2.0 WORKING GROUPS

2.1 Disbanded Working Groups

2.1.1 SCOR WG 131 on The Legacy of in situ Iron Enrichment: Data Compilation and Modeling *Urban*

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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SCOR WG 131 on The Legacy of in situ Iron Enrichment: Data Compilation and Modeling

The original intention of this group was to quickly compile the data from the previous ocean iron enrichment e*xperiments, make the data available in a form that would be useful for modellers, and convene a modeling workshop whose focus would be to use the compiled data. It became apparent before the full working group was formed that the compilation of data and metadata from the experiments would be much harder than expected, would probably take all of the time normally allotted to a SCOR working group, and would require a different mode of operation. SCOR agreed to let the two co-chairs focus on data rescue and compilation of an openly available database, which they did by their own efforts and enlisted the aid of two post-doctoral fellows in New Zealand and the Biological and Chemical Oceanography Data Management Office (BCO-DMO) at the Woods Hole Oceanographic Institution.

The co-chairs held small workshops at the 2010 Ocean Sciences Meeting in Portland, Oregon and the 2010 European Geosciences Union meeting in Vienna, Austria to announce the database and explain how it could be used. The group enlisted various modellers to improve the access to the data, most notably Fei Chai of the University of Maine (USA).

Finally, the two co-chairs and Cyndy Chandler of BCO-DMO published a paper in *Oceanography* magazine to announce the database to the international oceanographic community (see next page and http://www.tos.org/oceanography/archive/25-4_boyd.html).

REGULAR ISSUE FEATURE

A New Database to Explore the Findings from Large-Scale Ocean Iron Enrichment Experiments

BY PHILIP W. BOYD,
DOROTHEE C.E. BAKKER, AND
CYNTHIA CHANDLER

ABSTRACT. Some of the largest scientific manipulation experiments conducted on our planet have enriched broad swaths of the surface ocean with iron. Surface ocean signatures of these iron enrichment experiments have covered areas up to > 1,000 km^2 and have been conspicuous from space. Twelve of these multidisciplinary studies have been conducted since the early 1990s in three specific ocean regions—the Southern Ocean, and equatorial and sub-Arctic areas of the Pacific Ocean—where plant nutrients are perennially high (termed high nutrient low chlorophyll, or HNLC). In addition, a combined phosphorus and iron enrichment experiment was conducted in the oligotrophic North Atlantic Ocean. Together, these studies represent a unique set of physical, chemical, optical, biological, and ecological data. The richness of these data sets is captured in an open-access relational database at the Biological and Chemical Oceanography Data Management Office (BCO_DMO; http://osprey.bco-dmo.org/program.cfm?flag=viewp&id=10&sortby=program). It is a product of Working Group 131 (The Legacy of in situ Iron Enrichment: Data Compilation and Modeling; http://www.scor-int.org/Working_Groups/wg131.htm) of the Scientific Committee on Oceanic Research. The purpose of this article is to make the wider community aware of this resource. It also presents the merits and provides examples of the utility of this database for exploring emerging topics in oceanography, such as the links between ecosystem processes and biogeochemical cycles; the feasibility and many side effects of oceanic geoengineering; and how understanding the coupling among physical, chemical, and biological processes at the mesoscale can inform the emerging field of submesoscale biogeochemistry.

2.1.2 SCOR/LOICZ WG 132 on Land-based Nutrient Pollution and the Relationship to Harmful Algal Blooms in Coastal Marine Systems
Taguchi

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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Paul Harrison (China-Beijing)	
Jorge A. Herrera-Silveira (Mexico)	
Sandor Mulsow (Chile)	
Sybil Seitzinger (USA)	
Mingjiang Zhou (China-Beijing)	

Executive Committee Reporter: Satoru Taguchi

The group has continued to work since being disbanded and have the following two papers in review:

Bouwman, L., A. Beusen, P.M. Glibert, C. Overbeek, M. Pawlowski, J. Herrera, S. Mulsow, R. Yu, M.-J. Zhou. In Review. Mariculture: Significant and Expanding Cause of Coastal Nutrient Enrichment**.** *Environmental Research Letters*

Glibert, P.M., J.I. Allen, Y. Artoli, A. Beusen, L. Bouwman, J. Harle, R. Holmes, and J. Holt. In Review. Climate change projected to affect expansion of different types of harmful algal blooms differentially in temperate and subtropical waters: a coupled oceanographic -biogeochemical model analysis. *Global Change Biology.*

The committee was disbanded and the members thanked for their service.

2.1.3 SCOR/WCRP/IAPSO Working Group 136 on the Climatic Importance of the Greater Agulhas System *Urban*

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.

Co-chairs:

Lisa Beal (USA) RSMAS/MPO University of Miami 4600 Rickenbacker Causeway Miami, FL 33149 Phone:+1- 305-421-4093 lbeal@rsmas.miami.edu	Arne Biastoch (Germany) Leibniz-Institut für Meereswissenschaften (IFM-GEOMAR) FB1 Ozeanzirkulation und Klimadynamik Düsternbrooker Weg 20 24105 Kiel Germany phone: ++49 (0)431 600-4013 fax : ++49 (0)431 600-4012 abiastoch@ifm-geomar.de
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Executive Committee Reporter: John Compton

WG 136 on Climatic Importance of the Greater Agulhas System
(with WCRP and IAPSO)

The final activity of WG 136 was held shortly before the 2012 SCOR annual meeting. The working group convened the first Chapman Conference in Africa, on 8 - 12 October 2012 in Stellenbosch, Western Cape, South Africa. The group was disbanded and members thanked for their service.

AGU Chapman Conference on The Agulhas System and its Role in Changing Ocean Circulation, Climate, and Marine Ecosystems

Stellenbosch, Western Cape, Africa
8 - 12 October
2012

Conveners

Will de Ruijter, Utrecht University, The Netherlands
Rainer Zahn, Universitat Autònoma de Barcelona, Spain
Arne Biastoch, Helmholtz Centre for Ocean Research Kiel (GEOMAR), Germany
Lisa Beal, University of Miami, U.S.A.

Program Committee

SCOR WG 136 Members and Associate Members: Meghan Cronin, NOAA PMEL, Seattle, U.S.A. **Francis Marsac,** IRD, France
Juliet Hermes, SAEON, Cape Town, South Africa
Graham Quartly, NOCS, Great Britain
Tomoki Tozuka, University of Tokyo, Japan **Ian Hall,** Cardiff University, Great Britain **Pierrick Penven,** IRD, France
Herman Ridderinkhof, NIOZ, The Netherlands
Michael Roberts, DEA Oceans and Coasts, South Africa

Local Organizing Committee

David Vousden, ASCLME, Grahamstown, South Africa
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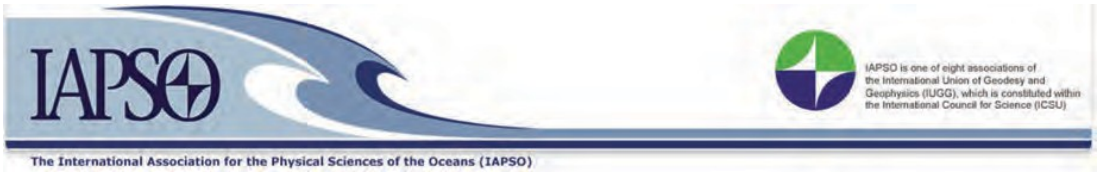
Financial Support

Universiteit Utrecht

nature

Thermo
SCIENTIFIC

UNESCO Intergovernmental Oceanographic Commission
Perth Regional Programme Office



AGU Chapman Conference on The Agulhas System and its Role in Changing Ocean Circulation, Climate, and Marine Ecosystems

Meeting At A Glance

Sunday, 7 October 2012

1600h – 1900h	Registration
1700h – 1900h	Welcome Reception

Monday, 8 October 2012

0830h – 0900h	Opening Remarks The Deputy Minister of Science and Technology, Derek Hanekom
0900h – 1220h	Session 1: The Agulhas System, present and Past
1040h – 1100h	Coffee Break
1100h – 1220h	Session 1: The Agulhas System, present and Past
1220h – 1250h	Plenary Discussion - The Agulhas System, present and Past
1300h – 1400h	Group lunch and Welcoming Remarks Lawrence Mysak, Immediate Past President of International Association for the Physical Sciences of the Oceans
1400h – 1700h	Organized Activity: Lawn Games 1
1700h – 1730h	Session 1: The Agulhas System, Present and Past (cont.)
1530h – 1945h	Poster Session 1 The Agulhas System, Present and Past
2000h – 2200h	Reception Dinner at Moyo

Tuesday, 9 October 2012

0900h – 1220h	Session 2: Effects of Agulhas System Variability on Regional Weather, Climate, Ecosystems, and Fisheries ('regional interactions')
1040h – 1100h	Coffee Break
1220h – 1250h	Plenary Discussion - Effects of Agulhas System Variability on Regional Weather, Climate, Ecosystems, and Fisheries ('regional interactions')
1300h – 1400h	Lunch
1400h – 1700h	Organized Activity – Hike on Helderberg
1700h – 1730h	Session 2: Effects of Agulhas System Variability on Regional Weather, Climate, Ecosystems, and Fisheries ('regional interactions') (cont.)
1730h – 1945h	Poster Session 2 - Effects of Agulhas System Variability on Regional Weather, Climate, Ecosystems, and Fisheries ('regional interactions')
2000h – 2200h	Dinner on Your Own in Stellenbosch

Wednesday, 10 October 2012

0900h – 1245h	Group Discussions: Future Research Directions and Implementation of Sustained Observations
0900h – 0905h	Group Discussions: Introduction - de Ruijter
0905h – 0915h	Group Discussions: Ongoing/Necessary Observations - Beal, Zahn
0915h – 0925h	Group Discussions: Modelling - Biastoch, Tozuka
0925h – 0940h	Group Discussions: Implementation and the WIO Strategic Alliance - Vousden
0940h – 1100h	Breakout for Discussion Groups
1100h – 1120h	Coffee Break
1120h – 1245h	Group Reporting and Plenary Discussion
1300h – 1400h	Lunch
1400h – 2200h	Organized Activities – Township or Table Mountain Tours
1800h – 2200h	Dinner on Your Own

Thursday, 11 October 2012

0900h – 1040h	Session 3: Mechanisms that Link the Agulhas to Ocean Circulation and Climate ('controls')
1040h – 1100h	Coffee Break
1100h – 1210h	Session 3: Mechanisms that Link the Agulhas to Ocean Circulation and Climate ('controls')
1210h – 1250h	Plenary Discussion - Mechanisms that Link the Agulhas to Ocean Circulation and Climate ('controls')
1300h – 1400h	Lunch
1400h – 1700h	Organized Activity – Lawn Games 2
1700h – 1730h	Session 3: Mechanisms that Link the Agulhas to Ocean Circulation and Climate ('controls') (cont.)
1730h – 1945h	Poster Session 3 - Mechanisms that Link the Agulhas to Ocean Circulation and Climate ('controls') (cont.)
2000h – 2200h	Conference Dinner at the Spier Hotel

Friday, 12 October 2012

0900h – 1040h	Session 4: Impact of Agulhas Retroflection and Leakage on Large-scale Circulation and Climate ('global effects')
1040h – 1100h	Coffee Break
1100h – 1210h	Session 4: Impact of Agulhas Retroflection and Leakage on Large-scale Circulation and Climate ('global effects')
1210h – 1250h	Plenary Discussion - : Impact of Agulhas Retroflection and Leakage on Large-scale Circulation and Climate ('global effects')
1300h – 1400h	Lunch
1400h – 1530h	Poster Session - : Impact of Agulhas Retroflection and Leakage on Large-scale Circulation and Climate ('global effects')

1530h – 1600h	Lutjeharms Memorial Lecture
1600h – 1615h	Conference Outcomes: Summary and Points of Action Will de Ruijter, Lisa Beal, Arne Biastoch, Rainer Zahn and SCOR/IAPSO/WCRP WG 136
1615h – 1630h	Closing Remarks Michael McPhaden, President, American Geophysical Union
1700h – 2330h	Cape Town Excursion and Dinner on Your Own

2.2 Current Working Groups

2.2.1 SCOR WG 134: The Microbial Carbon Pump in the Ocean *Urban* (2008)

Terms of Reference:

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

Co-chairs:

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Colin Stedmon (Denmark)	Richard Sempere (France)
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	Steven Wilhem (USA)
	Susan Ziegler (Canada)

Executive Committee Reporter: Bjørn Sundby

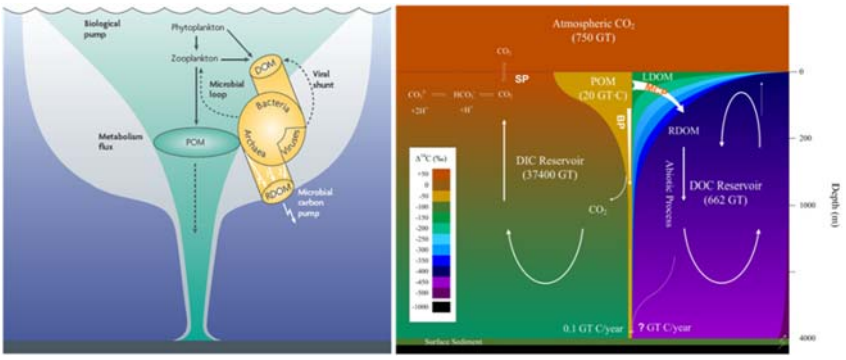
Final Report
SCOR WG134-The Microbial Carbon Pump (MCP) in the Ocean

Part I. Summary of SCOR WG134 (2009-2012)

1. Scientific progress and outcome

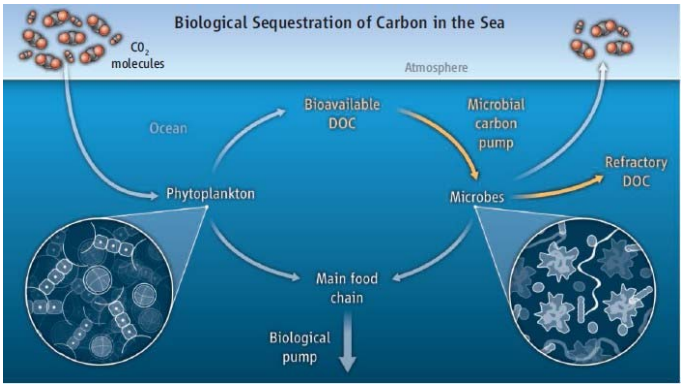
SCOR WG134 on the MCP was founded in 2009, led by Dr. Nianzhi Jiao (China) and Dr. Farooq Azam (USA) and joined by 26 scientists from 12 countries. It had been successfully carried on for four years by 2012, with a series of scientific achievements and terms of reference completed. The MCP theory is not only a conceptual framework which covers a broad range of disciplines, but also aims to seek a synthesis for future research on and an in-depth understanding of the kinetics and mechanistic processes of dissolved organic matter (DOM) dynamics in the oceans. Thus the core aim of WG 134 is to obtain a better understanding of microbial and biogeochemical processes causing labile DOM (LDOM) degradation and alteration, along with the microbial and chemical formation and modification of refractory DOM (RDOM) in the ocean.

The MCP concept was established with the publication of a featured article in *Nature Review Microbiology (NRM)* 2010, volume 8. In the paper, the background, rationale and application of the MCP concept were discussed, including representative microbial data on biomass, production and diversity of marine microbial communities in the context of DOM dynamics along environmental gradients; the current state of knowledge about microbial processes that utilize, generate and transform DOM; and essential scientific questions and hypotheses regarding DOC accumulation through the MCP. Moreover, the gaps in our understanding of marine DOC and the microbial community structure in different marine regions regarding bioreactivity and future research directions were also addressed. It is noteworthy that this paper was highlighted on the cover and the contents of the issue as well as on the website of *Nature Reviews Microbiology*.



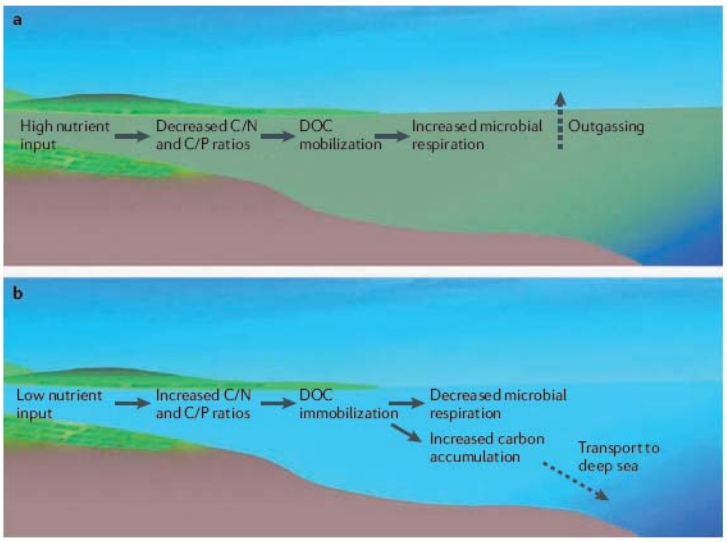
Diagrams showing the concept of the MCP and its relationship with the biological pump (left) and the major carbon reservoirs and carbon storage in the ocean (right)
(Jiao et al. *Nature Review Microbiology* 2010 (8):593-599)

Not long after the publication of the MCP theory, a *Science News Focus* article (*SCIENCE* 328:1476-1477, 2010) made another presention about the MCP: its origin, rationale, implications, applications, impacts, and prospects. In this article, the MCP is considered as “An invisible hand behind the vast carbon reservoir”.



The so called "double-barrel pump" pointed that each year, the biological pump deposits some 300 million tons of carbon in the deep ocean sink. However, even more massive amounts are suspended in the water column as dissolved organic carbon, much of which is converted into refractory forms by the microbial carbon pump.
(R. Stone. *Science* 18 June 2010: Vol. 328. no. 5985, pp. 1476 -1477)

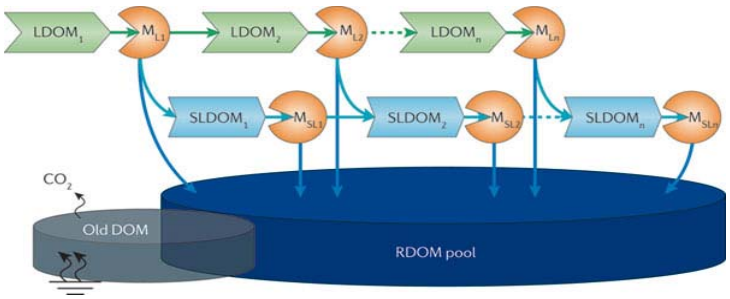
In addition, the principle of MCP has been adapted to land carbon sequestration by other colleagues in soil science and Dr. Nianzhi Jiao proposed the idea of "Increasing the microbial carbon sink in the sea by reducing chemical fertilization on the land".



The key information delivered by the aforesaid paper: Microbial carbon processing scenarios under different environmental conditions. Figure a shows that microbial respiration of DOC is mobilized by enhanced terrestrial nutrient input, and b shows microbial carbon sequestration is enhanced by reducing terrestrial nutrient input.
(Jiao, et al. *Nature Reviews Microbiology*. 2011. 9(1):75.)

Currently, most coastal waters suffer from excessive nutrient (nitrogen and phosphorus) discharge, which result in eutrophication and harmful algal blooms. More importantly, when nutrients are replete, dissolved organic carbon can be mobilized for microbial degradation and respiration. That is why the estuarine waters, being productive, are often sources rather than "sinks" of atmospheric CO_2. Reducing nutrient input from the land would be a realistic way to increase microbial carbon sink in such coastal waters.

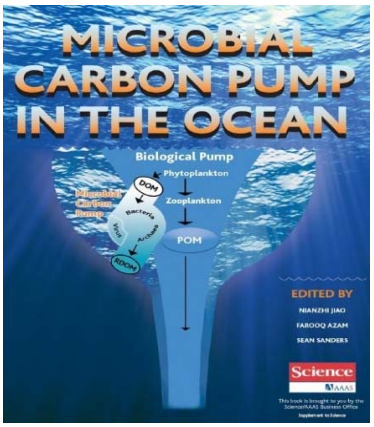
In correspondence, an article entitled "The microbial carbon pump and the oceanic recalcitrant dissolved organic matter pool" was published in *Nature Reviews Microbiology* 9, 555 (July 2011)



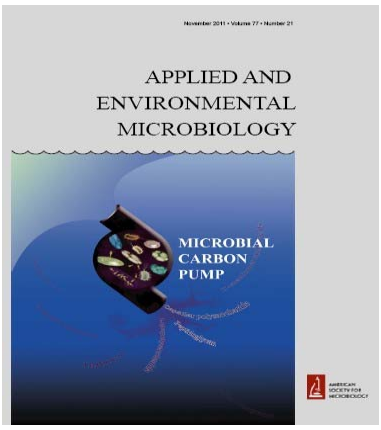
A representative figure from the paper indicates the successive microbial carbon pump processes for RDOM formation and subsequent contribution to the oceanic RDOM pool. ML and MSL represent those microorganisms that can use labile dissolved organic matter (LDOM) or semi-labile DOM (SLDOM), respectively. The subscript numbers indicate the numerous compounds or microbes.
(Jiao et al, *Nature Reviews Microbiology* 9, 555, July 2011))

A *Science* booklet on MCP including 10 papers previously published in *Science* and 10 new articles written by the WG134 members, appeared as a "Supplement to *Science*", and was distributed worldwide with the 13 May 2011 issue of *Science*. Its electronic version is available on the *Science* website at the following link (http://science.imirus.com/Mpowered/book/vscim11/i2/p1)

A special section on MCP in *Applied and Environmental Microbiology* was published in 2011. The MCP image was published on the cover of AEM, Nov. 2011, Vol 77, No. 21.

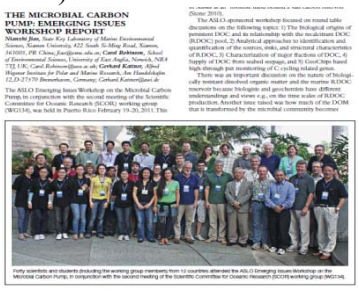


The MCP booklet supplemental to *Science* (left)
The *AEM* cover with MCP image (right)



Other representative publications and interesting research findings related to MCP by WG134 members are summarized here:

- Marine snow are active sites of microbial remineralization
  Bochdansky, A.B., H.M. van Aken, and G.J. Herndl, 2010: Role of macroscopic particles in deep-sea oxygen consumption. *Proc. Natl. Acad. Sci. USA*, 107: 8287-8291.
- ASLO Emerging issues workshop report, Limnology and Oceanography Bulletin 20(2) June 2011, 37-38.(see below)


THE MICROBIAL CARBON PUMP: EMERGING ISSUES WORKSHOP REPORT


Challenger Wave
The monthly newsletter of the Challenger Society for Marine Science
March 2011

ASLO-SCOR Workshop on the Microbial Carbon Pump.
An ASLO Emerging Issues Workshop on the Microbial Carbon Pump (MCP), in conjunction with the second meeting of the Scientific Committee for Oceanic Research (SCOR) working group (WG134) was held in Puerto Rico in February 2011. This event was also linked to the ASLO special session #55 on "The MCP: A multidisciplinary focus on origins, cycling and storage of dissolved organic carbon (DOC) in the ocean". Forty scientists and students (including the working group members) from 12 countries attended the workshop.

- ASLO–SCOR Workshop on the Microbial Carbon Pump (the picture above)
  Challenger Society for Marine Science, Challenger Wave – March 2011: 8-9
- Molecular biogeochemical provinces in the eastern Atlantic Ocean.
  Editors: Boris Koch, Gerhard Kattner, Gerhard Herndl. Special Issue in *Biogeosciences*, 2011.
- Kawasaki, N., R. Sohrin, H. Ogawa, T. Nagata, and R. Benner. 2011. Bacterial carbon content and the living and detrital bacterial contributions to suspended particulate organic carbon in the North Pacific Ocean. *Aquat. Microb. Ecol*. 62: 165-176.
- Kaiser, K., and R. Benner. 2012. Organic matter transformations in the upper mesopelagic zone of the North Pacific: chemical composition and linkages to microbial community structure. *J. Geophys. Res*., 117, C01023, doi: 10.1029/2011JC007141.

2. Academic Meetings and Research Activities

(A) SCOR WG134 workshops

The first WG 134 meeting was held in Xiamen, China, from October 27 to 30, 2009, under the theme of "Bridging Biology and Chemistry in Ocean Carbon Sequestration".

Open Science Meeting (left) and Closed Workshop (right) of WG134 1st meeting

The second meeting was held in Puerto Rico, USA during February 19-20, 2011, along with the ASLO Emerging Issue Workshop on MCP (it was selected by ASLO as an emerging issue for the 2011 Aquatic Science Meeting).

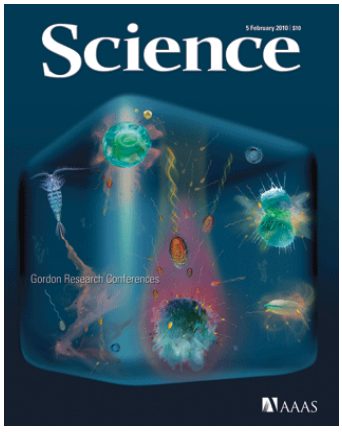
WG134 2nd meeting in conjunction with the ASLO Emerging Issues Workshop on the MCP

Our third meeting of SCOR WG134 was held in Hanse Institute for Advanced Study (HWK) of Delmenhorst in Germany, during August 26 to 29, 2012.

WG134 3rd meeting at HWK on 27 Aug. 2012

This meeting aimed at summarizing the microbial and geochemical research progress in recent years in the context of MCP and its impact on microbial oceanography research with specialization in DOM cycling and diagenetic alterations. In addition, future research activities within the conceptual framework of the MCP were discussed and put forward.

(B) Meeting sessions hosted/chaired by WG134 members beyond the SCOR workshops



- The cross-disciplinary Workshop (Beijing, China, 24-26, July, 2009)
- The "International Training Workshop on Organic Matter Characterization Using Spectroscopic Techniques" (Granada, Spain, 19-21 May 2010)
- A special session on microbes and carbon cycling in the ocean at the First International Conference on Marine Science and Earth System (Shanghai, China, 27-30 June 2010)
- Gordon Research Conference on Marine Microbes from Genes to Global Cycles (Tilton School, NH, USA, 4-9 July 2010). The image (Glynn Gorick; Roman Stocker; Justin Seymour) interpreting the microbes-DOC interaction (see right) selected for use as the cover of *Science* journal (Feb. 2010)
- A session on Microbial Roles in Marine Carbon Cycling and Ocean Acidification Impacts during the AOGS 2010 Meeting (Hyderabad, India, 5-9 July 2010)
- A session on Marine Microbiology at ISME 13 (Seattle, USA, 22-27 August 2010)
- AAPB workshop (Trebon, Czech Republic, 22-24 September 2010)
- The 9th International Marine Biotechnology Conference (IMBC) with session of Biotic Carbon Sequestration (Qingdao, China, 8-12 October 2010.)
- the ASLO Aquatic Science Meeting Special Session 55 on the Microbial Carbon Pump in the Ocean, (San Juan, Puerto Rico, 17-18 February 2011) ,
- A Chinese Science & Technology Association Forum on Marine Carbon Sink (Sanya, China, 15-16 Dec. 2011)
- The 2012 Ocean Science meeting sessions of "Shedding Light on the Dark Ocean: Advances in Linking Physical and Microbial Oceanography to Biogeochemistry" and "Dissolved Organic Matter and the "Hidden' Carbon Cycle" (Salt Lake City, Utah, USA, 20-24 February 2012)
- A special session titled "Microbes and Carbon Cycling in the Ocean" at the Second International Conference on Marine Science and Earth System (Shanghai, China, 2-4 July 2012)
- A session titled "The Global Ocean Ecosystem: Patterns, Drivers and Change" at the ASLO Aquatic Science Meeting (Lake Biwa, Japan, 9–13 July 2012)

(C) Meetings participated by WG134 members, mainly listed below:

- The AGU Chapman Conference on the Biological Carbon Pump of the Oceans (Brockenhurst, Hampshire, England, 14 September 2009) and AGU Fall Meeting (San Francisco, USA, 13-17 December 2010).
- The 11th International Estuarine Biogeochemistry Symposium (Atlantic Beach, NC, USA, 15-19 May 2011)
- The Symposium on Aquatic Microbial Ecology SAME-12 (Rostock, Germany, 28 Aug-2 Sept. 2011)
- The ISME 14 (Copenhagen, Denmark, 19-24 August 2012)

3. Research activities

A variety of experiments were carried out through oceanographic cruises participated by our work group members, namely the 2010 Svalbard pelagic mesocosm experiment of European Project on Ocean Acidification (May 18-July 16, 2010), two cruises to the Western Pacific Warm Pool during 2010 and 2011 designed as pilot studies of the nutrient enrichment effects on MCP efficiency, and another two cruises (funded by the U.S. National Science Foundation) to the Ross Sea in January-March 2013 and the Gulf of Alaska in June-July 2013 with the aim to evaluate organic carbon dynamics in the meso- and bathypelagic ocean. As for research projects and proposals, a European Science Foundation project on the role of deep water autotrophic prokaryotes in the organic matter synthesis of the deep North Atlantic was launched in 2010, an MCP-based proposal under the grand project was sponsored by the Ministry of Science and Technology of China, and also the project of "Qualitative and Quantitative Evaluation of Processes Governing Microbial Carbon Pump in the Indian Ocean Regions" was provided by the Ministry of Earth Sciences of Government of India.

4. Academic Honors

- WG134 member **Ronald Benner** was awarded the Einstein Professorship of the Chinese Academy of Sciences (CAS) in 2010 and was elected a Fellow of the American Geophysical Union (AGU) in 2011.
- WG134 member **Gerhard Herndl** received the Wittgenstein-Prize, the highest Austrian science honor and prize (1.5M €), 2010.
- WG134 chair **Nianzhi Jiao** was elected a member of the Chinese Academy of Sciences (CAS) in 2011.
- WG134 member **Chen-Tung Arthur Chen** was reappointed a vice chair of the International Geosphere-Biosphere Programme in 2011.
- WG134 memb**er Virginia Edgcomb** was awarded the 2012 Seymour H. Hutner Prize in Protistology by International Society for Protistologist.
- WG134 member **Michal Koblizek** has continued his service to the Czech National Committee of the Intergovernmental Oceanographic Commission, UNESCO.
- WG 134 co-chair **Farooq Azam** was selected by the ASM to receive the 2013 D. C. White Award for interdisciplinary research and mentoring.

Part II. Follow-up activities of SCOR WG 134

1. Workshop at IMBER IMBIZO III conference and outputs

A workshop entitled "Impacts of anthropogenic perturbations on ocean carbon sequestration via BP and MCP" (2), was convened by Dr. Nianzhi Jiao, Dr. Farooq Azam, and Dr. Carol Robinson et al., during the 2013 IMBER IMBIZO III conference held in Goa, India. This workshop attracted scientists from multiple disciplines, including microbial ecology, biogeochemistry, organic chemistry, climate science, fisheries and marine economy. All together, we shared exciting ideas and discussed methods to integrate MCP into the oceans and global carbon cycle through innovative carbon sequestration models. Three scientific sessions in total covered topics of the nature of DOC, microbial processing of DOC and genetic diversity, the interaction between MCP and BP and their responses to anthropogenic perturbation, and large temporal and spatial scale dynamics and links to humanity. During the meeting, a keynote presentation from workshop 2 was given by Dr. Farooq Azam on “Microbial carbon pump and ecosystem connectivity.” The presentation focused mainly on the opportunity exploring the linkages and interaction between MCP and Biological Pump (BP). During the plenary session, Dr. Jiao addressed the importance of reducing the use of chemical fertilization on the land, which could lead to an enhancement of the MCP as a carbon sink in eutrophic coastal waters. Results of microbiological and photochemical transformation of organic carbon during an in situ iron and phosphate addition experiment conducted by Dr. Carol Robinson indicated that the important role of both microbial and biological carbon pump to organic carbon under changing nutrient conditions.

Very importantly, a key question concerning the MCP theory received lots of attention and was well discussed by the conference attendees: how does carbon transform through both MCP and BP and how do these two pumps interact with each other? The following keywords emphasized during the discussion session of the meeting are noteworthy: anthropogenic perturbation, land and atmospheric nutrient loading, higher trophic levels, natural scenarios from estuary to deep ocean, and upwelling and eddy habitats. It was suggested that future work should focus on the quantity, rate and proportion of the role MCP plays, through a combination of multiple efforts from genes to ecosystems, and from observations to modeling.

Additionally, a summary report and a template for a workshop synthesis paper were accomplished during the meeting synthesis session. A special issue on MCP in the journal of *Biogeosciences* will bring together articles arising from this workshop. Topics to be investigated include the organisms and microbial processes which produce and transform dissolved organic carbon in the ocean, organisms and processes influencing the interaction between the BP and the MCP, and the impact of anthropogenic perturbations, such as nutrient addition and ocean acidification on oceanic carbon transformation, export and sequestration. Manuscripts under review for the Special Issue are listed below:

- Presence of *Prochlorococcus* in the aphotic waters of the western Pacific Ocean. N. Jiao, T. Luo, R. Zhang, W. Yan, Y. Lin, Z.I. Johnson, J. Tian, D. Yuan, Q. Yang, J. Sun, D. Hu, and P. Wang. *Biogeosciences Discuss*., 10, 9345-9371, 2013.
- Why productive upwelling areas are often sources rather than sinks of CO2? – a comparative study on eddy upwellings in the South China Sea. N. Jiao, Y. Zhang, K. Zhou, Q. Li, M. Dai, J. Liu, J. Guo, and B. Huang. *Biogeosciences Discuss*., 10, 13399-13426, 2013.
- Natural ocean carbon cycle sensitivity to parameterizations of the recycling in a climate model. A. Romanou, J. Romanski, and W.W. Gregg. *Biogeosciences Discuss*., 10, 11111-11153, 2013
- Temperature and phytoplankton cell size regulate carbon uptake and carbon overconsumption in the ocean. S.E. Craig, H. Thomas, C.T. Jones, W. K.W. Li, B.J.W. Greenan, E.H. Shadwick, and W.J.

Burt. *Biogeosciences Discuss*., 10, 11255-11282, 2013.

- The role of mixotrophic protists in the biological carbon pump. A. Mitra, K.J. Flynn, J.M. Burkholder, T. Berge, A. Calbet, J.A. Raven, E. Granéli, P.M. Glibert, P.J. Hansen, D.K. Stoecker, F. Thingstad, U. Tillmann, S. Våge, S. Wilken, and M.V. Zubkov. *Biogeosciences Discuss*., 10, 13535-13562, 2013
- Mechanism for initiation of the offshore phytoplankton bloom in the Taiwan Strait during winter: a physical–biological coupled modeling study. J. Wang, H. Hong, Y. Jiang, and X.-H. Yan. *Biogeosciences Discuss*., 10, 14685-14714, 2013

2. Coming Meetings Planned

- In December 2013, WG134 members (Chuanlun Zhang and Nianzhi Jiao) together with Holly Simon will convene the **AGU session OS005--** From mountains to the ocean: Physical, chemical and microbial impacts on carbon fluxes.
- At the **IMBER Open Science Conference** that will be held at Norway during 23-27 June 2014, a session titled "Microbial and geochemical perspectives of global carbon cycling and climate change: from genes to ecosystems, from ancient to current" will be convened by WG members Farooq Azam, Carol Robinson, Nianzhi Jiao.
- WG134 members Kang-Jin Kim, Nianzhi Jiao, Joe Zhou are involved as local organizers in the **15th International Symposium on Microbial Ecology (ISME-15)** in Korea in August 2014.
- The **2014 WG134 meeting** focusing on the mechanisms of MCP at the modern scales is in the planning stage.

3. Pan-China Ocean Carbon Alliance, COCA

A large increase in the amount of CO_2 released into the atmosphere has resulted in the intensification of global warming. The ocean has been discovered to be a large carbon reservoir, and oceanic carbon storage mechanisms are the vanguard of global warming research. The recognized mechanism that allows for this carbon storage relies on two separate processes: the POC-based "biological pump" and the dissolved inorganic carbon-based "solubility pump". Although research into these two areas of study has proven to be a great success, there still exists many inexplicable and unknown scientific anomalies and mechanical processes that have yet to be explored. The MCP exposed a new mechanism of carbon storage that does not rely on the sinking of POC and offered up a potential research based strategic solution for China to reach its "low carbon" goals.

Based on the MCP and related background, a national organization, entitled "Pan-China Ocean Carbon Alliance, COCA" was launched. It was initiated by a CAS Academician research group led by Dr. Nianzhi Jiao, and supported by the State Oceanic Administration, China Association for Science and Technology, Chinese Academy of Sciences, Ministry of Environmental Protection (Chinese Research Academy of Environmental Sciences), the National Climate Committee, etc. The COCA members consists of marine science and technology personnel from 21 domestic research institutes including Xiamen University, and enterprises including China National Offshore Oil Corporation (CNOOC).

COCA, therefore emerged in an attempt to partially alleviate the pressure on the organizations that are focused on decreasing CO_2 emissions. We believe that cultivation of prime MCP conditions could enhance the carbon absorption and storing capabilities within the ocean surrounding the Chinese coast, thus become a potentially complete solution. The final goal of COCA is to seek ocean carbon storage mechanisms by uniting national strengths and make the best of both carbon emission reduction and sink increase through "policy-industry-research" cooperation strategy.

Main targets and tasks of COCA:

1) **To build an international monitoring station of ocean carbon sink**
   Using the world famous ocean time series station ALOHA in the Northern Pacific and BATS in the Northern Atlantic Ocean as our benchmark, a Coastal Ocean Time Series Station (COTS) under the influence of human activities will be constructed as a research and development base for ocean carbon sink through jointly cooperation with CNOOC.
2) **To establish a standing international forum of ocean carbon sink**
   Based on our academic advantages of MCP study and past experience of hosting/chairing various international scientific conferences, we plan to set up an International Forum for Ocean Carbon Utility and Sequestration (FOCUS) through collaboration with the world class Gordon Research Conference organization. This forum will appeal international colleagues, collect think tank in relevant fields of marine science and serve as incubator for the formation of "Ocean Carbon Sink International protocols and Standards".
3) **To draft the ocean carbon sink international technical protocols**
   An international protocol draft for ocean carbon sink which has not been addressed so far, will be ultimately established with the combined data achievements from COTS and efficient international collaboration system built through FOCUS.

4. Chinese open program-2011 Collaborative Innovation Cluster on marine carbon sink

Initiated from the MCP, and added together with the typical biological pump (BP), the 2011 Collaborative Innovation Cluster on marine carbon sink focuses on research in the wide range of in-depth understanding of biological processes and mechanisms of the MCP theory, systematically assessing the potential of carbon storage in Chinese coastal waters, and its controlling factors through biological, chemical and physical pathways. The major goal is to develop ocean carbon sink detection and monitoring technology, to establish monitoring system of stereoscopic coastal ocean carbon sink, to promote in-depth studies on marine carbon sink theories and pathways, and to draft the ocean carbon sink international technical protocols.

The program will be supported by the National 2011 Program of China, a highly innovative program initiated by the Ministry of Education of P.R. China. It aims to become a world-leading research cluster on frontiers of ocean carbon sink and related fields. It will act as a platform for joint and interdisciplinary research involving research groups covering biologists, chemists and geologists, and comparative studies between ancient and modern marine environments. Facilities and platforms have been developed both within and outside of Xiamen University, including coastal marine station, BP-MCP research and monitoring station, offshore platform for BP-MCP time series study, and general-purpose university-class research vessel. By putting the MCP theoretical framework into practical field and laboratory studies, we hope to ultimately provide a new, integrated view of microbial-mediated carbon flow in the marine environment to fill knowledge gaps in oceanic carbon sequestration.

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

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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Executive Committee Reporter: Missy Feeley

WG 135 is planning a special session at the 2014 European Geoscience Union (EGU) meeting, and the final meeting of the group will be held in conjunction with the EGU meeting. Two papers are being prepared for publication:

- Chris German, Sylvia Sanders, and Louis Legendre: **Coupled cycling of Fe and C_{org} in submarine hydrothermal plumes: potential for impact on the global deep-ocean carbon cycle.**
- Nadine Le Bris et al.: **Hydrothermal energy transfer and the ocean carbon cycling: how to assess vent ecosystem productivity?**

The group's work resulted in two papers presented at the Goldschmidt Conference on 25-30 August 2012 in Florence, Italy.

Coupled cycling of Fe and C_{org} in submarine hydrothermal systems: an ocean biogeochemistry perspective

CHRISTOPHER R.GERMAN[1]
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Submarine hydrothermal venting was first discovered in the late 1970s. For decades the potential impact that vent fluxes could have on global ocean budgets was restricted to consideration of processes in hydrothermal plumes in which the majority of chemical species are incorporated into polymetallic sulfide and/or oxyhydroxide particles close to the ridge-crest and sink to the underlying seafloor. This restricted view of the role that hydrothermal systems might play in global-ocean budgets has been challenged, more recently, by the recognition that there might also be a significant flux of dissolved Fe from hydrothermal systems to the oceans that is facilitated through organic complexation. In this paper we review field-based and modeling results, including investigations that we have carried out under the auspices of SCOR-InterRidge Working Group 135, that reveal potential relationships between Corg and Fe in hydrothermal plumes, and indicate that hydrothermal systems may play significant roles in both the global biogeochemical Fe cycle and the global ocean carbon cycle.

2-24

Coupled cycling of Fe and C_{org} in submarine hydrothermal systems:Modeling approach.

LOUIS LEGENDRE[1,2]
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We investigated the fate of dissolved Fe released from hydrothermal systems to the overlying ocean using an approach that combined modelling and field values. We based our work on a consensus conceptual model developed by members of SCOR-InterRidge Working Group 135. This model was both complex enough to capture the main processes of dissolved Fe release from hydrothermal systems and chemical transformation in the hydrothermal plume, and simple enough to be parameterized with existing field data. It included the following flows: Fe, water and heat in the hightemperature vent fluids, in the fluids diffusing around the vent, and in the entrained seawater; Fe precipitated in sulfides near the vent, and in particles onto the sea bottom away from the vent; and Fe dissolving into deep-sea waters. Through trials and errors, we transformed the conceptual model into equations, which were parameterized with field data. We used the resulting set of equations (model) to explore various scenarios of Fe emissions and transformations. The modelling exercises suggested that hydrothermal systems may play significant roles in the global biogeochemical Fe cycle.

The group has also proposed a special session at EGU 2014, with Nadine Le Bris and Chris German, the Working Group 135 co-chairs, as conveners.

Hydrothermal energy transfer and its relation to ocean carbon cycling: from mechanisms and rates to services for marine ecosystems

Hydrothermal systems in the deep ocean have been studied from the past 37 years, but their impact on the ocean biogeochemistry and related ecological processes is far from being understood. Vent ecosystems were long described as largely independent from the photosynthesis-driven biosphere, a paradigm which no longer stands. Today we have a slightly clearer picture of the role energy transfer from hydrothermal circulation could play on ecosystems across a range of depths and on subseafloor carbon sequestration. At a time the exploration and exploitation of deep-sea mineral resources is rapidly developing, with potential impacts to habitats and biodiversity, there is a urgent need to consider the potential 'services' that is provided by these systems to the ocean.

The aim of this session is to synthesize the most advanced knowledge on:

1) carbon-fixation pathways in the different compartments influenced by hydrothermal activity, the metabolic diversity sustaining them and their dependence on oceanic processes,
2) biotic and abiotic drivers of productivity of related seafloor and subseafloor ecosystems, their natural dynamics and sensitivity to disturbance,
3) hydrothermally-derived fluxes of micronutrients and exported DOC and their potential influence on ocean biogeochemistry at larger scale.
4) integration of these processes into conceptual models of energy transfer and carbon cycling.

Our objective is also to enlarge the discussion outside the field of vent research with a broader scientific community and determine the opportunities to bridge scientific efforts focussing on these environments with larger marine science programmes in view of a future assessment the potential contribution that they may make to the ocean ecosystems and carbon cycle at different scales.

2.2.3 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.

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Executive Committee Reporter: John Volkman

A Joint SCOR/PICES Workshop W7:
Global Patterns of Phytoplankton Dynamics in Coastal Ecosystems, 12-14 Oct., 2012)
at the PICES 2012 Annual Meeting (12-21 October, 2012)
Co-Conveners: Kedong Yin and Hans W. Paerl

Meeting Summary

W7 was a joint SCORWG137/PICES workshop. The meeting objectives were for participants to (1) present progress made on data synthesis and cross-system comparisons of anthropogenic and climatic impacts on coastal phytoplankton community structure and function since the WG137 1st and 2nd meetings, (2) review and revise research questions, (3) discuss the approaches (what data sets to use, what analysis to perform, etc.) needed to address questions and formulate the framework (outline) of papers related to the questions, and (4) determine take-home assignments for preparing publications.

W7 invited William Li from the Bedford Institute of Oceanography, Halifax, Canada, who gave a presentation on "An ecological status report for phytoplankton and microbial plankton in the North Atlantic and adjacent seas" by ICES Working Group on Phytoplankton and Microbial Ecology (WGPME). This excellent, thought-provoking presentation stimulated much cross-disciplinary discussion on climatically and anthropogenically altered trends in oceanic and coastal phytoplankton communities, and it stressed the overall importance of the <3 μm diameter picophytoplankton in the world's oceanic and coastal waters.

There were several additional coastal phytoplankton dynamics presentations by PICES participants in the open session component of the WG 137 workshop. These included participants form Russia, Spain, Canada, Japan and South Korea.

Overall, there were more than 30 participants at the W7 workshop, of which 11 made presentations. In particular, Todd O'Brien reported data sets available for use by participants**.** He has developed the http://WG137.net Web site, which contains links to an interactive map and data and site summary tables that list and link to standard summary pages for each of the existing time series sites.

Two new online time series tools are available to the WG137 community. The COPEPOD Interactive Time-series Explorer (COPEPODITE, http://www.st.nmfs.noaa.gov/copepodite/) is a publicly available, online toolkit that allows any user to upload their own time series data and select from a variety of standard analyses and visualizations to be applied their data. The second tool is the Multi-Site Time-Series Explorer (MSTSE). This tool is not public, with access controlled by email-based login.

W7 participants also discussed questions for future publications as follows.

Do changes in nutrient supplies, sources (new vs. regenerated), concentrations and ratios cause shifts in phytobiomass and community composition?
- Subquestion 1: nutrients vs species diversity
- Subquestion 2: nutrients vs community status
- Subquestion 3: ammonium/nitrate, Si, vs community structure (diatoms/(diatoms+dinos)), hypothesis HN4, or DON favours dinoflagellates

Are there temperature thresholds that determine dominance of different phytoplankton groups and do temperature regimes and ranges govern interactions?

How is phytoplankton cell size a reflection of environmental conditions across systems?

How does variability of hydrology/salinity, residence time influence phytoplankton

How to establish the relationship between residence times and phytoplankton community structure

What are the common seasonal patterns along single species & communities?

How much local scale variation can be explained by progressively larger scale variation?

What role does bottom-up vs. top-down processes play in regulating planktonic communities? To what extent does phytoplankton composition affect food quality?

We appreciate the opportunity to have had the WG 137 Workshop in conjunction with the PICES meeting. The participation of PICES attendees added both new information on potentially useful long-term data sets and dimensionality to the Workshop.

This year, the group is planning a special session and a workshop at the 22nd Biennial Conference of the Coastal and Estuarine Research Federation in San Diego during Nov 3-7 (see below). This session will help the group gather new data sets for their analyses and involve a greater number of scientists in the effort.

Special Session

SCI-062 **Global Patterns of Phytoplankton Dynamics in Estuarine and Coastal Ecosystems**
Convened by: Hans Paerl (hpaerl@email.unc.edu), Kedong Yin (k.yin@griffith.edu.au), James Cloern (jecloern@usgs.gov) and Paul Harrison (pharrison@eos.ubc.ca)

Phytoplankton biomass and community structure have undergone dramatic changes in estuarine and 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. SCOR Working Group 137 (WG 137) has been gathering long time-series data sets from estuarine and coastal systems worldwide in order to examine patterns of anthropogenic and climate-driven change. We encourage participation from investigators with decadal observational data from geographically diverse regions. 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.

Workshop

SCOR Working Group 137, Global Patterns of Phytoplankton Dynamics in Estuarine and Coastal Ecosystems

Conveners: Kedong Yin (yinkd@mail.sysu.edu.cn, School of Marine Sciences, Sun Yat-Sen (Zhongshan) University Guangzhou, China and Griffith Univeristy, QLD, Australia) and Hans Paerl (hpaerl@email.unc.edu, Institute of Marine Sciences, University of North Carolina at Chapel Hill, Morehead City, North Carolina, USA)
(8:00am – 5:00 pm)

Phytoplankton biomass and community structure have undergone dramatic changes in estuarine and 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. The SCOR Working Group 137: "Global Patterns of Phytoplankton Dynamics in Coastal Ecosystems: Comparative Analysis of Time Series Observations" was formed in 2009 to examine the questions: 1) the qualitative character of the ecosystem responses ("what changes"), 2) their amplitudes ("by how much"), and 3) their timing and spatial and temporal scales ("when and where are rates of change the strongest." This two day workshop is the fourth in a series aimed at identifying the underlying processes and measuring rates at which phytoplankton alter coastal ecosystems on a global scale. Day 1 (2 Nov.) of the workshop is a closed meeting during which SCOR Working Group 137 members will discuss and synthesize long time-series data sets from estuarine and coastal systems worldwide in order to examine patterns of anthropogenic and climate-driven change. Day 2 (3 Nov.) is an open meeting during which CERF members who have experience with decadal observational data from geographically diverse regions to join the Working Group to continue discussions. 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. For more information please visit the SCOR Working Group 137 website: http://wg137.net/

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

Terms of Reference:

1. Synthesize the state of the science of modern planktic foraminifera, from pioneering to ongoing research including
    1. their spatial and temporal distribution in the world ocean
    2. their calcification mechanisms and shell chemistry
    3. 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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Margarita Marchant (Chile)	Steve Eggins (Australia)
Divakar Naidu (India)	Baerbel Hoenisch (USA)
Daniela Schmidt (UK)	Sangmin Hyun (Korea)
Howard Spero (USA)	Zhimin Jian (China)
Richard Zeebe (USA)	Thorsten Kiefer (Switzerland)
	Dirk Kroon (UK)
	Stefan Mulitza (Germany)
	Frank Peeters (The Netherlands)

	Michael Schulz (Germany) Kazuyo Tachikawa (France) Rashieda Toefy (South Africa) Jaroslaw Tyszka (Poland)

Executive Committee Reporter: Missy Feeley

SCOR/IGBP Working Group 138

Modern Planktonic Foraminifera and Ocean Changes

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

Annual report: 23.9.2013
Reporting period: September 2012 – August 2013

The priority of the second year of the WG has been to achieve progress in standardization of procedures applied on data on modern planktonic foraminifera. To this end, two parallel workshops have been organized in association with The Micropaleontological Society (TMS) spring meeting in Prague in June 2013. During these workshops future priorities for research were discussed based on the WG goals, but to be funded independently. As a result, a plan has been set up to apply for a dedicated cruise with a collection programme that will allow us to answer a range of outstanding issues on the ecology and population dynamics of planktonic foraminifera. The answers to these issues are urgently needed to improve accuracy and precision when applying foraminifera as proxies as well as to constrain their role in carbon cycling and mass flux to the sea floor. Finally, negotiations have been initiated with Copernicus Publications to develop and host an open-access eBook that will allow us not only to collate published work as chapters in a synthesis text but also to gather various types of resources in a formal but flexible framework. The next year of the WG work will include an engagement at the international FORAMS2014 meeting in Chile, where we will host a special session. The evolving eBook should take its form and the results of the workshops in Prague should materialize into publications and a cruise proposal.

Specific achievements during the reporting period include the following.

Evolving eBook concept

The WG has further pursued the innovative idea of presenting the results of its work in an open-access multi-media format. Having established that the diverse range of products cannot be accommodated optimally in the format of a special issue of a regular journal, nor can it be fully served by a dedicated, but isolated website, an alternative concept has been developed with Copernicus Publications. The envisaged final product – an evolving eBook – will be able to integrate work in any format (papers published in regular journals, reviews, taxonomic keys, data collection, video manuals), publish each item separately, incorporate updates (versions), link to other existing content and allow incorporation of rare back content (data and information rescue). Every item in the eBook will obtain a DOI and permanent hosting will be secured by Copernicus. The concept is expected to take form during fall 2013.

Taxonomy and Methods Workshops in Prague, June 24-27, 2013
http://web.natur.cuni.cz/ugp/main/msfng2013/satwork.html

Engaging 15 participants, including 7 WG members and 8 colleagues from the community, the two workshops mark the most productive period of the WG yet. Taking advantage of the excellent facilities at the Faculty of Science of the Charles University in Prague, the four days of the workshops were dedicated to alternating joint and split writing and discussing sessions that yielded draft documents and recommendations on the following issues:

- Draft of guidelines for defining and naming "cryptic" genetic lineages in modern planktonic foraminifera, intended to be published in mainstream literature
- Identification of all outstanding taxonomic issues, including specific points that have been presented to relevant taxonomic community projects for joint consideration
- Development of a new taxonomic key, devised in several variants considering different application circumstances (field or laboratory, adult or juvenile specimens)
- Summary and recommendation on all collection and sample processing methods concerning specimens from the plankton and sediment traps, formalized in text and in flow-charts
- Draft of guidelines for reporting of census data from plankton and sediment-trap counts

In connection with the above documents, which are currently in review by the WG community and beyond, the following priority tasks have been identified for the near future:

- Develop an illustrated glossary of terms used in the classification of modern planktonic foraminifera
- Develop a library of images of all living species based on transmitted light observations of live specimens and on 3D imaging of empty shells
- Document with images and movies key concepts and procedures (separation between live and dead specimens, operation of plankton net and sediment trap)
- Collate and annotate a definitive database of DNA sequences from planktonic foraminifera
- Carry out a test of procedures for sample splitting used to generate census counts and evaluate the associated uncertainty

Finally, the workshop has been used to discuss the outstanding unresolved questions concerning population dynamics of planktonic foraminifera and how these can be best addressed. The most important issues, which were considered as tractable, were then converted into a hypothesis-driven experimental framework. It was realized that the sampling and observations required for this framework could be carried out during a dedicated expedition and it was agreed to jointly support the application for such expedition by the WG co-chair M. Kucera, to take place on a German research vessel. The long-standing "mysteries" to be addressed during such a cruise include:

- existence and extent of a daily vertical migration
- spatiotemporal scale of population patchiness
- existence and pattern of ontogenetic vertical migration and calcification depth of species
- existence of lunar reproductive cycle
- Assessment of determinants of population density and living/calcification depth of species
- search for occurrence of propagules and habitat of minute juvenile stages
- confirmation of the presence and prevalence of algal symbiosis in uncultured species
- determination of buoyancy and sinking speed of live specimens

Outlook

The third year of the WG should culminate in the setup of the evolving eBook, including the publication of first items. To this end, following a meeting of a part of the WG in January 2014 during the FORAMS2014 conference in Chile (http://www2.udec.cl/forams2014/), a plenary meeting of the WG is expected to take place in late 2014. At that meeting, the progress of all tasks and chapters for the eBook will be reviewed and pending shiptime approval, planning of the joint cruise will be carried out.

Overview of progress on individual deliverables:

1. Synthesize the state of the science of modern planktonic foraminifera, from pioneering to ongoing research including as a peer-reviewed publication in an open-access journal (**deliverable 1**).

> A concept of chapters for a virtual book/special issue has been agreed (thus effectively merging deliverables 1 and 5) and a concept of an evolving eBook has been developed together with Copernicus Publications, following negotiations with the journal *Biogeosciences*, which revealed that a special issue in regular literature cannot comprise all aspects of the envisaged synthesis. Work on individual chapters is in progress.

2. Provide guidelines (cookbooks) in terms of species identification, experimental setup for culture studies, laboratory treatment prior to geochemical analysis (**deliverable 2**).

> The workshops in Prague in June 2013 allowed us to review all aspects of methods and procedures and standardization that required review and resulted in drafts of multiple aspects as described above.

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

> The concept of such resource has been developed in the form of an evolving eBook.

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**).

Deliverable 5 – see deliverable 1. The science of the WG will be promoted by organizing a special session at FORAMS2014 (co-chairs M. Kucera and K. Darling), with a keynote lecture by H. Spero.

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. Jaroslaw Tyszka (eForams), Poland
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)

2.2.5 SCOR WG 139 on Organic Ligands – A Key Control on Trace Metal Biogeochemistry in the Ocean (2011)

Terms of Reference:

1. To inform the Ocean Sciences community of this WG and related objectives via a widely distributed publication in *EOS* or analogous journal.
2. 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). The summary will be included in a review paper published after year 2, as well as in the database on the proposed website.
3. 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.In a recent intercalibration the preservation of samples for Fe and Cu-organic speciation by freezing at -20°C as been found suitable and will enable to make samples taken during GEOTRACES cruises available to interested scientists. A large intercalibration will thus be possible in the future without additional joint cruises or sampling exercises, but could be performed with samples from several 'normal stations' of a GEOTRACES leg. Results from intercalibration efforts will be presented in a manual available via download from the proposed WG website.
4. To identify how best to incorporate published and future data into biogeochemical models.
5. 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.
6. 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. Such future recommendations will also be included in the aforementioned downloadable manual on the WG website.
7. To establish a webpage for this SCOR working group, to promote a forum for discussion of ideas and results in form of a blog, 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.
8. To produce conclusions resulting from the outcome of the above objectives in the form of a Website, a journal special issue or book, and a report to SCOR.

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	Stan van den Berg (UK)

Executive Committee Reporter:

SCOR Working Group
139:
Organic Ligands – A Key Control on Trace Metal Biogeochemistry in the Ocean

Co-Chairs
Kristen Buck, Bermuda/USA
Maeve Lohan, UK
Sylvia Sander, New Zealand

Recent meetings
The second meeting of WG 139 members was held on 16 February 2013 in New Orleans, Louisiana, USA preceding the ASLO Aquatic Sciences meeting. All ten Full Members of the working group attended the meeting, as did four of the group's Associate Members. Members discussed several Terms of Reference in this meeting, including construction of a ligand-DOM database, continued intercalibration exercises, incorporating data into models, a special issue for publications, and future meetings and symposia.

Databases for trace elements, metal-binding ligands, dissolved organic matter (DOM), and DOM constituents are increasingly common. A primary point of discussion for the WG 139 database was the parameters preferred for database submissions to allow for use by modelers and analysts looking at overarching trends. Members have identified several existing data repositories and current databases for metal-binding ligands and DOM data. As a launching point for the WG database, existing ligand and DOM databases will be gathered and linked from the working group website: http://neon.otago.ac.nz/research/scor/index.html.

Working group members have completed an intercalibration exercise focused specifically on interpretation techniques for simulated titration data. Altogether, 23 datasets from 15 participants were included in the exercise; 9 of the participants were from outside the membership of the working group. The results from this exercise highlight several issues inherent to current interpretation techniques and have fueled efforts to make automated programs widely available and to develop better approaches. Results of this exercise are in preparation for publication and outcomes will be highlighted on our website as they develop. The next step, a sample-based intercalibration exercise for CLE-ACSV and DOM analyses, is planned for samples collected from the Celtic Sea in 2014. A special issue is planned in *Marine Chemistry* for publications resulting from this working group's activities to date. The working group is currently soliciting submissions from members, ASLO special session contributors and the interested science community, with a tentative spring 2014 deadline for the issue.

In addition to the meeting of WG members, the co-chairs of WG 139 also chaired a special session at the ASLO Aquatic Sciences meeting in 2013. This special session was awarded a full day of oral presentations, 21 in total, as well as a supplementary poster session. Presentations in the session covered a wide range of topics related to metal-binding ligands, including distributions in marine and estuarine environments, sources and sinks, advances in characterization by mass spectrometry, and progress in modeling efforts.

Plans for work between meetings

The working group has identified action items resulting from each meeting that are assigned to specific members for completion, facilitating continued progress in accomplishing the terms of reference between meetings. The co-chairs are tasked with following up on assigned action items and coordinating activities with each other via regular phone conferences and email contact.

Plans for next meeting

The next meeting of SCOR WG 139 members is planned for the 22 February 2014, in tandem with the ASLO-TOS-AGU Ocean Sciences Meeting in Honolulu, Hawaii. The co-chairs of the working group have also applied for, and been granted, a special session at the Ocean Sciences Meeting. In addition to a meeting of working group members, a town hall meeting is being organized to take place during the 2014 Ocean Sciences Meeting to allow the broader science community to catch up on working group activities and get involved with ongoing and future activities. This town hall meeting will also be used to gauge interest for a larger symposium proposed for late 2014 or early 2015.

Linking the working group meetings to conference meetings has afforded considerable savings in the WG budget. The first two meetings of this working group have cost a total of $18,439, well under the allotted $15,000 per meeting. The third working group meeting planned for February 2014 in tandem with the Ocean Sciences Meeting is also expected to stay well under budget. These savings on member meetings are anticipated to allow for additional meetings and symposia to further advancements toward completing the group's Terms of Reference.

Overall progress toward Terms of Reference

The working group is making steady progress toward accomplishing the terms of reference laid out in the original proposal and amended in the first group meeting. Two publications (*Eos*, IUPAC *Chemistry International*), email distribution lists (contact a chair to join), and a website (http://neon.otago.ac.nz/research/scor/index.html) have been completed. Two members-only meetings have taken place, with a third is planned for February 2014. The working group has also hosted an ASLO Aquatic Sciences meeting special session with a second special session granted for the Ocean Sciences Meeting in 2014. Organization of an open town hall meeting is also in progress for the 2014 Ocean Sciences Meeting. Progress on several other Terms of Reference are also ongoing, including assembly of a metal-binding ligand and DOM database, continued intercalibration activities, collation of a best practices manual to guide future approaches and submission of a special issue in *Marine Chemistry* to highlight the efforts of this working group.

Updates on SCOR WG 139 activities, links to published articles and minutes from WG meetings may be found on the website, as well as several other useful links and documents for information relating to ligands in the marine environment.

Special Session at Ocean Sciences Meeting
From: ocb-all-bounces@whoi.edu [mailto:ocb-all-bounces@whoi.edu] **On Behalf Of** Mary Zawoysky
Sent: Friday, September 06, 2013 7:28 AM

To: ocb-all@whoi.edu
Subject: [Ocb-all] OSM special session from SCOR WG 139 - Organic Ligands—A Key Control on Trace Metal Biogeochemistry in the Ocean

Dear SCOR WG 139 members and interested colleagues,

The **SCOR WG 139 - Organic Ligands—A Key Control on Trace Metal Biogeochemistry in the Ocean** has hosted two very interesting and well attended sessions during the 2012 and 2013 ALSO meetings. We would like to draw your attention now to a special session on metal-binding ligands that we will convene at the 2014 Ocean Sciences Meeting 23-28 February 2014 / Hawaii Convention Center, Honolulu, Hawaii, USA (http://www.sgmeet.com/osm2014/default.asp). Please consider submitting an abstract for a presentation, oral or poster, in this session. Registration and abstract submission are now open, deadline is 4 October 2013.

Furthermore, I would like to invite you to submit a manuscript to the SCOR WG 139 **special issue in Marine Chemistry**. Manuscripts registered at the same time as abstract submission will receive extra fast priority handling throughout the peer review process. Please let us know, by replying to this email, if you are able to contribute your work to this special issue.

OSM special session 116 - Advances in approaches to assess metal-binding organic ligands and perspectives on the impacts of ligands on metal-biota interactions in the oceans

The bioactive trace metals iron (Fe), copper (Cu), cobalt (Co), nickel (Ni), zinc (Zn) and cadmium (Cd) are essential micronutrients for marine phytoplankton and exert a major influence on the global carbon and nitrogen cycles. Fully understanding the marine carbon and nitrogen cycles is, thus, intimately tied to our efforts to determine the distribution, chemical speciation and resulting bioavailability of trace metals to the marine biota. Complexation of these metals by organic ligands may enhance or reduce bioavailability depending upon the metal-ligand complex formed. Yet, 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. New and fruitful collaborations between trace metal biogeochemists, organic geochemists and biogeochemical modelers are being achieved through a SCOR working group (WG139) "Organic Ligands-A key control on trace metal cycling in the ocean". We invite submissions to this session that highlight recent accomplishments in metal-binding ligand characterization and in approaches for assessing ligand distributions, composition, sources, cycling processes, and impacts on metal- biota interactions in the oceans.

Organizers	Maeve Lohan , University of Plymouth maeve.lohan@plymouth.ac.uk	Kristen Buck , Bermuda Institute of Ocean Sciences kristen.buck@bios.edu	Sylvia Sander , Research Centre for Oceanography, University of Otago sylvias@chemistry.otago.ac.nz

2.2.6 WG 140 on Biogeochemical Exchange Processes at the Sea-Ice Interfaces (BEPSII) (2011) *Volkman*

Terms of Reference:

1. Standardisation of methods for data intercomparison.
2. Summarizing existing knowledge in order to prioritise processes and model parameterizations.
3. Upscaling of processes from 1D to earth system models.
4. Analysing the role of sea ice biogeochemistry in climate simulations.

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Executive Committee Reporter: John Volkman

BEPSII Update, June 2013

Below is an update of the activities within the three Task Groups of SCOR WG-140 "BEPSII", based on a Skype meeting on June 20 attended by: Klaus Meiners, Lisa Miller, Lynn Russell, Jacqueline Stefels, Nadja Steiner. *It is the intention to have these Skype meetings every 2-3 months; attendants may vary as activities progress.*

Task Group 1 (Methods)

Task 1: Methods review paper

- Contributions to biological section coming in
- Synthesis and homogenization underway
- Follow-up still required on a number of identified gaps
- Draft for circulation to entire working group targeted for mid-summer

Task 2: Intercalibration experiments

- Specific members have been asked to investigate potential field and laboratory sites for experiments, with a deadline of the end of September
- Nomura and Nishioka have sent a very detailed and encouraging report on using Saramo-Ko, a coastal lagoon on the north coast of Japan (attached)
- Fripiat has drafted a plan for biological intercalibration experiments; still needs to be circulated in the group
- Nomura has volunteered to organize an experiment at Saramo-Ko, and is drafting a white paper

Task 3: Manual of best practices

- Hajo Eicken has responded positively to our participation in any new edition of his sea-ice field methods manual; the decision on whether to proceed with a second edition is still pending; Nomura has agreed to act as our liaison with Hajo
- van Leeuwe has drafted recommendations for statistically relevant sea-ice sampling; still needs to be circulated in the group

Task Group 2 (Data)

The first dataset on chlorophyll-a in sea ice from the Antarctic has been published (Meiners et al., 2012)[1] through ASPeCt activities and in collaboration with BEPSII (WG 140 is mentioned in the paper). The data are now publicly available through the Australian Antarctic Data Centre. For the Antarctic database, we are currently collating additional parameters with a focus on DOC, POC and macro-nutrients. An Australian proposal to gain additional funding for collation of Antarctic data, including data from fast ice, is in preparation.

For the Arctic effort, Christine Michel and Michel Gosselin have agreed to lead, also starting with chlorophyll-a. The collation of Arctic data will follow the same procedures as the Antarctic database for easy hemispheric comparison. Data entry forms etc. have been provided to the Arctic sea ice colleagues.

[1] Meiners, K.M., et al. 2012. Chlorophyll a in Antarctic sea ice from historical ice core data. *Geophys. Res. Lett*. 39, L21602, doi:10.1029/2012GL053478.

Task Group 3 (Modelling)

1. *Recommendations from modellers to observationalists*:
   Brainstorming continued, the decision has been made to write a citable paper, which can then feed into the Polar Working Group working document. Delphine L. expressed interest to participate. Nadja and Clara had a discussion last week and will reconnect in August.

2. *Review papers on major biogeochemical processes*
Review by Vancoppenolle et al. is out.[2] Other issues:

a) DIC/Alk separation during the freezing process: need to identify lead. E-mailed Bruno and Rosina, but didn't receive any response.
b) release and transfer of iron and other minerals: Delphine and Veronique started working on this. Tried to contact Ben as well – no response yet.
c) Parameterization of light transfer in sea ice – Some progress with help of Nadja's student. We will decide if to add some literature review with the publication of an improved parameterisation for light transfer in transition times, or to send out a call to a larger audience and write a separate review.
d) processes of ice algal release into the water – no progress yet. Letizia has been identified as potential lead at the GRC, but need to be confirmed.
e) link to atmospheric chemistry – Roland pointed out recent AICI review papers 2007, 2012/13 on snow microstructure (a.o.). Might not need an update at this point.
f) review of parameterizations for turbulent mixing in Arctic Ocean models. Elena lead, awaiting update. AOMIP/FAMOS just announced a workshop on mixing processes in the Arctic in October which could link to this.

3. *Intercomparison of 1-D models and publication of a review*

a) biogeochemical: This component is led by Letizia. A group of people responded to her call with short information on the models they would like to include. She just sent out another final reminder.
b) Physical: Waiting for update from Elena
c) DMS: Clara is just finishing up a paper on her regional Arctic DMS model. Will look into 1-D models after. Nadja has a student starting in September who will work on a 1-D DMS model for the Arctic within the new Canadian NETCARE network (Arctic aerosols).
d) Atmosphere. At the moment there doesn't seem to be a useful amount of atmosphere 1-D models for the Arctic. We will revisit next year.

4. *Application in regional models with links to global & regional climate modeling*.
Some progress has been made with individual model developments.
Clara:

- DMS model publication in preparation
- Planning of an “ecosystem regions” - link to AOMIP/FAMOS, will make use of recently published chlorophyll analysis in the Arctic.

[2] Vancoppenolle, M. , K.M. Meiners, C. Michel, L. Bopp, F. Brabant, G. Carnat, B. Delille, D. Lannuzel, G. Madec, S. Moreau, J.-L. Tison, and P. van der Merwe. 2013. Role of sea ice in global biogeochemical cycles: emerging views and challenges. Quaternary Science Reviews. In Press

Nadja:

- put in proposal for regional Arctic model support - looks promising.
- Progress has been made with model set up at IOS and parallel NEMO-BGC development for CCCma's Earth System Model (ESM).

Katya:

- submitted a paper on Acidification

Martin and Nadja have prepared ESM model comparisons for Arctic biogeochemistry with limited analysis on causes for model differences including parameterisations. None of these models contains sea-ice algae, however:

Vancoppenolle, M., L. Bopp, G. Madec, J. Dunne, T. Ilyina, P.R. Halloran, N. Steiner, 2013. Future Arctic Ocean Primary Productivity from CMIP5 Simulations: Uncertain Outcome, but Consistent Mechanisms. Global Biogeochemical Cycles, in press.

Steiner, N, J. Christian, K. Six, A. Yamamoto, M. Yamamoto-Kawai, 2013b, Future ocean acidification in the Canada Basin and surrounding Arctic Ocean from CMIP5 earth system models, JGR Oceans, submitted.

Steiner, N. S., Lee, W. G., Christian, J. R., 2013a. Enhanced gas fluxes in small sea ice leads and cracks - effects on CO2 exchange and ocean acidification. JGR Oceans, 118,3, 1195–1205. DOI:10.1002/jgrc.20100

More discussions are planned for the FAMOS workshop in October.

On a final note, Nadja is just finalizing an assessment report for the DFO (Department of Fisheries and Oceans) Canada Aquatic Climate Change Adaptation Services Program. The assessment contains a summary of available trends and projections information for key drivers of Arctic ecosystems. This report is “grey literature” but will be published online and be made available to the public. It might provide some useful input to the group. (Details to follow as soon as the Weblink is available).

Other business

Francois Fripiat and JiaYun Zhou are working on a Facebook page. They plan to incorporate:

- sampling pictures
- a short abstract about the group
- the members and their institutions
- links to different programs (SCOR, SOLAS, APECS, PAGES, ...).
- and a place where the members can insert some news (conference, finding, ...).

JS has provided them with a summary of BEPSII’s task groups.

The poll amongst members on the next BEPSII meeting indicated a slight preference for **Hobart** (IGS meeting, March 10-14, 2014).

2.2.7 WG 141 on Sea-Surface Microlayers *Volkman* (2012)

Terms of Reference:

1. Review sampling techniques and provide best practice sampling protocols. Such protocols will support new scientists entering the field of SML research to produce reliable and comparable data among different research groups/oceanic regions. The best practice sampling document will be made freely available online.
2. Create a consensus definition of the SML in terms of physical, chemical and biological perspectives for a better understanding within the ocean science community, and discuss the SML's role in a changing ocean. This will be delivered as an opinion/position paper in a peer-reviewed journal and will support future international projects concerning the SML and ocean change.
3. Initiate sessions on SML research during major meetings (e.g., Ocean Sciences Meetings), to increase the awareness of the importance of the SML within the general ocean science community.
4. Summarize and publish the latest advances in microlayer research in a special issue of a peer-reviewed journal, including consolidation of existing sea surface microlayer datasets among different disciplines (chemistry, biology, atmospheric, physics). The publication will promote new research ideas and projects at an interdisciplinary level.

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Executive Committee Reporter: John Volkman

SCOR Working Group #141
Report on the first annual meeting

O. Wurl, Leibniz Institute for Baltic Sea Research

The group met on 11 April 2013 for its first annual group meeting during European Geophysical Union (EGU) General Assembly in Vienna, Austria. The full members M. Cunliffe (UK), O. Wurl (Germany), A. Engel (Germany), S. Frka (Crotia) and M.T. Talif (Malaysia) attended the meeting. Before the meeting, the chairs (M. Cunliffe and O. Wurl) were approached by A. Soloviev (USA) and K. Laß (Germany) expressing their interest to join the meeting. The chairs were also approached by D. Carlson, an emeritus professor advancing research on microlayers in the 1980s, and the chairs met D. Carlson on the following day for sharing ideas and experience. The group decided to invite A. Soloviev, K. Laß and D. Carlson as additional Associate Members, and the final list of group members can be found at the end of this report. (The SCOR Executive Committee Reporter for the group approved the additions.)

The agenda included discussion on organizing the workshop in Qingdao (China) in 2014. Prof. Yang, full member of the group and faculty member of the Ocean University of Qingdao, kindly agreed to be the host for the workshop. It was agreed that the four-day workshop should have an open session with invitation to Chinese students, and a closed session during which group members would work on a communication paper. The open session will also include training in microlayer sampling to the younger generation of oceanographers. Currently, the chairs ask the members to indicate their preferred time for holding the workshop (between July and Nov 2014).

The second agenda item was the organization of a special session during a major science meeting. The group decided that the SOLAS Summer Meeting in Kiel, Germany (2015) and the Ocean Sciences Meeting in New Orleans, USA (2016) are most suitable in regard to audience and timing.

The third agenda item included discussion on the deliverables of the working group. During the meeting and after a survey among all members, it has been decided to publish a free guideline for sampling the microlayer or an extended version for investigating the ocean's surface. The guideline will become available as a downloadable pdf file. During the workshop in Qingdao, the group will work together on a communication paper highlighting the role of microlayers in the changing ocean, aerosol chemistry, gas exchange, eutrophication, ecosystem health and hydrophysical modeling. In conjunction with organizing a special session during a science meeting, the group agreed to publish a special issue of a peer-reviewed journal on microlayer research. The present members discussed potential journals in terms of open access, costs of print and impact factor, and the journals *Biogeosciences* (BG), *Journal of Geophysical Research* (JGR) and *Progress in Oceanography* (PO) were considered. We sent an inquiry to the journals, and JGR responded positive, whereas BG and PO have not responded yet.

Finally, the group discussed miscellaneous issues, including finalizing the list of group members. During the discussions the need for an expert in zooneuston studies was highlighted, and the group nominated Dr. Ekau from Leibniz Center for Tropical Marine Ecology in Bremen (Germany) for

this role. He kindly agreed to our invitation to join the group. The group members presented also their research during the EGU meeting in Vienna.

Name	Type	Title
S. Frka	Oral	Physicochemical signatures of natural surfactant sea films from coastal Middle Adriatic stations
A. Engel	Oral	Responses of marine microorganisms to ocean acidification during a mesocosm study in the Arctic (Svalbard)
T. Talib	Poster	Composition of surfactants in the sea-surface microlayer and atmospheric aerosols around coastal areas of the Peninsular Malaysia
M. Cunliffe	Oral	Quantifying the microbial regulation of gel particle biogeochemical cycling in the surface waters of the coastal sea (solicited)
O. Wurl	Oral	The gelatinous nature of the sea-surface microlayer

As a further outcome of the first annual meeting, M.T. Talif and O. Wurl agreed to organize a lecture at the Universiti Kebangsaan Malaysia (UKM), but also presentations on current microlayer research from students at UKM as part of capacity building. This event was held on the 8 May 2013 (without request of SCOR funding). Further collaborations are in planning.

Final group member list

Full members

1. Michael Cunliffe, Marine Biological Association (UK) – Biological Oceanography
2. Oliver Wurl, Institute for Baltic Sea Research (Germany) – Chemical Oceanography
3. Anja Engel, IFM-GEOMAR (Germany) – Biological Oceanography
4. Sanja Frka, Ruđer Bošković Institute (Croatia) – Chemical Oceanography
5. Chris Zappa, Lamont-Doherty Earth Observatory (USA) – Physical Oceanography
6. Caroline Leck, Stockholm University (Sweden) – Meteorology
7. Sonia Giasenella, Instituto Oceanográfico da USP (Brazil)
8. Mohd T. Latif, Universiti Kebangsaan (Malaysia) – Environmental Science
9. Bill Landing, Florida State University (USA) – Chemical Oceanography
10. Gui-Peng Yang, Ocean University of Qingdao (China) – Chemical Oceanography

Associate Members

1. Robert Upstill-Goddard, Newcastle University (UK) - Physical Oceanography
2. Blaženka Gašparović, Ruđer Bošković Institute (Croatia) – Chemical Oceanography
3. Kenneth Mopper, Old Dominion University (USA) – Chemical Oceanography
4. Anna Lindroos, University of Turku (Finland) – Biological Oceanography
5. Alina Ebling, Florida State University (USA) – Chemical Oceanography
6. Miguel Leal, Skidaway Institute of Oceanography (USA) – Biological Oceanography
7. Svein Vagle, Institute of Ocean Sciences (Canada) – Physical Oceanography
8. Werner Ekau, Leibniz Center for Tropical Marine Ecology (Germany) – Fishery Biology
9. Alexander Soloviev, Nova Southeastern University (USA) – Physical Oceanography
10. David Carlson, Emeritus, Chemical Oceanography
11. Karsten Laß, University of Kiel (Germany), Physical Chemistry

2.2.8 WG 142 on Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders *Feeley*

(2012)

Terms of Reference:

1. Summarize and assess the current status of biogeochemical sensor technology with particular emphasis on float-/glider-readiness (pressure and temperature dependence, long-term stability, calibration accuracy, measurements time constant, etc.).
2. Develop pre- and post-deployment quality control metrics and procedures for oxygen and other biogeochemical sensors deployed on floats and gliders providing a research-quality synthesis data product.
3. Collaborate with Argo and other data centers to implement these procedures in their standard routines.
4. Disseminate procedures widely to ensure rapid adoption in the community. Develop ideas for capacity building in this context.

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Executive Committee Reporter: Missy Feeley

2.3 Working Group Proposals

2.3.1 SCOR Working Group on Zooplankton Production Measurement Methodologies and Their Application *Burkill*

Proposal for a SCOR Working Group
Zooplankton Production Measurement Methodologies and Their Application

Abstract
Climate change will affect material and energy flux pathways in marine ecosystems. Zooplankton communities and their rates of production represent key aspects of the structure and function of marine ecosystems. Unfortunately, our understanding of the processes driving variation in zooplankton production is limited and this is due in part to difficulties identifying which methods are the most practical and relevant for measuring the production rates of natural zooplankton populations and/or communities across a wide range of phyla and trophic levels. A quantitative evaluation of existing, new and emerging methodologies is urgently required.

The proposed Working Group will focus its attention on assessing the applicability of existing methods (i.e. traditional methodologies) as well as the development of novel methodologies (i.e. biochemical-based approaches) for measuring zooplankton production rates. Work will be conducted over a period of four years, culminating in a final report that will:

1. Summarize the assumptions, recent advances and limitations of the traditional methodologies and novel biochemical-based approaches used to estimate production of zooplankton populations or communities
2. Present experimental protocols for biochemical-based approaches to estimate zooplankton production, and post these to a web site as well as publish them in a peer-reviewed journal
3. Validate and calibrate zooplankton production rate estimates measured by biochemical-based approaches and traditional methodologies through a cooperative and collaborative research program
4. Propose zooplankton production research activities to be encouraged in ocean science plans of PICES (North Pacific Marine Science Organization) and ICES (International Council for the Exploration of the Sea) membership nations

Rationale
Secondary production represents the rate of elaboration of biomass (via growth and reproduction) for direct and indirect consumers of primary production in marine food-webs. Zooplankton in particular occupy a central position in marine food webs, but we lack accurate estimates of their production. Reliable estimates are needed to fully understand the functional response of marine ecosystems to global climate change. Traditionally, zooplankton production has been measured as one of the quantitative evaluations of ecosystem function, integrating the production estimate for each zooplankton population or group. Despite the use of several methods for estimating zooplankton production over the last century, the routine and

universal application of each of these methods is limited because they can only be used under specified conditions and are not necessarily comparable. Also, the estimates include some uncertainty because zooplankton communities span a wide range of phyla and trophic levels.

It is particularly timely to focus on zooplankton production methodologies because assumptions underlying the most commonly applied traditional methods have been re-evaluated and new approaches have been proposed since the publication of the ICES Zooplankton Methodology Manual in 2000. At this stage, a comprehensive comparison of these methods (in the context of recent advances) may allow us to:

1) evaluate advantages and limitations of these methodologies for their application to zooplankton populations or communities; 2) compare the production rates estimated by each method; and 3) to propose one or more as a "routine" method for natural zooplankton populations and communities.

A Working Group formed in SCOR and endorsed by the PICES and ICES would be the best way of focusing a global scientific effort on the topic of zooplankton production. Since this topic is fundamental to oceanographic science, it is appropriate that the activity is carried out by an international scientific organization such as SCOR. Moreover, an endorsement by both PICES and ICES would enhance the exchange of information and discussion between members of these organizations as well as between advanced and developing countries. We want to assemble scientific expertise from PICES and ICES nations and several developing nations in order to fully represent the world-wide zooplankton community.

Scientific Background

Zooplankton communities play a dominant role in the flow of matter and energy passing from primary producers to animals at higher trophic levels in marine ecosystems (e.g. Lalli and Parsons 1993). Over the past two decades, the need for quantitative evaluation of marine ecosystem function has been emphasized as a necessary component of improving our understanding of how marine ecosystems respond to global climate change (e.g. Walther et al. 2002; Edwards and Richardson 2004; Boyce et al. 2010). While SCOR has sponsored four working groups that focused on standardization for zooplankton sampling (WG3 and WG13) and preservation (WG23) of biomass estimation and global comparisons of zooplankton time-series (WG125), there is still little knowledge on the underlying rate processes. Over the past half century, phytoplankton production rates have been estimated using radio-isotopes (as originally proposed by Steeman-Neilsen 1952) and more recently using stable isotope-based approaches (Hama et al. 1983). In the early 1980's similar approaches were also developed for the measurement of bacterial production rates (Fuhrman and Azam 1982). A major consequence of the long-term use of routinely applicable *in situ* methods for primary productivity is that we can now generate spatio-temporally resolved maps of primary production rates coupled with satellite imagery. On the other hand, zooplankton production has been traditionally estimated with methods (i.e. traditional methods) that either: 1) follow the development of zooplankton populations or communities over the course of several weeks or months; or 2) employ fixed-period incubations (e.g. Burkill and Kendall 1982, Kimmerer and McKinnon 1987; Berggreen et al. 1988; Peterson et al. 1991). Incubation-based techniques with

simultaneous sampling of natural communities are the most widely used methods in the field. In 2000, Runge and Roff (2000) reviewed the field application of the traditional methods as well as the development of biochemical and radiochemical methods in a chapter in the ICES Zooplankton Methodology Manual (Harris et al. 2000). However, shortly after this publication, some studies (Hirst and McKinnon 2001; Hirst et al. 2005; Kimmerer et al. 2007) documented limitations of the incubation-based methods which necessitated revisions to application and interpretation of these approaches and their derived productivity estimates. Meanwhile, new approaches for measuring zooplankton production using biochemical materials and enzyme activity (i.e. biochemical-based approaches), which were not covered by Runge and Roff (2000), were also developed and explored (Wagner et al. 2001; Sastri and Roff 2000; Oosterhuis et al. 2000; Yebra and Hernández-León, 2004).

In October 2012, a PICES workshop was convened in Japan to discuss the issues surrounding the most commonly used methodologies for the assessment of zooplankton production. The motivation for this workshop was the recognition that there is still little knowledge of or confidence in the existing zooplankton production methodologies (relative to those used for estimating primary and bacterial productivity). Two major conclusions emerged from the activities at the workshop: 1) we need studies that compare traditional with biochemical-based approaches; and 2) there is no method that can be routinely applied to natural zooplankton populations and communities across a wide range of phyla and trophic levels. In order to resolve these significant issues, an international Working Group on zooplankton production methodologies was proposed during the workshop.

Statement of Work
The proposed Working Group would:

1. Summarize the assumptions, recent advances and limitations of the traditional and biochemical approaches used to estimate production of zooplankton populations or communities across a wide range of phyla and trophic levels
2. Present experimental protocols for biochemical-based approaches to estimate zooplankton production on a website and in a peer-reviewed journal
3. Validate and calibrate zooplankton production estimates by biochemical-based approaches and traditional methodologies through a cooperative research program
4. Propose and encourage zooplankton production research activities in science plans of PICES and ICES membership nations

Term
2014 to 2017 (4 years)

Meetings
To discuss the roadmap of this Working Group and to make a plan for a cooperative research program, the first meeting will be convened during March 2014 just before or after the meeting of the ICES Working Group on Zooplankton Ecology (WGZE). A second meeting will be held in association with the cooperative research program (see Statement of Work), during summer of 2015 or 2016 in Kagoshima, Japan. To discuss the Working Group's report and

prospective activities, a final meeting will be held just after the 2017 ASLO Summer Meeting.

Sessions held at international conferences

The Working Group proposes a session during the 2015 Zooplankton Production Symposium to share and discuss the assumptions, recent advances and limitations in zooplankton production methodologies and their applications to natural zooplankton populations and communities. Through this symposium, the working group will summarize the information. A session will be proposed for the 2017 ASLO Summer Meeting, to report the review on zooplankton production methodologies (both traditional and biochemical-based approaches) and measurements for natural populations and communities and the results from the above-mentioned cooperative research program by the working group.

Capacity Building

The Working Group will contribute to promote a cooperative research program measuring zooplankton production among ICES and PICES nations including developing countries. Also, the working group members will encourage a summer school on the methodologies for young scientists.

Working Group Membership

Working Group membership is proposed to consist of 14 specialists in zooplankton production ecology who have experience with the use of traditional methodologies and/or biochemical-based approaches. We also recognize that the Working Group members should be represented from both ICES and PICES countries in order to properly cover the global scale of this subject area. Full members would steer this working group and associate members would help with the tasks of full members.

Members

Full Members

1. Toru Kobari (Japan, T/B: Co-Chair)
2. Lidia Yebra* (Spain, B: Co-Chair)
3. Akash Sastri (Canada, B)
4. William T. Peterson (USA, T)
5. Andrew Hirst (UK, T)
6. Wim J. Kimmerer (USA, T)
7. David McKinnon (Australia, T/B)
8. Sigrún Jónasdóttir* (Denmark, T/B)
9. Felipe Gusmao (Brazil, T/B)
10. Jenny Ann Huggett* (South Africa, T/B)

Associate Members

1. Ruben Escribano (Chile, T)
2. Hyung-Ku Kang (Korea, T)
3. Tomonari Kotani (Japan, T)
4. Marina Sabatini* (Argentina, T)

*: female scientists
T: contribution to traditional methodologies
B: contribution to biochemical-based approaches

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2.3.2 SCOR Working Group on Response of marine biota to complex global environmental change: co-ordination and harmonization of experimental Approaches *Brussaard*

Proposal for a SCOR Working Group:

Response of marine biota to complex global environmental change: co-ordination and harmonization of experimental approaches

Abstract
All climate models project concurrent changes to multiple oceanic properties, due to the effects of anthropogenic climate change, in the coming decades. There is also a growing body of evidence from ocean observatories to support model predictions of simultaneous modification of temperature, CO_2/pH, O_2, nutrients and irradiance. Hence, a major and urgent challenge for the ocean science community is to establish how widespread alteration of oceanic conditions will manifest itself as cumulative environmental stress on ocean biota and ecosystems. This challenge is multi-faceted as it will test our abilities ranging from conceptualization/modeling of how a changing ocean will alter the physiology and ecology of the biota, to how to design and conduct manipulation experiments to mimic such ongoing and complex shifts in the oceanic environment. This challenge is further compounded by forcing individual scientists to consider a major dilemma – *the need as an ocean science community to collectively make sense of the next decade of global environmental research requires co- ordination and harmonization (as opposed to standardization) of experimental approaches, yet such co-ordination may be seen as violating a fundamental right for researchers to conduct independently planned research based on the need to address very specific questions.*

Experiments investigating how biota will respond to environmental manipulation have, until recently, mainly focused on the perturbation of a sole oceanic property such as iron or pH. Such relatively 'simple' studies have revealed a wide range of responses to perturbations. Subsequent analysis of these experiments has uncovered a wide range of protocols *such that the reason(s) for the experimental outcome could be the environmental manipulation but also the adopted protocol and/or incubation apparatus.* Increasingly, investigators are conducting experiments in which multiple properties are altered – to mimic model projections of complex environmental change. For example, in 2012, 1/3 of the 225 papers which reported a biological response to Ocean Acidification (OA) also manipulated at least one other property. The challenges associated with conducting more complex manipulation experiments are technological but also relate to experimental design (replication vs. regression approach, pseudo-replication, number of treatments etc.). We have learnt much from the last decade of OA studies. Perhaps most importantly, that there is a real danger that unless a group of experts provides leadership in raising awareness about this "Co-ordination dilemma", followed by clear guidance on the issues surrounding implementation of best practices and experimental approaches, the international research community will generate a divergent and disparate range of datasets in the coming decade. Such datasets are time-consuming and expensive to produce, yet they will potentially make data synthesis and interpretation extremely difficult, possibly leaving our understanding no further along.

This SCOR Working Group will tackle this pressing issue of co-ordination and harmonization of experimental approaches head on by:

a) Publicizing - the issues surrounding a lack of co-ordination/harmonization of experimental approaches to the effects of complex environmental change on biota.
b) Gauging the wide range of opinions across our research community to the "Co- ordination dilemma' using questionnaires and complex-decision making software to assess the weighting that scientists give to these issues. This is essential prior to the WG planning workshops to continue this debate.
c) Conversing with the climate change modeling community to assemble the best estimates of a complex matrix of environmental change, to help explore the co- ordination of experimental approaches – how will each individual property change and at what rate.
d) Communicating with experimental evolutionary biologists to gauge how acclimation times, to altered oceanic conditions, will impact the outcome of the manipulation experiment, to assist the debate around co-ordination and harmonization of experimental approaches.
e) Discussing with engineers, chemical engineers, chemists (carbonate, trace metal), bio-statisticians, the issues surrounding the design of robust incubation systems that can be mass-produced but also customized for specialized experiments – for example in polar waters, and which provide replication of treatments.
f) Using outcomes a) to d) to build on the seminal advance, of publishing a Best Practices Guide (BPG) to OA Research (Riebesell et al., 2010), to produce a new format of BPG's that take into account: changes to multiple oceanic properties; acclimation of different organisms to a range of altered conditions; and critically a recommended suite of incubation systems to be paired with the BPG approach.

Rationale / Background

The recent SCOR-sponsored "Ocean in a high CO_2 world" provided two compelling datasets. Firstly, Sarah Cooley (Woods Hole Oceanographic Institution, USA) reproduced a talk at this meeting as an article (Cooley, 2012) revealing that increasingly investigators are designing and running multi-property perturbation experiments, for example pH and temperature manipulations. The second dataset was a collation, shown at the meeting, which revealed that despite the publication of the OA BPG (already cited ~100 times) some researchers continue to use a disparate range of CO_2 concentrations in perturbation experiments (Figure 1). There are certainly valid reasons for choosing different [CO_2] for different experiments; for instance, those examining 100-year projections will differ from others examining shorter or longer timescales, and incubations with organisms from CO_2-enriched upwelling zones necessarily employ different conditions from those testing biota from the central gyres. <u>It is, however, important to ensure that experiments simulating these different scenarios are internally consistent and comparable.</u>

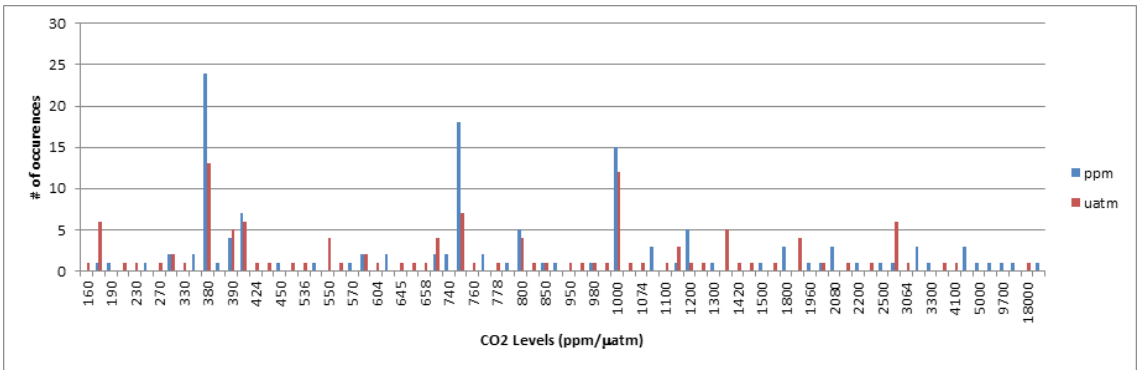

Figure 1 Summary of CO_2 concentrations used by researchers in recent OA manipulation studies.

Together, these two pieces of evidence provide a glimpse of both ongoing research trends, but also of where the rapidly evolving research field of global change biology is headed in the coming decade. It requires little imagination to picture that 10 years hence datasets could be 'awash' with a large number of permutations of different experimental conditions of pH, nutrients, irradiance etc. such that conducting robust analysis, meta-analysis and forming synthetic reviews of how a changing ocean will influence the biota becomes very difficult.

Gauging how the biota will respond to such altered conditions will be further confounded by labs using different acclimation times (from none to months) and a wide range of often in-house built incubation systems. There is much to learn from the seminal progress made by the "OA and biological responses" community, who foresaw this issue and published a BPG in 2010. Since then this field-leading community has advocated the deployment of multiple large-scale marine CO_2 experiments called Free Ocean CO_2 Enrichment (FOCE). Significantly, the FOCE approach enables both a mass-produced incubation system to be adopted but also one that can be customized for a particularly exacting set of environmental conditions. Thus, it provides a powerful illustrative example of a combination of a standardized basic format incubator whose accessory components can be modified as required. We believe that publicizing such an approach is a powerful way of *convincing a research community with a diverse set of views and opinions to co-ordinate and harmonize (as opposed to standardize) their research efforts such that we have a coherent intercomparable body of datasets being produced regularly over the coming decade, without the risk of alienating large parts of the research community by imposing the strictures imposed by co-ordination*. Such co-ordination will enable our community to address fundamental questions about the alteration of marine ecosystem structure and function, and any associated biogeochemical or climatic feedbacks.

Three issues must be addressed by this WG in order to explore how to produce a BPG to better address complex environmental change in the ocean.

Assembling 'best' estimates of a complex matrix of environmental change

Ocean ecosystems are increasingly stressed by anthropogenic alteration of their physical, chemical and biological environment. The design of experimental incubation systems and

recommendations on treatments requires the assembly of regional best estimates of how multiple oceanic conditions will be altered, and at what rates, in the coming decades. Recently, the accuracy of model projections has improved considerably, in conjunction with the preparation of IPCC AR5 report. For example, Bopp et al. (2013) used the most recent simulations performed in the framework of the Coupled Model Intercomparison Project 5 to assess how several drivers will evolve during the 21st century. The ten Earth System Models predict similar trends in ocean warming, acidification, deoxygenation and reduced primary productivity for each of the IPCC's representative concentration pathways. Furthermore, although these stressors operate globally, they display distinct regional patterns which will be considered by this WG. Studies such as these will help to address an important consideration – how to design manipulation experiments that employ variables, such as iron supply, for which future projections are highly uncertain (Boyd et al., 2010).

Incorporation of acclimation, to altered oceanic conditions, into experimental design. In the last 2-3 years, a growing number of studies have investigated how environmental conditioning time affects organismal responses to multiple environmental drivers. Researchers are also increasingly focussing on the relative roles of environmental acclimation, plasticity and adaptation by biota over different timescales. An important task of the WG will be to initiate discussions with the experimental evolutionary biology community to gauge how conditioning times to an altered oceanic environment affect outcomes and interpretation of experiments. The field of marine experimental evolution is still in its infancy (Collins 2011, Schaum et al., 2012, Lohbeck et al. 2013, Reusch & Boyd, 2013, Tatters et al., 2013), but there is much current interest and nascent research activity in this discipline. One challenge for the WG will be to ensure recommendations for experimental conditioning times are responsive to newly emerging information in this rapidly moving field. For example, one critical question is, how many generations should an organism be conditioned to ensure its response represents mostly physiological acclimation and not genetic adaptation, and vice versa? As with other issues discussed above, the answers will be organism- and habitat-specific. For instance, adequate conditioning times will obviously vary widely between rapidly reproducing microbes and large, slowly reproducing metazoans. The WG will undertake to help the community define realistic conditioning time parameters for a range of important marine functional groups, with the ultimate aim of facilitating inter-comparability and quantitatively modelling of acclimatization and adaptive responses to global environmental change.

The power of widespread collaboration to design and produce incubation systems. The FOCE system provides an illustrative example of new technology under development to meet the current needs of OA researchers. FOCE is based on successful large-scale terrestrial experiments (FACE) that released CO_2 into the local atmosphere at controlled rates to expose terrestrial vegetation to elevated CO_2 levels to simulate conditions expected in the late 21st century. Studies are presently underway around the globe using regional modification of the original FOCE concept.

FOCE experiments offer 'closed loop control' around variables such as current velocity, mixing dynamics and pH. Collaborations between scientists and engineers have demonstrated that

systems can be built, integrated, and deployed in situ to successfully obtain inter- comparable datasets (Brewer et al., 2013). Two FOCE systems have tested the extremes of environmental conditions: Deep FOCE (Figure 2a), which operated for 18 months at 900 m depth at 4 °C and the Coral Prototype FOCE (Figure 2b), deployed on the Great Barrier Reef in currents > 1 m/s, temperatures of 18-29 °C, and a tidal range of ~ 3 m.

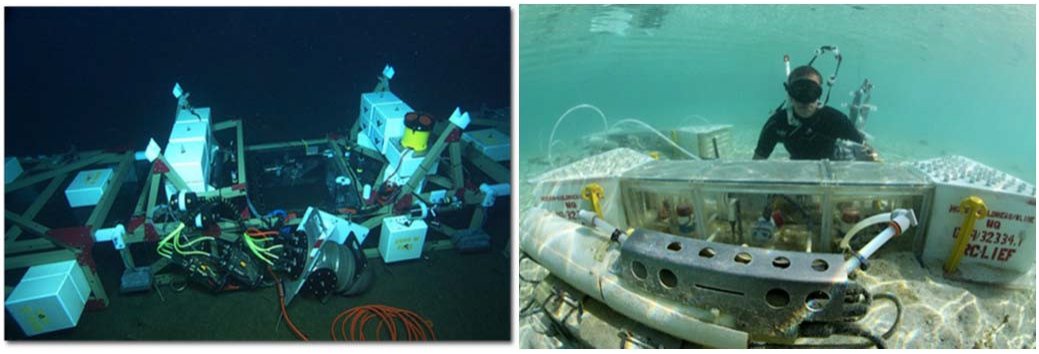

Figure 2 a) 1: dpFOCE deployed at 900 m; b) cpFOCE at Heron Island.
Although dpFOCE and cpFOCE look entirely different their underlying systems and algorithms are very similar.

FOCE experiments are particularly useful for examining longer term responses of sessile benthic organisms to altered pCO_2. Other types of incubation systems have recently been designed successfully by teams comprising chemical engineers, carbonate chemists, biologists and bio-statisticians to examine the responses of planktonic communities to climate change (Figure 3). Other commonly used incubation systems include: small-volume "batch" incubation systems, continuous culture systems, and very large (>> 1000 L) volume mesocosms. All of these systems are useful for particular applications and questions, but the selection of a combination of a range of standardised formats needs careful attention.

Production of a new format of Best Practice Guides.
Together, the above approaches would inform the production of a BPG that critically will be linked and readily combined with a recommended incubation system(s) whose technology can be customized to meet the needs of a particular site (Figures 2 & 3).

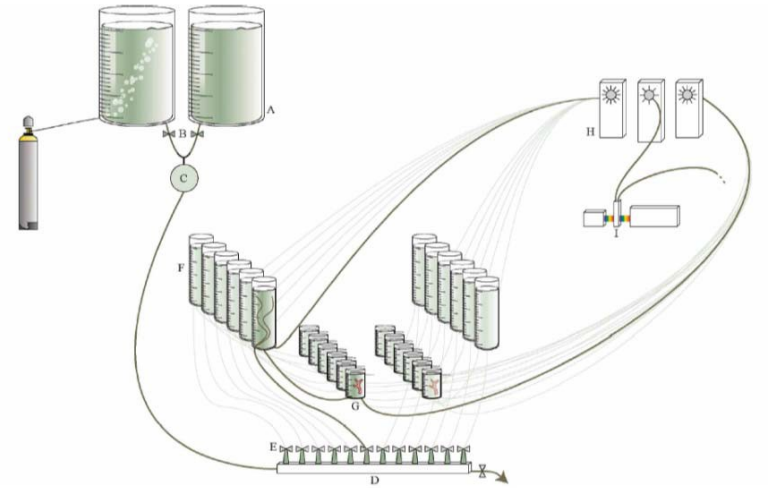

Figure 3 An example of a next-generation environmental manipulation incubator, designed an interdisciplinary team approach (McGraw et al., 2010).

Statement of Work/Terms of Reference

1. **Document the range of environmental conditions currently used for experiments on the effects of future global change** (pH, CO_2, temperature, salinity, light) on marine organisms.
2. **Identify problems arising from incomparable experimental conditions** in terms of statistical analysis and the ability to extrapolate research results and use in modeling.
3. **Seek the views of the ocean research community regarding the necessity for, and details of, a commonly agreed set of best practices for research on the biological effects of global changes.** The community will be canvassed through customized questionnaires (see Gattuso et al., 2013) and by developing interactive 'scripts' using complex decision-making tools to provide web-based tools on this topic (c.f. http://www.royalsociety.org.nz/expert-advice/information- papers/yr2011/geo-engineering-an-interactive-workshop/).
4. **Interact with the global modeling community to determine the experimental datasets most needed by climate modelers** and engage with ongoing efforts like Stanford University's Center for Ocean Solutions (www.centerforoceansolutions.org/).
5. **Communicate the findings of the activity to the scientific community through special sessions at scientific meetings and publication.** a) Organize at least two sessions at AGU and EGU meetings on the issue of co-ordination and harmonization of experimental approaches to investigate the impact of climate change. Additionally, incorporate this theme as a session for future "Ocean in a High- CO_2 World" meetings; b) Publicize the growing complexity of global environmental change, and the need for a co-ordinated plan to guide manipulation experiments in the coming decade by communication in a popular science journal; c) Run a workshop with key experts/authors to discuss and plan the format of a BPG needed to cover a broad range of topics such as projected environmental changes, to scientific and technical issues, benthic and pelagic communities, acclimation and adaptation, biostatistics, data management. Incorporate this workshop to either precede or follow a future "Ocean in a High-CO_2 World" meeting. Note, partial financial support for such a workshop has already been secured from the OA International Coordination Centre.

Additional modes of communication will include the preparation of: a simple and short co-ordination plan - to be circulated to the environmental science and wider community - as a glossy poster/report card for manipulation experiments in the coming decade; a detailed web-based co-ordination plan - combining BPG's and recommended incubation systems.

6. **Ensure capacity building through**: support for efforts like xFOCE which maintain open source access to the required knowledge base and techniques (www.xFOCE.org); stimulation of a new generation of researchers who are aware of the role, and drawbacks, of the co-ordination and harmonization of approaches as a metric of quality assurance; use of the BPG as a capacity building tool.

WG Meetings

WG meetings will be run in conjunction with a funded Gordon Research Conference (on Ocean Global Change Biology) in mid 2014 and 2016 meetings, and/or other venues such as American Geophysical Union Ocean Sciences, and/or European Geophysical Union to keep costs down for travel etc.

Working Group Membership

Boyd will chair the WG in year 1 if the proposal is successful, Hutchins and Gattuso will be co-chairs, and the position of chair will be circulated each year.

Philip Boyd (Australia), marine experimental manipulations.
David Hutchins (USA), global environmental change and marine biota. Jean-Pierre Gattuso (France), ocean acidification.
Bill Kirkwood (USA), engineering solutions for researchers.
Christina McGraw (Australia), Chemical engineering solutions for biologists. Peter O. Zavialov (Russia) ocean physics and climate change.
Sinead Collins (UK) Experimental evolutionary biology. Marcello Vichi (Italy) Climate modelling.
Jorge Navarro (Chile) Environmental drivers on higher trophic levels. Kunshan Gao (China) Marine photosynthesis and climate change.

Associate members

Peter Brewer (USA) Carbonate chemistry, OA, FOCE.
Graham Bell (Canada) Evolutionary rescue and climate change. Gorann Nilsson (Norway) Fish and climate change.
Malcolm Marker (Australia) Engineering solutions for researchers.
Haruko Kurihara (Japan) Environmental impact assessment and marine ecosystems. Laurent Bopp (France) Climate modelling.
Peter Dilligham (Australia) Bio-statistics.
John Havenhand (Sweden) Biostatistics and OA studies.
Catriona Hurd (Australia) hydrodynamics and experimental design.
Ulf Riebesell (Germany) Global environmental change and marine biota.

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2.3.3 SCOR Working Group on Dissolved N_2O and CH_4 measurements: Working towards a global network of ocean time series measurements of N_2O and CH_4

Volkman

Proposal for Scientific Committee on Ocean Research (SCOR) Working Group Dissolved N_2O and CH_4 measurements: Working towards a global network of ocean time series measurements of N_2O and CH_4

Overview

This proposal aims to improve and consolidate measurements of the greenhouse gases nitrous oxide (N_2O) and methane (CH_4) dissolved in seawater. This work will be achieved over a 4 year time period by conducting the following activity: Firstly, an intercalibration exercise will be conducted amongst WG members targeting discrete N_2O and CH_4 measurements. Recommendations and protocols for calibration, quantification, and data reporting will be published following this exercise. This part of the project will also provide a review of existing and near-future methods for quantifying N_2O and CH_4 in seawater including spectroscopy measurements. The second part of the project will be to conduct an overall assessment on the status of dissolved N_2O and CH_4 measurements in the global oceans. Key regions and recommendations on the necessary temporal and spatial scale for sampling will be identified. Conducting this N_2O and CH_4 work within the SCOR framework will bring available information and international expertise together and develop community-based and accepted procedures. In this regard, the successful track record of SCOR in conducting international intercalibration exercises (e.g. WG2 'Carbon Dioxide in the Ocean', and WG16 'General Problems of Intercalibration and Standardization') will be very beneficial.

Scientific Background

Why measure N_2O and CH_4 in the marine environment?

In the Earth's atmosphere, N_2O and CH_4 account for 24% of the total radiative forcing associated with greenhouse gases. Whilst CO_2 is the most abundant greenhouse gas, N_2O and CH_4 are more virulent, respectively exerting ~300 and 25 times more radiative forcing than CO_2 over a period of 100 years (IPCC, 2007). The atmospheric burden of N_2O and CH_4 is increasing at an annual rate of 0.4% and 0.25%, respectively, and there is an ever increasing need to better constrain and understand the sources and sinks of both gases at the Earth's surface (Keeling 2008). The global oceans represent a source of both N_2O and CH_4 to the overlying atmosphere. The IPCC (2007) estimates oceanic CH_4 emissions range from 4-15 Tg CH_4 yr^{-1} and the rate of oceanic N_2O emissions to range from 1.8-5.8 Tg N yr^{-1}, although it should be noted that this is considered to be an underestimation by at least a factor of 2 (Bange 2006; Naqvi et al. 2000). The biogeochemical cycling of both gases in the environment is sensitive to temperature and redox conditions, and thus potential feedbacks to anthropogenic perturbations such as global warming, eutrophication, and spreading anoxia represent challenges for future marine scientific research.

Conducting measurements of N_2O and CH_4 in seawater

N_2O and CH_4 are routinely measured in diverse parts of the world's oceans either as discrete or continual measurements. Discrete measurements rely on the collection, preservation, and subsequent analysis of seawater samples using widely available gas chromatography (GC) techniques (e.g. Elkins 1980). Continual measurements of surface water saturations rely on a seawater equilibrator unit connected to an underway systems (e.g. Weiss 1981). More recently, within the last 5 years, there has been increasing use of Cavity Ring-down Spectroscopy and Off-Axis Integrated Cavity Output Spectroscopy analyzers (CRDS and OA-ICOS) for the analysis of trace gases. The use of optical absorption technology to measure trace gases including N_2O and CH_4 has advanced rapidly and offer precise measurements with unprecedented time resolution (Gülzow et al. 2011, 2013). To date, CRDS and OA-ICOS have been used in continual sampling mode, however it will not be long before they are also used to analyze discrete samples.

It should be clarified that the focus of the intercalibration exercise is discrete measurements of N_2O and CH_4 dissolved in seawater. Discussion and comparison of other analytical systems e.g. equilibrator units, spectroscopy technology, will follow on from the intercalibration of discrete measurements. We envisage that the WG meetings will be used to discuss use of the CRDS and OA-ICOS analyzers for both continual measurements and discrete analysis. Sales and engineer representatives from the manufacturing companies (LGR and/or Picarro) can attend a WG meeting and demonstrate the application of their analyzers (see Terms of Reference #1)

Why conduct an intercalibration exercise for N_2O and CH_4 measurements?

A number of laboratories throughout the world have developed analytical systems for measuring dissolved N_2O and CH_4 in seawater and undoubtedly new groups will make these measurements in the future. To maximize the scientific value of these studies, it is important that the measurements made by all groups are intercomparable and of the highest possible accuracy and precision. We adopt the definition of intercalibration as "The process, procedures, and activities used to ensure that the several laboratories engaged in a monitoring program can produce compatible data. When compatible data outputs are achieved and this situation is maintained, the laboratories can be said to be intercalibrated (Taylor, 1987)."

Similar exercises have been conducted for other oceanographic analyses including DIC (Dickson 2010), dissolved organic carbon (Sharp et al. 2002), sulfur hexafluoride and chlorofluorocarbons (Bullister and Tanhua 2010), halocarbons (Jones et al. 2011), and trace elements (Cutter et al. 2010). Therefore we will work with members of the scientific community actively involved in inter-laboratory collaborative exercises e.g. John Bullister at NOAA PMEL and Andrew Dickson at SIO to learn from their experience.

Improvements to the CO_2 analytical system (Dickson et al. 2003) and implementing best practices (Dickson et al. 2007) represent several decades of coordinated effort, however the successes are apparent with the accurate reporting of CO_2 increase in seawater (Dore et al. 2009; Keeling et al. 2004; Winn et al. 1998) and the concomitant decrease in seawater pH (Dore et al. 2009). It is imperative to set the N_2O and CH_4 on the correct path if we are to accurately determine the role of the oceans in climate change as detailed in the 'Scientific Background'.

Network of time series measurements of N_2O and CH_4.

Time series measurements of dissolved trace gases are a critical element of marine sciences. They are crucial to decipher the feedbacks between formation and emissions of climate relevant trace gas and short- and long-term environmental repercussions such as climate change, eutrophication, ocean deoxygenation and acidification. Currently, dissolved trace gases such as N_2O and CH_4 are regularly measured at only a few time series sites such as Stn. ALOHA (Hawaii), CaTS (off Goa, India), Line P (North Pacific), Boknis Eck (SW Baltic Sea) and off Chile. With a common measurement protocol, we will establish the basis for a world-wide network of compatible measurements of oceanic N_2O and CH_4.

Beginning in Year 2 of the project, the SCOR working group will compile existing measurements of N_2O and CH_4 in the marine environment including both time series and repeat hydrographic surveys. It will provide a framework for linking and bringing together existing measurements (e.g. in a joint internet platform such as MEMENTO* which provides access to the data from all sites), and recommend locations for new N_2O/CH_4 time series measurements which may either be undersampled or be more susceptible to change due to natural or anthropogenic perturbations.

*MEMENTO (the MarinE MethanE and NiTrous Oxide database) has been recently established as a subproject of SOPRAN which is the German contribution to SOLAS. Dr. Annette Kock, nominated as Associated Member of this WG will coordinate the activities MEMENTO. Moreover, MEMENTO will be powered and maintained by the Kiel Data Management Team, thus MEMENTO has a long-term commitment by GEOMAR including the establishment of a joint internet platform beyond the duration of SOPRAN and the SCOR WG. All data archived in MEMENTO will be linked to and archived at CDIAC, PANGAEA etc. as well.

Working Group Composition

The Full Members of the Working Group represents a balance between scientists actively engaged in measuring N_2O and CH_4 as part of time-series programs and having a global distribution of scientists with both senior and early career personnel. Associate members are represented by analytical experts in either trace gas chemistry and/or previously involved in intercalibration exercises. We have also attached an Appendix to this proposal which provides a brief outline of the members' research interests as they relate to N_2O and CH_4 in the marine environment. (m) and (f) flag male or female members, respectively.

Full members

1. Hermann Bange (m), Co-chair (GEOMAR; Kiel, Germany) *Time series: Boknis Eck*
2. Mercedes de la Paz Arándiga (f) (Instituto de Investigaciones Marinas-CSIC, Vigo, Spain)
3. Laura Farias (f) (COPAS Center; Concepción, Chile) *Time series: ESP-OMZ*
4. Cliff Law (m) (NIWA; Wellington, New Zealand)
5. Wajih Naqvi (m) (National Institute of Oceanography, Goa, India) *Time series: Candolim*
6. Gregor Rehder (m) (IOW, Warnemünde, Germany)
7. Philippe Tortell (m) (UBC; Vancouver, Canada) *Time series: Line P Program*
8. Rob Upstill-Goddard (m) (University of Newcastle; Newcastle, UK)
9. Sam Wilson (m), Co-chair (C-MORE; Hawaii, USA) *Time series: Stn ALOHA*
10. Guiling Zhang (f) (Ocean University of China, Qingdao, China)

Associate members
1. John Bullister (m) (NOAA-PMEL, Washington, USA)
2. Jan Kaiser (m) (UEA, Norwich, UK)
3. Annette Kock (f) MEMENTO (GEOMAR, Kiel, Germany)
4. Andy Rees (m) (Plymouth Marine Lab; Plymouth, UK)

Terms of Reference
We outline four Terms of Reference for this WG. These activities are integrated into the international meetings, which are outlined in the Timetable below. The publications resulting from the activity of this WG are indicated in Terms of Reference #3 and #4.

1. Conduct an intercalibration exercise between the time series programs
2. Establish the appropriate standards to be used by the scientific community
3. Recommend the analytical reporting procedures to be used for N_2O and CH_4
4. Establish framework for an N_2O/CH_4 ocean time series network and write a global oceanic N_2O/CH_4 summary paper for publication in an open access journal.

1. Conduct an intercalibration exercise between the time series programs.
The first intercalibration exercise will occur in Year 1 of the project in time to present the findings at the first WG meeting, prior to the Ocean Sciences conference in Honolulu, Hawaii. Its purpose is to fully evaluate the analytical procedures for quantifying N_2O and CH_4 dissolved in seawater. A second intercalibration exercise has also been included in the timetable scheduled to occur in Year 2 of the project to resolve long-term issues associated with the analysis *e.g.* preservation and storage of samples. Each intercalibration exercise will consider specific items:

- Instrument set-up: Calibration procedures, sample blanks, the stripping efficiency, and instrument drift over a 1 year period.
- Transportation and preservation of samples .This will also help determine the possibility of reference material.
- Exchange seawater samples in order to determine any offset between the N_2O and CH_4 datasets.

Ultimately, the intercalibration exercise will help improve the analytical systems used by the different laboratories. It will also help recommend an 'ideal' analytical system for future laboratories establishing reduced gas analysis. The WG will also host a practical demonstration of an analytical system capable of delivering high-precision measurements of N2O and CH4.

2. Initiate common protocols, including primary N_2O and CH_4 standards, working standards, and measurement of N_2O and CH_4 in the overlying atmosphere.

- Laboratory gas standards. To assist the compatibility of the measurements, at least one of the standard gas mixtures used by the separate laboratories should be derived from NOAA ESRL GMD which is the central calibration laboratory for the World Meteorological Organization (WMO), Global Atmosphere Watch (GAW). The concentration values of the laboratory reference standards will be close to that of modern air *i.e.* 0.325 ppm for N_2O and 1.6 ppm for

CH_4. These gas standards have an accuracy of ± 1 ppb (IMBER/SOLAS Implementation Plan 2006). The approximate total cost for standard gas mixtures of N_2O and CH_4 (150 cubic ft. cylinder) is $2,600. The cost of the cylinders will be handled by each laboratory and if financial support is required, funding will be requested from the respective national agencies.

- Liquid Reference Materials. In addition to gas standards, we will investigate the feasibility of incorporating control measurements into the analytical procedures. Other analyses refer to these as Certified Reference Materials which are used to relate the concentration of dissolved N_2O or CH_4 to a reference database for calibration. We will assess the suitability of having non-certified liquid reference materials for N_2O or CH_4 during Year 2 of the project. For example, a seawater sample equilibrated with a known atmospheric concentration at a fixed temperature.

Ensure all Working Group members have access to primary standards by May 2014 and establish the feasibility of a working standard reference material by May 2015 (see timeline below).

3. Establish N_2O and CH_4 reporting procedures

The information to be included in the reporting procedures will be agreed upon by the WG. This documentation should be provided with the N_2O and CH_4 datasets stored at publicly available national and international data centers. Publication of the intercalibration exercise (Terms of Reference #1) will provide an opportunity to highlight these reporting procedures to the wider oceanographic scientific community. This publication will be drafted before the second planned WG meeting which will be held in Kiel, Germany, in September 2015 at the SOLAS Open Science Conference. We will collaborate with relevant major international programmes such SOLAS, IMBER, and CLIVAR to make sure that the WG recommendations for reporting procedures are recognized for future N_2O/CH_4 measurements.

The outcome and conclusions of the intercalibration exercise will be published in a refereed scientific journal, alongside the reporting procedures outlined in Terms of Reference #1.

4. Establish a framework for an N_2O/CH_4 ocean time series network

The SCOR WG will compile available N_2O and CH_4 data from the global ocean (both open and coastal), sourcing both peer reviewed publications, unpublished reports and data archives such as MEMENTO. In instances of data being stored with other repositories, we will provide a link to these separate archives. These data will be reviewed and checked for data consistency. Maps of the global N_2O/CH_4 distribution in the ocean will be produced (if possible with a monthly resolution). Based on these data, locations for new time series measurements (sites and lines for VOS, volunteer observing ships) will identified. Additionally, recommendations will be published on how to link the existing time series data and how to make them available to the public in order to facilitate the use of data by modellers, stakeholders, and policy makers.

The recommendations for a global network of N_2O/CH_4 oceanic measurements will be published in a refereed scientific journal. To aid this coordinating work, WG members will submit N_2O and CH_4 datasets using the agreed N_2O and CH_4 reporting procedures to a publicly available data center (MEMENTO; Bange et al., 2009) by December 2014.

Timeline

Calendar Year	Key dates	WG activity
2013	May: Submission of proposal Nov: Decision by SCOR on support	We would like the first intercalibration exercise to be completed prior to the Feb 2014 WG meeting. In June-Dec 2014, a 2nd intercalibration exercise is planned to fulfill this part of the project Presentation of intercalibration results at SOLAS. In Year 3-4, the WG assesses our ability to track changes in N_2O and CH_4 concentrations in the marine environment.
2014	Feb: WG meeting in Hawaii, (followed by ASLO 2013)	
2015	Sept: WG meeting in Germany, (followed by SOLAS conf)	
2016	Feb: Publish recommendations for analysis and reporting	
2017	February: 3 year review and Working Group meeting followed by Ocean Sciences Publication of recommendation for N_2O/CH_4 Time Series Station Network	

Capacity Building

To help achieve the objectives of this proposal and build the capacity to improve and sustain accurate N_2O and CH_4 measurements we will encourage all the Working Group core members to involve an early career scientist in the intercalibration exercise. This working group proposal engages oceanographers across the world and we will insure full participation in the international meetings to be held in 2014 and 2015 by core members of the Working Group and make the resulting publications are freely available. The WG plans to get in contact with the Partnership for Observation of the Global Oceans, POGO, to see if the WG procedures could be added to POGO's portfolio of training & education activities. This will facilitate the establishment and maintenance of additional high quality N_2O/CH_4 time series measurements world-wide. We do not believe the financial costs of participating in the intercalibration exercise to be prohibitive as all participating laboratories currently conduct the measurements. The main costs will be shipping, travel, and the certified gas standards.

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Appendix A. Research interests of WG members

This appendix contains an outline of the Working Group member's research interests as they relate to N_2O and CH_4 oceanic measurements.

Mercedes de la Paz Arándiga: My research deals with the dynamics of climatically active trace-gas cycling of N_2O, CO_2 and CH_4 and air–sea exchange in coastal and oceanic waters. As part of my postdoc research at the Oceanography department in Vigo, I initiated a new research line leading the project OSIMON for the development of the chromatographic technique for the simultaneous analysis of N_2O and CH_4. As a member of the Department of Oceanography at the IIM-CSIC I participated in several projects (e.g. MOC, CATARINA and GIFT) determining N_2O and CH_4 in different areas of the North Atlantic Ocean. Currently, I am involved in the European project for Integrated non-CO_2 Greenhouse Observing Systems (InGOS), which aims to harmonize, exchange and disseminate data on the EU greenhouse gas budget. As a result of the work carried out in these projects, we have generated the following N_2O and CH_4 databases, the availability of which is specifically detailed below:

1) MOC Project: analysis of N_2O and CH_4 full water samples in the Atlantic section 8ºN in May of 2010, which is a repetition of the WOCE–A06 section done in 1993.

2) GIFT series comprise of data from 3 stations throughout the east-west axis of the Gibraltar Strait where discrete samples were collected at 5 depths. This strategy is aimed at collecting samples within the different water bodies present in the Strait. N_2O and CH_4 were already collected in Sept 2011, Nov 2011 and Feb 2012, and the time series is expected to continue in progress.

3) CATARINA project: The OVIDE repeated hydrography section, which connects the Portuguese coast with Greenland, was occupied during July 2012 to assess the vertical distribution of N2O and CH4. The OVIDE was conceived as a decadal experiment that commenced back in 1997 and has been sampled every two years ever since, but until 2012 no trace gases measurements were done. The next cruise is scheduled for summer 2014, and trace gas measurements are integrated in the cruise plan.

Hermann Bange: .My research interest includes N_2O and CH_4 measurements (both continuous surface and depth profiles) in order to estimate their oceanic emissions to decipher their oceanic distributions. Since 1991 I have been involved in several studies about N_2O and CH_4 in the major

basins of the Atlantic, Indian and Pacific Oceans as well as in the Baltic and North Seas and the Mediterranean Sea. I am coordinating the activities the Boknis Eck Time Series Station (SW Baltic Sea). Monthly measurements of N_2O and CH_4 at the Boknis Eck site started in July 2005 and June 2006, respectively.

John Bullister: My scientific research interests regarding N_2O and CH_4 include the large-scale distribution of these compounds in the global ocean and potential changes in the distributions and air-sea fluxes of these compounds in the future. Our group is currently developing techniques for routinely including measurements of dissolved N_2O in the water column as part of the CLIVAR/GO-SHIP Repeat Hydrography program. The goal of this program is to repeat (at ~ 10 year intervals) a set of key hydrographic sections in all of the major ocean basins. Hydrographic stations are occupied at ~ 60 nautical mile spacing along each of these sections, and collect full water column profiles of a variety of physical and chemical parameters. By including dissolved N_2O measurements on these sections, we hope to be able to detect long-term changes in the global distribution of dissolved N_2O in the ocean interior, and possible relationships to other ocean processes (expanding low-oxygen zones, changes in the nitrogen cycle) as well as changes in air-sea fluxes of this compound. Data from CLIVAR sections will be archived at: http://cchdo.ucsd.edu/. We also interested in dissolved methane in Arctic regions, and using radiocarbon as a tracer to help determine the impact of methane released from warming permafrost on observed methane super-saturations in this region.

Laura Farias: Time series: ESP-OMZ

Jan Kaiser: Over the past 2 years, we have used Los Gatos Integrated Cavity Output Spectrometers to measure N_2O, CH_4, CO and CO_2 concentrations in seawater. The analysers have been deployed on four cruises (AMT20, October 2010, Southampton to Punta Arenas; D366, Summer 2011, Ocean acidification cruise around the UK [incl. North Sea, Skagerrak, North Atlantic, Irish Sea, Celtic Sea, English Channel]; ARK XXVII/1, June 2012 Bremerhaven to Spitsbergen [incl. Fram Strait]; AMT22, October 2012, Southampton to Punta Arenas) and run mostly successfully. Consequently, we have several large datasets, which are currently being analysed, calibrated and processed. Two PhD students and one research technician have been involved directly with the work at UEA. In the future, we are planning to participate in AMT23, October 2013, again from Southampton to Punta Arenas as part of the NERC-funded project RAGNARoCC. Additional funding for N_2O/CH_4 related work on voluntary observing ships has been allocated to Watson & Schuster via the European FP7 infrastructure project INGOS. In addition to greenhouse gas abundance measurements in the ocean, I am interested in particular in using their isotopic composition as an additional constraint on sources and sinks. We have built an extraction system for N2O isotopologue measurements, which, in principle, could also be used for dissolved N2O concentration measurements (albeit at reduced precision).

Annette Kock: I have been involved in several N_2O/CH_4 measurements campaigns in the tropical Atlantic Ocean, off Peru, in the Arabian Sea and in the Labrador Sea as well as at the Boknis Eck Time Series site. Moreover, I am especially interested in the effect of surfactants on trace gas exchange. Since the beginning of 2013 I am coordinating the activities of MEMENTO (the MarinE MethanE and NiTrous Oxide database).

Cliff Law: My interest is primarily in understanding the mechanisms of production and cycling of both gases via Lagrangian studies of surface phytoplankton blooms in NZ waters, laboratory culture experiments and isotope measurements. Current field measurements focus on methane production and emission from NZ methane hydrate seeps and in NZ coastal regions. The Biophysical Moorings Time Series programme has just ended and so we don't currently operate

an open ocean CH_4 & N_2O time-series in NZ, but opportunities exist on the Munida line (South Island, New Zealand, includes neritic, sub-tropical & sub-Antarctic water, bimonthly sampling for CO_2 & carbonate system), & also on a ship of opportunity transect between NZ and Japan (every 3-4 months). We have collected a large dataset (~3000 measurements) of surface water CH_4 measurements from around the New Zealand Economic Exclusion Zone over the last decade; this should be published in the next year and so the dataset will be available.

Wajih Naqvi: Time series: Candolim Time Series Station off Goa (Arabian Sea); Greenhouse gases in the ocean: Production, consumption and emission to the atmosphere of CO_2, N_2O, CH_4 and halocarbons.

Andy Rees: Historical data-sets collected during JGOFS & SOLAS cruises to the Bellingshausen Sea (1992) and Mauritanian Upwelling (2009) have been submitted to Memento and British Oceanographic Data Centre (BODC), these data are freely available. More recently my group have collected data (N_2O & CH_4) over 12 months at the Plymouth Marine Laboratory time station site L4 (2011 & 2013 onwards), during UK ocean acidification cruises; around UK (2011), Arctic (2012) and Antarctic (2013). This data is or will soon be deposited at the BODC and can be deposited with Memento in the near future. I have funding for N_2O (only) analysis during the UK Shelf Seas Biogeochemistry Programme (3 cruises in the Celtic Sea during 2014) and in collaboration with Jan Kaiser funding for N_2O and CH_4 analysis during the UK Greenhouse Gases Programme (3 cruises in the North Atlantic 2013 – 2015). To date all PML data has been collected by GC (ECD and FID), though we have funding to purchase 2 cavity ringdown analysers under the Greenhouse Gas funding which hopefully will be deployed from 2014 onwards.

Gregor Rehder: I have been mostly focusing on methane measurements covering a vast variety of areas in the past. However, in the framework of this proposal, the most important part is the effort in the Baltic Sea since I started to establish the volatile group at the Baltic Sea Research Institute. Since late 2009, we emended a continual measurement system for methane to the pCO_2 system on board the VOS Finnmaid running between Helsinki and Travemünde (Gülzow et al., 2011 and 2013). The system will be extended to the measurement of N2O by the end of the year, and is a designated component of the ocean component of the German Contribution to ICOS, with a long term commitment by the institute for at least a decade. It has a special situation in ICOS, as it is bridging the land efforts and the ocean component, and therefore it is the only ocean component measuring the non-CO_2 greenhouse gases (i.e. our favorites). We have also established “continuous” sampling at the central stations of the Arkona Basin, Bornholm Basin and Gotland Basin since 2 years. Cont. measurement here means organizing the sampling during all monitoring stations, i.e. 5 times per year. It is however not sure that we will / can continue this series.

Philippe Tortell: We have been collecting samples 3 x per year (~ Feb., June, Aug.) since 2007 of CH_4 and N_2O along Line P in the Subarctic NE Pacific. A number of profiles were analyzed using a static head-space equilibration technique with a GC-MS. More recently, we've put a large amount of effort moving towards a fully automated purge and trap system. In terms of scientific questions, there are a number of interesting avenues related to the effects of declining ocean O_2 levels on N_2O and CH_4 production, as well as continental vs. open ocean sources of these gases. I also think it would be extremely valuable to put together time-series observations comparing CH_4 and N_2O in the Chilean, Hawaiian programs with the Line P data. This would give us some insight into patterns which may exist across different sub-regions of the Pacific Ocean.

Rob Upstill-Goddard: My research has involved evaluating the marine biogeochemical cycling of N_2O and CH_4 since 1992. My research group has been involved in cruises in the Arabian Sea/NWIO, the Atlantic, Arctic and Southern Oceans and in the North Sea, as well as carrying out surveys of several UK estuaries and mangrove surrounding waters in India. We have estimated air-sea fluxes in all open ocean and coastal work and in addition have examined sediment cycling/fluxes in coastal work. We also carried out an evaluation of potential geological sources of atmospheric methane on the UK continental shelf and have an interest in N_2O and CH_4 cycling at estuarine turbidity maxima. We are also involved in quantifying the controls on air-sea trace gas exchange and to that end we are examining CH_4 and N_2O transfer velocities under varying environmental conditions using a laboratory gas exchange tank of our own design. A new project is involved in quantifying the role of coastal sediment denitrification in N_2O cycling using laboratory mesocosm experiments. To date we have tended not to be involved in time-series measurements at a single station although there is potential to do that by incorporating CH_4 and N_2O measurements into those currently made routinely at Newcastle as part of the "Dove Time Series", which involves long-term sampling of several variables at sites located approximately 10 and 20 km offshore of Newcastle in the North Sea, which are indicators of long-term ecosystem variability http://www.mba.ac.uk/mecn/timeseries.htms.

Sam Wilson: My research involves measuring trace gases in the surface waters of oligotrophic North Pacific Ocean, mainly at the Hawaiian Ocean Time (HOT) series program station. The trace gases include N_2O, CH_4, H_2, CO, and DMS. N2O measurements were conducted for 4 years in the mid-1990s at Stn ALOHA by John Dore and others and more recently by myself from 2008 onwards. In addition to the trace gas measurements we try to understand the microbial biogeochemical cycling that lead to their formation such as N_2 fixation, nitrification, and sinking particles.

Guiling Zhang: My present research is mainly focused on the biogeochemistry of trace gases (CH_4 and N_2O) in the rivers, estuaries, coastal and shelf waters of China Seas. Dissolved CH_4 and N_2O have been observed monthly at the most downstream main channel station Xuliujing of Yangtze River since 2007 and at station Kenli of Yellow River since 2008 to monitor the long term variations of dissolved CH_4 and N_2O in large Chinese rivers. Distributions and sea-to-air fluxes of CH_4 and N_2O in the Yellow Sea, the Yangtze River Estuary and the East China Sea were determined during the period of 2001-2011. Annual CH_4 and N_2O input to the East China Sea via Yangtze River, CH_4 and N_2O exchange between sediment-water interface and between shelf and Kuroshio waters were also estimated and preliminary CH_4 and N_2O budgets were obtained for the East China Sea.

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6 May, 2013

Subject: SOLAS support for SCOR Working Group on Dissolved N_2O and CH_4 measurements: Working towards a global network of ocean time series measurements of N_2O and CH_4

Dear Ed,

With this letter SOLAS expresses strong support for the proposal to establish a SCOR Working Group on Dissolved N_2O and CH_4 measurements, submitted by Hermann Bange, Sam Wilson, and others. The proposal is a response to the need for intercalibration and standardization of protocols for the measurement of oceanic dissolved N_2O and CH_4. This effort will enhance the scientific value of the existing database for these greenhouse gases, and improve the quality of the data going forward. Intercalibration and standardization will improve the utility of the database both for the study of processes controlling the distribution and cycling of these gases and for the detection of future ocean change. This is a frontier issue scientifically and one of the scientific priorities for SOLAS.

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 the proposed activity. SOLAS 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 Working Group's activities to other ongoing SOLAS planning activities and scientific meetings. We expect that regular communiqués on the group's activities can be published via the SOLAS Newsletter and e-Bulletin.

The international team assembled for this Working Group is well qualified to carry out its mission and we hope that SCOR will be able to support the proposal. I look forward to this becoming one more area in which SOLAS and SCOR can continue our productive cooperation.

With very best regards,

Eric S. Saltzman
Chair, SOLAS Scientific Steering Committee

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2.3.4 SCOR Working Group on Climate and tsunami science with green repeaters submarine cable systems *Feeley*

SCOR Working Group Proposal

Climate and tsunami science with green repeaters on submarine cable systems

Summary
The goal of this SCOR working group is to promote the development of a new modality of ocean observing – the integration of sensors into commercial submarine telecommunication cable systems – by providing a cogent analysis of the scientific benefits, providing science guidance for the larger effort, and engaging the scientific community. Such new dual-use systems combining the communications arteries of our planet with environmental sensing will ultimately form an enduring global network that fills crucial gaps in current sampling, knowledge and application.

Current planning efforts have attracted significant commercial and government interest. The UN International Telecommunication Union (ITU) with UNESCO-IOC and WMO are leading the overall coordination effort that includes engineering, business and legal aspects; the SCOR Working Group (WG) will provide the crucial science review and guidance. The makeup of the WG reflects the international participation and cooperation needed to accomplish the goal. As this is a new, developing observing modality, entraining younger people to plan, develop, and eventually use it, is essential. We will produce a review of the science enabled by this technology including expected quantitative impacts on observing capability on implementation time scales of years to centuries. In addition to group telecommunications, a workshop and conference will be held.

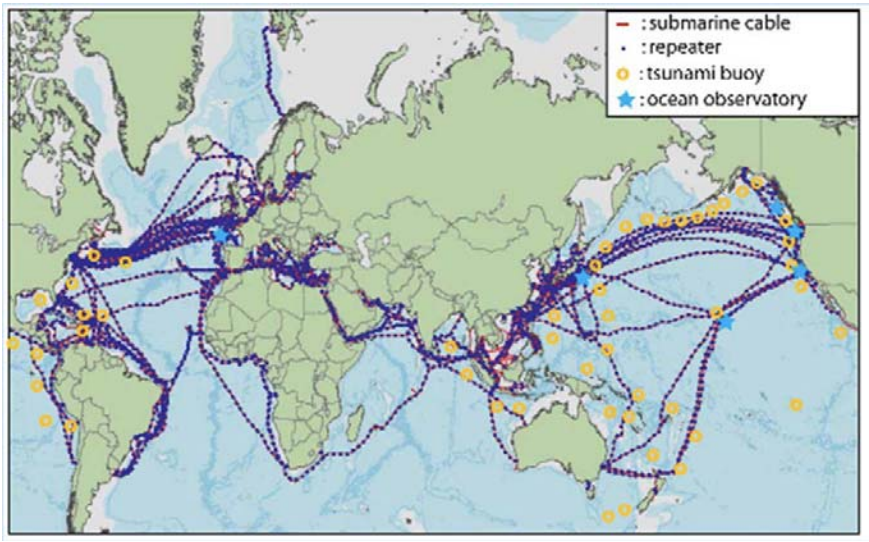

Figure 1: Abridged map of current submarine cable routes (red), with cable repeaters (dots, x4 less than actual). Tsunami buoys and other ocean observatories are also plotted. Initial plans call for pressure, temperature and acceleration sensors to be incorporated into repeaters of new "green" systems as they are deployed; subsequent systems could have additional sensors, with expected lifetimes of decades. Note, new systems are planned for the Arctic and the South Atlantic to reduce latency and improve spatial diversity.

SCOR Working Group

Developing a real-time global deep ocean system for understanding climate change and tsunami processes is a bold vision that has a high probability of success at this particular time given recent technology developments. Local and regional scale science cabled ocean observatory systems are now proven, e.g., NEPTUNE Canada, DONET in Japan, MACHO in Taiwan (Favali et al., 2010; Barnes et al., 2013). You (2010) proposed the much more global concept of incorporating sensors into repeaters on trans-ocean telecommunication cable systems.

The International Telecommunication Union (ITU), the World Meteorological Organization (WMO), and the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (UNESCO IOC) have joined together to promote, develop and transition this concept to reality (see ITU references and web pages below). Workshops (Submarine Cables for Ocean/Climate Monitoring and Disaster Warning: Science, Engineering, Business and Law) were held in Rome and Paris in 2011 and 2012, respectively, and the next workshop will be within the third ITU Green Standards Week in Madrid 19-20 September 2013. A Call to Action resulted in a Joint Task Force (JTF; 2012) to explore the potential of a submarine climate monitoring and disaster warning system.

The JTF is composed of over 80 experts from the science, engineering, business, marketing and law communities. Six committees have been established: Executive, Science and Society, Engineering, Business Model, Legal, and Publicity, and Awareness and Marketing. The JTF currently has limited financial support but does have the secretariat support of ITU. It is developing a pilot project to design, build and test a new repeater with a simple suite of sensors (pressure, temperature, acceleration), with possible partnership with industry (a multi-million dollar project over 2-3 years). In parallel, the JTF needs to see the science framework and international relationships established. We are requesting SCOR fund and oversee this activity over a four-year period. The resulting progress reports, publications, final reports and both a workshop and conference will be integrated with the parallel progress made by the other JTF committees. The current JTF plan calls for the green system to be developed and accepted by the telecommunications industry by 2017 and then implemented on an ongoing basis. Some companies have already expressed an expectation of being required to provide such environmental data, e.g. Arctic Fibre Inc. proposing a system from Japan to Europe through the Canadian Arctic Islands with science sensors and links with remote communities, arcticfibre.com; and a cable linking Australia, New Zealand and the United States, hawaikicable.co.nz.

Science Background

While there have been significant advances in ocean observing, the ocean remains poorly sampled, and the sampling that does occur is often aliased and incoherent. Consequently, there is a poor understanding of the ocean science and ocean processes in the vast areas of particularly the deep oceans, which is critical for issues of climate change and tsunamis dynamics. Dual-use commercial telecommunication cables provide an opportunity to rectify this situation. Below we highlight the science and operational observing that can be accomplished, emphasizing longer- term observations for climate and shorter-term tsunami detection.

The role of the deep ocean in climate change. The deep ocean is largely unknown. Understanding the deep ocean is indispensable to sustaining humankind on planet Earth and avoiding major

disruptions to the climate and life systems. The oceans are the primary driver of climate change, representing the largest store of energy and absorbing a third of the anthropogenic CO_2 produced.

Still largely unknown is the rate of temperature and circulation change in the bottom of the oceans, especially those areas affected by deep ocean meridional overturning circulation (MOC) such as in the North Atlantic and Southern Hemisphere around Antarctica (Stouffer et al., 2006; Purkey and Johnson, 2012). Descending cold, salty polar waters sink to the bottom of the ocean and circulate throughout the world ocean as part of the now well-know global ocean conveyor belt (Broecker, 2005, 2010). Studies have shown that the broad current patterns are rather more complex that first envisaged with many deflected side currents and influenced by seabed and ocean ridge topography (Richardson, 2008). Concerns about the more rapid than expected melting of Arctic sea ice and the Greenland ice cap (Alley, 2002) suggest that the models of climate change are not precise and need more input of observational data (Wijffels et al., 2010). A fundamental missing portion of critical climate observational data is the precise and changing temperature and pressure (measure of circulation) of ocean bottom waters along a variety of transects across the world's oceans. This is the *first key focus of this WG proposal*, using these new cable systems with added sensors to measure key variables such as ocean floor water temperatures.

Tsunami dynamics: much improved tracking of tsunamis across the world's oceans. The *second key focus of this WG proposal* is to use the same approach to better understand ocean hazards such as tsunamis generated by both large earthquakes and seabed slope failures. Major tsunamis have occurred several times in the last decade, most notably associated with megathrust earthquakes between M_W 7.7 and 9.1 in Sumatra (2004), Java (2006), US Samoa (2009), Mantawai (2010), Chile (2010) and Japan (2011) resulting in severe loss of life and billions of dollars of anthropogenic and environmental damage. Reducing such losses and mitigating damage is a key factor in developing tsunami warning systems (Bernard and Robinson, 2009; Whitmore, 2009). The offshore tsunami buoys (see Figure) provide some measure of warning but are widely spaced and prone to vandalism and failure (often only 60 percent available; National Academy of Science, 2010). This second focus of the WG includes using the network of sensor-equipped green repeaters located about every ~50 km along submarine cables to measure pressure and acceleration and thus establish a network of mini-observatories across many ocean transects that could map out in real time the speed, track and pattern of tsunamis.

Ocean floor topography and ridges, both in the open ocean and along continental margins and coasts, affect the speed and track of major tsunamis. Computer simulation models developed to help predict the affects of tsunamis along particular coastlines are constrained by variable previous and present tsunami data. The new data established by the many sensor-equipped trans- ocean cables could substantially improve the models and generate social and economic benefits, especially to non-developed countries (such as many Pacific Ocean and Indian Ocean island states).

Other science topics

While this four year WG project would emphasize the science of climate change and tsunamis using new bottom sensors (p,T,a) on green repeaters and with an initial pilot project, we emphasize that this could evolve into a long-term effort to include others sensors (inverted

echosounder/acoustic modem, salinity, O_2, CO_2, pH, bio-optics, etc.) that enable much broader spatial coverage and diversity of science.

Also, there are too few environmental measurements made consistently over many years, especially long-term measurements at the bottom of the oceans. Many of these sensors cut across and support different science topics and disciplines. A comprehensive modeling and observing system simulation will be required to quantify absolute and relative value of these measurements.

Terms of Reference
The Terms of Reference for the Working Group are:

1. Evaluate the scientific opportunities for understanding ocean circulation and climate change, and tsunami dynamics, using new green repeaters on submarine telecommunication cables.
2. Develop a science strategy and schedule to adopt modified submarine systems equipped with scientific sensors such as pressure, temperature, acceleration, salinity/conductivity, and hydroacoustic. Review future opportunities for acoustic monitoring of marine life, earthquakes, and volcanism.
3. Identify specific types of sensors currently available, or in development, that could meet the needs of the scientific community, be reasonably inexpensive, small, integrative, robust, reliable, long-lasting, and readily deployable to meet the design connections within, or connected to, the green repeaters. The aim is to establish a new and increasing global network of ocean environmental sensors for ocean climate and tsunami research and warning systems.
4. Analyze the development of current and planned commercial and major scientific repeatered ocean observatory projects that could include new, renovated, and relocated retired out-of-service cables that could host the new network.
5. Cooperate closely with the ITU/WMO/UNESCO IOC Joint Task Force (JTF) and the International Cable Protection Committee (ICPC) to support dual-use of cables by safely incorporating the required scientific sensors into green submarine repeaters without affecting normal cable systems and telecommunication signals (http://www.itu.int/en/ITU-T/climatechange/task-force-sc/Pages/default.aspx; http://www.iscpc.org/).
6. Organize teleconferences, symposia and workshops to report on progress, engage with interested and vested research communities. Two to three such meetings would be arranged over the four years. Produce journal publications as well as formal interim and final reports to SCOR, JTF and ICPC.

List of Products from the WG

1. Introductory article in *Eos.*
2. Article(s) on science potential in a peer-reviewed journal.
3. Report on recommendations for future directions and guidance for the larger effort, for dissemination to ITU, WMO, UNESCO IOC, as well as CLIVAR, GOOS, GEOSS, and others.
4. One early workshop and a final conference.

Collaboration and Capacity Building
As noted in several places in this proposal, the WG will be well connected into agencies that can assist with capacity building, such as SCOR, ITU, WMO, UNESCO IOC, as well as POGO.

Collaboration with scientific programs is noted (e.g. CLIVAR, GOOS, GEOSS) and with the JTF and ICPC. Committee members are already well connected into relevant networks and programs.

Timeline
We will begin immediately with an *Eos* article to encourage participation and interaction in the scientific community.

1. The first meeting will be held in conjunction with the AGU Ocean Sciences Meeting in Honolulu, Hawaii in February 2014. At this meeting we will:
   a. Outline the project: schedule, opportunities, networking strategy and planned publications and meetings
   b. Encourage WG members to participate in related activities in home countries/institutions and with dissemination
   c. Identify strategies for further study (e.g., observing system simulation experiments) and promotion of concept
   d. Address interaction with ITU/IOC/WMO and related programs. e. Develop a detailed capacity-building plan
2. A second meeting, as a workshop, will be held in 2015, possibly in conjunction with an ITU Green Week and/or a JTF meeting. Students and alternates will be invited to attend. We will:
   a. Finalize paper(s) for submission
   b. Prepare the conference proposal and funding requests c. Outline the Report for recommendations
3. In the third meeting (possibly by telecommunication) in 2016, we will
   a. Finalize the report
   b. Finalize conference planning
4. The conference (and associated report) in 2017 will be the final activity of the WG.

Chairs and Working Group Members
The proposed working group (table below) has extensive field, analysis, and modeling expertise: all readily have agreed to serve. The two co-chairs are Bruce Howe at the School of Ocean and Earth Science and Technology, University of Hawaii, and John Yuzhu You at the Institute of Marine Science, University of Sydney. Howe has worked on basin-scale acoustic thermometry, the NEPTUNE cabled observatory systems, and now is now operating the ALOHA Cabled Observatory. You has worked on a broad range of topics including paleo and present climate, general ocean circulation, and mixing; he organized the PACSWIN (Indonesian Throughflow: PACific Source Water Investigation) Submarine Cable Workshop 2009 from which this current effort has evolved. The seven other members of the proposed WG represent a balance of expertise, national representation, seniority and gender.

Name	Seniority/ Gender	Affiliation	Expertise
Bruce Howe (co-chair)	sr/m	University of Hawaii, USA	Physical oceanography, ocean heat content, cabled ocean observatories
John Yuzhu You (co-chair)	sr/m	University of Sydney, Australia	Climate and ocean data analysis and modeling
Jerome Aucan	jr/m	IRD-LEGOS, France	Physical oceanography, tides, bottom pressure, tsunamis
Molly Baringer	mid/f	NOAA-AOML, USA	Abyssal temperature, cable-measured transport, meridional
Gerard McCarthy	jr/m	National Ocean Center, UK	Meridional overturning circulation
Wahyu Pandoe	mid/m	BPPT, Indonesia	Indonesian Tsunami Program, deep sea tsunami
Jae-Hun Park	mid/m	KIOST, Korea	Physical oceanography, bottom pressure, internal
Hanne Sagen	mid/f	Nansen Center, Norway	Polar oceanography and observing systems
Rick Thomson	sr/m	Fisheries and Oceans, Canada	Coastal and deep-sea physical oceanography, tsunami propagation physics

We have six volunteer Associate members who will support the effort with their particular expertise: Juliet Hermes, physical oceanography, long term observations of the southern oceans, member GCOS steering committee and Ocean Observations Panel for Climate (OOPC), South African Environmental Observation Network, South Africa; Steven Jayne, ocean and climate modeling, data assimilation, WHOI, USA; Janet Sprintall, physical oceanography, ocean observations and network design, SIO, USA; Fadli Syamsudin, physical oceanography, Indonesian Through Flow, BPPT, Indonesia; Ikuko Wada, subduction zone geodynamics, International Research Institute of Disaster Science, Tohoku University, Japan; and Jing Zhang, chemical oceanography and ocean circulation, University of Toyama, Japan.

SCOR support through the Working Group

SCOR is the most logical organization to support this proposal given the vital scientific issues, global approach, and socio-economic benefits. It is not surprising that the proposal is not too closely allied to earlier WGs. With the onset of a new era of cabled ocean observatories and real-time data, it is likely that SCOR will receive an increasing number of WG proposals related to cabled observatory science. The science supported through a SCOR WG would provide excellent arms-length oversight and credibility.

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October 23, 2013 R/PMEL

Dr. Ed Urban
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RE: SCOR WG Proposal on Climate and Tsunami science with green repeaters on submarine cable systems

Dear Ed:

I am writing in support of the proposal submitted for review by SCOR next month on "Climate and tsunami science with green repeaters on submarine cable systems" in my role as Engineering Chair of the WMO-ITU-UNESCO IOC Joint Task Force and as Director of Engineering of the Pacific Marine Environmental Lab that has been involved in tsunami and climate research for over 30 years.

The JTF was established jointly by three UN agencies in 2012, namely the International Telecommunications Union (ITU), UNESCO Intergovernmental Oceanographic Commission (UNESCO IOC) and the World Meteorological Organization (WMO). The JTF is tasked with developing a strategy and roadmap that could lead to enabling the availability of submarine cable repeaters equipped with scientific sensors for climate monitoring and disaster risk reduction (tsunamis, slope failures, meteo-tsunamis).

NOAA-PMEL has been investigating the 'dual-use' of commercial telecom cables as a long term replacement or enhancement of the present DART (Deep-ocean Assessment and Reporting of Tsunamis) buoy array. While the data from DART moorings have enabled accurate tsunami forecasts, they are subject to vandalism and have relatively high operation and maintenance costs. Similar or higher frequency measurements from 'dual-use' telecom cables have the potential for much longer deployment life and are less likely to be vandalized. Additionally, high accuracy temperature sensors in the poorly sampled abyssal ocean also have great potential for scientific advancements. These measurements are certainly worthy of independent scientific investigation.

I highly recommend the establishment of a small number of science specialists as a SCOR Working Group to consider and provide scientific analysis, advice and publications on the wider scientific implications of this revolutionary concept for a global network of sensors integrated on trans-ocean and regional telecommunication cables. The acquisition of such decadal real time

data represents a profound contribution to understanding changes in deep ocean temperature and circulation as well as adding vast scope to the present tsunami networks for hazard mitigation and tsunami research.

With regards,

Christian Meinig
Chair, Engineering Committee, Joint Task Force

Dr. Ed Urban
Executive Officer
Scientific Committee on Oceanic Research (SCOR)
College of Earth, Ocean, and Environment
Robinson Hall
University of Delaware
Newark, DE 19716 US

22 October 2013

Dear Ed:

RE: SCOR Working Group Proposal on Climate and tsunami science with green repeaters on submarine cable systems

I am writing on behalf of the WMO-ITU-UNESCO IOC Joint Task Force in support of the proposal submitted for review by SCOR next month on "Climate and tsunami science with green repeaters on submarine cable systems".

The JTF was established jointly by three UN agencies in 2012, namely the International Telecommunications Union (ITU), UNESCO Intergovernmental Oceanographic Commission (UNESCO IOC) and the World Meteorological Organization (WMO). The TJF is tasked with developing a strategy and roadmap that could lead to enabling the availability of submarine cable repeaters equipped with scientific sensors for climate monitoring and disaster risk reduction (tsunamis, slope failures). Following a two-day workshop last month in Madrid as part of the ITU Green Week conference, the next stage will be to complete two studies: a) a technical Functional Requirements Study that will meet the detailed evaluation needs of the telecommunication industry, and b) a Business Model Study to establish the financial basis for the Wet Demonstrator Project and the Operational Phase. We anticipate funding these short-term (3-5 month) studies through contributions from the member supplier companies in the telecommunication sector in Q1-2 of 2014.

The three UN agencies are each under severe financial pressure these days and can only provide secretariat support, coordination and communications. The JTF has six standing committees: Executive, Science and Society, Engineering, Business Model, Legal, and Publicity, Outreach and Marketing. We would welcome most highly the establishment of a small number of science specialists as a SCOR Working Group to consider and provide scientific analysis, advice and publications on the wider scientific implications of this revolutionary concept for a global network of sensors integrated on trans-ocean and regional telecommunication cables.

The WG would connect the interests of the developed and less developed world and communicate on these issues with the wider scientific community. The requested four-year support would integrate perfectly with the anticipated development, testing and validation of the Wet Demonstrator by industry and academic researchers. The successful demonstration (proof of concept) would then be the basis for industry to deploy green cable systems on new networks and refurbished systems and for the consideration by government regulators. Dual connector systems have recently been commercialized by industry. The acquisition of such decadal real time data represents a profound contribution to understanding changes in deep ocean temperature and circulation as well as adding vast scope to the present tsunami networks for hazard mitigation.

Yours sincerely,

Christopher R. Barnes

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October 24, 2013

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RE: SCOR Working Group Proposal on Climate and tsunami science with green repeaters on submarine cable systems

Dear Ed:

I am writing in support of the proposal submitted for review by SCOR next month on "Climate and tsunami science with green repeaters on submarine cable systems".

Let me provide some brief historical background to put this opportunity in context. In the early 1990's when the first generation of fiber-optic cables were being designed, the U.S. scientific community led by Lou Lanzerotti at Bell Labs tried to have AT&T incorporate temperature sensors into the electro-optical regenerators. Although this was doable from the AT&T design engineers' perspective, the plan was nixed by AT&T brass as an unwarranted risk to the system. Imagine today if temperature sensors had been incorporated into TAT-8, -9, -10, -12, Hawaii-4, -5, TPC-3, -4, and PacRimEast, and other cables of this generation—the extraordinary deep-ocean temperature data set in the Atlantic and Pacific for global change since the 1990's, lost.

A new effort and opportunity now exists, led jointly by three U.N. Agencies: International Telecommunications Union (ITU), UNESCO Intergovernmental Oceanographic Commission (UNESCO-IOC) and the World Meteorological Organization (WMO). Because ITU's membership includes the global communications companies, the industry is engaged. Furthermore, the increasingly high profile of ocean climate change and tsunami disasters has led to a broad recognition of mankind's need to obtain fundamental data from the sea floor.

The explicitly international nature of this endeavor necessitates scientific input from the broad international community. At the same time, international scientific recognition of this opportunity is needed to establish a strong foundation for working with the telecommunication companies and governments. The Scientific Committee on Oceanic Research (SCOR) provides such a respected framework.

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I strongly recommend SCOR to take this first step for establishing a SCOR Working Group to provide an international focus and scientific framework for establishing scientific sensors in future submarine telecommunications cables. The time is ripe to leverage the interests of the U.N. and telecommunications industry. Let's not lose another decade of deep-ocean data for lack of action and resolve.

Sincerely yours,

Rhett Butler
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Hawai'i Institute of Geophysics and Planetology
University of Hawai'i at Mānoa

2.3.5 SCOR Working Group Towards harmonization of global oceanic nutrient data

Proposal for a SCOR Working Group: Towards harmonization of global oceanic nutrient data

Rationale

One of the major challenges for the future of planet Earth will be the accurate observation of changes to both the upper water column and also to deep oceanic waters, in particular with respect to carbon and dissolved nutrients, with the important requirement to be able to detect global changes in geochemical cycles. We therefore need to be able to reliably compare results for oceanic waters from different sources, with total confidence. However, there are currently no mechanisms for global consensus to obtain consistently accurate nutrient data. We believe that there is a requirement for laboratories around the globe involved in these studies to harmonize their analytical outputs of global oceanic nutrients in order to achieve this aim of accurate comparisons. We also recognize the importance of quality and harmonization in coastal and shelf water nutrient analysis, but here we focus only on the important scientific question of any climate-induced changes to the upper and deep oceanic nutrient regimes. The significance of harmonization of a number of other important ocean processes such as, temperature measurements (ITS90, traceable to SI using Standard Platinum Resistance Thermometer, SPRT), salinity measurements (comparability ensured using IAPSO salinity standard seawater provided by OSI, UK) and carbonate system parameter measurements (comparability and traceability ensured using CRMs provided by Dickson's laboratory, SIO, USA, Dickson, 2003; 2010), have already all been established.

Since 1965 there have been a number of inter-laboratory comparison studies, of various magnitudes, that have been conducted to investigate the comparability of nutrient analyses between laboratories. These were led by UNESCO, ICES, NOAA/NRC, QUASIMEME and MRI (UNESCO, 1965, 1967; ICES 1967, 1977; Kirkwood, 1991, Aminot and Kirkwood., 1995; Topping, 1997; Willie and Clancy, 2000; Clancy and Willie, 2003; Aoyama et al., 2006, 2008, 2010, 2013), and recently the updated nutrient analytical manual based on best practices (GO-SHIP manual by IOC-ICES Study Group on Nutrient Standards (SGONS), Hydes et al 2010) has been published. These initiatives have all aimed at contributing to improving nutrient analysis and comparability during these several decades. However, there has never yet been a properly coordinated effort to harmonize these studies and allow us to combine results from different laboratories with confidence. This will be the first step in allowing us to be able to detect any changes to oceanic nutrients over time, and open the opportunity of determining how these changes are affecting global geochemical cycles.

The IPCC Report in 2007 highlighted the current problem inherent in comparing existing data sets stating that: "Uncertainties in deep ocean nutrient observations may be responsible for the lack of coherence in the nutrient changes. Sources of inaccuracy include the limited number of observations and the lack of compatibility between measurements from different laboratories at different times" (Bindoff et al., 2007). Actually, results of global crossover station analysis showed discrepancies of up to 10 % for deep nutrient data during the last three decades (Aoyama et al., 2013), and the results of inter-laboratory comparison studies since 2003 showed a similar

magnitude of discrepancy among some of the participant laboratories (Aoyama et al., 2007; 2008; 2010). This also indicates that analytical problems may cause larger discrepancies for deep water nutrients. Although this situation has been improved somewhat, it is still difficult to ascertain with any certainty temporal changes in ocean nutrients. We can however now detect changes in deep ocean temperature (and hence heat content) (Levitus et al., 2009; 2012; Kouketsu et al. 2009) from observations due to their relatively larger changes compared with those in nutrients, and comparability of temperature measurements are possible in the order of mK. Changes to the carbonate system parameters in the deep ocean are also reported with comparability being ensured by the use of CRMs (e.g. Wanninkhof et al., 2010, Ríos et al., 2012, Khatiwala et al., 2012). Similarly, changes to the oceanic oxygen can now be accurately observed (Stendardo and Gruber, 2012).

If we can establish mechanisms to harmonize the quality of oceanic nutrient data, we will be able to detect changes in nutrient levels due to human impact and shifting physical processes, which might alter the supply of nutrients to the upper ocean and/or due to changes of ocean circulation which might be the cause of changes to nutrients in deep waters. Improved comparability of nutrient concentrations in the water column will also help us to improve estimation of the anthropogenic portion of the observed increase of total carbon in the water column.

Marine chemists have previously been active in the pursuit of establishing reliable comparability of nutrient measurements. A consensus was achieved through the former IOC-ICES Study Group (SGONS – Study Group on Nutrient Standards, 2009-2012) activity in realizing (i) the limits imposed on the work by the purity of "off-the-shelf" chemicals, (ii) the form that reference materials should take, (iii) the quantities that would need to be produced for global use, and (iv) that use of the reference materials would also need to be accompanied by adherence to "best practice for their use".

To properly guarantee comparability of data from different laboratories and from different research cruises, the precise mechanisms for a global consensus for nutrient levels need to be developed. This will foster a move towards the harmonization of nutrient data using globally accepted RMs/CRMs, followed by the recommendation of protocols for their use throughout the world-wide marine chemistry community. This has already been achieved both by the use of CRMs for measurements of the CO_2 system, and the use of the IAPSO standard seawater for salinity measurements.

The situation now calls for further international collaboration through SCOR, and a Working Group to establish the mechanisms required to harmonize the quality of oceanic nutrient data, using globally accepted RMs/CRMs. A major challenge with this SCOR WG and one which is particularly important for the study of changes in properties of deep water masses is to develop a system by which the comparability of data within and between laboratories is better than 0.2 % at full scale of nitrate, phosphate and silicate concentration. This level of comparability has already been achieved for the measurement of total carbon.

This objective should be the goal for data generated during individual research cruises and extended to allowing comparisons between cruises separated by decades. The experiences of this SCOR WG will also give positive feed-back to the scientific communities of coastal ocean observatories, and for researchers developing nutrient sensors for buoys and floats, by providing and recommending globally accepted RMs/CRMs for the calibration of instruments and sensors, and providing globally accepted analytical methods based on best practices. Such feedbacks will move towards the goal of achieving comparability of nutrient data throughout the oceans, which will have been obtained by different methods, instruments, and technologies.

A recent Framework of Ocean Observing (FOO) statement introduced the concept of Essential Ocean Variables (EOVs), and the assessment and development of readiness for sustained observations, with the aim of promoting collaboration in developing requirements, observing networks, and data and information streams. Nutrients are identified as one of these EOVs (Fischer & Grimes, 2013).

We propose that a SCOR working group would be the most effective and timely way to now develop the mechanisms to harmonize nutrient data using globally accepted RMs/CRMs with, and for, the global oceanographic community, and for it to become involved through SCOR and promote the global use of CRMs for oceanic nutrient analysis. This initiative will be based on previously developed collaboration with the IOC-ICES SGONS which ended in 2012. For future generations it is unacceptable to produce historical data sets without having an acceptable reference scale for multi-year comparisons.

Scientific and Technological Background

Measurements of nitrogen (as NO_3), phosphorus (as PO_4), and silicon (as $Si(OH)_4$) are fundamental requirements for oceanographic studies of hydrography, biogeochemistry and biology.

For example, accurate measurement of nutrients is essential for tracing the uptake of anthropogenic carbon into the ocean and is also essential for observing changes in deep ocean dissolved nutrients, all as a part of the global changes to geochemical cycles. However, at the current time, the reliability of such assessments are uncertain, due mainly to the lack of widely useable reference materials that would allow for more confidence when comparing crucial data sets, taken from different laboratories worldwide.

Large global observing programs and more local projects require more-comparable information to support assessments of the health and productivity of coastal oceans, changes to the deep oceans, sustainability of marine ecosystems, and predictability of climate change, as well as other processes that affect the Earth's population on many levels. The accuracy of chemical oceanographic measurements depends on calibration against certified reference materials to ensure global comparability over time.

In 2002, a U.S. National Research Council (USNRC) report (Dickson et al., 2002) clearly stated that key parameters (including nutrients) lacked reliable and readily available reference materials. The USNRC report identified the most urgently required chemical reference materials based on certain key themes for oceanographic research. At the top of the report's list of the new reference

materials needed were standards for the measurement of nutrients. The report stated: "There is an urgent need for a certified reference material for nutrients. Completed global surveys already suffer from the lack of previously available standards, and the success of future surveys as well as the development of instruments capable of remote time-series measurements will rest on the availability and use of good nutrient reference materials". Since that time there have been developed a number of reference materials for oceanographic use have been developed i.e., a Danish RM, NRC-Canada RM, and one developed by KANSO-Japan. The responsibility for resource seawater sampling, onboard pasteurization and the distribution of this RM will be taken on by JAMSTEC (Japan Agency for Marine-Earth Science and Technology), which will distribute the RM globally, in the same manner as the carbonate system CRMs from Dickson's laboratory (SIO, Scripps).

The WOCE guidelines published in 1991 (Joyce et al., 1991) suggested that levels of precision (0.2% of full scale for nitrate and silicate concentrations, with 0.4 % for phosphate concentrations) were achievable by the better performing laboratories individually, without RMs/CRMs. However, this level of relative precision has not actually been achieved between laboratories. We need to put into place the tools needed for the improvement of inter-laboratory precision. Key to achieving the required accuracy is having reliable RM's which enables the linkage of data between laboratories.

In-situ nutrient sensors are a future nutrient analytical technology that needs addressing and hence the need for their use of CRM's to be able to give confidence to the output data quality. Currently there is the Alliance of Coastal Technologies (ACT) group which has had 2 previous workshops devoted to nutrient measurements by sensors (ACT 2003; 2006), and we would look to include representatives from this sensor group in the future international inter-calibration exercise.

Terms of Reference and products

ToRs:

1. The Working Group will assess the homogeneity and stability of currently available RMs/CRMs. It will also determine if the currently available producers are achieving a level of precision within and between laboratories which is comparable to or better than 0.2 %. This task requires two things; consensus on the assigned value between laboratories (which can demonstrate they are producing data which is internally consistent at the 0.2 % level) and a system for carrying forward in time, the assignment of values which will be consistent over decades.
2. The Working Group will consider and report on how effective feedback loops could be established between data generators, database managers, and data users, so that effective alignment of, and complete traceability of any future measurements of nitrate, nitrite, phosphate and silicate in seawater would be achieved. This will require the development of standardized data-handling procedures, with common data vocabularies and formats across producers and users, and would also include the future linking of national and international data archives. The group will seek to involve international data center representatives to contribute to and lead this task.
3. The Group will report on a plan for the promotion of the use of RM in the global marine observing community. This will include:- (i) reporting of the results from previous global stability tests [see list at end for countries involved in the 2012 exercise]; (ii) promoting

the wider global use of RMs by arranging workshops to actively encourage their use and to provide training in best practice particularly in developing countries, and (iii) continuing regular global inter-comparison studies, following on from the previous exercises in 2003, 2006, 2008 and 2012, with collaboration with funding by the IOCCP-SSG in 2014/2015.

4. The GO-SHIP nutrients measurement manual which was a product of the IOC-ICES SGONS (Hydes et al., 2009, see http://go-ship.org/Manual/Hydes_et_al_Nutrients.pdf) will be updated as part of this SCOR WG to include detailed protocols for the use of the RM solutions and the reporting of the analytical results based on a NIOZ/PML analytical workshop held in late 2012.

Products:
The WG will write an article for publication in EOS after its first meeting in early 2014 to inform the international community about the objectives and future plans of the SCOR WG. Talks and posters will be presented at the first Workshop proposed to be held at Ocean Sciences 2014 as to the current situation with regard to the issues of RM's, intercalibration exercises and issues related to the quality analysis of nutrients. Also, a written document will be produced from each WG meeting.

As a final product there will be produced a "best practices" manual which will provide the community with a recommended consistent approach to the sampling, analysis, use of RM's, quality control of nutrients, and the subsequent data handling

Meetings

Kick-off Meeting: Upon funding, the WG will have a kick-off meeting in early to mid 2014. In order to provide good international visibility, the most suitable international platform would be the OSM 2014 (February 23-28 2014, Hawaii, USA), where a workshop on changes of nutrients in the world's oceans and use of RMs/CRMs will be held, or alternatively this will be proposed at the 2014 EGU General Assembly (April 27 – 2 May 2014, Vienna, Austria).

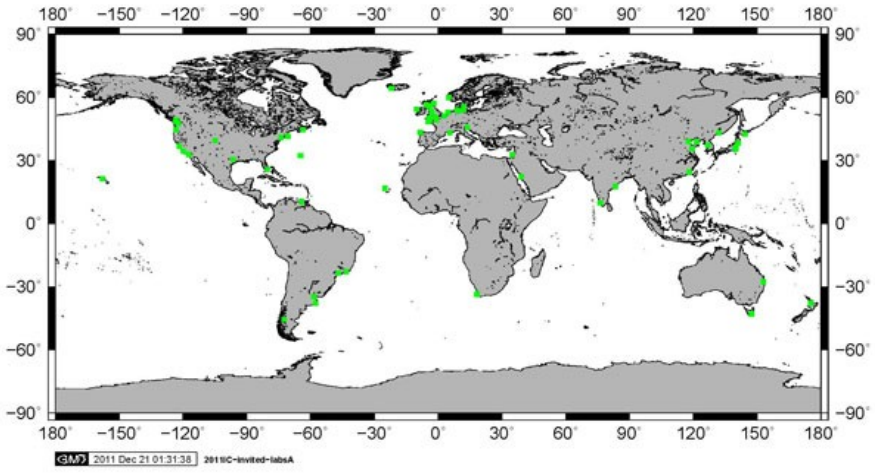
Main Meetings: Two main WG meetings will be held – one about half-way through and the other one towards the end of the WG lifetime in 2017. Potential venues for the half- way meeting are the AGU fall meeting in 2015 or the 2016 Ocean Sciences Meeting. Candidates for the final meeting could be the 2017 AGU fall meeting or 2017 EGU General Assembly.

Capacity building
This important aspect is reflected in two ways. The first is to promote participation of developing countries in inter-laboratory comparison studies of RM's through the POGO involvement. Secondly, is to invite participating laboratories to a 3-day workshop in 2015 planned to be held at the Scripps Institution (SIO), USA (depending on additional funding) to discuss results of inter-laboratory comparison studies of RM's.

Building capacities in developing countries can be accelerated by providing a good simple manual based on "best practices" and we will encourage greater participation in the future inter-laboratory comparison study of RM's proposed for 2015. The aspect of capacity building could be further augmented by hosting a session (in conjunction with a WG meeting/AGU meeting/OSM meeting), at approximately mid-term, to discuss the needs and capabilities of developing countries with respect to using other suitable programs. We will initially instigate a targeted questionnaire to laboratories in developing countries to highlight their most important analytical needs, this all be accomplished with the help and advice of POGO.

There is also agreement for sea-time to hold a nutrient inter calibration research cruise in late 2014 on the new Australian research ship the RV Investigator. Should the WG be funded then the intention would be to go ahead with this research voyage (potential funding is in discussion) with 6 or 7 global laboratories being represented to make comparative measurements at sea, and to test the use of suitable RM's in the working environment. The WG will also seek funding to host a POGO fellowship to take a scientist from a developing country on this voyage to work alongside experienced nutrient chemists, thus offering a unique training opportunity. This fellowship would also involve pre and post study time at the host laboratory in preparation for the voyage.

The laboratories that took part in the 2012 inter-comparison exercise of nutrients in seawater are shown below. The IOCCP-SSG will fund the next inter-comparison exercise of nutrient reference materials in seawater in 2015, collaborating with this proposed SCOR WG to expand global participation from the 2012 representatives from the following countries: Argentina, Australia, Belgium, Bermuda, Brazil, Canada, Cape Verde, Chile, China, Denmark, France, Germany, Iceland, India, Israel, Italy, Japan, Netherlands, New Zealand, Norway, Russia, Saudi Arabia, South Africa, South Korea, Spain, UK, USA, Venezuela. The 2015 inter-calibration exercise will expand this global group with more partners from developing countries.



The WG has been in contact with the Partnership for Observation of the Global Oceans, POGO, to also investigate hosting a nutrient training workshop in 2016 as part of POGO's portfolio of training and education activities.

Membership of Working Group

Full Members:

1. Michio Aoyama, MRI, Japan, Co-Chair, geochemistry (M)
2. Malcolm Woodward, PML, UK, Co-Chair, Low level precision measurements (M)
3. Toste Tanhua, GEOMAR, Germany, Chairman of the International Ocean Carbon Coordination Project: IOCCP (M)
4. Andrew Dickson, SIO, USA, CRM experience (M)
5. Bernadette Sloyan, CSIRO, Australia, CLIVAR/GO-SHIP (F)
6. Anne Daniel, IFREMER, France, analytical methodologies (F)
7. Susan Becker, SIO, USA CLIVAR/GO-SHIP hydrography (F)
8. Minhan Dai, Xiamen University, China, Large global (LOICZ and Chinese programs (M)
9. Akihiko Murata, JAMSTEC, Japan, Chemical oceanography, Global carbon/nutrient stoichiometry (M)
10. Howard Waldron, Department of Oceanography, University of Cape Town, South Africa (M)

Associate Members:

Trevor Platt, Executive Director, POGO
Alex Kozyr, USA, experience with multiple user database access (SOCAT): Karel Bakker, NIOZ, The Netherlands sea-going analytical facility:
David Hydes, NOC, UK, ICES Marine Chemistry working group, (ICES/PICES): Takeshi Yoshimura, CRIEPI, Organic Nutrients
Jonathan Sharp, University of Delaware, USA, DOC RM experience
Akiharu Hioki, NMIJ, Japan, certification of RM Ralph Sturgeon, NRC, Canada, CRM producer.

FOO project: The group will be linked to the development of the FOO (Framework of Ocean Observations) effort by input from Toste Tanhua (currently Chairman of the International Ocean Carbon Coordination Project: IOCCP).

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Acronyms:

CLIVAR	Climate Variability and Predictability
CRIEPI	Central Research Institute of Electric Power Industry
CRMs	Certified Reference Materials
CSIRO	The Commonwealth Scientific and Industrial Research Organisation
DIC	Dissolved Inorganic Carbon
DOC	Dissolved organic carbon
EOVs	Essential Ocean Variables
EOS	Eos, Transactions American Geophysical Union
FOO	Framework of Ocean Observations
GO_SHIP	Global Ocean ship-based hydrographic investigations program
ICES	International Council for the Exploration of the Sea
IFM-GEOMAR	Leibniz Institute of Marine Sciences - Marine Biogeochemistry
IFREMER	French Research Institute for Exploitation of the Sea
IOC	Intergovernmental Oceanographic Commission
IOCCP	International Ocean Carbon Coordination Project

IPCC AR4	IPCC Fourth Assessment Report
ITS90	The International Temperature Scale of 1990
JAMSTEC	Japan Agency for Marine-Earth Science and Technology
LOICZ	Land-Ocean Interactions in the Coastal Zone
NIOZ	Royal Netherlands Institute for Sea Research
NMIJ	National Metrology Institute of Japan
NRC	National Research Council Canada
PICES	The North Pacific Marine Science Organization
PML	Plymouth Marine Laboratory
POGO	Partnership for Observation of the Global Ocean
RM	Reference Material
RMNS	Reference Materials for Nutrients in Seawater
SCOR	Scientific Committee on Oceanic Research
SGONS	The Joint ICES-IOC Study Group on Nutrients Standards
SIO	Scripps Institution of Oceanography
SPRT	Standard Platinum Resistance Thermometer
SOCAT	Surface Ocean CO2 Atlas
SSG	Science Steering Group
ToR	Terms of Reference
UNESCO	United Nations Educational Science and Culture Organization
USNRC	United States National Research Council
WG	working group
WOCE	World Ocean Circulation Experiment

2.3.6 SCOR Working Group on Development of new methodologies for chemical and other branches of oceanography *Volkman*

Proposal for a SCOR working group on the development of new methodologies for chemical and other branches of oceanography

Abstract

The construction of large networked observing systems and the development of a variety of autonomous vehicles have provided an unprecedented opportunity to study the ocean at spatial and temporal scales that have not been previously available to the ocean research community. However, as a result of power availability, mass and size constraints, and the limited ability to service instruments on these platforms, there are only a few parameters of interest to oceanographers that can take advantage of this expensive infrastructure. SCOR WG 142 on Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders was created to optimize the use of existing sensors. However, there is also an urgent need to develop new methodologies in oceanography that can meet these constraints on the development and deployment of new sensors, and a need to catalyze interactions among chemical oceanographers, analytical chemists, and ocean engineers to bring new technologies into use for ocean sensors.

The proposed SCOR working group would bring together members of the analytical chemistry, oceanography and ocean engineering communities to develop long-term collaborations across disciplinary boundaries to catalyse a fundamental shift in the analytical methodology used in chemical oceanography and allied fields.

Specifically the SCOR working group over a 4-year period would achieve the following tasks:

1) Produce and publish in a peer-reviewed journal an in-depth report providing a wide-ranging critical assessment of which new technologies in analytical chemistry might be profitably applied to the development of new measurement techniques in oceanographic research that would be compatible with the newly available observational infrastructure.
2) Identify existing funding sources within the global research community that could be targeted to support short-term exchanges of personnel between analytical chemistry and oceanographic laboratories to facilitate technology transfer.
3) Develop and submit coordinated proposals from the collaborating communities to international funding groups to facilitate an ongoing series of meetings between the groups.
4) Develop a web site to act as a clearing-house for the dissemination of information arising from tasks 1-3, to encourage new ideas and entrain new individuals into the collaborative process.

Rationale

Recognition of the need to observe the response of the ocean to climate forcing at a variety of temporal and spatial scales has led to large investments globally in the infrastructure of ocean observing systems (Clark, 2001, Cowles et al., 2010) that range from networked moorings to a variety of autonomous vehicles (Rudnick et al., 2004) that can telemeter real-time data back to shore and be used to develop and constrain oceanic models. These new platforms, however, have very severe operational constraints, such as low power availability, restricted weight capacity, limited access for servicing, etc. Currently, there are few sensors or methodologies available that can actually make measurements of oceanic properties that meet these requirements. Thus, only a few of the parameters of interest to oceanographers can be determined because current methodologies used in chemical and allied fields of oceanography are inconsistent with the constraints associated with these platforms. In order to take advantage of these new platforms it is clear that new approaches are needed to making analyte determinations in the ocean. There is thus an urgent need to catalyse a fundamental improvement in the methodologies used to determine a large number of oceanographic parameters in order to take advantage of this newly developed observational infrastructure.

Timeliness and Scientific Background

As a result of the development of new instrumentation and materials, the field of analytical chemistry, at this time, is a rapidly evolving area. While many chemical oceanographers have had a basic undergraduate training in chemistry, the inexorable increase in time since that training means that few practicing oceanographers are familiar with the latest developments in the field of analytical chemistry. As a result it is difficult, if not impossible, for chemical oceanographers to remain cognizant of fundamental improvements in the field of analytical chemistry that could be applied to the development of a new class of oceanographic methodologies. There is a need to bridge the gap between chemical oceanographers and analytical chemists; this has been recognized for a long time (Goldberg, 1988) and past suggestions to improve the measurement of carbon system parameters (among others), by bringing together oceanographers and analytical chemists (NRC, 1993; Walt and Urban, 1995) have produced tangible results. However, in rapidly changing fields the connection between the fields needs to be reinforced at regular intervals or, preferably, on a semi-continuous basis. Additionally, the advent of the new oceanographic observing infrastructure imposes requirements for miniaturisation, process control, and incorporation of instruments into pressure cases that requires engineering skills that few chemical oceanographers possess. There is therefore a need to bring together skilled individuals from these fields to focus on the development of new technologies that can fully utilise these new sampling platforms.

A recent meeting, held at the University of Hawaii, and funded by the US National Science Foundation's Chemical Oceanography and Chemicals Imaging programs,

provided an initial opportunity to bring together ~ 50 people from 14 countries representing the analytical chemistry, chemical oceanography and ocean engineering communities to initiate a dialogue amongst the communities and to identify promising technologies that might be applicable to the analytical requirements in oceanography (see http://www.soest.hawaii.edu/oceanography/faculty/chrism/COCA/Home.html).
The meeting successfully identified a critical mass of interested individuals and ideas and has been promoted in the analytical chemistry community by one of the attendees, but this was designed as a single meeting.
(http://www.soest.hawaii.edu/oceanography/faculty/chrism/COCA/Outcomes.html)
What is needed now is a continued effort to build on the foundation of connections created at the University of Hawaii meeting, continue the dialogue, and develop a longer-term association.

Reason for SCOR
SCOR is an ideal mechanism to achieve the next stage of this process as it will allow members of that original meeting, and the extended contacts that have now been made, to entrain others in those communities into a framework that will develop longer term plans that will continue after the SCOR working group completes its terms of reference. SCOR has played an important role in improving the measurements of chemical elements in seawater from SCOR's early years, starting with SCOR WG 6 on Chemical Oceanography and most recently through SCOR WG 109 on the Biogeochemistry of Iron in Seawater. The SCOR GEOTRACES project has stimulated improvements in the measurement of many trace elements and isotopes through an extensive intercalibration process for key GEOTRACES parameters.

The specific tasks that are envisaged for this working group will create a set of publications and activities that will define the success of the working group, but which will also provide a solid foundation for a self-sustaining cross-disciplinary collaboration that specifically targets fundamental problems in oceanography and that will lead to long-lasting capacity building benefits for our field. We have also approached the International Union of Pure and Applied Chemistry (IUPAC) to invite them to co-sponsor this working group

Thus the tasks that are envisaged for the working group consist of immediately reachable goals that will then be used to develop the most promising direction for future collaborations. Since the SCOR working group is deliberative in nature it is expected that the shape of the plan resulting from the SCOR working group may differ from that originally envisaged by the NSF, or this proposal, however, that is both expected and welcomed.

SCOR is also appropriate because the original Hawaii workshop attracted participants from 14 different countries as well as several representatives from manufacturers of commercial instrumentation. Although this broad international interest was gratifying, we believe that there will be interest in developing countries and countries with economies in transition and look forward to getting SCOR input to help entrain individuals from such places so that capacity building between the disciplines can be extended across national and economic boundaries, enriching nascent oceanographic programs in other countries. It is likely that minituarised sensor technology will eventually be much cheaper than currently available methodology and this will bring the opportunity to monitor critical chemical parameters within the economic reach of

countries with limited budgets for oceanographic research and will also increase their participation in important global studies.

Working group tasks and timeline

It is proposed that the WG will have a 4-year timeline with 3 meetings amongst the Full and Associate members. Since the project is cross–disciplinary, we will hold one of the group's meetings associated with an international oceanography meeting and another associated with a chemistry meeting of similar stature. This will also allow us to advertise the existence of this initiative to other members of those communities and bring new people and ideas into the process. The final meeting would be planned to coincide with a dedicated workshop. The design of the workshop and development of a funding plan for it is one of the WG tasks (**task 3, below**).

TOR #1: Produce and publish in a peer-reviewed journal a critical assessment of which analytical chemistry technologies might be newly applied to oceanographic research.

After approval, we would write a short article announcing the formation of the WG and soliciting input and submit this to *Eos* and also to a suitable forum that is seen by the analytical chemistry community. An initial meeting in the first full year would be held to develop and to assign groups of individuals to specific topics in analytical methodology that might be applied to oceanography. The NSF-funded meeting in Hawaii developed several target areas for research that now need to undergo rigorous in-depth evaluation. As part of this process the working group would identify particular topical areas of ocean science that would benefit from the individual development areas recommended. This would highlight the immediate practical benefits that would flow to understanding oceanic processes arising from the recommended development work.

It is expected that the individuals who take on this **first task** would use networks within their communities to evaluate current state of the art, inherent limitations of techniques, potential solutions to problems associated with oceanographic implementation and a list of scientific applications that the new technologies would enable. It is expected that this task will require 1 year. We would plan to publish the report that would be assembled from this task in the peer-reviewed literature. Since there is little overlap between the analytical chemistry and oceanography literature we would probably plan to publish in the oceanography literature but arrange for simultaneous publicising of the work in the analytical chemistry journals though articles tailored to the interests of this community. This decision would be made by the working group members.

TOR #2: Identify existing funding sources within the global research community that could be targeted to support short-term exchanges of personnel between analytical chemistry and oceanographic laboratories to facilitate technology transfer.

The **second task** that members would be asked to undertake simultaneously is to identify within their disciplines and countries, sources of funding that might be approached to support exchange of individuals between laboratories to enable technology transfer and understanding between the fields. We would also identify funding that could be used to host future training workshops that could be used to enable capacity building in under-represented regions.

It is expected that at least one video conference would be scheduled during this period to deal with issues arising and to modify topics if deemed appropriate.

A second full meeting in the group's year 2 would assess progress on the first and second terms of reference.

TOR #3: Develop and submit coordinated proposals from the collaborating communities to international funding groups to facilitate an ongoing series of meetings between the groups.

The second meeting will also undertake the third task:

The **third task** of the working group would be to identify and develop collaborative proposals to a variety of funding agencies to support a series of workshops that would become the next stage of the collaboration. It would be intended that the initial workshop would be near the end of the life of the SCOR working group and the final meeting of the SCOR working group would be at this meeting, signaling a transition of the effort from a SCOR-supported working group to a self-sustaining initiative with its own goals and membership.

TOR #4: Develop a web site to act as a clearing-house for the dissemination of information arising from tasks 1-3, to encourage new ideas and entrain new individuals into the collaborative process.

The final, **fourth task** of the working group, which would proceed in tandem with the first three would be to develop a web-based resource for individuals who are interested in participating in these developments by:

1) Disseminating the results of **task 1** widely for comment and to encourage individuals to take up research in these areas,
2) Provide a forum for discussion of **task 1** ideas and suggestion of others.
3) Advertise the availability and deadlines for grant applications identified by **task 2**.
4) Act as a matchmaker where possible to bring together individuals from the various communities to develop research proposals or pursue ideas under **task 1 & 2.**
5) Advertise and develop the workshop under **task 3** that would show progress in and encourage new developments.

Working group membership

The working group membership is designed to cover all of the three disciplines and also to ensure participation by younger scientists who will eventually be the standard bearers of this initiative. At this stage we have identified individuals from the pool of people who attended the University of Hawaii workshop. The expertise in ocean research and advanced analytical instrumentation tends to be largely confined to a few wealthy countries, although we are proposing two Full Members from developing countries. In addition, since capacity building would be one of the goals of this working group, with SCOR's assistance we would endeavour to identify individuals from these places, and would seek SCOR's assistance in funding their participation in the meetings through SCOR’s fund for travel of developing country scientists. The proposed members would create good connections between this working group and other relevant SCOR working groups, as well as with the SCOR- sponsored GEOTRACES project. The work of this group will benefit

the field of chemical oceanography mostly after GEOTRACES is completed and GEOTRACES does not fund this kind of activity.

Expertise
O = Oceanography
AC = Analytical Chemistry
OE = Ocean Engineering

Full members

O Chris Measures (USA), *Chair* – Co-chair of GEOTRACES Data Management Committee and expert on measurement of iron and aluminum in the ocean.

AC Sandy Dasgupta (USA) Editor Analytica Chimica Acta and expert in development of miniature detectors and automated instrumentation, expert in membrane systems and ion chromatography.

AC Paul Worsfold (UK) Past President, Analytical Division of the Royal Society of Chemistry, current Chair, Division of Analytical Chemistry, The European Association of Chemical and Molecular Sciences (EuCheMS) and expert in research at the interface of analytical chemistry and oceanography.

OE Matt Mowlem (UK) Expert in development of low cost high performance electrochemical, lab on a chip and optical sensors for nutrients, metals, gasses and carbonate system parameters.

O Kristin Buck (Bermuda) – Co-Chair of SCOR WG 139 on Organic Ligands: A Key Control on Trace Metal Biogeochemistry in the Ocean and expert in ligand chemistry.

O Sunil Singh (India) – Leader of GEOTRACES India, expert in the development of measurement techniques of various stable, radiogenic and radioactive isotopes and trace elements in the ocean.

AC Spas Kolev (Australia) Expert in aquatic analysis and monitoring of analytes at trace levels based on the application of advanced sampling and preconcentration techniques.

AC Raquel Mesquita (Portugal) Expert in developing robust, versatile and miniaturized automatic flow systems for studying water quality in dynamic systems

AC Jian Ma (China-Beijing) Background in both analytical chemistry and the oceanography with expertise in the application of solid phase extraction to ocean waters

O/AC Suenghee Han (Korea) Expert in mercury determination in coastal waters and sediments

Associate members

O Ed Boyle (USA) – Co-chair of GEOTRACES project and expert on measurement of iron and iron isotopes and lead and lead isotopes in the ocean.

O Maeve Lohan (UK) - Co-Chair of SCOR WG 139 on Organic Ligands: A Key Control on Trace Metal Biogeochemistry in the Ocean, member of GEOTRACES Scientific Steering Committee, and expert in ligand chemistry.

OE Ken Johnson (USA) – Co-Chair of SCOR WG 142 on Quality Control Procedures for Oxygen and Other Biogeochemical Sensors on Floats and Gliders, chemical oceanographer who has become an expert in instrument development, and member of the committee that produced the 1993 NRC report cited herein.

OE Carsten Frank (Germany) Expert in developing chemical analyzers and sensors for oceanographic applications.

OE Carole Barus (France) Expert in development of low energy electrochemical sensors for ocean use that generate reagents in situ.

AC Steven Soper (USA) Expert in developing minituarised chemical analysis systems, micro and nanofabrication, and LOC systems for field monitoring of both organic and inorganic ions.

AC Gary Heiftje (USA) Expert in the development of novel instrumentation for mass and optical spectrometry and elemental analysis.

O Tung Yuan Ho (China-Taipei) – Member of the GEOTRACES Scientific Steering Committee. Expert in marine trace metal biogeochemistry, trace metal analysis in seawater

O George Luther (USA) – Member of SCOR WG 135 on Hydrothermal Energy Transfer and its Impact on Ocean Carbon Cycles, and expert on development and measurements of sedimentary geochemistry using microelectrodes. Also a physical chemist.

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2.3.7 SCOR Working Group on Microbial Community Responses to Ocean Deoxygenation

Microbial Community Responses to Ocean Deoxygenation

Summary: Water column oxygen (O_2) deficiency shapes food web structure by progressively directing nutrients and energy away from higher trophic levels and into microbial community metabolism. There is increasing evidence that ocean warming trends will decrease dissolved O_2 concentrations within the coastal and interior regions of the ocean, resulting in oxygen minimum zone (OMZ) expansion. These processes will directly impact coastal benthic ecosystems and fisheries productivity due to habitat compression and changes in nutrient cycles with currently unconstrained feedbacks on the global ocean. Our SCOR working group will catalyze knowledge creation at the forefront of research on microbial community responses to changing levels of water column O_2-deficiency. We will unite oceanographers, microbial ecologists and biogeochemists to define model ecosystems, new standards of practice, and economies of scale needed for effective comparative analyses and enhanced forecasts of ocean deoxygenation. Our deliverables will include one field experience, two program meetings, a white paper on best practices, and a peer-reviewed monograph.

Objectives and timeliness: Direct quantitative comparisons of microbial community structure and function in O2-deficient marine waters are currently stymied by a lack of standards for process rate and molecular data collection. This deficiency prevents cross-scale analysis linking the genotypic properties of microbial communities to higher order biogeochemical cycles and impedes synergistic scientific collaborations. Moreover, we need to formally define model ecosystems and concerted community initiatives to address fundamental questions and take advantage of appropriate economies of scale for transformative knowledge creation and translation. Our working group proposal was inspired by a recent exploratory workshop sponsored by the Moore Foundation and the Agouron Institute in Santa Cruz, Chile, which focused on identifying opportunities and bottlenecks for collaborative research in O_2-deficient marine waters. This workshop identified cross-scale comparisons and standardized measurements as a key bottleneck and an urgent opportunity for transformative science. Here we propose the establishment of a working group that networks the intellectual power of oceanographers, microbial ecologists and biogeochemists to build on the momentum of the Chilean workshop based on the following program objectives:

1. Identify model ecosystems manifesting ecological and biogeochemical phenotypes across a range of water column O_2-deficiency states
2. Develop community standards of data collection for both process rate and molecular measurements enabling cross-scale comparisons
3. Establish core metrics for modeling microbial community responses to changing levels of O_2-deficiency.
4. Disseminate standards, data sets and comparative analysis to the wider oceanographic and Earth system science communities and the public.

Terms of Reference: Our working group will catalyze research network formation and collaborative scientific practices over a four-year time frame that progressively transforms participants into a more focused and effective research community.

1. In year 1 of the working group we will convene a practical workshop in Saanich Inlet, a seasonally anoxic fjord off the coast of Vancouver Island British Columbia, Canada, to ground truth common standards for process rate and molecular measurements and identify model ecosystems for future cross-scale comparative analyses.
2. In year 2, we will convene a meeting at the Leibniz Institute for Baltic Sea Research in Warnemünde, Germany to codify standards of best practice, identify leveraged funding opportunities and economies of scale, and compose a white paper describing said standards and opportunities.
3. In year 3, we will sponsor a topical session at an international conference such as ASLO, ISME, or ASM to highlight research findings informed by the best practices described in the white paper.
4. In year 4, we will convene a meeting at the National Institute of Oceanography in Goa, India to compile a peer-reviewed monograph, which we tentatively plan to publish as an electronic book in the Frontiers or PLoS open access journals to ensure both visibility and long-term access.

Scientific background and rationale: Ocean deoxygenation directly impacts marine ecosystem functions and services through changes in food web structure and biodiversity.[1] Climate change induced water column stratification and anthropogenic discharges are enhancing deoxygenation throughout the modern ocean.[2-6] As oxygen levels decline, energy is increasingly diverted away from higher trophic levels into microbial community metabolism resulting in significant environmental changes including fixed nitrogen loss, possible accumulation of hydrogen sulfide, and the production of climate active trace gases. Current research efforts are defining the interaction networks underlying microbial community metabolism in O_2-deficient waters and are rapidly generating new insights into coupled biogeochemical processes in the ocean.[7,8] However, many open questions remain regarding the commonalities and differences among and between locales, sensitivities to climate forcing, underlying regulatory mechanisms, and biotic interactions that modulate microbial community metabolism including grazing and viral infection. Moreover, we are presently unable to accurately forecast biogeochemical dynamics associated with changing levels of water column O_2-deficiency due, in part, to the limited integration of process rate and microbial community structure and function information between locales. Thus, the inevitable impacts of deoxygenation on ocean ecosystems, climate and human society remain uncertain. Technological innovations from high throughput sequencing to in situ monitoring and paired isotope labeling methods have increased our analytical capacity to probe the mechanisms underlying microbial community responses to ocean deoxygenation.[8-14] These technical innovations have yet to be standardized and applied in a cross-scale collaborative scientific endeavor to integrate process rate and microbial community structure and function information. A SCOR working group is needed to overcome existing activation barriers and achieve such cross-scale syntheses.

Why a SCOR Working Group?: Contemporary international collaborations can be effective in charting the microbial ecology and biogeochemistry of O_2-deficient waters. However these collaborations are almost exclusively compartmentalized into groups focused on specific biogeochemical processes in disparate oceanic locales. A SCOR working group would provide the opportunity to fuse these disparate efforts into a *bona fide* scientific network enabling synergistic cross-scale studies between locales that address long-term goals. Our working group focused on microbial controls on biogeochemical transformation and ecosystem stability in O_2-deficient marine waters is both timely and pressing as it directly addresses the ecological implications associated with current global warming trends and OMZ expansion. Our working group will promote idea exchange, community engagement and transformative collaborative research projects on a global-scale by uniting oceanographers, microbial ecologists and biogeochemists across geopolitical and traditional disciplinary boundaries. The resulting network will build capacity in developing nations (India, Chile) and promote best practices at the epicenter of a pivotal issue in marine and climate science. We expect that our working group will inspire national agencies and international organizations to support operational components of our combined research programs, promote economies of scale that leverage matching funds between stakeholders including national and regional funding agencies and the private sector.

Relevance to other SCOR activities: Our proposed working group synergies with existing SCOR working groups including WG5 "The International Indian Ocean Expedition", WG128 "Natural and Human-Induced Hypoxia and Consequences for Coastal Areas", WG134 "Microbial Carbon pump in the Ocean" and WG137 "Patterns of Phytoplankton Dynamics in Coastal Systems". SCOR has a record of sustained interest in water column O2-deficiency with a regional focus. Here we seek to develop an integrated science program that builds on previous working group successes on a global scale. Indeed a number of our members have participated in prior working groups bringing continuity and historical perspective to our new initiative. For example, between 2006-2010 associate members Daniel Conley, Nancy Rabalais, and SWA Naqvi participated in Working Group 128 focused on spatio-temporal variability, anthropogenic causes, ecological and biogeochemical impacts and ecosystem responses to coastal O_2-deficiency at a time when molecular methods for charting microbial community structure and function were still emerging. Our working group is differentiated from WG128 in its emphasis on cross-scale comparative analyses and standardization of process rate and molecular measurements. Our initiative is a direct and pressing response to recent scientific discoveries including the discovery of a cryptic sulfur cycle in the Eastern Tropical South Pacific OMZ[2] and the recent expansion of high throughput sequencing technologies opening a functional genomic window into microbial community metabolic potential and phenotypic expression. The monograph that we produce will integrate new data collected with best practices in working group defined model ecosystems to provide direct insight into the paradoxical role of microbial communities in biogeochemical transformation and ecosystem stability in O_2-deficient marine waters.

Composition of the group: Our working group management structure will be dynamic with leadership rotating between chairs each year. Bess Ward will serve as the leadership coordinator, working closely with the rotating chairs to ensure that working group objectives are met in accordance with the terms of reference. Sean Crowe and Steven Hallam will co-chair the field experience in year 1, Klaus Jurgens will chair the standards meeting in year 2, Virginia Edgcomb

and Veronique Garcon will co-chair the session searches in year 3 and Nagappa Ramaiah will chair the synthesis meeting in year 4. All full members are committed to participating in working group activities and will engage associate members in collaborative scientific endeavors. Sean Crowe and Steven Hallam will edit the monograph.. Associate members augment the experience and expertise of the working group and in several cases provide an intellectual bridge to prior SCOR working groups.

Full Members

Name	Expertise/System Focus	Institution	Email
Bess Ward	Biogeochemistry Open Ocean	Princeton University, USA	bbw@princeton.edu
Nagappa Ramaiah	Biogeochemistry Coastal Ocean	National Institute of Oceanography, India	ramaiah@nio.org
Phyllis Lam	Biogeochemistry Coastal/Open Ocean	University of Southampton, UK	P.Lam@soton.ac.uk
Sean Crowe	Biogeochemistry Coastal/Open Ocean	University of British Columbia, Canada	sacrowe@mail.ubc.ca
Veronique Garcon	Physical Oceanography Coastal/Open Ocean	Centre National de la Recherche Scientifique, France	veronique.garcon@legos.obs- mip.fr
Osvaldo Ulloa	Biological Oceanography Open Ocean	Universidad Concepcion, Chile	oulloa@udec.cl
Virginia Edgcomb	Microbial Ecology Coastal/Open Ocean	Woods Hole Oceanographic Institute, USA	vedgcomb@whoi.edu
Steven Hallam	Microbial Ecology Coastal/Open Ocean	University of British Columbia, Canada	shallam@mail.ubc.ca
Klaus Juergens	Microbial Ecology Enclosed Basin	Leibniz Institute for Baltic Sea Research, Germany	klaus.juergens@io-warnemuende.de
Matt Sullivan	Viral Ecology Open Ocean	University of Arizona, USA	mbsulli@email.arizona.edu

Bess Ward is the William J. Sinclair Professor of Geosciences and the Chair of the Department of Geosciences at Princeton University. She has pioneered nitrogen cycle process rate measurements in O_2- deficient coastal and open ocean waters helping to elucidate the distributed nature of nitrogen transformations within microbial communities. Her research focuses on the marine and global nitrogen cycle, using molecular biological investigations of marine bacteria and bacterial processes. A major and continuing theme in her work is nitrification and denitrification. She is a Fellow of the American Academy of Microbiology, the American Geophysical Union and the American Academy of Arts and Sciences. She has received numerous awards including the G. Evelyn Hutchinson Medal from the American Society of Limnology and Oceanography making her the first women and the youngest person ever to receive such an award.

Nagappa Ramaiah is chief scientist at the National Institute of Oceanography in Goa, India. He is a biological oceanographer with a deep and abiding interest in microbial mediated biogeochemical cycles. He has extensive leadership experience and has participated in numerous international oceanographic initiatives including previous SCOR working groups.
Phyllis Lam is a Lecturer at the University of Southampton and National Oceanography Centre in Southampton, UK. She is a microbial ecologist and biogeochemist with expertise in coupled process rate and molecular analyses including functional genomics, gene expression and nanoSIMS. Phyllis has extensive expertise in describing nitrogen cycling in both coastal and open ocean OMZs with particular emphasis on microbial controls on anaerobic ammonia oxidation.
Sean Crowe is an Assistant professor and Canada Research Chair nominee cross-appointed to the departments of Microbiology & Immunology, and Earth, Ocean & Atmospheric Sciences at the University of British Columbia. His background is transdisciplinary spanning the fields of geology, geochemistry and environmental microbiology. His specific interests are in the coupled evolution of microorganisms and Earth surface chemistry over multiple scales of space and time.
Veronique Garcon is a CNRS senior scientist at the Laboratoire d'Etudes en Géophysique et Océanographie Spatiales where she develops coupled physical/biogeochemical models of marine ecosystem function. Her research interests include marine biogeochemistry and ecosystem dynamics, large-scale ocean circulation and tracers, global carbon and nitrogen cycles, physical-biological interactions, eastern boundary upwelling systems and biogeochemical climatic monitoring. She is currently a steering committee member for SOLAS (Surface Ocean Lower Atmosphere Study) and has participated in numerous international collaborative initiatives.
Osvaldo Ulloa is Professor of Biological Oceanography at the University of Concepcion, in Concepcion, Chile. He is an international leader in the study of microbial community responses to marine O_2-deficiency with extensive biological oceanographic experience. He currently runs a time-series monitoring program in permanent and seasonal OMZs off the Chilean coast that has been the source of fundamental new insight into coupled biogeochemical cycling in the ocean.
Virginia Edgcomb is a Research Specialist in the department of Geology & Geophysics at the Woods Hole Oceanographic Institution. Her research focuses on the ecology and evolution of protists and their interactions with other microorganisms in marine micro-oxic and anoxic/sulfidic environments including coastal OMZs and semi-enclosed basins.
Steven Hallam is a Canada Research Chair in Environmental Genomics. He is an Associate Professor in the Department of Microbiology and Immunology and program faculty member in the bioinformatics training program at the University of British Columbia. His background is in the field of microbial ecological genomics and genetics with specific emphasis on the creation of computational tools and workflows for taxonomic and functional binning, population genome assembly, and comparative community analysis. He currently runs a time-series monitoring program in the northeast subarctic Pacific Ocean focused on microbial community structure and function in coastal and open ocean OMZs.
Klaus Jurgens is Professor of Biological Oceanography at the University of Rostock, Germany and the Deputy Head of Biological Oceanography at the Leibniz Institute for Baltic Sea Research in Warnemünde. He is international leader in the study of microbial community structure and function in O_2-deficient waters, with particular emphasis on

chemolithoautotrophic prokaryotes and protist interactions in enclosed basins including the Baltic and Black Seas.

Matt Sullivan is an Assistant Professor in Ecology & Evolutionary Biology and a Joint Assistant Professor of Molecular & Cellular Biology at the University of Arizona. His research aims to elucidate the mechanisms of phage and host genome evolution, as well as to explore the roles of ocean viruses in global biogeochemical cycling. In 2013 he was awarded a Marine Microbiology Investigator Award from the Gordon and Betty Moore Foundation in recognition of his ground breaking contributions to the field of viral ecology.

Associate Members

- Konstantinos Kormas (University of Thessaly, Greece: Microbial Ecologist)
- Daniel Conley (Lund University, Sweden: Quaternary Sciences),
- Karen Casciotti (Stanford University, USA: Geochemistry),
- Nancy Rabalais (Louisiana Universities Marine Consortium, USA: Biological Oceanography),
- Raquel Vaquer-Sunyer (Lund University, Sweden: Biogeochemistry),
- Frank Stewart (Georgia Tech, USA: Microbial Ecology),
- Mark Altabet (University of Massachusetts, USA: Geochemistry),
- SWA Naqvi (National Institute of Oceanography, India),
- Jody Wright (University of British Columbia, Canada: Microbial Ecologist),
- David Karl (University of Hawaii, USA: Biological Oceanographer),
- Jon Kaye (Gordon and Betty Moore Foundation: Program manager),
- Robinson (Wally) Fulweiler (Boston University, USA: Biogeochemist)
- Annie Bourbonnais (University of Massachusetts, USA: Geochemistry),
- Mak Saito (Woods Hole, USA, geochemistry).

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2.3.8 SCOR Working Group on Surface Wave in Ocean Circulation and Climate System

Coustenis

Proposal for a SCOR Working Group on Surface Waves in Ocean Circulation and Climate System

Abstract: Surface waves, as the most energetic motion in the ocean, are traditionally left out of large- scale ocean general circulation and climate models. Recent studies have shown that ocean surface waves could have decisive influence on basin scale temperature structure and circulation pattern through the surface wave-induced vertical mixing. This working group will explore and identify the crucial importance of surface waves in the upper ocean and climate system through modulation of the ocean vertical mixing and air-sea interaction, and will assess new observational programs needed to better parameterize the wave-induced vertical mixing in the upper ocean and the air-sea interaction processes at sea surface. This will make it possible to improve ocean and climate models by including the mixing effects associated with the surface waves through the whole water column. It may be a new channel to connect small-scale surface wave and large scale ocean circulation and global climate change.

1. Rationale

Wind energy input to surface waves is estimated as 60~70 TW (Wang and Huang, 2004; Rascle et al., 2008), which is much greater than the mechanical energy from all other sources in the ocean. A review by Wunsch and Ferrari (2004) clearly states the critical role of surface waves in vertical mixing of momentum and energy in the global ocean. However, nearly all previous scientific studies of large-scale oceanic and climate phenomena treat waves as a superfluous nuisance. Although wave-breaking is considered, its effects on large scale are limited in the top few meters, in the depth order of wave amplitude. Part of the reason is that waves were thought to be of small scales and therefore irrelevant; the other factor is that wave studies have been confined to studying waves for the sake of understanding the dynamics of waves only (Yuan and Huang, 2012). In fact, vertical mixing in the upper ocean and air-sea fluxes at the sea surface are not only strongly modulated but also determined by the surface wave conditions.

Climate and weather are essentially ocean-atmospheric interaction phenomena. Their dynamic and thermal regimes imply physical coupling of atmosphere and ocean in such a complicate way that the physical details are still elusive. The past parameterization approach to study such coupled models appear to have reached a limit in their performance, and failed to reproduce aspects of important observed air-sea interaction phenomena such as the phase of the ENSO cycle and tropical-cyclone intensity, among others. There is an urgent need for better physics for related numerical models.

Air-sea interaction phenomena, including weather and climate, represent a complicated chain of inter-connected and coupled processes. If, for example, global warming is happening non-uniformly, it will lead to changes of the atmospheric pressure gradients and therefore of wind systems, which should bring about alterations to the wave fields. The latter will provide

feedback on the winds and, most importantly, on the ocean mixing (Cavaleri et al., 2012). If the average prevalence or size of surface waves increase, which appears to be the case over the last 25 years (Young et al., 2011), they can mix the ocean deeper (Babanin, 2006). Since 2-3m of ocean water has the same heat capacity as the entire dry atmosphere (Soloviev and Lukas, 2003) and the deeper ocean is cold, such extra mixing should dampen the surface ocean warming. So, surface wave plays crucial role in the climate system.

2. Scientific Background

Simulations of the wave-mixing effects in climate models clearly demonstrate significant feedbacks from the ocean because of the additional mixing due to wave actions. This feedback impacts both the magnitudes and global distribution of primary atmospheric features such as temperature oscillations, pressure patterns and rainfall. When wave mixing is included, rainfall in summer months in Southeastern Asia, for example, is increased by 3mm per day. When full GCMs are explicitly coupled with the wave models (i.e., climate-model winds are used to generate and drive the waves, whose effects are then fed to the upper ocean), the correlation between simulated and observed sea temperatures increases by as much as 30% (Qiao et al., 2010). Note that the outcome is not entirely local, for the ocean circulation is affected, which makes the sea surface temperature is not necessarily decreased locally. It is interesting that an ocean circulation model can works well with wave-induced mixing even excluding the shear-induced vertical mixing (Qiao and Huang, 2012).

This working group will bring together the wave-coupled effects on the upper ocean, weather and climate. Weather and climate are phenomena of very different scales (days vs. years and decades, respectively). Both scales, however, are much larger with respect to the scale of ocean surface waves (seconds). Consequently, wave-related air-sea interactions in weather and in climate research have not been coupled due to the following two main reasons: In terms of geophysics, there is a traditional perception that processes of such distant scales can be studied and modeled separately, and exchange between the scales can be parameterized as some larger-scale average (mean fluxes of energy and momentum in this case). In terms of technicality, the computational costs of such coupling have been prohibitive until recently, and are still very expensive.

The fluxes, however, are not constant in the course of wave evolution, even if the wind is constant. These fluxes are determined by a great variety of wave-related properties which vary at time scale of hours, which is comparable with the lower time scale of evolution for weather patterns. Since the concurrent wave pattern is very complicated, it appears necessary to know the wave properties explicitly at each step of cyclone development.

On the atmospheric side of the ocean interface, waves determine the surface drag that is how much the surface winds are slowed down because of the wave presence. In very simple terms, the drag should increase as the winds grow, but there is experimental evidence that this growth slows down and even decreases at higher wind speeds (Powel et al., 2003), either due to aerodynamic effects imposed by waves (e.g., Donelan et al., 2006) or due to spray produced by the waves (e.g., Kudryavtsev and Makin, 2011), or due to a combination of these and other influences. Recent hurricane-wave coupling investigations have demonstrated the significance of such feedback processes (Moon et al., 2008).

Below the surface, the effects of turbulence induced by breaking waves have long been appreciated (Soloviev and Lukas, 2003). The mixing and the turbulence induced by non-breaking waves, however, are new concepts (Yuan et al, 1999; Qiao et al., 2004; Babanin, 2006). The non-breaking wave-induced mixing can affect the water column to a depth of the scale of the wavelength, which is of the order of 100m and is comparable with the mixed layer depth; while, the wave breaking-related mixing only affects the scale of wave height. Therefore, the non-breaking wave effects provide a ready explanation for turbulence diffusion or advection in order to mix the seasonal ocean layer through the thermocline below. Ever since the proposal of this concept, it has been confirmed through extensively tested in the laboratory (Babanin and Haus, 2009; Dai et al, 2010; Savelyev et al, 2012) and in the field (Pleskachevski et al., 2011).

Implementation of this wave-turbulence mixing in climate models leads to significant impacts, as mentioned above, both on the atmospheric side and in the ocean (Qiao et al., 2010). This implementation is particularly necessary since the wind/wave climate itself has been changing, both in the mean and in its extremes (Young et al., 2011). The wind/wave growth is most relevant for ocean mixing, air-sea interactions and extreme oceanic conditions. The sea drag coefficient, which is the main property to describe the air-sea interaction in GCMs, also explicitly depends on the waves as discussed above. Thus, it appears that neither climate trends nor wave trends can be adequately addressed unless GCMs are fully coupled with wave models.

In short, without accounting for the wave effects directly, the physics of large-scale ocean circulation and air-sea interactions is inaccurate, inadequate and incomplete. The proposed working group will bring together experts in ocean waves, ocean circulation and climate models. Two main reasons make coupling of waves with the dynamics of large-scale phenomena necessary and feasible now: First, since the waves evolve in response to air/sea forcing, by receiving energy and momentum from the winds and by passing it on to ocean turbulence and currents, their feedback cannot be efficiently averaged and parameterized, but has to be unambiguously evaluated and accounted for at every instant. Second, modern-day computer facilities have caught up with the needs of coupling small-scale and large-scale phenomena.

3. Terms of Reference

The proposed working group would

(1) Comprehensively summarize past results of all scientific aspects of surface wave on upper ocean and lower atmosphere;
(2) Identify new observational techniques needed to fill gaps in understanding essential physics and dynamics of the wave-induced vertical mixing in upper ocean and air-sea fluxes to provide useful information for parameterization;
(3) Explore new and effective ways to make the atmosphere, wave and general ocean circulation models to couple together seamlessly and efficiently;
(4) Convene both open and by invitation working group meetings and publish the progressive assessments in open literatures such as publishing a special issue of a major journal dedicated to this topic, or proceedings of the Air-Sea Symposium;
(5) Finally, produce a comprehensive final report incorporating the study results and the state-of-the-arts summary of the above topics in a monogram to be published by a leading

publishing house, such as the Cambridge University Press, as a milestone and land mark for the air-sea fully coupled climate modeling.

4. Working Group Membership, Group Activities and Capacity Building

(1) Membership

Ten full members are as follows (Profs. Fangli Qiao and Alexander V Babanin will co-chair WG/)

No	Name	Institute/University	Nation	Gender
1	Fangli Qiao	First Institute of Oceanography	China	M
2	Alexander V Babanin	Swinburne University of Technology	Australia	M
3	Mikhail Dobrynin	University of Hamburg	Germany	M
4	Yign Noh	Yonsei University	Korea	M
5	Erick Rogers	Naval Research Laboratory	USA	M
6	Anna O. Rutgersson	Uppsala University	Sweden	F
7	Fredolin T. Tangang	National University of Malaysia	Malaysia	M
8	Yu-heng Tseng	NCAR	USA	M
9	Yuliya Troitskaya	Institute of Applied Physics	Russian	F
10	Judith Wolf	National Oceanography Centre	UK	F

Six Associate members are as follows:

No	Name	Institute/University	Nation	Gender
1	Tal Ezer	Old Dominion University	USA	M
2	Safwan Hadi	Institute of Technology Bandong	Indonesia	M
3	Norden E Huang	National Central University	China	M
4	Somkiat Khokiattiwong	Phuket Marine Biological Center	Thailand	M
5	Yeli Yuan	First Institute of Oceanography	China	M
6	Will Perrie	Bedford Institute of oceanography	Canada	M

Note: All 10 members and 6 associated members are Professors. And more associate members may be included.

(2) Working group activities

Annual meetings (by invitation): The attendees would be limited to the members and invited experts in the proposed subject to summarize the progress and assess the future direction of action for the working group. It is proposed that three annual meeting will be organized during 2014-2016. The first meeting will be an Open Science Meeting which is scheduled in China in 2014.

The second meeting may be in Australia in 2015, an article to EOS (2014) and a possible article to BOMS (2015) are expected respectively. The venue of the third meeting in 2016 will be discussed among working group members and a proceedings or a special issue of a journal is expected in the third year.

Scientific sessions (Open to public): organize 2 scientific sessions at the General Assembly of the European Geosciences Union and in 2015 and 2016 to announce the progress and to solicit a wider view from the community on the proposed subject

Symposium: In 2017 of the last year of this working group, a special Air-Sea Interaction Symposium will be organized in China, dedicated to the wave-coupled effects in ocean circulation, weather and climate.

Additional editorial meeting of selected members in the last year will be organized, if necessary, to work out the final report which will be published by a leading publishing house, such as the Cambridge University Press.

(3) Capacity building
Other than the open meetings, capacity building will be accomplished mainly through two additional kinds of activities:

Firstly, establish and maintain a Web site as a "virtual workshop" that can be used by the scientific community for exchange and discussion of ideas, results, and future planning on the surface wave effects in ocean and climate; and secondly, to host two training courses on wave effects on ocean and climate, and support at least 15 trainees from all different countries each time on the platform of the UNESCO/IOC Regional Training and Research Center on Ocean Dynamics and Climate (http://www.fio.org.cn/english/training_center/index.htm). The chair of this working group will seek additional financial support for the related capacity building.

5. The Relationship with Previous SCOR Working Groups and Other Organizations

WG 28 air-sea interaction focused the traditional air-sea exchange processes, while the present WG will focus on the surface wave effects on air-sea interaction with a special emphasis on the effects in the water column through mixing. WG 69 studied small-scale turbulence and mixing in the ocean, while the present WG will focus on the surface wave-induced mixing; WG 103 focused on wave breaking on upper ocean dynamics, while the present WG will focus on the non-breaking surface wave-induced mixing; WG 111 focused on the coupling processes among surface waves, currents and winds in coastal area, while the present WG will focus on open sea. WG 121 focused on mixing in the deep ocean, whereas the present WG will focus on the ocean mixing in the upper ocean. The work of this group is closely relevant to the SCOR-IGBP-WCRP- CACGP Surface Ocean – Lower Atmosphere Study (SOLAS), Intergovernmental Oceanographic Commission (IOC), as well as to the World Climate Research Programme (WCRP) and the International Association for the Physical Sciences of the Ocean (IAPSO).

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1 August 2013

Dear Fangli

On behalf of the CLIVAR project of the WCRP, I wish to express our support for the proposed SCOR Working Group on Surface Waves in Ocean Circulation and the Climate System.

The proposal will identify new observational programs needed to better parameterize upper ocean wave-induced vertical mixing and the associated air-sea interaction processes. This will make it possible to improve ocean and climate models by including the mixing effects associated with the surface waves, providing an avenue to link small-scale surface waves with large scale ocean circulation and global climate change.

We have obtained feedback from members of the CLIVAR community for your consideration and these are attached. We encourage the group to consider these suggestions, which would add weight to your proposal and improve its prospects for success.

Yours sincerely

Professor Roger Barry
Director - ICPO

2.3.9 SCOR Working Group on Standard protocols for the development of an atlas of marine plankton biogeography *Costello*

Proposal for a SCOR working group on Standard protocols for the development of an atlas of marine plankton biogeography

Abstract

Deciphering the structure and functioning of marine planktonic ecosystems is becoming increasingly important to help us understand and predict their role in an Earth System Science context. This is especially critical as climate change and other anthropogenic impacts are altering marine ecosystems at an unprecedented rate. Marine planktonic ecosystems are key players in driving global biogeochemical cycles. They respond to changes in environmental conditions such as global warming and ocean acidification, but they also drive global biogeochemical cycles themselves. Thus, a major reorganization in plankton biogeography due to climate change will feed back onto climate and global biogeochemical cycling by modulating ocean CO_2 storage and emissions of climatically important trace gases. A recent data collection effort, the MARine Ecosystem DATa (MAREDAT) initiative, brought together over 500'000 abundance and biomass measurements. For the first time, it is possible to investigate plankton biogeography at the global scale, and within the context of a diverse set of applications from marine ecosystem model validation to applications in theoretical ecology and remote sensing. The MAREDAT datasets are publically available with unique, citable digital object identifiers (DOIs) at the data publisher PANGAEA and summary papers on methods and the data are published in the open-access journal *Earth System Science Data*. However, many existing data sources could not be included in the initial release of MAREDAT, and important biases remain in both the temporal and spatial domain. Furthermore, the analysis of the MAREDAT data set reveals that a more uniform structure would allow data to be useful for a wider range of applications.

Here, we propose a SCOR working group for the development of new protocols for the reporting and collection of global-scale planktonic ecosystem data such as abundance and biomass measurements. We also propose to include pigments, which can be used to estimate phytoplankton taxonomy, as well as those biological rates and plankton physiological traits that can be geo-referenced, as each will further define plankton biogeography. Furthermore, we propose to pioneer a standard methodology for the interpolation of scarce biological data. The working group would develop a common protocol for data reporting for a global plankton atlas in collaboration with data archives and data users from different fields, and implement them for the new release of MAREDAT in 2015. It would then test and recommend new global data interpolation routines based on neural networks, biomes or other large-scale properties. The working group would answer important questions on how to link different data sources, such as biomass, pigment and trait data, and would collaborate on the analysis of the data for an improved understanding of marine ecosystem structure and functioning in a changing world. The main product of the proposed SCOR group would be MAREDAT2015, an extension of the

MAREDAT2012 global atlas of plankton biogeography (http://www.earth-syst-sci-data.net/special_issue7.html). The working group would define guidelines on standard data protocols and quality control during year 1 of the working group, collect and archive data during years 2 and 3, and publish MAREDAT2015 at the end of the third year. The fourth year of the SCOR working group would be dedicated to the analysis of the data, in collaboration with colleagues from trait ecology and remote sensing fields, and the results would be published in a scientific article.

1. Rationale

Anthropogenic climate change has been shown to impact marine planktonic ecosystems in several crucial ways: On a global scale, the ocean is simultaneously undergoing warming, deoxygenation and ocean acidification (Doney, 2010); that is, the ocean is "warming up, losing breath, and turning sour" (Gruber, 2011). Increased stratification in subtropical and temperate latitudes may limit nutrient availability and decrease primary productivity over the coming century (Steinacher et al. 2010). These changes may already be underway: For example, the oligotrophic regions of the oceans appear to be expanding (Polovina et al. 2008), Pacific species have been shown to migrate into the Atlantic (Reid et al. 2001), zooplankton species shifts have been recorded in the North Atlantic (Beaugrand et al. 2004, 2008), and regime shifts have occurred in the Black and Caspian seas due to overfishing and the invasion of non-native species (Oguz & Gilbert, 2007). These and many more studies show that climate change and other anthropogenic impacts affect ecosystems across multiple trophic levels and in many different ways (Doney et al. 2012).

Marine planktonic ecosystems play an important role in the global biogeochemical cycling of key elements such as carbon, nitrogen and sulfur. Marine plankton form the base of the food web, and are of crucial importance for everything from the marine biological pump and ocean CO_2 storage, to global fisheries and food security in developing countries. Specific plankton groups produce nitrogen, sulfur and organohalide-based trace gases that can affect climate and atmospheric chemistry. Marine biodiversity forms a resource that is exploited in many industrial ways from the use of genes that code for low-temperature enzymes in detergents, to food supplies and animal food stocks. However, many marine ecosystem services related to global biogeochemical cycling, food provision and genetic diversity are still poorly quantified (Worm et al. 2006), since not all aspects of marine ecosystem structure and composition are routinely monitored on the global scale. Thus, changes in lower trophic level marine ecosystem structure and functioning may crucially impact global climate in the long term, and through trophic cascades the livelihood of millions of people relying on marine resources. The FAO estimates that about one billion people worldwide rely on fish as their primary source of animal protein (FAO, 2000).

Recent advances in remote sensing now allow the estimation of different plankton functional groups and size structure from space using relationships between phytoplankton and water-leaving reflectance (Alvain et al. 2005), backscattering (Kostadinov et al. 2009, 2010) or pigment concentrations and chlorophyll-a (Hirata et al. 2008, 2011). However, most remote sensing algorithms have been validated using only a few hundred data points in limited ocean regions (e.g. Hirata et al. 2011, Alvain et al. 2012). Extensive sets of validation data are essential

for groundtruthing these algorithms in order to use the high-resolution products to monitor patterns of change in lower trophic level marine ecosystems on the synoptic global scale.
Satellites are an essential tool for present and past assessment of marine planktonic ecosystem changes, but in order to quantify potential future change, ecosystem model simulations are required (Bopp et al. 2001, Hashioka et al. 2009, Steinacher et al. 2010). Marine ecosystem models are becoming increasingly complex (Follows et al. 2007), and the availability of trait data for their parameterization, and biomass data for their evaluation, is an important determinant in the rate of progress (Le Quéré et al. 2005). Models thus require information on both the biomass and behavior of the groups modeled, with many parameters still poorly constrained (Anderson et al. 2005), as well as bulk properties such as net primary or bacterial production (Buitenhuis et al., *submitted*). Marine ecosystems are still significantly less well understood than their terrestrial analogues, and an understanding of marine ecosystem structure and functioning based on first principles of ecology remains elusive. Observational evidence remains episodic, and limited to a few regions with good data coverage.

Data availability remains one of the primary limiting factors for the development of important tools to understand, detect, and project potential changes in marine ecosystem structure and functioning that may have wide implications for present and future marine ecosystem service provision. For improved understanding of plankton biogeography and its drivers, existing data need to be compiled in a global atlas (Buitenhuis et al. 2013) to facilitate ecosystem model and remote sensing algorithm validation. An atlas of plankton biogeography will need to include data on the abundance and biomass of different marine planktonic ecosystem constituents, data on phytoplankton pigments for comparison with satellite products, physiological rates and behavioral traits for model development and validation, and bulk rates such as primary and bacterial production, nitrogen fixation and calcification.

We propose the formation of a SCOR working group to build upon existing efforts to establish a global marine planktonic ecosystem database (Buitenhuis et al. 2013) by developing guidelines on how to optimize such an atlas for use in applications from theoretical ecology to model development and for the validation of remote sensing algorithms. The proposed SCOR group would bring together marine ecosystem scientists from different fields to achieve a product that fulfills an extensive set of data requirements: The SCOR working group will need to develop guidelines and standard protocols on how to extract, quality control and archive existing data, and how to record abundance and biomass information together with crucial ancillary information for every important plankton functional group. Data will need to be open access, well documented and easy to use for a diverse community with different data needs. In order for the data to be useful for the quantification of ecosystem services, scarce and variable biological data will need to be interpolated to larger scales of common function, such as that of biomes or biogeochemical provinces of the ocean (Longhurst, 2010). Different data streams, such as abundance, pigment, rate and trait data will need to be combined in new and innovative ways to translate plankton biogeography into ecosystem function. The proposed SCOR working group would further scientific progress by taking a first step in this direction. This working group will incorporate institutional data contacts and spatial survey data sources identified by SCOR working groups 125 and 137. While those previous groups focused more on single geographic point time series, this group will pursue additional spatial (larger area)

data. Together, these efforts will create a global collection of long temporal and comprehensive spatial plankton data sets.

1.1 Scientific Background

The MARine Ecosystem DATa (MAREDAT) has recently published the first global atlas of marine plankton functional type abundance and biomass data in a special issue of the journal *Earth System Science Data* (ESSD; Buitenhuis et al. 2013). The initiative has collected around 500'000 abundance and biomass observations for 11 autotrophic and heterotrophic plankton functional types: the diatoms (Leblanc et al. 2012), coccolithophores (O'Brien et al. 2013), nitrogen fixers (Luo et al. 2012), *Phaeocystis* (Vogt et al. 2012), picophytoplankton (Buitenhuis et al. 2012a), bacteria (Buitenhuis et al. 2012b), micro- (Buitenhuis et al. 2010, 2013), meso- (Moriarty and O'Brien, 2012) and macrozooplankton (Moriarty et al. 2013), as well as pteropods (Bednarsek et al. 2012) and planktic foraminifers (Schiebel and Movellan 2012). Furthermore, MAREDAT contains a global HPLC pigment database with ca. 34'000 measurements (Peloquin et al. 2013). The MAREDAT datasets are publically available with unique, citable digital object identifiers (DOI's) at the data publisher PANGAEA (http://www.pangaea.de/search?q=maredat+), and summary papers on methods and the data are published in the open-access journal ESSD (http://www.earth-syst-sci-data.net/special_issue7.html); both mechanisms provide an important route for observational scientists to receive proper credit for their work.

Recent years have also seen an exponential increase in the availability of plankton trait data, describing plankton behavior, metabolic rates, morphology and life cycle characteristics. Published phytoplankton trait data comprises maximum growth rates for 105 marine phytoplankton species (Edwards et al. 2012), minimum nitrogen and phosphate cell quota, nutrient uptake rates for iron, nitrate, phosphate and ammonium, half-saturation constants for nutrient and light uptake (Klausmeier et al. 2004; Litchman and Klausmeier 2008; Edwards et al. 2012), and optimal temperatures for phytoplankton growth (Thomas et al. 2012). Zooplankton trait data on size distribution, feeding strategies and behavioral patterns are also abundantly available (Forster et al. 2011, Kiørboe, 2008, Kiørboe 2011). In their recent review, Barton et al. (2013) suggest that an initiative to collect trait data in a concerted manner similar to MAREDAT is essential for further progress on the understanding of marine planktonic ecosystem structure and functioning.

MAREDAT data have been recognized as valuable for applications in biogeography, biological oceanography, biogeochemistry, as well as for marine ecosystem model validation purposes and for the quantification of important ecosystem services such as those related to the global biogeochemical cycling of important elements. Furthermore, the data can be used for the validation of new methods to detect and monitor plankton groups from space. The initial analysis of the data sets has revealed their potential to link patterns in global plankton biogeography that have not previously been understood. A major limitation of the present data set is the poor spatial and temporal resolution of the data in some under-sampled ocean regions. There is a consensus that much more data exists, and that a second release of the atlas is necessary in order to allow for a better representation of global plankton distribution (Buitenhuis et al. 2013).

MAREDAT has started to shed light on global plankton biogeography in terms of abundance and biomass (Buitenhuis et al. 2013). However, in order to quantify marine ecosystem service provision and its drivers, a combination of biomass with trait and rate data is necessary. In terrestrial ecosystems, trait and abundance measures have been combined into multiple indices of, for example, functional diversity, which is shown to relate to the magnitude of ecosystem services concerning production, nitrogen fixation and above- and below-ground biomass (e.g. Randerson et al. 2009; Clark et al. 2012). In order to quantify ecosystem services in the marine realm, a similar effort is necessary to understand, model and predict present and future changes in marine planktonic ecosystems, and their consequences for ecosystem service provision. The systematic data collection we propose opens the door for a variety of different applications. Raw data can be used 1) to predict spatio-temporal patterns in species characteristics (Edwards et al. 2012, Thomas et al. 2012), 2) to elucidate biodiversity patterns (O'Brien et al., in prep., Worm et al. 2006, Irigoien et al. 2004, Rutherford et al. 1999), 3) to study the flow of matter across different trophic levels (Buitenhuis et al. 2013), 4) to study ecological niches of plankton species (Brun et al., in prep., Irwin et al. 2012), 5) to investigate species and biome shifts in marine planktonic ecosystems (e.g. Beaugrand, 2004, Beaugrand et al. 2008, Alvain et al. 2013), 6) to assess global patterns of elemental ratios that are crucial for global biogeochemical cycling (Martiny et al. 2013), and 7) to determine the drivers of plankton biogeography (Dutkiewicz et al. 2011, Luo et al., 2013). Data will also be useful to quantify ecosystem services related to global biogeochemical cycling; that is, for the determination of rates of primary production (Buitenhuis et al., *submitted*) nitrogen fixation (Luo et al. 2013), DMS production (Schoemann et al. 2005), and opal production and export (Sarmiento and Gruber, 2006).

In parallel, the data can be used to inform other fields of marine ecology, provided that it is made available in the appropriate format. Advances in remote sensing allow for the discrimination of several types of plankton from space (Alvain et al. 2012, 2013, Hirata et al. 2011). These algorithms still differ significantly in their results, but the availability of easily accessible validation data offers great chances for future ecosystem monitoring on the global scale. Furthermore, marine ecosystem models have now reached the level of complexity required to resolve different players in the marine food-web differentially, through either the inclusion of plankton functional groups (Le Quéré et al. 2005, Hood et al. 2006) or flexible biodiversity (Follows et al. 2007), or through the representation of plankton traits in trait-based models (e.g. Bruggeman and Kooijman 2007). Global model inter-comparison efforts such as the MARine Ecosystem Inter-comparison Project (MAREMIP) have started to validate model projections against satellite and experimental data, as well as hypotheses from theoretical ecology. These studies find significant differences in the model structure and functioning, and the drivers of plankton biogeography (Hashioka et al. 2012, Sailley et al., *in press*, Vogt et al., in preparation). For realistic simulations of future ecosystem structure and functioning, as well as ecosystem service provision, an understanding of the mechanisms driving these factors is crucial.

Since an update of MAREDAT is planned for the year 2015 that will take into account the experiences of the first MAREDAT release, a coordination of the efforts to collect plankton biomass data in the future is essential. The data will be optimized to be suitable for studies in several different disciplines of oceanography and ecosystem modeling, and it is thus essential

to establish common protocols on the reporting, quality control of the data, and on the use and development of new and innovative interpolation methods. Furthermore, the combination of different methodologies for data collection for different plankton groups into one consistent product needs to be addressed. A combination of different types of data, which is of utmost importance for the understanding of properties related to functional diversity and ecosystem service provision, will only be possible if data fulfill compatibility requirements and follow common standards. A mutual exchange of experiences and data needs between members of MAREDAT, field-based biological oceanographers, ecologists working on the characterization of plankton traits and ecosystem modelers will guarantee an optimization of the versatility of the data for use in different disciplines of marine ecosystem research. Thus, the establishment of a SCOR working group on this issue is timely and arguably one of the best ways to bring together available expertise. Expertise on data collection and archiving from the MAREDAT community will be complemented by that of the trait community and ecosystem modelers for the development of the MAREDAT2015 global atlas of plankton biogeography. The mutual collaboration on new and important concepts in ecosystem research, such as the quantification of functional diversity or the new and innovative use of statistical tools common in terrestrial ecosystem research, such as species distribution models, as well as the joint analysis of different data sources, will be of tremendous benefit for both communities. Thus, a SCOR working group is optimal for community and expertise building in this area, with a focus on building a common base for the understanding of marine planktonic ecosystem structure and functioning, and present and future global plankton biogeography.

In times when the ocean is undergoing unprecedented changes due to anthropogenic climate change, the proposed SCOR working group on plankton biogeography is timely, due to (1) an increased availability of data owing to progress with *in situ* collection methods (2) the availability of statistical tools such as species distribution models (Elith et al. 2006) or concepts such as functional diversity (Tilman et al. 1997) that have yet to be explored in the marine realm, and (3) an increased international collaboration between the researchers interested in these questions. A SCOR working group would allow us to build on our existing expertise, and shape a tightly linked and fully interdisciplinary community of scientists tackling new standards for future data collection, archiving and collaborative analysis of important issues in marine ecosystem research.

1.2 Detailed questions that would be addressed

In the proposed SCOR working group, we would address the following key methodological questions in marine ecosystem research:

(1) How accurate and yet intuitive are the vocabularies used by data archives to describe what is measured in marine ecosystem research, particularly in plankton ecology?
(2) Which formats and standards should be adopted to provide data products that are most useful for a wide variety of applications in marine ecosystem research?
(3) Which methods of quality control are most sensible for the post-processing of scarce and highly variable marine planktonic ecosystem data sets that span several orders of concentrations, and may change on the daily scale?
(4) Which ancillary data are essential for the correct interpretation of the recorded data?

(5) How can different data types be combined to address new questions of ecosystem research?
(6) How can data be interpolated to larger scales using new and innovative techniques such as biome-scale interpolation, neural networks and other methods?
(7) How can we as a community assist each other in the interpretation of our data sets?
(8) How should future measurement programs be designed in a way to provide data of maximum usefulness for the international research community? Which data do we lack, and how can we inform the experimental community and funding bodies of our data needs?

1.3 Timeliness and relevance of the activity

The proposed activity is timely, as global data sets have only recently become available, and standards for their formats, archiving and quality control have not yet been set. Defining standards for these data sets, and joining forces in their interpretation will provide added value to the scientific community, and will speed up research on the impact of climate change on marine ecosystems. Furthermore, a SCOR working group will increase the international visibility of these efforts, and may lead to joint proposals with a larger impact. The understanding gained through the joint analysis and collection of the different ecosystem data streams will be of particular importance for the economies of developing countries, and for those countries that rely heavily on the use of goods and services from the sea.

1.4 Relevance for SCOR sponsorship

The proposed topic of this proposal is highly relevant for SCOR sponsorship, since it addresses a topic at the forefront of current marine ecosystem research, focuses on global patterns of marine biogeography and potential changes in marine ecosystem structure and functioning, and because it will solve essential methodological questions that would otherwise remain unanswered were it not for the synergy between the MAREDAT and trait communities that a SCOR working group provides on an international level. The improvement of scientific methods to collect, compile and archive data, and the intent of the proposed SCOR working group to actively inform the observational community about our data needs and the gaps in our knowledge is completely within the scope of SCOR. The proposed working group would allow knowledge transfer from SCOR working groups 125 (Global Comparisons of Zooplankton Time Series) and 137 (Patterns of Phytoplankton Dynamics in Coastal Ecosystems: Comparative Analysis of Time Series Observation), but it would focus on open ocean and global scale patterns of both autotrophic and heterotrophic constituents of lower trophic level ecosystems, and the combination of different data types.

2. Statement of Work/Terms of Reference

The proposed working group would

(1) summarize and assess the current status of biomass, pigment and trait measurements with a particular focus on the format of existing databases
(2) compile a comprehensive list of standard protocols for data reporting and archiving for each of the major plankton groups, collection method and data types
(3) use existing structural frameworks for organizing information to formalize concepts describing what is measured in marine ecosystem research, and build standard

vocabularies that will be (a) accurate enough for an intelligent/automated compilation/integration of data, and (b) intuitive enough for data discovery using facetted search engines

(4) establish common, generally agreed quality control procedures for the compilation of plankton data
(5) collaborate with data archives such as PANGAEA, BCO-DMO, and COPEPOD, and with SeaDataNet, the ICSU World Data System and the IMBER data management group in order to implement these standard procedures in the large data archives
(6) develop new methods to interpolate scarce biological data to scales relevant for the quantification of important ecosystem services
(7) disseminate those procedures widely to ensure rapid adoption by the community
(8) inform the observational community of our data needs and current gaps in our understanding of marine ecosystem structure and functioning
(9) collaborate on the analysis of different data sources using statistical tools from terrestrial ecosystem research and important concepts of theoretical ecology, and the quantification of important ecosystem services.

2.1 Conferences and Workshops planned

Pre-meeting: The Copenhagen trait-based workshop from August 26-28, 2013 will bring together scientists listed as members of proposed SCOR working group, but it will not rely on SCOR funding. This meeting presents an ideal occasion for a pre-meeting among the members of the proposed SCOR working group, and for discussion between members of trait ecology and plankton biogeography on how to combine abundance and biomass data with trait and pigment data. Furthermore, a discussion on how to link abundance and trait data for a better quantification of ecosystem services can be started.

Kick-Off Meeting: In order to provide good international visibility and assure high attendance, the kick-off meeting would coincide with a major relevant international conference. A thematically suitable meeting would be the Ocean Sciences Conference (February 2014, Hawaii, USA), where a relevant session proposed jointly by several working group participants has been accepted. An alternative conference suitable for the kick-off meeting of the proposed SCOR working group meeting could be the IMBER Open Science Conference in Bergen in July 2014. A common session between the trait and biomass community has just been accepted for this meeting. The title of the session is “Data synthesis and modeling of marine planktonic ecosystems with plankton functional types and trait-based models”.

Further Meetings: Further candidates for meetings could be the ASLO Aquatic Sciences meeting in 2015 in Granada, Spain, where another joint session could be proposed. In the beginning of 2017, the proposed SCOR working group would host a workshop at the University of East Anglia to discuss the progress of the data compilation for MAREDAT2015, and further steps. The focus of the workshop would be the development of data interpolation strategies for scarce and highly variable data sets, and the joint analysis of the MAREDAT2015 datasets.

Products: The main final product of the SCOR working group is the updated MAREDAT2015 atlas of global plankton biogeography by the end of 2016, consisting of a set of at least 12

papers on plankton abundance, biomass and pigment data and geo-referenced trait data. A common quality control procedure for newly submitted data will be published along with guidelines on the best format of data submission and publication. The latter will contain information on how to report taxonomic information, which ancillary data to include the definition of standard units for abundance, biomass and pigment data that are suitable for a wide set of applications in biological oceanography and marine ecosystem modeling. Common software will be created and published on the MAREDAT website (www.maredat.info) that handles (1) the quality control procedure, (2) the generation of gridded products, and (3) routines for the interpolation of data to larger scales using novel techniques (e.g., Lana et al. 2011; Landschützer et al., 2013). A white paper will be written by the end of year 3 that informs funding bodies and experimental scientists of the gaps in our current understanding of marine ecosystem structure and functioning, and details future data needs for improved ecosystem understanding. The first joint interpretation of the data and recommendations from the group will also be highlighted in a high-profile publication written by the group at the end of year 4.

2.2 Working group activities/Capacity building

From a socioeconomic perspective, many issues in current marine ecosystem research, such as the quantification of potential impacts of global change on marine ecosystem service provision is highly important for developing countries and economies in transition. The results of the proposed activity will inform policy makers and the public on potential hotspots of ecological change, and on locations with a high degree of diversity. The proposed SCOR working group would bring together the MAREDAT community with marine ecosystem modelers who are part of the MAREMIP initiative, as well as researchers working on trait-based models and members of the remote sensing community. These communities have a common goal – the understanding of present and future marine ecosystem structure and functioning – but are currently not linked through an international working group. The SCOR working group would thus facilitate the important exchange of ecosystem data between different ecosystem researchers working toward a common goal. For example, the remote sensing community may require data for the evaluation of their algorithms, while marine ecosystem modelers will need physiological rates/trait data to implement further complexity into their models. A SCOR working group would also lead to the identification of data requirements and needs by these different communities, and how MAREDAT could accommodate a maximal set of such needs through sensible and simple data standards. Bringing modelers and experimentalists together around a table would also increase the international visibility of marine ecosystem research, and will lead to future collaboration, ideas and findings. The SCOR working group would also increase efficiency in the expansion and establishment of global plankton data sets. The MAREDAT community already has experience with the generation of a global plankton atlas, and this know-how can be exploited by the trait community to collect and archive data more effectively. In addition, close contacts will be established with members of the terrestrial ecosystem community through the use of statistical tools and concepts that are common in terrestrial ecosystem research. Building necessary capacities in developing countries can be fostered by providing access to open-source data, best practice manuals and standard protocols that will augment access by members from countries with limited financial and infrastructural means to generate their own data. Additional funding would be requested from SCOR's travel grant program to finance the attendance of at least one additional young scientist from a

developing country to attend international meetings, whenever the proposed SCOR group members meet. Thus, young scientists would be trained in essential networking and technical skills while being introduced to leading international members in the field.

2.3 Timeline

Year 1 (2014): Establishment of common protocols for data collection and archiving, as well as quality control procedures, data call for MAREDAT 2015
Milestones:

A) Compilation of guidelines specific for each data type, method and plankton group.
B) Identification of traits with sufficient data coverage, in space and time, to incorporate into atlas.
C) Development of guidelines for quality control. D) Dissemination of the guidelines.
E) Data call for MAREDAT 2015.

Year 2-3 (2015 -2016): Data collection for MAREDAT2015
Milestones:

A) Special MAREDAT issue set up in a relevant journal such as ESSD.
B) Quality control procedures developed.
C) Data collection for the different plankton groups to be included in MAREDAT 2015.
D) Individual MAREDAT2015 papers published as discussion papers.

Year 3 (2016): Publication of an updated global atlas of plankton biomass (MAREDAT2015), as well as standard protocols and software.
Milestones:

A) Final version of individual MAREDAT2015 papers published in collaboration with data archives and publishers.

Year 4 (2017): Joint analysis of abundance, biomass, pigment and trait data, joint publication. Milestones:

A) Development of methods to interpolate scarce and highly variable biological data sets to larger scales.
B) Initial paper analyzing and comparing MAREDAT2015 data across different plankton groups.

3. Working Group Membership

3.1 Full Members

1 Meike Vogt (co-chair), f, senior scientist, ETH Zürich, Switzerland: Meike is one of the co-coordinators of MAREDAT 2012 and has several years of experience in the collection of standardized plankton data for use in biological oceanography and ecosystem modeling. Meike will provide expertise on standard protocols and data collection for use in model validation and marine ecology, and will co-coordinate MAREDAT2015.

2 Erik Buitenhuis (co-chair), m, senior scientist, University of East Anglia, UK: Erik is one of the co-coordinators of MAREDAT 2012 and has been working on data collection and ecosystem model development and validation for 15 years. Erik will provide expertise on data protocols and data interpolation for use in model validation and marine ecology, and will co-coordinate MAREDAT2015.

3 Stephane Pesant, m, senior scientist, MARUM, University of Bremen, Germany: Stephane coordinates data integration for several European projects and is editor for biological data collections at PANGAEA, data publisher for Earth and Environmental Sciences. PANGAEA is a strong building block of the ICSU World Data System. Stephane is a member of MAREDAT and SeaDataNet, and will provide expertise on data archiving and reporting. Stephane is a coordinator of Tara-Oceans and of the Ocean Sampling Day (http://www.microb3.eu/work-packages/wp2) aimed at the gathering of information on marine ecosystems and biodiversity.

4 Yawei Luo, m, senior scientist, Xiamen University, China: Yawei is a member of MAREDAT, and an expert on nitrogen fixers and nitrogen fixation. Yawei will provide expertise on data collection and on the reporting of traits related to global biogeochemical cycling.

5 Todd O'Brien, m, senior scientist, NOAA, USA: Todd is the head of the COPEPOD database and has years of experience in the collection and archiving of zooplankton data. Todd will provide expertise on data standards and data interpretation, and he is a member of MAREDAT.

6 Róisín Moriarty, f, senior research associate, University of East Anglia, UK: Róisín is an expert on zooplankton ecology and physiological traits, and a member of MAREDAT. Róisín is currently analyzing diversity patterns in MAREDAT, and will provide expertise on data collection and interpretation. She is an experienced plankton functional type modeller with end-to-end knowledge of marine ecosystem modeling from data collection, implementation in models and model-data validation.

7 Maria Deng Palomares, f, senior researcher, University of British Columbia and World Fish Centre Philippines, Canada/Philippines: Maria is an expert on fish population dynamics and fish data, and she is now coordinator of the SeaLifeBase, a project whose aim is to provide a 'FishBase-like' database for all other marine organisms that are not included in fish databases. Maria would provide input on data formats and archiving, and she would link our group with the scientists working on higher trophic level ecosystems, such as the FishBase team.

8 Takafumi Hirata, m, senior scientist, Hokkaido University, Japan: Takafumi Hirata is the executive officer of the MARine Ecosystem Modeling Inter-comparison Project (MAREMIP) and an expert on the detection of plankton functional groups from space. Takafumi will provide expertise on remote sensing, and the data needs of the remote sensing community.

9 Severine Alvain, f, senior scientist, CNRS, France: Severine Alvain is an expert on the detection of phytoplankton groups from space. Severine will provide expertise on remote sensing, and collaborate on the data requirements of the remote sensing community.

10 Forough Fendereski, f, PhD student, Gorgan University, Iran: Forough is a marine ecologist working on plankton biogeography, and on neural networking methods for the definition of marine biomes. She will provide expertise on the intelligent clustering and interpolation of marine ecosystem data, and on the collection of data in under-sampled regions.

3.2. Associate Members

1 Nicolas Gruber, m, professor, ETH Zürich, Switzerland: Nicolas Gruber is a marine biogeochemist with years of experience in marine ecosystem modeling. Nicolas has been part of several large data collection enterprise such as the CARINA oxygen data, and he has been a member of MAREDAT. Nicolas will provide input on marine ecosystem modeling and the data needed for the quantification of important ecosystem services related to global biogeochemical cycling.
2 Thomas Kiørboe, m, professor, DTU-Aqua, Denmark: Thomas is an expert on zooplankton traits. Thomas will advise MAREDAT2015 on how to provide data that can easily be combined with trait information for the quantification of important ecosystem services.
3 Elena Litchman, f, professor, Michigan State University, USA: Elena is a theoretical ecologist and an expert on plankton trait data. Elena will provide expertise on how to make abundance and biomass data useful for applications in theoretical ecology, on the interpretation of patterns from first principles and on the combination of trait and abundance data.
4 Scott Doney, m, professor, Woods Hole Oceanographic, Institution, USA: Scott Doney is a marine ecosystem modeler with many years of experience in ocean biogeochemistry and climate modeling. Scott is the head of the steering committee of MAREMIP, and will provide input on how to make MAREDAT2015 as useful as possible for model validation. Scott will also provide input on novel interpolation methods and quality control.
5 Stephanie Dutkiewicz, f, senior scientist, MIT, USA: Stephanie is a senior scientist in the MIT marine ecosystem modeling group and an expert on phytoplankton biogeography and trait-based ecosystem modeling. Stephanie will provide expertise on trait biogeography and the use of the data for modeling purposes.
6 Andrew Barton, m, postdoctoral fellow, Duke University, USA: Andrew is an ecosystem modeler and trait ecologist with an interest in building a global marine lower trophic level trait data base. Andrew will collaborate on the combination of abundance and trait data.
7 Chantal Swan, f, postdoctoral fellow, ETH Zürich, Switzerland: Chantal is an expert on remote sensing and HPLC pigments. Chantal is a member of MAREDAT and will provide input on how to link pigment and abundance data, and on how to use pigment data for the validation of remote sensing methods.
8 Ralf Schiebel, m, professor, University of Angers, France: Ralf Schiebel is an expert on foraminifera and palaeoceanography, and a member of MAREDAT. Ralf will provide expertise on long-term changes in marine ecosystem structure and functioning, with a focus on calcifying organisms.
9 Karine Leblanc, f, senior scientist, MIO CNRS, France: Karine Leblanc is a member of MAREDAT and an expert on marine biology with a focus on diatoms and biogeochemical flux measurements. Karine will provide input on the perspective of data originators, and will link the modeling and data analysis community with the observational community.
10 Nina Bednarsek, f, postdoctoral fellow, NOAA, USA: Nina Bednarsek is a member of MAREDAT, and an expert on the impact of ocean acidification on marine calcifiers. Nina will provide input on zooplankton ecology, and the potential impacts of global change on calcifiers.
11 Colleen O'Brien, f, PhD student, ETH Zürich, Switzerland: Colleen O'Brien is a marine ecologist, and a member of the MAREDAT. Colleen will provide expertise on data standards and data organization, and on issues related to plankton biodiversity.

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2.3.10 SCOR Working Group on Studying Ocean Acidification Effects on Continental Margin Ecosystems *Taguchi*

Proposal for a SCOR Working Group on Studying Ocean Acidification Effects on Continental Margin Ecosystems

Abstract

The increase in atmospheric CO_2 concentrations caused mainly by fossil fuel combustion is changing ocean carbonate chemistry equilibrium and decreasing seawater pH.[1] On continental margins these changes are less clear, which could be due to a variety of reasons, among them ***i)*** the extreme ecosystem heterogeneity, ***ii)*** the fact that carbonate chemistry is strongly regulated by riverine and open ocean delivery of nutrients and biological processes in these areas, ***iii)*** natural variation of pH in these areas at daily and/or seasonal timescales,[2] and ***iv)*** lack of observations and the inadequacy of global biogeochemistry models in resolving these areas.[3] The extent of ocean acidification effects on continental margin ecosystems, and the interaction of carbonate chemistry with other human-induced changes like eutrophication need to be better constrained.[4] This Working Group (WG) proposal focus on an integrated effort to put together the current knowledge on ocean acidification effects on continental margins (including boundary zones – e.g. coastal areas and shelf slope zone) to identify common features, regional contrasts, and sensitive areas. The WG Members will, over the 4-year period, ***a)*** *synthesize the current knowledge* of impacts of ocean acidification on continental margin ecosystems; ***b)*** *identify gaps* in current knowledge, taking into consideration the physical and biogeochemical variability of ecosystems; ***c)*** propose *best practices for observing and modeling ocean acidification impacts in these ecosystems*, including an intercalibration exercise for marine carbonate chemistry in continental margin areas; and ***d)*** *publish* the results of the working group either as a special issue of a peer-reviewed international journal or a book by a major world publisher.

Rationale

The absorption by the oceans of the excess atmospheric CO_2 changes the carbonate equilibrium of seawater, lowering the pH and carbonate ion concentrations, a process widely known as Ocean Acidification.[1,5] Field datasets have shown a clear decreasing trend in surface, open ocean pH[6] while in coastal seas and adjacent shelves this trend is not that clear and may be due to a variety of reasons including distinct dynamics over the continental shelf when compared to the deep ocean regime, the different biogeochemistry (i.e. higher and variable rates of primary production and respiration), and regional drivers such as nutrient input from riverine, atmospheric, and anthropogenic sources or upwelling of nutrient-rich water masses.[4,7-9] *The multiple factors controlling carbonate chemistry in continental margins imply that procedures commonly applied in ocean acidification research in deep waters cannot be simply translated to shelf regions*.[10] Moreover, the fact that these processes are dependent not only on the biogeochemistry but also on the physics make it necessary to have integrated studies on changes in the marine carbonate chemistry to eutrophication and ocean physics (e.g. circulation and seawater warming).[11] Because of the socio-economic importance of continental margins (e.g. fisheries, tourism, biodiversity), it

is important to integrate efforts on ocean acidification effects in these areas in order to enable near- future adaptation or mitigation strategies.

A SCOR Working Group is the best strategy to coordinate an international research group focusing on the issue of ocean acidification effects on continental margin ecosystems. There is a strong consensus in the scientific community about their socio-economic importance for the world population and the regional diversity of this land ↔ ocean interface area. The scientific rationale for this working group comes from the timeliness of an integrated effort to put together the existing knowledge on carbonate chemistry over continental margin ecosystems so that the common features, regional contrasts, and ocean acidification and man-made impacts can be identified through observational and modeling studies. A sponsorship from SCOR will help regional groups to attract financial support from national research funding agencies, especially *for those countries where ocean acidification research is still at an early stage*.

Scientific background

Because of their proximity to land and large metropolitan areas, continental margin ecosystems are at present threatened by human exploitation of their resources as well as by impacts associated to climate change: warming of the oceans, expansion of low-oxygen areas, and ocean acidification.[12,13] Continental margins have a disproportionately large contribution to the global cycle of essential elements of marine biogeochemistry. Although they occupy approximately 8% of the oceanic global area their contribution to global primary production ranges from 19-28%.[14]

Ocean acidification is caused when the excess CO_2 in the atmosphere is absorbed by seawater and causes a disequilibrium in the aquatic inorganic carbon (carbonate) system.[1,9] This disequilibrium leads to lower seawater pH, lower concentration of ion carbonate [CO_3], and reduces the saturation state of the biominerals aragonite and calcite, upon which aquatic calcifying organisms build their shells,[15] and affects the physiology of marine organisms.[1]

Continental margin areas have their carbonate chemistry strongly regulated by riverine and open ocean delivery of nutrients and biological processes.[7,16] However, there are (few) available datasets for the coastal oceans do not reveal the trends in changing carbonate chemistry as for open ocean areas.[4,6] Changes in nutrient delivery to the coastal ocean, and hence to primary production and organic matter remineralization, may enhance the impacts of ocean acidification on the continental margin carbonate system.[2,4]

Several studies show that continental margins currently play a role as carbon sinks (~ 0.2 – 0.3 Pg C yr^{-1}).[16-19] Additionally, continental margins house large benthic calcifying, reef building organisms, comparable to marine calcifying phytoplankton.[20-21] Despite the large ecosystem heterogeneity, these areas can be divided into near-shore (including estuaries and bays) and distal portions.[22] The former would act as net CO_2 sources to the atmosphere while the latter are net atmospheric CO_2 sinks. Concomitantly, geographical position also affects the sea ↔ air CO_2 fluxes. Temperate and sub-polar continental shelves would act as atmospheric CO_2 sinks while tropical and subtropical shelves would act as a source of CO_2 to the atmosphere.[22,23] *It is timely to understand the response of this "continental shelf pump"[24] to the combined effects of ocean acidification and eutrophication, both globally and regionally.*

There is a need for assessing ocean acidification (OA) effects on coastal and continental margin ecosystems, together with the current efforts to understand OA impacts in the open ocean carbonate system. For instance, recent technological developments now enable scientists to measure parameters (e.g. pCO_2, pH) of the marine carbonate system using moored equipment in continental margin areas.[21] Modeling efforts are also a valuable tool for assessing regional changes in the carbonate chemistry over continental margins because both physical and biogeochemical processes can be coupled to understand natural variability and predict future changes. Marine biogeochemistry models may have different levels of spatial resolution and complexity, both in the ecosystem (e.g. plankton functional types) and biogeochemistry processes representation.[8]

The challenge of understanding ocean acidification effects in such heterogeneous portion of the world ocean cannot be achieved by isolated studies. It requires an integration of long term observational data (e.g. from regional studies) and ecosystem-biogeochemistry models. This is the main purpose of creating this SCOR Working Group. Lastly, this proposed Working Group should also encourage the adoption of best practices for carbonate system measurements in the coastal and continental shelf oceans, especially for early stage research groups interested in ocean acidification.

Terms of reference

The proposed Working group would:

1. Synthesize the current knowledge of impacts of ocean acidification on continental margin ecosystems (Year 1);
2. Identify gaps in current knowledge, taking into consideration the physical and biogeochemical variability of ecosystems in distinct biogeochemical provinces (Years 1 and 2);
3. Propose best practices for observing and modeling ocean acidification impacts in these ecosystems, including an intercalibration exercise for marine carbonate chemistry in continental margin areas (Years 2 to 4); and
4. Publish the results of the working group either as a special issue of a peer-reviewed international journal or a book by a major world publisher (Year 4).

Working Group Membership

The tasks proposed in this document would be carried out by the proposed Full Members and Working Group Associate Members. The full and associate members listed here below have already accepted to participate to the working group in case it is funded by SCOR. Additional Associate Members may be nominated during the first Working Group Meeting. The proposed full and associate member lists here below would ensure a broad geographic coverage, including experts in Marine Biogeochemistry, Physical, Chemical and Biological Oceanography and Ecosystem Modeling.

Full Members

1. Leticia Cotrim da Cunha – (UERJ, Brazil, co-chair) – Coastal Ocean Biogeochemistry
2. Arne Koertzinger – (GEOMAR, Germany) – Chemical Oceanography
3. Paulo Calil (FURG, Brazil) – Ocean Biogeochemistry Modeling
4. Peter Croot (Univ. Galway, Ireland) – Marine Chemistry
5. Gwenaël Abril (Univ. Bordeaux, France) – Estuarine and Coastal Ocean Biogeochemistry
6. Claudine Hauri – (Univ. Alaska, USA) – Ocean Biogeochemistry Observations
7. Zouhair Lachkar – (ETH Zürich, Switzerland, co-chair) – Ocean Biogeochemistry Modeling

Associate Members

1. Rodrigo Kerr – (FURG, Brazil) – Physical Oceanography, carbonate system observations
2. Marcelo F. Landim de Souza – (UESC. Brazil) – Coastal Ocean Biogeochemistry
3. Katrin Meissner – (Univ. New South Wales, Australia) – Ocean-Atmosphere Interactions
4. Óscar Melício (INDP, Cape Verde) – Biological and Fisheries Oceanography

Working Group Activities

If approved, the WG would organize its first meeting in 2014 during a large marine science meeting (e.g. Ocean Sciences Meeting). At the first meeting, WG Members will have the opportunity to meet and present their research activities, and discuss about the division of tasks in the WG (according to the main terms of reference). Another important topic to be discussed during the first Meeting is the potential names for new Associated Members. The activities proposed here could be linked to many global ocean research projects, especially LOICZ, SOLAS, IMBER, GLODAP, EUROCEANS and GOOS. The WG will strongly encourage that all observational data generated within this framework to contribute to global ocean databases such as SOCAT, PANGAEA, and IODE.

WG Meetings

It is proposed that WG Meetings will take place annually before or during large related events such as the Ocean Sciences Meeting, or the EGU Meeting. The WG Agenda, the following meetings, the strategy for the intercalibration and modeling exercises, and the preparation of the final WG publication will be set up during this first meeting.

Capacity building

The proposed best practices and intercalibration results will be a helpful tool for all scientists (confirmed and especially the newcomers) studying ocean acidification effects in coastal and continental shelf areas. The WG will strongly encourage the exchange of scientists (e.g. learning new analysis techniques, modeling efforts, manuscript preparation) by seeking financial support from national funding agencies (e.g. CNPq, DAAD, NSF, COST, CNRS).

The aspect of capacity building could be further improved by hosting a session during a WG meeting to discuss the real needs and capabilities of countries bordering sensitive continental margin areas with respect to future strategies to face ocean acidification effects.

The proposed WG will create a web-based platform to post the documents (analytical procedures and recommendations) and results from intercalibration exercises and modeling efforts executed by different international groups.

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2.3.11 SCOR Working Group on Science and Technology Imperatives Created by Deep-Ocean Industrialization *Fennel*

Science and Technology Imperatives Created by Deep-Ocean Industrialization.

TERMS OF REFERENCE:

(1) Define the science that must underpin comprehensive, ecosystem-based management of deep-ocean environments subject to increasing industrialization via human extraction, harvest, disposal and contamination. Consider the science needed to maintain ecosystem functions in areas within and beyond national jurisdiction.
(2) Identify the state of scientific knowledge and knowledge gaps critical for effective stewardship of deep-seafloor environments. Consider influences of changing climate, cumulative human impacts, and biogeographic classifications.
(3) Evaluate technology and innovations needed for deep-ocean observations, monitoring and assessments in the face of seafloor industrialization.

POTENTIAL PRODUCTS:

(1) Short publication identifying growing industrialization of the deep seafloor and the need this generates for scientific knowledge (to enable sustainable ecosystem-based management of deep-sea ecosystems).
(2) Special contributed volume on the science of deep-sea stewardship. Possible venues: J. of Marine Systems, Marine Ecology, Biogeosciences. The volume may include papers on deep-sea classification, connectivity, recovery from disturbance, resilience and stability, susceptibility to climate change, marine protected areas.
(3) Group of themed papers on technology needs and options in the deep sea: Ocean observing, Long-term monitoring, Ocean enforcement. Possible link to DOOS group (Eric Linstroem).
(4) Special session at AGU or EGU "Science and technology gaps and opportunities linked to industrialization of the deep ocean"
(5) Development of "Deep-Ocean School of Excellence" course material for use in deep-sea regional training in less developed countries

RATIONALE:

The deep waters and seabed of the world ocean constitute the largest biosphere on this planet, supporting a wealth of species and habitat diversity, performing key ecosystem functions and providing valuable food, energy, pharmaceutical, and potentially mineral resources. Once considered pristine, the deep sea (from 200-11,000 m) is of growing economic interest. There is increasing pressure on deep-sea ecosystems from extraction activities such as fishing, oil and gas exploitation, bioprospecting, and minerals mining (for polymetallic nodules, massive sulfides, cobalt-rich ferromanganese crusts, phosphorites, and rare earths), as well as from waste disposal,

CO_2 storage, and contamination. Large-scale leasing of the seabed is occurring in some parts of the world with little or no existing baseline studies. Concurrently, CO_2-driven climate change is altering ocean temperatures, oxygen and pH with effects on deep-sea species distributions and ecosystem processes, and on their services and functions. All of this occurs out of sight, and thus out of mind. There is a pressing need for scientific information to enable sustainable management of deep-water ecosystems that reside within EEZs and international waters. Scientific themes such as biogeography, endemism and connectivity, disturbance and restoration ecology, resilience of ecosystem function, multiple stressors and cumulative impacts all emerge as important for making decisions and about deep-ocean activities.

This proposal is timely because the deep seafloor is undergoing rapid industrialization by oil and gas extraction, deep-water fisheries, and seabed mining. Exploitation activities are outstripping the available science needed to maintain the integrity of deep-ocean ecosystems and their functions. **This topic should be a high priority for SCOR** because many of the industrialization activities in the deep ocean target less developed countries, where the science knowledge base is limited or non-existent. This working group can help to identify and define the types of information needed and stimulate international programs to generate the needed knowledge. **Thus it provides an excellent mechanism to advance this topic**. The terms of reference are seen as gathering and synthesizing information that is ultimately needed to engage the global science community in long-term research efforts. The deep-sea community is fairly small, and practically non existent in developing countries. **The suggested membership** includes a mix of genders, ages, and representatives from countries in different stages of development. All are scientists who have identified an interest in and actively engaged in the issues.
We envision that this science core working group would team with **associate members** expert in policy and economics to help apply the science to environmental management issues, and with scientists from additional countries to broaden the global reach of the information gathering and its application**. Capacity building** will take the form of member engagement, identification of regional deep- ocean science needs for less developed countries, and development of 'Deep-Ocean School of Excellence' course materials for use in regional training.

POSSIBLE MEMBERSHIP (up to 10) Elva Escobar, Mexico (Lead)

- Lisa Levin, USA (Co-lead)
- Maria Baker, United Kingdom
- Cindy Van Dover, USA
- Hiroyuki Yamamoto, Japan
- Lenaick Menot, France
- Javier Sellanes, Chile
- Ashley Rowden, New Zealand
- Andrew Sweetman, Norway
- Aquila Tawake, Fiji
- Bronwen Currie, Namibia

POSSIBLE ASSOCIATE MEMBERS:

- Kristina Gjerde, Poland
- Tony Koslow, USA (biology)
- Baban Ingole, India (biology)
- Andrey Gebruk, Russia (biology)
- Linwood Pendleton, USA (economics)
- Dale Squires (economics)
- Paul Snelgrove, Canada (biology)
- Tracey Sutton, USA (biology)
- Jeff Ardron, Germany (policy)
- Kathryn Mengerink, USA (policy)
- Ursula Witte, United Kingdom (biology)
- Christian Neumann, Norway (communication)

TIMELINE:

Year 1: Workshop to consider Reference term 1 and organize data gathering for reference term 2; Formation of subgroup to address 'Deep-Ocean School of Excellence'

Year 2: Workshop to present/synthesize material for reference term 2 and organize data gathering for reference term 3. Organize Special Volume for publication in year 3. Gather resources for 'Deep-Ocean School of Excellence'

Year 3: Workshop to present and synthesize reference term 3. Organize/hold themed session at international meeting; organize technology papers for publication in year 4. Hold 'Deep-Ocean School of Excellence' test sessions.

Year 4: Complete publications. Develop workshop follow on activities.