Canada	Atmospheric chemistry, CO_2 fluxes
Tim Papakyriakou	University of Manitoba	Canada	ice-atmosphere gas fluxes
Michael Scarratt	Université Laval	Canada	Ocean S-cycle
Gauthier Carnat	Dept of Environment & Geography, University Of Manitoba	Canada	Glaciologist, S-cycle
Lise-Lotte Soerensen*	Aarhus University	Denmark	air-ice exchange of CO_2
Søren Rysgaard	Greenland Climate Research Centre & University of	Greenland/Canada	Biogeochemistry, microbiology, C-cycle

	Manitoba		
Letizia Tedesco	Finnish Environment Institute	Finland	Small-scale modelling, Ice ecosystems
Christine Provost*	LOCEAN, Paris	France	Physical oceanography
Christoph Garbe*	University of Heidelberg	Germany	Image Processing and modelling polar regions
Michael Fischer	Alfred Wegener Institute For Polar Research	Germany	C-biogeochemistry
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, modelling
Jun Nishioka	Hokkaido University	Japan	Fe biogeochemistry, Sea Of Okhotsk
Daiki Nomura	Japan National Institute of Polar Research	Japan	Ice DMS fluxes
Hyoung Chul Shin	KOPRI	Korea	Biogeochemistry and Ecosystem processes
Veronique Schoemann*	Royal Netherlands Institute For Sea Research	Netherlands	Ocean-ice biochemistry, Fe-cycle
Maria van Leeuwe*	Univ of Groningen	Netherlands	photophysiology
Igor Semiletov	Pacific Ocean. Institute, Russian Academy of Sciences	Russia	Atmospheric CO_2 and CH_4 balance
Agneta Fransson*	University of Gothenburg	Sweden	Inorganic carbon dynamics
Caroline Leck	Stockholm University	Sweden	Atmospheric chemistry, aerosols
Claire Hughes*	Univ East Anglia	UK	Halocarbon chemistry
Lucie Carpenter	Univ of York	UK	Atmospheric chemistry, halogens
Stathis Papadimitriou	Bangor University	UK	Ice biochemistry, C-cycle,

			isotopes
David Thomas	Bangor University	UK	Biochemistry, nutrients, C-cycle
Roland von Glasow	Univ East Anglia	UK	Atmospheric chemistry and physics,modeling
Eric Wolff*	British Antarctic Survey	UK	palaeoclimatology, atmospheric chemistry
Clara Deal*	IARC, Univ of Alaska Fairbanks	USA	Sea-ice biogeochemical modeling
Scott Elliot*	Los Alamos Nat Lab	USA	Sea-ice and global ocean modeling
Paty Matrai*	Bigelow Laboratory for Ocean Sciences	USA	Ocean-ice ecosystem processes, S-cycle

*Participants of the COST-Action workshop, 12-14 April 2011, on Sea-ice biogeochemistry and exchange with the atmosphere.

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Dr E.R. Urban
Executive Director Scientific Committee on Oceanic Research
College of Earth, Ocean, and Environment
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June 30, 2011

Dear Ed,

Last week a workshop on the follow-up of OASIS was organized in Telluride, Colorado. OASIS is a SOLAS, IGAC, WCRP/SCAR CLiC, AMAP, and IPY (http://www.oasishome.net/) endorsed project that was set-up in 2004 and culminated in several sea-ice field campaigns during IPY. Although the original aim was to study the Ocean-Atmosphere-Sea Ice-Snow (OASIS) reservoirs and their interactions, the main theme during IPY was halogen chemistry in snow and lower atmosphere.
After the successful finalization of these campaigns, the question on OASIS' future was put forward. This led to the organization of the Telluride workshop in which presentations were given covering all the OASIS reservoirs and interactions as mentioned in the original workplan. Participants included several participants of the SOLAS-COST meeting held in Amsterdam, April 2011, when the SCOR Working-group proposal on Biogeochemical Exchange Processes at the Sea-Ice Interfaces was written.
The Telluride meeting was very successful and a general agreement on an OASIS – phase 2 was drawn. It was also agreed that the OASIS team and the SOLAS Mid-Term Strategy on sea ice should join forces. The main short-term decisions taken were:

- writing of a white paper to be published in EOS;
- finding resources for sustaining an OASIS-phase 2 network

For the transition phase, coordination will be done by Patricia Matrai and Jacqueline Stefels, with the help of a team representing the different science areas, several countries in order to be able to apply for various network funding schemes, and representing both SOLAS and IGAC's AICI (atmosphere - ice chemical interactions task).
The goal of the new network will be to facilitate international and national collaboration among field, laboratory and modeling scientists regarding O-A-SI-S reservoirs, interfaces, and processes. The network will organize at least biannual meetings and discussion fora that lead to research proposals and projects on "the effects and feedbacks of changing sea ice on OASIS biogeochemistry of polar regions"

A SCOR WG would be an excellent vehicle to start this new network, with the objectives as formulated in the proposal. In the attached table we have listed all those scientists that made the Telluride meeting a success and ask they be added as associate members to the current WG proposal.

Sincerely,

Paty Matrai
Jacqueline Stefels

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25th June 2011

Dr. Jacqueline Stefels
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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

Dr Ed Urban
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Scientific Committee on Oceanic Research
College of Earth, Ocean, and Environment
Robinson Hall
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13 July 2011

Subject: SOLAS support for SCOR Working Group on Sea Ice Biogeochemistry

Dear Ed,

With this letter SOLAS expresses strong support for the proposal to establish a SCOR Working Group on Sea Ice Biogeochemistry, which was recently submitted by Dr. Jacqueline Stefels. As you know, the SOLAS SSC has identified a short-list of key research areas that require a coordinated, international research effort. Understanding the biogeochemical processes operating within and under sea ice is one of these selected areas.

Sea ice represents an important and poorly understood link between the high latitude surface ocean and lower atmosphere. Understanding the full climate forcing and response of sea ice requires a full understanding of its biogeochemistry and associated ocean/atmosphere exchanges of gases and particles. The research questions addressed by the proposed working group are broad and multidisciplinary in nature, and field efforts to study sea ice are logistically difficult. For both reasons, coordinated, international collaboration is required if progress is to be made within a reasonable amount of time. Given the very rapid pace of change in sea ice distribution, such a proposal is very timely indeed.

The SOLAS IPO, as you know, has limited financial resources with which it must support activities across the full scope of the SOLAS Science Plan. As a result, there are insufficient resources available for SOLAS to fund an activity of the scope proposed by Dr. Stefels. The IPO can sponsor Dr Stefels to attend the WG meetings. The IPO will support the group to the best of its ability, ensure access to the communications and organizational capabilities of the IPO, and help link the that the Working Group's activities to other ongoing SOLAS planning activities. For example, sea ice biogeochemistry will be the focus of a plenary session at the forthcoming SOLAS Open Science Conference in the USA, and we expect that regular communiqués on the group's activities can be published via the SOLAS Newsletter and e-Bulletin. Assistance with website hosting and maintenance can also be provided.

I am impressed by the scope of Dr. Stefels' proposal and the impressive team of scientists that she has assembled to participate. I hope sincerely that SCOR will be able to support the proposal and I look forward to this becoming one more area in which SOLAS and SCOR can cooperate.

With very best regards

Prof. Eric S. Saltzman
Chair, SOLAS SSC

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2.3.8 Understanding the global impacts and implications of range-shifting species in marine systems

Costello

SUMMARY

Changes in the distribution and abundance of marine species are being reported around the globe; however, much of the present scientific focus has been on documenting these biological responses. Less well recognised is that many of the changes will affect the utilisation of marine resources with ramifications that range from fishers' profitability and livelihoods to food security, poverty and social cohesion. Species 'range shifts', have been documented from across polar, temperate and tropical regions, in both developed and developing countries, and are considered one of the most significant and immediate effects of global warming in the marine domain. Nevertheless, range shifts will not occur uniformly around the world as climate change is not impacting all areas equally. Regions where ocean warming is occurring most rapidly (marine hotspots) represent an opportunity to quickly advance our understanding of current and likely future changes. Synthesising available data on biological responses and subsequent human impacts (economic, social and governance) across marine hotspots will provide the basis for a comprehensive assessment of the dynamics and implications of range-shifting species. The major challenge addressed by the proposed working group is to identify key issues for marine resource management and governance arising from predicted marine species range shifts and provide a framework for developing contextually relevant adaptation options. This will be achieved by collating and analysing the latest biophysical and ecological data from the fastest warming global regions to generate a stronger understanding of the mechanisms that regulate range shifts and the traits that favour range shifts. This will provide the basis for predictions of potential consequences of range shifts and the development of appropriate adaptation options to assist communities, industry and governments to reduce negative impacts and maximise opportunities.

RATIONALE, SCIENTIFIC BACKGROUND AND SIGNIFICANCE

Climate change is considered one of the greatest ecological, economic and social challenges of our time[1,2]. The impacts of climate change are being felt around the globe, in developed and in developing countries, on land and in the ocean. Recent work has suggested that given observed emission and climate trends[3] planning for adaptation to a 4°C temperature rise is prudent.[4,5] Along with the political and logistical complexity surrounding mitigation solutions, it is critical to recognise the enormity of the global adaptation challenge. Adaptation to the effects of predicted warming will be a complex, difficult and multi-dimensional undertaking, but one that is necessary for lessening the impacts of climate change in a warming world. Our understanding of climate change impacts in the ocean has lagged behind that of terrestrial systems.[6] Likewise, adaptation efforts to date have focused on terrestrial systems,[7] with the options for adaptation in ocean systems largely neglected.

The oceans are the earth's main buffer to climate change, absorbing up to 80% of the heat and 50% of the atmospheric carbon emitted[8,9,10] and thus suffer the double effect of warming and ocean acidification.[11,12] Changes in air and sea temperatures, rainfall, ocean acidification, sea

level, and wind patterns are all contributing to modifications in productivity, distribution and phenology of marine species, affecting ecosystem processes and altering food webs.[13,14,15] The world's oceans provide close to 90% of the world's harvestable aquatic resources and fishing activity affects countries in a range of ways from food security and poverty, to regional and national balance sheets. In 2006 the global production from fishing and aquaculture combined reached approximately 144 million tonnes, of which 110 million were for human consumption. Fish provided more than 2.9 billion people with at least 15% of their average per capita animal protein intake, with figures exceeding 18% for low income food deficient countries.[16] Fisheries and aquaculture are a significant source of protein,income, or family stability for around 520 million people.[17],[18],[19]. In 2006, an estimated 43.5 million people were directly engaged, part time or full time, in primary production of fish either in capture from the wild or in aquaculture, and a further four million people were engaged on an occasional basis.[20]

With escalating demands in developing countries and a rapidly increasing human population, the global demand for seafood products will intensify.[21,22] Identifying the opportunities and threats from climate change, and developing adaptation options is essential to optimising the benefits that society can continue to derive from the goods and services provided by marine resources. Early warning of detrimental changes in marine resources provides communities with an opportunity to minimise costs associated with restructuring as well as social tensions (e.g. increased poverty, income redistribution and resource allocation). Early detection of biological responses to climate change will also identify emerging opportunities – for resource dependent communities it is critical these opportunities are identified early and managed appropriately. By synthesising existing data on range shifting species from the world fastest warming regions and predicting the spatial and temporal nature of future range shifts, outcomes from the proposed working group will enable resource users and managers to make informed decisions on their futures.

WHY RANGE-SHIFTING SPECIES?

One of the most widely documented impacts of climate change in marine systems is the shift in the distribution and abundance of animals as waters warm.[23,24] Range shifts in marine taxa have been described for waters around all continents, including Antarctica, and the Pacific Islands.[25,26] These 'range shifts' bring with them challenges for governments, resource users and coastal communities, particularly when they cross jurisdictional boundaries. Although the biophysical changes have been documented in some regions (e.g. SE Australia), limited attention has been focused on options for adaptive management and governance in the presence of range-shifting species or for identifying options capable of supporting communities as their resource base changes.

The un-replicated nature of species' range shifts renders attribution of causality notoriously difficult.[27] However, some 75% of marine range shifts reported in the peer-reviewed literature have been polewards in direction – symptomatic of broad-scale environmental changes such as those predicted under global climate change scenarios.[25] In light of even the most conservative

future climate change projections,[28] coupled with the available evidence that climate change is likely responsible for shifts in many species' biogeographic ranges, more research is needed to understand the full extent of realised and potential future range shifts in marine taxa, and in particular the role that climate change plays in these shifts.[29] Because range shifts effect the distribution and abundance of harvested marine resources, as well as the dynamics of the ecosystems that underpin the productivity of marine resources, examining the diverse consequences of climate change-induced marine range shifts is critical. Although range shifts have been documented in the marine environment, far fewer studies consider the mechanisms underpinning range-shifting dynamics,[30,31] and even fewer the socioeconomic consequences or optimal management responses. Likewise, the appropriateness of existing or potential management responses has not been comprehensively explored.[32] As the global climate continues to change, range shifts driven by this globally ubiquitous process will likely broaden in both number and geographic extent. Considering the ecological, socioeconomic, and management implications of these changes before they occur is essential to mitigating their negative effects and developing effective adaptive response strategies and to seize opportunities.

WHY HOTSPOTS?

While water temperature is the major driver of distribution, abundance, phenology and life-history of marine species,[33,34] it is only one climate change driver of biological change, with other drivers including sea-level rise, circulation changes, acidification, stratification change, salinity, upwelling and nutrient supply. Range shifts can also potentially occur via a number of non-mutually exclusive pathways, including environmental changes leading to latitudinal changes in range limits or alteration in depth ranges;[35] changes in current patterns leading to dispersal of organisms to new locations; and/or ecological changes leading to opening of formerly occupied niche space beyond former range limits.[36]

The oceans are not warming evenly and those areas that are warming the fastest (i.e. marine hotspots) will become the world's natural 'early warning' laboratories to provide the knowledge and ultimately the tools to enable us to adapt wisely, efficiently and effectively to meet the challenges of a warming environment.

Based on historical (last 50 years) and projected (next 50 years) rates of ocean warming, 24 regional hotspots – areas that are warming faster than 90% of the oceans – have been identified.[37] These hotspots occur in all regions of the globe, from polar to tropical, and affect developed and developing countries. These regions are expected to provide early evidence of the response by natural resource systems to climate change and thus provide the most comprehensive understanding of the impacts of global warming in marine environments. In addition to providing the earliest examples of change, they will also provide the first opportunity to validate model predictions and evaluate the success of adaption options. These examples are urgently required to enable managers to prepare for climate change and to instil greater community confidence in the need for adaptation. There is consequently a critical need for a coordinated approach to impact and adaptation research in hotspots, encompassing the broadest

range of ecosystem and resource types, with a commitment to sharing pertinent insights regarding impacts and adaptation.

These marine climate change hotspots represent a natural and replicated laboratory for assessing climate change impacts and developing, evaluating and implementing adaptation options to cope with a changing future. As such, synthesizing outcomes from across these hotspots will also facilitate accelerated learning and indicate sensible pathways for maximising adaptation and minimising impacts of climate change for other marine regions. A systematic approach in the analysis and monitoring of information from these regions will therefore facilitate the advancement of adaptation science globally.

TERMS OF REFERENCE / OUTLINE OF PROJECT, INCLUDING WORKSHOPS

Changes in the abundance and distribution of marine resources will have biological, social and economic implications around the globe. The proposed SCOR Working Group will provide the most comprehensive analysis to date of the dynamics and implications of marine range shifts to provide researchers, industry, communities and governments with the knowledge to optimise the environmental, economic and social values from climate-induced range shifting species. We have assembled an international and interdisciplinary team to:

1. Synthesise the latest biophysical and ecological data to generate a thorough process-based understanding of recent range shifts in key global marine hotspots.
2. Synthesise the information from global hotspots to determine the generic similarities and specific differences across hotspot regions and to validate hypotheses regarding the mechanisms that regulate range shifts, the traits that favour range shifts and how communities, industry and governments are adapting.
3. Develop projections of likely future range shifts in key fisheries and biodiversity resources in a range of hotspot regions, based on the mechanistic understanding generated above.
4. Model the predicted effects of marine species range shifts on the social and economic components of linked human systems at various scales (e.g. fisher, fishery, community) and across marine resources in developed and developing countries.
5. Identify key challenges for marine resource management and governance arising from predicted marine species range shifts and provide a framework for developing contextually relevant adaptations

A GLOBAL APPROACH

This research team is well positioned to lead international initiatives. In April 2010 we organised a workshop ‘*Networking across global marine “hotspots”’* at the International symposium *‘Climate Change Effects on Fish and Fisheries:Forecasting impacts, Assessing Ecosystem Responses, and Evaluating Management Strategies’* held in Sendai, Japan.[38] The most common observation from the hotspot regions was range shifts to higher latitudes and to deeper waters often resulting in an increased diversity and species richness of fishes. However, many of the

species moving into temperate fishing grounds were of lower market value, whereas changes in ice cover in arctic regions resulted in increased yield from traditional fisheries through increased primary production39. Consensus from the workshop identified the benefits that could be achieved by synthesising, contrasting and comparing across locations as the best possible learning opportunity to address climate challenges and that a network would provide a mechanism for capitalising, as efficiently and effectively as possible, on emerging information in a rapidly changing world.

The aim of this proposal is to bring together an inter-disciplinary team studying marine hotspots around the world to synthesise the existing and latest data available from these hotspot regions. This will be achieved through three workshops. The first will be in conjunction with the World Fisheries Congress in Edinburgh, Scotland (7–11 May 2012): *Sustainable Fisheries in a Changing World*. The second workshop will be held in late 2012/early 2013, located in South America, South Africa or Asia. The third and final workshop will be held in mid-late 2013. Our team includes experts in oceanography, biology, ecology, social science, economics, modelling and policy, and spans highly experienced senior researchers through to dynamic early career researchers and PhD students. We are thus building international capacity to develop a comprehensive and process-based understanding of the implications of range shifts in marine systems – a critical issue in marine science that will only become more pervasive and ubiquitous as climate change continues. Importantly it is an issue that will alter international marine landscapes with resultant impacts on fishers and communities and thus requires the development of adaptation options and planned government responses.

The first workshop "*The changing demographics of global marine ecosystems: climate change and range shifts*" will be held at the World Fisheries Congress in Scotland, May 2012. We have already been selected as workshop convenors, under the banner of the *Global Network of Marine Hotpots*, following an invitation from the World Fisheries Congress and will refocus the workshop to reflect the SCOR initiative, providing global exposure to the SCOR Working Group. This multi-day workshop will have two main components 1/ "*Synthesis of range shifting species: what, where, when and why*" and will focus on improving our understanding of range shifts in key hotspot regions through the synthesis of existing physical (e.g. Global Observation Systems), biological, ecological and habitat mapping data associated with range shifting species. We will link biological observations with physical observations to delineate patterns, drivers and potential processes associated with range shifting species. This exploration will be mechanistic as well as statistical in nature and will utilise a variety of modelling approaches. The second part of this workshop will determine what emerging patterns and processes are evident from across the global hotspots. Importantly, we will be able to develop an understanding of what issues are generic across locations or specific to particular regions or conditions. Prior to the workshop, working group members will have developed a range-shifting species database **(Deliverable 1)** and collated the existing data and knowledge from as many of the 24 hotspot regions as possible. This will provide maximum opportunity at the workshop for participants to explore and model the data and to brainstorm ways of conceptualising and presenting the data to a variety

of audiences/stakeholders. Participants will also populate the Global Marine Hotspots website (under development, www.marinehotspots.org) with the latest findings from the workshops and broader project **(Deliverable 2).**

By synthesising information across the fastest changing regions in the world, workshop 1 will assess the biological and physical traits that may be used to predict why some species have already shifted distributions more than others in response to recent climate change. We will compile data on the traits of species and 'receiving' ecosystems, and analyse variation in documented range shifts from major hotspots to determine whether such traits can predict differences in the rate or magnitude of recent range shifts. For example, range shifts may be positively related to traits allowing greater dispersal, intrinsic rates of increase (like generation time and reproductive output), and ecological specialisation/generalisation (diet breadth, climatic variance within the species' range). While there are large scale and general climate change global synthesises underway, they are very broad brush and conceptual in focus. Our synthesis will allow us to look at detail including an examination of systems and species. Our synthesis will be collated as a paper contribution to a high ranking journal **(Deliverable 3)** and will also be a bridge between small-scale experimental studies where the biological details are thought to be crucial and broad-scale modelling/synthesis efforts where the biological details are often ignored. **The second workshop** "*The role of range shifting species in the future of global marine systems*" will take the understanding developed in the first workshop to predict the magnitude of range shifts of key fisheries and biodiversity resources under differing climate change scenarios, using global climate models (GCM's) and envelope modelling (e.g.species distribution modelling). This workshop will include an analysis of the social and economic impacts of range shifting species on marine resources in a range of developed and developing countries. While we expect fewer existing studies on social and economic impacts, we will expect regional participants to source data from their respective sectors. The data required will be discussed during the first workshop. The output from this workshop will be the first comprehensive study on the consequences of range shifting species and the observed responses by communities, industries and governments that crosses polar, temperate and tropical domains as well as commercial, artisanal and subsistence fisheries. We will use these observations to predict future impacts from range shifting species from global ecosystem models. Outputs from this workshop will include a minimum of two major papers **(Deliverable 4).**

The third workshop *"Adapting to a brave new world: Lessons from the fastest warming marine regions in the world"* will focus on the management and governance of marine resources to optimise consumptive and conservation values in the presence of range shifts. The workshop will also investigate the potential to detect range shifts in a range of fished and non-fished species given the design of existing monitoring programs and include the evaluation of cost-effective global programs to detect range-shifts including the design of monitoring programs that are effective and consistent across regions. By synthesising across the fastest changing regions in the world this workshop will aim to demonstrate how fisheries are being impacted and how communities, industries and governments are adapting to ensure sustainable use of marine

resources for current and future generations. Findings will be presented at an appropriate symposium or conference identified closer to 2013 with subsequent publication in an international journal **(Deliverable 5).**

Outputs from workshops will be developed into journal publications for *Nature: Climate change*, *Science*, *Ecology* and other high profile journals. Additionally, the project, and therefore SCOR and the participant institutes, will be showcased via the Global Network of Marine Hotspots website and forums. The website development has already been supported by the UNDP/GEF funded Agulhas and Somali Current Large Marine Ecosystems (ASCLME) Project and the on-going development of this network will enable the SCOR Working Group to foster long-term international high level collaborations.

SUMMARY OF DELIVERABLES

- Deliverable 1: Development of a database of the life history, population and ecosystem characteristics associated with observed marine range shifts from within global hotpots.
- Deliverable 2: Communication of the findings from the working group workshops and broader project via population of the Global Marine Hotspots website (under development, www.marinehotspots.org).
- Deliverable 3: Production of the synthesis paper '*The changing demographics of global marine ecosystems: climate change and range shifts'*, which will examine the traits of range shifting species and 'receiving' ecosystems to determine whether such traits can explain differences in the rate or magnitude of recent range shifts.
- Deliverable 4: Publication of at least two papers on "*The role of range shifting species in the future of global marine systems*". These papers will develop predictions for range shifts and assess the likely socio-economic consequences of these in developed and developing countries.
- Deliverable 5: Production of a synthesis paper focusing on the management and governance of marine resources to optimise consumptive and conservation values in the presence of range shifts, "Adapting to a brave new world: Lessons from the fastest warming marine regions in the world".

PROPOSED PARTICIPANTS

Full Members	Institute	Country	Specialization	Regional Hotspot
Gretta Pecl (Co-Chair)	IMAS	Australia	marine ecology; fisheries adaptation; range shifts	SE Australia
Warwick Sauer (Co-Chair)	Rhodes University	South Africa	ecology; LME projects	SW Africa including Benguela System
Alistair Hobday	CSIRO	Australia	biological oceanography	SE & SW Australia
Thomas	UWA Oceans	Australia	biogeography;	SW Australia

Wernberg (ECR)	Institute		physiology	
Nicholas Dulvy	Simon Fraser University	Canada & UK	biodiversity; range shifts	North Sea and Canadian hotspots
Amanda Bates (ECR)	Deakin University	Canada & Australia	macroecology; range shifts	Global syntheses
Tom Okey	West Coast Aquatic Management Board	Canada	marine ecology	Bering Sea and North West America
Janet Nye (ECR)	US Environmental Protection Agency	USA	fisheries; range shifts	North East America
Stewart Frusher	IMAS	Australia	Fisheries science; change adaptation	SW & SE Australia
Yury Zuenko	Pacific Fisheries Research Center	Russia	biological oceanography	Eastern Russia and Sea of Japan

Associate Members	Institute	Country	Specialization	Regional Hotspot
Satoshi Nojima	Kyushu University	Japan	biodiversity	Southern Japan
Dan Smale (ECR)	University of Western Australia	Australia	biodiversity; EBFM	SW Australia
Ben Radford (ECR)	Australian Institute of Marine Science	Australia	biodiversity; spatial modelling	SW Australia
Neil Holbrook	University of Tasmania	Australia	physical oceanography; climate change science; adaptation	South Pacific region
Marcus Haward	Antarctic CRC	Australia	governance	Global
Sarah Jennings	University of Tasmania	Australia	economics; adaptation	SW & SE Australia
Graham Edgar	IMAS	Australia	ecology	Galapagos Islands
Beth Fulton	CSIRO	Australia	ecosystem modelling	Global

Nikki James	South African Institute for Aquatic Biodiversity (SAIAB)	South Africa	aquatic biology	SW Africa including Benguela System
Monica Mwale	South African Institute for Aquatic Biodiversity (SAIAB)	South Africa	fish genetics	SW Africa including Benguela System
Warren Potts	Rhodes University	South Africa	fisheries ecology	SW Africa including Benguela System
Jonathan Fisher (ECR)	Fisheries & Oceans Canada	Canada	macroecology	Canada
José H. Muelbert	Institute of Oceanography at FURG	Brazil	Biological oceanography	Brazil
E. Vivekananda	Central Marine Fisheries Institute	India	Fisheries science	Southern India

Ph.D. Students	Institute	Country	Specialization	Regional Hotspot
Jennifer Sunday	Simon Fraser University	Canada	macroecology	North America
Mike Litzow	IMAS	Australia	regime shifts	North America & Australia

SHORT BIOGRAPHICAL PARAGRAPH FOR EACH PARTICIPANT (alphabetical)

Dr Amanda Bates is a post-doctoral ecologist with an interest in the role that environmental thresholds play in regulating the distribution, abundance and functioning of ectotherms in an era of climate change. Dr Bates has studied thermal tolerances in diverse organisms (e.g., bacteria, algae, invertebrates and fish) from Antarctica to the deep sea to advance both general ecological theory and applied management issues. During this time, she has been privileged to work with world-experts in the field of thermal physiology at some of the best institutions in the world including Harvard University (USA). At present, Dr Bates is working with collaborators to generate a theoretical framework for predicting the range responses of ectotherms to warming environmental temperatures with the goal of producing high-impact, widely read manuscripts.

Dr Nicholas Dulvy is a Canada Research Chair in Marine Biodiversity and Conservation and Co-Chair of the International Union for the Conservation of Nature's Shark Specialist Group, a global network of 160 scientists and experts with the mission to promote the long-term

conservation and management of the world's sharks, rays and chimaeras. Dr Dulvy works on the ecological, economic and social impacts of climate change in marine ecosystems. He is known for providing some of the first evidence that marine organisms are deepening in response to climate change and for mapping the national vulnerability of the fisheries sectors of 132 countries to global climate change.

Associate Professor Graham Edgar's recent research interests primarily involve the investigation of broad temporal- and spatial-scale patterns of human impact on the marine environment, including fishing, climate change, introduced and invasive taxa, oil spills and fish farm effluent. Through studies disseminated in conference talks and over 100 reviewed journal articles, books, book chapters and edited conference proceedings, Dr Edgar has made major contributions internationally within the fields of marine ecology and conservation, in particular through studies of interactions between macrofaunal invertebrates, fishes and plants, through clarifying important metabolic-based regularities in faunal communities, and through assessment of threats to marine biodiversity. His contributions in the field of marine conservation science were recognised internationally by my selection as Director of Marine Research and Conservation at the Charles Darwin Research Station, Galapagos Islands, Ecuador, a position responsible for 50 employees, students and volunteers (2000-2002). Recent studies have primarily involved investigation over time of large-scale human impacts on marine ecosystems (in Tasmania, WA, SA, Victoria, NSW and the eastern tropical Pacific), including effects of fishing, sedimentation, oil spills, introduced species and aquaculture. A particularly notable aspect of recent studies is that they involve huge spatial, temporal and taxonomic scales, in some cases (e.g. empirical analysis of MPA effects) greater than any other previously attempted worldwide These studies have been particularly innovative in showing that studies at continental geographic scales, where outcomes of broad generality are deduced, can be conducted at low cost. His scientific papers are highly regarded and widely cited in the global ecological literature.

Associate Professor Stewart Frusher leads the Climate Change Theme of the Tasmanian Aquaculture and Fisheries Institute (TAFI) at the University of Tasmania. He led the successful inter-disciplinary bid for the Australian Government's Department of Climate Change National Coastal Vulnerability assessment case study on fisheries. He is also the co-leader of the Marine Biodiversity and Resources node of the National Climate Change Adaptation Research Facility's Marine Biodiversity and Resources Network. Assoc Prof Frusher was co-convener of INTECOL's symposium on Climate Change, Changing Opportunities in Southern Coastal Temperate Ecosystems and co-convener of the PICES/ICES Workshop on Networking across global marine 'hotspots' at the Climate Change Effects on Fish and Fisheries: Forecasting impacts, Assessing Ecosystem Responses, and Evaluating Management Strategies Symposium. He chaired the climate change sessions at the 8th International Conference and Workshop on Lobster Biology and Management (2008) and Recent Advances in Lobster Biology and Management (2010). Assoc Prof Frusher has over 30 years of experience in marine science, specialising in fisheries science. He has worked with fisheries from subsistence, artisanal to industrial. He is a regular reviewer for a range of fisheries and marine ecology international

journals and reviewer for international research grant agencies. In 2002 Assoc Prof Frusher was award the Dean's Award for Research Excellence. He has published over 50 international publications and has been the recipient of $1.6 million in research grants as a Chief Investigator and $4.5 million as a partner investigator. Assoc Prof Frusher is recognised for his development of interdisciplinary studies through external funding support for the Coastal vulnerability assessment project (as mentioned above), 'Building Economic Capability to Improve the Management of Marine Resources in Australia' and 'Integrated simulation tools for the bio-economic assessment of renewable resource systems'. He has recently been award a large national project spanning south-eastern, western and northern Australia to develop 'A climate change adaptation blueprint for coastal regional communities' that also crosses the biophysical, social, economic and governance disciplines.

Dr Beth Fulton is a CSIRO science leader. She received her PhD from University of Tasmania in 2001, receiving a Dean's commendation for a PhD by research. Dr Fulton works extensively with marine ecosystem modelling. She developed *Atlantis* and co-developed *InVitro*, which are used to support sustainable multiple use management options for marine environments in Australia and internationally. These tools help identify sensible development and resource use with the conservation of biodiversity and functioning marine ecosystems. Dr Fulton's current work involves implementing ecosystem-based models for regional-scale management strategy evaluation in Australia and internationally, modelling for understanding climate change effects and associated biodiversity and evolutionary shifts, leading CSIRO's marine ecological and ecosystem modelling group, and supervising two post-doctoral fellows and five graduate students. In 2010, Dr Fulton was awarded a prestigious Pew Fellowship in Marine Conservation. She has also been awarded: the Science Minister's Prize for Life Scientist of the Year in 2007.

Associate Professor Marcus Haward is a political scientist specialising in oceans governance and marine resources management. He is internationally recognised as a leader in his field as demonstrated by research collaborations and number of publications including books and book chapters. Assoc Prof Haward is also an active supervisor of graduate students, having supervised 28 PhD students and two research MA students to completion since 1993. He is currently teaching in the School of Government, University of Tasmania with appointments to the Antarctic Climate and Ecosystems Cooperative Research Centre (ACE CRC) and the Adaptation Research Network for Marine Biodiversity and Resources under the National Climate Change Adaptation Research Facility. He has over 137 publications covering fields such as Antarctica, fisheries management, and coastal and oceans governance as well as Australian politics and government.

Dr Alistair Hobday is Principal Research Scientist at CSIRO Marine and Atmospheric Research in Hobart and leads the Marine Climate Impacts and Adaptation area within CSIRO. He has raised the profile of climate change for Australian marine systems, via workshops, conferences, and collaborative initiatives. Together with his team, Dr Hobday ran the first National Symposia on Climate Change and Marine Life; and he has been co-editor of two recent reports on the

impacts of climate change on (i) fisheries and aquaculture, and (ii) Australian marine life. Recently Dr Hobday's team delivered the 'ecosystems' chapter to the Department of Climate Change National Coastal Vulnerability Assessment. Dr Hobday and contributed to the IPCC 4th assessment report, and to the 5th. He is co-chair of the IMBER program CLIOTOP (Climate Impacts on Oceanic Top Ocean Predators) program, was a member of the National Drafting Team for the National Adaptation Plan for Marine Biodiversity and Resources, and is a node leader for the National Adaptation Research Network for Marine Biodiversity and Resources. He also leads the biophysical work area within the fisheries and climate change Southeast Australia Program (SEAP). Dr Hobday has been published 70 peer-reviewed papers, and is an expert reviewer for the ARC, the National Biodiversity Strategy, the National Climate Change Action Plan for Fisheries and Aquaculture, and overseas organizations including the Marine Stewardship Council and the National Marine Fisheries Service (USA). He has also provided national climate change research and policy advice for AFMA, BRS, and FRDC, as well as state agencies including Tasmania, Victoria, and South Australia.

Associate Professor Neil Holbrook is one of the world's leading authorities on the upper ocean dynamics and climate of the southwest Pacific Ocean, making important contributions to their understanding during the past 13 years. Assoc Prof Holbrook (1) provided the first published quantification of the multi-decadal upper ocean warming in the southwest Tasman Sea, and its contribution to steric sea level rise (Holbrook and Bindoff 1997); (2) demonstrated the significant modulating effect of El Niño-Southern Oscillation (ENSO) and decadal variability throughout the southwest Pacific Ocean, that connects through the East Australian Current and Tasman Front (Holbrook et al. 2005), and affects subtropical mode water formation (Holbrook and Maharaj 2008); and (3) discovered the essential role of forced Rossby waves on seasonal variations in southwest Pacific upper ocean temperatures (Holbrook and Bindoff 1999). Following this, Assoc Prof Holbrook developed a research program and built a research group (largely of postgraduate students) to investigate the role of oceanic Rossby waves on interannual-to-decadal scale climate variability in the South Pacific. This research has improved our understanding of (4) the mechanisms underpinning Pacific Ocean interannual dynamics (Perkins and Holbrook 2001); (5) interdecadal climate variability and predictability (McGregor, Holbrook and Power 2004, 2007, 2008, 2009ab); and (6) the importance of Rossby wave modes in the presence of bottom topography using satellite observations (Maharaj, Cipollini, Holbrook 2005; Maharaj, Cipollini, Holbrook, Killworth, Blundell 2007; Maharaj, Holbrook, Cipollini 2009). Most recently, Neil has led an important research direction demonstrating the strong and significant link between changes in the large-scale South Pacific climate and winds, East Australian Current intensity and sea level at the coast in Sydney Harbour (Holbrook 2010; Holbrook et al. 2010).

Dr Nikki James is employed as an Aquatic Biologist at the South African Institute for Aquatic Biodiversity (SAIAB) in Grahamstown South Africa, focusing on global change research. She is co-leader of a programme investigating the effects of climate change on sub-tropical Western Indian Ocean fish species. The study uses a climatic envelope method to explore the extent to

which the range of selected shared fisheries species endemic to the subtropical WIO might shift in response to changes in the surrounding environment with climate change.

Dr Sarah Jennings is a natural resource economist with particular expertise in applied welfare analysis, including cost-benefit analysis and non-market valuation. Dr Jennings heads the School of Economics and Finance at the University of Tasmania. Her involvement in marine economics includes the evaluation of climate change impacts and adaptation strategies, and exploration of the behavioural responses of recreational fishers to climate-induced changes in the quality of recreational fishing opportunities and policies. Dr Jennings leads the national FRDC Building Capability in Fisheries Economics Project which involves providing research higher degree training in fisheries economics.

Mike Litzow, although recently commencing a PhD with QMS, has worked in the area of marine ecology in North Pacific ecosystems for 12 years. Mike has broad interests in ecological effects of fishing and climate change and using ecological theory concerning alternate stable states to understand threshold responses of exploited marine ecosystems to external forcing. He has 15 publications in high quality international journals including *Ecological Applications*, *Oceologia*, and *Fisheries Oceanography*.

Dr. José H. Muelbert has a Bachelor degree in Oceanography from Universidade Federal do Rio Grande (FURG-Brazil)), an MSc in Biological Oceanography from FURG and a PhD in Biological Oceanography from Dalhousie University (Canada). He is an Associate Professor at the Institute of Oceanography at FURG, where he acts as Vice-Director. Dr. Muelbert served at the Global Ocean Observing System (GOOS) Scientific Steering Committee (GSSC) between 2002 and 2006, and currently is the Co-chair os the Panel for the Implemention of Coastal Observations (PICO). His research interests involve physical-biological interactions in marine pelagic ecosystems, fish eggs and larvae, modeling of larval fish transport, and climate change. Dr. Muelbert is a Co-Pi in the the South American Climate Change (SACC) Consortium, an initiative sponsored by the IAI through the Cooperative Research Networks (CRN) Program (http://www.sacc.org.uy/). He is also the Vice-Coordinator for the Coastal Zone program of the Brazilian National Institute of Science and Technology (INCT) for Climate Change (http://www.zonascosteiras.com.br/).

Dr Monica Mwale is employed as an Aquatic Biologist at the South African Institute for Aquatic Biodiversity (SAIAB) in Grahamstown, South Africa and, with Nikki James, leads a project focusing on the effects of climate change on sub-tropical Western Indian Ocean fish species. Monica specialises in genetic research, and specialises in the determination of genetic diversity in relation to the traits responsible for adaptation and the level of gene flow between populations, determined by their ability to migrate to more suitable habitats.

Dr Janet Nye is a fisheries ecologist who has documented shifts in distribution of Northeast US fish stocks and communities related to warming. Her current research attempts to understand the

mechanisms behind these shifts in distribution, particularly the influence of fishing, climate change, and large scale oceanographic features. She is interested in incorporating large-scale oceanographic features into both single-species stock assessments and ecosystem assessments. She is also an expert in downscaling global climate models to forecast changes in the distribution and productivity of marine and estuarine organisms. She is currently a research ecologist at the US Environmental Protection Agency.

Dr Tom Okey is Director of Ecosystem Sciences for the West Coast Vancouver Island Aquatic Management Board. He is an Adjunct Professor in the School of Environmental Studies at the University of Victoria, Canada, and he holds a Pew Fellowship in Marine Conservation on the effects of climate change on Pacific marine life and ecosystems. His projects include the development of an Integrated Ecosystem Assessment for the West Coast of Vancouver Island as a case study for distinguishing the effects of climate change from other anthropogenic stressors in a coastal marine setting, and as a practical application for integrating ecosystem-based and multidisciplinary marine and ocean science with policy. Other recent initiatives include the development of international networks and collaborations for the development of marine climate impacts forecasting tools, and for the development of marine climate adaptation approaches. Dr Okey has been involved marine ecological studies in many areas of the Pacific during the last 24 years. He has worked in government, academia, the private sector, and with non-governmental conservation organisations conducting work ranging from small-scale ecological field experimentation to ecological and human health risk assessments to the development and expansion of fisheries and marine conservation programs to large-scale ecosystem modelling and assessments. His original training is in marine benthic disturbance ecology, but is more recently renowned for constructing high quality and highly articulated and trophodynamic models of marine ecosystems in settings throughout the world. Dr Okey has initiated and is otherwise involved in some meta-analyses of ecosystem models to understand the impacts of climate change and fisheries. He is the founder and Science Director of Conservation Science Institute.

Dr Gretta Pecl is a Fulbright Fellow and a Senior Research Fellow leading several projects within the Climate Change Impacts and Adaptation Theme at the Institute of Marine and Antarctic Studies. She is also a Research Fellow with the Australian Marine Adaptation Network (http://arnmbr.org/content/index.php/site/aboutus/). Dr Pecl's current research activity spans a range of topics including range extensions associated with climate change, evaluating adaptation options in socio-ecological systems, assessing population and fishery responses to climate change, and on using citizen science approaches for ecological monitoring and engagement (e.g. www.REDMAP.org.au). She was lead author of the recent Australian Federal Department of Climate Change interdisciplinary report into the impacts and adaptation response options for the Tasmanian Rock Lobster Fishery (see http://www.climatechange.gov.au/en/publications/coastline/east-coast-rock-lobster.aspx), and the FRDC *Climate Change Risk Assessment for Key Marine Species in South Eastern Australia*. Dr Pecl's recent Fulbright Fellowship was undertaken in Alaska, a project developed specifically to

facilitate collaboration and knowledge exchange between northern and southern hemisphere marine hotspot regions. She has 35 publications in high quality international journals including *Oecologia*, *Proceedings B*, *Global Environmental Change* and several feature articles in *Marine Ecology Progress Series*. In addition to her Fulbright, Dr Pecl has been awarded a 2010 UTAS 'Rising Star' and the Redmap project she leads has been nationally recognised with a 2010 Whitely award.

Dr Warren Potts is a senior lecturer at the Department of Ichthyology and Fisheries Science at Rhodes University and an honorary research associate of the South African Institute of Aquatic Biodiversity. He specialises in ecological research on linefish with particular emphasis on fisheries development, fisheries management and the impact of global change on fishery species. Dr Potts has led a research programs in Angola and South Africa and has extensive regional and international collaborative relationships. Dr Potts's publications include 18 peer reviewed articles in scientific journals, 9 scientific reports, 1 book chapter on the impact of climate change on inshore fishes in South Africa, numerous conference presentations and six popular articles. He has supervised 14 honours, four MSc students and lectured fishery field techniques, practical techniques, fish anatomy, statistics, fisheries management and limnology.

Dr Ben Radford is a spatial modeller with the Australian Institute of Marine Science and concurrently holds an adjunct research position at UWA. He gained his PhD in 2007 and his research has focused on applying novel modelling methods to areas ranging from the production of spatially explicit habitat models to the prediction of patterns of biodiversity based upon an understanding of biophysical surrogates and ecological processes. This work has been recognised with a number of awards such as the Victorian Coastal Council Annual Award for Innovation, the Australasian Hydrographic Society Award for recognition of scientific & technical achievement, The CRC Chair's Innovation Award for novel and unique interdisciplinary research and the State Coastal Conference Award for Excellence in Marine Research. To date Dr Radford has published 12 papers in journals such as *Journal of Biodiversity*, *PLoS One* and *Conservation Letters*
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Professor Warwick Sauer is Professor and Head of the Department of Ichthyology and Fisheries Science at Rhodes University in South Africa. His interests are in fisheries ecology and management, particularly in the translation of science into practical fisheries management. He serves on a number of management bodies, including the International Cephalopod Advisory Council, and has been involved in numerous regional research projects covering Sub Saharan Africa and the western Indian Ocean. Professor Sauer currently serves as a member of the Project Coordination Unit for the Agulhas and Somali Large Marine Ecosystem Project, and coordinates training and capacity building initiatives across the Agulhas region.

Dr Dan Smale is post-doctoral research fellow at the University of Western Australia. His research has documented how patterns of marine biodiversity vary over space and time, and has improved understanding of the processes that drive such variability. He completed his PhD with

the British Antarctic Survey in 2008, after spending 5 years investigating the role of iceberg disturbance on the structure of benthic communities. This work culminated in a paper in *Science* and the 2008 'Law's Prize' for an outstanding contribution to polar science by an early career researcher. Dr Smale subsequently relocated to Australia to work on a large state-funded initiative to implement Ecosystem-Based Fisheries Management in the West Coast Bioregion. To date, he has published 21 papers on ecological datasets from Antarctica, Australia and the Seychelles, in journals such as *Science*, *PLoS One*, and *Diversity and Distributions*.

Jennifer Sunday has nearly finished her PhD and is interested in the distribution, ecology, and evolution of marine populations under natural and human-influenced environmental change. Through large-scale comparative work, Jennifer, Dr Bates and Dr Dulvy have revealed key differences in how terrestrial and marine ectotherms are distributed globally in relation to their thermal physiology, and indeed how their distributions have responded to recent climate change. Jennifer also leads a cross-university project addressing the potential for adaptive evolution in marine organisms under ocean acidification. Jennifer's PhD thesis at Simon Fraser University focuses on the historical climate-related range shifts, and processes leading population differentiation in marine dispersing animals.

Dr Thomas Wernberg is an Assistant Professor at the UWA Oceans Institute and a research fellow at the Australian Institute for Marine Science. His PhD in Marine Botany (UWA, 2003) and was awarded a Distinction (top 5%). DR Wernberg is a productive researcher who has published >50 research papers, and received $1.1M in funding predominantly as the lead CI of competitive grants. He is still early in his career, but is already gaining recognition for his contributions in climate related marine ecology. For example, in 2010 he was invited to present at a symposium on climate change at the International Seaweed Symposium in Mexico. Most recently, Dr Wernberg was invited to lead a review of marine climate change in temperate Australia for the 400th special issue of the *Journal of Experimental Marine Biology and Ecology* (Wernberg et al., in press, JEMBE). Previously, Dr Wernberg led the chapter on macroalgae and temperate reefs in the National Marine Climate Change Report Card (2009), and convened a working group on Climate Impacts on Marine Flora under the ARC NZ Vegetation Function Network (2009). His current research focuses on the nexus between physiology, ecology and biogeography, with an emphasis on understanding the ecological costs of physiological adaptations (e.g., Wernberg et al., 2010, *Ecol Lett*, Wernberg et al. in press, *PLoS One*). Dr Wernberg has worked extensively throughout Australia's temperate waters and in the tropical Northwest (Ningaloo), and he is currently leading an international collaboration focused on understanding environmental drivers of kelp productivity through the Worldwide Universities Network.

Dr E. Vivekananda leads the ICAR Network Project "Impact, Adaptation and Vulnerability of Indian Marine Fisheries to Climate Change". He has contributed to the Second National Communication on Climate Change (NATCOM) to the Ministry of Environment & Forests in

India. He has over thirty years of experience in marine fisheries, stock assessment and ecosystem analysis. He has served as a consultant for FAO in Stock Assessment, Prospects of Deep Sea Fisheries and Developing Vulnerability Indices for Marine Fisheries. He is a Task Force Member in the Bay of Bengal Large Marine Ecosystem Project of GEF and FAO.

Dr Zuenko Yury, D.Sc. is Head of the Japan Sea and North-West Pacific Oceanography Section, Pacific Fisheries Research Center (TINRO), Vladivostok, Russia. He graduated the State Marine Academy in Sankt-Peterburg in 1981 and worked in Pacific Fisheries Research Center in Vladivostok since 1985 as engineer, researcher, head of laboratory, and head of section. He got his Ph.D. degree in Far-Eastern Branch of Russian Academy of Science in 1995 on physical processes on the shelves of the Far-Eastern Seas. In the last decade, the main direction of his studies is fisheries oceanography, in particular in the Japan Sea. As one of these studies results, he has successfully defended the D.Sc. thesis on climate change influence on the Japan Sea ecosystem in Russian Hydrometeorological University in 2009.

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